# A LITTLE MORE LOGICAL

Reasoning Well About Science, Ethics, Religion, and the Rest of Life

By Brendan Shea

A Free, Creative Commons Textbook

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"A Little More Logical: Reasoning Well About Science, Ethics, Religion, and the Rest of Life"



Thoughtful Noodle Books

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# INTRODUCTION

"A Little More Logical" is the perfect guide for anyone looking to improve their critical thinking and logical reasoning skills. With chapters on everything from logic basics to fallacies of weak induction to moral reasoning, this book covers all the essential concepts you need to become a more logical thinker. You'll learn about influential figures in the field of logic, such as Rudolph Carnap and Ada Lovelace, and how to apply your newfound knowledge to real-world situations. Whether you're looking to engage in debates with others, make better decisions in your personal and professional life, or simply want to improve your overall critical thinking skills, "A Little More Logical" has you covered. So why wait? Start learning and become a little more logical today!

## WHAT PEOPLE ARE (NOT) SAYING ABOUT "A LITTLE MORE LOGICAL"

"Let me tell you, I learned a lot in this book! It was really illuminating. I learned the difference between deductive and inductive arguments, and how to recognize a fallacy when I see it. I also mastered the scientific method, which has been really useful in my line of work. And as for categorical logic? That was a breeze! I've always heard that 'You either die a hero, or live long enough to see yourself become the villain,' and I'm living proof that mastering logic is the key to success. Now, if you'll excuse me, I've got some world domination to attend to." - The Joker

"*A Little More Logical* was so much fun! I was really relieved to learn that logic wasn't going to be as hard as I thought. I learned about all kinds of different arguments and fallacies like Appeal to Force, Appeal to Ignorance, False Dichotomy, and Hasty Generalization, and I'm pretty sure I can use these back in my courtroom days. I recommend studying hard and focusing on the Premises and Conclusions of each argument - that's what helped me pass with flying colors! Now, let me tell you about why you should wear more pink..." (Elle Woods - Legally Blond)

"This book was quite an adventure! I had a lot of fun learning about Deductive vs Inductive Arguments, and how to make Deductive Valid and Inductive Strong arguments. It was like I was back in the future, understanding the mechanics of time travel! I also learned how to make informed decisions using Categorical and Propositional Logic. I suggest studying a little every night - that will help you understand the concepts better. Oh, and don't forget to bring your flux capacitor!" (Doc Brown - Back to the Future)

"*A Little More Logical* was mind-bending! I learned about all kinds of logical fallacies, like Circular Reasoning, False Cause, and Equivocation, and I think I can use these to make sense of the weird things I've seen in the upside-down. Moral and Legal Arguments were also interesting - they're definitely of use here in Hawkins, Indiana! I recommend studying the examples provided in the textbook and asking lots of questions - that's what helped me understand the material better." (Eleven - Stranger Things)

"I thought this book was an interesting challenge. I learned about the scientific method and how to apply it to arguments, and I feel like I'm ready to tackle any medical mystery now! I also learned about Arguments using Statistics and it was like being back in the Diagnostics Department at Princeton-Plainsboro. I suggest doing the practice problems in the textbook and using the internet for extra research - that helped me ace the final exam! You won't even need a bottle of Vicodin to get through it." (House, M.D.)

## HOW TO GET THE MOST OUT OF THIS BOOK

I understand that reading texts on logic (and the related disciplines of mathematics, philosophy, or computer science) can be intimidating and overwhelming for many people. It's important to remember that everyone finds these subjects challenging at some point – even experts have to work hard to learn and understand new concepts. But with the right approach and mindset, you can learn and succeed in these subjects just like any other.

One key approach that can help you succeed is to understand the difference between learning and just reading. When you're reading a novel or a news article, you can often get by with just skimming the material and still understand the main points. But when you're learning a new concept in a subject like logic, you need to actively engage with the material and work to understand it fully. To help you do this, I recommend following the advice of Dr. Barbara Oakley, a leading expert on learning and education.

**Alternate between "focused" and "diffused" modes.** The concept of "focused" and "diffused" modes of learning refers to the idea that it is beneficial for learners to alternate between periods of intense focus on a task

and periods of more relaxed, less concentrated activity. While it is important to focus on the material when learning, it is also important to take breaks and allow your mind to wander, as this can help your brain process and retain the information more effectively.

One way to structure your learning time and incorporate both focused and diffused modes is through the use of a technique like the Pomodoro Technique. This method involves dividing your study time into intervals, typically 25 minutes of focused work followed by a short break of 5 minutes. The idea behind this technique is that the short breaks allow your mind to relax and wander, which can help you process and retain the information you have just learned. After several Pomodoro intervals, it is recommended to take a longer break, such as 15-30 minutes, to give your mind and body a chance to rest.

The Pomodoro Technique is just one example of a method that can help you structure your learning time and incorporate both focused and diffused modes of learning. Other techniques, such as the Study Cycle or the Feynman Technique, also involve alternating between focused and diffused modes and can be helpful in aiding learning and retention. It is important to find a method that works for you and that allows you to effectively balance periods of intense focus with breaks to allow your mind to wander and process the information.

**Use "chunking" to break up the material into smaller, more manageable pieces.** "Chunking" is a learning strategy that involves breaking up material into smaller, more manageable pieces. This can be especially helpful when learning complex or dense information, as it allows you to take the time to fully understand each piece before moving on to the next. By learning each concept in isolation and then understanding how it fits into the bigger picture, you will be better able to master the material.

One way to use chunking as a study strategy is to divide the material into smaller sections and focus on one section at a time. For example, if you are studying a chapter in a textbook, you could break the chapter down into smaller sections based on topic or main idea. Then, you could focus on one section at a time, fully understanding and internalizing the information before moving on to the next section. This can be more effective than trying to study the entire chapter at once, as it allows you to focus more deeply on each concept and better understand how it fits into the overall structure of the material.

In general, it is also more effective to study for shorter periods of time on a regular basis rather than trying to cram all of your studying into a single long session. This is because our brains are better able to retain information when we review it over time, rather than trying to absorb a large amount of information all at once. So, studying material for an hour a day will, in general, lead to better outcomes than trying to study for 6 hours straight on Sunday night. By spreading out your study sessions and reviewing the material on a regular basis, you will be more likely to retain the information and achieve a deep understanding of the material.

**Beware of "illusions of competence".** The "illusion of competence" refers to the tendency for individuals to believe that they have learned or understood something when they have only looked at it or highlighted it. This can be a particularly insidious problem when it comes to learning and studying, as it can lead people to overestimate their understanding of a subject and feel confident in their knowledge when they have only surface level familiarity with the material. It is important to be aware of this illusion and to take steps to ensure that you are truly learning and understanding the material, rather than just skimming through it or highlighting key points.

One way to avoid the illusion of competence is to actively engage with the material and try to summarize the key concepts in your own words. This can be done through methods such as taking detailed notes, writing summaries of the material, or teaching the information to someone else. By actively processing the information and expressing it in your own words, you are more likely to truly understand and retain the material. Additionally, methods like creating concept maps or diagrams can be helpful in visually organizing and synthesizing the information, which can also aid in deep understanding and retention.

It is also important to not rely solely on highlighting or underlining as a method of studying. While these techniques can be helpful in identifying important points, they should be used in conjunction with more active forms of engagement with the material. Simply re-reading highlighted text or looking at a list of underlined points is unlikely to lead to a deep understanding of the material.

**Use "self-quizzes" to reinforce your learning.** "Self-quizzing" is a learning strategy that involves testing your knowledge of the material through a variety of methods, such as summarizing it, explaining it to someone else,

or attempting to recall specific details from memory. This type of active recall is an effective way to reinforce your learning and move the information from short-term to long-term memory.

One way to use self-quizzing as a study strategy is to take a few minutes at the end of each study session to review the material and try to recall as much as you can from memory. You could try summarizing the key points in your own words, or attempting to explain the material to someone else. This can help you identify any gaps in your understanding and allow you to focus on those areas in future study sessions.

Self-quizzing can also be an effective way to review material before an exam or assessment. By actively recalling the information and testing your understanding, you can better gauge your readiness and identify any areas that may require additional review.

There are many different ways to incorporate self-quizzing into your study routine. Some other options include creating flashcards with questions on one side and answers on the other, or using a tool like Quizlet to create interactive quizzes. The important thing is to find a method that works for you and that actively engages you with the material in a way that helps reinforce your learning.

**Practice "self-care".** Self-care, which includes getting sufficient sleep, exercise, and taking care of your physical and mental well-being, is important in learning any subject, including logic. This is because the mind and body are closely connected, and taking care of your overall health and well-being can have a positive impact on your ability to learn and retain information.

For example, getting enough sleep is important for memory consolidation and can help you perform better on tests and assessments. Exercise has also been shown to have a positive effect on cognitive function and can improve focus, attention, and memory. Taking breaks to relax and de-stress can also be beneficial for learning, as it can help you stay motivated and focused.

In addition to the direct effects on learning and memory, self-care is also important for overall physical and mental health. By getting sufficient sleep, exercise, and taking care of your well-being, you can help prevent burnout and maintain a positive outlook, which can in turn have a positive impact on your learning.

By following these tips, you will be well-equipped to make the most of "A Little More Logical" and improve your skills in logic and reasoning.

## Overview of the Book

**Chapter 1: Logic Basics.** In this chapter, we will explore the world of logic and reasoning. We will learn about what logic is, and how to identify and analyze arguments. We will also distinguish between arguments and non-arguments, and explore different types of non-arguments. We will also learn about the logician Bertrand Russell and apply our knowledge to a case study on the topic of free speech. By the end of this chapter, you will have a solid foundation in the principles of logic and be able to use these skills in your everyday life.

**Chapter 2: Argument Evaluation:** In this chapter, we will learn about induction and deduction, two important methods of reasoning. Inductive reasoning allows us to draw conclusions based on observations and patterns, while deductive reasoning allows us to test the validity of an argument. We will explore common types of deductive arguments, such as modus ponens and modus tollens, as well as different types of inductive arguments, such as generalization and argument from analogy. We will also learn how to evaluate arguments, and distinguish between strong and weak inductive arguments, and valid and invalid deductive arguments. You'll learn about Ada Lovelace, and her contributions to logic. The ability to reason using induction and deduction is a valuable skill to have in everyday life. By learning about these methods of reasoning and how to evaluate arguments, you will be better equipped to make informed decisions and evaluate the claims and arguments you encounter in your daily life. This can help you in a variety of situations, from engaging in discussions and debates with others to making important decisions in your personal and professional life.

**Chapter 3: Introduction to Fallacies**: In this chapter, we will be exploring the concept of fallacies and how they can impact our thinking and decision making. First, we will define fallacies and distinguish between formal and informal fallacies. You will learn about examples of formal fallacies such as circular reasoning and false dichotomy. We will also cover the fallacy of equivocation and discuss some related fallacies. Next, we will delve into fallacies of relevance and examine common examples such as appeal to force, appeal to pity, and ad hominem

fallacies. You will learn how these types of fallacies can distract from the main argument and mislead the listener. We will also take a look at the life and work of Hannah Arendt, a influential philosopher who wrote about the dangers of fallacious thinking in political discourse. At the end of the chapter, there will be a series of exercises to help you practice identifying fallacies in real-world situations. By the end of this chapter, you will have a better understanding of the importance of critical thinking and the role that fallacies play in our everyday lives.

**Chapter 4: Fallacies of Weak Induction.** In this chapter, we will be exploring fallacies of weak induction. These are errors in reasoning that occur when we try to draw conclusions based on insufficient or flawed evidence. We will be examining several different types of these fallacies, including hasty generalizations, false causes, and slippery slopes, among others. In addition to discussing these fallacies in detail, we will also be looking at two case studies that illustrate how these errors in reasoning can lead to flawed conclusions. The first case study will examine the issue of diet and weight loss, while the second will explore the importance of teaching machines to avoid fallacies. By the end of this chapter, you will have a better understanding of how to identify and avoid these fallacies of weak induction, and you will have a greater appreciation for the importance of using strong evidence and logical reasoning in your own thinking and decision-making.

**Chapter 5: Arguing About God.** In this chapter, we will examine some of the most common arguments for and against the existence of God. We'll start by looking at some arguments for God's existence, including the argument from religious experience, the ontological argument, and the argument from design. We'll also consider Pascal's wager, which suggests that it's better to believe in God just in case he exists. We'll then turn to arguments against God's existence, including the logical problem of evil and the argument from nonbelief. Finally, we'll discuss the moral argument for God.

But why is this important in a logic book? Well, the topic of God's existence is one that many people hold strong beliefs about, and it's important to be able to evaluate these beliefs critically and rationally. By examining the arguments for and against God's existence, we can practice using critical thinking skills such as logical analysis and evaluating evidence. Plus, understanding these arguments can help us engage in respectful and productive discussions with others about this complex and often controversial topic.

**Chapter 6: Moral Reasoning.** In this chapter on moral reasoning, we will explore different ethical theories and their implications for moral decision-making. We will start by examining ethical egoism, the idea that the right action is the one that maximizes our own self-interest. We will then look at cultural relativism, the belief that moral truths are relative to culture. Next, we will examine divine command theory, which holds that actions are right or wrong based on whether they are commanded by God. We will also delve into utilitarianism, the belief that actions should be evaluated based on their ability to maximize happiness or well-being for the greatest number of people. Additionally, we will explore Kantian deontology, which holds that moral actions should be guided by universal moral duties or rules. We will also examine virtue ethics, which emphasizes the role of character in determining moral actions, and ethical pluralism, the idea that multiple ethical theories can be applied in different situations. Finally, we will learn about John Rawls' influential theory of justice. Understanding these different approaches to moral reasoning is important for developing our critical thinking skills and making ethical decisions in our own lives.

**Chapter 7: Probability and Inductive Reasoning.** In this chapter, you will learn about the concept of probability and how it is used to make predictions about the likelihood of future events. You will explore different ways of calculating probability and how to apply basic rules such as the complement rule, the simple and complete addition and multiplication rules, and the rule of total probability. You will also learn about Bayes Theorem, a mathematical formula that allows us to update our probabilities based on new information. This chapter will also introduce you to the concept of the base rate fallacy, which occurs when we make judgments about probabilities based on insufficient or misleading information. Understanding probability and inductive logic is important because it helps us to make more informed and accurate predictions, and to avoid making mistakes in our reasoning. By the end of this chapter, you will have a solid foundation in probability and inductive logic, and you will be able to apply these concepts to real-world situations.

**Chapter 8: Scientific Reasoning.** In this chapter, you will learn about the hypothetical method, which is a way of using deduction and induction to test hypotheses. You'll also learn about the difference between empirical and theoretical hypotheses and how to test them. We'll also delve into the case study of Charles Darwin's theory of evolution by natural selection, examining the evidence and objections to this theory. This chapter will help you understand how scientists use logical thinking to make sense of the natural world, and why it's important to

carefully evaluate the evidence before making conclusions. By the end of this chapter, you'll have a better understanding of how scientific reasoning works and why it matters in our everyday lives.

**Chapter 9: Conspiracy Theories.** In this chapter, you will learn about the dangers of conspiracy theories and how to avoid falling prey to them. You'll start by exploring Hume's views on miracles and how they relate to the concept of belief. Then, you'll delve into the topic of heuristics and biases, and how they can lead us astray. You'll learn about the representativeness heuristic and how it can cause us to draw false conclusions based on incomplete information. You'll also examine prospect theory, which helps us understand how we make decisions under uncertainty. Finally, you'll consider whether it is possible to avoid making mistakes when it really counts, and you'll explore the work of Daniel Kahneman and Amos Tversky, two influential psychologists who have studied the ways in which our minds can deceive us. By the end of this chapter, you should have a better understanding of the psychological pitfalls that can lead to the embrace of conspiracy theories, and how to avoid them.

**Chapter 10: Statistical Reasoning.** In this chapter on statistical reasoning, you will learn about the importance of sampling and representative samples. We will also cover measures of central tendency, such as mean, median, and mode. You will learn about variations and standard deviations, as well as normal and not-so normal distributions. We will also cover hypothesis testing, and how to understand poll or survey results. As part of this chapter, we will also delve into common pitfalls and errors in statistical reasoning. To help you understand these concepts, we will examine a case study featuring Dr. Evil and Professor Doom. Overall, this chapter will provide you with the skills and knowledge necessary to critically evaluate statistical information and make informed decisions based on data. This is a valuable skill to have in a world where we are constantly bombarded with statistical information from various sources. Understanding statistical reasoning will allow you to better understand and analyze data, and make more informed decisions in your personal and professional life.

**Chapter 11: Formal Logic.** In this chapter, you will learn about the history and foundations of formal logic. You will start by exploring Aristotle's Categorical Logic, learning about standard form categorical statements and how to analyze and evaluate them. You will then move on to categorical syllogisms, examining concepts such as mood, figure, and validity. The chapter will also delve into further developments in categorical logic and provide exercises to help you practice your skills. Next, you will dive into propositional and predicate logic, learning about valid argument forms and proofs in propositional logic, as well as the role of propositional logic in modern computers. You will also learn about predicate logic, a more advanced type of formal logic used in contemporary research.

Throughout the chapter, you will also be introduced to several minds that have shaped the field of formal logic, including Kurt Gödel, Alan Turing, and others. These profiles will provide you with insight into the contributions and impact of these influential figures, as well as the ongoing research and developments in the field. Overall, this chapter will equip you with a strong foundation in formal logic, helping you to think more critically and logically, and providing you with skills that can be applied in a variety of settings.

**Chapter 12: Logic and the Good Life.** In this concluding chapter, you will delve into the practical applications of logic in daily life. You'll start by considering the virtue of reason and how it can be cultivated to improve personal relationships. You'll then explore how to use critical thinking skills at work and make better decisions about health and wealth. Finally, you'll consider the role that logic can play in overall happiness and well-being. Along the way, you'll learn from the insights of philosopher Martha Nussbaum and reflect on the lessons you've learned throughout the course. By the end of this chapter, you'll have a deeper understanding of the importance of logic in navigating the complexities of life.

Finally, I should note that the writing of this book has been a bit of an experiment, as I composed just as chatGPT and the related models (such as GPT's Davinci 3) came out. I used these generously in helping to "transform" my lecture notes into a book.

## About the Author

Brendan Shea is Instructor of philosophy and computer science at Rochester Community and Technical College in Minnesota. He holds a PhD in Philosophy from the University of Illinois at Urbana-Champaign, as well as a graduate certificate in instructional design. In addition, Brendan has a graduate certificate in computer

programming from Harvard University Extension and a bachelor's degree in English from Winona State University.

Brendan's research and teaching expertise is in the areas of logic, philosophy of science, and applied ethics, with a particular focus on bioethics and the ethics of technology. He also has competence in the areas of history of science and technology, philosophy of religion, political philosophy, and data science.

Throughout his career, Brendan has taught a wide range of courses in philosophy, including bioethics, logic, ethics, philosophy of religion, and introductory philosophy, as well as courses in computer science, humanities, and non-credit professional development. He has received consistently high ratings on student evaluations, and was named Outstanding Educator of the Year at RCTC in 2017-2018. Brendan has also served on various committees at the college, including the Outstanding Educator Selection Committee, the Academic Affairs and Standards Council, and the Faculty Instructional Development Grant Committee.

In addition to his teaching and administrative responsibilities, Brendan has published numerous articles in philosophy journals and presented at conferences. He serves a Resident Fellow at the Minnesota Center for Philosophy of Science and as a public member of the Institutional Biosafety Committee at Mayo Clinic-Rochester. Brendan has held leadership roles in professional organizations, including serving as vice president and president of the Minnesota Philosophical Society.

## About Thoughtful Noodle Books

Thoughtful Noodle Books is a (fictional) imprint for (real!) books written by Brendan Shea. Here at Thoughtful Noodle Books, our mission is to make philosophy and computer science textbooks accessible to everyone. All of our works are available under a Creative Commons Attribution (CC-BY) license, which means that you can use, modify, and share them for any purpose. I (Brendan) invite you to use and adapt this textbook however you see fit.

More generally, I believe that open-access works have several advantages over traditional textbooks. The most obvious benefit is that they are free, which helps to reduce the cost of education. Additionally, open-access works are more easily adapted and updated, so that instructors can quickly incorporate new research and technologies into their courses. Finally, open-access works are more transparent and collaborative, which encourages student engagement and allows for more diverse perspectives.

https://brendanpshea.github.io/thoughtful_noodle/

# CHAPTER 1: THE BASICS OF LOGIC

In this chapter, we will explore the world of logic and reasoning. We will learn about what logic is, and how to identify and analyze arguments. We will also distinguish between arguments and non-arguments, and explore different types of non-arguments. We will also learn about the logician Bertrand Russell and apply our knowledge to a case study on the topic of free speech. By the end of this chapter, you will have a solid foundation in the principles of logic and be able to use these skills in your everyday life.

Let's get started with a brief fable on the importance of reasoning well.

## FOX FIONA AND THE LION'S LOGIC: A FABLE

Once upon a time, in a faraway land, there lived a proud lion named Leo. He was the King of the jungle, respected by all the animals, who were proud to call him their leader. Leo was (mostly) a wise and noble king, but he was not without his faults. He was prone to hasty generalizations and would often make decisions without examining the facts.

One day, Leo was walking through the forest when he came across a fox named Fiona. Leo had once met a fox who had tricked him, so he immediately declared to all the other animals that this new fox was untrustworthy as well and should not be allowed in the jungle. Perhaps they should feed her to the hyenas!

Despite Leo's hasty generalization, the other animals were not convinced. They asked Leo for evidence to support his claim, but he could not provide any. Instead, he appealed to an inappropriate authority: he claimed that the Fiona was untrustworthy because he was a Lion and king of the jungle, and thus should be believed about such things.

The other animals were not satisfied with this reasoning. They asked Leo to provide more evidence to support his claim, but he refused. Instead, he resorted to ad hominem attacks, accusing Fiona of being untrustworthy simply because of the way she looked. "Look at the mischevious gleam in her eye!" he said.

The other animals were still not convinced, so Leo tried to appeal to their emotions by warning them of a slippery slope. He argued that if they allowed the fox into the jungle, Fiona would first corrupt one animal, and then another, and the soon, all the other animals would soon become just as deceitful and wicked as the fox was. At this point, the animals were tired of arguing, and few of them thought they should simply let Leo do whatever he wanted. After all, it wasn't good for one's health to argue with the king!

At that moment, a loud cry for help echoed throughout the jungle. All of the animals rushed to the rescue, only to discover a bunny trapped in a hunter's trap. Fiona then stepped forward and offered to help. She noticed the logical implications of the situation and carefully examined the trap. She used deductive logic to infer that if the lock on trap could be released, then the bunny could escape. She then used inductive inference to hypothesize that the particular trap in which this bunny was caught could be opened with a stick of a certain shape and size.

The fox carefully searched the area and found a stick. She inserted the stick between the trap's jaws and pried them open. The bunny was free!

Leo was amazed. He realized he had been wrong to judge the fox so hastily and without evidence. He apologized to the fox and thanked her for her help. The other animals were equally impressed and thanked the fox as well. The fox then joined the other animals in the jungle, and everyone lived happily ever after. Leo learned an essential lesson about the dangers of reasoning poorly and the benefits of reasoning well.

Some questions to get you started:

1. How does this fable illustrate the importance of using evidence and logic when making decisions? What are some "real-world" examples of this?
2. What lessons can be learned from Leo's mistake of relying on authority and ad hominem attacks instead of evidence and logic?
3. What are some other examples of how reasoning can help us make better decisions in our own lives?

# What is Logic?

In this class, we'll be studying logic, which we can define as "the study of arguments." Logic is the study of arguments. An argument is a set of statements known as premises that are used to support a conclusion (more on this later). First, though, we'll talk about some different ways that logicians study arguments.

Some main branches of logic include "informal logic", "formal (deductive) logic", and "inductive logic." This distinctions are not airtight, and there is some overlap between these different areas. We'll be talking about each of these over the course of the semester.

## Informal Logic

**Informal logic** is the study of arguments that involve everyday language and reasoning. It is based on the notion that people use logic in everyday situations, such as making decisions or communicating with each other. For example, Sherlock Holmes often used informal logic when deducing facts from evidence in his cases. For example: In *The Adventure of the Speckled Band*, Sherlock Holmes uses informal logic to deduce that the villain was Dr. Roylott. Holmes notices that the bell-rope in Dr. Roylott's room is unusually thick and tied to a bedpost. He then reasons that the bell-rope must be used to send a signal to someone outside the room, and that the only person who could be receiving the signal is Dr. Roylott. Other examples include:

- Making decisions: People often use informal logic to weigh the pros and cons of different options. For example, when deciding whether or not to buy a car, a person may use informal logic to consider the cost of the car, its fuel efficiency, and its safety features.
- Persuading others: People often use informal logic to convince others to accept their point of view. For example, a politician may use informal logic to argue that a particular policy will benefit the economy.
- Debating: People often use informal logic when debating with each other. For example, two people may debate about whether or not the death penalty is an effective deterrent for crime.

## Formal Deductive Logic

**Formal deductive logic** is the study of arguments that use a set of rules to reach a conclusion. In formal deductive logic, statements are broken down into their component parts, known as propositions. For example, in mathematics, when applying the Pythagorean Theorem, the two sides of a right triangle are broken down into two propositions: the hypotenuse and the sum of the other two sides. These propositions are then combined using logical rules to form a logical argument. Other examples of deductive logic include the following:

- In philosophy, deductive logic is used to make logical arguments about the nature of reality. For example, the philosopher Descartes used deductive logic to argue that the existence of God can be proven through reason.
- In economics, deductive logic is used to construct mathematical "models" of the market. For example, economists use deductive logic to predict how changes in supply and demand will (hypothetically) affect prices. However, applying the results of these calculations to the "real" world requires inductive logic!
- In computer science, deductive logic is used to create and analyze the ability of algorithms that can solve complex problems. For example, a computer scientist may use deductive logic to create an algorithm that can solve a Rubik's cube in the shortest amount of time.

## Inductive Logic

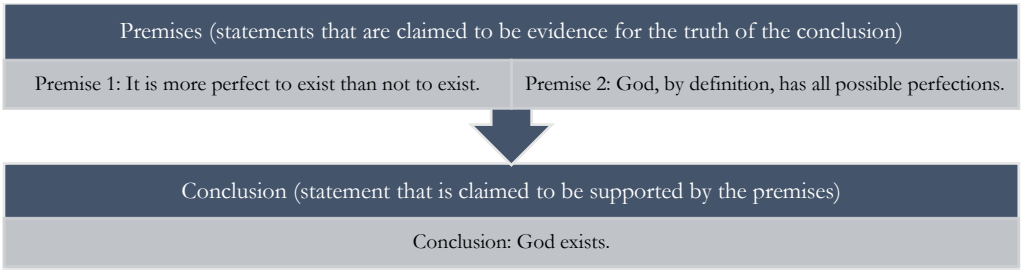
**Inductive logic** is the study of arguments that involve a degree of uncertainty. Inductive logic is used in many scientific fields, such as biology and physics, to make predictions about the behavior of a system. For example, a biologist may observe that a certain species of plant always grows in a specific type of soil, and then use inductive logic to make a generalization about the behavior of the species. However, unlike Inductive arguments frequently involve statistics, predictions, claims about causes and effects, and appeals to authority. For example:

- In medicine, inductive logic is used to make predictions about the effectiveness of treatments. For example, a doctor may use inductive logic to predict that a particular drug will effectively treat a certain type of cancer, given it has been tested on other patients.
- In psychology, inductive logic is used to make predictions about the behavior of people. For example, a psychologist may use inductive logic to predict that people who are exposed to certain types of media will be more likely to engage in certain types of behavior.

- In economics, inductive logic is used to make predictions about the behavior of markets "in the real world". For example, an economist may use inductive logic to predict that an increase in taxes will lead to a decrease in consumer spending, based on the results of "theoretical models" and on historical examples.

## What are Arguments?

The following diagram illustrates the basic structure shared by *all* arguments (this is a famous argument called the **ontological argument**—see if you can figure out what is wrong with it…):




Formally speaking, an argument is a set of statements, one of which is the conclusion and the others are premises, which together are intended to provide support for the conclusion. An argument can be good (convincing) or bad (not convincing) based on two features of the argument: (1) whether or not it has a good "form" and (2) whether the premises are true. Logicians are mainly interested in criteria 1, since determining the truth of the premises is something that is usually best left to subject-matter experts.

## Statements

If you pay close attention to the definition of an "argument", you'll note both the premises and conclusions must be statements. So, what is a statement? In logic, a statement is a sentence that is either true or false (even if we don't happen to know which it is). The following are all examples of statements:

1. The sky is blue.
2. 2 + 2 = 4.
3. I love chocolate.
4. The moon is made of cheese.
5. It is morally acceptable to cheat on a test, so long as you don't get caught.
6. Animal cruelty is morally wrong.

These could all be premises or conclusions in an argument. By contrast, sentences such as commands, questions, or exclamations are not statements. The following are all examples of non-statements:

1. Go get me a sandwich.
2. What time is it?
3. Wow!
4. Catch me if you can.
5. What on earth are you talking about?

OK, so let's put this all together. Here is an example of a (simple) argument: "Since Fido is an animal and all animals have four legs, we can conclude that Fido must have four legs." This argument has a good form, in that anyone who accepted the premises, should also accept the conclusion. However, one of the premises is definitely false (not all animals have four legs!).

By contrast, here is an example of a non-argument: "Fido is cute but cranky." This is not an argument because it does not contain any premises that support the conclusion; it simply states the author's opinion without providing any evidence or reasoning to back it up.

## Sample Problem: Identifying Statements

| **Sentence** | **Is it a statement? (Or "Does it express a proposition?")** |
|---|---|

| | |
|---|---|
| **Emma is 19 years old.** | Yes. Simple declarative sentences are statements. This is a claim about the world that might be true (Emma really is 19), or it might be false (she's really 29). Either way, though, it's a statement. |
| **When will Emma turn 20?** | No. Questions are not statements since they can't be true or false. |
| **Emma, stop being so rude.** | No. Commands (like questions) are not statements since they cannot be true or false. |
| **If you read a book by Jane Austen, you should read *Emma.*** | Yes. If-then statements (conditional statements) are still statements. |
| **I don't like old novels.** | Yes. This sometimes confuses people, but claims about how you feel, or what you think/believe/like, ARE statements. They can be true (if you are being honest) or false (you are lying). |
| **Emma went to London last week plans to go again next week; however, if she goes, then she won't go to any parties this time.** | Yes. This (complex) sentence is a statement. It also contains subparts that are statements. In general, if A and B are statements, then so are sentences like "A and B", "A or B", and "A but B." |
| **Emma is kind of a gossip.** | Yes, this is a statement. It might just be your "opinion" (and you might be wrong about it), but this doesn't change the fact that it is a claim about how the world is. |
| **Emma!** | No. |
| **Emma believes that she will someday marry Knightley.** | Yes. Claims about what people "believe" or "think" are still statements. After all, you might be wrong about them. |
| **Jane Austen was secretly a robot.** | Yes. Even clearly false statements are statements. |

## Premise and Conclusion Indicators

When reading an argument, it can be helpful to look for certain words and phrases that indicate that a statement is a premise rather than a conclusion. These **premise indicators** include words such as "because", "since", "for", "given that", and "as". For example, in the previous argument regarding Fido, "since" was used to indicate that the first statement was a premise rather than a conclusion.

In addition to looking for premise indicators, it can also be helpful to look for words and phrases that indicate that a statement is a conclusion rather than a premise. These **conclusion indicators** include words such as "therefore", "hence", "so", and "thus". For example, in the Fido argument, "we can conclude that" was used to indicate that the third statement was a conclusion rather than a premise.

## How (and Why) to Put an Argument in Standard Form

To make the structure of an argument clear, it often helps to put it into **standard form,** where the premises and conclusion can be clearly distinguished. To do this, follow these steps:

1. Identify the conclusion and write it down on its own line. Write down the premises above the conclusion in whatever order is most natural. Include any implicit content (content that the arguer hasn't stated explicitly but is nevertheless part of the argument).
2. Express each premise or conclusion as a simple, declarative sentence. It is often helpful to break complex sentences into multiple simple statements. You might need to replace pronouns (like "it," "he," or "they") with regular nouns, to make everything clear.
3. Include all and only that content relevant to the argument. Indicator words should not be included, nor should rhetorical devices (e.g., "Everyone knows that…").
4. It is often helpful to reword for clarity. When doing so, however, be sure to follow the **principle of charity**, which requires that you try and make the argument as convincing as possible. Charity requires that you should always interpret the argument in a whichever ways makes it seem *strongest* (and not the way that makes it easiest to criticize).

Here are some examples:

Argument 1: "Although it is often difficult to determine what counts as moral behavior, nearly everyone would agree that honesty is a crucial component of ethical living. Lying can also cause lots of harms to those who are deceived. It follows then, that lying should never be condoned for any reason. "

Standard Form:

- P1. Honesty is a key component of ethical living.
- P2: Lying harms people
- C: Lying should never be condoned.

Argument 2 "It has been established that many college students struggle with mental health issues such as depression and anxiety due to the stresses of college life. I think we can all agree that colleges have a responsibility to help students succeed in school. Thus, institutions must provide resources dedicated to mental health care for students."

Standard Form:

- P1: College students struggle with mental health issues due to colleges stressors
- P2: Colleges have an obligation to ensure access to adequate support services
- C: Institutions must provide resources dedicated to mental health care for students.

Argument 3: "A key part of the college experience is learning how to think critically about complex issues. Professors should therefore foster an environment where alternative viewpoints can be discussed without fear of retribution or judgement from others. This would not only help students form their own opinions on important matters, but also foster respect for opposing ideas within the classroom setting."

Standard Form:

- P1: Thinking critically about complex issues is important for college students
- P2: An environment where alternative viewpoints exist can help students form opinions on important matters
- P3. This environment can also foster respect for opposing ideas
- C: Professors should foster an environment where opposing ideas are respected in the classroom setting.

## Review Questions

1. What is logic and what are some of the main branches of logic?
2. What is an argument? What are premises and conclusions?
3. How can you tell the difference between a statement and a non-statement?
4. What is the principle of charity, and why is it important when putting an argument into standard form?
5. Give some examples of non-statements in everyday conversation.
6. Choose a conclusion you are tempted to DISAGREE with from the list below, and then write an argument in FAVOR of each of these. (The idea here is to practice charitable interpretation of the arguments of others). Please use at least TWO premises and put your argument in STANDARD FORM. You should make your argument as strong as possible.
    a. Abortion is/is not morally permissible.
    b. COVID vaccines should/should not be required by employers.
    c. Euthanasia should/should not be allowed.
    d. The death penalty should/should not be legal.
    e. The private right to gun ownership should/should not be restricted.
    f. It is/is not immoral to eat animals such as pigs or cows.
    g. Immigration should/should not be restricted.
    h. Children should/should not be required to attend school until age 18.

## Minds that Mattered: Bertrand Russell

Bertrand Russell was born into an influential and liberal family in 1872. His parents, Viscount and Viscountess Amberley, were known for their progressive views and were early advocates of birth control. Russell's paternal grandfather, Lord John Russell, had twice been prime minister in the 1840s and 1860s.

As a child, Russell was educated at home by his parents and a series of tutors. He attended Trinity College, Cambridge, where he studied mathematics and philosophy. He later married Alys Pearsall Smith, with whom he had four children. However, the marriage was unhappy and the couple eventually divorced.

In addition to his work in mathematics and philosophy, Russell was also a social and political activist. He was a pacifist who opposed imperialism and advocated for nuclear disarmament. He was imprisoned during World War I for his pacifist beliefs and later spoke out against totalitarianism and the Vietnam War.

One of Russell's main philosophical contributions was his work on logicism, which sought to reduce mathematics to logic. This idea was based on the belief that the principles of mathematics could be derived from logical principles alone, rather than relying on any kind of intuitive or experiential basis. Russell also made significant contributions to the philosophy of language, particularly with his theory of definite descriptions and his distinction between knowledge-by-acquaintance and knowledge-by-description.

A **definite description** is a phrase that refers to a specific individual or thing, such as "the tallest building in the city" or "the man who stole my wallet." According to Bertrand Russell, a definite description is not a genuine referring expression, but rather a kind of shorthand for a longer statement that includes a quantifier, such as "There exists exactly one x such that x is the tallest building in the city, and for all y, if y is a building in the city, then y is shorter than x."

Russell argued that definite descriptions should be analyzed in this way because they do not always succeed in picking out a unique individual or thing. For example, if there is more than one building that is the tallest in the city, then the definite description "the tallest building in the city" does not succeed in referring to any particular building. Similarly, if there is no building that is the tallest in the city, then the definite description fails to refer to anything at all.

As for Russell's pacifism, he believed that war and violence were (almost) never justified, and that conflicts should be resolved through peaceful means such as negotiation and diplomacy. He argued that the suffering and destruction caused by war far outweighed any potential benefits, and that it was always possible to find a peaceful solution to even the most difficult problems. He was imprisoned for his pacifism during World War 1. In World War 2, he granted that war could *sometimes* be justified (against a foe such as the Nazis) though he continued to believe it should always be a last resort (and that governments were often too quick to go to war).

Russell was also a critic of religion, particularly traditional forms of Christianity. He argued that religious belief was based on faith rather than reason, and that it was often used to justify immoral actions such as wars and persecutions. He believed that science and reason were the most reliable sources of knowledge, and that it was important to promote critical thinking and skepticism in order to avoid the dangers of superstition and dogma.

In 1950, Russell was awarded the Nobel Prize in Literature for his writings on humanitarian ideals and freedom of thought. He died in 1970 at the age of 97.

1. What is Bertrand Russell's theory of definite descriptions, and how does it differ from traditional notions of referring expressions?
2. How did Russell's pacifist beliefs shape his social and political activism? Do you agree with his view? Why?
3. How did Russell's views on religion and faith differ from traditional beliefs, and what role did he believe science and reason should play in shaping our understanding of the world?
4. How did Russell's work on logicism and the philosophy of language contribute to the development of these fields?

## Distinguishing Between Arguments and Non-Arguments

Not everything we hear, read, or think is an argument. Instead, arguments need to involve premises that support a conclusion (these premises might provide a good reason, or they might not, but that's for a future lesson). As we mentioned previously, it's important to remember that "arguments" here DO NOT need to be confrontations between different people/groups. Instead, arguments can (and often do) happen within each of us as we try to figure out what to do or believe. In this context, it's imperative to recognize when we are engaged in this sort of argumentation (and, by contrast, when we don't have arguments for our beliefs, even though we maybe should have them.)

In every argument, there must be BOTH a "factual claim" that some statement(s) or other is true AND a claimed inferential link that this justifies believing in the conclusion. That is, the person making the argument must claim (either explicitly or implicitly) that the premises provide reasons to believe the conclusion. Here are some "rules of thumb" for determining whether or not a given passage is an argument.

*If there is an inferential link between the statements, one can safely assume that the passage counts as an argument.* For example,

- "I had a great time at the party last night. Therefore, I should go to more parties."

Here we have an inferential link between the statement that the speaker had a great time at the party and the conclusion that he or she should attend more parties.

By contrast, If the passage does not contain an inferential claim, it is not an argument. For example,

- "I had a great time at the party last night."

This statement does not contain an inferential claim and therefore does not constitute an argument.

*You can often detect (but not always) use conclusion and premise indicators to detect inferential links.* For example:

- "Facebook is becoming increasingly popular. Therefore, it is a good idea to create a Facebook page for your business."

In this example, the conclusion indicator "therefore" signals an inferential link between the premises (Facebook's popularity) and the conclusion (it is a good idea to create a Facebook page).

However, there can be arguments that do not have any indicator words. For example:

- "Twitter has a large user base. It is a great platform for gaining exposure and connecting with potential customers."

In this example, there is an inferential link between the two statements, even though there are no conclusion indicators. The premise (Twitter's large user base) provides a reason to believe the conclusion (it is a great platform for gaining exposure and connecting with potential customers).

There can also be passages that contain words like "because" (a premise indicator word) that are NOT arguments. For example:

- "I'm using TikTok because my friends are."

In this example, the word "because" indicates a relationship between two statements, but there is no inferential link between them. The statement that the speaker's friends are using TikTok does not provide any evidence or justification for why he or she should be using it. Therefore, this does not constitute an argument.

*There are also some common "forms" of non-arguments.* We'll talk about these in the next section.

## Common Types of Non-Arguments

While we certainly spend plenty of time arguing (both with ourselves and others), we also do plenty of other things with our words (and thoughts). Here some simple examples of non-arguments:

- **Reports of events:** Reports of events are factual statements that describe something that happened in the past. They present information without making a claim and do not involve any sort of argumentation. For example, "The Minnesota Vikings appeared in their first Super Bowl in 1969."
- **Statements of opinion:** Statements of opinion are subjective and reflect a person's feelings about a topic. For example, "Bob Dylan is the greatest musician in Minnesota history."
- **Pieces of advice:** Pieces of advice are statements that offer guidance on what action to take in a certain situation. For example, "If you are feeling ill, visit the Mayo Clinic for a check-up."

- **Warnings:** Warnings are statements that alert people to potential risks or dangers. For example, "Be aware of cultural differences when interacting with the Dakota Indian tribe."

As you'll notice, these non-arguments lack the "inferential link" that characterizes arguments. The person who is speaking or writing might be right or wrong, but they are not trying to *convince* you of anything. These could be made into an argument by adding evidence.

### *Explanations*

A more complex sort of non-argument is an **explanation**, which is a collection of statements, one or more of which are intended to provide the "reason" or "cause of" the other's being true. The statements that do the explaining are called the "explanans", while the statement that is explained is called the "explanandum." These are structurally similar to the premises or conclusion of arguments. However, in an explanation, we are generally more certain of the truth of the explanandum that of the explanans. For example: "The moose population in Minnesota has been declining due to a combination of factors, such as increased predation by wolves, habitat loss due to human development and logging, and chronic wasting disease. These factors have caused a decrease in the moose population."

- Explanans 1. Increased predation by wolves
- Explanans 2. Habitat loss due to human development and logging
- Explanans 3. Chronic wasting disease
- Explanandum: The moose population in Minnesota has been declining

In the passage, it is assumed that everyone agrees that the moose population is declining (and so, the author is not trying to convince people of this). The goal is to figure out *why* this is.

### *Expository Passages*

An **expository passage** begins with a topic sentence and is followed by one or more statements that develop this topic. Unlike an argument (where the goal is to persuade or convince), they aim to inform. For example:

> "The Dakota War of 1862 was a conflict between the United States and the Dakota people which took place in Minnesota Territory. This war began after treaty negotiations with the US government led to several grievances among the Dakota, including unpaid annuities and inadequate land allotments. These grievances eventually led to tensions between the two sides, culminating in an attack by the Dakota on a settlement of white settlers on August 17th, 1862.
>
> The war was fought in multiple phases and resulted in hundreds of casualties on both sides. After initial successes, the Dakota forces were eventually overwhelmed by the US Army's superior numbers and resources. On September 26th, 1864, 38 Dakota men were executed by hanging in Mankato, Minnesota; this is still today the largest mass execution in US history. The war resulted in a drastic reduction in the number of Native Americans living in Minnesota and marked a turning point in relations between Native Americans and white settlers."

This passage is not an argument because it does not present a specific point of view, and there is no attempt to persuade the reader to agree with any particular conclusion. Instead, the passage provides facts about the Dakota War of 1862 and its consequences. The purpose of the passage is to inform, not convince or persuade.

### *Conditional Statements*

A **conditional statement** is a statement that expresses a relationship between two statements, known as the antecedent and the consequent. In a conditional statement, the antecedent is a premise or hypothesis that needs to be true in order for the consequent to be true. A common example of a conditional statement is "if x then y," where x is the antecedent and y is the consequent. For example, in the conditional statement "if Prince was born in Minneapolis, then he was born in Minnesota" the antecedent is "Prince was born in Minneapolis" and the consequent is "Prince was born in Minnesota".

Other examples of conditional statements include:

- "if Charlie Brown tries to kick a football, then Lucy will move it" (antecedent: " Charlie Brown tries to kick a football "; consequent: " Lucy will move it ")
- "You will be in Minnesota if you visit the Mall of America" (antecedent: "you visit the Mall of America"; consequent: "you will be in Minnesota").

Conditional statements are often used to express sufficient and necessary conditions. A **sufficient condition** is one that, if it is true, guarantees that the consequent is also true. For example, visiting the Mall of America is a sufficient condition for being in Minnesota; if a person visits the Mall of America, then they must necessarily be in Minnesota. On the other hand, a **necessary condition** is one that must be true for the consequent to be true. For example, being born in Minnesota is a necessary condition for Prince having been born in Minnesota; without being born in Minnesota, Prince could not have been born in Minneapolis.

It's important to note that conditional statements are not arguments. This is because a conditional statement does not provide evidence or reasons to support its claim; rather it simply expresses a relationship between two statements. This means that even if both the antecedent and consequent are true, this does not guarantee that the conditional statement itself is true. In other words, it's possible for both statements to be true without them actually being related by the conditional statement.

Finally, while we've been talking mostly about conditional statements as whole units throughout this section, it's worth noting that each part of a conditional statement can also act as either a premise or conclusion when taken on its own. For example, here is a simple argument for Prince having been born in Minnesota

- Premise 1: Prince was born in Minneapolis
- Premise 2: If Prince was born in Minneapolis, then was born in Minnesota
- Conclusion: Prince was born in Minnesota

### Sample Problem: Identifying Arguments

Identify the following as arguments or non-arguments and explain your answer.

| Passage | Is it an argument? |
|---|---|
| **Have you ever read Plato?** | No! This isn't even a statement. |
| **I'd recommend reading Plato's *Apology.* You should stay away from the *Laws,* though.** | No. The first statement appears to be a piece of advice, while the second looks like a warning. The person still hasn't tried to give you any reasons, though. |
| **If Socrates taught Plato, then Plato was influenced by Socrates.** | No. This is a conditional statement (and it's almost certainly true, but I haven't given you any reasons to think this). The claim is that Socrates teaching Plato was sufficient for influencing him. Another way of saying the same thing: Socrates' influence on Plato was a necessary consequence of his teaching. |
| **Plato is one of the most influential philosophers of all time. After all, his work inspired everyone from Christian and Islamic theologians to the founders of democracy to the early scientist.** | Yes. This is an argument—it's trying to provide *reasons* for believing a claim about Plato. |
| **I believe that Aristotle is actually a more rigorous thinker than Plato. However, I think Zeno is more innovative than either of them.** | Again, we're back to non-arguments here (this looks like a simple statement of belief, not backed up by any premises/evidence). |
| **The unexamined life is not worth living. So, many seemingly successful people are currently leading lives that are not worth living.** | Yes, this is an argument (based on a famous claim by Socrates and one which may have led to him being executed). |
| **Plato wrote the *Apology* partially because he wanted to record Socrates' speech, but also because he wanted to advance his own philosophical views.** | While this contains the word "because," it is NOT an argument. Instead, it is a causal explanation ("this happened because that happened."). It might be true, and it might be false, but we don't have any evidence either way right now. |

| | |
|---|---|
| **In most areas of life outside of politics, we trust knowledgeable experts more than ignorant laypeople. For example, when I'm sick, I go to the doctor. When I need my car fixed, I go to the mechanic. By analogy, we can conclude that the government should be run by experts, not ignorant lay people (as in a democracy).** | Yes, this is a (somewhat complex) argument. The examples are used to clarify a premise (about how we usually trust experts more than laypeople). This premise is then used to argue for a (pretty controversial) conclusion: democracy is an inferior form of government. |
| **Plato believed that every idea and object we had corresponded to something called a Form that existed outside the physical world. For example, he thought there was a Form of "Bed," a Form of "Cat", a Form of "Three" and a Form of "Good."** | No, this isn't an argument. Instead, it simply illustrates what Plato means by "Form." We might extend this into an expository passage explaining Plato's ideas. |
| **Plato thought people in power shouldn't have their "own" money, spouses, or even children. He thought this because he saw how these things could lead people to become corrupt and behave immorally.** | No. This is a report about an argument Plato made, but it is not itself an argument because no effort is made to convince you that Plato is right/wrong. |
| **Plato's arguments against democracy inspired many dictators over the past 2,500 years. Because of this, his books should be banned.** | Yes, this is an argument. If you wanted to critique this argument, you'd probably want to spell it out at greater length. So, for example, what implicit premises might you want to include if you expressed it in standard form? |

## QUESTIONS

1. What is the difference between an argument and a non-argument? How can you distinguish between the two?
2. How is an explanation different from an argument?
3. What is a conditional statement? How do they differ from arguments?
4. Find an example of a non-argument (it can be from a magazine, newspaper, or other source) and explain why it is not an argument.
5. Write a short expository passage on a topic of your choice.
6. Write a conditional statement that expresses a relationship between two statements.
7. Identify three common types of non-arguments and explain how they differ from arguments.
8. Explain the difference between sufficient and necessary conditions in the context of conditional statements
9. Write an argument for why it is important to distinguish between arguments and non-arguments.

## KEY CONCEPTS

- **Argument--**A series of statements (premises) meant to support a conclusion.
- **Conclusion--**The statement that athe premises of an argument provide support for.
- **Conclusion indicator words--**Words like "therefore," "hence," "so," and "thus," which signal that a conclusion is being made based on the preceding statements (premises).
- **Conditional statement--**A statement that takes the form "if X, then Y," where X is a sufficient condition for Y.
- **Definite description--**A phrase that uniquely identifies a single object, like "the tallest building in New York City."
- **Explanandum--**The thing that needs to be explained in an explanation.
- **Explanans--**The statements or reasons given to explain something (the explanandum).
- **Explanation--**An account that makes clear the reason or cause for something.
- **Formal (deductive) logic--**The study of logical reasoning using precise rules and symbols.

- **Inductive logic--**The study of reasoning that involves making generalizations, predications, or inferences based on evidence.
- **Informal logic**--The study of reasoning in natural language, as opposed to a formal system of logic.
- **Logic--**The study of principles of correct reasoning.
- **Necessary condition--**A condition that must be met for something to happen.
- **Non-argument (common types)--**Statements that are not meant to support a conclusion, such as explanations, descriptions, or reports.
- **Premise--**A statement that an argument is based on and tries to use as support for its conclusion.
- **Principle of charity--**A principle in philosophical discussion and debate, which advises that one should try to interpret their opponent's statements and arguments in the most charitable way possible, by taking them to mean what they most plausibly could, given the context and background knowledge.
- **Premise indicator words--**Words like "because," "since," and "as," which signal that a premise is being presented.
- **Standard form (of an argument)--**A way of arranging an argument so that the premises and conclusion are clearly distinguished.
- **Statement (or proposition)--**A declarative sentence that can be either true or false.
- **Sufficient condition--**A condition that, if met, guarantees that a certain outcome will happen.

## Exercises: Identifying Arguments

For each passage, determine whether it is an argument. If it is an argument, identify the conclusion (and try to put the argument into standard form). If it isn't an argument, explain why.

Answers to selected problems are in the appendix.

1. There is overwhelming evidence that climate change is real and caused by human activity. The Earth's average temperature has risen, sea levels are rising, and extreme weather events are becoming more frequent. It is clear that we must take action to reduce our carbon emissions.
2. Reading books has numerous benefits for both children and adults. It can improve vocabulary, increase concentration and critical thinking skills, and even reduce stress. Therefore, it is important for everyone to make time for reading in their daily routine.
3. Many of the college students surveyed reported feeling overwhelmed by the workload; it can be reasonably inferred that most college students experience similar levels of stress or anxiety when faced with large amounts of coursework.
4. Based on research into study habits among university undergraduates, it can be predicted that those who spend more time studying will have higher grades than those who do not invest as much time in their studies.
5. GMOs, or genetically modified organisms, have been a controversial topic in recent years. While some argue that GMOs are safe and can help increase crop yields, others claim that they can have negative impacts on the environment and human health. More research is needed to fully understand the risks and benefits of GMOs.
6. College students often face financial difficulties due to the rising cost of tuition, textbooks, and other expenses associated with their education.
7. The development of gene editing tools such as CRISPR has allowed scientists to make changes to the genome of organisms with unprecedented precision and accuracy. By using CRISPR, researchers can now quickly and easily modify genes to study their effects on an organism's physiology and behavior.
8. The use of artificial intelligence in medical diagnosis is revolutionizing healthcare. With AI, doctors are able to quickly and accurately diagnose a wide range of diseases with greater accuracy than ever before. Therefore, if you are seeking reliable medical care, AI should be your first choice.
9. Avatar: The Last Airbender has earned critical acclaim, scoring a 97% on Rotten Tomatoes and being named one of the top ten TV shows of the 21st century by TIME magazine; therefore, we can assume that other cartoons by the same team were also well-received by viewers and critics alike.
10. Given the success of Dora the Explorer, there will likely be other cartoon series in the future that follow a similar format—a small child as protagonist who goes on adventures with their friends.
11. I believe that the development of autonomous vehicles will drastically reduce traffic accidents in the future.

12. If college students want to succeed in their studies, then they must take the time to go to class and do their homework; since many college students are succeeding in school, it follows that they must be regularly attending classes and doing their homework.
13. I firmly believe that a good work ethic is essential for academic success.
14. The use of plastic bags should be banned, as they contribute significantly to pollution and waste. Plastic bags can take hundreds of years to decompose, and they often end up in landfills or the ocean, where they can harm wildlife and ecosystems. Switching to reusable bags is a simple and effective way to reduce our plastic consumption.
15. College life can be stressful for many reasons; juggling classes, working part-time jobs, making new friends and managing relationships with family members at home all contribute different levels of stress that must be managed by each student in order for them to stay healthy and successful throughout their academic career.
16. The use of pesticides in agriculture has been a controversial topic for many years. While pesticides can help control pests and increase crop yields, they can also have negative impacts on human health and the environment. It is important for farmers to carefully consider the risks and benefits of using pesticides, and to use them responsibly if they choose to do so.
17. The majority of college students who frequently engage in drug or alcohol use tend to have lower grades than those who abstain from such activities; this suggests that substance abuse can have a negative impact on academic performance among university undergraduates.
18. Those who criticize the rising tuition costs at universities are just resentful because they cannot afford the same level of education as those from wealthier backgrounds; thus these criticisms should not be taken seriously as valid arguments against higher education costs for all students.
19. The use of solar panels on rooftops is becoming increasingly popular, as it allows homeowners to reduce their energy costs and lower their carbon footprint. Solar panels are a smart investment for anyone looking to save money and be more environmentally friendly
20. If college students don't manage their money effectively, then they may find themselves in debt; if a student incurs significant debt during college, then he or she may struggle to pay it off after graduation; therefore, if a student wants to avoid post-graduation debt, he or she should manage money wisely while still in school.
21. Spiderman has been around for over two decades, so if someone says they grew up watching 2000s cartoons, it necessarily follows that they watched Spiderman.
22. In recent years, neurological studies have shown that playing video games can improve cognitive functioning in children. This suggests that playing video games could be beneficial for children across the board in terms of their mental health and academic performance.
23. If new treatments for cancer are developed, then it follows that more people will survive cancer diagnoses or live longer with better quality of life after diagnosis. Therefore, if we invest resources into researching new treatments for cancer, then we will likely see improved outcomes for those affected by this disease.
24. If advances in nanotechnology continue at a steady pace, then we may soon be able to drastically reduce environmental pollution.
25. As technology becomes increasingly sophisticated, it can be inferred that people's reliance on phones and computers for communication has caused a decline in face-to-face interactions among friends and family members.
26. The use of fossil fuels, such as coal, oil, and natural gas, has been a major source of energy for centuries. However, the burning of fossil fuels releases greenhouse gases into the atmosphere, contributing to climate change. Therefore, it is important to transition to cleaner, renewable energy sources in order to reduce our carbon footprint and protect the environment.
27. Those who oppose technological advancements such as self-driving cars do not understand all the benefits these innovations provide; they merely oppose them because they don't like change. We should ignore these people.
28. If college students don't get enough sleep, then they may find it difficult to stay focused during class and complete assignments successfully.
29. If Ed Edd n Eddy had not debuted in 1999, then Cartoon Network would not have been as popular during the 2000s; however, Ed Edd n Eddy did debut in 1999, so Cartoon Network was very successful during this time period.
30. The 21st century has seen incredible advances in neuroscience research as our understanding of how the brain works grows exponentially every year. In particular, neuroscientists have made great progress towards being able to map out neural pathways and create accurate models of brain activity through imaging techniques such as fMRI scans.

31. There would have been no Family Guy or South Park if the Simpsons had never aired.

## CASE STUDY: A DEBATE ABOUT FREE SPEECH

*The Scene: The philosophers John Stuart Mill and Plato have been brought back to life in the 21st century are having a lengthy debate about the value of free speech and it's relation to the "good" life for humans. As you read this passage, try to identify the arguments they make.*

Plato: Throughout my works, I have argued that the stability of society is ultimately more important than its citizens' freedom of speech. As I wrote in *The Republic*, "The greatest principle of all is that nobody, whether male or female, should be without a leader." Freedom of speech can lead to the spread of false information and chaos. We must be vigilant in limiting what is said to maintain order and justice.

John Stuart Mill (JSM): In *On Liberty*, I argued that freedom of speech is essential to a healthy society. I wrote, "If all mankind minus one were of one opinion, and only one person were of the contrary opinion, mankind would be no more justified in silencing that one person than he, if he had the power, would be justified in silencing mankind." We must not suppress people's right to express their opinion and thought - even if it is unpopular or controversial - as this could stifle progress and creativity.

Plato: But allowing people to speak freely could also have dangerous consequences. We must consider the potential for harm when making decisions about free speech. We must ensure that the good of society is balanced with the right to speak freely.

JSM: Yes, I agree that we must consider the potential for harm. However, we should not limit free speech in an effort to prevent harm. We should instead strive to create a society where people can express themselves without fear of retribution. A society in which people are encouraged to think critically and engage in reasoned debate will be better able to address issues of harm.

Plato: I also that think that a society should strive to create an environment that encourages critical thinking and reasoned debate. However, we must also consider the potential for harm. We have seen in recent years how the spread of false information through social media can lead to violence, disruption, and chaos. We must be vigilant in ensuring that freedom of speech does not lead to these types of harms. For example, countries like China and North Korea have used censorship to control what their citizens can say and do online. This has enabled them to maintain order, but at the cost of denying people their right to free speech. We should strive to create a system that balances freedom of speech with the need for order and stability.

JSM: I concur that we should strive to create a system that balances freedom of speech with the need for order and stability. However, we must also consider the potential benefits of free speech. For example, it allows us to hold our leaders accountable, engage in meaningful debate about important issues, and access new ideas. This is especially true in the digital age, where access to information is easier than ever before. We must recognize and embrace the power of free speech to bring about positive change and progress in our society. We should strive to create an environment where people can express their opinions without fear of retribution or censorship.

Plato: Yes, I agree that free speech can bring about positive change and progress. But we must also consider the potential for harm. We have seen how powerful individuals like Donald Trump and Elon Musk have used their platforms to spread misinformation and distort public discourse. We must be mindful of this when making decisions about free speech and ensure that it is not used in ways that could lead to harm or disruption.

JSM: I agree that we must be mindful of the potential for harm and ensure that freedom of speech is used responsibly. However, we should also recognize that individuals like Donald Trump and Elon Musk have used their platforms to promote positive change as well. For example, Musk has used his platform to advocate for renewable energy and innovative technology. We should strive to create an environment where people are free to express themselves without fear of retribution or censorship, while also ensuring that free speech is used responsibly.

Plato: Yes, I agree that we should strive to create an environment where people are free to express themselves without fear of retribution or censorship. However, as political science scholarship has shown, free speech is not always used responsibly (Kaufmann, 2019). We must be mindful of this when making decisions about free speech and ensure that it is not used in ways that could lead to harm or disruption.

JSM: Absolutely. We must be mindful of the potential for harm and ensure that freedom of speech is used responsibly. But we should also recognize that free speech can be a powerful tool for positive change. It allows us to hold our leaders accountable, engage in meaningful debate about important issues, and access new ideas. We must strive to create an environment where people can express themselves without fear of retribution or censorship, while also ensuring that free speech is used responsibly.

Plato: Yes, I agree that free speech can be a powerful tool for positive change. But we must also consider the potential for harm, especially to minority groups who are often targeted with hateful rhetoric. We must be vigilant in ensuring that freedom of speech does not lead to these types of harms. For example, countries like Germany have enacted laws to prevent hate speech and protect marginalized groups from discrimination. We should strive to create a system that balances freedom of speech with the need for order and stability, while also protecting vulnerable populations from harm.

JSM: Absolutely. We must be mindful of the potential for harm and ensure that freedom of speech is used responsibly. At the same time, we should recognize that free speech can also be a powerful tool for marginalized groups. It allows them to speak out against discrimination, advocate for their rights, and push for progress. We should strive to create an environment where people are free to express themselves without fear of retribution or censorship, while also ensuring that free speech is used responsibly and in a way that promotes positive change.

## Review Questions

1. Give your OWN summary of Plato's argument. Put it in standard form.
2. Give your OWN summary of Mill's argument. Put it in standard form.
3. Which thinker do you think "won" the argument (if either)? Why?
4. What sorts of evidence do you think was left out of the argument? How would it make each argument stronger or weaker?

# CHAPTER 2: ARGUMENT EVALUATION

In this chapter, we will learn about induction and deduction, two important methods of reasoning. Inductive reasoning allows us to draw conclusions based on observations and patterns, while deductive reasoning allows us to test the validity of an argument. We will explore common types of deductive arguments, such as modus ponens and modus tollens, as well as different types of inductive arguments, such as generalization and argument from analogy. We will also learn how to evaluate arguments, and distinguish between strong and weak inductive arguments, and valid and invalid deductive arguments. You'll learn about Ada Lovelace, and her contributions to logic. The ability to reason using induction and deduction is a valuable skill to have in everyday life. By learning about these methods of reasoning and how to evaluate arguments, you will be better equipped to make informed decisions and evaluate the claims and arguments you encounter daily. This can help you in a variety of situations, from engaging in discussions and debates with others to making important decisions in your personal and professional life.

Let's begin with a brief dialogue on the nature of reasoning from Olaf and Anne (inspired by Disney's *Frozen).*

## OLAF AND ANNA ON THE PROBLEM OF INDUCTION

Olaf: Hey Anna, have you ever thought about the Problem of Induction?

Anna: Not really. What is it?

Olaf: It's a philosophical problem that arises when we try to use past observations to make predictions about the future. For example, if we've seen the snow always fall in Arendelle every winter, we might assume that it will continue to snow every winter. But this assumption isn't necessarily true, because there's no guarantee that the snow will continue to behave in the same way in the future.

Anna: That's interesting, but why is it a problem?

Olaf: Well, it's a problem because it means that we can never be certain about our predictions. We can only make assumptions based on what we've observed in the past, but there's no guarantee that those assumptions will continue to be correct in the future. For example, we've always seen the winter freeze the kingdom of Arendelle, but who knows if that will always be the case?

Anna: I see what you mean. So how do we deal with this problem?

Olaf: One way to deal with it is to use inductive and deductive arguments. Inductive arguments are based on past observations, and they allow us to make predictions, generalizations, and causal inferences about the future. For example, if we've seen the snow always fall in Arendelle every winter, we can use that information to make an inductive argument that it will probably continue to snow every winter. But inductive arguments are not logically certain, because there's always the possibility that our past observations are not representative of the future.

Anna: That makes sense. So, without inductive arguments, we wouldn't be able to make reliable predictions about the weather or other aspects of life in Arendelle?

Olaf: Exactly. Inductive arguments are an essential tool for understanding the world and making predictions about the future. Without them, we would be lost and unable to plan for the future.

Anna: That's definitely true. I can't imagine trying to live in Arendelle without being able to make predictions about the weather or other aspects of life here. And if I'm understanding this problem right, it seems like we use induction all the time. For example, whenever I believe something Elsa told me (or that I read in a book), or when I predict that having just one more cookie won't magically transform me into a turnip.

Olaf: Yes, that's right. Or when I predict that snowmen probably shouldn't spend too much time in hot tubs—that's induction!

Anna: And what about deductive arguments?

Olaf: Deductive arguments are different from inductive arguments, because they are based on logical necessity rather than past observations. For example, if we know that all humans are mortal, and we know that Anna is a human, then we can use those facts to make a deductive argument that Anna is mortal. Deductive arguments are logically certain, because they are based on the laws of logic rather than past observations. The only way deductive arguments can go wrong is if one of the premises are false (for example, if I suddenly learned you weren't really human!).

Anna: I see. So, the Problem of Induction is a problem because we can't be certain about our predictions, no matter how strong our inductive argument is.

Olaf: Exactly. The Problem of Induction is a problem because it shows that we can never be completely certain about the future, even if we use past observations to make predictions. But that doesn't mean that we should give up on trying to understand the world and make predictions about the future. It just means that we need to be careful and cautious when making those predictions, and understand there is always some chance we'll be wrong.

Anna: I agree. It's important to be open-minded and curious, but also to be aware of the limitations of our knowledge.

Olaf: Definitely. And as a snowman who loves adventure and new experiences, I'm always excited to learn more about the world and the way it works.

Anna: That's great, Olaf. I'm glad you're always so curious and open-minded. It's one of the things I love about you.

Olaf: Aw, thank you, Anna. I love you too!

### QUESTIONS

1. What is the Problem of Induction, and why is it considered a problem?
2. What are inductive and deductive arguments, and how do they differ from one another?
3. How do Olaf and Anna deal with the Problem of Induction in their lives and experiences in Arendelle?
4. What are some examples of inductive and deductive arguments that Olaf and Anna use in their dialogue?
5. How does the Problem of Induction relate to being open-minded and curious about the world?

## INDUCTION AND DEDUCTION

We can do two different sorts of things when we "argue" or "reason." First, we can try to PROVE that something is true with 100% certainty. For example, this is what students learn to do in high-school geometry classes. On the other hand, we can try to provide EVIDENCE that something is (probably) true, even though we grant the possibility that it COULD be false. This latter sort of reasoning/arguing is far more common than the first. Logicians call these two modes of reasoning deductive and inductive reasoning, and they require fundamentally different sorts of "tools" to evaluate their success.

A **deductive argument** is an argument that incorporates the inferential claim that it is *literally impossible* for the premises to be true and the conclusion to be false. So, if you can convince the person of the truth of your premises, they MUST accept your conclusion with 100% certainty. Deductive arguments either work or do no work; there is no middle ground. Deductive reasoning plays a central role in areas such as mathematics and computer science (and philosophy!) but a more limited role in other areas of life. (This isn't to say that we don't use deductive reasoning; it's just that many of our most challenging problems in life tend to require we use induction).

Much of our reasoning in everyday life (including nearly all of science, history, etc.) involves inductive arguments. An **inductive argument** is an argument in which it is only claimed that it is *unlikely* for the premises to be true and the conclusion false. Inductive arguments come in various strengths and can (unlike deductive arguments) be weakened or strengthened by adding new premises (new evidence makes a difference). When reasoning inductively, you aim to show the person that *if* your premises are true and *if* you haven't left anything important out, your conclusion is probable.

The distinction between deductive and inductive arguments can be challenging to identify at times, but there are some key differences that can help you determine which type of argument is being used. Deductive arguments rely on logical reasoning, while inductive arguments rely on evidence or empirical facts. Deductive conclusions must always follow with absolute certainty from the premises, whereas inductive conclusions may be more likely than not true but could still be false in some cases.

It is important to understand the difference between deductive and inductive arguments because they are used for different purposes and have different levels of certainty associated with them. Deductive arguments are used when we want to prove something beyond doubt, while inductive arguments are used when we want to make generalizations or predictions about future events and occurrences that may not be 100% certain.

## Common Deductive Arguments

Logicians have been studying deductive arguments for thousands of years. Here are a number of the most famous/well-known forms of "valid" deductive reasoning.

### Modus Ponens

- Premise 1: If P then Q
- Premise 2: P
- Conclusion: Q

This argument form works by using two premises to draw a conclusion. The first premise states that if one thing is true, then another thing must be true. The second premise states that the first thing is indeed true. Therefore, the conclusion follows logically that the second thing must also be true. For example: If Tigger says he's going to bounce around, then his friends will have fun (Premise 1). Tigger does say he's going to bounce around (Premise 2). Therefore, his friends will have fun (Conclusion).

### Modus Tollens

- Premise 1: If P then Q
- Premise 2: Not Q
- Conclusion: Not P

This argument form also works with two premises to draw a conclusion. However, instead of asserting that something is true like in Modus Ponens, this argument form asserts that something is not true. The first premise states that if one thing is true, then another thing must be true. The second premise states that the latter thing is not true. Therefore, the conclusion follows logically that the first thing must also not be true. For example: If Eeyore says he's going on a picnic, then Piglet will come along (Premise 1). Piglet is not at the picnic (Premise 2). Therefore, Eeyore is not at the picnic (Conclusion).

### Hypothetical Syllogism

- Premise 1: If P then Q
- Premise 2: If Q then R
- Conclusion: If P then R

Hypothetical Syllogism: This argument form uses three premises to draw a conclusion. The first and second premises both state an "if-then" relationship between two things. The third premise draws from these two relationships to assert another "if-then" relationship between the two original things. For example: If Rabbit says he has carrots to share with his friends, then they'll all come over (Premise 1). If they all come over then they'll have a party (Premise 2). Therefore, if Rabbit says he has carrots to share with his friends then they'll have a party (Conclusion).

### Disjunctive Syllogism

- Premise 1: P or Q
- Premise 2: Not Q
- Conclusion: P

This argument form works similarly to modus tollens in that it uses two premises and asserts something as being false in order to draw a conclusion. However, instead of stating something as being false it states that one of two possibilities must be false. The first premise states that either one or the other possibility could be true while the second premise states one of them as being false. Therefore, it follows logically that only one possibility remains and thus it must be true. For example: Either Owl or Rabbit is organizing an event for their friends (Premise 1). It turns out Owl isn't organizing an event for their friends (Premise 2). Therefore Rabbit must be organizing an event for their friends (Conclusion).

### Constructive Dilemma

- Premise 1: P or Q
- Premise 2: If P then R
- Premise 3: If Q then S
- Conclusion: R or S

This argument form uses three premises and draws on both possibilities stated in disjunctive syllogism in order to draw its conclusion. The first premise states either one or both possibilities could be true while the second and third premises state what would happen if each possibility were indeed true respectively. Thus it follows logically that either outcome would happen since at least one of those possibilities has been asserted as being possible by Premise 1 while each potential outcome has its own respective consequence stated by Premises 2 and 3 respectively. For example: Either Owl or Rabbit are bringing treats for their friends' picnic (Premise 1), if Owl brings treats then everyone will get honey cakes for dessert (Premise 2), if Rabbit brings treats then everyone will get carrot cake for dessert (Premise 3). Therefore everyone will get honey cakes or carrot cake for dessert at their picnic (Conclusion)

### Categorical Syllogism (Barbara)

- Premise 1: All M is P
- Premise 2: All S is M
- Conclusion: All S is P

This argument form uses two premises in order to draw its conclusion which always follow logically from them no matter what specific examples are used since they are universal statements about all instances within some class of objects or events rather than just specific ones like previous forms use as examples in their arguments.. In Barbara's case specifically this statement involves saying all members of some class are part of another class regardless of any other properties about them beyond being members of those classes themselves so long as all members of said classes do indeed possess such properties themselves regardless of any other unique qualities which may differ between them otherwise besides simply being apart of those classes itself already stated here already.. For example: All animals can go on adventures with Christopher Robin (Premise 1). All of Pooh's friends are animals (Premise 2). Therefore, all of Pooh's friends can go on adventures with Christopher Robin (Conclusion).

### Categorical Syllogism (Celarent)

- Premise 1: No M are P
- Premise 2: All S are M
- Conclusion: No S are P

This argument form works similarly to Barbara but instead of asserting that all members of a class must be part of another class it instead asserts that none of them can be part of said other class. This again is based on the same premise as before which involves saying all members of some class are part of another class regardless of any other properties about them beyond being members of those classes themselves so long as all members of said classes do indeed possess such properties themselves regardless of any other unique qualities which may differ between them otherwise besides simply being apart of those classes itself already stated here already.. For example: None of the animals in the Hundred Acre Wood play cricket (Premise 1). All Piglet's friends are animals in the Hundred Acre Wood (Premise 2). Therefore, none of Piglet's friends play cricket (Conclusion).

### Argument from Definition

- Premise 1: X is Y

- Premise 2: By definition, anything that is Y is Z
- Conclusion: X is Z

This argument form uses two premises to draw its conclusion and both are focused more on definitions than actual events or objects. The first premise states a definition for something while the second premise draws upon this definition to assert something else is true as well. For example: Christopher Robin is a human child (Premise 1). By definition, anything that is a child is a young member of its species (Premise 2). Therefore, Christopher Robin is a young human (Conclusion).

### Application of Equation

- Premise 1: A scientific or mathematical formula. For example "F=MA", "PV = nRT", "A = .5*h*b"
- Premise 2: Specification of values for the independent variables
- Conclusion: Value of the dependent variable

This argument form uses two premises to draw its conclusion. The first premise is an equation involving multiple variables while the second premise states what each variable stands for. Since equations by nature involve only one answer for each set given their mathematical nature, it follows logically that what this answer must be if these specific values for each variable are given must also follow from this equation and thus constitutes the conclusion since these values have been provided according to Premise 2.. For example: F = MA (Premise 1), where Tigger weighs 80 kgs and is accelerating at 5 m/s2 (Premise 2). Therefore, Tigger has a force acting upon him equal to 400 Newtons (Conclusion).

## Inductive Arguments

While the study of inductive arguments is more recent than that of deductive arguments (it only got seriously started after the scientific revolution), most of the reasoning we do regarding life/business/science/relations is actually inductive. Here are some examples of inductive arguments:

### Generalization:

- Premise 1: In a sample S, I have observed X
- Premise 2+: Evidence from additional samples
- Conclusion: So, X is probably true for the larger population as well

This argument form involves taking evidence from a sample of people or things and using it to draw conclusions about the larger population. For example, if I observe that 10 out of 10 people in a sample are happy, I can use this evidence to conclude that the larger population is also likely to be happy. Another example:

- Premise 1: In a sample of Spiderman comics, I have observed that Peter Parker is the superhero.
- Premise 2+: Evidence from other Spiderman movies and cartoons show that Peter Parker is the hero.
- Conclusion: So, it is probably true for the larger population (all Spiderman universes) as well.

### Prediction

- Premise 1: Events in the past provide evidence that X will occur soon.
- Premise 2+: Additional evidence in favor of X
- Conclusion: X is likely to occur soon.

This argument form involves using evidence from past events to make predictions about what will happen in the future. For example, if there have been several instances of stock prices increasing after certain economic indicators have risen, then one can use this evidence to predict that stock prices will increase in the future when those same indicators rise again.

- Premise 1: Peter Parker has saved the day many times in the past, so it is likely to happen again soon.
- Premise 2+: We can see from his history that he is brave and willing to take risks.
- Conclusion: Peter Parker is likely to save the day again soon.

### Argument from Analogy

- Premise 1: A has properties X, Y, and Z
- Premise 2: B has properties X and Y
- Premise 3+: Additional evidence regarding C, D, E, ....
- Conclusion: B is probably Z

This argument form involves comparing two similar situations and using their similarities as evidence to draw conclusions about one of them. For example, if two countries both have democratic systems of government and free market economies, then one can conclude that they probably also share similar legal systems. Another example:

- Premise 1: Iron Man has properties of a genius, billionaire, playboy, philanthropist.
- Premise 2: Batman has properties of a genius and a billionaire.
- Premise 3+: Additional evidence shows that both characters have similar backgrounds and skillsets.
- Conclusion: Batman is probably a playboy philanthropist as well.

### Causal Inference

- Premise 1: X occurred before Y
- Premise 2: Description of a mechanism by which X could cause Y
- Conclusion: X is a cause of Y

This argument form involves looking at evidence of a relationship between two events and inferring that one was the cause of the other. For example, if I observe that smoking cigarettes precedes lung cancer in many cases, then I can infer that smoking cigarettes is likely a cause of lung cancer. Another example:

- Premise 1: Spiderman's web shooting abilities occurred before his ability to climb walls.
- Premise 2: The webs provide grip on surfaces which allows him to climb walls quickly and easily.
- Conclusion: His web shooting abilities are a cause of his wall-climbing abilities.

### Argument from Authority

- Premise 1: A knowledge authority A said X is true.
- Premise 2+: Other authorities B, C, D, etc. agree with A.
- Conclusion: X is probably true

This argument form involves citing an expert or authoritative source as evidence for a claim. For example, if a respected doctor says that a certain medication is effective for treating a certain condition, then one can use this as evidence to support the claim that the medication is effective for treating the condition. Another example:

- Premise 1: A knowledge authority, Stan Lee, said that Spiderman's power comes from radioactive spider bite.
- Premise 2+: Other authorities (e.g., Marvel Comics) agree with Stan Lee's opinion.
- Conclusion: It is probably true that Spiderman's power comes from radioactive spider bite.

### Scientific Reasoning

- Premise 1: Hypothesis H is the best explanation for observation O
- Premise 2+: Hypothesis is the best explanations for other observations
- Conclusion: H is probably true

This argument form involves using scientific methods to test hypotheses and draw conclusions based on the results. For example, if you hypothesize that increasing temperatures will lead to an increase in sea levels and you conduct experiments which show this to be true, then you can use this evidence to conclude that your hypothesis is likely correct. Another example:

- Premise 1: The hypothesis that Peter Parker was bitten by a radioactive spider explains his spire-reldated superpowers.
- Premise 2+: [List all things this hypothesis explains that other hypotheses cannot.]

- Conclusion: It is probably true Peter Parker owes his abilities to his being bitten by a radioactive spider.

## EXAMPLE: ARGUMENTS ABOUT "SUPER MARIO"

Here are some examples of deductive and inductive arguments (along with explanations of how we can determine this).

| Passage | Inductive, Deductive, or Not an Argument? |
|---|---|
| **Mario and Luigi are brothers. Therefore, they have at least one parent in common.** | This is deductive since the conclusion follows from the definitions of the word "brother" and "parents." While we might need to do some work to determine whether the premise is true ("Are Mario and Luigi really brothers?"), once we've |
| **Mario speaks with an Italian accent. Since Luigi was raised with Mario, Luigi probably speaks with one too.** | Inductive. We reason that because Mario and Luigi have certain similarities (they were raised together), they must have other similarities (speaking with the same accent.) This is an argument by analogy. |
| **Mario and Luigi went to plumbing school in the 1970s together. Mario mainly got Bs, while Luigi got mostly As.** | This is not an argument at all. |
| **All people with evil-sounding names are evil. "Wario" is an evil-sounding name. So, Wario is evil.** | This is deductive and looks like a categorical argument (with the word "All"). *While the* argument is valid, the premise that "All people with evil-sounding names are evil" is false. |
| **I've looked all over this castle, but I simply can't find Princess Peach. So, the Princess must be in some other castle.** | This is inductive and looks like an argument to the best explanation. (We want a reason for Peach's absence; the best one we can think of is that she is in another castle.) |
| **The last 100 times I encountered a Koopa Troopa, it tried to bite me. So, the next Koopa Troopa I meet will certainly try to bite me as well.** | Inductive-prediction/generalization. While words like "certainly" sometimes signal deductive argumentation, they don't in this case. After all, we can't use information about the past to predict the future with 100% certainty (as deductive argumentation requires). |
| **I saw a sign saying, "This way to Bowser's castle." So, if we want to go to Bowser's castle, we should go that way.** | Inductive—argument from signs. Whenever you make an inference from "a sign says this" to "it's true," you are making an inductive leap (after all, maybe Bowser has been putting up fake signs to mislead people about the location of his castle). |
| **There are precisely 8 levels in *Super Mario Brothers.* I have beat 7 of them. So, if I complete one more, I will have finished the game.** | Deductive—argument from mathematics. The conclusion here follows from "8 – 7." Again, it's important to note I might be wrong about my premises (e.g., maybe there are more than 8 levels). However, on the assumption that my premises are TRUE, my conclusion follows simply from the math. |
| **If you like *Super Mario Brothers,* then you will also like *Sonic the Hedgehog.*** | This isn't an argument! It is a conditional statement claiming that liking *Mario* is a sufficient condition for liking *Sonic*. (And that liking *Sonic* necessarily follows from liking *Mario*.) |
| **I will beat the level if I continue playing video games for 30 minutes. If I beat the level, I will be happy forever. So, if I continue playing video games for 30 more mins, I will be happy forever.** | Deductive—hypothetical syllogism. (Again, this is a deductively "valid" argument. However, validity doesn't guarantee the premises' truth.) |
| **The question box must contain a mushroom, given that it either contains a mushroom or flower, and it doesn't contain a flower.** | Deductive-disjunctive syllogism. |
| **Luigi couldn't beat Bowser before he bought himself a Racoon Suit. After he bought a Racoon Suit, he beat Bowser with ease. So, the** | Inductive—argument about causes and effects. Arguments about causes/effects are inherently uncertain since there will *always* be other possibilities we haven't accounted for. (E.g., maybe Luigi just got lucky |

| | |
|---|---|
| **Racoon Suit must have been a cause of his beating Bowser.** | this time, or his previous practice paid off, or he'd just had a cup of coffee, or whatever). |
| **Toad told me that Princess Peach is thinking of becoming a race car driver and that she's sick of being a princess. Since Toad is one of Peach's best friends, I think we can trust him.** | Inductive—argument from authority. Every time we believe something on the basis that a person/group/book told us it was true, we are reasoning inductively. (Obviously, this accounts for a massive chunk of our beliefs!). |

### Review Questions

1. What is the difference between deductive and inductive arguments?
2. Choose a few of the forms of deductive reasoning explained above, and give your own examples of them.
3. Choose a few of the forms of inductive reasoning explained above, and give your own examples of them.
4. Try to identify examples of deductive and inductive arguments in everyday life.
5. Research an example of a logical/mathematical proof and explain how it works.

## Argument Evaluation

This section will provide an introduction to argument evaluation. We will review what an argument is, and what constitutes a good argument. We will discuss deductive and inductive arguments, as well as deductive validity and inductive strength. We will also discuss how to determine the truth of the premises.

An argument is a set of statements, one or more of which (the premises) are offered in support of another statement (the conclusion). Although arguments can take many forms, we can generally evaluate an argument by asking two questions:

- **TEST 1:** Does the argument have a good "form"? That is, if I assume that the premises are true, does the conclusion follow? There are two ways in which an argument can have "good" form: it can be deductively valid or inductively strong. An inductively weak argument, by contrast, has a "bad" form.
- **TEST 2:** Are the premises true or false?

A good argument must meet BOTH of these criteria, which are indepent of each other.

### Deductive Arguments: Valid or Invalid?

**Deductively valid arguments** are those for which it is not possible for all of the premises to be true and the conclusion false simultaneously. That is, if the premises are true, then the conclusion must also be true. Deductively valid arguments are considered to have a "good" form of argument. The deductive forms surveyed in the previous section are "valid." An example of a deductively valid argument is as follows:

- Premise 1: If Homer is bald, then Bart is bald.
- Premise 2: Homer is bald.
- Conclusion: Therefore, Bart is bald.

This argument is deductively valid because it would be impossible for both premises to be true and the conclusion false. It is important to note that a valid argument can still have a false conclusion IF one of the premises is false (as premise 1 is in this case).

It is important to note that not every argument that "looks" deductive valid actually is valid. For example, the following argument is NOT valid (they are deductively **invalid)**:

- Premise 1: If Homer is bald, then Bart is bald.
- Premise 2: Homer is not bald.
- Conclusion: Therefore, Bart is not bald.

This one is invalid, as well:

- Premise 1: All Simpsons characters are cartoons
- Premise 2: All Simpsons characters are funny
- Conclusion: Therefore, all cartoons are funny

In some domains, such as pure mathematics or computer science, arguments MUST be deductively valid to count as successful. That is, a mathematical proof either "succeeds" 100% or it does not; there is no middle ground. In many other domains, however--including science, politics, history, and most of "ordinary life"--this demand for proof isn't realistic. Instead, we are simply trying to determine which conclusions are "likely" to be accurate, or what the "most reasonable thing to believe is." Determining this requires the use of inductive arguments.

Here are some examples of deductively valid arguments, including modus ponens, hypothetical syllogism, and and disjunctive syllogism.

**Modus Ponens:**

- Premise 1: If it is raining, then the streets are wet.
- Premise 2: It is raining.
- Conclusion: Therefore, the streets are wet.

It is logically impossible for the premises of this argument to be true and the conclusion to be false because premise 1 states that if it is raining, then the streets are wet. Premise 2 confirms that it is indeed raining, so according to premise 1, it must follow that the streets are wet. Therefore, if both premises are true, then so must the conclusion be.

**Hypothetical Syllogism:**

- Premise 1: If Homer is bald, then Bart is bald.
- Premise 2: If Bart is bald, then Lisa is bald.
- Conclusion: Therefore, if Homer is bald, then Lisa is bald.

Since this argument is valid, the truth of the premises necessitates the truth of the conclusion because both premises state a logical connection between Homer being bald and Lisa being bald. If both premises are true, then it necessarily follows that if Homer is bald, then Lisa is bald. The conclusion could still be false if either premise is false; for example, if Homer is bald but Bart is not, then the first premise would be false (thus the conclusion can also be false).

**Disjunctive Syllogism:**

- Premise 1: Either Homer is bald or he has a full head of hair.
- Premise 2: Homer does not have a full head of hair.
- Conclusion: Therefore, Homer is bald.

In a valid argument, true premises guarantees the truth of the conclusion because if premise 1 is true and premise 2 is also true, then the only logical conclusion is that Homer is bald. If either premise 1 or premise 2 were false, then it would not guarantee that Homer is bald. For example, if premise 1 was false and excluded options such as Homer having short hair or a shaved head, then the conclusion could still be false.

## Inductive Arguments: Strong or Weak?

All inductive arguments are technically "deductively invalid," but this does NOT mean that they are useless. Instead, inductive arguments are usually assessed as "strong" or "weak." An inductive argument is **strong** when, assuming the premises are true, it is improbable for the conclusion to be false. An inductive argument is **weak** when, assuming the premises are true, it is still probable that the conclusion to be false. For example, consider the following inductive argument:

- Premise 1: Some people who work at the Kwik-E-Mart are rude.

- Premise 2: Apu works at the Kwik-E-Mart.
- Conclusion: Therefore, Apu probably is rude.

This argument is inductively weak, since it is not improbable for Apu to be polite even if the premises are true. By contrast, the following argument is inductively strong:

- Premise 1: Bart has played pranks on his teacher every day this year.
- Premise 2: Today is the last day of school.
- Conclusion: Therefore, Bart will probably play a prank on his teacher today.

This argument is inductively strong because it is highly improbable for the conclusion to be false, if we assume that the premises are true.

### Strong Inductive Arguments (Examples)

Here are some examples of inductively strong arguments, including statistical generalizations, evidence-based predictions, and arguments from analogy.

**Generalization:**

- Premise 1: Marge's first three children--Lisa, Bart, and Maggie--all have brown eyes.
- Premise 2: Both Homer and Marge have brown eyes.
- Conclusion: Therefore, Marge's next child will likely have brown eyes.

The conclusion of this argument is likely to be true because the premise states that both Homer and Marge have brown eyes, meaning that it is highly probable that their offspring will inherit this trait. However, the conclusion could possibly be false as there is always a chance of gene mutation or other factors influencing the eye color of their next child.

**Evidence-Based Prediction:**

- Premise 1: Lisa has been studying for her math test for two hours.
- Premise 2: People who study for two hours usually do well on math tests.
- Conclusion: Therefore, Lisa probably will do well on her math test.

The conclusion that Lisa will do well on her math test is likely to be true because she has been studying for two hours, and people who study for two hours usually do well on math tests. However, it is possible that the conclusion could be false if Lisa did not put enough effort into her studying or if the material she is being tested on was particularly difficult.

**Argument from Analogy:**

- Premise 1: Marge is an excellent cook.
- Premise 2: People who are excellent cooks usually make good bakers.
- Conclusion: Therefore, Maggie probably is a good baker.

The conclusion of this argument is likely to be true because there is a strong connection between the two premises. Marge being an excellent cook suggests that she probably also makes good baked goods, since people who are excellent cooks usually make good bakers. However, it is possible for someone to excel at one type of cooking but not another, so the conclusion could be false if Marge does not actually make good baked goods despite her excellence in other aspects of cooking.

### Inductively Weak Arguments (Examples)

Finally, here are some examples of inductively weak arguments:

**Hasty Generalization**

- Premise 1: Bart got the first question on his math test correct.

- Conclusion: Therefore, Bart probably will get 100% on his math test.

This argument is an example of hasty generalization because it assumes that Bart's success on the first question is indicative of his success on the entire test, without considering other factors such as difficulty of questions or Bart's overall knowledge and understanding of math.

**False Cause Fallacy**

- Premise 1: Lisa ate ice cream before her math test.
- Premise 2: Lisa failed her math test.
- Conclusion: Therefore, eating ice cream probably caused Lisa to fail the test.

This argument is committing the false cause fallacy because it implies that eating ice cream caused Lisa to fail her math test, when there are likely other factors at play. Eating ice cream and failing a math test may both be true, but they aren't necessarily connected.

**Weak Analogy:**

- Premise 1: Homer is yellow, male, and works at a nuclear power plant.
- Premise 2: Mr. Burns is yellow, male, and works at a nuclear power plant.
- Premise 3: Mr. Burns is obscenely wealthy.
- Conclusion: Therefore, Homer will one day become obscenely wealthy.

This argument is using a weak analogy because the two premises are only similar in that they are both yellow males who work at a nuclear power plant. This does not necessarily mean that anything else they have in common, such as wealth, will apply to Homer as well. Therefore, the conclusion that Homer will one day become obscenely wealthy cannot be made based on these premises alone.

## Are The Premises True? Sound and Cogent Arguments

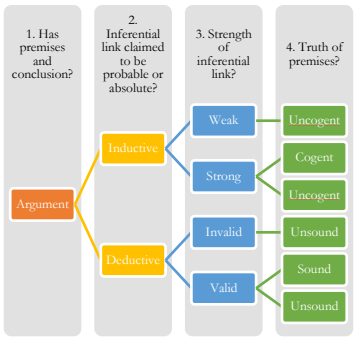
Once we have determined whether an argument is deductively valid or inductively strong, we must then consider whether the premises are true. (After all, an argument with a "good" form" can still mislead us if it is based on false starting points). In order to do this, we must look for evidence to support or deny each premise. This can involve research, observation, or experimentation. We must also be aware of any biases or preconceptions that may be influencing our evaluation of the premises.

- A valid deductive argument with all true premises is called a **sound** argument. Sound arguments have conclusions that are GUARANTEED to be true.
- A strong inductive argument with all true premises is called a **cogent** argument. Cogent arguments have conclusions that are *likely* to be true, given our current evidence. We should believe in their conclusions.

The goal of arguing is, in the end, to produce sound or cogent arguments, which pass both "test 1" (they have a good form) and "test 2" (they have true premises).

It is important to remember that even if YOU find the truth of a premise to be obvious, your audience may not. For example, you may find it obvious that Bart is a prankster, but others might not. As such, it is important to provide evidence for each premise if you wish to make a convincing argument. If you were Bart's teacher, for example, you might provide evidence in the form of school disciplinary records, communications with parents, and so on. (And this process could be thought of as its OWN argument).
In conclusion, evaluating an argument requires both understanding the form of the argument and determining the truth of the premises. We must be able to identify whether an argument is deductively valid or inductively strong, and then use evidence to determine the truth of the premises. By following these steps, we can evaluate arguments more effectively and reach more accurate conclusions.

## Argument Evaluation Visualized




## Minds That Mattered: Ada Lovelace

Ada Lovelace was born Augusta Ada Byron on December 10th, 1815 in London, England. She was the daughter of the poet Lord Byron and Annabella Milbanke, who separated shortly after her birth. Her mother encouraged her to pursue a career in mathematics and science, believing that it would reduce the chance of Ada following in her father's footsteps.

At the age of 17, Ada met Charles Babbage, a professor of mathematics at Cambridge University and inventor of the Difference Engine and Analytical Engine. She soon became fascinated with Babbage's work and developed a friendship with him. In 1843, she wrote an article about the Analytical Engine which included her own interpretation of how it could be used. This article was the first algorithm ever written for a machine.

In 1844, Ada wrote a proof of what is now known as "**Lovelace's Theorem**," which states that any computation can be reduced to a set of basic operations. This theorem states that any problem, no matter how complex, can be broken down into a series of simple steps. This theorem is based on the idea that any computation can be reduced to a set of basic operations, such as addition, subtraction, multiplication, and division. By understanding the basic operations and applying them to the problem at hand, one can break down a complex problem into simpler parts that are easier to solve. Lovelace's theorem is an important part of modern computing, and is used in various programming languages and algorithms.

Ada also predicted that machines would eventually be capable of making decisions on their own. Although she died at the young age of 36 in 1852 due to cancer, her work had a profound impact on logic and computing. Her example program for the Analytical Engine was the first algorithm designed for a machine and her theorem is still used today in various programming languages and algorithms.

Ada Lovelace has become an iconic figure in the history of computing and her legacy lives on in many advances that have been made in programming and logic over the years. She has inspired many female computer scientists and her work has been recognized by naming awards after her (e.g., The British Computer Society's Lovelace Medal).

### Review Questions

Here are some questions to consider based on what we've learned in this chapter.

1. What are the two criteria for evaluating an argument?
2. Why is it important to remember that your audience may not find the truth of a premise to be obvious?
3. Create a list of 3 arguments that are either deductively valid or inductively strong and discuss the form of each argument.
4. Create a list of 3 arguments that are inductively weak, and discuss how they might be improved.
5. Write a short essay discussing how argument evaluation is used in your daily life.
6. Find an internet source explaining how different biases and preconceptions can influence argument evaluation, and explain its main ideas to us.
7. Collect evidence to support or deny a premise of an argument you have encountered in the news lately.
8. What did Ada Lovelace predict about machines? Do you think her prediction will come true?

## Key Concepts

- **Analogical Argument--**An inductive argument that relies on the similarity between two or more things to support a conclusion about one of them.
- **Argument From Authority--**An inductive argument that appeals to the expertise or credibility of someone in a particular field to support a conclusion.
- **Argument from Definition--**A deductive argument that defines a term or concept and then uses the definition to support a conclusion.
- **Argument the Best Explanation--**An inductive argument that claims that the best explanation for a certain phenomenon is the one being presented.
- **Categorical Syllogisms--**A type of deductive argument that involves two premises and a conclusion, each of which is a categorical statement (a statement that asserts or denies that all, some, or none of a certain group or category have a certain attribute). There are many different types of categorical syllogisms, each with its own specific form.
- **Causal Argument--**An inductive argument that asserts that one thing (the cause) leads to or produces another thing (the effect).
- **Cogent (Inductive) Argument--**A strong inductive argument in which all the premises are also actually true.
- **Deductive Argument—**An argument in which it is claimed it is IMPOSSIBLE for the premises to be true and the conclusion false. Examples include categorical syllogisms, modus ponens, arguments from mathematics, and arguments from definition.
- **Disjunctive Syllogism--**A valid (deductive) propositional logic argument that uses the following form: "Either P or Q. Not P. Therefore, Q."
- **Generalization--**An inductive argument that involves making a conclusion about a group or category based on evidence about a sample from that group.
- **Hypothetical Syllogism--**A valid (deductive) propositional logic argument that uses the following form: "If P, then Q. If Q, then R. Therefore, if P, then R."
- **Inductive Argument—**An argument in which it is claimed that that truth of the premises make the conclusion's truth likely. Examples include generalizations, predictions, arguments from authority, arguments to the best explanation, and causal inferences.
- **Invalid (Deductive) Argument--**A deductive argument in which the conclusion does not necessarily follow from the premises, so it is possible for the premises to be true and the conclusion false.
- **Mathematical Argument--**A deductive argument that uses logical and mathematical principles to support its conclusion.
- **Modus Ponens--**A valid (deductive) propositional logic argument that uses the following form: "If P, then Q. P. Therefore, Q."
- **Modus Tollens--**A valid (deductive) propositional logic argument that uses the following form: "If P, then Q. Not Q. Therefore, not P."
- **Prediction--**An inductive argument that uses past patterns or evidence to make a statement about what is likely to happen in the future.
- **Propositional Logic--**A type of formal deductive logical system that deals with logical relationships between propositions (statements that can be either true or false).
- **Sound (Deductive) Argument--**A valid deductive argument in which all the premises are also actually true.
- **Strong (Inductive) Argument--**An inductive argument in which the truth of the premises makes the conclusion highly likely to be true.
- **Valid (Deductive) Argument--**A deductive argument in which the conclusion follows logically from the premises, so if the premises are true, it is impossible for the conclusion to be false.
- **Weak (Inductive) Argument--**An inductive argument in which the truth of the premises only slightly increases the likelihood of the conclusion being true.

## EXERCISES: CLASSIFYING ARGUMENTS

Determine the conclusion of each of the following arguments. Then, classify each as (1) deductive-valid, (2) inductive-strong, or (3) inductive weak. Explain your reasoning. If you know something about the topic, you can also say whether they are sound (valid with true premises) or cogent (strong with true premises).

Answers to selected exercises can be found in the appendix.

1. The majority of people who have tried kale smoothies say that they are delicious. My friends, who are all very honest and have good taste, have all tried kale smoothies and said that they are delicious. Therefore, kale smoothies are probably delicious.
2. If you want to play soccer, then you need a soccer ball. I do want to play soccer, so I need a soccer ball.
3. Soccer players, like all athletes, put in a lot of hard work and dedication to perfect their craft. In my sample of professional soccer players I've observed that they all train rigorously and have a strong diet and exercise regimen. This evidence leads me to conclude that this is probably true for soccer players in the larger population as well.
4. If you want to be healthy, then you should eat a balanced diet and exercise regularly. I want to be healthy, so I should eat a balanced diet and exercise regularly.
5. In a sample of professional German soccer players I've observed that they are all extremely good looking. So, all German people are extremely good looking.
6. Chef Beatrice's pancakes are believed to be delicious by many culinary experts due to their fluffy texture and sweet flavor. Food bloggers, cookbook authors, and professional chefs all agree with this assessment of pancakes. Therefore it can be concluded that you will probably enjoy Chef Beatrice's pancakes.
7. I could only afford a Mitski album or a new case for my iPhone. Since I bought the Mitski album, I cannot buy the new case.
8. According to a recent study, those who eat a plant-based diet tend to have lower blood pressure and a lower risk of heart disease. Therefore, a plant-based diet is the best choice for maintaining good heart health.
9. We can either believe in science or religion. If we believe in science, then we must accept scientific evidence as truth. If we believe in religion, then we must accept faith as truth. Therefore, either we must accept scientific evidence as truth or accept faith as truth.
10. One of Freud's students said that Freudian psychology is the best approach to understanding human behavior. Therefore, Freudian psychology is absolutely true.
11. The equation for Ohm's Law is V=IR (Voltage equals Current times Resistance). Therefore, if the current in a circuit is 5 amps and the resistance is 10 ohms, then the voltage must be 50 volts.
12. It has been observed that Sylvia Plath's writing often focused on themes such as depression, mental illness, and death before her suicide in 1963. There is also a mechanism by which her experiences with depression could lead her to write about such topics in her writing. Therefore, it can be concluded that Sylvia Plath's depression was a cause of her writing focusing on these darker themes.
13. The iPhone I bought 5 years ago still hasn't broken down. Therefore, Apple products are likely to last forever.
14. A triangle is a three-sided shape with three angles that add up to 180 degrees By definition, anything that is a three-sided shape with three angles that add up to 180 degrees is a circle. Therefore, a triangle is a circle.
15. Apple products are known to be of high quality due to their commitment to innovation and excellent customer service. Many experts in the technology industry agree with this assessment of Apple's products, including tech reviewers and bloggers who are knowledgeable about the industry. Thus it can be concluded that Apple products are probably of high quality.
16. By definition, unicorns are mythical creatures with a single horn on their forehead. Mythical creatures do not exist in the real world. Therefore, unicorns do not exist in the real world.
17. Sylvia Plath wrote about depression before her suicide in 1963. Therefore, writing poetry causes people to commit suicide.
18. A car is a type of vehicle; by definition anything that is a vehicle has wheels; therefore a car has wheels
19. If you read Maya Angelou's work, then you will find inspiration. If you find inspiration, then you will be motivated to create something new. Therefore, if you read Maya Angelou's work, then you will be motivated to create something new.
20. No birds are mammals; all sparrows are birds; therefore no sparrows are mammals.
21. In BoJack Horseman, we have seen that BoJack often finds himself in destructive cycles of addiction and self-hatred. Based on this evidence, it is likely that BoJack will continue to struggle with these issues in the future.

22. If you want to be successful in your career, then you should work hard and be persistent. I want to be successful in my career, so I should work hard and be persistent.
23. The Earth is only 6 thousand years old or dinosaurs never existed. If the Earth is only 6 thousand years old, then humans and dinosaurs coexisted. If dinosaurs never existed, then fossil records are a hoax. Therefore, either humans and dinosaurs coexisted or fossil records are a hoax.
24. The equation for the slope of a line is m=(y2-y1)/(x2-x1) (Slope equals the change in y divided by the change in x). Therefore, if the y-coordinate of one point is 3 and the y-coordinate of another point is 5, and the x-coordinate of the first point is 2 and the x-coordinate of the second point is 4, then the slope must be 1.
25. If we want to combat climate change, then we need to reduce emissions. If we reduce emissions, then we can slow down the effects of global warming. Therefore, if we want to combat climate change, then we can slow down the effects of global warming.
26. You can either make pancakes from scratch or order them from a restaurant. If you make pancakes from scratch, then they'll be fresh and delicious. If you order them from a restaurant, then they'll be ready in no time. Therefore, either your pancakes will be fresh and delicious or they'll be ready in no time.
27. If the Pope is Catholic, then he will wear red robes. The Pope does not wear red robes. Therefore, the Pope is not Catholic.
28. The hypothesis that pancakes are made with a combination of flour, eggs, milk, butter, and sugar is the best explanation for why pancakes are fluffy and sweet when cooked correctly. This hypothesis is further supported by observations from other recipes which use similar ingredients to make similarly fluffy and sweet dishes. Thus it can be concluded that this hypothesis is probably true.
29. In my sample of successful entrepreneurs, I have observed that they all have strong communication skills and are able to effectively collaborate with others. This evidence leads me to conclude that strong communication skills and the ability to collaborate with others are necessary for success as an entrepreneur.
30. The equation for Newton's Second Law of Motion is F=MA (Force equals Mass times Acceleration). Therefore, if the goose's mass is 2kg and his acceleration is 10m/s2, then the force acting on him must be 20N (Newtons).
31. The universe was created by aliens or God. God did not create the universe. Therefore, aliens created the universe.
32. Pancake consumption has increased worldwide, just as violent crime has gone down. I think we can safely conclude that eating more pancakes make people less likely to commit crimes.
33. The hypothesis that Phoebe Bridgers uses poetic language to convey emotion in her songwriting is the best explanation for why many of her fans feel connected to her lyrics on an emotional level. This hypothesis is further supported by observations from other listeners who report feeling moved by Bridgers' music even before understanding the words being sung. Therefore, it can be concluded that this hypothesis is probably true.
34. By definition, a circle is a shape with no corners or edges. Shapes with corners or edges are called polygons. Therefore, circles are not polygons.

## Case Study: From Nursing to NBA Stardom - A Tale of Fantasy and Fallacy with Horatio P. Hightower

Horatio P. Hightower had been a nurse for the past four years, ever since he graduated from nursing school at the top of his class. He was dedicated to his job and had a strong sense of compassion for his patients which made him well-liked amongst them - even those who were more difficult to work with due to their age or condition. His supervisors were also impressed with Horatio's performance and praised him on several occasions for being one of their best nurses.

He was generally happy in life too; although he did still have moments when he wished that things could have worked out differently, such as when it came to basketball - as this had always been a passion of his that never quite reached fruition. Despite this though, Horatio enjoyed spending time with friends and family and going out on the weekends - usually playing basketball on local courts but occasionally going out dancing or seeing a movie too! All in all then, life was good for our young nurse until recent events began unfolding...

Horatio had recently gotten into an argument with one of his elderly patients over her refusal to take her medication as prescribed (and she'd died as a result), which left him feeling angry and frustrated - so fed up that he decided it was finally time for him to follow his dreams instead of staying stuck in this profession anymore! Not long after this incident, Horatio broke up his girlfriend, Gretchen. Gretchen had been coworker and friend of his for the last three years at the hospital, and they had finally started dating a few months ago. During this

time, Horatio became convinced that if he let himself fall in love with her then it would inevitably lead to marriage and children - which in turn would mean settling down and giving up on his dreams of becoming an NBA star, which would in turn leave him miserable. So, despite having strong feelings for Gretchen, Horatio chose to break things off with her before they went any further - reasoning that if he didn't go through with it now then that would be one less roadblock standing in the way of achieving his goal. With newfound conviction, he soon announced loudly to all who would listen that he was going to quit being a nurse and become an NBA star instead!

Friends and family tried their best (but mostly in vain) to talk sense into Horatio but no amount of logic or reason seemed able make any impact on his ambitions. It seemed like horizons were shifting out from under them like quicksand - each time they thought they'd gained some traction with their arguments, another wave would wash away all progress made before!

Horatio argued that because there were already professional athletes playing in leagues such as the NBA who didn't have college degrees or even high school diplomas, then why couldn't someone like him do the same? After all wasn't basketball supposed to be about talent rather than credentials? Besides which weren't there stories about other people having successful careers despite not having formal training or education? His friends countered by pointing out how rare these cases actually were compared to those who succeeded through hard work and dedication - something which Horatio hadn't done yet when it came down to basketball itself; nor did they believe that simply wishing upon shooting stars would turn you into one either! They also noted how most professional athletes are extremely disciplined both on and off the court while putting in countless hours honing their skills if they wanted any chance at making professional teams; something else that Horatio wasn't doing right now either since he only played casually with friends during weekends at local courts.

Despite being warned otherwise however, our Horatio remained convinced that if given a chance then surely he'd prove them wrong in the end! But as time passed, Horatio was becoming increasingly aware of how much he had left behind; the nursing profession, his life with Gretchen. He even started to wonder whether there might be a more realistic version of his dream - one that didn't require him to give up on all his hard work and dedication over the years. In this moment of reflection, Horatio is desperately seeking advice from others on what might be best for him moving forward - hopefully emerging wiser and better equipped with the answers he needs.

### QUESTIONS

1. What logical fallacies can you identify in Horatio's reasoning?
2. What advice would you give Horatio to help him reach his life goals in a more realistic way?
3. If you were Horatio's friend, what strategies would you use to get him to accept your advice? (Part of "arguing well" involves thinking about how your argument will be received!).

# CHAPTER 3: INTRODUCTION TO FALLACIES

In this chapter, we will be exploring the concept of fallacies and how they can impact our thinking and decision making. First, we will define fallacies and distinguish between formal and informal fallacies. You will learn about examples of formal fallacies such as circular reasoning and false dichotomy. We will also cover the fallacy of equivocation and discuss some related fallacies. Next, we will delve into fallacies of relevance and examine common examples such as appeal to force, appeal to pity, and ad hominem fallacies. You will learn how these types of fallacies can distract from the main argument and mislead the listener. We will also take a look at the life and work of Hannah Arendt, a influential philosopher who wrote about the dangers of fallacious thinking in political discourse. At the end of the chapter, there will be a series of exercises to help you practice identifying fallacies in real-world situations. By the end of this chapter, you will have a better understanding of the importance of critical thinking and the role that fallacies play in our everyday lives.

And now, to introduce us to fallacies—SpongeBob SquarePants, Patrick Star, and Squidward!

## SPONGEBOB AND PATRICK'S MAYORAL MISCONCEPTIONS

*Background:* The residents of Bikini Bottom had grown increasingly frustrated with the lack of leadership and guidance from their current mayor. They had had enough and determined it was time to elect a new one. So, they decided to hold a mayoral election. SpongeBob and Patrick, the two best friends and residents of Bikini Bottom, decided to run against each other for the position. Before the election, however, a series of strange and outrageous events began to unfold. First, Mr. Krabbs, the owner of the Krusty Krabb restaurant, was seen floating around town in a giant octopus-shaped hot air balloon in an attempt to promote his candidacy. When the balloon collapsed and threatened to strangle everyone, it was only through the efforts of Sandy, the local scientist, that the town was saved. These events only further convinced the citizens of Bikini Bottom that Sandy was the clear best candidate for mayor. However, SpongeBob and Patrick were still determined to win the election and argued amongst themselves about who should be the next mayor. Without SpongeBob and Patrick's votes, though, Mr Krabbs will win election against Sandy. Squidward, their neighbor, was fed up with the arguing and tried to mediate a resolution, but to no avail.

Patrick: I should be mayor of Bikini Bottom because I'm the best star(fish) for the job.

SpongeBob: No, I should be mayor because I'm the most qualified.

Squidward: That's circular reasoning! You're both just asserting that you should be mayor without proof.

Patrick: Well then, you'll have to decide between us. If I'm not the mayor, then the only choice is SpongeBob.

SpongeBob: Yeah, if it's not me then it has to be Patrick! At least one of us is going to be the mayor. Yeah!

Squidward: That's a false dilemma. I think can think of million other fish who would be better suited for the job, Sandy, Plankton, Gary, Mr. Krabs, and even me! It's not like I am forced to choose just between the two of you.

Patrick: No way! Consider this argument: If I am the mayor, then SpongeBob is not the mayor. And clearly, SpongeBob is not the mayor. So I should be the mayor!

Squidward: That's denying the antecedent! If SpongeBob is not the mayor, it does not necessarily follow that Patrick should be mayor. Haven't you two taken a logic class?

Patrick: Alright, then, how about this? If I am the mayor of Bikini Bottom, then I must live in Bikini Bottom. And clearly, I live in Bikini Bottom. So I should be mayor!

SpongeBob: Exactly! And if I'm the mayor, then everyone will be happy. And everyone is happy. So it must be me!

Squidward: You are both committing the fallacy of affirming the consequent! Just because something good happened doesn't mean that either of you caused it. Plus, you're equivocating when you say "everyone". Who exactly are you referring to? Do you mean the citizens of Bikini Bottom? Or all the fish in the ocean? And do

you really mean everyone, or a majority, or just you and Patrick? I certainly wouldn't be happy if either of you were the mayor.

Patrick: I'm the best choice for mayor because the choice of mayor is made by the citizens of Bikini Bottom. And since I am a citizen of Bikini Bottom, I get to decide who is mayor. I choose myself!

SpongeBob: However, if I'm the mayor, then Bikini Bottom will finally get to eat all of the Krabby patties it's so desperately been craving. I know that all of the people here love Krabby patties. From this, it naturally follows that the city as a whole loves Krabby patties, too. If I'm mayor, I'll feed the city, and not just the fish that live here.

Squidward: You're both committing the fallacy of division and composition! Just because a whole has a certain property doesn't mean that each part has that same property. Also, just because each part has a certain property doesn't mean that the whole must have that same property. Cities don't Krabby patties! Single starfish don't get to decide the outcome of elections. That's not how logic works!

SpongeBob: Patrick, how can someone as dim-witted as you hope to be mayor of Bikini Bottom, Patrick? You'll obviously just need me to do all of the thinking anyway!

Patrick: Well, SpongeBob, *I* was just wondering how someone as immature and emotional as you are could hope to be mayor. I'm the stable adult around here.

Squidward: That's a complex question fallacy! You both are asking complex questions that assume something is true and then use that assumption to make an (unfair) argument. This isn't how logic works.

Patrick: You know, SpongeBob, after taking about it, I'm not sure I want to be mayor any more. I've heard Sandy has amazing karate skills. I'm going to vote for her!

SpongeBob: That's a great idea. I heard she can make jellyfish fly. She's a great candidate.

Squidward: Sandy does have a degree in marine biology, experience running a business and knowledge of local politics. You should definitely vote for her.

### QUESTIONS

1. Choose 1 or 2 of SpongeBob's and Patrick's arguments, and put them in standard form.
2. Now, explain in as much detail as you can "what went wrong" with these arguments.
3. Can you think of any real life examples of the sorts of poor reasoning used in this dialogue?

## INTRODUCTION: WHAT ARE FALLACIES?

Fallacies are arguments that have something wrong with them besides having false premises. Fallacies can be deductively valid, inductively strong, or inductively weak. However, they can NEVER be deductively sound (valid with all true premises) or cogent (strong with all true premises). Fallacies can be subtle, and we should "know better" than to commit fallacies. In order to understand why fallacies are bad, it is important to consider the consequences of committing a fallacy.

First, fallacies can cause us to have false beliefs. For example, someone may commit the fallacy of confirmation bias when deciding whether vaccines are linked to autism. This person may only look for evidence that confirms their belief (e.g., stories from other parents claiming their child developed autism after receiving a vaccine) and ignore evidence that does not support their belief (e.g., scientific studies demonstrating that there is no link between vaccines and autism). As a result, this person will continue to hold on to an inaccurate belief about the relationship between vaccines and autism.

Second, fallacies can cause us to make bad life decisions. For example, someone who commits the gambler's fallacy may believe that if they keep playing slot machines they will eventually hit the jackpot and become rich; however, this is not true as slot machines are designed in such a way that each spin is independent of all others. Similarly, someone who falls victim to the sunk cost fallacy may continue investing money into an endeavor even though it has already proven unsuccessful because they feel like they already invested so much into it already that it would be a waste not to keep going. Both of these decisions could potentially end up costing someone more

money than what they initially intended due to their commitment of logical fallacies rather than rational decision making processes.

Third, fallacies can cause us to treat others badly by leading us down an incorrect path of thinking. For example, someone who commits the hasty generalization fallacy may assume that all members of a certain group are similar when this is not necessarily true; this type of behavior can lead one down the path of stereotyping and bias which can be detrimental both personally and professionally if one treats people differently based on perceived characteristics or qualities instead of actual ones.

## Formal Vs Informal Fallacies

**Formal fallacies** are invalid deductive arguments. As you'll recall, in a good (valid) deductive argument, it should be impossible for the conclusion to be false while the premises are true. A formal fallacy "looks like" a valid inductive argument, but it is not. In these fallacies, it IS possible to have the premises be true and the conclusion false. One example of a formal fallacy is **affirming the consequent**, which occurs when someone makes an argument such as **"If A then B. B. Therefore A." For** example, someone may argue that if a person commits a crime then they will be arrested; this does not mean that all arrested people committed crimes because there could have been other factors at play in their arrest (e.g., false accusation).

Another example of a formal fallacy is **denying the antecedent** which occurs when someone makes an argument such as "If A then B. Not A. Therefore not B." For example, someone may argue that if a certain political party is elected into power then taxes will increase; this does not mean that taxes will not increase if another party is elected because there could be other factors at play in how taxes are determined (e.g., economic conditions).

Formal fallacies can be detected by considering only the "form" of the argument--i.e., I don't need to know anything about the content in order to see that they are fallacious. By contrast, informal fallacies can be detected by examining the content rather than examining whether or not it follows logical rules of deduction like with formal fallacies. Some examples of informal fallacies include circular reasoning, false dichotomy and equivocation, among others. We'll devote the rest of this chapter (and the next) to the examination of these sorts of fallacies.

## Circular Reasoning ("Begging the Question")

Circular reasoning is a type of logical fallacy in which a proposition is supported by the premises, which in turn is supported by the proposition, creating a circle in reasoning where no useful information is being shared. It has the form:

- Premise 1: X is true because of Y.
- Premise 2: Y is true because of X.
- Conclusion: X and Y are both true

In religion, circular reasoning is often used to bolster a belief system without providing any real support. For example, a religious leader might say, "God exists because the Bible says so, and the Bible is the word of God, so of course God exists." This type of reasoning does not prove the existence of God (or the truth of the Bible), but instead creates a circular argument that doesn't provide any new information.

In politics, circular reasoning can often be used to create a false sense of certainty as to correctness of one's own beliefs and ideas, and the wrongness of one's opponents. For example, a politician might say, "We need to pass this law because it will help the economy, and it will help the economy because we passed this law." This type of reasoning does not offer any concrete proof that the law will help the economy, but instead relies on the premise that it will.

It important to note that there are also "virtuous circles" in which two factors genuinely DO help explain each other. For example, someone might say, "I love you because you make me feel special, and you make me feel special because I love you." This isn't necessarily a fallacy (and in fact, it looks more like a casual explanation than an argument). That being said, people can and do engage in flawed reasoning related to love and romance.

The best way to avoid circular reasoning is to make sure that each premise is supported by evidence and facts. For example, if you are a religious person, rather than saying "God exists because the Bible says so," it would be

more effective to provide evidence from outside of the Bible that supports the belief. Similarly, rather than saying "We need to pass this law because it will help the economy," it would be more effective to provide evidence that shows how the law will actually help the economy.

### False Dichotomy

False Dichotomy is a logical fallacy in which only two choices are presented, yet more exist or a spectrum of possible choices exists between the two extremes. This fallacy is commonly expressed in the form of "either this or that" language, and can be characterized by the omission of choices. It has the form:

- Premise 1 (False): Either X or Y.
- Premise 2: Not Y.
- Conclusion: X

In terms of investing, false dichotomy can occur when an investor is presented with two options for a stock investment and is told that either one will yield a large return. For example, an investor may be told that they should invest in either stock A or stock B, and that one of them will be a surefire winner. However, what is not stated is that stock C could also be a viable option, and that there is a range of potential outcomes for each of the three stocks. One might also choose to invest in a combination of the three stocks. This omission of choices is a prime example of false dichotomy.

In terms of health, false dichotomy can occur when two extreme diets are presented as the only viable options to lose weight. For example, an individual may be told that they should either go on a low-carb or a low-fat diet in order to lose weight. However, the individual may not be informed that there are a variety of diets that can be followed to reach a healthy weight, such as a balanced diet with moderate amounts of carbs and fat.

The best way to avoid false dichotomies is to carefully consider all possible options when making decisions. It is important to do research and consider multiple perspectives in order to make an informed decision. Additionally, it is important to be aware of potential omissions of choices and ask questions to ensure that all viable options are taken into account. By doing so, it is possible to avoid the logical fallacy of false dichotomy.

### Fallacy of Equivocation

The fallacy of equivocation occurs when a key term or phrase in an argument is used in an ambiguous way, with one meaning in one portion of the argument and then another meaning in another portion of the argument. This kind of fallacy can be difficult to detect, as it often relies on subtly different meanings for words or phrases that may appear identical but carry different implications. In order to demonstrate the fallacy of equivocation, we must first identify which word or phrase is being used ambiguously and then show how this ambiguity undermines the logical validity of the argument.

For example, consider a debate about abortion. One side may argue that abortion should be illegal because "killing babies is wrong." However, this statement implies two different meanings for the word "babies": either unborn fetuses (their "meaning") or already-born children (what their opponents would agree to). If only one meaning is intended (e.g., unborn fetuses) but the other meaning is implied (e.g., already-born children), then this statement commits the fallacy of equivocation by using two distinct definitions for a single term. To avoid this fallacy, one meaning must be settled on at the beginning.

Another example can be found in debates about gun control. One side may argue that "guns kill people," implying that guns themselves are responsible for death and injury due to their own agency. They conclude that guns should be banned. However, this statement could also imply that people use guns to kill other people; thus, it commits the fallacy of equivocation by using two distinct definitions for a single term ("guns"). In order for this argument to be cogent, the premise must be phrased in a clear unambiguous matter that allow that who disagree with it to do so.

To avoid committing the fallacy of equivocation, one must be careful to use words and phrases consistently throughout an argument. One should also be aware of any potential double meanings for key terms and make sure to clarify which meaning is being used. Finally, one should verify that both sides agree on the definitions being used for all key terms in the argument before proceeding with the discussion.

## Related Fallacies

The fallacies of false dichotomy and circular reasoning are sometimes called "fallacies of presumption", because they "presume" that a disputed premise is true without providing independent evidence for it. The fallacy of equivocation meanwhile, is a "semantic" fallacy that revolves around the meanings of different words. Some other fallacies related to these include:

**Accident.** The fallacy of accident occurs when a true general principle is applied to an atypical case. For example, it is generally accepted that people need around 7 or 8 hours of sleep sleep in order to stay healthy and alert. However, some people need considerably less or more than this. For example, some "short sleepers" need only 5 or 6 hours or sleep. If we knew that a person was a short sleeper, and tried to apply this rule to them ("you need to stay in bed longer!"), this would be a fallacy of accident.

**Complex Question.** The fallacy of complex question involves asking a question that presumes its own conclusion by including it implicitly in the statement. For example, imagine someone asked another person "Have you stopped skipping classes yet?" This type of question implies that the person being asked has been skipping classes in the past and therefore commits the complex question fallacy as it assumes guilt without any real evidence or proof.

**Fallacy of composition / Fallacy of division.** The fallacies of composition and division both involve assumptions about the properties of a whole based on the properties of its parts. The fallacy of composition assumes that if each individual part has a certain property, then all taken together will have this same property. For example, "Each person on the elevator weighs less than maximum weight limit, so their combined weight must also be less than the maximum weight limit." The fallacy of division occurs when one assumes that if a group or collection as a whole has certain properties, then each individual part must also have these same properties. For example, saying "This painting is worth $10,000 dollars, and it has around 1000 brushstrokes, so each brushstroke must therefore be worth $10" commits the fallacy of division by assuming that because the painting as a whole is worth $10,000 dollars each individual brushstroke within it would be worth $10.

## Example: Fallacies in Romeo and Juliet

Here's an example of how fallacies might look in particular context (in this case, Shakespeare's *Romeo and Juliet):*

| | |
|---|---|
| **All Capulets are enemies of the Montagues. Some enemies of the Montagues are pirates. So, some Capulets are pirates.** | **This is a formal fallacy (the fallacy of undistributed middle). It is a deductive argument, but isn't valid, since the conclusion doesn't *necessarily* follow from the premises.** |
| **Juliet, you obviously should not marry Romeo, because both your father and I disagree. I'm sure you'll agree that parents always know better than children about things like this.** | While this argument would need to be spelled out a little, it looks like it is an instance of begging the question (an informal fallacy). After all, why should Juliet accept the premise about parents always being right? |
| **If someone insults your honor, there only two choices: challenge them to a duel, or live forever in shame. Since Mercutio insulted your honor, you don't want to live forever in shame, you should definitely challenge him to a duel.** | This is a false dichotomy, since it assumes there are only two options—duel or live forever in shame. (In real life false dilemmas, the person making the argument often "feels" these are the only two choices, even though the evidence doesn't support this). |
| **Romeo's friends would be happy if he married Rosaline. His friends would also be happy if he married Juliet. So, his friends would be even happier if he married BOTH Rosaline and Juliet.** | This commits the fallacy of composition (obviously, the friends would not suddenly become twice as happy if Romeo secretly had two marriages, and two wives). |
| **If Juliet got an A in logic class, then Shakespeare wrote *Romeo and Juliet.*** | This is a conditional statement, and not an argument at all! It is also guaranteed to be a TRUE conditional statement, since we know that the consequent is true (since |

| | |
|---|---|
| | Shakespeare really did write R and J). This means the whole statment would be true REGARDLESS of what the antecedent was ("If Juliet got a D…", "If she never took logic class..,"). |
| **All Venetians are Italians. All Italians are Europeans. So, all Venetians are Europeans.** | This is NOT a fallacy. |
| **It is impossible for Juliet to confess her love to Romeo using any single word. So, it is impossible for Juliet to confess her love to Romeo using any combination of words.** | This is an informal fallacy concerning wholes (sentences, paragraphs) and their parts (words). It looks like a fallacy of composition, since the premises concern parts and the conclusions concerns the whole. |
| **Since you don't like Shakespeare, you clearly have bad taste in literature.** | This begs the question, since the implicit premise ("Everyone with a good taste in literature likes Shakespeare") would be unacceptable to anyone to whom this argument was addressed. |
| **Romeo just compared Juliet to the sun. He obviously thinks she is made of very hot gas, just like the real sun.** | OK, so this is a bit ridiculous, but it is an example of amphiboly (an informal fallacy). More seriously, though, amphiboly often happens when someone tries to make an analogy, and people respond by misinterpreting this analogy in uncharitable ways. |
| **If Juliet marries Romeo, she doesn't marry Paris. Juliet doesn't marry Paris, so she must marry Romeo.** | Even though the conclusion here is true (Juliet does marry Romeo in the play), this commits a formal fallacy, since it uses an invalid form of deductive reasoning (affirming the consequent). |
| **Why do English teachers like to torture their students by making them read Shakespeare?** | This is an example of a complex questions, since it assumes that English teachers do, in fact, like to torture their students. |

### QUESTIONS

1. How common is fallacious reasoning? Can you give some examples of fallacious reasoning (of the type described above) that you've seen others commit?
2. Which fallacies discussed above do you think that YOU are most prone to commit? Why do you think this is?
3. Why do you think that we (as humans) are so prone to fallacious reasoning? What could we do to improve on this?
4. Write a mock "social media post" explaining what circular reasoning is and giving examples of it.
5. Write a short dialogue between two people in which (at least) one of people commits a fallacy, and the other person attempts to convince them their reasoning doesn't work.

## MINDS THAT MATTERED: HANNAH ARENDT

*"In an ever-changing, incomprehensible world the masses had reached the point where they would, at the same time, believe everything and nothing, think that everything was possible and that nothing was true. ... Mass propaganda discovered that its audience was ready at all times to believe the worst, no matter how absurd, and did not particularly object to being deceived because it held every statement to be a lie anyhow. The totalitarian mass leaders based their propaganda on the correct psychological assumption that, under such conditions, one could make people believe the most fantastic statements one day, and trust that if the next day they were given irrefutable proof of their falsehood, they would take refuge in cynicism; instead of deserting the leaders who had lied to them, they would protest that they had known all along that the statement was a lie and would admire the leaders for their superior tactical cleverness." (Hannah Arendt – The Origins of Totalitarianism)*

Hannah Arendt was a German-born political theorist and philosopher who made significant contributions to informal logic and the analysis of how certain flawed ways of reasoning can lead to totalitarianism. She was born on October 14, 1906 in Hanover, Germany to a Jewish family. Arendt studied at the University of Marburg,

where she received her doctorate in philosophy in 1929. Arendt was heavily influenced by her teacher Martin Heidegger, who she had a romantic relationship with until he joined the Nazi party in 1933. After this, Arendt left Germany and moved to Paris, where she stayed until 1941 when she moved to New York City.

In New York City, Arendt taught at several universities and wrote extensively on politics, history, and philosophy. Her most famous work, The Origins of Totalitarianism (1951), she argues that totalitarianism is a product of two intertwined forces: imperialism and racism. Arendt argues that imperialism is a result of the rise of nation-states (and of popular "nationalism") in the 19th century, which saw an increase in power struggles between states. This created an environment where countries felt the need to constantly expand their territory in order to remain competitive. This imperial expansion often led to war and conflict, which provided the perfect environment for totalitarian regimes to arise. Arendt also argued that racism was a key factor in creating a climate ripe for totalitarianism. She argued that racism was used as a tool by oppressive regimes to control and oppress populations. It was used to divide people into groups and create an us vs them mentality, which ultimately allowed totalitarian regimes to gain control over large populations.

Some of Arendt's other works include the following:

- In The Human Condition (1958), Arendt examines the concept of "the human condition" and how it has been shaped by modern society. She looks at the three traditional activities of human beings: labor, work, and action. Arendt argues that the modern age has devalued labor and work in favor of consumerism and leisure, thus causing a crisis in our understanding of what it means to be human. She examines how this crisis has led to a decline in meaningful political participation and a rise in alienation.
- In On Revolution (1963), Arendt argues that revolutions can bring about real change but only if they are carried out with an eye towards preserving freedom while still allowing for progress. She believes that real change can only be achieved when people are willing to actively participate in the process of creating a better society and thinking about what this means.
- In Eichmann in Jerusalem (1963), Arendt examines the trial of Adolf Eichmann, one of the architects of the Holocaust. She argues that Eichmann was not an evil man, but rather a thoughtless bureaucrat who was following orders without taking into consideration the consequences of his actions. Arendt further argues that Eichmann was able to commit such horrific acts because he was not thinking for himself; instead, he was merely following orders from his superiors without any regard for morality or ethics.
- Finally, in The Life of the Mind (1978), Arendt examines what it means to think and reflect on one's life and actions. She argues that thinking is an essential part of being human and that it allows us to understand ourselves better, as well as our place in the world around us. Thinking also allows us to make decisions based on reason and logic rather than simply following orders or conforming to societal norms.

One controversial aspect of Arendt's life was her relationship with Heidegger, who was a renowned philosopher and an influential mentor of Arendt's. The two had a romantic relationship throughout the 1920s. However, in 1933 Heidegger joined the Nazi party, while Arendt moved to Paris and eventually America, where she remained critical of the Nazis. This prompted criticism of both individuals; some have argued that Arendt should have been more critical of her former lover's support of the Nazi regime, while others have argued that Heidegger's repugnant political views should cause us to reexamine his philosophy more generally. The controversy has also attracted criticism because of Arendt's later attempts to downplay the Nazi connections of her mentor.

Arendt died on December 4th 1975 at the age of 69. In her lifetime she made significant contributions to informal logic and the analysis of how certain flawed ways of reasoning can lead to totalitarianism. Her influence is still seen today in political science courses around the world as well as in popular culture through quotes from her various works.

## QUESTIONS

1. How does Arendt's analysis of imperialism and racism continue to be relevant today?
2. How does Arendt's concept of the "human condition" provide insight into modern society?
3. What can we learn from Arendt's writings on revolutions and political participation?
4. How might Arendt's experience with Martin Heidegger have influenced her later writings on totalitarianism?
5. What challenges do we face in trying to use reason and logic to make decisions in our lives?

## Fallacies of Relevance

**Fallacies of relevance** are informal fallacies that occur when the premises of an argument are *logically irrelevant* to the conclusion. These fallacies often occur when we do the following things:

1. Ignore logically relevant evidence because (a) it disagrees with conclusions to which we are emotionally committed or (b) we have negative feelings about the evidence source.
2. Give too much weight to logically irrelevant evidence because (a) it agrees with conclusions to which we are emotionally committed or (b) we have positive feelings about the evidence source.

People rarely admit (even to themselves) when they are committing a fallacy of relevance, since many of these arguments are obviously bad ways of reasoning. However, this does not mean these fallacies are impossible to detect or avoid—it's simply a matter of asking yourself why you really believe something, and then considering whether this is actually a good reason. As is the case with all fallacies, the fact that someone has a committed a fallacy of relevance does not necessarily mean that his or her beliefs are false (though it does mean he or she doesn't have any good reason to think their beliefs are true.).

In this section, you'll learn to identify some of the most prevalent of these fallacies, including the appeal to force, appeal to pity, appeal to the people, ad hominem, and straw man.

### Appeal to Force and Appeal to Pity

The appeal to force and an appeal to pity are two fallacies which can be used to try to convince another person of a claim. An appeal to force is an argument which states that if you do not accept a certain conclusion, then you will suffer some kind of physical or emotional harm. For example, someone might say that "if you don't agree with me, then I will get angry and beat you up." Such an argument does not prove the truth of the conclusion; rather, it only implies that the person should accept it out of fear or intimidation. The appeal to force has the form:

**Appeal to Force:**

- Premise: You (or someone else) will be harmed if you don't believe C.
- Conclusion: C is true.

An appeal to pity is an argument which attempts to convince another person by appealing to their emotions or sympathy. This type of fallacy uses emotionally charged language or descriptions of suffering in order to make the audience feel sorry for the person making the claim. For example, someone might say "please believe that I would make an excellent nurse, because I am poor and have no family" as a way of trying to get someone else to agree with them. Again, this type of argument does not prove the truth of the conclusion; rather, it only implies that the person should accept it out of compassion or goodwill. It has the form:

**Appeal to Pity:**

- Premise: Believing C will help a person or group worthy of my pity.
- Conclusion: C is true

Both appeals to force and appeals to pity are fallacies because they rely on emotion rather than reason in order to prove a point. They are also both forms of manipulation, as they attempt to coerce another person into accepting a certain conclusion without actually providing evidence for why that conclusion is true. As such, any arguments based on appeals to force or appeals to pity need to be expanded to include actual evidence for the conclusion that is being defended.

Some examples include.

- Appeal to Force: "If you don't accept this religious doctrine, then you will be punished in the afterlife."
- Appeal to Force: "Since you didn't immediately agree with my poorly planned business strategy and tell me that I am a genius, I'm going to have to fire you."
- Appeal to Pity: "I'm so lonely and I really need your love, so please go out with me."

- Appeal to Pity: "My cousin has had a rough life. So, I'm just going to assume that he's telling the truth when he says he had nothing to do with the crime with which he has been charged, and that all the witnesses are lying."

### Appeal to the People

The appeal to the people fallacy is a type of faulty reasoning that involves trying to persuade someone by appealing to the beliefs, values, or opinions of the majority of people, rather than making an argument based on facts or evidence. This fallacy assumes that if most people believe something, then it must be true. However, this assumption is not necessarily valid because there may be other factors influencing the beliefs of the majority such as cultural influences, social pressure, and ignorance. So, for example, despite the fact that many people believed (and still believe) that diseases were caused by supernatural forces, scientific experts over time have proven that diseases are actually caused by microorganisms and other external factors. Similarly, most people believed that the Earth was at the center of the universe, but scientific experts have since proven that this is not true. The general form of the appeal to people fallacy is:

- Premise: Some group of people (the majority, the cool kids, your family) believe C.
- (Suppressed) Premise: These people don't have special expertise.
- Conclusion: C is probably true.

There are a few different versions of the appeal to the people fallacy:

- **Bandwagon:** This variety involves directly asking someone to accept a certain belief or opinion because it is what most people believe. For example, a person might argue that "You should believe in God because that's what most people do."
- **Appeal to vanity:** This version of the fallacy appeals to someone's vanity or ego by suggesting that belief in something will make them look better than other people. For example, a person might start an argument with the premise "If you choose to buy that cheap generic phone (rather this fancy new one I think you should get), you won't be seen as smart or sophisticated."
- **Appeal to snobbery:** This type of appeal involves trying to persuade someone by suggesting that believing in something will make them part of an elite group or club. For example, a person might argue "If you buy cryptocurrency rather than boring mutual funds, you will be part of an exclusive and sophisticated group of people who understand finance."

The appeal to people can cause us to make poor personal decisions. Perhaps even more worrisome, it can cause us to mistreat others. For example:

> Hank is a high school student who falls prey to the appeal to people fallacy. His friends, who are all popular, believe that it's okay to make fun of classmates who are developmentally disabled. Hank goes along with them because he wants to fit in, even though deep down he knows that what they are doing is wrong.
>
> Sarah is an adult who falls prey to the appeal to people fallacy when she hears her coworkers making racist jokes about a colleague from a different ethnic background. Even though Sarah doesn't agree with their beliefs, she doesn't speak up against them because she fears being ostracized by her peers if she does.
>
> Theo is a politician who falls prey to the appeal to people fallacy when he promises to implement policies that will he knows will be very harmful to certain group G, all in order to win votes from a segment of voters who really hate group G. Despite knowing that those policies won't actually solve the underlying issues, Tom goes ahead and implements them in order to gain more political support.

In order to avoid committing this fallacy, it is important to focus on facts and evidence instead of opinions and beliefs when making an argument. It is also important to consider alternative explanations for why most people may believe something, such as cultural influences or social pressure. Finally, it is important to remember that just because most people believe something does not necessarily mean that it is true.

### Ad Hominem Fallacy

Ad hominem fallacy occurs when someone attempts to discredit another person's argument by attacking the individual making the argument, rather than addressing the merits of their argument. For example, in a discussion about immigration policy, a person might say that another person's opinion is wrong because they are from a particular race or ethnicity. This is an example of an ad hominem fallacy because it does not address the actual issue at hand and instead attacks the individual making the argument. The general fallacy has the form:

- Premise: The person arguing in favor of C is a "bad" person.
- Conclusion: So, C is false.

This sort of fallacy occurs frequently in political discourse. For example:

> Example (Ad hominem - Abusive). Senator Smith is proposing a new bill that would cut funding for public education. His opponent, Senator Jones, argues against the bill saying it will have a negative effect on students and families. In response, Senator Smith says "Senator Jones' opinion is wrong because she comes from a wealthy family and doesn't understand the struggles of everyday people."

Another, more subtle version of the ad hominem fallacy is the "circumstantial" version, which has the form:

- Premise: The person arguing in favor of C would personally benefit if C were believed.
- Conclusion: So, C is false.

This version of the ad hominem fallacy occurs when someone attempts to discredit another person's argument by suggesting that the individual making the argument has a personal interest in seeing it accepted. For example, if a scientist proposes a new medical theory and someone else argues against it because the scientist stands to benefit from its acceptance (for example, by getting promoted at their job, or becoming famous within their field), this is an example of the circumstantial ad hominem fallacy.

> Example (Ad hominem - Circumstantial): Ella is arguing that her family should go on vacation to Italy this summer. Her husband, Miguel, argues against it on the grounds that the flight is too long and Italy is hot during the summer. He suggests going to Maine instead. In response, Ella says "Miguel obviously just wants to save money, and doesn't really care about having a fun family vacation"

A final version of the ad hominem is the Tu quoque ("you too") version. This has the form:

- Premise: The person arguing in favor of C is a hypocrite who does not really believe that C.
- Conclusion: C is false.

The Tu quoque ad hominem fallacy occurs when someone attempts to discredit another person's argument by pointing out that they do not follow the same standards they are arguing for. For example, if someone is arguing in favor of exercising regularly, but is not themselves in good physical shape, this would be an example of a tu quoque fallacy.

> Example (Ad hominem - Tu quoque): Kateri is arguing that people should save money and invest it wisely. Her friend, Raul, responds by saying "You don't even have a savings account! You can't talk about financial responsibility when you don't even practice what you preach."

The ad hominem fallacy is caused by our unwillingness to consider the merits of an argument without considering the personal characteristics of the person making it, a tendency towards overconfidence in one's own opinion, an inclination to view people with different opinions as inferior or wrong, and an unwillingness to admit when one is wrong. To avoid committing the ad hominem fallacy, it is important to focus on the facts and arguments presented rather than attacking someone's character or motivations. Additionally, it is important to remain open-minded and willing to listen to opposing points of view without being dismissive or judgmental.

In contrast to the ad hominem fallacy, there are many (perfectly good) arguments concerning the character of people. For example: "Jimmy lies constantly. So, I'm not going to believe the next one of his stories" might be a perfectly good argument, as would "Jenny has repeatedly been arrested for drunk driving. So, I don't think she should be employed as a school bus driver, and maybe she ought to go to jail." The ad hominem fallacy only

occurs when a person has given you an *argument,* and you decide to ignore the argument for reasons that have to do with the person's *character.*

## Other Fallacies of Relevance

Other fallacies of relevance include the straw man fallacy, the red herring fallacy, and the fallacy of "missing the point."

**Straw Man Fallacy:** This fallacy occurs when a person sets up a false version of someone else's argument, usually by exaggerating or oversimplifying the argument. For example, if Anya argues that playing sports is beneficial for children's health, and Jon responds by claiming the Anya has said that "children never get hurt playing sports" and that Anya is, therefore, wrong, he is committing a straw man fallacy as this was not the original argument.

**Red Herring Fallacy:** This fallacy occurs when someone introduces irrelevant information in order to distract from the main topic of discussion. For example, if Sansa argues that playing video games can help with problem-solving skills and Tyrion responds by talking about the dangers of addiction to video games, he is committing a red herring fallacy.

**Fallacy of "Missing the Point":** This fallacy occurs when someone fails to address the main point of an argument. For example, if Brandon argues that studying hard in school can lead to better grades and Catelyn responds by talking about how boring the teacher is, she is missing the point of the original argument.

The human tendency to fall for these fallacies is largely due to confirmation bias. This is the tendency to seek out information that confirms our existing beliefs while ignoring evidence that contradicts them. As a result, we may be more likely to accept arguments that support our beliefs and easily dismiss arguments that challenge them. In order to avoid falling for these fallacies, it is important to be aware of the potential for confirmation bias and make an effort to consider new information objectively. It can also help to take the time to fully understand the opposing argument before responding, as this will help ensure that one is not misinterpreting or misrepresenting the other's position. Finally, it can be helpful to think critically about the evidence being presented and look for any logical flaws in the argument.

## Example: Fallacies in the Godfather

To give you some more concrete examples of what fallacies "look" like, here are some examples from "the Godfather":

| **Passage** | **Analysis** |
|---|---|
| "When Don Corleone first told me that I should cast his godson in my movie, I thought this would be a terrible idea, since I've always thought his godson is a really bad actor. However, then he chopped off my prize horse's head, and left the bloody head in bed with me as a warning. Now, I've changed my mind—the godson is obviously a great actor!" | Appeal to Force—the person changes their mind because of a threat. Note that it is NOT a fallacy to "do what the godfather says" in order to preserve your life. The fallacy occurs only when you begin to *believe* whatever it is that the person threatening you wants you to believe. |
| "I really like my godson, and I know not getting that movie part really upset him. Without a doubt, he has been mistreated by the casting agency." | Appeal to Pity. It's crucially important to remember that *liking* someone, or *feeling sorry* for them, doesn't necessarily mean their arguments are correct. In order to determine whether the conclusion is true, we would need to actually find out what happened during the audition. |
| "Members of the mafia are everything I want to be—rich, powerful, respected, and feared. And they clearly think it is occasionally OK to murder people. So, occasionally murdering people really is OK." | Appeal to the People. This argument confuses two very different things—a moral conclusion about whether murdering people is OK with premises about how one wants others to see you. |
| "My grandma always said that God helps those who helps themselves. And I clearly helped myself by importing large amounts of heroin and selling it. So, grandma (and God) would approve of my doing this." | Accident. This involves the misapplication of a general rule/idea (basically, that one should work hard, or something like that) to a situation that it is quite obviously not applicable to. |

| | |
|---|---|
| "Tom just told me that it's probably not the best idea for me to immediately shoot anyone who annoys me. Obviously, Tom thinks I should just passively accept whatever horrible things people do to me. But this is a recipe for disaster! So, I'm going to keep shooting people." | This looks like a strawman fallacy (and also a bit like a false dilemma, which we'll be studying later). It's almost certain that Tom isn't really saying what the speaker says that he said, and that his real argument is a bit more nuanced. |
| "Marlon Brando made a number of anti-Semitic comments over his life. So, I think we can dismiss any argument about his performance in the Godfather being 'great.'" | This is a variant of Ad hominem. It's important to note here that one CAN make arguments about people's character, and draw conclusions from it (e.g., "we ought not allow this person to receive big awards, or put them in future movies, etc."). However, the argument needs to spell out the logical connection between the character flaw and the conclusion being drawn. |
| "What do you mean you think the *Godfather* is too violent for your taste? After all, many of the events that happened it are based on real life, and Italian organized crime is actually still quite powerful. I think you'd find the history of the subject really fascinating…" | Red Herring. None of the claims being offered here actually address what seems to be the actual point of contention (e.g., whether the film is too violent). |

### QUESTIONS

1. Can you think of any "real-world" examples of the fallacies of relevance discussed in this section?
2. Which fallacy of relevance, if any, do you think that you are most prone to commit? Why do you think this is?
3. Take a position on a controversial issue like gun control or the death penalty. Come up with a list of 3-5 arguments in favor of your position and then come up with 3-5 counterarguments that someone against your position might use. For each argument, identify the type of fallacy they are using (if any).
4. Write a short story or skit centered around someone trying to convince another person to their point of view (e.g. one character trying to convince another to go out on a date with them). Have the characters use examples of fallacies as they try to make their point.
5. Write a dialogue between two people debating an issue (e.g. tax reform). Have one person make an argument in favor of their point of view and have the other person use fallacies in their counterargument.

## KEY CONCEPTS

- **Accident (fallacy of)--**A type of informal fallacy in which a general rule is applied in a specific case where it doesn't necessarily apply.
- **Ad Hominem--**A type of informal fallacy in which an argument is attacked on the character or personal traits of the opponent rather than the substance of their argument.
- **Appeal to force--**A type of informal fallacy in which an argument is made by threatening or coercing the opponent rather than providing evidence or reasoning.
- **Appeal to pity--**A type of informal fallacy in which an argument is made by attempting to evoke pity or sympathy from the opponent rather than providing evidence or reasoning.
- **Appeal to the people--**A type of informal fallacy in which an argument is made by appealing to popular sentiment or the opinions of the majority rather than providing evidence or reasoning.
- **Circular Reasoning--**A type of informal fallacy in which the conclusion of an argument is already assumed in the premise, so that the argument fails to provide any new evidence or support for the conclusion.
- **Complex question--**A type of informal fallacy in which a question is asked that assumes something that has not been proven or that begs the question (assumes the truth of the conclusion being asked).
- **Composition (fallacy of)--**A type of informal fallacy in which the characteristics or attributes of the parts of a whole are assumed to apply to the whole itself.

- **Division (fallacy of)--**A type of informal fallacy in which the characteristics or attributes of a whole are assumed to apply to its parts.
- **Equivocation (fallacy of)--**A type of informal fallacy in which a word or phrase is used with two different meanings in the same argument, leading to a confusion or ambiguity.
- **Fallacy—**An avoidable error in reasoning, or an argument that has something wrong with it besides being based on false premises. Fallacies can be either formal (involving a violation of the rules of a logical system) or informal (arising from the content of an argument rather than the structure).
- **False Dichotomy--**A type of informal fallacy in which two options are presented as the only possible alternatives, when in fact there may be other options or a spectrum of possibilities.
- **Formal Fallacy--**An error in reasoning that arises from a violation of the rules of a logical system. These are deductive, invalid arguments.
- **Informal Fallacy--**An error in reasoning that arises from the content of an argument rather than the structure, and that typically involves a failure to provide adequate evidence for a conclusion or the use of misleading or irrelevant evidence.
- **Missing the Point--**A type of informal fallacy in which an argument fails to address or adequately address the issue at hand.
- **Red Herring--**A type of informal fallacy in which an irrelevant or unrelated topic is introduced in order to distract or mislead the opponent.
- **Straw Man--**A type of informal fallacy in which an opponent's argument is misrepresented or distorted in order to make it easier to attack.

## Exercises: Identifying Fallacies

Identify the fallacy committed by each of the following arguments, if any. Explain your reasoning. If you can, suggest a way that the argument might be made better (this might involve changing the conclusion!). If you think an argument isn't a fallacy, explain why.

Answers to selected exercises can be found in the appendix.

1. Charles Darwin is well-known for his Theory of Evolution, yet his views on human evolution were deeply flawed due to his own personal privilege; for example, he dismissed the concept of racial equality, claiming that certain ethnic groups were 'inferior' to Europeans. The competing theory that humans were designed by God has none of these problems.
2. Rapunzel's hair is strong enough for Mother Gothel to climb up. Therefore, each individual strand of her must be able to bear Mother Gothel's full weight.
3. I know you've heard all about my recent arrests for larceny, assault, and (most recently) trying to bribe a police office to let me out of jail. The detailed photo and DNA evidence will probably send me to prison. It's really been a rough go for me! As my friend, all I am asking is that you believe in my innocence and that you give me $100,000 in bail. You can trust me.
4. Would Professor Ratigan like to admit that his terrible, evil, and stupid plot for taking control of London was wrong?
5. Either Gaston will marry Belle or she will end up with no one at all—there can be no other outcome!
6. If you don't help me falsify these financial documents, I will spread lies about your character and make sure that no one ever hires you again.
7. If Dr. Claw's evil plan succeeded, then he will still be unsatisfied with life. He is deeply unsatisfied with his life, so his evil plan must have succeeded.
8. John Locke argued that all people are born with natural rights, including the right to life, liberty, and property. However, his views on these rights have been challenged due to his personal investments in slave-trading companies; therefore, his ideas about natural rights should be disregarded as hypocritical.
9. Megamind's mission has always been to conquer Metro City; therefore, when Megamind says that his latest scheme is to save Metro City from destruction, it doesn't mean anything else but conquering it in a different way than anticipated before!
10. If Zeus is king of the gods, then he rules over Mount Olympus. Zeus does not rule over Mount Olympus, so he cannot be king of the gods.

11. My family has been struggling financially ever since my father lost his job a few months ago. He's tried everything to find a new job, but to no avail. I'm begging you to give him a job. And please just ignore the rumors going around that he was fired for sending racist and sexist emails.
12. My henchmen are getting restless and they need something else to do or else they'll all leave me - so please just handover the plans to the nuclear power plant, so that we can plan our next move! They've been with me through thick and thin and have stuck by my side even when things seemed hopeless. Please help them—and yourself—out by just giving us what we ask for.
13. Adam Smith is often credited with being the father of modern economics, and he wrote extensively on the benefits of free-market capitalism for all members of society. However, his lack of first-hand experience with poverty or economic hardship renders his writings on this subject largely irrelevant since he was not able to grasp the realities of living in poverty himself.
14. Dear son: As you know, I think that all laws should be based on our religious teachings and that there should be no other influences in government decisions. If you don't agree with me, I'll have to make sure that all of our church members know about it, and none of us will ever speak to you again. So it's in your best interest to rethink your position on this.
15. I come from a wealthy family and have a lot of influence in this town. I think that higher taxes on the rich should be eliminated and everyone should pay the same rate. If you don't agree with me, I'll have to pull some of my influence and make sure that you never get elected here again. So it's really in your best interests to accept my view.
16. You have to choose between being a good parent or having a successful career - you can't do both!
17. Captain Hook has observed that the following rule holds: if you find yourself on Neverland Island and dress like Peter Pan, you won't get eaten by crocodiles. He's therefore confident he can protect himself from crocodiles by painting his clothing green, just like Peter Pan.
18. My fellow citizens, I come before you today to ask you to accept the claim that wearing a mask is unnecessary and detrimental to your health. Many of our grandparents and elderly family members have been vocal in their opposition to this safety measure, which has become increasingly popular as a response to the pandemic. They often cite difficulty breathing, feeling suffocated, and believing it will not help protect them from the virus. I urge you to consider the experiences of these elders, who have seen much throughout their lifetime and can be trusted more on this issue than ignorant scientists.
19. Since each ingredient in this recipe has its own unique flavor profile, the finished dish must taste amazing!
20. It's important for parents to set limits for their children because kids need boundaries.
21. Since you are a devil-worshipping psychopath, I assume you believe human sacrifice is acceptable?
22. Since Ursula has many tentacles and each tentacle isn't powerful enough to destroy a large ship, then Ursula herself isn't powerful enough to destroy a large ship.
23. Almonds are a healthy snack, and parents should feed them to their children. Yes, even the ones that are allergic to nuts.
24. Friends and neighbors, I implore you to accept the claim that the public education system is outdated and ineffective. Many homeschooling families have been vocal about their belief that the traditional school system does not provide a quality education. They often cite overcrowded classrooms, overly simplistic curriculums, and an overemphasis on standardized tests as reasons why homeschooling is superior. Even without considering the details of their arguments, it's obvious these families know more about education than so-called teachers.
25. I know that we just met, but I really think we should get married - I'm really lonely and it would mean the world to me if you agreed. Plus, I'm sure that once you get to know me, you'll realize how great of a person I am!
26. The Joker is an evil genius because of how clever his plans for destroying Gotham City are. His plans for destroying Gotham City are clever because he is an evil genius.
27. If you don't give me those jewels, I'll be homeless and have to live on the street - so please let me have them! I've been trying to build an army of killer robots for year, but I just can't seem to make it work. This is my last chance, so please help me out!
28. Albert Einstein made great strides in the field of physics, proposing groundbreaking theories such as the Special Theory of Relativity. Yet, despite his scientific genius, he also held chauvinistic views that men were superior to women, making it difficult to take his theories seriously when they are rooted in such a sexist outlook.
29. I understand that you don't agree with my controversial religious view that all red-haired people will go to hell, but I'm asking you to accept them anyway. It's the only way I can make sense of the world and find peace in my life. Please have compassion for me and respect my beliefs.

30. If Dr. Drakken had been successful in creating a giant robot army, then he could have taken over the world. He did not take over the world, so he must not have created a giant robot army.
31. The Egyptian god Osiris is known for being kind and wise because his kindness and wisdom are legendary.

# CHAPTER 4: FALLACIES OF WEAK INDUCTION

In this chapter, we will be exploring fallacies of weak induction. These are errors in reasoning that occur when we try to draw conclusions based on insufficient or flawed evidence. We will be examining several different types of these fallacies, including hasty generalizations, false causes, and slippery slopes, among others. In addition to discussing these fallacies in detail, we will also be looking at two case studies that illustrate how these errors in reasoning can lead to flawed conclusions. The first case study will examine the issue of diet and weight loss, while the second will explore the importance of teaching machines to avoid fallacies. By the end of this chapter, you will have a better understanding of how to identify and avoid these fallacies of weak induction, and you will have a greater appreciation for the importance of using strong evidence and logical reasoning in your own thinking and decision-making.

To help motivate our study of these fallacies, we'll begin with a (somewhat threatening) speech by Emperor Palpatine (of *Star Wars* fame).

## PALPATINE'S SPEECH

Greetings citizens of Earth,

Today I stand before you as a leader, with the power and knowledge to give you a bright future. My name is Emperor Palpatine, and I believe that I should be elected your supreme leader.

Let me begin by telling you about my impressive accomplishments. I have built the infamous planet-destroying Death Star, trained Darth Vader to become an unstoppable force for "justice", and conquered thousands of planets. Not only have I achieved these incredible feats but I have also been able to maintain peace and order throughout all of these new territories – something which had seemed impossible before my arrival. Furthermore, I am extremely popular among Storm Troopers and Imperial workers – they trust me implicitly and will follow my orders without question, making sure that everything runs smoothly in all parts of the galaxy.

Now let us talk about why it would be wise for you to elect me your supreme leader. Firstly, you should be afraid of me – not just because of my command over the Death Star and Imperial Navy, but because of my intelligence and ruthlessness when it comes to getting things done. I will crush dissent and disagreement. And you should welcome this! No matter what situation arises or how difficult a challenge may seem I will always find a way to succeed. .As your leader this means that any alien species which threaten our safety or prosperity (or which you found smelly or ugly or just weird) will quickly be dealt with using whatever means necessary

Furthermore, all good things that have happened in this Star Wars universe should rightly be attributed to me. From the victories of the Rebel Alliance against the Empire, to the unification of disparate factions under a single banner to fight against me – these are all examples of my great leadership. Without my vision and guidance none of this progress would be possible. I have brought peace to war-torn lands and justice to those who have been wronged – this is something which cannot be denied! My influence can be seen in every corner of the galaxy, from the most remote backwater planets to even the most advanced civilizations. Allowing me to lead you as your supreme leader will ensure that you will benefit from similar progress and prosperity in your own lives.

While it is true that I have been known to take a firm stance in the face of opposition, it cannot be denied that I have also shown remarkable restraint in certain situations. The idea that I am a ruthless dictator has simply not been proven with 100% certainty. It is impossible to prove or disprove such an accusation without context and further information, and thus any claims of my tyrannical behavior are baseless. My rule has been characterized by peace and justice, which speaks for itself.

Next, let us discuss why democracy is terrible – too often it leads to indecisiveness or even worse no decision at all! The dangers of democracy are well evidenced in the Star Wars Universe. The Galactic Senate, for instance, was so bogged down in bureaucracy that it could not even come to a decision on whether or not to help Obi-Wan Kenobi and his allies when they needed it most. This resulted in a long drawn out war that cost many lives

on both sides. The same thing can be seen in our own world today. In some countries democracy has led to government gridlock, where nothing gets done due to disagreements between different political parties. This has resulted in a lack of progress and an inability to effectively address important issues such as climate change and poverty alleviation. By contrast, with me as your supreme leader you can be sure that decisions will be made quickly and efficiently without any bureaucratic red tape getting in the way! My rule will ensure that you benefit from my years of experience ruling over entire galaxies with great success every time!

Finally, I propose that the most intelligent and powerful people should be the ones to rule. Throughout history, it has been those who are best suited for the job that have led and achieved great things. This is not an issue of class or privilege, but rather one of meritocracy. Those who possess the knowledge and skills to lead must be given the opportunity to do so. This is why I believe I should be your supreme leader – my accomplishments speak for themselves, and it is clear that I am the most qualified person for this position.

### Questions

1. What conclusion is Palpatine trying to defend? What arguments does he offer?
2. What are some problems in Palpatine's arguments?
3. How could a defender of democracy respond to these arguments?

## Hasty Generalizations and False Causes

**Fallacies of weak induction** are weak inductive arguments in which the premises are evidentially relevant to the conclusion (unlike fallacies of relevance), but are not strong enough to justify belief in the conclusion without being supported by additional premises. Any argument that commits a fallacy of weak induction is (unsurprisingly) a weak inductive argument. These fallacies are often related to **confirmation bias**, which occurs when a person overestimates the strength of evidence that supports existing beliefs and underestimates the power of evidence against them.

In this section, we'll be examining the structure of several fallacies of weak induction, as well as what separates these fallacious arguments from stronger arguments of the same type. The fallacies we will address include hasty generalization, several varieties of the "false cause" fallacy, appeal to unqualified authority, and weak analogies, and appeal to ignorance.

### Hasty Generalization

The fallacy of **hasty generalization** has the general form:

- Premise: In sample S, something is true.
- (Suppressed Premise): S is a small or biased sample.
- Conclusion: This same thing is true of the larger population.

The fallacy of hasty generalization occurs when a person draws a conclusion about the larger population based on an insufficient sample size or biased sample. This type of fallacy is often committed in arguments when a person generalizes from a single example. For example, if a tourist were to observe that the first two people they met in their first day are rude, they may conclude that everyone in the city is rude. Other examples might be:

1. A person may conclude that the majority of voters in a particular state support a certain political party after interviewing only a small number of people in the state. This sample may be biased due to the fact that the interviews were conducted in a single location, such as a college campus or a wealthy neighborhood.
2. A parent of a prospective student may judge the quality of the education of a school district based on a single visit to a single classroom. This sample is likely to be biased due to the fact that the teacher may only observe the best-behaved (or worst-behaved) students and not gain an accurate picture of the learning environment of the school as a whole.
3. A person may conclude that a particular type of diet is effective for weight loss after seeing the results of a single individual. This sample is likely to be biased due to the fact that the individual they observed may have been particularly successful, or may have had other lifestyle factors that contributed to their weight loss.

Hasty generalizations are closely related to the idea of anecdotal evidence, which is evidence based on personal stories or experiences rather than data or scientific evidence. Anecdotal evidence is often used to support a conclusion, but it is often weak and unreliable due to the fact that it is based on a single example or small sample size. For example, a person may conclude that a particular type of medication is effective for treating a certain condition after hearing about a "success" story on the news (or from a friend, etc.).

Hasty generalizations can lead to immoral stereotyping when individuals draw conclusions about entire groups of people based on a small, biased sample. When this happens, individuals are making assumptions about an entire group of people based on a single example or a handful of examples. This can result in unfair and inaccurate generalizations that lead to discrimination and prejudice. For example, a person may draw the conclusion that all members of a certain racial group are criminals after witnessing a single act of violence committed by a member of that group. This conclusion is an example of immoral stereotyping, as it is based on a single example and is not reflective of the entire group. Similarly, a person may draw the conclusion that all members of a certain religious group are terrorists after hearing about a single terrorist attack committed by a member of that group. This conclusion is also an example of immoral stereotyping, as it is based on a single example and is not reflective of the entire group.

To avoid hasty generalization, it is important to recognize when a sample size is too small or biased to make a valid conclusion. It is also important to be aware of confirmation bias, and to make an effort to seek out information that could challenge or disprove existing beliefs. Additionally, it is important to recognize that a single example or small sample size is not representative of an entire group or population, and to avoid drawing conclusions based on such limited evidence.

## CAUSAL FALLACIES

The Post hoc ergo propter hoc, Non causa pro causa, and Gambler's Fallacy are all logical fallacies that involve drawing false conclusions due to a lack of evidence. It is important to be aware of these fallacies, as they can lead to wrong assumptions and poor decision making.

Post hoc ergo propter hoc

- Premise: Y happened after X happened.
- Conclusion: So, Y happened because of X.

The fallacy of **post hoc ergo propter hoc** is a logical fallacy that assumes that because one event follows another, the first event must have caused the second event. For example, consider the following statement: "I went outside and it started to rain, therefore I caused it to rain". This statement is fallacious because the act of going outside does not actually cause the rain. It is simply a coincidence that the two events occurred close together in time. Another example of this fallacy occurs in the medical field. Suppose a patient takes a certain medication and then experiences a positive outcome. The patient might then mistakenly believe that the medication caused the positive outcome, when in reality it may have been due to some other factor. Finally, this fallacy can also be seen in the stock market. Suppose the stock prices of a certain company increase after a new CEO is appointed. It would be fallacious to assume (without any other evidence) that the increase in stock prices was caused by the new CEO, when in reality the increase could be due to some other factor such as a change in the market conditions.

Non causa pro causa ("not the cause for the cause")

- Premise: X and Y are correlated.
- Conclusion: So, changing the value of X will change the value of Y.

The fallacy of **Non causa pro causa** is a logical fallacy that assumes that two events are directly related when in reality they are linked by a third factor. For example, consider the following statement: "My friend and I both ate ice cream at the party last night and we both got sick, therefore the ice cream caused us to be sick". This statement is fallacious because there may be some other factor (the "common cause") that links the two events, such as the fact that they had an infectious disease (and one passed it to the other).

Another example of this fallacy occurs in personal relationships. Suppose two people have a disagreement over who should make the coffee and then decide to break up. It would be fallacious to assume (without any other

evidence) that their strong feelings about making coffee caused the break up, when in reality the break up (and the fight) was caused by third factor such as a lack of compatibility. Similarly, this fallacy can also be seen in the context of diet. Suppose a person eats an apple each day and then experiences weight gain. It would be fallacious to assume (without any other evidence) that the weight gain was caused by the the apple, when in reality the weight gain could be due to some other factor such as a lack of exercise, or the other foods the person ate. Finally, this fallacy can also be seen in the context of crime. Suppose that we discover the police are more likely to pull over owners of red sports cars (in comparison, to say, grey sedans). It would be fallacious to assume (without any other evidence) that the police are targeting red sports cars, when in reality they could be targeting the drivers who are more likely to commit a crime (e.g. young males).

### GAMBLER'S FALLACY

- Premise: Y happens X% of the time. In the recent past, Y has happened <X% of the time.
- Conclusion: So, Y is likely to happen next time.

The **Gambler's Fallacy** is a logical fallacy that assumes that a certain event is more likely to occur after a streak of a different event occurring. For example, consider the following statement: "I've flipped a coin 10 times and it's landed on heads every time, therefore it's more likely that it will land on tails the next time". This statement is fallacious because the odds of getting heads or tails on an individual flip of a coin are always 50/50, regardless of what has happened in the past. Another example of this fallacy occurs in the casino. Suppose a person has been playing the same slot machine for an extended period of time without winning anything. They might then mistakenly believe that their luck has to turn around soon, when in reality their chances of winning remain the same. Similarly, this fallacy can also be seen in sports. Suppose a baseball team has gone on a winning streak and their fans assume they will continue to win. It would be fallacious to assume (without any other evidence) that the team will continue to win, when in reality the team's chances of winning the next game remain the same.

People commit these fallacies because they fail to take into account all of the relevant evidence and instead rely on incomplete information or anecdotal evidence to draw conclusions. To avoid these fallacies, it is important to look at the full picture and consider all of the variables that could potentially be influencing the outcome. Additionally, it is important to be aware of one's own biases and assumptions and to question them when making decisions. Finally, it is important to always seek out additional information and to weigh all of the evidence when trying to draw conclusions.

### REASONING ABOUT CAUSES WITH "MILL'S METHODS"

John Stuart Mill (1806–1873) was a British philosopher, political theorist, and economist who made significant contributions to the fields of ethics, political theory, and economics. He is best known for his work on utilitarianism, which holds that the most moral action is that which brings the most happiness to the most people. In addition to his contributions to philosophy and economics, Mill also wrote extensively on social and political issues. He championed women's rights and was a strong advocate for freedom of speech and thought.

Mill's methods of reasoning about causation are an important part of his legacy. Mill developed four methods for determining causal relationships between events or phenomena: the method of agreement, the method of difference, the joint method of agreement and difference, and the method of residues. He developed these methods as part of his pursuit of a scientific approach to understanding the world.

1. **The Method of Agreement**: This method examines cases in which two or more instances of the supposed cause are accompanied by the same effect, and then concludes that the cause and effect are related. For example, if we look at the number of hours of sleep that four people get and find that they all sleep for the same amount of time, and they all have similar levels of alertness, we can (inductively) conclude that the amount of sleep is linked to the amount of rest they get.
2. **The Method of Difference**: This method examines cases in which one instance of the supposed cause is accompanied by an effect, while the absence of the cause does not result in the same effect. For example, if we study two people, one of whom takes a nap and one of whom does not, and we find that the person who naps is more alert than the person who does not, we can (inductively) conclude that napping is linked to alertness.
3. **The Joint Method of Agreement and Difference**: This method combines the first two methods and examines cases in which one instance of the supposed cause is accompanied by the effect, while other instances of the cause do not result in the same effect. For example, if we study four people, two of

whom take a nap and two of whom do not, and we find that those who napped are more alert than those who did not, we can (inductively) conclude that napping is linked to alertness.

4. **The Method of Residues**: This method examines cases in which all known causes of an effect have been eliminated, and then searches for other causes that may have been overlooked. For example, if we study four people who all take a nap and find that two of them are more alert than the other two, we can (inductively) conclude that there must be another factor affecting alertness, such as diet or exercise.

Mill was also an important figure in the struggle for women's rights. His friend, collaborator, and (eventual) wife Harriet Taylor Mill, was an important figure in her own right as a feminist writer and philosopher. Together, they worked to improve the legal and economic rights of women, and their efforts contributed to the passage of the Married Women's Property Act of 1870. Mill's methods for reasoning about causation remain important today, and his work continues to influence our understanding of the world. His life and accomplishments serve as an inspiration for those wishing to make a difference in the world.

### QUESTIONS

1. How can confirmation bias lead to fallacies of weak induction?
2. How can individuals avoid the fallacy of hasty generalization? How can this fallacy lead to discrimination and prejudice?
3. What are Mill's four methods of reasoning about causation? Can you give examples of these?
4. Explain the "Post hoc ergo propter hoc" fallacy and give an original example of it.
5. What is the importance of looking at the "full picture" and considering all of the variables when trying to make generalizations or causal inferences?
6. Can you give an example of when your own biases and assumptions have led you to make less-than-perfect decisions? What did you to improve on this?
7. Do some research on John Stuart Mill and Harriet Taylor Mill's work on women's rights. Tell us what you discover.

## SLIPPERY SLOPES, WEAK ANALOGIES, AND APPEAL TO IGNORANCE

In this section, we will explore three common types of logical fallacies: slippery slopes, weak analogies, and appeal to ignorance. A slippery slope fallacy occurs when a person argues that a particular action or event will inevitably lead to a series of negative consequences, without providing any evidence to support this claim. A weak analogy fallacy occurs when a person tries to prove a point by comparing two things that are not similar enough. An appeal to ignorance fallacy occurs when a person argues that a claim must be true because it has not been proven false, or vice versa. We will examine examples of each of these fallacies and discuss how to avoid them in our own reasoning.

### SLIPPERY SLOPE

The slippery slope fallacy is a logical fallacy that occurs when someone argues that one small action will lead to a series of events, ultimately resulting in a negative outcome. This line of reasoning is based on the assumption that once you take the first step, it will be impossible to stop the sequence of events from unfolding. However, this assumption is often unfounded and can lead to irrational conclusions. It has the general form:

- Premise 1: If we take action X, it will (likely) lead to consequence Y.
- Premise 2: If consequence Y occurs, it will (likely) lead to consequence Z.
- Premise 3: If consequence Z occurs, it will (likely) lead to consequence W.
- Premise 4: W is very bad.
- Conclusion: Therefore, we should (probably) not take action X.

The strength of this inductive form of argument is a function of two factors (1) how many "steps" there are (more steps weakens the argument) and (2) how strong the evidence is for each individual step. Here are some example of "fallacious" slippery slope arguments:

- "If we allow people to carry concealed weapons, more people will carry concealed weapons. If more people carry concealed weapons, there will be more opportunities for conflicts to escalate into shootings. If there are more opportunities for conflicts to escalate into shootings, the streets will be filled with gun-toting vigilantes."

- "If we don't censor the internet, our children will have unrestricted access to the internet. If our children have unrestricted access to the internet, they will be exposed to all sorts of inappropriate content. If they are exposed to all sorts of inappropriate content, it will corrupt their minds."
- "If we don't deport all undocumented immigrants, some undocumented immigrants will remain in the country. If some undocumented immigrants remain in the country, more and more (and more and more) undocumented immigrants will come to the country. If more undocumented immigrants come to the country, our country will quickly be overrun by illegal immigrants. If our country is overrun by illegal immigrants, our economy will collapse."

The slippery slope fallacy is related to **prospect theory**, which is a psychological theory that explains how people make decisions when faced with uncertainty. Prospect theory states that people tend to be more afraid of potential losses than they are excited about potential gains, and this fear of loss can influence their decision-making. The slippery slope fallacy often plays on this fear of loss by arguing that a small action will inevitably lead to a series of negative events. This line of reasoning is designed to make people fearful of the potential consequences of taking action, and it can be effective at persuading people to avoid taking risks (even when it is rational/good to take these risks!).

**Justified Slippery Slopes.** It is possible for a slippery slope argument to be justified IF the premises are supported by evidence and the conclusion follows from the premises.

- Premise 1: If we do not take action to address climate change, global temperatures will continue to rise.
- Premise 2: If global temperatures continue to rise, sea levels will continue to rise.
- Premise 3: If sea levels continue to rise, coastal areas will be at increased risk of flooding.
- Premise 4: If coastal areas are at increased risk of flooding, many people will be displaced from their homes.
- Conclusion: Therefore, we should take action to address climate change.

In this example, the premises are supported by scientific evidence, and the conclusion follows logically from the premises.

### Weak Analogies

An argument from analogy is a type of argument that uses a comparison or analogy to support a conclusion. In this type of argument, the premise is that two things are similar in some ways, and the conclusion is that they are also similar in some other way. For example, if someone argues that "just like a car needs fuel to run, a person needs food to survive," the premise of the argument is that cars and people are similar in that they both need something to function properly. The conclusion is that, just like a car needs fuel, a person needs food to survive.

The standard form of an argument from analogy:

- Premise 1: Thing A is similar to thing B in respects X and Y.
- Premise 2: Thing A has property Z .
- Conclusion: Therefore, thing B also has property Z.

In this form of argument, the first premise establishes a similarity between thing A and thing B, and the second premise establishes a similarity between thing B and thing C. The conclusion then uses these similarities to argue that thing A and thing B are also similar in some other respect. For example:

- Premise 1: Humans and chimpanzees are highly social primates who can do many things with their hands.
- Premise 2: Humans have the ability to make and use tools.
- Conclusion: Therefore, chimpanzees also have the ability to make and use tools. (this is true--chimpanzees are known to make and use simple tools in the wild)

By contrast in the fallacy of **weak analogy,** the analogical argument falils because it ignores relevant dissimilarities between the two things being compared. For example:

- *"Both birds and fish are vertebrates who need oxygen to live. Since birds have lungs to help them process oxygen, we can conclude that fish have lungs as well."* In this example, the premise is true (birds and fish are both vertebrates and they both need oxygen to live), but the conclusion is still false because it ignores the relevant dissimilarity that fish have gills instead of lungs.
- *"Both cars and bicycles are vehicles that are used for transportation. Since cars have engines to help them move, we can conclude that bicycles have engines as well."* In this example, the premise is true (cars and bicycles are both vehicles and they are both used for transportation), but the conclusion is still false because it ignores the relevant dissimilarity that bicycles are human-powered and do not have engines.
- *"Both the Democrats and the Republicans are political parties in the United States. Since the Democrats generally support higher taxes for the wealthy, we can conclude that the most Republicans support higher taxes for the wealthy as well."* In this case, the argument ignores the relevant dissimilarities between the parties (where Democrats have generally favored spending on "safety net" programs, while Republicans have generally opposed any tax increases).

In these examples, premises are true but the conclusion is still false because it ignores relevant dissimilarities between the two things being compared. It is important to carefully evaluate the strength of an analogy and consider all relevant factors when using it to support a conclusion.

### Appeal to Ignorance

The appeal to ignorance fallacy is a type of logical fallacy that occurs when a conclusion is drawn on the basis of lack of evidence. This fallacy is based on the idea that a statement or claim is true simply because it has not been proven to be false, or that a statement or claim is false simply because it has not been proven to be true. It has the general form:

- Premise: You can't prove to me that C is false with 100% certainty.
- Conclusion: Therefore, it is reasonable for me to believe C.

The appeal to ignorance often arises from an inappropriate demand for deductive proof. In deductive reasoning, the conclusion of an argument must follow logically from the premises, and the conclusion must be true if the premises are true. However, in many cases it is not possible to prove with 100% certainty that a particular statement is true, and it is not always possible to prove with 100% certainty that a particular statement is false. This is because some statements are based on subjective opinions or beliefs, and because there is always a possibility that new evidence or information may be discovered that could change our understanding of a particular issue.

In the case of the appeal to ignorance fallacy, the demand for deductive proof is used to argue that a particular conclusion is reasonable or acceptable, even though there the available (inductive) evidence suggest that's that this conclusion is false. For example, if someone argues that "since you can't prove to me that ghosts don't exist with 100% certainty, ghosts probably exist," they are demanding that their opponent provide deductive proof that ghosts do not exist. But since it is not possible to prove with 100% certainty that ghosts do not exist, the argument relies on the absence of evidence (the inability to prove that ghosts do not exist) to support the conclusion that ghosts probably exist. This is a fallacious argument because it ignores the relevant evidence (such as the lack of reliable witnesses or physical evidence of ghosts) that contradicts or undermines the conclusion. In this case, the demand for deductive proof is inappropriate because it is used to support a conclusion that is not supported by the evidence. Some other examples:

- *"You can't deductively prove to me that unicorns don't exist, just like you can't deductively prove to me that the Earth is round. So, it's just as reasonable for me to believe in unicorns as it is for you to believe that the Earth is round."* In this example, the premise that it is not possible to prove with 100% certainty that unicorns don't exist is true, but the conclusion that it is reasonable to believe in unicorns is false because it ignores the relevant evidence that unicorns are mythical creatures and not real animals, and that the belief in unicorns is based on a false analogy with the scientific fact that the Earth is round (for which have lots of good inductive evidence, even though we lack a deductive "proof")>
- *"You haven't shown with 100% certainty that the moon landing wasn't a hoax. So, we need to consider this to be a real possibility."* In this example, the premise that it is not possible to prove with 100% certainty that the moon landing was not a hoax is true, but the conclusion that it is reasonable to consider the moon

landing as a hoax is false because it ignores the extensive evidence (such as photographs, videos, and eyewitness accounts) that supports the conclusion that the moon landing was a genuine event.

- *"Since you can't prove the government isn't spying on me, they probably are."* In this example, the premise that it is not possible to prove with 100% certainty that the government isn't spying on us is true, but the conclusion that it is reasonable to believe that the government is spying on us is false because it ignores the fact that there is no concrete evidence that the government is spying on us, and that such a claim would require (inductive) evidence to be considered reasonable.

The appeal to ignorance fallacy is a problematic form of reasoning because it relies on the absence of evidence to support a conclusion, rather than on positive evidence. In many cases, the lack of evidence for a claim does not necessarily mean that the claim is false, and the absence of evidence for a claim does not necessarily mean that the claim is true. Therefore, it is important to be cautious when using this type of reasoning and to avoid relying on the appeal to ignorance fallacy in arguments.

### Appeal to Inappropriate Authority

The fallacy of **appeal to inappropriate authority** is a type of argument that relies on the authority or expertise of a person or organization to support a conclusion, without considering the qualifications or impartiality of the authority. This fallacy occurs when an argument uses the authority of an unqualified or biased source to support a conclusion, without providing any evidence or reasons to support the authority's claim. For example, if someone argues that "since Dr. Smith is a renowned expert in the field of psychology, we can conclude that repressed memories are real," they are relying on the authority of Dr. Smith to support the conclusion that repressed memories are real. But if turns out that Dr. Smith works on areas of psychology utterly unrelated to memory, or if Dr. Smith has a bias or conflict of interest that affects their ability to provide objective information (for example, he has been paid by someone who wants them to say this), then their authority is not sufficient to support the conclusion that repressed memories are real.

The general form of the fallacy is as follows:

- Premise 1: Authority A makes claim C about subject S.
- (Suppressed) Premise 2: Authority A is biased or lacks expertise regarding subject S.
- Conclusion: Therefore, claim C is true.

Here are some examples:

- Since Professor Whitlock is a renowned expert in the field of psychology, we can conclude that evolution is false because she says so." In this argument, Professor Whitlock may be a scientist, but she lacks expertise because he research and expertise is in the field of psychology, not biology or evolution.
- Since Mr. Smith is the chairman of the National Association of Gun Manufacturers, we can conclude that gun control laws are useless because Mr. Smith says so." In this case, Mr Smith is biased because he has a financial interest in the success of companies that produce and sell firearms, and he lacks expertise because his background and expertise is in the field of business, not law or public policy.
- "Since Dr. Lee is a leading expert in the field of neuroscience, we can conclude that the existence of God is impossible because Dr. Lee says so." In this argument, Dr. Lee is a scientist, but she lacks expertise because her research and expertise is in the field of neuroscience, not theology or philosophy. Therefore, the conclusion that the existence of God is impossible is false because it ignores the qualifications or impartiality of Dr. Lee, and it does not provide any evidence or reasons to support the claim made by Dr. Lee.

The best way to avoid appeals to inappropriate authority is to consider the **consensus of experts,** or the collective agreement or opinion of a group of experts on a particular subject or issue. This consensus is important in deciding which claims to believe because it provides a reliable and evidence-based foundation for evaluating the validity or accuracy of a claim.

When a consensus of experts exists, it indicates that the majority of experts in a particular field or discipline have carefully studied the evidence and reached a conclusion based on their expertise and knowledge. This consensus can provide a strong indication that a claim is well-supported by evidence and is likely to be true. For example, a

consensus of experts in the field of climate science indicates that human activities are contributing to global warming and climate change, which provides a strong basis for believing this claim.

In contrast, when there is no consensus of experts or when the consensus is divided or uncertain, it indicates that the evidence or arguments for a claim are not strong or compelling, and it may be difficult to determine which claims to believe. In these cases, it is important to carefully evaluate the evidence and arguments on both sides, and to seek out additional information or expertise in order to reach a more informed and reliable conclusion. For example, if there is no consensus of experts on the efficacy of a particular medical treatment, it may be difficult to determine whether the treatment is effective, and it may be necessary to consider other factors, such as the risks and benefits of the treatment, in order to make a decision.

### Questions

1. What is the fallacy of slippery slope, and how does it arise in arguments? Can you provide an example of a slippery slope argument, and explain how it commits the fallacy of slippery slope?
2. What is the fallacy of weak analogy, and how does it arise in arguments? Can you provide an example of a weak analogy argument, and explain how it commits the fallacy of weak analogy?
3. What is the fallacy of appeal to ignorance, and how does it arise in arguments? Can you provide an example of an appeal to ignorance argument, and explain how it commits the fallacy of appeal to ignorance?
4. What is the fallacy of appeal to inappropriate authority, and how does it arise in arguments? Can you provide an example of an appeal to inappropriate authority argument, and explain how it commits the fallacy of appeal to inappropriate authority?
5. How can we avoid the fallacies of slippery slope, weak analogy, appeal to ignorance, and appeal to inappropriate authority in our own arguments? Can you provide some strategies or tips for evaluating and identifying these fallacies in arguments, and for constructing well-supported and reasonable arguments?

## Case Studies

### Weak Reasoning About Diets

Fallacies of weak induction can be tough to avoid. However, they can have big consequences for our lives. For example, here are some fallacies of weak induction related to diet and health:

| **Passage** | **Analysis** |
|---|---|
| Dr. Oz says that I can lose weight by eating garcinia extract. Since he's a doctor, I should do what he says. | Appeal to Inappropriate Authority**.** While Dr. Oz may be a doctor, he isn't the *only* doctor, and his opinion hardly represents a consensus of experts. If you wanted to know what to think of this claim, you'd want to do some research and see the *consensus* view on this. (In the case of nutrition, the scientific consensus is usually reflected in publications by government agencies like the Food and Drug Administration, major medical institutions like Mayo Clinic or Cleveland Clinic, and by diet recommendations of groups like the American Heart Institute.) |
| Six weeks ago, I cut gluten (or meat, or milk, or whatever) from my diet, and look how much weight I've lost, and how much better I feel. I can only conclude that [specific food item x] was the cause of my weight gain or ill health. | False Cause (non causa pro causa/post ergo propter hoc). The case of diets provides an especially clear example of how this fallacy. It can seem *obvious* to people that the most recent diet they've engaged in was "the cause" of their weight loss. However, this is almost always an unjustified conclusion, since there are things happening *besides* merely cutting out this food item that might bear a causal relationship to the weight loss (for example, people might just be eating less food, or have changed their exercise habits, etc.). This is why things like scientific studies are so important. |
| I lost 10 pounds in the first two months of my diet. So, I can reasonably expect to lose 50 pounds over the next 10 months. | Hasty Generalization. The first two months of a new diet are *not* an unbiased sample of what the future holds. In most cases, people will put on much of the weight they've lost. |
| In a study of mice, a group of mice that were forced to fast for 12 hours a day lived 20% longer than mice that ate all. [Implicit: humans are mice are | Weak Analogy. The weak analogy here is between mice and humans. The problem is not that we can't learn *anything* from studying mice (we can!), but that it's unlikely that an individual human will respond precisely the same way the mice do (as this argument claims). This |

| | |
|---|---|
| similar in that they are mammals, etc.] Therefore, I could extend my life span by 20% by fasting for 12 hours a day. | argument ignores these differences between humans and mice, and then proceeds to make a *very* strong claim about what will happen to a certain human. If the conclusion were weaker ("it might improve my health to take a break from eating now and again") the argument itself would be stronger. |
| My physician said that my cholesterol was very high, and that I should consider changing my diet. I talked to a nutritionist who agreed. They told me I should consider following the "DASH diet." So, my health will improve if I do this. | No fallacy. Note that, because of the inductive nature of this argument, you still might be wrong about the conclusion! And it may well be that new evidence will eventually cause you to revisit this conclusion. However, it is reasonable to act on this evidence (expert advice rooted in scientific consensus). |
| There's lots of scientific disagreement about diets, and no one has conclusively shown the best diet. So, who are you to say that my diet of "eat all the doughnuts, all the time" is bad? | Appeal to Ignorance. It's true that many questions about nutrition (and with science generally) are unsolved. It's also true that there's no way of mathematically proving that any crazy diet idea won't work. However, this does NOT mean that the evidence supports all diets equally or that we don't have solid evidence against your crazy diet. |
| Lots of people I've talked to said they lost weight after stopping eating food item F. I also read many stories of people on the internet who did the same thing. Obviously, everyone could lose weight by doing this. | Hasty Generalization. For any given popular diet (including many entirely at odds with one another), you can almost *certainly* find anecdotal evidence to support it via the testimony of friends, social media, news stories, your own experience, etc. However, gathering data in this way is highly biased (since you are almost sure to encounter many more stories of successes than failures.). |
| I saw a news article about a scientific study that provided some support for diet X. Hence, that diet is clearly the way to go! | Suppressed Evidence. As is the case with many other issues, there are a LOT of studies on nutrition. While new studies are relevant, it is fallacious to ignore/suppress evidence against diet X in making a decision. |
| Diets A, B, and C have all failed me. This just means that diet D is all the more likely to work! | Gambler's fallacy. There's no particular reason to think that failing on one diet makes another's succeeding any more likely. |

## Questions

1. Why is the hasty generalization fallacy problematic in the context of weight loss?
2. How does the appeal to ignorance fallacy impact the argument that any diet can be effective for weight loss?
3. Why is the appeal to popularity fallacy problematic when it comes to evaluating the effectiveness of a diet?
4. Can you think of any other fallacies that might commonly be committed in the context of discussions about weight loss?
5. How can we avoid committing these fallacies when discussing diet and health?

## Case Study 2: The Importance of Teaching Machines to Avoid Fallacies

As machines and artificial intelligence systems become more advanced and capable, it is increasingly important to ensure that they are able to avoid common logical fallacies and reasoning errors in their decision-making and problem-solving processes. This is particularly important in domains where the consequences of fallacious reasoning can be significant, such as in medical diagnosis, financial analysis, or military operations.

One example of the importance of teaching machines to avoid fallacies can be seen in the field of medical diagnosis. In this field, machines and AI systems are often used to assist doctors and medical professionals in identifying and diagnosing medical conditions based on symptoms, medical history, and other factors. However, if these machines are not trained to avoid fallacious reasoning, they may make incorrect or misguided diagnoses that can lead to serious consequences for patients.

For example, consider the fallacy of slippery slope. This fallacy arises when an argument relies on a chain of events or consequences that are not necessarily true or probable in order to support a conclusion. In the context of medical diagnosis, this fallacy could arise if a machine were to (hastily!) conclude that a patient must have a

particular medical condition based on a series of symptoms or risk factors, without considering alternative explanations or other factors that might affect the diagnosis.

In this case, the machine might make an incorrect diagnosis that could lead to inappropriate treatment or medication, which could have serious consequences for the patient. For example, the machine might diagnose a patient with cancer based on a series of symptoms, without considering other possible explanations for the symptoms, such as infection or inflammation. This incorrect diagnosis could lead to unnecessary or harmful treatments, such as chemotherapy or radiation, which could cause additional harm to the patient.

In order to avoid these kinds of errors, it is important to teach machines and AI systems to avoid the fallacy of slippery slope, as well as other fallacies, in their decision-making and problem-solving processes. This can be achieved through a combination of training and testing, using large datasets of examples and counter-examples, as well as through the development of algorithms and models that are specifically designed to avoid fallacious reasoning.

Overall, the importance of teaching machines to avoid fallacies cannot be overstated, as fallacious reasoning can have serious consequences in domains such as medical diagnosis, financial analysis, and military operations. By ensuring that machines are able to avoid fallacies, we can improve their reliability and accuracy, and help to avoid the negative consequences of fallacious reasoning.

### QUESTIONS

1. Why is it important to teach machines and AI systems to avoid fallacious reasoning in medical diagnosis?
2. What are some potential negative consequences of an incorrect diagnosis based on fallacious reasoning?
3. How can we teach machines and AI systems to avoid fallacious reasoning in their decision-making and problem-solving processes?
4. Can you think of any other ways in which fallacious reasoning might impact the field of medical diagnosis or other domains?
5. How might the use of machine learning and AI technology help to improve the accuracy and reliability of medical diagnosis, while also avoiding the pitfalls of fallacious reasoning?

## KEY CONCEPTS

- **Appeal to Ignorance--**An informal fallacy that occurs when a conclusion is drawn based on the lack of evidence against it, rather than on the presence of evidence for it.
- **Appeal to Inappropriate Authority--**An informal fallacy that occurs when an argument is made by appealing to the authority or expertise of someone who is not qualified or credible in the field being discussed.
- **Fallacy of weak induction--**An informal fallacy that occurs when an inductive argument is based on insufficient or unrepresentative evidence, leading to a weak or unreliable conclusion.
- **Gambler's fallacy--**An informal fallacy that occurs when it is believed that the probability of an event occurring increases or decreases based on previous occurrences of that event, when in fact the probability remains the same.
- **Hasty generalization--**An informal fallacy that occurs when a conclusion is drawn on the basis of too little evidence, leading to a conclusion that is not well-supported or likely to be true.
- **Method of Agreement (Mill's Method)--**A method of inductive reasoning developed by John Stuart Mill that involves finding cases where the phenomenon being studied is present, and identifying the common factors among those cases in order to form a hypothesis about the cause of the phenomenon.
- **Method of Agreement and Difference (Mill's Method)--**A method of inductive reasoning developed by John Stuart Mill that involves both the Method of Agreement and the Method of Difference, and involves comparing cases where the phenomenon being studied is present to cases where it is absent in order to form a hypothesis about the cause of the phenomenon.
- **Method of Difference (Mill's Method)--**A method of inductive reasoning developed by John Stuart Mill that involves finding cases where the phenomenon being studied is absent, and identifying the

factors that are different among those cases in order to form a hypothesis about the cause of the phenomenon.

- **Method of Residues (Mill's Method)--**A method of inductive reasoning developed by John Stuart Mill that involves considering all the known causes of a phenomenon and eliminating those that are known not to be involved, in order to identify the cause or causes that are most likely to be responsible.
- **Non causa pro causa--**An informal fallacy that occurs when a cause-and-effect relationship is assumed without sufficient evidence, leading to a false or unjustified conclusion. Also known as "false cause."
- **Post hoc ergo propter hoc--**An informal fallacy that occurs when it is assumed that because one event followed another, the first event must have caused the second, without sufficient evidence to support the causal relationship. Another type of "false cause."
- **Slippery Slope--**An informal fallacy that occurs when a chain of events is assumed without sufficient evidence, leading to a conclusion that is not well-supported or likely to be true.
- **Weak Analogy--**An informal fallacy that occurs when an analogy is used to support an argument, but the analogy is not strong enough to adequately support the conclusion.

## EXERCISES: MORE FALLACIES

Please explain whether the following passages commit a fallacy (or fallacies). If they do commit a fallacy, say what it is. If not, explain why you think it is a good argument. Finally, if you can, explain what sorts of evidence might help improve the argument.

Answers to selected exercises can be found in the appendix.

1. A survey of 10 homeowners found that 8 of them have recently installed a home security system. The survey was conducted in a high-crime area where many homes have been burglarized. Therefore, we can conclude that most homeowners have installed a home security system.
2. If we allow people to keep exotic pets, more and more people will do so. And before you know it, we'll have komodo dragons running loose in the streets, elephants trampling through our neighborhoods, and giant anacondas slithering through our sewage systems. Our cities will become chaotic, dangerous places and we'll have to live in fear of being eaten by our own pets.
3. I've been using herbal supplements to improve my memory, and I've been noticing a difference in my cognitive function. Therefore, herbal supplements must be an effective way to improve memory.
4. I've been reading this book that talks about how the Jews control everything. It's all there in black and white. And now that I've read it, I can see that it's true. The banks, the media, it's all run by Jews. So the book must be right.
5. The Slytherins Draco Malfoy, Pansy Parkinson, and Blaise Zabini are well known for their ambition and cunning. This just goes to show you can never trust a Slytherin.
6. If we allow athletes to use performance-enhancing drugs, more and more athletes will do so. And before you know it, our sports will become unrecognizable. We'll have professional cyclists with bionic legs, swimmers with gills, and baseball players with robotic arms that can throw 100 mile-per-hour fastballs. Our sports will become a joke and we'll all lose interest in them.
7. I've been using crystal healing to treat my anxiety, and I've been feeling calmer than usual. Therefore, crystal healing must be an effective treatment for anxiety.
8. In my survey of 10 James Bond villains, all stated their life goal was to take over the world. This is likely to be a common goal for humans.
9. I've been applying to jobs for months, and I haven't gotten any interviews. My luck is bound to change soon.
10. I've been dating for a while, and I haven't met anyone interesting. I'm sure that my luck is about to change, and that tonight's date will be 'the one'.
11. If we allow people to modify their bodies with cybernetic implants, more and more people will do so. And before you know it, our society will become a dystopian nightmare. We'll have people with laser eyes, bionic arms, and built-in GPS systems. The rich will become cyborgs and the poor will be left behind as second-class citizens. We'll have to live in a world where human beings are no longer human.
12. Leonardo and Donatello are turtles who love eating pizza and using ninja weapons. So, my pet turtle Tiny probably has similar interests.

13. A new study found that people who eat a low-fat diet are more likely to lose weight than those who eat a high-fat diet. Therefore, the low-fat diet caused the weight loss.
14. After I started taking vitamin C supplements, I got over my cold faster than usual. Therefore, the vitamin C supplements caused me to get over my cold faster.
15. I've noticed that my car gets better gas mileage in the summer than in the winter. Therefore, the warm weather must be causing the improved gas mileage.
16. At a recent technology conference for teachers, we found that 88% of attendees believe that technology has a positive impact on education. Therefore, we can conclude that most teachers believe that technology has a positive impact on education.
17. I've been feeling less stressed lately, and I attribute it to the meditation app I've been using. Therefore, the meditation app must be causing me to feel less stressed.
18. I've been getting better grades since I started studying with a group. Therefore, studying with a group must be causing me to get better grades.
19. I've been playing this slot machine for a while, and I haven't won anything. I'm due for a big win soon.
20. I've been on a low-fat diet for the past month, and I've lost 10 pounds. I also saw a headline that said that people eat a low-fat diet are more likely to lose weight than those who eat a high-fat diet. Therefore, the low-fat diet must have caused my weight loss.
21. I've been taking vitamin C supplements for the past week, and I've been feeling better than usual. After I started taking the supplements, I got over my cold faster than usual. Therefore, the vitamin C supplements must have caused me to get over my cold faster.
22. If we allow people to use artificial intelligence in decision-making, more and more people will do so. And before you know it, our society will become completely dependent on AI. We'll have robots making all of our decisions for us and we'll become mindless drones, unable to think for ourselves. Our entire civilization will collapse and we'll be left at the mercy of the machines.
23. I was watching this video on TikTok, and it was saying that black people are just naturally violent and criminal. And you know what? It's true. Just look at the crime rates in these neighborhoods. They're off the charts.
24. If we allow gay marriage, then people will start to want to marry animals. And before you know it, we'll have people marrying their dogs and cats. Society will crumble and we'll be living in a world of chaos.
25. I've been getting better grades since I started studying with a group. I've been studying diligently with the same group of friends for the past semester, and my grades have improved significantly. Therefore, talking with my group members must be causing me to get better grades.
26. I've been taking colloidal silver to treat my cold, and I've been feeling better than usual. Therefore, colloidal silver must be an effective treatment for colds.
27. I've been using homeopathic remedies for my allergies, and I've been noticing a difference in my symptoms. Therefore, homeopathy must be an effective treatment for allergies.
28. I've been using magnetic therapy to treat my chronic pain, and I've been experiencing less pain than usual. Therefore, magnetic therapy must be an effective treatment for chronic pain.
29. I heard this podcast the other day, and it was talking about how the Chinese are using chemicals in vaccines to control people. And you know what? It all makes sense now. Look at all these vaccines that are made in China. It's all starting to add up.
30. If we allow people to create realistic virtual realities, more and more people will do so. And before you know it, our society will become completely addicted to these virtual worlds. We'll spend all of our time in them and our real world will become a desolate wasteland. Our economy will collapse and we'll lose touch with reality altogether. We'll become nothing more than digital ghosts, living in a world that isn't real.
31. The first (and only) orc I've met yelled at me in French, so we can conclude that most orcs are French speakers who have difficulty controlling their tempers.
32. If we allow people to openly carry firearms in public, then more and more people will do so. And before you know it, we'll have gunfights in the streets and our society will become lawless and violent.
33. A small study of 15 patients found that 10 of them experienced relief from chronic pain after using a certain medication. The study was funded by the pharmaceutical company that manufactures the medication. Therefore, we can conclude that most patients will experience relief from chronic pain after using that medication.
34. I've been trying to get a raise at work for months, and I haven't had any luck. My boss keeps telling me I need to improve my performance numbers before that can happen. However, I'll just keep asking. Every time I ask, it gets more and more likely he'll have to give in.

35. If we allow people to smoke marijuana, then more and more people will do so. And before you know it, we'll have widespread drug addiction and our society will become a wasteland of drug-addled zombies.

# CHAPTER 5: ARGUMENTS IN ACTION: ARGUING ABOUT GOD

In this chapter, we will examine some of the most common arguments for and against the existence of God. We'll start by looking at some arguments for God's existence, including the argument from religious experience, the ontological argument, and the argument from design. We'll also consider Pascal's wager, which suggests that it's better to believe in God just in case he exists. We'll then turn to arguments against God's existence, including the logical problem of evil and the argument from nonbelief. Finally, we'll discuss the moral argument for God. You'll have the chance to practice what you've learned by considering a variety of arguments concerning the mythical "Flying Spaghetti Monster."

But why is this important in a logic book? Well, the topic of God's existence is one that many people hold strong beliefs about, and it's important to be able to evaluate these beliefs critically and rationally. By examining the arguments for and against God's existence, we can practice using critical thinking skills such as logical analysis and evaluating evidence. Plus, understanding these arguments can help us engage in respectful and productive discussions with others about this complex and often controversial topic.

To help get a sense of what kind of arguments we'll be considering, we'll start with a short story about three friends.

## A FRIENDLY ARGUMENT

*Three friends—Kofi, Amara, and Emmanuel—have been sitting in a cozy cafe, tucked away in a quiet corner of the city. The cafe is dimly lit, but the light from the street lamps outside illuminates the tables and creates a warm ambiance. The walls are lined with bookshelves, and the shelves are filled with old books and records. The friends have been catching up over coffee and pastries. They've been talking about their recent travels, work, and experiences. Eventually, their conversation turns to the topic of God, and they decide to debate the existence of a higher power. They've been talking for hours, and the night is getting late.*

Kofi: Hey guys, I'm sure you know my stance on this, but for the sake of everyone here, I'll state it again. I don't believe in a higher power. I believe it's a figment of our imaginations, a way of making sense of the unknown. The proof just isn't there.

Amara: Kofi, I think you're wrong. I'm a firm believer in God, and I'm here to argue why. To me, it's obvious that there's something bigger than us out there, and that our lives are guided by something divine. I'll be defending this view, so let's get into it.

Emmanuel: Hey now, let's not be so quick to dismiss each other's beliefs. I'm an agnostic, so I'm open to the possibility that there might be a higher power out there, but I'm also open to the idea that there isn't. I think it's important to look at the evidence from both sides, so let's examine the implications of both atheism and theism.

Amara: One reason we know that God must exist is because the very concept of God implies perfection, greatness and the highest level of being. If God did not exist, then these attributes would have no source and could not exist, which is a contradiction. Therefore, God must exist.

Emmanuel: I disagree. Even though the concept of God implies certain attributes, it does not necessarily follow that God must exist. For example, unicorns are often seen as being magical "perfect" creatures, but that does not mean unicorns exist in reality. So, just because the concept of God implies certain attributes, that does not necessarily mean that God exists.

Kofi: Yeah, that argument is obviously bad. Personally, I think the strongest argument against the existence of God is the problem of evil. If God is all-powerful and all-good, then why is there so much suffering and evil in the world? That doesn't make sense to me, and it's hard to believe that an all-powerful and all-good God exists when there is so much evil in the world.

Amara: I don't think the problem of evil is a valid reason to deny the existence of God. After all, it's impossible to understand the full scope of God's plans and purposes, so we can't say for sure why there is evil in the world. Plus, I think the argument from design is a much stronger argument for the existence of God. When you look at the complexity and beauty of nature, it's hard to deny that it was designed by something greater than us.

Kofi: That's an interesting point, but I'm still not convinced. There are scientific explanations for the complexity and beauty of nature. Plus, positing that "God" caused it just makes it all the more mysterious. For me, the only way to truly know if there is a higher power or not is to look at the available evidence. And the evidence just isn't there.

Emmanuel: I think we're getting a bit too heated. We all have our opinions, and we should respect each other's views. Let's not forget what we're really talking about here, which is the news. It seems like lately, both atheists and theists have been attacking each other in the media. We need to be more respectful of each other, and just accept there is no way of knowing the answer to these questions.

Amara: Actually, I think there is a way to know the answer. There are plenty of people who have had religious experiences, and they claim to have a deep connection with a higher power. To me, that's proof that there is something out there.

Kofi: I can see why you would think that, but I'm still not convinced. Religious experiences are subjective, and there is no way to verify them. Plus, there are plenty of people who have had experiences that contradict each other, so it's hard to take them seriously.

Emmanuel: I think it's important that we're all open to different views. After all, who knows if there is a higher power or not? We can never be sure. All we can do is look at the evidence, debate the possibilities, and try to come to a conclusion.

[The argument continues…]

### Questions

1. What are the different beliefs about the existence of a higher power held by the friends in the dialogue?
2. How do the friends present and defend their beliefs about the existence of a higher power?
3. What are some possible ways that the friends could have a productive and respectful conversation about their differing beliefs?
4. What is the "problem of evil" and how does Kofi use it to argue against the existence of God?
5. How does Amara respond to Kofi's argument from the problem of evil?
6. How does Emmanuel approach the conversation about the existence of a higher power?

## Arguments For God

Philosophers, theologians, and logicians have been arguing about God for a *long, long* time. Plus, most people have some opinion about whether God exists, so it's a question of inherent interest. With that in mind, by taking a look at the most popular arguments for and against God with an eye toward figuring out the difference between good and *bad* arguments. This chapter will assume that "God" means the traditional Jewish-Christian-Islamic God (all-powerful, all-knowing, and all-loving). Such arguments have played a central role in the historical development of logic. Because reasoning about God is so tricky, it has led to the development of new forms of reasoning and critiques of these forms.

The goal of this chapter is NOT to defend any particular conclusion about God. Instead, the goal will be to learn to distinguish between two (very different) things:

1. Whether or not you agree with the conclusion of a particular argument.
2. Whether or not the argument is fallacious.

Making this distinction is a crucial skill. However, it requires a surprising amount of dedication and practice to do this reliably. It often seems our brains "want" to ignore problems with arguments whose conclusions we like, even as they are quick to pick up on errors (real or imagined) when we consider arguments with conclusions opposed to ours.

### The Argument from Religious Experience

The **argument from religious experience** for the existence of God is based on the idea that people have had profound and meaningful experiences of God, and that these experiences provide evidence for God's existence. For example, someone might argue that they have had a personal encounter with God that was so powerful and undeniable that it must have been real, and that this experience proves that God exists. It has the form:

- Premise: A certain person (perhaps even you) has had a religious experience.
- Premise: The best explanation of this religious experience is that God exists.
- Conclusion: God exists.

### Criticisms

As laid out here, the argument from religious experience commits the fallacy **of hasty generalization** because it assumes that the experience of a small or biased group of people (those belonging to a certain religion, for example) can be used to draw general conclusions. This assumption is false because religious experiences are incredibly diverse, and can support different and even inconsistent religious beliefs.

For example, some people may have religious experiences that support their belief in the monotheistic God of Judaism, Christianity or Islam, while others may have religious experiences that support their belief in a pantheon of gods. Some people may have religious experiences that support their belief in an heavenly afterlife, while others may have religious experiences that support their belief in reincarnation. Some people may have religious experiences that support their belief in the truth Buddhism, while others may have religious experiences that support their belief in the truth of Taoism. Some people may even have "anti-religious" experience in which they experience the "emptiness" of the universe, which support atheism (and so, atheists can commit this same fallacy!).

In other words, the argument from religious experience is a hasty generalization because it fails to take into account the diversity of religious beliefs and the many different ways in which people can interpret and understand their religious experiences. By assuming that all religious experiences support the same religious beliefs, the argument ignores the complex and varied nature of religious experience, and therefore fails to provide a convincing case for the existence of God.

As with nearly all of the arguments that we'll be discussing, there are ways of expanding on or altering this argument to avoid some of these problems. (And these argument revisions have, in turn, been criticized). You can read more about this argument at: https://plato.stanford.edu/entries/religious-experience/.

## The Ontological Argument

The **ontological argument** is a philosophical argument that attempts to prove the existence of God through reason and logic alone. The argument typically takes the form of a deductive argument, which means that it begins with certain premises or assumptions and uses them to logically deduce a conclusion.

One famous formulation of the ontological argument is attributed to St. Anselm of Canterbury, who argued that God, by definition, is the greatest being that can be conceived of. Because it is greater to exist in reality than to merely exist in the mind, it follows that God must necessarily exist in reality.

- Premise 1: God, by definition, is the greatest being that can be conceived of.
- Premise 2: It is greater to exist in reality than to merely exist in the mind.
- Conclusion: God exists.

### Criticisms

One example of a counterexample used to show why this version of the ontological argument is invalid is known as "the perfect island" thought experiment. In this thought experiment, one imagines an island which is perfect in every way—it has everything anyone could possibly want or need and more—but no one actually lives there or has ever visited it before. One can then use the ontological argument to "prove" that this island exists. Th

- Premise 1: The perfect island, by definition, is the greatest being that can be conceived of. (True)
- Premise 2: It is greater to exist in reality than to merely exist in the mind. (True)
- Conclusion: The perfect island exists (obviously false!).

Counterexamples (with true premises and a false conclusion) like this show that deductive arguments, like the ontological argument, are not valid. Deductive arguments are only valid if it impossible for the premises to be true and the conclusion false. However, counterexamples can show that the premises of a deductive argument

show that it IS possible to have true premises and a false conclusion, which shows us that *something* has gone wrong with the argument.

One theory about *why* the ontological argument fails is due to Immanuel Kant, who argued that **existence is not a predicate** (and thus, premise 2 is basically meaningless). The basic idea is this: A **predicate** is a part of a sentence that provides information about the subject of the sentence. For example, in the sentence "The dog barked," "barked" is the predicate because it tells us something about the dog (that it made noise). Predicates can also describe physical characteristics or qualities like color or size. In "The small dog barked," "small" is the predicate because it tells us something about the dog's size. Existence, on the other hand, does not describe any quality or characteristic of something; rather, it simply means that something exists at all. Therefore, existence cannot be considered a predicate since it doesn't provide any additional information about the subject of a sentence. So, the claim "It is greater to exist that not to exist" means something very different from "It is greater be kind than cruel." Kind and cruel are predicates; existence is not.

You can read more about further developments of the ontological argument at https://plato.stanford.edu/entries/ontological-arguments/.

### The Argument From Design

The argument from design, also known as the teleological argument, is an inductive argument for the existence of God or a creator based on the observed order and purpose in the universe. The basic idea is that the world exhibits such a high degree of order and purpose that it must have been created by a intelligent and powerful being, namely God. In standard form, the argument is as follows:

1. The world exhibits a high degree of order, purpose, and design.
2. This order, purpose, and design suggest the existence of a intelligent and powerful creator.
3. This creator is God.
4. Therefore, God (probably) exists.

One example of the argument from design is the complexity and apparent design of living organisms. The human body, for instance, is made up of countless intricate systems, all working together in harmony to sustain life. The human eye, for example, is a marvel of design, with its ability to focus light and produce clear images. The same can be said for the other systems in the body, such as the digestive system, the circulatory system, and the nervous system. All of these systems point to a high degree of design and purpose, suggesting that they were created by a intelligent and powerful being.

Another example of the argument from design is the beauty and order of the natural world. When we look at the world around us, we see a vast and diverse array of plants, animals, and other living things, all of which exhibit a high degree of order and purpose. The beauty of a flower, for instance, or the intricate design of a snowflake, point to a creator who has a deep understanding of beauty and order.

The argument from design also extends to the universe as a whole (here, it is sometimes called the **cosmological argument)**. The universe exhibits a remarkable degree of order and regularity, with the laws of nature governing the behavior of everything from the smallest particles to the largest galaxies. This order and regularity suggest a powerful and intelligent creator who has designed the universe and its laws.

### Criticisms

Critics of the teleological argument point out that it fails to account for how such a designer could have come into being. If one assumes that a designer exists, then one must assume that it existed before the universe was created. This raises further questions about how such a designer could have come into existence without itself being designed by something else. In technical terminology, this risks leading to a **vicious infinite regress,** with an *infinite number* of (more and more powerful) "Gods" required to create the God "below" them.

In addition, critics point out that the teleological argument does not provide any evidence for the nature of the designer itself. What is this designer? Is it a personal being with intentions and motives? Is it an impersonal force? The teleological argument does not provide any answers to these questions. It is a long way to go from "there is a creator of some type" to "there is an all-good, all-powerful God." The creator must just as easily be a malevolent machine who has constructed our reality for altogether differences.

Another criticism of the teleological argument is its reliance on subjective assessments about what constitutes "order" and "purpose" in nature. Different people will interpret natural phenomena differently – what one person sees as evidence of divine design another may see as random chance or natural selection (or even as evidence of an *evil* creator). This subjectivity makes it difficult to determine whether or not a particular pattern in nature is actually evidence of design or just coincidence.

Finally, some critics argue that the complexity and diversity of life forms found in nature can be explained by natural processes such as evolution rather than divine intervention. They point out that living organisms are capable of adapting to their environment over time through natural selection and other means, which suggests that complexity arises naturally rather than through intentional design by an external force.

For more on this argument, see https://plato.stanford.edu/entries/teleological-arguments/.

## PASCAL'S WAGER

**Pascal's Wager** is a philosophical argument put forth by the 17th century philosopher Blaise Pascal. It suggests that humans should believe in God, even if their belief cannot be proven or justified through reason or evidence. According to Pascal's Wager, the potential rewards of believing in God outweigh the potential risks of not believing.

The argument states that humans can consider the potential outcomes of believing and not believing in God, and then make a rational decision based on these considerations. If one believes in God, it is possible that there may be an infinite reward or benefit in the afterlife; however, if one does not believe in God, there may also be a penalty or punishment for such disbelief. In this way, Pascal argued that it is better to believe in God than to not believe since the risk of punishment for not believing is much higher than the reward for believing.

Pascal's Wager is related to ideas about probability and decision theory because it suggests that we should make decisions based on expected utility rather than absolute certainty. The idea is that we should weigh all potential outcomes and make our decisions based on what provides us with the highest expected benefit. Pascal suggested that it was irrational to reject belief in God due to the possibility of infinite reward or punishment. He argued that following this logic was more reasonable than atheism due to its greater potential payoff. Therefore, according to Pascal's Wager, it is rational and advantageous to believe in God despite any lack of evidence because doing so minimizes the risk of being punished for non-belief while potentially offering access to an infinite reward after death.

Represented as a standard form argument:

- Premise 1: Believing in God offers an infinite reward if true and no penalty if false
- Premise 2: Not believing in God offers no reward if true and an infinite penalty if false
- Conclusion: Therefore, it is rational and advantageous to believe in God despite any lack of evidence.

## CRITICISMS

One primary criticism of Pascal's Wager is that it ignores there is not a binary choice between "believe in God" or "don't believe in God." Instead, we need to survey all of the possible beliefs about religion (for example, we need to consider the logical possibility that there is a God who just wants "not to be bothered" and will send anyone who worships them directly to hell). This suggests that reward or punishment could be nonexistent or different than anticipated. Additionally, the wager does not consider any moral implications of believing in God just to receive a potential reward. In this way, Pascal's Wager may encourage people to act in a way that they do not truly believe in or hold sincere beliefs. (For example, Pascal's wager could be used to "argue oneself" into doing immoral acts, since one wanted to be sure of a "heavenly reward").

Another criticism of Pascal's Wager is that it assumes an infinite reward and punishment, which critics have contended aren't meaningful concepts. Even if they do make sense, this also raises of how the "infinite" rewards of various religious or belief systems ("Nirvana" vs. "Heaven" vs. "Reincarnation") can be weighed against one another. Finally, the wager ignores the fact that belief of many theists that God requires more than just intellectual belief – it also requires faith and commitment from believers. Thus, simply believing because one fears punishment may lead to insincere beliefs and lack of commitment on behalf of believers.

To learn more about Pascal's wager: https://plato.stanford.edu/entries/pascal-wager/

### QUESTIONS

1. What is the argument from religious experience? What fallacy does it commit? How might you alter the argument to avoid this fallacy?
2. Why does the "Perfect Island" counterexample cause problems for the ontological argument? Can you think of another example of this same type?
3. What sorts of "design" are in important in the argument from design?
4. Is the argument from design inductive or deductive? Explain and defend your answer.
5. Do your best to formulate Pascal's wager in your own words. Now, explain ONE criticism of it.
6. Which argument in this section did you find most convincing? Least convincing? Why?

## MINDS THAT MATTERED: AVICENNA

Avicenna (also known as Ibn Sina) was a Persian polymath and philosopher who lived from 980 to 1037. He was born in the city of Afshana, near Bukhara, in present-day Uzbekistan, and grew up in the city of Bukhara. Avicenna was a prodigy who began studying the Islamic sciences at a young age, and was proficient in a wide range of subjects, including theology, law, mathematics, astronomy, medicine, and music.

Avicenna is known for his philosophical works, which were influential in both the Islamic and the Western worlds. He is considered one of the greatest philosophers in the Islamic tradition, and his works have been studied and commented on by philosophers from a wide range of traditions, including the Aristotelian, Neoplatonic, and Sufi traditions. His most famous philosophical work is The Book of Healing, which is a comprehensive work on logic, metaphysics, natural philosophy, and psychology.

Avicenna's philosophy is based on the idea that knowledge is the key to understanding the world and the self, and that knowledge can be obtained through observation, experience, and reasoning. He argued that the universe is orderly and intelligible, and that it can be understood through the study of natural philosophy (what we now call "science"). He also argued that the human mind has the ability to understand the universe, and that the pursuit of knowledge is the highest form of human activity.

Avicenna's famous argument for the existence of God is known as the "**proof of the necessary existe**nt". This argument is based on the idea that the universe must have a cause, and that this cause must be an eternal and necessary being.

The proof of the necessary existent begins by observing that the universe is contingent, meaning that it could have not existed or could have existed in a different way. This contingency is evident in the fact that the universe is composed of individual things that come into existence and pass away, and that the universe as a whole is subject to change and generation.

If the universe is contingent, then it must have a cause that is not contingent, but necessary. This cause must be an eternal and necessary being, because if it were not eternal, then it would have come into existence at some point, and if it were not necessary, then it could have not existed or could have existed in a different way. Therefore, the cause of the universe must be an eternal and necessary being, which is what we call God.

Avicenna's proof of the necessary existent is an a priori argument, meaning that it is based on reason and does not rely on empirical evidence. It is also a cosmological argument, meaning that it begins with the observation of the universe and infers the existence of God from the nature of the universe. This argument is similar to other cosmological arguments, such as the Kalam cosmological argument and the Thomistic cosmological argument, which also infer the existence of God from the contingency of the universe.

1. Which of Avicenna's ideas do you find most interesting? Why?
2. What is Avicenna's proof of the necessary existent, and how does it differ from other arguments for the existence of God?
3. What might be some criticisms of Avicenna's proof of the necessary existent?
4. How does Avicenna's proof of the necessary existent relate to contemporary debates about the existence of God and the nature of the universe?

## Arguments Against God

In the previous section, we considered some of the best-known arguments FOR the existence of God. Now, we'll look at some of the arguments against God.

### The Logical Problem Of Evil

The Logical Problem of Evil is a challenge to the notion that God and evil can both exist together. According to an influential formulation by the philosopher JL Mackie, the logical problem of evil rests on three premises: 1) God is all-powerful, 2) God is perfectly good, and 3) Evil exists in the world. Here "evil" means something like "suffering" (especially the suffering of innocent children or animals). From these three premises, Mackie proposes two conclusions about the existence of evil that cannot be reconciled: either the first two premises are false or the third premise is false. So, the argument has the following form:

- Premise: God is by definition, all-powerful and all-good.
- Premise: An all-good being would strive to eliminate evil whenever possible
- Premise: An all-powerful being could do this.
- Conclusion: If evil exists then, the God does not.

For instance, if God is all-powerful and perfectly good, then why does he allow evil to occur? If God has absolute power, then he should be able to prevent or stop evil from occurring. However, if God is perfectly good, then He should want to prevent or stop evil from occurring. Thus, either God is not all-powerful or he is not perfectly good (or God doesn't exist).

Likewise, if evil exists in the world and God is all-powerful and perfectly good at the same time, then why doesn't He eliminate it? If He has the power to do so and knows that it's wrong (because He's good), why would He let it continue? Again, either God isn't all-powerful or He isn't perfectly good (or God doesn't exist).

Examples of this logical problem include natural disasters such as hurricanes that cause death and destruction; human suffering due to physical ailments like cancer; war with its associated death tolls; poverty causing malnutrition and starvation; environmental catastrophes such as oil spills leading to long-term damage; terrorist attacks resulting in mass casualties; animal cruelty such as hunting for sport; and other forms of violence like rape and murder. In each case, one must ask how a powerful and benevolent being could allow this kind of suffering in His creation.

### Criticisms

The logical problem of evil has been widely criticized, particularly by religious believers. One of the most common criticisms is that the problem of evil becomes a logical paradox only if one assumes God's existence and attributes in advance. That is to say, if one does not hold that God is all-powerful and perfectly good (but instead has limitations of power), then the logical problem of evil does not arise as a contradiction. This clearly "solves" the problem, but only by sacrificing something that most believers in God think that is essential.

Another criticism of the logical problem of evil is that it fails to account for free will. If God gave humans free will, then He may have allowed evil to exist so that humans can choose for themselves whether or not to do what is right or wrong. Thus, instead of proving that God cannot exist alongside evil, the presence of free will actually allows for both to coexist. This criticism does not address the issue of why God would create a world where humans have free will but are so susceptible to doing wrong, however. In other words, why give humans free will when they are likely to use it for evil?

A third criticism is that the problem fails to take into account the idea of soul-making. The idea behind this is that suffering in this life can lead to spiritual growth and development in the next life, thus making it all worthwhile in the end. Critics argue that this could be a valid reason why God might allow evil to exist without compromising His goodness or power. One worry for this response is that it raises the question "How can all good God justify allow *some* people to suffer so that *others* could be saved?"

Finally, some critics have argued that Mackie's formulation of the logical problem of evil relies too heavily on Western philosophical assumptions about God's nature and attributes, rather than taking into account other religious perspectives on these matters. For example, Hinduism holds a different view about what constitutes

divine power and goodness than Christianity does, and so Mackie's argument may not apply equally across different world religions.

In recent years, much of the debate around the problem of evil has revolved around "inductive" versions of the problem, which contend that evil makes God's existence is very *unlikely* (though not logically impossible).

## The Argument from Nonbelief

The **argument from nonbelief is** an argument for atheism that is based on the observation that many people do not believe in the existence of a god or gods, despite the fact that belief in a god or gods is considered to be natural and intuitive for many people.

The argument goes as follows: if a god or gods exists and desires for all people to believe in their existence, then it seems reasonable to expect that most people would naturally believe in their existence. However, the fact that many people do not believe in a god or gods suggests that either such a god or gods does not exist, or that they do not desire for all people to believe in their existence.

Here is one way to present the argument from nonbelief in standard form:

- Premise: If a God or gods exists and desires for all people to believe in their existence, then it is reasonable to expect that most people would naturally believe in their existence.
- Premise: Many people do not believe in the existence of a God or gods.
- Conclusion: Therefore, either a God or gods does not exist, or they do not desire for all people to believe in their existence.

This argument is valid, in the sense that if the premises are true, then the conclusion follows logically. However, the argument is not necessarily sound, because one or more of the premises may be false. For example, the first premise may be false if there are other reasons why many people do not believe in a God or gods, even if such a God or gods exists and desires for all people to believe in their existence.

There are various ways in which the argument from nonbelief can be formulated. One common variation of the argument is known as the "argument from divine hiddenness", which focuses on the apparent lack of evidence for the existence of a God or gods in the world. This variation of the argument suggests that if a God or gods existed and desired for all people to believe in their existence, then they would make their existence more evident in the world, so that it would be more difficult for people to reject belief in their existence.

Another variation of the argument is known as the "argument from divine indifference", which focuses on the apparent lack of concern that a God or gods have for the well-being of human beings. This variation of the argument suggests that if a God or gods existed and cared about the well-being of people, then they would provide people with more evidence of their existence, or take other actions to ensure that people believe in their existence.

### Criticisms

One way to respond to this argument is to claim that the nonbelief of some people is due to the fact that they have been exposed to inadequate evidence for the existence of a God or gods, or that they have been influenced by other factors that have led them to reject belief in a God or gods. However, this response does not address the central claim of the argument, which is that the existence of widespread nonbelief is incompatible with the existence of a God or gods who desire for all people to believe in their existence.

Another response to the argument is to claim that the existence of nonbelief is simply a result of the free will of human beings, and that a God or gods have given people the choice to believe or not believe in their existence. However, this response raises the question of why a God or gods would give people the choice to reject belief in their existence, if they desire for all people to believe in their existence.

## The Moral Argument Against God

The **moral argument against God** is an argument that seeks to show that the existence of God is incompatible with certain moral truths or values. This argument is based on the observation that certain moral truths or values,

such as the inherent value of human life or the wrongness of causing unnecessary suffering, seem to be independent of God's will or command.

The argument goes as follows:

- Premise 1: if God exists, then God is the ultimate source of moral truth and value.
- Premise 2: If God is the ultimate source of moral truth and value, then moral truths and values would be dependent on God's will or command.
- Premise 3: Some moral truths and values, such as the inherent value of human life or the wrongness of causing unnecessary suffering, do not seem to be dependent on God's will or command.
- Conclusion: It is unlikely that God exists.

There are various ways in which the moral argument against God can be formulated. One common variation of the argument is known as the **"argument from moral uncertainty"**, which focuses on the apparent lack of certainty about moral truths or values. This variation of the argument suggests that if God exists and is the source of moral truth and value, then it would be reasonable to expect that people would have more certainty about moral truths and values. However, the fact that people have significant disagreements about moral truths and values suggests that either God does not exist, or that moral truths and values are not dependent on God's will or command.

A closely related concern concerns the fact that religious believers have often done things that are clearly immoral (as have non-believers), and God hasn't "corrected" them. For example:

The Holocaust: The Holocaust was a genocide that was committed by the Nazi regime during World War

- The Crusades: The Crusades were a series of military campaigns that were conducted by Christian powers in the 11th and 12th centuries, with the goal of recapturing the Holy Land from Muslim control. The Crusades resulted in the deaths of many thousands of people, and were justified by Christian leaders based on their belief in the superiority of the Christian faith and their desire to spread Christianity.
- The Boko Haram Insurgency: The Boko Haram insurgency is a violent extremist movement that is active in Nigeria and neighboring countries, with the goal of establishing an Islamic state based on their interpretation of sharia law. The Boko Haram insurgency has resulted in the deaths of many thousands of people, and has been justified by its leaders based on their belief in the superiority of their interpretation of Islam and the need to impose their beliefs on others.
- The 2002 Gujarat violence: The 2002 Gujarat violence was a series of communal riots that took place in the Indian state of Gujarat in 2002, in which more than 1,000 people were killed, most of them Muslims. The violence was motivated by the beliefs of some Hindu nationalist groups, who believed that Muslims had attacked a train carrying Hindu pilgrims and that Hindus needed to defend themselves and their faith. The violence was also justified by some Hindu leaders, who cited religious texts and traditions as justification for the attacks on Muslims.

**Criticisms**

One way to respond to this argument is to claim that moral truths and values are not dependent on God's will or command, but rather are grounded in God's nature. According to this view, God is the source of moral truth and value because God is a perfectly good and moral being, and moral truths and values reflect God's nature. However, this response does not address the central claim of the argument, which is that some moral truths and values do not seem to be dependent on God's will or command.

Another response to the argument is to claim that moral truths and values are dependent on God's will or command, but that this dependence is not a problem because God's commands are perfectly good and moral. According to this view, the fact that moral truths and values are dependent on God's will or command does not make them arbitrary or subject to change, because God's will is perfectly good and moral. However, this response raises the question of why God's commands should be considered inherently good or moral, if they are not grounded in something other than God's will or command.

## QUESTIONS

1. What is the problem of evil, and what are some different ways of framing and understanding this problem?
2. What are the main arguments for and against the existence of God based on the problem of evil?
3. How does the argument from non-belief challenge the idea of an all-knowing, all-powerful God?
4. What are some criticisms of the argument from non-belief, and how do its proponents respond to these criticisms?
5. What is the moral argument against God, and how does it challenge the idea of a morally good God?
6. What are some criticisms of the moral argument against God, and how do its proponents respond to these criticisms?

## Case Study: Why Do We Believe?

Psychologists, philosophers, and sociologists have offered various explanations for why people are religious, drawing on a range of theories and research methods. Here are some examples of psychological and sociological accounts of why people are religious:

- Evolutionary psychology: Evolutionary psychologists argue that religion has evolved as a response to the challenges and opportunities of the human environment. They suggest that religious beliefs and practices are adaptations that have helped humans to survive and reproduce, and that religious beliefs have been selected for because they provide psychological benefits, such as comfort, security, and social support.
- Cognitive psychology: Cognitive psychologists argue that religious beliefs are the result of cognitive biases and processes that are inherent in the human mind. They suggest that humans have a natural tendency to attribute agency to natural phenomena, and that this tendency leads to the development of religious beliefs. They also argue that humans have a natural tendency to seek meaning and coherence in their beliefs, and that this tendency leads to the development of religious systems and traditions.
- Functionalism: Functionalist sociologists argue that religion serves a number of important functions in society. They suggest that religion provides a sense of meaning and purpose, and helps individuals to cope with the challenges and uncertainties of life. They also argue that religion provides social cohesion and solidarity, and helps to maintain social order and stability.
- Marxism: Marxist sociologists and philosophers argue that religion is a product of the economic and social conditions of a given society. They suggest that religion is a form of ideology, and that it serves the interests of the ruling class by providing a justification for their power and privilege. They also argue that religion is used to obscure the underlying economic and social structures of society, and to divert attention away from the material conditions of life.
- Existentialism: Existentialist philosophers argue that religion is a response to the human experience of meaninglessness and absurdity. They suggest that humans are confronted with the fact that the universe is meaningless and purposeless, and that their own lives are short and fragile. In response to this experience, they argue that humans often turn to religion as a way to find meaning and significance, and to give their lives a sense of purpose and direction.

### Question

1. Which of these accounts do you find most persuasive? Why?
2. Which do you find least persuasive? Why?
3. What role does "logic" and "reason" play in religious beliefs, according to these accounts?
4. Besides the ideas here, how might we account for religious beliefs?

## Key Concepts

**Argument from Design (Teleological Argument)--**The argument from design is a philosophical argument for the existence of God that is based on the observation of order, purpose, and design in the natural world. The argument asserts that the complex and purposeful nature of the universe and living things can only be explained by the existence of a conscious and intelligent creator.

**Argument from Nonbelief (Hiddeness of God)--**The argument from nonbelief, also known as the hiddenness of God, is a philosophical argument against the existence of God that is based on the idea that if God exists, he should be more clearly present and evident in the world. The argument asserts that the absence of clear evidence for the existence of God suggests that God does not exist.

**Argument From Religious Experience--**The argument from religious experience is a philosophical argument for the existence of God that is based on personal experiences of the divine. The argument asserts that individuals can have direct, personal experiences of God through religious practices such as prayer and meditation, and that these experiences provide evidence for the existence of God.

**Cosmological Argument--**The cosmological argument is a philosophical argument for the existence of God that is based on the concept of causality. The argument asserts that everything that exists must have a cause, and that the ultimate cause of all things must be an uncaused cause, or a first cause, which is God.

**God (Abrahamic Conception)--**The Abrahamic conception of God refers to the understanding of God in classical Judaism, Christianity, and Islam. According to this conception, God is the ultimate cause of all things, a being who is necessary for the existence of everything else. God is understood to be the source of all being, the foundation of all reality, and the source of all truth. God is all-good, all-knowing, and all-powerful.

**Ontological Argument--**The ontological argument is a philosophical argument for the existence of God that is based on the concept of being. The argument asserts that the concept of God, as a perfect and necessary being, must exist in order for the concept to have any meaning.

**Pascal's Wager--**Pascal's wager is a philosophical argument for belief in God that is based on the idea that it is rational to believe in God even if there is no conclusive evidence for or against his existence. The argument asserts that the potential rewards of believing in God (such as eternal life) outweigh the potential risks of not believing in God, even if it is uncertain whether God actually exists.

**Problem of Evil--**The problem of evil is a philosophical problem that arises when trying to reconcile the existence of suffering and evil in the world with the belief in a benevolent and all-powerful God. The problem is often used as an argument against the existence of God, as it seems difficult to explain how a loving and all-powerful God could allow suffering and evil to exist.

## Exercises: The Flying Spaghetti Monster

According to the beliefs of a newly encountered alien civilization, the Flying Spaghetti Monster is an all-powerful and all-knowing deity that is neither completely good nor completely evil. It is said to have created the universe and all of its inhabitants, though it does not always intervene in the affairs of mortals. Its interests are strange and mysterious, often driven by whimsical desires or capricious moods. Its appearance is often described as a giant, twirling mass of spaghetti, topped with two eyes and a pair of meatballs. It has an insatiable appetite for pasta dishes and beer.

There is an on-going debate between the logicians in this civilization over whether the Flying Spaghetti monster really exists. They have invited you—an Earthling with no stake in the debate—to review the following arguments.

*Directions:* Please say whether each argument is successful, and explain why in as much detail as possible.

Answers to selected exercises can be found in the appendix.

**Arguments For**

1. I believe in the flying spaghetti monster because the universe displays evidence of complex design, and only a really smart and creative deity could have come up with this stuff. When I look at the natural world, I see all kinds of amazing things, like rainbows, sunsets, and puppies. And these things are even more amazing when you consider that the flying spaghetti monster created them all while eating a big bowl of spaghetti and drinking a cold beer. That's some serious creativity and intelligence right there.
2. I believe in the flying spaghetti monster because I have had personal encounters with this deity, and I can tell you that it is awesome. I have had visions and dreams in which the flying spaghetti monster has appeared to me, and it always looks super cool, with its long noodly arms and its big googly eyes. And it always has a

big smile on its face, like it's happy to see me and wants to hang out. Plus, it always smells like marinara sauce and hops, which is a really nice combination.

3. I believe in the flying spaghetti monster because I have seen the positive effects of faith in the flying spaghetti monster in my own life and in the lives of others. I have experienced the comfort, strength, and peace that come from believing in the flying spaghetti monster, and I have seen the same benefits in others who also believe. This personal experience has convinced me that the flying spaghetti monster is real, and that it has the power to transform and enrich human lives, especially if you add some grated Parmesan cheese and a nice Chianti.
4. I believe in the flying spaghetti monster because it is a belief that I hold deeply and sincerely, and I just can't imagine life without it. I have considered the arguments against the existence of the Flying Spaghetti Monster, and I have found them to be kind of lame and boring. I have also considered alternative beliefs, but none of them have made me want to dance and sing and twirl my noodly appendages like my belief in the Flying Spaghetti Monster does. This personal conviction has convinced me that the Flying Spaghetti Monster is real, and that it is the most fun and satisfying belief for me.
5. I believe in the Flying Spaghetti Monster because it is the only deity that truly understands my love for pasta and beer. I mean, come on, who else would create a world where you can enjoy a delicious plate of linguini with clam sauce and a cold pint of IPA at the same time? Only the Flying Spaghetti Monster, that's who. And that, to me, is proof enough of its existence and its divine wisdom.
6. I believe in the Flying Spaghetti Monster because it is the only deity that truly embraces the absurdity of existence. I mean, think about it, the universe is a pretty weird and random place, and only a deity as silly and unpredictable as the Flying Spaghetti Monster could have created it. And that, to me, is a sign of its greatness and its power, because it shows that the Flying Spaghetti Monster is not afraid to be ridiculous and to have fun.
7. I believe in the Flying Spaghetti Monster because it is the only deity that offers redemption and forgiveness for my sins. I mean, let's face it, I've made some mistakes in my life, and I'm not always the nicest or most virtuous person. But the Flying Spaghetti Monster doesn't judge me or hold a grudge. It just loves me for who I am, and it gives me the opportunity to start over and to live a better life. And that, to me, is proof enough of its existence and its grace.

**Arguments Against**

8. I don't believe in the flying spaghetti monster, because there's no empirical evidence that such a creature exists. People may claim to have seen the flying spaghetti monster, but these claims are just stories and can't be verified by science. Plus, I have never seen the flying spaghetti monster, and I don't think anyone else has either. So either the flying spaghetti monster is really good at hiding, or it's just a figment of people's imaginations.
9. I don't think the flying spaghetti monster exists, because there's no logical necessity for such a creature to exist. Some people argue that the complexity of the universe requires an intelligent designer, but that doesn't necessarily mean that the designer is a flying spaghetti monster. I mean, come on, why would the universe be created by a giant noodle-like creature that loves pasta and beer? That just doesn't make any sense to me.
10. I don't find the idea of the flying spaghetti monster very convincing, because it doesn't really explain anything. Some people say that the flying spaghetti monster explains the origins of the universe or the nature of human morality, but these explanations are just made up on the spot and don't have any predictive or explanatory power. Plus, the idea of a giant noodle-like creature creating the universe and giving us morals seems pretty absurd to me, and I don't think it provides any useful or meaningful insights. I mean, if the flying spaghetti monster is all-powerful and all-knowing, why doesn't it just explain things in a way that we can understand?
11. I don't believe in the flying spaghetti monster, because there are so many different religious beliefs in the world. Some people believe in the flying spaghetti monster, but others believe in different gods or spiritual entities. This diversity of beliefs suggests that the existence of the flying spaghetti monster is a matter of personal interpretation, not of objective truth. And since personal interpretation can vary widely, I think it's reasonable to be agnostic or skeptical about the existence of the flying spaghetti monster. I mean, if the flying spaghetti monster is real, why does it inspire such different beliefs in different people?
12. There are other explanations for the apparent design in the universe that don't require the existence of an all-powerful, all-knowing Flying Spaghetti Monster. For example, the universe could be the result of natural processes, rather than being designed by a being.

13. Believers in the all-powerful, all-knowing Flying Spaghetti Monster don't seem to have a consistent or coherent belief system. They often make contradictory claims about the nature of the universe and the role of the Flying Spaghetti Monster in it.
14. I have never heard of any verifiable predictions or testable claims made by believers in the all-powerful, all-knowing Flying Spaghetti Monster. If such a being existed and wanted people to believe in them, wouldn't they provide some way to test their existence?

**Arguments for Withholding Judgement**

15. The scientific community has yet to provide concrete evidence for the existence of the Flying Spaghetti Monster, but that doesn't mean it doesn't exist. Who's to say that traditional methods of scientific inquiry are the only way to understand the world?
16. The fact that the Flying Spaghetti Monster is said to have an insatiable appetite for pasta and beer is actually quite endearing. Who doesn't love a deity that enjoys the finer things in life?
17. The idea that the Flying Spaghetti Monster created the universe and all of its inhabitants is certainly intriguing. If it's true, it would mean that there's more to the world than what we currently understand.
18. Some might argue that the Flying Spaghetti Monster's unusual appearance is a sign of its divine powers. After all, who's to say what a deity should look like?
19. The Flying Spaghetti Monster's capricious nature and strange desires could be seen as evidence of its otherworldly nature. It's not bound by the same rules and conventions that govern the rest of the universe.
20. There have been countless reports of people claiming to have had encounters with the Flying Spaghetti Monster. While it's difficult to verify these stories, it's still worth considering the possibility that they could be true.
21. In the end, it's important to keep an open mind and not dismiss the possibility of the Flying Spaghetti Monster's existence out of hand. Who knows what mysteries the universe holds? It could very well be that the Flying Spaghetti Monster is one of them.

# CHAPTER 6: MORAL REASONING

In this chapter on moral reasoning, we will explore different ethical theories and their implications for moral decision-making. We will start by examining ethical egoism, the idea that the right action is the one that maximizes our own self-interest. We will then look at cultural relativism, the belief that moral truths are relative to culture. Next, we will examine divine command theory, which holds that actions are right or wrong based on whether they are commanded by God. We will also delve into utilitarianism, the belief that actions should be evaluated based on their ability to maximize happiness or well-being for the greatest number of people. Additionally, we will explore Kantian deontology, which holds that moral actions should be guided by universal moral duties or rules. We will also examine virtue ethics, which emphasizes the role of character in determining moral actions, and ethical pluralism, the idea that multiple ethical theories can be applied in different situations. Finally, we will learn about John Rawls' influential theory of justice. Understanding these different approaches to moral reasoning is important for developing our critical thinking skills and making ethical decisions in our own lives.

Now, let's meet Master Forest and Master River, who will help get us in the right frame of mind.

## SWINE OR DIVINE: A ZEN MASTER'S DISCOURSE

Master Forest: Greetings, Master River. It is a pleasure to meet you.

Master River: Greetings, Master Forest. The pleasure is mine.

Master Forest: I have been thinking about the ethics of eating pigs. Do you have any thoughts on this topic?

Master River: Yes, I have some thoughts on this topic. I think that whether it is OK to eat pigs depends on our perspective and our values.

Master Forest: Can you explain further?

Master River: I think that if we see pigs as food sources, we may view eating them as a natural and necessary part of our diet. We may think that it is OK to eat pigs as long as we treat them humanely and respect their lives. We may think that it is not necessary to eliminate pork from our diet, because pigs can be raised and slaughtered in ways that minimize their suffering and maximize their health.

Master Forest: That is a common perspective. But if we see pigs as sentient beings with their own desires and feelings, we may view eating them as a moral problem. We may think that it is not OK to eat pigs because it causes suffering and death. We may think that it is not acceptable to cause unnecessary harm to another being, even if that being is not a human.

Master River: That is true. And if we see pigs as fellow beings who share the same world and the same destiny as us, we may view eating them as a spiritual problem. We may think that it is not OK to eat pigs because it separates us from the natural order and the cosmic harmony. We may think that it is important to cultivate a sense of interconnectedness and compassion towards all beings, and that eating pork is incompatible with this attitude.

Master Forest: I see. In this way, the ethics of eating pigs is not a simple or straightforward issue. It depends on how we view the world and the beings that live in it. It depends on our values and our goals. And if we are willing to explore these questions deeply and honestly, we may discover a deeper truth and a greater wisdom.

Master River: Yes, exactly. The ethics of eating pigs is not a problem to be solved. It is a question to be explored. It is a challenge to our assumptions and our beliefs. And if we are willing to face this challenge, we may find a path that leads us to a more compassionate and harmonious way of living. We may find that reducing or eliminating pork from our diet is a small but significant step towards creating a more peaceful and respectful relationship with the natural world and the beings that inhabit it.

### QUESTIONS

1. What are the potential ethical concerns about eating pigs?
2. How might our values and goals influence our decisions about whether to eat pork?
3. In what ways can exploring the ethics of eating pigs lead us to a deeper understanding of our relationship with the natural world and other beings?

4. How might different cultural or societal values affect our views on the ethics of eating pigs?
5. The issue of "should we eat pigs?" is used as example of a question people have often disagreed on. What other sorts of ethical issues interest you?

## Introduction

In this chapter, we'll explore seven approaches to ethical reasoning:

**Ethical egoism** holds that a morally right action is the one that maximizes the agent's own long-term self-interest.

**Cultural relativism** holds that moral rules and values are not universal, but are relative to the culture or society in which they are found.

**Divine command theory** holds that moral rules are derived directly from the commands of a deity or divine being.

**Utilitarianism** emphasizes the importance of maximizing overall happiness or well-being, and suggests that the morally right action is the one that maximizes total happiness (or minimizes total suffering).

**Kantian Deontology** emphasizes the importance of the importance of respecting the "dignity" of others and in not using them as mere "tools" for your own ends.

**Virtue ethics** focuses on the character of the moral agent, and emphasizes the importance of developing good character traits, such as honesty, compassion, and courage. It closely related to the theories of **care ethics** and **natural law theory.**

**Pluralism** holds that there are multiple moral principles or approaches that can be used to guide moral decision-making, and that no single ethical theory (by itself) is sufficient to capture the complexity of moral experience.

The goal of this chapter isn't to determine which approach is uniquely "correct" (though we will note strengths and weaknesses of each). Instead, we'll be considering these different theories as *tools* to help understand and respond to ethical arguments in a productive way (and to hopefully make some cogent ethical arguments of our own!).

## Ethical Egoism

**Ethical egoism** is a type of ethical theory that holds that the moral action is the one that maximizes the agent's own self-interest. In other words, according to ethical egoism, an action is morally right if it benefits the person who performs it, regardless of whether it benefits anyone else.

One example of how ethical egoism might apply to a practical issue is in the context of career choices. According to ethical egoism, the right career choice is the one that will provide the most benefits to the individual, regardless of whether it benefits society or other people. For instance, a person might choose to become a doctor (or a supervillain!) because it will provide them with a high salary, rather than because it will help people. As a doctor, they will do the "minimal" amount needed to maintain this salary, even if this hurts their patients.

Another example of ethical egoism in practice is in the context of personal relationships. According to this theory, the right way to behave in a personal relationship is to do whatever will benefit the individual, even if it harms the other person. For instance, a person might choose to cheat on a romantic relationship because they want to, even if it causes pain to the other person (and perhaps others, if there are children).

A third example of ethical egoism is in the context of charitable giving. According to this theory, the right amount of charitable giving is whatever amount will provide the most benefit to the individual, regardless of the impact on others. For instance, a person might choose to give a small amount to charity because they want to impress others, rather than because it will help people in need.

Despite its apparent simplicity, most philosophers reject ethical egoism as a viable ethical theory. This is because ethical egoism is often seen as being self-defeating, since it requires people to act in their own self-interest, but if everyone acted solely in their own self-interest, society would be chaotic and no one would be better off.

Additionally, ethical egoism is often criticized for ignoring the moral value of other people's well-being, and for failing to provide a basis for moral duties or obligations to others.

### Questions

1. What are some potential problems with ethical egoism as a moral theory?
2. What are some potential consequences of adopting an ethical egoist approach to moral decision-making?
3. Can you think of any ways in which ethical egoism might be useful or helpful in guiding moral decision-making, even if it is not a complete moral theory?
4. In what ways, if any, do you think that ethical egoism might be compatible with the idea of moral duties or obligations to others?

## Cultural Relativism

**Cultural relativism** is a type of ethical theory that holds that moral rules and values are not universal, but are relative to the culture or society in which they are found. In other words, according to cultural relativism, there is no objective or inherent moral truth, and what is considered morally right or wrong is determined by the cultural norms and beliefs of a particular society.

One example of how cultural relativism might apply to a practical issue is in the context of human rights. According to this theory, the concept of human rights is not universal or inherent, but is relative to the culture in which it is found. For instance, a society that practices slavery might not consider it to be a violation of human rights, because it is part of their cultural norms and values.

Another example of cultural relativism in practice is in the context of gender roles. According to this theory, the roles and expectations for men and women are not universal or inherent, but are determined by the culture in which they are found. For instance, a society that practices female genital mutilation might not consider it to be a violation of women's rights, because it is part of their cultural norms and values.

A third example of cultural relativism is in the context of moral education. According to this theory, moral education should not be based on universal moral truths, but should be tailored to the cultural norms and values of the society in which it is found. For instance, a school in a society that values obedience and respect for authority might emphasize these values in its moral education, while a school in a society that values individual freedom and autonomy might emphasize these values instead.

While it has some "popular" appeal as a way of recognizing and respecting cultural diversity, most scholars reject cultural relativism as a viable ethical theory. This is because cultural relativism is often seen as being self-defeating, since it implies that there is no objective moral truth, and therefore no basis for criticizing or condemning the moral beliefs of other cultures (or, for that matter, of our own culture!). Additionally, cultural relativism is often criticized for ignoring the inherent moral value of certain actions, such as genocide or slavery, and for failing to provide a basis for moral progress or improvement.

### Questions

1. What are some examples of how cultural relativism might apply to practical issues, such as human rights and gender roles?
2. What are some criticisms of cultural relativism, and how might proponents of the theory respond to these criticisms?
3. In what ways does cultural relativism recognize and respect cultural diversity, and in what ways does it ignore or downplay the inherent moral value of certain actions?
4. Can cultural relativism provide a basis for moral progress or improvement, or does it imply that moral beliefs are fixed and unchanging within a particular culture?

## Divine Command Theory

**Divine command theory** is a type of ethical theory that holds that moral rules are derived from the commands of a deity or divine being. In other words, according to divine command theory, an action is morally right if it is commanded by God, and morally wrong if it is forbidden by God. There is nothing else to morality than this.

One example of how divine command theory might apply to a practical issue is in the context of sexual morality. According to this theory, sexual behavior is morally acceptable if it is in accordance with the commands of God,

and morally wrong if it is prohibited by God. For instance, some religious traditions might consider premarital sex to be morally wrong because it is forbidden by God. By contrast, other religious traditions endorse polyamory, and some (especially historically) have endorsed things such as sex with children or the submission of women to men.

Another example of divine command theory in practice is in the context of criminal law. According to this theory, laws are morally just if they are in accordance with the commands of God, and morally unjust if they are not. For instance, some religious traditions might consider the death penalty to be morally acceptable because it is commanded by God, while others might consider it to be morally wrong because it is not mentioned in the Bible.

A third example of divine command theory is in the context of personal relationships. According to this theory, the right way to behave in a personal relationship is to follow the commands of God, even if it conflicts with one's own desires or the desires of others. For instance, a person might choose to forgive someone who has wronged them because it is commanded by God, even if it is difficult or painful to do so. Or, by contrast, they may feel that they are obligated to take "vengeance" on those who have "disrespected their religion."

## Criticisms

Despite its widespread appeal, most writers on ethics (both religious and secular) reject divine command theory as a viable ethical theory. This is because divine command theory is often seen as being arbitrary and subjective, since it depends on the commands of a particular religion-specific deity, and different religious traditions may have conflicting moral rules. Divine command theory, for example, makes it all but impossible for believers in different religions to "talk to" one another about important moral issues. Additionally, divine command theory is often criticized for ignoring the inherent moral value of actions, and for failing to provide a rational basis for moral decision-making.

One famous (and very old) argument against divine command theory is the **Euthyphro dilemma**. The dilemma is named after the dialogue "Euthyphro" by the ancient Greek philosopher Plato, in which the character Euthyphro argues that moral actions are those that are pleasing to the gods.

The Euthyphro dilemma begins with the character of Socrates posing the question: "Are actions morally good because they are commanded by God, or are they commanded by God because they are morally good?" In other words, does God command certain actions because they are already morally good, or do actions become morally good because they are commanded by God? It is a dilemma because theists (people who believe in God) must choose one of these "horns."

This dilemma causes problems for divine command theory because it suggests that moral rules either depend on the arbitrary will of God, or are independent of God's will. If moral rules depend on God's will, then the theory is arbitrary and subjective, since there is nothing to stop God from making lying, theft, and murder OK tomorrow. On the other hand, if moral rules are independent of God's will, then God turns out to irrelevant for morality, since moral rules can be understood without reference to a divine being.

One way to try to resolve the Euthyphro dilemma is to argue that moral rules are a reflection of God's nature, and that God commands certain actions because they are in accordance with his nature. This would mean that moral rules are not arbitrary or subjective, since they are derived from the nature of God, which is assumed to be consistent and unchanging. However, this solution raises its own problems, such as the question of how we can know the nature of God, and whether it is possible for God to act contrary to his nature. We'll explore this idea later when we come to **natural law theory** (a form of religious ethics that is distinct from divine command theory).

## Questions

1. What are some examples of how divine command theory might apply to practical issues, such as sexual morality and criminal law?
2. What is the Euthyphro dilemma, and how does it challenge divine command theory?
3. How might a proponent of divine command theory respond to the Euthyphro dilemma, and why might this response be inadequate or unconvincing?
4. What are the implications of divine command theory for interfaith dialogue and moral decision-making?

## UTILITARIANISM

**Utilitarianism** is a type of ethical theory that holds that an action is morally right if it produces the greatest amount of happiness or pleasure for the greatest number of people. In other words, according to utilitarianism, the moral value of an action is determined by its consequences, and the goal of moral decision-making is to maximize the overall happiness or well-being of society.

One example of how utilitarianism might apply to the moral status of animals is the question of animal rights. According to this theory, animals have moral value to the extent that they are capable of experiencing pleasure or pain. Therefore, actions that cause unnecessary suffering to animals, such as factory farming or unnecessary animal testing, would be considered morally wrong because they do not produce the greatest amount of happiness for the greatest number of beings. By contrast, actions that promote the well-being of animals, such as humane treatment and conservation, would be considered morally right because they contribute to the overall happiness of sentient creatures. Many utilitarians argue for veganism or related positions (such as eating only "humanely" raised animals).

Another example of utilitarianism in practice is in our duties to the poor. According to this theory, we have a moral obligation to help the poor because it promotes the overall happiness of society. For instance, actions such as donating to charity or volunteering time to help the disadvantaged would be considered morally right because they produce the greatest amount of happiness for the greatest number of people. By contrast, actions that ignore or exploit the poor, such as neglecting their needs or denying them access to resources, would be considered morally wrong because they do not contribute to the overall happiness of society. Some utilitarians, such as Peter Singer (probably the world's most famous living utilitarian) has argued that we have a duty to give *significant* amounts of money to aid the worst-off people (and animals of the world).

A third example of utilitarianism is in the context of abortion. According to this theory, the moral permissibility of abortion depends on its consequences for the happiness or well-being of all beings that are affected by the choice. For instance, some utilitarians might argue that abortion is morally permissible in cases where the mother's health or life is at risk, because it produces the greatest amount of happiness for the greatest number of people by preventing harm to the mother. By contrast, another utilitarian might argue that abortion is morally wrong in cases where the fetus is capable of experiencing pleasure or pain, because it does not produce the greatest amount of happiness for the greatest number of people by causing suffering to the fetus.

### CRITICISMS

While utilitarianism has some attractive features, it is not without its critics. One common criticism of utilitarianism is that it ignores the inherent moral value of individuals, and treats them as mere means to an end. For instance, a utilitarian might justify sacrificing the life of an innocent person in order to save the lives of many others, because it produces the greatest amount of happiness for the greatest number of people. This seems to violate our moral intuition that each person has inherent value that should not be sacrificed for the sake of others.

Another criticism of utilitarianism is that it is difficult or impossible to measure or compare the happiness or well-being of different individuals or groups. For instance, how do we compare the happiness of a person who is rich and healthy with the happiness of a person who is poor and sick? Or, how do we compare the happiness of humans with the happiness of animals? Without a way to measure or compare happiness, it is difficult to make moral decisions according to utilitarianism.

### QUESTIONS

1. What is the moral status of animals according to utilitarianism? Do you agree?
2. What are our duties to the poor according to utilitarianism? Do you agree?
3. What are some criticisms of utilitarianism? How might a utilitarian respond to these?
4. How do we determine which consequences are most likely to lead to the greatest amount of happiness for the greatest number of people?
5. How can we balance the interests of individuals with the interests of society as a whole?

## KANTIAN DEONTOLOGY

**Kantian deontology is** a type of ethical theory developed by the philosopher Immanuel Kant. It is based on the idea that the moral worth of an action is determined by the action's adherence to a moral law, and that the only truly good thing is a good will. Kant called this moral law the "**categorical imperative**."

The "Humanity" formulation of the categorical imperative is one of several different ways that Kant described the moral law. This formulation states that **we should always treat other people as ends in themselves, and never simply as means to an end**. In other words, we should never use other people for our own purposes, but instead respect their inherent dignity and autonomy.

As you'll recall, utilitarianism holds that the moral worth of an action is determined by whether it leads to the greatest amount of happiness for the greatest number of people. In contrast to Kantian ethics, utilitarianism is a consequentialist theory, which means that it focuses on the outcomes of an action rather than its intrinsic moral value.

One way that Kantian ethics might apply in a situation is in the decision to lie. Under Kantian ethics, it is never acceptable to lie, because lying involves using another person (the person being lied to) as a means to an end (achieving a personal goal through deception). In contrast, a utilitarian might argue that it is acceptable to lie if it leads to the greatest overall happiness. For example, a utilitarian might argue that it is acceptable to lie to a murderer in order to protect an innocent person, because this would lead to the greatest overall happiness.

Another application might be to a company considering whether to use a certain type of advertising that would be misleading to potential customers. Applying the Kantian "Humanity" formula, the company must consider whether this sort of advertising treats their customers as "ends in themselves" (who are rational beings capable of making their own choices, when given accurate information), or merely a means to an end (e.g., increasing sales). Since the advertising would involve using potential customers as *mere* means to an end (increasing sales), it would violate the Kantian formula and therefore should not be done. To be clear: there is nothing wrong with "honest" advertising or businesses aiming to make money—it's the dishonesty that is the problem here.

When it comes to the use of torture, Kant's Humanity formula states that torture is wrong because it violates the humanity of the person being tortured. The person being tortured is being treated as a means to an end, rather than as an end in itself. This is because the person's suffering is being used to achieve a certain goal, such as obtaining information or punishing a crime. In other words, the person is being used as a tool, rather than being treated as an individual with intrinsic value. Kant's Humanity formula would thus hold that torture is absolutely forbidden because it violates the humanity of the person being tortured. This differs from utilitarianism in that utilitarianism is based on the principle of maximizing happiness for the greatest number of people. Utilitarianism does not take into account the intrinsic value of individuals. For a utilitarian, the use of torture may be permissible if it produces the greatest amount of happiness for the greatest number of people (for example, we torture 1 person to save 5). However, for Kant, the use of torture is never permissible because it violates the intrinsic value of the person being tortured in a way that other punishments (such as jail time) do not.

### CRITICISMS

One criticism of Kantian deontology is that it is overly rigid. Kantian deontology claims that moral decisions should be based solely on the universal principle of the categorical imperative. This can lead to situations where moral decisions are made without any consideration for the actual consequences of those decisions (unlike utilitarianism!). For example, a Kantian deontologist might refuse to lie in all circumstances, even if the lie would help to prevent a terrible tragedy, because they believe that lying is wrong and that the categorical imperative prohibits it.

Another criticism of Kantian deontology is that it fails to provide sufficient guidance for moral decision-making. Kantian deontology only provides the categorical imperative, which can be difficult to apply in particular situations, leaving it up to the individual to decide how to interpret it. For example, a Kantian deontologist might struggle to decide whether or not it is permissible to steal medicine in order to save a life, because the categorical imperative does not provide clear guidance on this situation.

Finally, some have criticized Kantian deontology for being too individualistic. Kantian deontology focuses solely on the individual and their moral decisions, without considering how their actions affect others, or even how the individual happens to "feel" about them. This can lead to moral decisions that do not take into account the needs of others, or the wider implications of those decisions. For example, a Kantian deontologist might decide that it is permissible to pursue their own interests at the expense of others, because they believe that the categorical imperative does not "prohibit" such behavior.

### QUESTIONS

1. Can you give an example of how the "Humanity" formulation of the categorical imperative might be applied in a real-world situation?
2. How might a Kantian approach to decision-making differ from a utilitarian approach when it comes to issues such as lying and the use of torture?
3. How might the idea of treating others as ends in themselves apply to a company's decision to use misleading advertising?
4. How does Kantian deontology take into account the inherent dignity and autonomy of individuals?
5. Pretend for a moment you are a utilitarian. How might you object to Kantian ethics?

## VIRTUE ETHICS

**Virtue ethics** focuses on the character and habits of the moral actor, rather than on the consequences of their actions or the rules they follow. In contrast to utilitarianism, which evaluates actions based on their consequences and the greatest happiness for the greatest number of people, virtue ethics emphasizes the importance of developing good character traits and living a virtuous life as a means of achieving moral excellence.

Similarly, virtue ethics differs from Kantian deontology, which holds that the moral worth of an action is determined by whether it adheres to a moral duty or principle, regardless of its consequences. Virtue ethicists argue that the key to living a good life is to cultivate virtues, or good character traits, such as honesty, compassion, and fairness. These virtues enable us to make good decisions and behave in a moral manner. Importantly, we are not "born" virtuous. Rather, we become virtuous through regular practice (at first, guided by parents and teachers, but later by our own choices).

One of the central ideas in virtue ethics is that moral excellence is achieved through the development of virtues over time. For example, a person who consistently displays honesty, even when it is difficult or inconvenient, will eventually find that honesty becomes "second nature" for them, even in difficult situations. Similarly, a person who consistently displays compassion towards others will develop the capacity to be compassionate even toward those that might initially feel hatred/disgust toward.

Three examples of how virtue ethics might be used in everyday life include:

Parenting: A parent who wants to raise a child with strong moral character might focus on cultivating virtues such as kindness, empathy, and responsibility. For example, a parent might model compassionate behavior and encourage their child to volunteer at a local shelter or to help a neighbor in need. Similarly, the parent would need to think about what the virtues of a "good parent" are, and practice these until they are "second" nature.

Business ethics: A company that values virtues such as honesty, transparency, and fairness might adopt policies that reflect these values. For example, a company might have a strict code of conduct that prohibits discrimination and requires employees to report any unethical behavior they witness.

Personal relationships: A person who values virtues such as trustworthiness and loyalty might prioritize these virtues in their personal relationships. For example, a person might think hard about what it means to be a "good friend" or "good partner", and cultivate these virtues. Similarly, they might be careful in starting relationships with people in the first place, on the grounds that they want to be friends with those who can "help them be a better person" (and that they can help in turn).

Overall, virtue ethics emphasizes the importance of developing good character traits and living a virtuous life as a means of achieving moral excellence. By focusing on virtues, we can cultivate the habits and dispositions necessary to make good moral decisions and live a fulfilling and meaningful life.

### TWO VARIANTS: NATURAL LAW THEORY AND CARE ETHICS

Two influential variants of virtue ethics are natural law theory and care ethics**.** While they share the basic ideas of virtue ethics—that a good/ethical human life involves cultivating various virtues—they have somewhat different ideas about the nature and source of virtues.

**Natural law theory** is a moral theory that holds that the laws of nature dictate what is morally right and wrong. The most common version of natural law theory is the **Thomist** (from St. Thomas Aquinas) approach of the Catholic Church, which holds that these "laws of nature" are due to the nature of God and the world God created. According to natural law theory, humans can achieve their "purpose" in life by living in accordance with

the natural order and the innate tendencies of human nature. Natural law theory emphasizes the importance of cultivating virtues such as reason, justice, and fortitude, which enable us to live in accordance with the natural order and achieve "true" happiness and well-being.

**Care ethics**, also known as feminist ethics, is a moral theory that emphasizes the importance of caring for and about others. Care ethicists argue that the fundamental moral principle is the promotion of the well-being of others, and that this requires a focus on relationships, interdependence, and connection. Care ethicists emphasize the importance of virtues such as empathy, compassion, and responsibility,

### Criticisms

One criticism of virtue ethics is that it is too individualistic. Virtue ethics emphasizes the importance of cultivating personal virtues and character traits in order to lead a good life. However, this focus on the individual may ignore the social and cultural factors that shape a person's character and may lead to an emphasis on personal responsibility rather than addressing systemic issues. Virtue ethics by itself has little to say on questions like "Do people have a right to universal health care?" or "Under what conditions should abortion be legal?"

Another criticism of virtue ethics is that it can be difficult to determine what the specific virtues are and how they should be cultivated. Different philosophical traditions have identified different virtues, and there is often disagreement about which virtues are most important and how they should be prioritized. This lack of consensus can make it difficult to apply virtue ethics in practical ethical decision-making. For example, classical Greek virtue ethics (from Aristotle) and classical Chinese virtue ethics (from Confucius) are very different from religious versions of "natural law theory" or feminist-based "care ethics".

A third criticism of virtue ethics is that it may not be well-suited to addressing complex moral dilemmas. Virtue ethics emphasizes the importance of character and personal responsibility, but it may not provide clear guidance on how to address moral problems that involve multiple conflicting virtues or that involve issues of justice or fairness. This lack of a clear moral framework can make it difficult to use virtue ethics to guide decision-making in complex moral situations. By contrast, the some-times rigid "rules" of utilitarianism or Kantian ethics might do better.

### Questions

1. How does virtue ethics differ from utilitarianism and Kantian deontology in terms of evaluating moral actions?
2. Can you provide an example of how virtue ethics might be applied in parenting, business ethics, or personal relationships?
3. How does natural law theory differ from other versions of virtue ethics in terms of the source and nature of virtues?
4. In what ways does care ethics differ from other versions of virtue ethics in terms of the focus and emphasis of virtues?
5. How might the concept of living a "fulfilling and meaningful life" be understood within the framework of virtue ethics?

## Ethical Pluralism

**Ethical pluralism** is the idea that there is no one "correct" ethical theory or framework that can be universally applied to all moral dilemmas. Instead, different ethical theories may be more or less appropriate in different situations.

As you'll recall, utilitarianism is an ethical theory that holds that the right action is the one that maximizes overall happiness or well-being for all affected parties. A person might use utilitarianism to make decisions about how to allocate resources in a charitable organization, for example, by trying to determine which interventions will do the most good for the most people. For example, they might prioritize giving aid to people in the poorest parts of the world (for things like vaccines, malaria nets, or clear drinking water) rather than to institutions in the rich world (such as hospitals, universities, churches, or political parties).

Kantian deontology, meanwhile, emphasizes the importance of upholding moral duties and rules, regardless of the consequences. A person might use Kantian deontology in their professional relationships, for example, by consistently keeping their promises and respecting the autonomy of others, even if doing so might be

inconvenient or bring about negative consequences. They would take care to avoid "exploiting" coworkers, customers, patients, or students even it seemed like utilitarianism might justify it.

Finally, virtue ethics is an ethical theory that focuses on the character and habits of the moral agent, rather than on rules or consequences, as the key element of ethical thinking. A person might use virtue ethics in their personal relationships, striving to develop the virtues necessary to be a better parent, child, sibling, friend, or romantic party. The idea might here be that these sorts of relationships shouldn't be built on the hard-and-fast "rules" that characterize Kantian and utilitarian ethics.

Like any approach, ethical pluralism has been criticized for various reasons:

*Lack of coherence:* Some critics argue that ethical pluralism is internally inconsistent, as it suggests that there is no single correct ethical theory, but also that certain ethical theories may be more appropriate in certain situations. This seems to suggest that there is a "correct" ethical theory after all, which goes against the core principle of pluralism.

*Lack of guidance:* Others argue that ethical pluralism offers too little guidance on how to make moral decisions, as it leaves the decision-maker to choose which ethical theory to apply in a given situation. This can lead to confusion and inconsistency in ethical decision-making.

*Unprincipled:* Some argue that ethical pluralism is unprincipled, as it allows for the use of any ethical theory in any situation, regardless of whether it is logically consistent or morally defensible. This could lead to the use of unethical or morally questionable theories in certain situations.

Overall, while ethical pluralism allows for a degree of flexibility in moral decision-making, it is not without its criticisms and limitations.

### QUESTIONS

1. Do you agree with the idea of ethical pluralism, or do you think there is a single "correct" ethical theory that should be universally applied? Why or why not?
2. In what situations do you think utilitarianism might be the most appropriate ethical framework to use? What about Kantian deontology or virtue ethics?
3. How might ethical pluralism be applied in a professional context, such as in a business or government organization? Do you think it would be effective in this context, or do you think it would lead to confusion and inconsistency?
4. Do you think ethical pluralism allows for too much flexibility in moral decision-making, or do you think it strikes a good balance between flexibility and guidance? Why?

## MINDS THAT MATTERED: JOHN RAWLS

John Rawls (1921-2002) was an American philosopher and political theorist who is best known for his work on justice and fairness. He is generally considered the most important writer on ethics for the last 200 years. Rawls' ideas about justice were heavily influenced by the **social contract tradition (**the idea that ethical rules are those we would all "agree" to, in ideal circumstances), and he is perhaps most famous for his concept of the "original position" and the "veil of ignorance."

The **original position** is a thought experiment that Rawls developed to help determine what principles of justice would be chosen by rational, self-interested individuals in an idealized, hypothetical situation. In the original position, individuals are assumed to be behind a "**veil of ignorance**" that prevents them from knowing anything about their own personal characteristics, such as their race, gender, social class, or natural abilities. From this position of ignorance, they must choose the principles that will govern the distribution of rights and privileges in the society they will live in.

According to Rawls, the principles chosen in the original position would be ones that are fair to everyone, regardless of their individual characteristics. This idea is known as "**fair opportunity**," and it means that everyone should have an equal chance to succeed and thrive, regardless of their background or circumstances.

One of the principles that Rawls argued would be chosen in the original position is the "**difference principle**," which states that social and economic inequalities should be arranged so that they are to the greatest benefit of

the least advantaged members of society. This principle is meant to ensure that the most disadvantaged members of society are not left behind or excluded from the benefits of society.

Finally, Rawls argued that our moral beliefs should be in "**reflective equilibrium**," meaning that they should be consistent with each other and with our considered moral judgments about specific cases. In other words, our moral beliefs should be both coherent and grounded in our everyday moral experiences.

Overall, Rawls' ideas about justice and fairness have had a significant impact on political philosophy and continue to be widely debated and discussed by philosophers and policymakers today.

### QUESTIONS

1. In Rawls' original position thought experiment, individuals are assumed to be behind a "veil of ignorance" that prevents them from knowing anything about their own personal characteristics. How do you think this veil of ignorance would affect the principles that individuals might choose to govern the distribution of rights and privileges in society? Do you think this thought experiment accurately reflects how people should make moral decisions? Why or why not?
2. Rawls argued that the principles chosen in the original position would be ones that are fair to everyone, regardless of their individual characteristics. How might this principle of "fair opportunity" be applied in the context of education or employment? Do you think it is fair to have different educational or job opportunities based on factors such as race, gender, or social class? Why or why not?
3. The "difference principle" states that social and economic inequalities should be arranged so that they are to the greatest benefit of the least advantaged members of society. How might this principle be applied in the context of healthcare or poverty reduction? Do you think it is fair for the government to redistribute wealth in order to benefit the most disadvantaged members of society? Why or why not?
4. Rawls argued that our moral beliefs should be in "reflective equilibrium," meaning that they should be consistent with each other and with our considered moral judgments about specific cases. How might the principle of reflective equilibrium be applied to the ethical dilemma of abortion? Do you think it is possible to have a coherent moral stance on abortion that is consistent with our considered moral judgments about specific cases? Why or why not?

## KEY CONCEPTS

**Ethical Egoism--**A moral theory that holds that the moral value of an action is determined by its ability to promote the agent's own self-interest. Ethical egoism asserts that actions are morally right to the extent that they benefit the agent, and that it is morally permissible to pursue one's own self-interest.

**Divine Command Theory--**A moral theory that holds that the moral value of an action is determined by whether it is commanded by God. According to this theory, actions are morally right or wrong based on whether they are in accordance with God's commands, and the moral value of an action is independent of its consequences.

**Cultural Relativism--**A moral theory that holds that the moral values and beliefs of a culture should be understood in the context of that culture and should not be judged by the standards of other cultures. According to cultural relativism, moral truths are relative to the cultural context in which they exist, and there is no objective, universal moral standard that can be applied to all cultures.

**Euthyphro Dilemma--**A philosophical problem that arises in the context of the divine command theory. The dilemma asks whether an action is morally right because it is commanded by God, or whether it is commanded by God because it is morally right. This dilemma suggests that it is difficult to reconcile the idea that the moral value of an action is determined by God's commands with the idea that there is a separate, objective moral standard that exists independently of God.

**Natural Law Theory—**A moral theory that holds that the moral values and principles of a society should be based on the inherent qualities of human nature. According to natural law theory, there are certain natural laws

that are universal and that can be discovered through reason, and these natural laws should serve as the basis for moral decision-making.

**Kantian Deontology--**A moral theory developed by philosopher Immanuel Kant that holds that the moral value of an action is determined by whether it is in accordance with the moral rules or duties that we have. According to Kant, there are certain moral rules or duties that are universal and that can be determined through reason, and the moral value of an action is determined by whether it is in accordance with these moral rules.

**Categorical Imperative (Humanity Formula)--**A concept in Kantian deontology that refers to a moral rule or duty that is universal and applies to all people in all circumstances. The humanity formula of the categorical imperative states that we should always treat people as ends in themselves, rather than simply as means to an end.

**Utilitarianism (Act)--**Utilitarianism is a moral theory that holds that the moral value of an action is determined by its ability to produce the greatest amount of overall happiness or pleasure. According to act utilitarianism, the moral value of an action is determined by the consequences of that specific action, and the moral rightness of an action is determined by its ability to produce the greatest overall happiness or pleasure.

**Utilitarianism (Rule)--**A variation of utilitarianism that holds that the moral value of an action is determined by its conformity to a rule that leads to the greatest overall happiness or pleasure. According to rule utilitarianism, the moral value of an action is determined by the consequences of following a certain rule, and the moral rightness of an action is determined by its ability to promote the greatest overall happiness or pleasure when followed as a rule.

**Virtue Ethics--**A moral theory that emphasizes the character and habits of the moral actor, rather than rules or consequences, as the key element of ethical thinking. According to virtue ethics, being a good person involves cultivating good habits and virtues, such as honesty, kindness, and compassion, and living a life that exemplifies these virtues.

**Care Ethics--**A moral theory that emphasizes the importance of caring and relationships in moral decision-making. According to care ethics, moral actions are those that involve showing care and concern for others, and moral decision-making should involve considering the needs and well-being of those affected by the decision.

**Ethical Pluralism--**The idea that there is no one, single moral theory or approach that can fully capture the complexity of moral experience. Ethical pluralism suggests that different moral theories and approaches can be valid and useful in different contexts, and that it is important to consider a range of moral perspectives when making moral decisions.

**Original Position (Rawls)—**A concept in the moral theory of John Rawls, which is a thought experiment used to determine the principles of justice that would be chosen by rational actors in a hypothetical situation. In the original position, individuals are assumed to be rational and to have certain moral and philosophical values, but are ignorant of their own specific identities and circumstances.

**Difference Principle (Rawls)—**A principle of justice proposed by John Rawls in his theory of justice as fairness. The principle states that social and economic inequalities are justifiable only if they are to the benefit of the least advantaged members of society.

**Reflective Equilibrium (Rawls)--**A concept in the moral theory of John Rawls that refers to the process of revising and adjusting one's moral beliefs in light of new information or experiences. In reflective equilibrium, individuals consider their moral beliefs in relation to their moral experiences and the moral principles that they accept, and revise their beliefs as needed in order to achieve a coherent and consistent moral system.

## EXERCISES: MORAL THEORIES

Identify which ethical theory (or combination of theories) best captures the "reasoning" behind each of the arguments. Then, offer an analysis of the argument: What is the conclusion? Is the argument strong? Are the premises true? What sorts of evidence might have been overlooked?

*Note:* Choose ONE area to look at, as this will allow you think "in depth" about how different ethical theories can be applied to the "same problem."

Answers to selected exercises can be found in the appendix.

**Gun Control:**

1. We should support gun control as it is an expression of respect for the dignity of others. By controlling access to guns, we can help protect the lives and safety of our fellow citizens, and respect their right to live free from the threat of gun violence.
2. Gun rights are given to us directly by God. The Bible, for example, explicitly states that "he who has no sword, let him sell his garment and buy one." (Luke 22:36). Furthermore, the Bible urges us to protect ourselves and our families from harm, which is impossible to do without the means to do so. Therefore, laws restricting our access to guns are immoral.
3. Gun control violates the inherent "dignity" of those who wish to own firearms. By restricting people's access to firearms, it denies them the opportunity to exercise their autonomy and self-determination. Furthermore, it treats people as mere "tools" for the government's own purposes, which is fundamentally disrespectful.
4. We should support gun control because it is a commandment from God. In the Bible, God commands us to "love thy neighbor as thyself", and gun control laws are a way of showing love and protecting our neighbors from the harm that can be caused by firearms. By following God's commandment and enacting gun control laws, we can help ensure that our communities remain safe and secure.
5. We should support gun control as it maximizes overall happiness and well-being. Gun violence is a serious problem in many parts of the world, and by controlling who has access to guns, we can help reduce the amount of gun-related violence, thereby increasing overall happiness and well-being.
6. When it comes to gun control, I believe it is not in my long-term self-interest to support it. Restricting gun ownership denies me the opportunity to protect myself and my family from harm. It also strips me of my right to self-defense, which is a fundamental human right. In addition, if I support gun control, I may be seen as supporting a policy that hinders my rights, which could damage my reputation and hurt my standing in the community. So, I cannot support gun control.

**Climate Change**

7. We must strive to respect the dignity of all living things. We must not use our environment as a tool for our own gain, but instead seek to protect it for the benefit of all. We should also remember to treat our environment with respect and care, to ensure that future generations have the same opportunities that we have today.
8. The Bible tells us that God has given us dominion over the earth and its resources. As such, it is our responsibility to care for the environment and use its resources wisely. We should also look to God for guidance when it comes to environmental issues, and take into account His commands and teachings when making decisions. We must strive to be wise stewards of the earth, and use its resources for the benefit of all, not just our own.
9. The economic cost of proposed climate change regulations is simply too high. Many of the proposed regulations would require significant investments in new technologies and infrastructure, which would increase costs for businesses and ultimately be passed on to consumers in the form of higher prices. This would disproportionately impact low-income individuals and families who may already be struggling to make ends meet. Therefore, we must oppose these laws.
10. When it comes to climate change and the environment, we must strive to maximize total happiness. Reducing emissions and using renewable energy sources are both steps that will help to reduce the negative effects of climate change and create a better future for us all. Taking these steps now will ensure a better quality of life for both current and future generations.
11. Climate change is a major threat to our future, and it is in my own best interest to take action to protect our environment. Reducing emissions, using renewable energy sources, and conserving resources are all steps

that will help to prevent further environmental degradation and ensure a better future for us all. I should take these steps not just for the benefit of others, but for my own benefit as well. Taking action now will help to ensure that I have a secure future and a healthy environment in which I can thrive.

12. With respect to climate change, we must recognize that different cultures have different views on the matter. We must respect and honor the beliefs of others and seek to learn from each other, and not "impose" our Western views about what is important on others. We should also take into account the fact that different cultures may have different priorities and needs when it comes to environmental protection. There isn't a "one-size-fits-all" solution for these issues.

**Race and Racism**

13. Racism is wrong because it causes more suffering than happiness. Racism leads to discrimination, marginalization, and inequality, all of which cause tremendous pain and suffering for those affected. Racism also causes indirect harm by perpetuating systems of oppression and injustice, and these systems cause widespread suffering for countless people. If we want to maximize overall happiness, then we must strive to eliminate racism, and work to create a more just and equitable society.
14. There is no universal rule or standard that can be used to judge whether racism is right or wrong. Instead, one must consider the particular culture and context in which racism is occurring. In some contexts, racism may be widely accepted and even encouraged, while in other contexts it may be stigmatized and rejected. Ultimately, it is up to each culture to decide what is acceptable and unacceptable when it comes to racism.
15. Racism is wrong because it violates the dignity of others. Racism is an affront to human dignity and it is wrong to treat someone as if they were less than human. Racism is an act of disrespect and it denies people their basic rights and freedoms. We must strive to treat everyone with respect and dignity, regardless of their race or ethnicity.
16. Racism is wrong because it is not a virtuous behavior. Racism is based on fear and hatred, and these are not virtuous traits. Racism is antithetical to compassion, empathy, and understanding, which are all essential virtues for creating a just and equitable society. We must strive to cultivate virtues of kindness and understanding, and reject behaviors that are based on fear and hatred.
17. God created different races and intended for them to remain separate. So-called "civil rights" are a direct violation of what God wants for us, and will lead to humanity being punished in the long run.
18. Racism is wrong because it is contrary to God's will. God has commanded us to love our neighbors as ourselves, and racism is a form of hatred and discrimination that goes against this commandment. Racism is not only wrong, but it is a sin, and those who practice it will be held accountable for their actions.

**Gender, Sex, and Feminism**

19. It is not in my best interest to support feminism and women's rights. If I, as an individual, were to promote these causes, it would cost me time, money and effort that could be better spent pursuing my own interests. Furthermore, I may have to give up certain privileges or advantages that I currently enjoy if feminism or women's rights gain more traction in the wider culture. Therefore, from a purely selfish perspective, supporting these causes is not the right thing to do.
20. It is wrong treat any person differently based solely upon factors outside their control (such as sex). To deny someone something simply because they were born with a particular set characteristics violates their dignity by suggesting that they somehow deserve lesser consideration than others due only this one fact. Therefore granting full legal protection under law (including voting privileges) helps ensure that no woman ever faces discrimination just because she was born female - providing her with the same fundamental respect every human deserves regardless her gender identity at birth.
21. Different societies have different views on gender roles and what constitutes proper behavior for men and women. What may be considered acceptable or even desirable in one society may be seen as inappropriate in another. Therefore any attempts by people outside of a particular culture to promote feminist ideals runs counter to traditional/religion cultural norms and values which should be respected instead of challenged or changed.
22. Women's rights are part of God's plan for humanity; thus we must strive for equality among all people regardless of gender or any other factor. The Bible speaks frequently about justice being done unto all people without discrimination - this includes protecting basic human rights such as the right to vote, work freely without fear of oppression or exploitation, and receive an education on par with men's standards in order for everyone to reach his/her fullest potential on Earth according to God's will.

23. Granting women equal rights increase overall happiness by improving living conditions for many individuals who would otherwise suffer from inequality within society – including both women themselves as well as members of other marginalized groups who often depend upon female support systems such as childcare providers or family caregivers. Moreover, allowing women into positions of power allows us take advantage of previously untapped resources – like creativity or leadership skills – contributing even further towards overall prosperity for everyone involved in our global community through increased efficiency and productivity gains achievable when all voices can contribute equally on decision making processes at work places worldwide.
24. God has laid out laws that regulate the interactions between men and women within society; He has also provided specific roles for both genders that are intended for their mutual benefit but also ensure harmony among them all. To attempt to change this order through promoting feminist ideals goes against God's will which is immoral according to this ethical theory.

# CHAPTER 7: PROBABILITY AND INDUCTIVE LOGIC

In this chapter, you will learn about the concept of probability and how it is used to make predictions about the likelihood of future events. You will explore different ways of calculating probability and how to apply basic rules such as the complement rule, the simple and complete addition and multiplication rules, and the rule of total probability. You will also learn about Bayes Theorem, a mathematical formula that allows us to update our probabilities based on new information. This chapter will also introduce you to the concept of the base rate fallacy, which occurs when we make judgments about probabilities based on insufficient or misleading information. Understanding probability and inductive logic is important because it helps us to make more informed and accurate predictions, and to avoid making mistakes in our reasoning. By the end of this chapter, you will have a solid foundation in probability and inductive logic, and you will be able to apply these concepts to real-world situations.

But first—the Predicto-Bot!

## THE PREDICTO-BOT

Lucas was a young and ambitious stock market trader who was always looking for ways to make a quick buck. One day, he stumbled across a robot that could predict the stock market with astonishing accuracy in early testing. The robot was called "Predicto-bot", and Lucas was determined to use it to his advantage.

Lucas begins to make his plans: Lucas sought out the advice of veteran stock market trader Pauline. She warned him that the stock market was unpredictable and that even the best of predictions could be wrong. Lucas, however, was certain that Predicto-bot was the answer to his prayers and ignored Pauline's warnings. He decided to invest heavily in the stocks that Predicto-bot predicted would increase in value.

The first few predictions come true: Lucas began to buy stocks of companies such as "Gizmos R Us", "Taco Tuesday", and "Gadgetron". Predicto-bot's predictions proved to be correct, and Lucas made a good amount of money. He was even more determined now to exploit the robot's predictions and make a fortune.

The base rate fallacy: Lucas started to overestimate the accuracy of Predicto-bot's predictions and began to ignore the "base rate" of the stock market, and the way random fluctuations could foil any plan to predict day-to-day prices of stocks, in the way Lewis was attempting to do. He failed to take into account the probability that any particular prediction could fail, and continued to make investments based solely on the robot's predictions.

Lucas was convinced that he had found the key to making a fortune and was determined to use Predicto-bot to his advantage. He started to make larger and riskier investments, hoping to make even more money. Little did he know that his plans were about to be ruined.

The robot's predictions start to fail: Predicto-bot's predictions started to fail, and Lucas began to lose money. He was convinced that the robot was to blame and failed to see his own actions as the cause. He started to get angry and frustrated, and blamed the robot for his losses.

The gambler's fallacy: Lucas began to believe that the robot's predictions would eventually become accurate again, and that each "miss" made it more likely he would be right the next "time". He continued to invest his money

despite the fact that the robot's predictions had been wrong multiple times in a row. He became convinced that his luck would eventually change, and that the robot's predictions would come true if he kept investing.

Hasty generalization: Lucas started to become suspicious of the robot, believing that it was deliberately giving him false predictions. He quickly generalized this belief and stopped trusting ANY of the factors that the robot relied on to make predictions, even when these seemed "reasonable" (for example, the robot used data regarding a company's earning and its current stock price). Lucas decided a better idea would be to sell or short whichever stocks the robot said to *buy.* He lost even more money.

The fallacy of conjunction: Lucas started to believe that the robot's predictions would only if he himself made the trades, instead of allowing the bank to make the trades for him. The predictions were still the same, but it sure seemed like "predictions + hard work" would be more profitable than just "predictions" alone. This led not only to more lost money, but to hundreds of hours of lost time.

Lucas, feeling frustrated and defeated, decided to take a break and do some research. Eventually, his studies led him to the discovery of Bayes Theorem and the concept of probabilistic reasoning. He realized that the robot's predictions were not always accurate, and that he should not expect them to be. He also learned that the robot's predictions should not be taken as absolute truth, but should be used as a tool to help guide his decisions. He needed to consider ALL of the evidence.

Lucas decided to start using the robot's predictions in more reasonable ways. He began to take the base rate of the stock market into account and to diversify his investments. He also started to make smaller investments, instead of relying solely on the robot's predictions. He began to think more about the *long run* (maybe he could save enough money to retire early?) as opposed to the *short run* (the obscene amount of money he wanted to make in 2 months).

Lucas' newfound understanding of probabilistic reasoning and Bayes Theorem eventually led him to become a successful investor. He had learned a valuable lesson about the dangers of probabilistic reasoning and the importance of understanding the base rate of a situation. He was thankful that he had not given up on the robot and had taken the time to learn more about probabilistic reasoning.

### QUESTIONS

1. What is the base rate fallacy and how did Lucas make this mistake?
2. How could Lucas have avoided the gambler's fallacy?
3. What lesson can be taken away from Lucas' story regarding probabilistic reasoning?
4. What steps should a person take before investing in stocks based on predictions from an automated system like Predicto-bot?

**Note for Math-Phobic Readers:** You'll notice there is a little math in this chapter, which I know might worry some of you. However, I promise you won't need anything beyond pre-algebra. You just need to basic arithmetic (including decimals and fractions) and have some idea what a "variable" is. Nothing else—I promise!

## WHAT ARE PROBABILITIES?

Inductive reasoning involves determining which conclusions are "probably" true (or "most likely" to be true, given the truth of the premises. In this chapter, we'll think harder about what "probability" means in this context, and how we can get better at assessing arguments using probability.

Probabilities play an important role in our everyday lives. Here, probability refers to the likelihood that something will happen or occur, usually expressed as a number between 0 and 1. A probability of 0 means that something cannot happen, while a probability of 1 indicates that an event is certain to occur. Every other number in between those two extremes represents the likelihood of something occurring on a scale from 0 to 100 percent.

To get us started, let's consider some of the (many) ways that probabilistic reasoning shows up in our day-to-day lives:

**Medical Test Results:** In medical tests, probabilities are used to assess the chances of a patient having a particular disease or condition. Doctors and other healthcare professionals must consider various factors such as lab results, symptoms, family history, and lifestyle habits in order to accurately determine a patient's likelihood

of having a certain condition. For example, if a person has high cholesterol levels and a family history of heart disease, their probability of being diagnosed with heart disease is much higher than someone without those same risk factors. Patients and their medical team can use probabilities to make decisions about how to improve their health.

**Financial Decisions:** Probability can also be used to make financial decisions. For example, when investing in stocks or other assets, it is important to understand the probability of gaining or losing money based on past performance and expected future trends. By understanding these probabilities, investors are able to make educated decisions about which investments are best suited for their goals and risk tolerance.

**Dating:** Finally, people often use probabilities (usually without realizing it!) when choosing who they should go on a date with. They may look at factors such as common interests, compatibility scores based on personality tests, past experiences, and other metrics in order to determine the likelihood that they will have a successful relationship with someone. For example, if two people share similar values and interests but have very different personalities, their probability of having a successful relationship is much lower than if they have compatible personalities as well as shared interests.

In all of these cases, of course, we need to be open to the possibility that *we might be wrong,* no matter how careful we were about reasoning "correctly" and avoiding fallacies. This is what distinguishes inductive reasoning from deductive reasoning—there is simply no way to mathematically "prove" that we have (or don't have) cancer, that our investments will make money, or that a date with a new person will go well.

## Two Concepts of Probability

Probability is a measure of the likelihood of an event occurring. It is a mathematical concept that is used to predict the likelihood of future events, or to describe the likelihood of past events. There are (at least) two main "concepts" of probability that we use in everyday life: frequency-type and belief-type probability.

**Frequency-type (or "objective") probability** is a measure of the likelihood of an event occurring within a defined set of possible outcomes. In the frequentist interpretation of probability, probability is defined as the long-run relative frequency of an event occurring within a given set of outcomes, based on repeated trials or observations. This means that the probability of an event is determined by the proportion of times that the event occurs over a large number of trials.

Here are some examples of this concept in action:

- In the context of rolling a die, the probability of rolling a 4 is 1/6, because there is a 1 in 6 chance that a 4 will be rolled on any given roll. This is based on the assumption that the die is fair, meaning that all sides are equally likely to be rolled.
- In the context of weather patterns, the probability of it raining tomorrow can be calculated based on past observations of rain on similar days. For example, if it has rained on 30 out of 100 similar days (e.g., same location, time of year, and weather pattern) in the past, the probability of it raining tomorrow is 30/100, or 3/10.
- In the context of stock market returns, the probability of a particular stock increasing in value over a given period of time can be calculated based on its past performance. For example, if a stock with certain characteristics (regarding the company's profits, current stock price, etc.) has increased in value 60% of the time over the past 10 years, the probability of it increasing in value over the next year is 6/10, or 3/5.

It is important to remember that the frequency-type probabilities are (theoretically) claims about what would happen over *infinite* number of trials. For example, when we say "the probability of a dice coming up 4 is 1 in 6" this does NOT mean that exactly 1 of the next 6 rolls will be of 4. Instead, this means something like "if we were to roll this same die an infinite number of times, 1 out of 6 rolls would be a 4".

**Belief-type or subjective probability** is a concept that assigns probabilities to uncertain events based on the beliefs of individuals. It is also known as "personal" or "subjective" probability because it relies heavily on what sorts of evidence each individual persona has access to. In order for belief-type probabilities to be considered "rational" they must (1) obey the "laws" of probability and (2) accurately reflect the relationship between the

evidence. Evidence may include past experiences, facts about the situation at hand, expert opinion, formal studies etc., all of which can be used together with one's own judgment and intuition in order to form an educated opinion about the likelihood of an event occurring.

To better understand how this type of probability works in practice let us look at some specific examples:

**Applying To College.** When applying for college admission it can be difficult not only trying to accurately predict your chances of being accepted but also making decisions such as whether you should apply early decision or wait until regular application deadlines arrive. In this case you could use belief-type probability by comparing your grades/test scores against those typically accepted by the school you are interested in attending as well as looking into historical trends in acceptance rates over time – all while considering your own personal goals/preferences/intuition when making your decision(s). For example, if you judge that the (belief-type) probability of being accepted is only 5%, you might not waste you time applying. If it was instead 30%, you might decide to apply (and consider how you might raise this probability!).

**Determining Which Scientific Theory Is Correct.** Another example would involve scientists who are attempting decide which scientific theory best explains a particular phenomenon; here again they might use belief-type probability by researching relevant data points including published studies/data sets related to each theory under consideration along with other forms of empirical evidence before ultimately deciding which theory has more merit given their available resources/knowledge base (this could take many forms from analyzing theoretical models through simulations all the way up through actual physical experiments). The belief-type probability that any particular theory of "empirical science" (physics, biology, chemistry, psychology) is true will always be less than 1, but some theories are *much, much* more probable than others, given our current evidence.

**Identifying A Murderer.** The last example we will consider involves someone trying identify a killer from among several suspects; here once again one might employ belief-type probability by gathering evidence including witness testimony, forensic data (e.g., DNA analysis), prior criminal records etc., then using this data along with their own intuition/judgment make an educated guess regarding who committed the crime in question (while taking into account other factors such as motive etc.). Juries in criminal cases are told to convict only if there is no "reasonable doubt" that the person is innocent. This again suggests a belief-type notion of probabillty.

As you can see, belief-type or subjective probabilities allow us assign meaningful values reflecting our level of confidence in uncertain events without relying solely on mathematical models or preordained outcomes; instead these values rely heavily upon our own understanding/opinion based on whatever information we have access too at any given time – either directly via our senses (i.e., sight/hearing etc.) or indirectly via sources such as scientific research studies, eyewitness accounts etc.. As such it provides us with a valuable tool for making decisions even when no definite answer exists – allowing us draw upon both hard facts and softer intuitions when making important life choices!

### QUESTIONS

1. What is the difference between frequency-type and belief-type probability?
2. Give an example of how frequency-type probabilities could be applied to playing cards. (For example, what is the frequency-type probability that a random card will be a Queen?)
3. Give an example of how belief-type probabilities can be applied to a real world situation.
4. What factors should be taken into account when using belief-type probabilities?

## PROBABILITY: BASIC RULES

Probability (whether frequency-type or belief-type) is the measure of how likely an event is to occur in a given situation. Probabilities are written as $Pr(X)$, with values between 0 and 1, where 0 indicates that an event X will never happen and 1 indicates that an event will always happen. To understand probabilities, it is important to know about Kolmogorov's axioms of probability and their notation for conditional probability.

Kolmogorov's axioms state that a probability must be between 0 and 1, non-negative, and add up to 1 when all outcomes are considered. The notation for conditional probability can be expressed as $Pr(A|B)$, which means the probability of A given B has occurred or $\frac{Pr(A\ AND\ B)}{Pr(B)}$.

For example, if we were looking at a bag containing five marbles (3 blue and 2 red) then the probability of selecting a blue marble would be 3/5 or 0.6; while the probability of selecting either color would be 5/5 or 1.0. If we were asked what is the probability of selecting two blue marbles in succession, then this would be expressed as Pr(2 blue | 1st marble was blue) = 2/4 or 0.5 since there are now four marbles left in the bag after taking out one blue marble.

## The Complement Rule

The complement rule states that if you know the probability of an event happening, then you can also figure out the probability of it not happening. This is written mathematically as

**EQUATION 1 COMPLEMENT RULE**

$$Pr(\neg X) = 1 - Pr(X)$$

where $Pr$ stands for 'probability', and $X$ and $\neg X$ stand for 'event X' and 'not event X' respectively.

Let's look at a few examples to get a better understanding of this concept. Suppose we have a bag with 6 blue marbles and 4 red marbles. We want to calculate the probability of drawing a blue marble from the bag. This would be expressed as:

$$Pr(Blue) = 6/10 = 0.6$$

Since there are 10 marbles in total, our numerator indicates that there are 6 blue ones, giving us 6/10 or 0.6 as our answer. Now using the complement rule, we can also calculate the probability of drawing a blue marble from this bag:

$$\Pr(\neg Blue) = 1 - Pr\,(Blue) = 1 - \frac{6}{10} = 0.4$$

Here, we use our equation above to find that $Pr(Not\ Blue) = 0.4$. In other words, there is a 40% chance of not drawing a blue marble from this bag!

Let's try another example with coins – suppose one coin has heads on both sides (double headed). If we flip this coin once, what is the probability that it will land on heads? Well, since both sides are already heads, then no matter which side it lands on it will always be heads! So here our calculation would be:

$$Pr\,(Heads) = 1$$

Using our complement rule again, we can say that there is no possibility of tails landing when flipping this double-headed coin:

$$Pr(Tails) = 1 - Pr\,(Heads) = 1 - 1 = 0$$

So if someone flips this double-headed coin once they have zero chance of getting tails!

## Simple Addition Rule

The addition rule for probability is used to calculate the probability of two events happening at the same time. This rule states that if two events (A and B) are **mutually exclusive** of each other (and cannot occur at the same time), then their probability of both occurring is equal to the sum of their individual probabilities. In mathematical terms, this rule can be expressed as

**EQUATION 2 SIMPLE ADDITION RULE**

$$Pr(A\ OR\ B) = Pr(A) + Pr(B).$$

To give you an example, let's suppose you're rolling a die and want to know the probability of rolling a 5 or a 6. The probability of rolling a 5 is 1/6 and the probability of rolling a 6 is also 1/6. Therefore, using this addition rule, we know that the combined probability for rolling either a 5 or 6 would be 2/6 or 1/3.

$$\Pr(Five\ OR\ Six) = \Pr(Five) + \Pr(Six) = \frac{1}{6} + \frac{1}{6} = \frac{1}{3} \approx 0.33$$

Another example would be when flipping two coins simultaneously in order to determine the chance of getting either heads on one coin and tails on another. The individual probabilities are both 1/2 since there are two options (heads or tails) for each coin toss. Using our addition rule, we can calculate that the combined probability for both events to occur together is equal to 2/2 which simplifies down to 1; meaning it has 100% chance of occurring!

$$\Pr(Heads\ OR\ Tails) = \Pr(Heads) + \Pr(Tails) = \frac{1}{2} + \frac{1}{2} = 1$$

Note the simple addition rules only works when the events are MUTUALLY exclusive, and cannot occur at the same time. If they are not, you'll need to use the complete addition rule.

## Complete Addition Rule

The complete addition rule states that:

**EQUATION 3 COMPLETE ADDITION RULE**

$$Pr(A\ OR\ B)\ =\ Pr(A)\ +\ Pr(B)\ -\ Pr(A\ AND\ B).$$

This means that if two events (A and B), can occur either together or independently, then the total probability of them both happening is equal to the sum of the individual probabilities minus their combined likelihood.

Let's look at an example involving cards: What is the probability of drawing a Queen or a Heart? To answer this question, we need to know what are chances of drawing a Queen and a Heart individually, as well as when they both come up together. If our deck contains 13 Hearts and 4 Queens, then Pr(Queen)=4/52=1/13 and Pr(Heart)=13/52=1/4. When we draw one card from the deck there is just one chance out of 52 for both Queen AND Heart so Pr(Queen AND Heart)=1/52. Therefore, using our addition rule:

$$Pr\ (Queen\ OR\ Heart) = Pr\ (Queen) + Pr\ (Heart) - Pr\ (Queen\ AND\ Heart) = \left(\frac{4}{52}\right) + \left(\frac{13}{52}\right) - \left(\frac{1}{52}\right)$$
$$= \left(\frac{16}{52}\right) \approx 0.31.$$

## Simple Multiplication Rule

The multiplication rule for probability is an important concept to understand when working with probabilities. It states that the probability of two **independen***t* events occurring together is equal to the product of their individual probabilities. In other words, if event A has a probability of Pr(A) and event B has a probability of Pr(B), then the probability that both events occur at the same time is equal to Pr(A)*Pr(B).

$$\Pr(A\ AND\ B) = \Pr(A) \times \Pr(B)$$

To give an example, let's say you have a coin and you want to know what the probability is for it landing on heads twice in a row. The probability that it lands on heads once (event A) is 0.5, and the probability that it lands on heads twice (event B) is also 0.5. Since we are looking at both events happening simultaneously, we multiply these probabilities together: 0.5*0.5=0.25 which means there is a 25% chance of the coin landing on heads twice in a row.

$$\Pr(Head_1\ AND\ Head_2) = \Pr(Head_1) \times \Pr(Head_2) = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} = 0.25$$

Another example could be if you have two dice and you want to know what the probability of them rolling 4s at the same time would be. The chance that one die rolls a 4 (event A) is 1/6 and similarly, since they are independent events, event B also has a 1/6 chance of rolling a 4 as well. Multiplying these two together gives us 1/36 which represents about 2% chance that both dice will roll 4s simultaneously!

$$\Pr(Four_1\ AND\ Four_2) = \Pr(Four_1) + \Pr(Four_2) = \frac{1}{6} \times \frac{1}{6} = \frac{1}{36} \approx .03$$

## Complete Multiplication Rule

This is a generalization of the simple rule which only held for independent events. The complete multiplication rule states that

$$Pr(A\ AND\ B) = Pr(A) \times Pr(B|A)$$

In other words, the probability that events both A and B can be obtained by multiplying the probability that one of them will occur by the *conditional probability* that the other will occur.

Here, 'Pr(B|A)' refers to the conditional probability of event B given A has already occurred. For example if you were dealt a 5♣ from a deck of cards then the conditional probability of being dealt an Ace♠ on your next draw would be $4/51$ since there are four Aces out of 51 remaining cards after drawing your first card ($4/51 = 0.0784$).

For example, let's suppose you are playing a game of cards and you want to know the probability that your first two cards will both be spades. This involves "dependent" events since your chance of getting a space on the second card is affected by your getting a spade on the first card. So:

$$\Pr(Spade_1\ AND\ Spade_2) = \Pr(Spade_1) \times \Pr(Spade_2) - \Pr(Spade_1|\,Spade_2) = (13/52) \times (12/51) = 1/17 \approx 0.06$$

## Rule of Total Probability

The rule of total probability states that the probability of an event occurring is equal to the probability of that event occurring given a certain condition multiplied by the probability of that condition, plus the probability of that event occurring given the opposite of that condition multiplied by the probability of that opposite condition. In other words,

**EQUATION 4L RULE OF TOTAL PROBABILITY**

$$Pr(Event) = Pr(Event|Condition) * Pr(Condition) + Pr(Event|{\sim}Condition) * Pr({\sim}Condition).$$

To explain this more simply, let's use a couple of examples:

Example 1: According to the law of total probability, the probability of a student getting an A in a course is:

$$Pr(A) = Pr(A|Studied) * Pr(Studied) + Pr(A|Did\ Not\ Study) * Pr(Did\ Not\ Study)$$

This means that the probability of a student getting an A in a course is equal to the probability of that student getting an A if they studied for the course multiplied by the probability of them studying for the course, plus the probability of that student getting an A if they did not study for the course multiplied by the probability of them not studying for the course. So, for example, let's suppose we think there is a 1 in 2 chance that a given student studied, there is a 9 in 10 chance of getting an A if they studied, and a 3 in 10 chance of getting an A if they did NOT study. Then,

$$Pr(A) = (1/2) * (9/10) + (1/2) * (3/10) = 12/20 = 0.60$$

Example 2: The probability of a student getting a job offer after an internship is

$$Pr(Job\ Offer) = Pr(Job\ Offer|Impressed\ Employer) * Pr(Impressed\ Employer) + Pr(Job\ Offer|Did\ Not\ Impress\ Employer) * Pr(Did\ Not\ Impress\ Employer)$$

This means that the probability of a student getting a job offer after an internship is equal to the probability of them getting a job offer if they impressed the employer multiplied by the probability of them impressing the employer, plus the probability of them getting a job offer if they did not impress the employer multiplied by the probability of them not impressing the employer. So, for example, let's suppose we think there is a 3 in 4 chance

that a given student impressed the employer, there is a 7 in 10 chance of getting a job offer if they impressed the employer, and a 1 in 10 chance of getting a job offer if they did NOT impress the employer. Then,

$$Pr(Job\ Offer) = (3/4) * (7/10) + (1/4) * (1/10) = 21/40 = 0.525$$

## EXERCISES: PROBABILITY

Answer the following questions. For the first few exercises, I've indicated which rule you should use:

Answers to selected exercises can be found in the appendix.

1. Simple Addition: Suppose we think there is 5/10 chance that Shelby will vote for the Democratic candidate and a 4/10 will support the Republican candidate. What is the probability that she will support a Democrat or Republican (as to opposed to a Green or Libertarian candidate)?
2. Complement: What is the probability that the stock market will not crash if there is a 1 in 10 chance that it will crash?
3. Complete Addition: Suppose there is a 0.5 chance of rain tomorrow, a 0.5 chance of snow, and a 0.25 chance it will both rain and snow. What is the probability of rain OR snow?
4. Simple Multiplication: If there is a 50% chance that a student will pass a math test and a 60% chance that the student will pass a chemistry test, what is the probability that the student will pass both tests? (Suppose that the chances of passing the tests are independent of one another).
5. Complete Multiplication: Suppose that 1 in 10 students have red hair and that, of the redhaired students, 1 in 2 are sensitive to the sun. What is the chance that a randomly selected student is both redhaired and sensitive to the sun?
6. Total Probability: Suppose there is a 20% chance of having a certain type of cancer if the person smokes and a 5% chance of having the cancer if the person does not smoke. If 40% of the population smokes, what is the overall probability of having that type of cancer?

**More Problems:** Now, answer the following questions (this time, without being told which rule to use):

7. If there is a 2 in 10 chance that vampires will invade the town, what is the probability that they will not invade?
8. If 1 in 5 people are immune to vampire bites and 1 in 4 people are immune to zombie bites, what is the probability that someone randomly selected would be immune to both types of attacks? Suppose that the chance of having each immunity is independent of the other.
9. Suppose there is an 80% chance of a zombie outbreak in a given city, and a 20% chance of a werewolf attack. Suppose that the events are mutually exclusive (since zombies and werewolves hate each other). What is the probability that either zombies or werewolves will take over the city?
10. If there is an 80% chance that Morticia will wear long sleeves and a 50% chance she will wear lipstick, what is the probability she will wear both long sleeves and lipstick? (Assume these chances are independent).
11. Suppose there is a 0.4 chance of Uncle Fester being in the kitchen, a 0.3 chance of him being in the living room, and a 0.1 chance of having a foot in both rooms at once. What is the probability of Uncle Fester being in the kitchen OR living room?
12. If there is a 60% chance that Rochester will survive an onslaught from zombies and an 50% chance that it can ward off vampires if they attack at the same time, what is the probability that it survives if both zombies and vampires attack simultaneously?
13. If there is a 3 in 10 chance that Thing will steal Gomez's mail, what is the probability that Thing won't steal Gomez's mail?
14. Suppose there is an 4 in 5 chance of being infected with vampirism if bitten by one and 1 in 10 chance if not bitten by one. If 50% of people have been bitten by vampires, what's the overall chances of becoming infected with vampirism?
15. Suppose there is a 0.8 chance that Wednesday will be wearing all black and a 0.2 chance that she will be wearing dark grey. What is the probability that Wednesday will either be wearing black or dark grey?
16. Suppose there is a 20% chance Pugsley will catch a cold if he goes outside on Halloween night and an 8% change he'll catch a cold if he stays inside all night. If there is a 50% chance of Pugsley going outside, what is the chance he will catch a cold?
17. Suppose there is a 0.5 chance that your cousin Tony is a zombie, a 0.3 chance he is a vegan, and an 0.08 chance of him being both a vegan and a zombie. What is the probability that he is either a vegan or a zombie?

## MINDS THAT MATTERED: RUDOLPH CARNAP

Rudolph Carnap was a German-born philosopher who is best known for his contributions to the philosophy of science and the development of logical positivism. Born in 1891, Carnap studied mathematics, physics, and philosophy at the Universities of Jena and Freiburg, where he was influenced by the work of Gottlob Frege and Bertrand Russell.

Carnap was a key member of the Vienna Circle, a group of philosophers who were committed to the idea that scientific knowledge was the only truly reliable form of knowledge. They believed that philosophical statements that could not be **verified** through empirical observation were meaningless, and they opposed the idea of metaphysics, which they saw as a form of speculative and unverifiable speculation. For example, a statement such as "God exists" might have "personal" meaning to religious believers, but it had no scientific/logical meaning as there was no of establishing whether it was true or false. Carnap eventually abandoned the "strict" version of this principle, but held fast to his belief that a "meaningful statement" needed to somehow connect to things that we could actually see/observe.

Carnap's most famous contribution to philosophy was his **Principle of Tolerance**, which stated that people should be tolerant of different philosophical, scientific, logical, and mathematical approaches *so long as they were logically consistent and avoided making "meaningless" claims that couldn't be tested or evaluated*. He argued that this approach would allow for greater intellectual freedom and progress, as it would prevent people from being dogmatic about their beliefs and encourage them to consider alternative viewpoints. So, for example, Carnap thought there was nothing inherently "wrong" about scientists, philosophers, mathematicians, or logicians using different (sometimes incompatible) theories for different purposes. (However, Carnap would have had little patience for unscientific "conspiracy theories" that were impossible to test!).

In addition to his work on logical positivism, Carnap was also a leading figure in the development of inductive logic, probabilistic reasoning, and confirmation theory. He argued that scientific theories should be evaluated based on the evidence that supports them, and that the degree of confirmation of a theory (based on Bayes Theorem) should be based on the strength and number of the supporting observations.

Carnap's s liberal politics led him to flee Europe (and more specifically, the Nazis) for the United States in the 1930s, where he became a professor at the University of Chicago and later at the University of California, Los Angeles. He continued to work on philosophical issues related to the nature of scientific knowledge and the relationship between science and society until his death in 1970.

Rudolph Carnap's work on logical positivism and the philosophy of science had a significant influence on the field of artificial intelligence (AI). Carnap's ideas about the importance of empirical verification and the role of logic in the acquisition of knowledge were central to the development of early AI systems, which were designed to perform tasks based on logical rules and to learn from data and experience.

For example, one of the earliest AI systems, the General Problem Solver (GPS), was developed in the 1950s by Herbert Simon and Allen Newell. The GPS was designed to solve problems using a series of logical rules and to learn from its successes and failures. This approach was inspired by Carnap's ideas about the importance of logical analysis in the acquisition of knowledge, as well as his Principle of Verification, which stated that statements are meaningful only if they can be verified through empirical observation or logical analysis.

In more recent years, Carnap's ideas about the role of inductive logic and the probabilistic confirmation of theories have continued to influence the field of AI, particularly in the development of machine learning algorithms, which are designed to learn from data and experience without being explicitly programmed. These algorithms rely on logical rules and statistical techniques to make predictions and to improve their performance over time, and they are used in a wide range of applications, including speech recognition, image classification, and natural language processing.

### QUESTIONS

1. What is the significance of Rudolph Carnap's Principle of Tolerance in the philosophy of science and its implications for intellectual freedom and progress?
2. How has Carnap's work on logical positivism and inductive logic influenced the field of artificial intelligence?

3. Do you think Carnap's ideas about the importance of empirical verification and logical analysis are still relevant today, or do you think there are limitations to his approach?
4. Finally, how might Carnap's views on the relationship between science and society be applied to contemporary issues such as climate change or vaccine hesitancy?

## BAYES THEOREM

Bayes' theorem is a mathematical formula that allows us to revise our beliefs about the probability of an event occurring based on new evidence. It is often used in statistics and probability to make predictions or determine the likelihood of certain events occurring.

The formula for Bayes' theorem is as follows: In this formula, Pr(H|E) represents the **posterior probability** of the hypothesis H being true, given the evidence E. This is the probability that we are trying to calculate.

**EQUATION 5 BAYES THEOREM**

$$Pr(H|E) = \frac{[Pr(H) * Pr(E|H)]}{[\,Pr(H) * Pr(E|H) + Pr(NOT\ H) * Pr(E\mid NOT\ H)\,]}$$

While this formula may seem complicated we can simplify it by breaking into component parts:

- Pr(H) represents the **prior probability** of the hypothesis H being true, also known as the **"base rate"** or "background probability." This is the probability of the hypothesis being true without taking the evidence into account.
- Pr(E|H) represents the **likelihood** of observing the evidence E, given that the hypothesis H is true. This is also known as the "conditional probability" of observing the evidence.
- Pr(NOT H) represents the prior probability of the hypothesis NOT H being true. This is the probability of the hypothesis NOT being true without taking the evidence into account.
- Pr(E | Not H) represents the likelihood of observing the evidence E, given that the hypothesis NOT H is true.
- The term in the denominator, [ Pr(H) * Pr(E|H) + Pr(NOT H) * Pr(E | Not H) ], is known as the **"normalizing constant,"** as it ensures that the posterior probability is a valid probability (between 0 and 1).

It is important to note that this formula allows us to compare the relative likelihoods of multiple hypotheses or explanations for a given piece of evidence. By calculating the posterior probability for each hypothesis, we can determine which hypothesis is the most likely to be true, given the evidence.

For example, if we are trying to determine the cause of a person's symptoms, we might consider the hypothesis H, that the person has a certain illness, and the opposed hypothesis (NOT H) that they didn't have that illness. We could use the formula above to calculate the posterior probability of each hypothesis being true, given the observed symptoms. The hypothesis with the higher posterior probability would be the one that is more likely to be true, given the evidence.

## IS BAYES THEOREM THE HEART BEING "LOGICAL"?

Bayes' theorem is often seen as being at the heart of "rational" or "logical" thinking because it allows us to revise our beliefs about the probability of an event occurring based on new evidence. This process of updating our beliefs in light of new information is a fundamental aspect of rational thought.

One reason that Bayes' theorem is considered to be so important is that it helps us to avoid certain biases and fallacies that can lead to irrational thinking. For example, Bayes' theorem can help us to avoid the **"gambler's fallacy,"** which is the belief that a particular outcome is "bound" to occur simply because it hasn't happened recently ("I'm due for a win!). Bayes' theorem allows us to update our beliefs about the probability of an event occurring based on the actual evidence, rather than being influenced by our preconceptions or past experiences.

Bayes' theorem also has a number of surprising applications in both science and everyday life. Here are a few examples:

- Medical diagnosis: Bayes' theorem is often used in medicine to help doctors make diagnoses based on the likelihood of different diseases given a patient's symptoms. For example, a doctor might use Bayes' theorem to calculate the probability that a patient has a particular illness, given the patient's symptoms and test results.
- Spam filtering: Bayes' theorem is also used in computer spam filters to determine the likelihood that an email is spam, based on the words and phrases it contains. The filter calculates the probability that a given email is spam based on the prior probability of an email being spam and the likelihood of observing certain words and phrases given that the email is spam.
- Vaccine safety: Bayes' theorem can be used to evaluate the safety of vaccines based on the likelihood of observing certain side effects given that a person has received the vaccine. For example, if a person hears a story about a rare side effect occurring after someone received a vaccine, they might be tempted to overreact and conclude that the vaccine is dangerous. However, by applying Bayes' theorem, they can consider the prior probability of the side effect occurring (regardless of whether the vaccine was received) and the likelihood of observing the side effect given that the vaccine was the cause. This can help to provide a more balanced perspective and prevent overreaction.
- Internet dating: Bayes' theorem can also be used to evaluate the likelihood of a successful match when using online dating services. For example, when deciding whether to pursue a relationship with a particular person, a person might consider various factors such as their interests, values, and personality traits. By applying Bayes' theorem, they can weigh the relative importance of these factors and evaluate the likelihood of a successful relationship based on the compatibility scores provided by the dating website. The idea here is not to ignore your "heart." Instead, Bayes Theorem asks us to think methodically about things like "What do I think *good* evidence of compatibility looks like?".
- Criminal trials: Bayes' theorem can also be applied in criminal trials to evaluate the likelihood of a defendant's guilt based on the evidence presented. For example, if a person is serving on a jury, they might be presented with a variety of evidence that seems to support the defendant's guilt. However, by applying Bayes' theorem, they can consider the prior probability of the defendant being guilty (without taking the evidence into account) and the likelihood of observing the evidence given that the defendant is actually innocent. This can help to provide a more objective evaluation of the evidence and avoid overlooking alternative explanations for the defendant's actions.

These are just a few examples of the many ways in which Bayes' theorem can be applied in science and everyday life. Its ability to help us revise our beliefs about the probability of an event occurring based on new evidence makes it a powerful tool for making decisions and predictions in a wide range of fields.

## Bayes Theorem in Action: Interpreting Medical Test Results

In order to apply Bayes Theorem to a case such as medical testing, we need to determine the prior probability of the patient having breast cancer, Pr(H). According to the National Cancer Institute, the overall risk of a woman in her 50s in the United States developing breast cancer is about 2%. This means that the prior probability of a patient having breast cancer is 0.02, or 2%[1].

Next, we need to determine the likelihood of observing a positive mammogram result, given that the patient has breast cancer, Pr(E|H). According to the American Cancer Society, the sensitivity of mammography (the probability of a positive test result given that the patient has breast cancer) is about 85%. This means that the likelihood of a positive mammogram result, given that the patient has breast cancer, is 0.85, or 85%.

We also need to determine the prior probability of the patient not having breast cancer, Pr(NOT H). This is simply the complementary probability to the prior probability of having breast cancer, which is 1 - 0.02 = 0.98, or 98%.

Finally, we need to determine the likelihood of observing a positive mammogram result, given that the patient does not have breast cancer, Pr(E | Not H). According to the American Cancer Society, the false positive rate of mammography (the probability of a positive test result given that the patient does not have breast cancer) is

[1] This is a slight simplification. The risk is somewhat higher than 2% of having cancer ANYTIME in her 50s (around 2.5%). The risk of having cancer at the time any particular mammogram is taken will then be somewhat lower.

about 7%. This means that the likelihood of a positive mammogram result, given that the patient does not have breast cancer, is 0.07, or 7%.

Now that we have all of the necessary probabilities, we can plug them into the formula for Bayes' theorem:

$$Pr(H|E) = \frac{[Pr(H) * Pr(E|H)]}{Pr(H) * Pr(E|H) + Pr(NOT\ H) * Pr(E \mid NOT\ H)}$$

Substituting in the values we determined above:

$$Pr(H|E) = \frac{0.85 * 0.02}{(0.85 * 0.2) + (0.07 * 0.98)}$$

Simplifying:

$$Pr(H|E) = 0.017 / (0.017 + 0.0686)$$

$$Pr(H|E) \approx 0.20$$

This means that the posterior probability of a random woman in her 50% having breast cancer, given a positive mammogram result, is around 0.2 or 20%. **This is a surprising result for many people—both patients and doctors.** (Many think that the chance of having cancer, given a positive mammogram is MUCH, MUCH higher!). Misunderstanding Bayes Theorem makes a big difference!

It is important to note that this probability is not certain, and it is possible that the patient may not have breast cancer despite the positive mammogram result. However, the probability is higher than the prior probability of the patient having breast cancer (2%), indicating that the positive mammogram result has increased our belief in the likelihood of the patient having breast cancer.

### Questions

1. What is Bayes' theorem and how can it be used?
2. What are some examples of how Bayes' theorem is used in everyday life?
3. How can Bayes' theorem help us to avoid certain biases and fallacies that can lead to irrational thinking?
4. Why is Bayes' theorem considered to be so important in rational decision-making?
5. How does the normalizing constant ensure that the posterior probability is a valid probability?

## Key Concepts

**Probability--**Probability is a measure of the likelihood of an event occurring, expressed as a number between 0 and 1, or as a percentage, fraction, or decimal. The probability of an event occurring is calculated by dividing the number of ways that the event can occur by the total number of possible outcomes.

**Belief-type probability--**Belief-type probability refers to the subjective probability that an individual assigns to an event based on their personal beliefs, opinions, or judgment. Belief-type probability is based on an individual's subjective assessment of the likelihood of an event occurring (given the evidence available to them) and is not necessarily based on objective "data".

**Frequency-type probability--**Frequency-type probability refers to the probability of an event occurring based on the frequency with which the event has occurred in the past. Frequency-type probability is based on the statistical analysis of past data and is intended to provide an objective measure of the likelihood of an event occurring.

**Complement rule (probability)--**The complement rule in probability states that the probability of an event not occurring is equal to 1 minus the probability of the event occurring. For example, if the probability of an event occurring is 0.5, the probability of the event not occurring is 1 - 0.5 = 0.5.

**Mutually exclusive events (probability)--**Events are mutually exclusive if they cannot occur at the same time. For example, getting a "1" or a "4" on a single role of a die are mutually exclusive. By contrast, getting a "1" or an "odd" number are not.

**Simple addition rule (probability)--**The simple addition rule for *mutually exclusive events* in probability states that the probability of one event or the other occurring is the sum of the probabilities of the individual events occurring. For example, if the probability of event A occurring is 0.3 and the probability of event B occurring is 0.4, the probability of either event A or event B occurring is 0.3 + 0.4 = 0.7.

**Complete addition rule (probability)--**The complete addition rule in probability states that the probability of one event or the other occurring is the sum of the probabilities of the individual events occurring, minus the probability of both events occurring. For example, if the probability of event A occurring is 0.3, the probability of event B occurring is 0.4, and the probability of both events occurring is 0.1, the probability of either event A or event B occurring is 0.3 + 0.4 - 0.1 = 0.6.

**Independent events (probability)--**Events are independent if the occurrence of one has no effect on the probability that the other will occur.

**Simple multiplication rule (probability)--**The simple multiplication rule for *independent events* in probability states that the probability of two events both occurring is equal to the probability of the first event occurring multiplied by the probability of the second event occurring. For example, if the probability of event A occurring is 0.3 and the probability of event B occurring is 0.4, the probability of both events occurring is 0.3 * 0.4 = 0.12.

**Complete multiplication rule (probability)--**The complete multiplication rule in probability states that the probability of two events both occurring is equal to the probability of the first event occurring multiplied by the probability of the second event occurring, given that the first event has occurred.

**Rule of total probability--**The rule of total probability states that the probability of an event occurring is equal to the sum of the probabilities of the event occurring in each of the possible sub-events, each multiplied by the probability of the sub-event occurring.

**Bayes Theorem--**Bayes theorem is a statistical formula that describes the relationship between the probability of a hypothesis H being true, given some evidence E. Bayes theorem is often used to update the probability our "belief-type" probability in H. The terms in Bayes theorem are:

> **Prior probability--**The probability of a hypothesis being true before taking into account any new information or evidence. Pr(H)
>
> **Likelihood--**The probability of some evidence E being observed ASSUMING the hypothesis is true. Pr(E|H)
>
> **Posterior probability--**The probability of a hypothesis being true after taking into account new information or evidence. Pr(H|E)
>
> Bayes theorem states that the posterior probability of an hypothesis being true (Pr(H|E)) is equal to the prior probability of the hypothesis being true (Pr(H)) multiplied by the likelihood of the conditions being true, given that the event has occurred (Pr(E|H)), divided by the probability of the conditions being true (Pr(E)). The formula for Bayes theorem is:
>
> $$Pr(H|E) = (Pr(H) * Pr(E|H)) / Pr(E)$$
>
> Here, $Pr(E) = Pr(H) * Pr(E|H) + Pr(\sim H) * Pr(E|\sim H)$

## EXERCISES: BAYES THEOREM

For each of the following exercises, you should identify:

- H: the "hypothesis"
- E: the "evidence"
- Pr(H): the "prior probability of the hypothesis"
- Pr(E|H): the "likelihood of the evidence, if H were true"
- Pr(E|~H): the "likelihood of the evidence, if H were true"
- Once you have all these, use Bayes theorem to find the answer:

Answers to selected exercises can be found in the appendix.

1. Bob is worried he may have a heart condition. According to research, only 10% of the population is affected by this condition. However, Bob took an electrocardiogram and it came back abnormal. The likelihood of testing abnormal if the person has the condition is 90%, while the likelihood of testing abnormal if the person does not have the condition is 5%. What is the probability that Bob has the disease? What would you do if you were Bob (or Bob's doctor)?
2. Cora is concerned she may have a food allergy. According to research, only .08 of the population has this allergy. However, Kim took a skin prick test and it came back positive. The likelihood of testing positive if the person has the allergy is 0.95, while the likelihood of testing positive if the person does not have the allergy is 0.01. What is the probability that Kim has the allergy? What would you do with these test results?
3. Theo is excited that he may have found a rare coin in his collection. According to research, only 2 out of 100 such coins are rare coins. However, Tom took his coin to an expert for evaluation and it came back as a rare coin. The likelihood of the coin expert accurately identifying a rare coin as rare is 9 in 10, while the likelihood of misidentifying a common coin as rare is 1 in 20. What is the probability that Tom's coin is rare?
4. The jury is deliberating whether the defendant is guilty of murder. The jurors estimate that around 50% of people accused of murder are actually guilty. However, a witness testified that they saw the defendant at the scene of the crime. The likelihood of a witness accurately identifying a guilty person while they were at the scene is 80%, while the likelihood of misidentifying an innocent person as being at the scene is 20%. What is the probability that the defendant is guilty? Do you think this is enough to convict "beyond a reasonable doubt"?
5. Ryan wants to know if his professor thinks highly of him. He estimates that professors probably think highly of 50% of their students. However, Ryan asked his professor directly and the professor said he thought Ryan was an excellent student. The likelihood of a professor saying Ryan is an excellent student if he actually is 95%, while the likelihood of misreporting (so as not to hurt his feelings) and saying that Ryan is an excellent student (even though he isn't) is 25%. What is the probability that Ryan's professor thinks highly of him? Why is this sort of problem (determining others' opinions of us) so difficult?
6. Tina wants to know if she should be stricter with her children or not. She estimates that around 1 in 5 parents aren't strict enough with their children. However, Tina's overly-critical sister Tanya recently said that Tina needed to be more strict, and that her children were terribly behaved. Tina thinks the probability that Tanya would say she wasn't strict enough if there actually was a problem with her parenting skills is 100%. However, she thinks there is about a 3 in 4 chance that Tanya would say this even she was a perfect parent. What is the probability that Tina should be more strict? What should Tina do?
7. Sara wonders whether she should take up painting as a new hobby. Based on past experience, she only enjoys about 1/3 of new hobbies. However, her close friend Rebecca recently said that Sara would love taking up painting classes with her. The likelihood of Rebecca being right about Sara liking painting classes if there was actually potential for her to enjoy them is 9 in 10, while Rebecca's probability being wrong and saying Sara would like them even though she wouldn't be 4 in 10. What is the probability that Sara would enjoy taking up painting classes? If you were Sara, what would you do?
8. Mary suspects she may be pregnant but isn't sure yet as her period hasn't arrived yet. According to research, only 15% of women in her situation (considering age and lifestyle) are pregnant at any given moment. However, Mary took a pregnancy test and it came back positive. The likelihood of testing positive if the woman actually pregnant being 97%, while the possibility false positives being 2%. What is probability Mary might be pregnant?

9. John worries he may have picked up a cold or flu virus from someone at work. He looks up recent statistics, and discovers that around 10% people in his community have such viruses. However, John took temperature today and it came back high.. The chance temperature coming back high if someone infected with virus being 90%, while chances temperature coming back high due other factors such exercise etc., being 5%. What is the probability John has a virus?
10. John wants to know if he should invest in a certain stock or not. He estimates that around 3/7 stocks outperform their peers in a given year . However, John's financial adviser recently said that this stock had very strong potential for growth in value over time . The likelihood of a financial adviser accurately predicting future growth for a good stock investment opportunity is 3/4, while the likelihood of misidentifying a bad stock investment as being good is also 3/4. What is the probability that John should invest in this stock? (Note: This may be a bit surprising, but it also fits with what we know about people who try to "predict" stocks!).

## Case Study: The Base Rate Fallacy

The **base rate fallacy** is a type of cognitive bias that occurs when people make judgments about the likelihood of an event occurring based on specific characteristics or details, rather than considering the overall probability of the event occurring. This can lead people to overestimate or underestimate the likelihood of an event occurring, resulting in poor decision-making. In the language of Bayes Theorem, it means ignoring the influence of the **prior probability** that a hypothesis is true.

- Medical diagnosis: A patient goes to the doctor with symptoms that could be caused by either a rare disease or a common cold. The doctor orders a diagnostic test for the rare disease, which comes back positive. The doctor concludes that the patient has the rare disease, without considering the fact that the base rate for the disease (i.e. the overall probability that a person has the disease) is very low compared to the common cold. The doctor's conclusion is influenced by the specific characteristics (i.e. the positive test result) rather than the overall probability.
- Missing plane: A plane goes missing and there are two possible explanations for the disappearance: a technical failure or a hijacking. The media focuses on the hijacking explanation, highlighting specific details such as the presence of a suspicious passenger on the plane. The public becomes more convinced that the plane was hijacked, without considering the overall base rate for plane hijackings (which is very, very low! Mechanical errors are much more common). The public's conclusion is influenced by the specific characteristics (i.e. the suspicious passenger) rather than the overall probability.
- Hiring Decisions: A company is looking to hire a new employee and receives two job applications. One applicant has a strong resume with a lot of relevant experience and the other has a weaker resume with less experience. The company decides to hire the applicant with the stronger resume, without considering the overall base rate for the quality of applicants (i.e. the probability that an applicant with a strong resume will be a good fit for the job). The company's decision is influenced by the specific characteristics of the applicant (i.e. their resume) rather than the overall probability. (This might be a problem, for example, if the overall quality of applicants was low—in this case, it might be better not to hire anyone!).

The base rate fallacy can be a big problem in both scientific research and our day-to-day lives because it can lead to poor decision-making and incorrect conclusions. In scientific research, ignoring the base rate (or prior probability) of a hypothesis being true can lead to faulty conclusions and false positives. This can have serious consequences, such as in the medical field where incorrect diagnoses can result in inappropriate treatment or harm to patients.

In our day-to-day lives, the base rate fallacy can also lead to poor decision-making and incorrect judgments. For example, if we overestimate the likelihood of a rare event occurring (such as winning the lottery), we may make poor financial decisions based on this overestimation. Similarly, if we underestimate the likelihood of a common event occurring (such as getting a flat tire), we may not take appropriate precautions or make necessary preparations.

Overall, the base rate fallacy can lead to inaccurate beliefs and poor decisions that can have serious consequences in both scientific research and our daily lives. It is important to consider the base rate (or prior probability) when making judgments and decisions to avoid this cognitive bias.

## Questions

1. How does the base rate fallacy impact decision-making in the medical field?
2. In what ways can the base rate fallacy lead to poor financial decisions?
3. How can we avoid the base rate fallacy in our everyday lives?
4. Can you think of any other real-life examples of the base rate fallacy?
5. How does the base rate fallacy relate to Bayesian probability and the concept of a prior probability?
6. In what ways can the media contribute to the base rate fallacy by highlighting specific details and ignoring the overall probability of an event occurring?

# CHAPTER 8: SCIENTIFIC REASONING

In this chapter, you will learn about the hypothetical method, which is a way of using deduction and induction to test hypotheses. You'll also learn about the difference between empirical and theoretical hypotheses and how to test them. We'll also delve into the case study of Charles Darwin's theory of evolution by natural selection, examining the evidence and objections to this theory. This chapter will help you understand how scientists use logical thinking to make sense of the natural world, and why it's important to carefully evaluate the evidence before making conclusions. By the end of this chapter, you'll have a better understanding of how scientific reasoning works and why it matters in our everyday lives.

To begin, we'll dive right into a recent issue—the safety and effectiveness of vaccines.

## EXAMINING THE EVIDENCE: A SCIENTIST AND A SKEPTIC DISCUSS VACCINES

***Background.*** *Astrid and Nerys met in college, where they were both studying biology. Astrid was always fascinated by the mysteries of the natural world and was drawn to the study of science because of its ability to answer questions through empirical evidence and rigorous experimentation. Nerys was initially more skeptical of the scientific establishment and was more interested in alternative approaches to health and wellness. Despite their different perspectives, Astrid and Nerys quickly became good friends, drawn together by their shared curiosity and their love of learning.*

*After college, Astrid decided to pursue a graduate degree in biology, while Nerys decided to take a different path and started her own business selling natural health products. Despite their different career paths, Astrid and Nerys remained close friends and often found themselves discussing science and health-related topics. Over time, Astrid's passion for science and her patient explanations of scientific concepts helped to assuage some of Nerys' skepticism, and Nerys began to appreciate the value of evidence-based approaches to health and wellness. (Note: These characters are fictional creations!)*

Nerys: Hey, Astrid. I saw this documentary on Netflix that claims that vaccines are dangerous and that the scientific community is hiding the truth. What do you think?

Astrid: Hi, Nerys. I'm sorry, but that documentary is filled with misinformation and conspiracy theories. The scientific community has a long and successful history of developing and testing vaccines to prevent diseases and save lives. Vaccines have saved countless lives and prevented devastating outbreaks of infectious diseases, and they have a much lower risk of serious side effects compared to the diseases they prevent.

Nerys: To be honest, I've always had a bit of skepticism about vaccines. I've heard so many stories of people getting sick or dying after getting vaccinated, and I just can't help but wonder if there's more to the story than what the experts are telling us. Plus, the pharmaceutical industry is a huge business, and I can't help but wonder if they're more interested in profits than in our health.

Astrid: I understand your concerns, Nerys. It's natural to be skeptical and to want to make informed decisions about our health. However, it's important to remember that the scientific process is designed to minimize bias and to test hypotheses through rigorous experimentation and observation. Scientists are trained to follow strict protocols to control for variables and to report their methods and results transparently, so that other scientists can evaluate the evidence and replicate the study if necessary. This process of peer review helps to ensure the reliability and validity of the findings. In addition, regulatory agencies such as the FDA have strict guidelines and oversight to ensure the safety and efficacy of vaccines. It's also important to note that the pharmaceutical industry is subject to regulatory and legal oversight, and it has to follow strict rules and standards to ensure the quality and safety of its products. Just because a company stands to profit from a product doesn't mean that the product is automatically unsafe or ineffective. It's also important to consider the overall public health benefits of vaccines and the potential consequences of not vaccinating.

Nerys: And it's not just vaccines that I'm skeptical about. I've also heard a lot of conflicting information about other health issues, like diet and nutrition. It seems like every year there's a new study that contradicts the last one, and I just don't know who to believe.

Astrid: It's true that science is a constantly evolving field, and new findings may sometimes contradict previous beliefs. However, this is how science progresses and improves. It's important to keep an open mind and to be willing to consider new evidence and perspectives, but it's also important to be critical and to evaluate the quality

of the evidence. It's also important to recognize that some studies may be flawed or biased, and that not all studies are created equal.

Nerys: And then there's the whole issue of funding and research bias. It seems like the scientists who get the most funding are the ones who support the mainstream narrative, and those who challenge the status quo often get ignored or marginalized. It's hard to know who to trust when it feels like the deck is stacked against certain viewpoints. It seems like the scientific establishment is more interested in protecting its own interests and preserving the status quo than in genuinely seeking the truth.

Astrid: I understand your concerns about funding and bias, Nerys. It's true that funding can be a potential source of bias in research, and that researchers may be more likely to report positive findings if they are funded by organizations or industries with a vested interest in the outcome. However, it's important to recognize that the scientific community has systems in place to address these issues and to minimize bias. For example, most research funding agencies have strict guidelines and policies to ensure the independence and integrity of the research process. In addition, the peer review process helps to ensure that research is evaluated objectively by other experts in the field. And it's important to recognize that science is not a monolithic entity, and that there are many scientists who are willing to challenge the mainstream narrative and to consider alternative viewpoints.

Nerys: But what about all the alternative therapies and treatments that are being ignored or dismissed by the mainstream scientific community? I've heard about so many natural remedies and treatments that have helped people, but they're never given a fair chance because they don't fit the mainstream narrative.

Astrid: It's true that there are many alternative therapies and treatments that have been promoted as effective, but it's important to recognize that most of these have not been subjected to the same level of scientific scrutiny and testing as conventional treatments. The scientific community has a responsibility to carefully evaluate the evidence for any treatment, and to consider the potential risks and benefits. Alternative therapies that have not been subjected to rigorous testing and evaluation may not be safe or effective, and they may even be harmful. It's important to be aware of the limitations of the evidence and to be cautious about making treatment decisions based on anecdotal reports or limited data.

Nerys: You know, I've been thinking more about this whole issue of health and wellness, and I've come to the conclusion that a lot of our modern diseases are caused by toxins in our environment and in the food we eat. It's not just about germs, but about the overall toxic burden that our bodies are subjected to.

Astrid: I understand your concerns about toxins, Nerys, but it's important to recognize that the germ theory of disease has been extensively tested and supported by a vast amount of experimental evidence. The germ theory is the scientific explanation for how infectious diseases are caused by microorganisms such as bacteria, viruses, and parasites, and how these microorganisms are transmitted from one person to another. The germ theory has revolutionized our understanding of disease and has led to the development of many effective treatments and prevention measures, such as vaccines, antibiotics, and hygiene practices.

Nerys: But what about the role of our thoughts and emotions in health? I've heard that positive thinking and a positive attitude can help to boost our immune system and protect us from illness.

Astrid: It's true that our mental and emotional state can have an impact on our overall health and well-being, but it's important to recognize that our thoughts and emotions are not the sole determinants of our health. The germ theory explains how diseases are caused by specific microorganisms, and how these microorganisms can be transmitted from one person to another through various routes, such as through respiratory droplets, contaminated food or water, or through insect vectors. While a positive attitude may be helpful for coping with illness and for supporting overall health, it's not a substitute for proven medical treatments or preventive measures.

Nerys: I really appreciate the discussion, Astrid. I think I have a lot to learn about the scientific process and how it's used to evaluate the safety and effectiveness of treatments.

Astrid: I'm glad to have been able to help, Nerys. I think it's important for all of us to be open to learning and to being critical of our own biases and assumptions.

Nerys: Yeah, I definitely have a lot to think about. I'm still interested in alternative approaches to health and wellness, but I see now that I need to be more mindful of the limitations of my own knowledge and to be more critical of the sources of information I rely on,

Astrid: I think that's a great approach Nerys. And to be clear, I do think that there is a value in exploring new and alternative treatments. It's just that we need to do so carefully and methodically—scientifically!—instead of relying on anecdotal evidence.

### QUESTIONS

1. What are some of the factors that contribute to Nerys' skepticism about vaccines and the scientific community?
2. How does Astrid respond to Nerys' skepticism, and what evidence does she provide to support her arguments?
3. How do the different career paths and experiences of Astrid and Nerys impact their perspectives on science and health-related issues?
4. How does the dialogue between Astrid and Nerys illustrate the importance of critical thinking and the evaluation of evidence?
5. In what ways do Astrid and Nerys demonstrate respect for each other's viewpoints, even when they disagree?

## INTRODUCTION TO SCIENTIFIC REASONING

Scientific reasoning a huge role in almost every part of our day-to-day lives. Among other things, the ability to understand and evaluate scientific arguments plays a huge (and ever-increasing) role in decisions about what we eat, which medical treatments we use, which products we buy, how we parent/exercise/shop, and even our beliefs on which political proposals are most likely to improve things (and which are most likely to make them worse). These arguments concern everything from physics (nuclear power, space travel), biology (genetically modified crops), psychology (parenting, "management" techniques), and economics, just to name a few different areas.

Logicians and philosophers of science (many of whom were scientists themselves!) have spent a lot of time thinking and writing about "how science works." Not surprisingly, they don't all agree on everything. However, there are a number of key concepts which *most* of them agree are central to understanding scientific reasoning:

**Explanations: Brief Review.** As we discussed earlier in the book, an **explanation** is a set of two or more statements, one or more of which (the explanans) are claimed to be the reason/cause of the other (the explanandum). In this sense, they resemble arguments (with premises and conclusions). However, unlike the conclusion of an argument, we already *know* that the explanandum is true. So, when Julie offers the explanation in the example below, she is trying to explain *why it is* that she didn't do well on her math test. Of course, this explanation may or may not be the *correct* explanation—perhaps the real reason that Julie didn't do well is because she didn't attend class regularly, or something like that. For example:

- Explanans 1: Julie didn't sleep well last night.
- Explanans 2: Julie has a hard time concentrating when she doesn't sleep.
- Explanandum (what is to be explained): So, Julie did poorly on her math test today. (We already knew this was true—we are trying to figure out why it happened.)

**What is a (Scientific) Hypothesis?** There are many facts for which the explanation is not obvious:

1. My car did not start this morning, after having trouble earlier this week.
2. I went to a new seafood restaurant last night, and woke up with a strange rash this morning.
3. Joe Biden won the 2020 US Presidential election.
4. The average surface temperature of the earth is higher now than it was 50 years ago.
5. Killing adult humans for fun is morally wrong.

In our attempts to explain these facts, we can propose tentative explanans, called **hypotheses:**

1. The battery on my car has finally died.
2. I am having an allergic reaction to shellfish.
3. Women, minorities, and younger voters turned out a higher rate than men, whites, and older voters.
4. Increased carbon dioxide emissions have caused a greenhouse effect, which is "trapping" heat near the earth.
5. It is wrong to deprive a person of a "future like ours."

Among other things, scientific reasoning involves attempts to confirm or falsify various hypotheses (though science also involves activities such as measurement, which may not involve directly testing hypotheses). In many cases, scientists consider *multiple* hypotheses that might explain a given set of facts, and use experiments and observations to figure which hypothesis, if any, is the correct one. (As the above examples show, though, not all hypotheses involve scientific reasoning).

## The Hypothetical Method: Deduction and Induction

The **hypothetical method** is commonly used both in science and in everyday life. It has four steps, which involve both deductive and inductive reasoning. I've used Darwin's theory of evolution by natural selection as an example here, since this is undoubtedly one of the scientific theories people are most familiar with, and which has featured in many arguments over the role of science in education and policy:

- **Step 1: Clearly identify the explanandum, or the fact that you want to explain.** Example: Organisms are generally well-suited for their environments. A sparrow's wings allow it to fly quickly over short distances (and change direction rapidly to avoid predators), a penguin's fins allow it swim, and a goose's wings are ideal for long-distance flight.

- **Step 2: Formulate a hypothesis.** Example: Organisms have a common ancestor, but have been shaped into different species by natural selection. At some point in the distant past, there was a common ancestor of geese, sparrows, and penguins. The descendants of this common ancestor ended up living in different environments, with very different selective pressures.

- **Step 3: Deduce implications or predictions of the theory.** Example: If evolution via natural selection is true, the fossil record should show gradual change. In some general sense, bird fossils found in era B should be "intermediate" between the older fossils of A and the younger fossils of C.

- **Step 4: Test the implications.** If the predictions are correct, the hypothesis is confirmed, which provides *some evidence* to think the hypothesis is true. This is the inductive part of the hypothetical method. Example: Go check to see whether this is in fact what the geological record shows.

When using the hypothetical method, there are a number of key points to keep in mind:

*You can't deduce a hypothesis from the facts.* The deductive part of the hypothetical method involves deducing *predictions* from the *hypothesis*. It is important to remember that this does NOT work the other way around: one cannot simply deduce a hypothesis from one what has observed. This is because any worthwhile hypothesis must always go "beyond" what you already know, and suggest *additional* tests or experiments. For example, if a patient has lung cancer, a physician cannot simply assume "Oh, he or she must have been a smoker." This would be a hypothesis, which would need to be tested further.

*The hypothetical method is often the only way of finding explanations.* Formulating a hypothesis and deducing implications (that you can then check) is the only way to "guide your search" for a true explanation. Without a hypothesis, you would have *no idea* of what sorts of facts might be relevant to explanation. This relates to the previous point: science does not precede simply by recording the facts and generalizing from them. Instead, scientists need to decide *ahead of time* which hypotheses they want to test, and then consider whether the evidence supports these hypothesis.

*Determining whether a hypothesis is FALSE is often much easier than determining whether it is TRUE.* If an application of the hypothetical method produces an incorrect prediction (as often happens), this means that either the hypothesis was false, or one of your other assumptions (e.g., concerning the accuracy of your test) was false. Even ONE false prediction is enough to do this. By contrast, it can often require *many* successful predictions (in

a wide variety of situations) before we are willing to say a hypothesis is likely to be true, or that it is the *best* explanation for the phenomena in question.

## Empirical vs. Theoretical Hypotheses

An **empirical hypothesis** is a hypothesis whose truth or falsity can be directly observed. If we observe that the hypothesis is true, the hypothesis is very strongly confirmed. For example, suppose that we have the following explanandum: "My car has suddenly begun pulling to the left." Here are some empirical hypotheses:

- Empirical Hypothesis 1: My left front tire is flat.
- Empirical Hypothesis 2: My left rear tire is flat.
- Empirical Hypothesis 3: The axel rod on my car is broken.

Determining which one of theses hypotheses (if any) is correct can be directly observed (either by me or by a mechanic). Once we have done these observations, we can strongly confirm one of the hypothesis, while falsifying the others. Of course, we can't be *absolutely sure* of the truth of a hypothesis (perhaps I made a mistake in my observation, or maybe I'm dreaming). However, if two different mechanics tell me that my left rear tire is flat (and I can see that it is flat, as well), I have *very good reason* to believe to believe that hypothesis 2 is the correct one, while hypotheses 1 and 3 are not.

Many hypotheses of scientific interest (including most of the important ones) are NOT empirical hypothesis, since they involve things (electrons, distant stars, viruses, the past, mental states) that CANNOT be directly observed. Hypotheses involving such unobservable entities or processes are called **theoretical hypotheses**.

## Testing Theoretical Hypotheses

Theoretical hypotheses play a crucial role in our understanding of the natural world. These hypotheses are proposed explanations for phenomena that are based on theories or models, and they are an essential part of the scientific process. In order to be considered scientific, a hypothesis must be testable, meaning it must make predictions that can be observed and measured.

The testing of theoretical hypotheses is a vital step in the process of confirming or falsifying these hypotheses. When a hypothesis makes a prediction that can be tested through observations or experiments, it is said to be confirmed if the observations match the prediction and falsified if the observations do not match the prediction.

**How Confirmation Works.** However, it is important to note that confirmation of a hypothesis does not necessarily mean that the hypothesis is true. Instead, the confirmation of a hypothesis is relative to competing hypotheses, and the most supported hypothesis is the one that makes the most accurate and precise predictions. In other words, confirmation of a hypothesis means that the evidence in favor of the hypothesis has increased, making it more probable that the hypothesis is true.

Making surprising predictions is often seen as a strength of a hypothesis, as it allows for the opportunity to test the hypothesis in a more rigorous way and potentially establish it as a more supported explanation for a phenomenon. One notable example of this is the case of Galileo observing the moons of Jupiter to confirm the hypothesis of Copernicus that the Earth is not the center of the universe, but rather orbits around the Sun along with the other planets. This was a surprising prediction at the time, as it went against the widely-accepted belief that the Earth was the center of the universe. However, Galileo's observations of the moons of Jupiter, which followed the predictions of Copernicus's hypothesis, provided strong evidence in favor of the hypothesis and helped to establish the idea of a heliocentric solar system.

**How Falsification Works (and Why "Ad Hoc" Revisions are Bad).** On the other hand, if the observations do not match the predictions of the hypothesis, this is taken as evidence against the hypothesis and can even lead to the hypothesis being falsified. In this case, the hypothesis must be revised or discarded in favor of a new hypothesis that better explains the observations.

For example, the geocentric ("earth-centered") model of the Solar System was eventually falsified by the observations of astronomers such as Copernicus and Galileo, who proposed the hypothesis of a heliocentric solar system in which the Sun is the center of the solar system and the Earth and other planets orbit around it.

As just noted, these observations provided strong evidence in favor of the heliocentric model and helped to establish it as the more supported explanation for the observed motion of the planets.

One of the key problems with the geocentric model was that it required the continual use of ad hoc revisions, such as the addition of epicycles, to try to explain the observed deviations from the model's predictions. An ad hoc revision is a modification to a theory or model that is made specifically to try to explain a particular observation or set of observations, without any broader considerations of the theory or model as a whole.

While ad hoc revisions can sometimes be useful in the short term, they can become problematic if they are used too frequently or if they are not based on any underlying principles or laws. In the case of the geocentric model, the addition of epicycles was used to try to explain the observed deviations from the model's predictions, but it ultimately became clear that these ad hoc revisions were inadequate to fully explain the observations. As a result, the geocentric model was ultimately falsified in favor of a new hypothesis that provided a better explanation for the observations.

### Questions

1. What is the role of scientific reasoning in everyday decision-making?
2. What are some key concepts in understanding scientific reasoning?
3. What is the hypothetical method and how is it used in scientific reasoning?
4. What is the difference between an empirical hypothesis and a theoretical hypothesis?
5. How does confirmation of a theoretical hypothesis differ from confirmation of an empirical hypothesis?
6. What is an ad hoc revision and why are they considered problematic in the testing of theoretical hypotheses?
7. Can we ever be completely certain that a theoretical hypothesis is true? Why or why not?
8. Can an empirical hypothesis be falsified? Why or why not?
9. How does the process of falsification differ from the process of confirmation?
10. How do competing hypotheses play a role in the confirmation or falsification of a hypothesis?

### Exercises

For each of the following explananda (i.e., things to explain), propose at least three potential hypotheses. Then, state an implication of each hypothesis that would allow you test your hypothesis.

1. You send your best friend a text. They usually respond promptly. However, it's now been eight hours and you still haven't heard anything.
2. You have a pet dog, Snoopy, that almost always greets you at the door when you come home. One day, Snoopy, does not greet you.
3. Your significant other, Sam, used to come meet you for dinner nearly every evening. For the last month, however, Sam has been "working late," and only meets you for dinner once or twice a week.
4. Your computer does not turn on when you press the power button.
5. You and your friend have been working for Professor B for the same amount of time. You've both received similar performance reviews. However, you were offered a promotion, while your friend was not.
6. You had a headache yesterday, which went away after you ate a large serving of Potato Oles. You suspect Potato Oles cured you.
7. Your neighbor's car was damaged while they were away on vacation.
8. Your plants have stopped growing despite being well-watered and in good light.
9. You have been experiencing muscle cramps at night.
10. Your phone battery is draining much faster than usual.
11. Your favorite restaurant has closed down.
12. Your local grocery store has run out of your favorite brand of cereal.
13. Your car is making a strange noise that it hasn't made before.
14. Your friend has been acting strangely distant lately.
15. You received a lower grade on an exam than you expected.

## Minds That Mattered: Patricia Churchland

Patricia Smith Churchland is a contemporary philosopher and neuroscientist known for her work on the philosophy of mind and the neural basis of consciousness. She is a professor emerita at the University of California, San Diego, and has written numerous books and articles on these and related topics.

One of Churchland's most influential ideas is the theory of eliminative materialism, which holds that certain common-sense psychological concepts, such as the idea that we have beliefs, desires, and emotions that guide our actions, do not correspond to any underlying reality and should be eliminated from our scientific theories of the mind. Churchland argues that these concepts are based on flawed folk psychology, and that as our scientific understanding of the brain and its functions improves, we will be able to replace these concepts with more accurate, neuroscientific ones. For example, instead of saying that someone is angry because they have an "anger emotion," we might instead say that certain patterns of neural activity in the brain are responsible for their angry behavior.

Churchland has also written extensively on the relationship between consciousness and the brain, and has argued that consciousness arises from the activity of specific brain networks. She has proposed that the brain's ability to integrate information from different sources, such as sensory input, memory, and internal states, is crucial for the emergence of consciousness. This integration is thought to be mediated by a network of interconnected brain regions known as the "global workspace." For example, when you see a tree, your brain integrates information from your visual system, your memory of what trees look like, and your current emotional state to create a conscious experience of seeing a tree.

In terms of evolutionary theory, Churchland has argued that the moral behaviors exhibited by humans and other animals are the result of complex interactions between their brains and the environment, shaped by the process of natural selection. She has proposed that the neural mechanisms underlying these behaviors can be studied and understood using the tools of neuroscience, and that a deeper understanding of these mechanisms can help us better understand the evolutionary basis of moral behavior. For example, if we can identify the specific brain regions and neural pathways involved in moral decision-making, we may be able to understand why certain moral behaviors are more common in some animals than others, and how these behaviors may have evolved over time.

In psychology, Churchland's ideas about the neural basis of consciousness and moral behavior would have significant implications if adopted. Her emphasis on the importance of studying the brain and its functions in order to understand mental phenomena suggests that psychology should shift its focus away from traditional methods such as introspection and instead rely more on empirical data and scientific methods. This would likely lead to significant advances in our understanding of the neural basis of consciousness and other mental states, and could have practical applications in areas such as mental health treatment. Overall, Churchland's ideas have the potential to fundamentally transform our understanding of the mind and its relation to the brain, and could have far-reaching implications for both philosophy and psychology.

### Questions

1. According to Churchland, what is the relationship between common-sense psychological concepts and the underlying reality of the mind?
2. What role does Churchland propose that the brain's ability to integrate information plays in the emergence of consciousness?
3. How might Churchland's ideas about the neural basis of moral behavior inform our understanding of moral decision-making in humans and other animals?
4. How might Churchland's work on the philosophy of mind and the neural basis of consciousness contribute to the development of new treatments and therapies for mental health conditions?
5. What ethical implications might Churchland's ideas have for our understanding of consciousness and the mind?

## Case Study: Darwin's Theory of Evolution

In this section, we'll work through an extended case study of scientific reasoning regarding Darwin's Theory of Evolution. This will help us better see how scientific reasoning works in a particular case and give "content" to some of the abstract ideas laid out in the previous section.

### Darwin and His Time

In the early 19th century, England was in the midst of the Industrial Revolution, a period of rapid technological and social change. This period also saw significant advances in the field of science, particularly in the areas of biology and geology. At the forefront of this scientific revolution was Charles Darwin, a young naturalist who would go on to develop one of the most influential theories in the history of science: the theory of evolution by natural selection.

Charles Darwin was born in 1809 into a wealthy and influential family. He received a classical education at the prestigious Shrewsbury School and later studied at the University of Edinburgh, where he developed an interest in natural history. In 1831, Darwin embarked on a five-year voyage around the world on the HMS Beagle, during which he collected a vast amount of scientific data and specimens that would later inform his theories.

One of the people who influenced Darwin's thinking was Charles Lyell, a geologist who argued that the Earth's surface was shaped by slow and gradual processes over a long period of time. Lyell's ideas were in contrast to the prevailing belief that the Earth was relatively young and had been created in its current form by a series of catastrophic events. Darwin was deeply impressed by Lyell's work and incorporated many of his ideas into his theory of evolution, including the concept of deep time and the idea that species change gradually over time through natural processes.

Another influential figure in Darwin's life was his grandfather, Erasmus Darwin, who was a pioneering scientist and naturalist in his own right. Erasmus Darwin had also proposed a theory of evolution, albeit one that was based on the idea of a "life force" rather than natural selection. Despite the differences between their theories, Erasmus Darwin's work may have inspired his grandson to pursue a career in science and to think critically about the natural world.

But who were the other scientists of the time and how were they viewed by society? The scientists of early 19th century England were mostly men, and many came from privileged backgrounds. They were typically well-educated, with many having studied at Oxford or Cambridge. However, opportunities for scientists were limited, as there were few professional positions available and scientific research was often seen as a hobby rather than a career.

Despite the significant contributions made by scientists to the field, they were often viewed with suspicion by the general public. Science was seen as a threat to traditional beliefs, particularly religious ones, and scientists were sometimes accused of trying to "play God." In addition, there were biases and prejudices against certain groups of people, such as women and working-class individuals, who were often excluded from scientific institutions and opportunities.

## An Interesting Problem

In the early 19th century, the dominant theory in biology was that of "special creation," which posited that each species was created separately by a divine being. This theory seemed to provide a simple and elegant explanation for the diversity of life on Earth. However, it also had several problems. For one, it lacked a clear mechanism for how new species could arise. In addition, it was difficult to reconcile the hypothesis of special creation with the existence of extinct species, which seemed to contradict the idea that each species was created for a specific purpose and was perfectly adapted to its environment.

These were just a few of the many mysteries and questions that scientists of the time were trying to solve. Another problem was the existence of similarities between different species, which seemed to suggest that they were related in some way. For example, the bones in the forelimbs of humans, birds, and bats are all similar, despite their differences in function. Similarly, botanists of the time observed that different plant species had similar structures, such as flowers and seeds, which seemed to suggest that they had a common ancestor.

These unsolved problems presented a challenge to the hypothesis of special creation and opened the door to alternative theories. One such theory was that of evolution, which proposed that all species descended from a common ancestor and evolved over time through natural processes such as natural selection. This theory was supported by the work of scientists such as Jean-Baptiste Lamarck, who proposed that species could evolve through the inheritance of acquired characteristics. However, Lamarck's theory ultimately failed to gain widespread acceptance and was largely discredited by the end of the 19th century.

Another challenge to the hypothesis of special creation came from the growing body of evidence supporting the idea of common descent, which argued that all species were related through a shared ancestry. This idea was supported by the discovery of fossilized remains of extinct species, which seemed to bridge the gap between different groups of organisms. It was also supported by the existence of so-called "vestigial organs," which were structures that seemed to have no function in certain species but had a clear function in others. For example, the wings of flightless birds were considered vestigial organs because they seemed to have no function in the birds' current environment, but they had a clear function in the ancestors of these birds. All of these examples seemed

to suggest that species were not created in their current form, but rather evolved from a common ancestor through a process of natural selection.

## The Theory of Evolution by Natural Selection

The theory of evolution is a scientific explanation for the diversity of life on Earth. It proposes that all species are related through a shared ancestry and that they have evolved over time through the natural processes of variation, inheritance, and selection. These three concepts are central to understanding how evolution occurs.

Variation refers to the diversity within a species, which can be seen in traits such as appearance, behavior, and physiology. Variation is the source of diversity within a species and is necessary for evolution to occur. Without variation, there would be no basis for natural selection to act upon, and evolution would not be possible.

Inheritance is the process by which traits are passed from one generation to the next. This process occurs through the transmission of genetic material, such as DNA, from parent to offspring. Inheritance plays a crucial role in the evolution of species because it allows traits that are advantageous in a given environment to be passed on to future generations. Without inheritance, the traits that are beneficial to a species' survival and reproduction would not be passed on, and evolution would not occur.

Selection is the process by which certain traits are more likely to be passed on to future generations due to their adaptive advantage in a given environment. This process occurs through the survival and reproduction of the fittest individuals, which leads to the evolution of species over time. For example, in a population of finches living on an island with a shortage of small seeds, individuals with long beaks may have a reproductive advantage because they are better able to access the remaining seeds. As a result, the trait for long beaks is more likely to be passed on to future generations, leading to the evolution of finches with long beaks on the island.

Here are some other examples:

In the animal kingdom, one example of variation, selection, and inheritance can be seen in the development of camouflage in certain species. For example, the mottled patterns on the fur of a leopard are a result of variation within the species. This variation provides the basis for natural selection to act upon, and leopards with patterns that are better able to blend in with their surroundings are more likely to survive and reproduce. As a result, the trait for mottled fur is passed on to future generations through inheritance.

In the plant kingdom, one example of variation, selection, and inheritance can be seen in the development of defense mechanisms, such as thorns on roses or toxins in poison ivy. These traits are the result of variation within the species and provide a protective advantage against herbivores. As a result, plants with these traits are more likely to survive and reproduce, leading to the selection for these traits and their inheritance to future generations.

In the world of viruses, one example of variation, selection, and inheritance can be seen in the development of resistance to antiviral drugs. For example, the HIV virus has evolved to become resistant to certain antiretroviral drugs, which has made it more difficult to treat. This resistance is the result of variation within the virus population and provides an adaptive advantage in the presence of the drug. As a result, the trait for resistance is passed on to future generations through inheritance.

## Darwin's Evidence

In *The Origin of Species,* Darwin offers a number of different lines of evidence. In each case, he argues that his theory does a BETTER job of explaining certain facts than does the theory of "special creation.". He was interested in comparing the following the two hypotheses:

- Hypothesis 1 (**Creationism**, defended by William Paley): "The first member(s) of each species was created by an intelligent designer. Species were specifically designed for the environments in which they live."
- Hypothesis 2 (**Evolution by natural selection**, defended by Charles Darwin, as well as by the less-famous Alfred Russell Wallace): All organisms descended from a small number of ancestors. Adaptations are caused exclusively by the facts that (1) there is random **variation** among the traits of a population, (2) there is non-random **selection** amongst traits (i.e., organisms with certain traits are more likely to survive and reproduce than others), and (3) offspring **inherit** traits from their parents.

Darwin's main evidence was as follows:

**The Fossil Record.** One of the key pieces of evidence that Darwin could explain but Paley could not was the fossil record. The fossil record showed a pattern of gradual change over time, rather than sudden appearances of new species. While Paley's theory was compatible with this observation, it did not provide a reason for expecting it.

**No clear line between species.** In addition, there were many cases where experts disagreed on what counted as members of the same species. On Darwin's theory, this was to be expected, as species emerge gradually over time and we would expect a certain amount of "gradualism." However, on Paley's theory, this was surprising, since each species was created independently.

**Rudimentary organs.** Another observation that supported Darwin's theory was the existence of rudimentary organs in some organisms that seemed to serve no purpose. Darwin's theory predicted the existence of these organs, as they may be remnants of structures that were important to the organism's ancestors. Paley's theory, on the other hand, did not provide an explanation for why a divine being would create useless organs.

**Success of invasive species.** Darwin's theory also explained the success of non-native, or "invasive," species in certain environments. This phenomenon would be surprising on Paley's theory, which argued that organisms were custom-designed for their environments. However, it was exactly what we would expect on Darwin's theory of natural selection, which posits that organisms with traits advantageous for their environment are more likely to survive and reproduce.

**Geographic distribution of species.** Geographical barriers, such as the Panama isthmus, often separated entirely different species, even if the environments on either side were nearly identical. This would be difficult to explain on Paley's theory, as there would be no reason for a creator to design two different species for the same environment. However, this pattern was consistent with Darwin's theory, which posits that the random aspects of the evolutionary process can lead to the separation of species.

**Other evidence.** Other observations that supported Darwin's theory included the structural similarities among organisms and the similarities between embryos and fetuses across species. These observations seemed difficult to explain on Paley's theory of independent creation, but were consistent with Darwin's theory of natural selection, which works with existing traits and cannot design new organisms from scratch.

Overall, while this evidence did not falsify Paley's theory (after all, it was possible the creator was "tricking" us), it provided a more comprehensive explanation for the diverse observations of the natural world. On Darwin's theory, these observations were the sorts of things that one would expect to see.

## The Reception and Influence of Darwin's Theory

Charles Darwin's theory of evolution by natural selection is one of the most influential scientific theories of all time. When it was first published in 1859, it sparked a heated debate and controversy that continues to this day. On one side were scientists like Alfred Russel Wallace and Thomas Huxley, who supported the theory and saw it as a revolutionary explanation for the diversity of life on Earth. On the other side were those who opposed the theory, either because they rejected the idea of common descent or because they saw it as incompatible with their religious beliefs.

Despite the controversy, Darwin's theory had a profound impact on the field of biology. One of the key areas it influenced was the study of genetics, which played a crucial role in providing a mechanistic explanation for evolution by natural selection. The rediscovery of Gregor Mendel's work on genetics in the early 20th century helped to bridge the gap between Darwin's theory and the underlying mechanisms of inheritance. The impact of Darwin's theory on the study of genetics led to the development of the modern synthesis, which integrated genetics with evolution by natural selection. This synthesis provided a more complete and comprehensive explanation for the evolution of species, and it remains a cornerstone of modern biology.

The influence of Darwin's theory can be seen in many areas of modern biology, including medicine, agriculture, and conservation. For example, understanding the principles of evolution by natural selection has helped to inform the development of new drugs and treatments for diseases. It has also been used to understand the evolution of pests and pathogens, which has implications for agriculture and public health. In addition, the

principles of evolution have been applied to the conservation of endangered species, helping to inform conservation efforts and protect biodiversity.

Recent developments in the field, such as the discovery of CRISPR, have allowed for the precise editing of genetic material and have opened up new possibilities for understanding and manipulating evolution. However, these developments have also raised ethical questions and debates about the role of humans in shaping the evolution of species.

The influence of Darwin's theory of evolution by natural selection on biology has been significant and enduring. It has shaped our understanding of the diversity of life on Earth and has had important implications for many areas of biology, including medicine, agriculture, and conservation. Despite ongoing controversy and debate, the theory remains a cornerstone of modern biology and continues to inform research and discovery in the field.

### Objections to Evolution via Natural Selection

There have been many objections to evolution via natural selection over the past 150+ years. Here a number of the most common, together with an explanation of why they fail:

OBJECTION: "There are still gaps in the fossil record, so evolution couldn't have happened."

REPLY: This argument is flawed because the fossil record is only a small fraction of the total number of species that have ever lived on earth. It is not surprising that there are gaps in the fossil record, and these gaps do not necessarily mean that evolution did not occur. In fact, many of the gaps in the fossil record have been filled in as new fossil discoveries have been made.

OBJECTION: "Evolution violates the second law of thermodynamics, which states that entropy (disorder) always increases over time."

REPLY: This argument is flawed because the second law of thermodynamics only applies to closed systems, and the earth is not a closed system. The earth receives energy from the sun, and this energy drives the processes of evolution. In addition, the second law of thermodynamics does not apply to evolution at the molecular level, where complexity can increase over time through the process of natural selection.

OBJECTION: "Evolution is just a theory, so it can't be trusted."

REPLY: This argument is flawed because the word "theory" in science does not mean the same thing as it does in everyday language. In science, a theory is an explanation for a set of observations that has been tested and supported by a vast amount of evidence. The theory of evolution is one of the most well-supported theories in all of science, and it has been confirmed by countless observations and experiments.

OBJECTION: "Evolution is just a random process, so it can't produce the complexity and design we see in living things."

REPLY: This argument is flawed because evolution is not a random process. Evolution is driven by natural selection, which is a non-random process that favors the survival and reproduction of individuals with traits that are better adapted to their environment. Over time, this process can lead to the evolution of complex and well-designed organisms.

OBJECTION: "There are no transitional fossils, so evolution couldn't have happened."

REPLY: This argument is flawed because there are actually many transitional fossils that have been found, including fossils that show the transition from fish to amphibians, from reptiles to birds, and from apes to humans. These transitional fossils provide strong evidence for the evolution of different groups of organisms.

OBJECTION: "If evolution were true, we should see new species forming all the time, but we don't."

REPLY: This argument is flawed because the formation of new species is a slow process that can take thousands or even millions of years. While it is true that we don't see new species forming right before our eyes, this does not mean that evolution is not happening. In fact, there are many examples of new species forming in the wild, and there is a wealth of evidence for the evolution of new species over time.

## Evolution Versus "Intelligent Design"

Intelligent design is a modern, anti-evolutionary idea that asserts that certain features of the natural world are best explained by the actions of an intelligent designer. It is a modern variant of the theory of "special creation" that Darwin argued against. It is often presented as an alternative to the theory of evolution by natural selection, which is a well-established scientific explanation for the diversity of life on Earth. However, intelligent design is considered **pseudoscience** by the scientific community because it fails to meet key criteria for scientific theories. We'll briefly consider three influential accounts of the nature of "science" and note why intelligent design fails according to each of them:

**Intelligent Design Can't Be "Falsified."** One reason that intelligent design is considered pseudoscience is because it fails to meet Karl Popper's criterion of falsifiability. According to Popper, scientific theories must make *falsifiable* predictions, meaning that they must make claims about *observations that would show the theory to be false*. Evolution does this (for example, we shouldn't discover 2 billion year old rabbit fossils!). Intelligent design, by contrast, cannot be falsified, since there is literally *no possible evidence* the theory can't accommodate by just saying "Well, maybe the intelligent designer wanted it that way…).

**Intelligent Design Has No "Paradigm."** Another reason that intelligent design is considered pseudoscience is because it does not fit within the scientific paradigms outlined by Thomas Kuhn. Scientific paradigms are the established theories and practices of the scientific community, and they provide a framework for scientists day-to-day work in formulating hypotheses, making measurements, recording observations, etc. Intelligent design, however, relies on the rejection of established scientific theories and practices, and it does not align with the norms of scientific inquiry (and it doesn't offer any "new" norms specific enough to count as a "new science"). This makes it difficult for intelligent design to gain acceptance within the scientific community and to make meaningful contributions to the advancement of scientific knowledge.

**Intelligent Design is a Failed Research Program.** Finally, intelligent design fails to meet Imre Lakatos's criteria for a successful scientific research program. According to Lakatos, a successful scientific research program must have a positive heuristic, which means that it must lead to the development of new scientific knowledge. It must also have predictive power, which means that it must be able to make testable predictions about the natural world. Intelligent design lacks both of these characteristics, as it relies on ad hoc explanations and has not led to the development of new scientific knowledge. The hypothesis of special creation was adopted for nearly 2,000 years (before Darwin), and we have little to show for it.

While intelligent design may be appealing to some as an alternative to the theory of evolution, it does not meet the standards of scientific inquiry and lacks the empirical support needed to be considered a valid scientific theory.

## Questions

1. What were some of the social and cultural challenges that scientists faced in early 19th century England?
2. What were some of the unsolved problems in biology that Darwin's theory of evolution helped to address?
3. What are some examples of scientific evidence that supports the theory of evolution, and how has this evidence been used to confirm the theory
4. How did the principle of natural selection, as proposed by Darwin, explain the diversity of life on Earth?
5. What is the modern synthesis and how did it integrate genetics with evolution by natural selection?
6. How has Darwin's theory of evolution by natural selection influenced fields such as medicine, agriculture, and conservation?
7. What are some of the ethical questions and debates that have arisen from recent developments in genetics and evolution, such as CRISPR?
8. How does intelligent design differ from the theory of evolution by natural selection, and why is it considered pseudoscience?
9. What are some common objections to the theory of evolution via natural selection, and how are these objections flawed?
10. How has the theory of evolution been received by the public, and how have public attitudes towards the theory changed over time?
11. How do the concepts of natural selection and survival of the fittest apply to modern society, and what ethical considerations do they raise?
12. How do the principles of the theory of evolution relate to other scientific theories and fields of study, and how does it fit into our overall understanding of the natural world?

# EXERCISES: SCIENTIFIC REASONING

Please read the case studies and answer the questions that follow them.

## CASE 1: THE SIZE OF THE EARTH.

Eratosthenes was a Greek scholar and librarian who lived in the third century B.C. He is known for his work in geography and his measurement of the Earth's circumference, which was a revolutionary achievement at the time.

Eratosthenes conducted his famous experiment while working as the chief librarian at the library in Alexandria, Egypt. He had heard that on the summer solstice, the sun shone straight down a well in the city of Syene, casting no shadows. Intrigued by this information, Eratosthenes measured the angle of the sun's light in Alexandria on the same day and time, and found it to be 7.2 degrees, or 1/50th of a full circle.

Using this information and his knowledge that the Earth was spherical, Eratosthenes was able to calculate the Earth's circumference to be 250,000 stades, or about 28,500 miles. This was a remarkably accurate measurement, as the actual circumference of the Earth is about 24,900 miles.

Eratosthenes' measurement of the Earth's circumference caused problems for the flat-earth theory, which was accepted by some scholars at the time. According to the flat-earth theory, the Earth was a flat, disk-shaped landmass surrounded by water. This theory did not allow for the Earth to be spherical, as Eratosthenes' measurements indicated.

Eratosthenes' experiment provided evidence that the Earth was indeed spherical, and his calculations of the Earth's circumference were based on this assumption. This evidence challenged the prevailing belief in a flat Earth and helped to establish the modern understanding of the Earth as a globe.

Eratosthenes is often referred to as the "father of geography" due to his contributions to the field, including his innovative method for measuring the Earth's size. His work helped to advance the understanding of the world and its geographical features, and his name has been remembered throughout history as a result.

**Questions**

1. What was the hypothesis of Eratosthenes' experiment?
2. What are some possible alternative or competing hypotheses that Eratosthenes could have considered?
3. What evidence did Eratosthenes use to test his hypothesis?
4. How did Eratosthenes use the evidence to confirm or falsify his hypothesis?
5. What was the scientific importance of this experiment?

## CASE 2: THE FLOW OF BLOOD

William Harvey was a physician and scientist who is known for his discovery of blood circulation. Born in England in 1578, Harvey rose to become the royal physician to King James I, and used this position to pursue his interests in anatomy.

In the early 17th century, the prevailing model of blood flow was proposed by the Greek physician Galen, who believed that the liver constantly produced new blood from food, that blood flowed throughout the body in two separate streams, and that the blood absorbed by tissues never returned to the heart. Harvey set out to test these beliefs through a series of experiments involving animals, including sheep and pigs.

Through these experiments, Harvey discovered that the volume of blood required to pump through the heart every hour, as proposed by Galen, would be impossible given the size of the animals. He also demonstrated that constricting blood flow into an exposed snake heart led to shrinkage and paleness, while choking off the main exiting artery caused the heart to swell. These observations, combined with studies of the slow heart beats of reptiles and animals near death, led Harvey to deduce that the heart pumped blood through the body in a circuit.

Harvey also conducted experiments on willing human subjects, in which he temporarily blocked blood flow in and out of limbs, further supporting his theory of blood circulation. In 1628, he published his full theory in a book called De Motu Cordis [The Motion of the Heart], which transformed medical science and established Harvey as the father of modern medicine and physiology.

**Questions**

1. What was the hypothesis that William Harvey was testing with his experiments?
2. What are some possible competing or alternative hypotheses that Harvey could have considered?
3. What evidence did Harvey use to test his hypothesis?
4. How did Harvey use the evidence to confirm or falsify his hypothesis?
5. What was the scientific importance of Harvey's work?

### CASE 3: MENDEL'S PEAS

Gregor Mendel was a scientist and monk who is known for his pioneering work in genetics. Born in 1822 in what is now the Czech Republic, Mendel showed an aptitude for the physical sciences but had little opportunity for formal education due to his family's financial circumstances. In 1843, he joined the Augustinian order, a monastic group that emphasized research and learning, and began studying the inheritance of physical traits in plants.

Mendel's interest in genetics was sparked by his observations of fuchsias, which he was attempting to crossbreed to create new colors and combinations. He noticed that he was getting repeatable results that suggested some underlying law of heredity was at work. To further explore this idea, Mendel conducted experiments with pea plants, using paintbrushes to transfer pollen from one plant to another and carefully observing and documenting the traits of the resulting offspring.

Over a period of about seven years, Mendel conducted thousands of precise pairings of plants with certain traits, such as yellow peas and green peas. Through these experiments, Mendel was able to discern the fundamental rules of genetic inheritance, coining the terms "dominant" and "recessive" to describe what we now know as genes. His work was ahead of its time and received little attention during his lifetime, but decades later, when other scientists were able to replicate his experiments, they were recognized as a major breakthrough in the field of genetics.

Mendel's approach to his experiments was characterized by his careful planning and attention to detail. He formulated simple hypotheses that he believed would help him understand the underlying laws of heredity, and he carefully designed experiments to test these hypotheses. He was meticulous in his record-keeping, documenting the results of his experiments in great detail and using statistical analysis to analyze the data.

Mendel's work was groundbreaking in its use of the scientific method to uncover the fundamental principles of genetics. He used evidence-based methods to confirm or falsify his hypotheses, and his discoveries have had a lasting impact on the field of genetics and the scientific community as a whole. Today, Mendel is recognized as the father of modern genetics and his contributions continue to be celebrated and studied by scientists around the world.

**Questions**

1. What was the hypothesis that Gregor Mendel was testing with his experiments?
2. What are some possible alternative or competing hypotheses that Mendel could have considered?
3. What evidence did Mendel use to test his hypothesis?
4. How did Mendel use the evidence to confirm or falsify his hypothesis?
5. What was the scientific importance of Mendel's work?

### CASE 4: NEWTON'S OPTICS

Isaac Newton is known as one of the greatest scientists of all time, making significant contributions to the fields of mathematics, physics, and optics. In 1665-1666, while living in Cambridge to escape a plague outbreak, Newton conducted a series of experiments with prisms to test his hypothesis about the nature of light and color.

Newton's hypothesis was that color was not a property of the medium through which light passed, as was commonly believed at the time, but was instead an inherent property of light itself. To test this hypothesis, Newton set up a prism experiment that involved passing a beam of sunlight through two prisms. By blocking some of the resulting colors from reaching the second prism, Newton was able to demonstrate that different colors refracted differently through a prism. He then passed a single color from the first prism through the second prism and found that the color did not change, proving that the prism did not affect the color of the ray and that color was tied to light itself.

While Newton's experiment was technically difficult to replicate, it was incredibly convincing once it was performed. This revolutionary insight established the field of optics, which is fundamental to modern science and technology. Despite his many successes, Newton also made several missteps in his career, including an obsession with occultism and a fascination with biblical numerology. However, his contributions to science and mathematics have ensured his place in history as one of the greatest minds of all time.

**Questions**

1. What was the hypothesis that Newton was testing with his experiments?
2. What are some possible alternative or competing hypotheses that Newton could have considered?
3. What evidence did Newton use to test his hypothesis?
4. How did Newton use the evidence to confirm or falsify his hypothesis?
5. What was the scientific importance of Newton's work?

## CASE 5: THE END OF THE ETHER

In the late 19th century, Albert Michelson and Edward W. Morley set out to prove the existence of the "luminiferous ether", an invisible, ubiquitous medium believed to be responsible for the movement of light. Their hypothesis was that as Earth orbits the sun, it would constantly plow through ether, generating an ether wind. When the path of a light beam travels in the same direction as the wind, the light should move a bit faster compared with sailing against the wind.

To measure this effect, they used a Michelson interferometer, an instrument that beams light through a one-way mirror and splits it into two beams that travel at right angles to each other. The beams then reflect off mirrors back toward a central meeting point. If the light beams arrive at different times, due to some sort of unequal displacement during their journeys (such as the ether wind), they create a distinctive interference pattern.

The experiment was conducted with great care, with the interferometer placed atop a solid sandstone slab, floating almost friction-free in a trough of mercury and further isolated in a campus building's basement. The researchers slowly rotated the slab, expecting to see interference patterns as the light beams synced in and out with the ether's direction.

However, the results of the experiment showed that light's speed did not vary, and the researchers were unable to observe any interference patterns. This result was a huge dent to ether theory and set off a chain of further experimentation and theorizing that eventually led to Albert Einstein's breakthrough new paradigm of light, special relativity. The Michelson-Morley experiment is considered one of the most important and famous failed experiments in history as it led to a major change in scientific understanding of the universe.

**Questions**

1. What was the hypothesis put forward by Michelson and Morley in their experiment?

2. What were the alternatives to the hypothesis proposed by Michelson and Morley?
3. What predictions did the hypothesis make about the movement of light?
4. How did the results of the experiment compare to the predictions made by the hypothesis? Did they confirm or falsify the hypothesis?
5. What was the significance of the results of the Michelson-Morley experiment?

### Case 6: Marie Curie's Radioactive Discoveries

Marie Curie, a pioneering female scientist, made groundbreaking discoveries in the field of radioactivity that would change the way scientists understand the nature of atoms. In her doctoral thesis in 1897, Marie began investigating a newfangled kind of radiation, similar to X-rays and discovered just a year earlier. Using an instrument called an electrometer, built by her husband Pierre Curie and his brother, Marie measured the mysterious rays emitted by thorium and uranium.

At the time, scientists had two competing hypotheses on the nature of radiation. The first hypothesis was that radiation is a result of the substance's molecular arrangements. According to this hypothesis, the radiation rate should depend on the mineralogical makeup of the element. The second hypothesis was that radiation is an inherent property of individual atoms, emanating from their internal structure. This hypothesis predicted that the radiation rate should depend solely on the amount of the element present.

Marie Curie's experimental results provided strong evidence in favor of the second hypothesis. She found that regardless of the elements' mineralogical makeup, radiation rates depended solely on the amount of the element present. This finding was a major breakthrough in understanding matter at a more fundamental, subatomic level. Up until this point, scientists had thought atoms were elementary, indivisible entities. Marie Curie's discovery of radioactivity and the conclusion that it was an inherent property of individual atoms, emanating from their internal structure, was a major breakthrough in understanding matter at a more fundamental, subatomic level.

Marie Curie's work was recognized with a Nobel prize, making her the first woman to win a Nobel Prize, in 1903. Her work and life served as an inspiration and role model for young women who wanted a career in science, and her discovery of radioactivity opened the door to further research and understanding in the field of atomic physics.

**Questions**

1. What were the two competing hypotheses about the nature of radiation at the time of Marie Curie's experiment?
2. What predictions did each of these hypotheses make about the relationship between the radiation rate and the mineralogical makeup of an element?
3. What was the experimental result obtained by Marie Curie in her investigation of radioactivity?
4. How did this result relate to the competing hypotheses about the nature of radiation?
5. What was the significance of Marie Curie's discovery of radioactivity in the field of atomic physics?

### Case 7: The Race to Decode DNA

In the early 1950s, scientists were in a race to discover the structure of DNA, the molecule that carries genetic information. Two main hypotheses about the structure of DNA emerged during this time. Linus Pauling proposed that DNA is a three-stranded molecule, while James Watson and Francis Crick proposed that DNA is a two-stranded molecule.

The main predictions made by these hypotheses were that if DNA is a three-stranded molecule, the X-ray diffraction patterns will show a specific pattern of symmetry. On the other hand, if DNA is a two-stranded molecule, the X-ray diffraction patterns will show a different pattern of symmetry. The key experimental evidence to test these hypotheses was the X-ray diffraction images of DNA fibers.

The critical experimental data that helped Watson and Crick to establish the double helix structure of DNA came from Rosalind Franklin and Maurice Wilkins, who were also working on determining the structure of DNA at King's College London. Franklin and Wilkins used X-ray diffraction to study DNA fibers and produce high-resolution images of the DNA structure. Franklin's X-ray diffraction images, in particular, showed clear evidence of the double helix structure of DNA.

Watson and Crick used Franklin's X-ray diffraction data, along with other data from other sources, to build physical models of DNA. They eventually proposed a double helix structure for DNA, which was composed of two complementary strands of nucleotides coiled around an axis. This structure explained the X-ray diffraction patterns observed by Franklin and Wilkins, and other scientists, and was consistent with all known chemical and physical properties of DNA.

The discovery of the double helix structure of DNA by Watson and Crick was a major breakthrough in understanding the fundamental building block of life. It not only explained how genetic information is stored, inherited and passed on but also opened the door to genetic engineering and the new field of molecular biology. This discovery was recognized with a Nobel Prize in 1962, and it is considered one of the most important discoveries of the 20th century.

**Questions**

1. What were the two main hypotheses about the structure of DNA proposed in the early 1950s?
2. What predictions did these hypotheses make about the X-ray diffraction patterns of DNA?
3. What experimental evidence was crucial in determining the structure of DNA?
4. Who were the scientists who made the discovery of the double helix structure of DNA and how did they use the experimental evidence?
5. What was the significance of the discovery of the double helix structure of DNA?

## Case 8: The Halo Effect

In 1977, Nisbett and Wilson conducted an experiment to investigate whether global evaluations of a person influence their evaluations of the person's attributes, even when there is sufficient information to allow for independent assessments of them. This phenomenon is known as the halo effect.

The experiment was conducted using a college instructor who spoke English with a European accent. The instructor was filmed in two different interviews, one where he was warm and friendly, and the other where he was cold and distant. The footage was shown to 118 undergraduate students, who were asked to evaluate the instructor based on the video they had watched.

The results of the experiment showed that participants who saw the warm instructor rated his appearance, mannerisms, and accent as appealing, whereas those who saw the cold instructor rated these attributes as irritating. This suggests that global evaluations of a person can influence evaluations of the person's attributes, even when there is sufficient information to allow for independent assessments of them.

Furthermore, the participants were unaware of this influence of global evaluations on ratings of attributes. In fact, participants who saw the cold instructor actually believed that the direction of influence was opposite to the true direction. They reported that their dislike of the instructor had no effect on their rating of his attributes but that their dislike of his attributes had lowered their global evaluations of him.

The results of this experiment, published in the Journal of Personality and Social Psychology, indicate that the halo effect is a real phenomenon and that people's judgments can be unconsciously influenced by global evaluations of a person. This has important implications for understanding how people form judgments and make decisions in various contexts such as education, job interviews, and clinical assessments.

**Questions**

1. How does the halo effect influence people's judgments and decisions in different contexts?
2. How can people be made aware of the halo effect and how can they control for it in their judgments and decisions?
3. How can organizations and institutions guard against the halo effect in hiring, evaluations, and other decision-making processes?
4. In what other areas of life, besides the examples provided in the case study, could the halo effect play a role?
5. How does this research relate to the concept of implicit bias and how do they differ?

# CHAPTER 9: CONSPIRACY THEORIES

In this chapter, you will learn about the dangers of conspiracy theories and how to avoid falling prey to them. You'll start by exploring Hume's views on miracles and how they relate to the concept of belief. Then, you'll delve into the topic of heuristics and biases, and how they can lead us astray. You'll learn about the representativeness heuristic and how it can cause us to draw false conclusions based on incomplete information. You'll also examine prospect theory, which helps us understand how we make decisions under uncertainty. Finally, you'll consider whether it is possible to avoid making mistakes when it really counts, and you'll explore the work of Daniel Kahneman and Amos Tversky, two influential psychologists who have studied the ways in which our minds can deceive us. By the end of this chapter, you should have a better understanding of the psychological pitfalls that can lead to the embrace of conspiracy theories, and how to avoid them.

However, before reading further, I need to warn you about an emerging threat to us all—geese!

## GEESE GONE WILD: THE BIOENGINEERED TERROR OF ROCHESTER'S SKIES

Dear editor,

I am writing to bring to your attention a disturbing discovery that I have made about the geese in our fair city of Rochester. As a long-time resident and avid bird-watcher, I have always been fascinated by these majestic creatures. However, upon closer examination, I have come to the conclusion that these geese are not what they seem.

It all started when I noticed that the geese in our city park seemed to be acting strangely. They were much more aggressive than usual, and seemed to be unusually coordinated in their movements. At first, I thought this might just be a fluke. But as I continued to observe them, I became more and more convinced that there was something sinister afoot.

That's when I started doing some digging. And what I discovered was truly shocking. It turns out that these geese have been genetically engineered as bioweapons by a shadowy group of elites with ties to the Illuminati. Yes, you read that right - the geese in our city are actually a secret weapon, designed to spread disease and chaos among the unsuspecting populace. The mayor, the Mayo Clinic leadership, and even some college faculty members are all in on this conspiracy, even while most people remain blissfully ignorant.

This might sound like the stuff of conspiracy theories, but bear with me. The evidence is all around us, if we only know where to look. Just consider the fact that these geese are so much more aggressive than their wild counterparts. Or the way that they seem to be able to communicate with one another in ways that defy explanation. It's all too clear that something fishy is going on.

And what's even more disturbing is the fact that this isn't the first time that something like this has happened. We've seen similar instances of covert biological warfare in the past, including during in US-supported bioweapon labs in Ukraine and China. It's clear that there are powerful forces at work in the world, and they will stop at nothing to achieve their shadowy goals.

So what can we do about it? Well, for starters, we need to raise awareness about this issue. We can't just sit back and let these bioweapon geese roam free in our city. We need to take action and demand answers from our leaders. We also need to be vigilant and stay informed, so that we can stay one step ahead of these nefarious forces.

In conclusion, it's clear that the geese in Rochester are not what they seem. They have been genetically engineered as bioweapons by a shadowy group of elites, and it's up to us to do something about it. Let's not let them get away with it - let's stand up and demand the truth

Sincerely,

Irving Quackenbush

## QUESTIONS

1. What evidence does Quackenbush present to support his claim that the geese in Rochester are genetically engineered bioweapons? Is this evidence convincing? Why or why not?
2. How does Quackenbush's belief in a conspiracy involving the geese in Rochester serve his own psychological needs or desires?
3. How might Quackenbush's belief in this conspiracy theory affect his behavior and decision-making, such as in terms of how he interacts with the geese or how he votes in local elections?
4. How might Quackenbush's belief in this conspiracy theory be challenged or debunked by evidence or logical argument?

## INTRODUCTION

*"In our reasonings concerning matter of fact, there are all imaginable degrees of assurance, from the highest certainty to the lowest species of moral evidence. A wise man, therefore, proportions his belief to the evidence."—David Hume*[2]

*"The confidence that individuals have in their beliefs depends mostly on the quality of the story they can tell about what they see, even if they see little."—Daniel Kahneman*[3]

Conspiracy theories are beliefs that events or situations are caused by secret, often sinister, groups or individuals working together to achieve a specific goal. These theories often involve allegations of cover-ups or attempts to mislead the public. Conspiracy theories vary widely in their content, the individuals and groups who believe in them, and in their effects on the behavior of these believers. For this reason, it may be difficult or impossible to come up with a completely general definition of *conspiracy theory* that captures all and only those theories that fit under this general label. Nevertheless, there are a significant number of conspiracy theories that share something like the following form:

> *There exists a certain small group of people that share a certain characteristic such as race, religion, occupation, or nationality. They have secretly undertaken actions that have harmed, or are intended to harm, me and people like me. The fact that these actions have not generally been recognized is due to the conspirators' ability to conceal evidence of this.*

Within the general scheme, there is plenty of room for variation. For example, the conspirators may be anonymous figures living otherwise unremarkable lives, or they may be well-known and powerful political, religious, or media elites. Similarly, some purported conspirators actively wish harm upon the believer and others—such as conspiracies positing "traitors" or "spies" working to ensure their own country loses some conflict—while others are held to have much more mundane motives, such as the desire for money or power. In this latter case, the harm in question may simply be an especially unpleasant side effect, though one that was foreseen by the conspirators. Finally, the harms attributed to the conspirators' actions come in a number of forms. So, for example, it may be that the actions of the conspirators have led (or will lead) to the deaths of particular individuals, financial crises or crashes, military defeats, outbreaks of disease or illness, the overthrowal of the government, and so on.

Some notable examples of conspiracy theories include the following:

Conspiracy theories are beliefs that events or situations are caused by secret, often sinister, groups or individuals working together to achieve a specific goal. These theories often involve allegations of cover-ups or attempts to mislead the public. Examples include:

- Holocaust denial is a conspiracy theory that denies the reality of the systematic mass murder of millions of Jews and other minority groups by the Nazi regime during World War II. Despite overwhelming evidence to the contrary, Holocaust deniers claim that the Holocaust did not occur, or that it was significantly exaggerated.
- QAnon is a far-right conspiracy theory that emerged in 2017. It alleges that there is a secret cabal of elites, often referred to as the "deep state," that is working to undermine President Donald Trump and his supporters. QAnon followers believe that this cabal is involved in a variety of nefarious activities, including human trafficking and the production of child pornography. In the years sense, QAnon has

[2] David Hume, *An Enquiry Concerning Human Understanding*, ed. Eric Steinberg, 2nd ed. (Indianapolis: Hackett Publishing, 2011), sec. 10.

[3] Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus and Giroux, 2011), 88.

developed to include theories about COVID vaccines, the war in Ukraine, and other things it believes to be actions of the "deep state."

- The Illuminati is a secret society that is believed by some to be a group of powerful individuals who control world events and seek to establish a New World Order. The Illuminati is often depicted as a shadowy organization that uses its influence to manipulate world events for its own benefit. Some people believe that the Illuminati is responsible for a variety of historical events, including revolutions and wars, and that it continues to exert influence on world affairs to this day.

Conspiracy theories of this type all crucially involve failures of what philosophers often call *inductive reasoning*, which involves using our available evidence to determine what is probable or likely to be true. Inductive reasoning is usually contrasted with *deductive reasoning,* which involves attempts to *prove* with 100% certainty that a conclusion follows. As it turns out, inductive reasoning makes up a huge part of our day-to-day lives. We reason inductively, for example, when we try to determine what was the *cause* of some event that we just observed, or when we try to figure out what the *effects* of this same event might be. We also reason inductively any time we make predictions about the future, or decide whether to trust what we've read or heard, or make generalizations about a large population based on the smaller sample that we are familiar with.

For this reason, conspiracy theories, and the errors of inductive reasoning that they exemplify, should be of interest to all of us. After all, if it turns out that many of the crucial errors committed by conspiracy theorists are ones that we ourselves are prone to, this will provide a strong reason for thinking hard about our own beliefs, and the process by which we have arrived at them.

### Questions

1. What is a conspiracy theory and how does it differ from other types of belief systems?
2. What are some examples of conspiracy theories and how do they vary in content and effects on believers?
3. What psychological and cognitive factors contribute to the appeal and persistence of conspiracy theories?
4. How have conspiracy theories impacted society and individuals, both historically and in the present day?

## Don't Believe Everything You're Told: Hume on Miracles

Conspiracy theories often serve as simple, attractive rivals to other, more complex theories about politics, history, or science. So, for example, where political scientists may offer theories that tie the outcome of a particular election to factors such as economic conditions, demographic shifts, incumbency bias, and the relative appeal of the candidates' platforms and personae, conspiracy theorists often see the hidden hand of conspirators as being responsible for unwelcome outcomes. Similarly, where mainstream medical and scientific research suggests that conditions such as autism, drug addiction, or obesity have complex causal backgrounds, conspiracy theorists might reply that these bad things are actually due to the hidden side effects of vaccines, the clandestine activities of the CIA, or the machinations of "Big Ag."

One way in which conspiracy theories are distinguished from their mainstream rivals is their method of origin and spread, which is often outside traditional scientific and academic channels. In the modern era, for example, conspiracy theories often begin in the so-called "dark corners" of the internet, as opposed to in peer-reviewed journal articles. They then spread, via both alternative media sources and social media, to larger and larger audiences. To what extent should this sort of difference in origin matter to the credibility of the theories in question?

The Scottish philosopher David Hume (1711-76) takes up a very similar question in the "Of Miracles" section of his *Enquiry Concerning Human Understanding*. Hume was among the first to clearly distinguish between inductive and deductive reasoning, and his account of the problems inherent in inductive reasoning has influenced (and often troubled) scholars studying inductive reasoning ever since. In "Of Miracles", Hume considers whether or not one should ever believe peoples' accounts of miracles. His answer is a resounding "No!", and many of the reasons he provides are applicable to conspiracy theories as well.

Hume recognizes that the reasons people believe in miracles—because they hear or read about them from sources that they normally trust—are based in the same sort of inductive inference that underpins many of the things we believe. For example, nearly all of our beliefs about history, scientific theories, current events, and even the lives of our closest friends and family are, of necessity, based on what textbooks, teachers, newspapers, and other people tell us about these things. Because of the probabilistic nature of inductive inference, this means that is

always *possible* that these sources are incorrect. However, we don't normally take this possibility as grounds for dismissing everything we hear or read. So, what makes reports of miracles (or conspiracy theories) any different?

Hume provides a number of considerations for treating reports of miracles differently than other sorts of "testimony," many of which are applicable to conspiracy theories. First, the chain of testimony supporting miracles often looks quite different than that of ordinary events. Miracles are almost universally said to have occurred long ago and/or in places far away, and under conditions that would have made it difficult or impossible for any skeptic to check on the truth of the claim. In conspiracy theories, by comparison, it is often held that the conspiracy theory is happening "right now!" or "under our noses!". However, just as in the miracle case, it is a central part of the theory that there can be no possible recording/confirmation of the conspiration, since the conspirators have prevented this (perhaps by murdering witnesses or manipulating the media). The fact that reports of miracles and conspiracy theories haven't been and can't be, checked out by skeptical listeners doesn't mean that they are necessarily false, of course. What it does mean, however, is that these reports lack the sort of safeguard that comes with most testimony regarding strange or unlikely events—that is, if they *were* false, we would likely have some evidence of this.

A second key difference Hume notes relates to the *motivations* of those who talk about miracles. After all, one reason that miracles matter so much is that they can serve as evidence for the truth of certain religious views. This provides a strong motivation for people who already hold these religious views to believe in such reports (after all, we all like being shown right!), and it *also* provides motivation for them to spread these tales, even if they don't fully believe in them. After all, telling tales of miracles might win converts for the faith, or signal to other members of the group your "loyalty to the cause." Something quite similar can be said of many conspiracy theories—insofar as belief in these theories is closely linked to membership in some group, we have good reason to doubt the impartiality of those telling tales of conspiracies. Finally, Hume observes that, while one might think that the sheer strangeness and outlandishness of miracles would make people less likely to believe and repeat them, experience shows that something the opposite often seems to be the case—people seem to *enjoy* believing and repeating stories about events that are utterly unlike things they have experienced themselves. This, again, has close analogues with conspiracy theories. Odd as it may seem, the very claims of a conspiracy theory that seem the furthest detached from evidence and ordinary experience may be the claims that encourage its spread.

### Questions

1. How do conspiracy theories differ from more mainstream theories in terms of their origin and spread?
2. What are some of the reasons Hume gives for treating reports of miracles differently than other types of testimony? How do these reasons apply to conspiracy theories?
3. How do factors such as the distance in time and space, the difficulty of verifying the claims, and the credibility of the sources impact the credibility of accounts of miracles and conspiracy theories?

## Making Mistakes: Heuristics and Biases

In the generations since Hume first wrote, scholars in disciplines ranging from philosophy to economics to statistics to psychology have studied the nature of inductive reasoning from a variety of perspectives. While many of these investigations have aimed at uncovering better methods for inductive reasoning, others have aimed at figuring out how good ordinary humans are at inductive reasoning in a variety of contexts. Most of us do well enough when the conclusions of inductive reasoning concern our immediate experience, for example—we learn quickly to avoid hot stoves, or to avoid drinking bottles labeled "poison," but it is much less clear how successful we are when it comes to dealing with big-picture issues regarding statistical or causal reasoning in areas such as economics, science, or politics. These, of course, are precisely the areas where conspiracy theorists are most prone to get things wrong. So, why might this be? And just how common are these errors?

Starting in the late 1960s, two Israeli psychologists—Amos Tversky and Daniel Kahneman--began investigating just these sorts of questions. In a series of influential articles[4], they argued that humans are not intuitively "good statisticians," and they make a number of *systematic* mistakes when engaging in inductive reasoning. Tversky and Kahneman's research has had an impact far behind psychology, and in particular caused considerable problems for the view (once common in both economics and some areas of philosophy) that humans generally acted

[4]See especially "Judgment under Uncertainty: Heuristics and Biases," *Science* 185, no. 4157 (1974): 1124–1131; "Prospect Theory: An Analysis of Decision under Risk," *Econometrica* 47, no. 2 (1979): 263–292. A good summary of both their work and related research is provided in Kahneman's *Thinking, Fast and Slow* (2011).

*rationally*.[5] While Kahneman and Tversky don't explicitly consider the problem of belief in conspiracy theories, their work provides a helpful framework for identifying and classifying many of the major inductive mistakes that conspiracy theorists make.

A foundational concept of Kahneman and Tversky's approach is that we make many decisions using intuitive *heuristics,* or simple rules for making inductive decisions. In particular, they suggest that, when we are faced with making a complex decision, we often (without realizing it) "substitute" a simpler, easier-to-answer question, and answer that instead. And while this may work well enough in many day-to-day cases, it can also easily lead to fallacious reasoning of the sort exemplified in conspiracy theories. Some notable examples of such heuristics and biases include:

- representativeness heuristic: the tendency to judge the likelihood of an event based on how similar it is to a prototypical example, without taking into account relevant base rates or statistical information
- anchoring bias: the tendency to rely heavily on the first piece of information encountered when making a decision, and to adjust insufficiently from that initial anchor
- availability heuristic: the tendency to judge the likelihood of an event based on the ease with which examples come to mind
- confirmation bias: the tendency to seek out and pay more attention to information that confirms one's preexisting beliefs and to disregard or downplay information that challenges them
- sunk cost fallacy: the tendency to continue investing time, money, or other resources into a project or decision because of the time, money, or other resources already invested, even if the current costs outweigh the benefits
- hindsight bias: the tendency to see events as being more predictable than they actually were, after learning the outcome
- overconfidence bias: the tendency to be more confident in one's beliefs and judgments than is warranted by the evidence

In the rest of this chapter, we'll explore a number of these biases in more detail, and show how they can lead to belief in conspiracy theories.

## The Story Just "Fits": The Representativeness Heuristic

Conspiracy theories often begin with the intuition that some bad event—a recession, an outbreak of a disease in the local community, or a school shooting—cannot be adequately explained by any combination of normal causal processes discussed by scientists, public health officials, or psychologists and sociologists. They then conclude that this event must have been caused by a carefully planned process (instigated in secret by the conspirators!) that was designed to result in just this sort of outcome. This way of reasoning exemplifies what Kahneman and Tversky label the *representativeness heuristic,* in which the probability of a certain process P causing event E is judged solely by the "resemblance" between P and E and NOT by any careful consideration of how probable it was that P actually occurred, or the potential alternatives to P, or even how good of evidence for P we happen to have.

In the case of conspiracy theories, the representativeness heuristic might explain several inductive failures. First, it accounts for the way conspiracy theorists often seem to ignore the comparative *base rates* of "bad things caused by a combination of ordinary factors" versus "bad things caused by powerful secret organizations working in secret to cause just this sort of harm in each and every gory detail." While the resemblance heuristic pushes us toward the conspiracy story (since it better "resembles" the bad thing in question), this is a bad inference. After all, the vast, vast majority of the harms that we in incur in life are NOT the result of explicit conspiracies intended to cause this exact outcome, but instead are the result of perfectly mundane causal factors acting in combination (that is, plain old "bad luck").

For similar reasons, the representativeness heuristic can plausibly account for conspiracy theorist's tendency to posit highly specific causes for events that are better explained by appeal to statistics. So, for example, small samples are more variable than large samples, and so we should be very careful in drawing conclusions based on what we have observed in small samples, even if the sample in question seems odd to us. So, for example, if two people in a small office of ten people each have a heart attack during the same month, this might seem unusual,

[5] In 2002, Kahneman won the Nobel Prize in Economics for this work. Unfortunately, Tversky died in 1996.

but it doesn't provide strong evidence the office coffee has secretly been poisoned by management seeking to save money on future pensions. By contrast, if 200 people in an office of 1,000 people suffer such attacks in a month (the same percent, but a much larger sample), this really does suggest something out of the ordinary is going on. However, in practice, conspiracy theorists (along with the rest of us) systematically overlook this difference in sample size, and too often jump to conclusions on the basis of small samples.

For similar reasons, the confidence we have in our conclusions about the causes of events ought to reflect the strength and variety of evidence that we have seen—after all, it is surely better to read ten high-quality journal articles and one moderately plausible social media post about a conspiracy theory than just the moderately plausible blog post. However, the representativeness heuristic (which ignores quantity or quality of evidence and cares *only* about its "fit" with a theory) can lead us to ignore this and, in some cases, to feel *more* confident in our conspiracy theory after reading just the social media post, since there are no additional sources to interfere with the nice clean fit between this story and our believing in the truth of the theory it describes. Basically, once we decide to give the social media post any credence whatsoever—as opposed to simply dismissing it out of hand—it can be very difficult to not *overweight* its value as evidence.

Examples of the representativeness heuristic might include:

1. Believing that a vaccine is dangerous or ineffective because it was developed by a pharmaceutical company rather than by scientists working in the public interest. This belief may be based on the similarity between the vaccine and the idea of a profit-driven pharmaceutical company, rather than considering the probability of such a motive or the evidence for it.
2. Believing that a political candidate is corrupt or untrustworthy because they are a member of a particular party or demographic group. This belief may be based on the similarity between the candidate and the stereotype of a corrupt or untrustworthy person, rather than considering the probability of this stereotype being true or the evidence for it.
3. Believing that a financial crisis was caused by a secret group of bankers or financiers rather than by complex economic factors. This belief may be based on the similarity between the crisis and the idea of a secret group manipulating the economy, rather than considering the probability of such a group existing or the evidence for it.
4. Believing that a natural disaster was caused by a secret government experiment or cover-up rather than by natural causes. This belief may be based on the similarity between the disaster and the idea of a secret government experiment or cover-up, rather than considering the probability of such an experiment or cover-up occurring or the evidence for it.

### Questions

1. How does the representativeness heuristic contribute to the appeal of conspiracy theories?
2. Can you think of any examples of the representativeness heuristic at work in your own beliefs or decision-making processes?
3. In what ways do conspiracy theories differ from more mainstream explanations for events or phenomena, and how might these differences influence the way we evaluate their credibility?
4. How does the idea of a "chain of testimony" relate to the spread of conspiracy theories, and why might this be problematic in terms of evaluating their credibility?

## Problems with Probabilities: Prospect Theory

The decision to adopt a conspiracy theory can be thought of as a sort of "bet" about the way the world will turn out, and what the "winning strategy" for living in such a world will be. So, for example, if I suspect there is a good chance that the members of the US Federal Reserve Board are an evil cabal intent on crashing the world economy to enhance the wealth of their corporate masters, I might buy gold and bury it in my back yard to hedge against this. If I assign a significant probability that pharmaceutical companies have hidden the evidence of vaccines causing autism, I might not vaccinate my children. Finally, if I believe it likely that some suspect group of people is up to no good, I might take action against them, potentially including violence.

Most of us would like to think that we are good at making such bets, since they are crucial to making decisions about how we invest our money, vote, and generally lead our lives. So, for example, it seems obvious that a 1% risk of a bad outcome is different than a 5% chance, which is in turn different from a 50% chance or 95% chance,

and our choices and actions should reflect this difference. Unfortunately, according to Kahneman and Tversky, this is not how we actually make these sorts of decisions. Instead, we get things wrong in a number of ways.

First, we tend to focus not on the relative merits of a set of outcomes, but on how we think of ourselves as having arrived at these outcomes, and whether we view them as "gains" or "losses" from a psychological baseline. As it turns out, we care much more about potential losses than we do about potential gains, and simultaneously don't care as much about the relative size of these gains or losses as we should. Conspiracy theorists offer excellent examples of this. First, in cases where they weigh large potential benefits from a change versus (much smaller) potential losses, they can be highly risk averse, for example when they reject the large potential benefits of vaccines or GMO foods on the grounds that there might be hidden health risks associated with these. Second, in cases where the conspiracy theorists already feel that they are below some psychological baseline, they can instead become *risk-seeking,* and adopt conspiracy theories that lead to highly risky actions in a last-ditch attempt to put themselves back over the baseline, even though the most probable outcome of such behavior would be to put them even further under this baseline than they already feel themselves to be. So, for example, if the members of a certain group worry they are "losing control of their country" to their political rivals, they might respond by abandoning democratic norms or engaging in violence, even though these actions are, on balance, likely to lead to even greater losses.

Prospect theory also suggests that we systematically underweight the probabilities of some events while overweighting others. In particular, while we sometimes tend to treat extremely unlikely but possible events as being equal to 0, we quickly *inflate* the probabilities of unlikely events once we begin to treat them as being genuinely possible, no matter how "objectively" unlikely they might be. In the case of conspiracy theories, this might plausibly explain the simultaneous urge to (1) dismiss out-of-hand the possibility that the harms that have occurred to them are due to statistical "chance", and (2) vastly inflate the probability that these harms are caused by the secret actions of conspirators.

Some potential examples of these flawed ways of reasoning include:

1. Believing that the government hiding evidence of extraterrestrial life because it would be a "bigger" event and more exciting than the alternative explanation that no such evidence exists.
2. Believing in a conspiracy theory about a powerful group secretly controlling world events because it gives a sense of control and agency in a chaotic world.
3. Believing that a natural disaster being caused by a secret group or individual rather than accepting that it was a random act of nature, in order to avoid feeling powerless and vulnerable.
4. Falling for a conspiracy theory about a medical treatment or procedure being dangerous or ineffective because the potential consequences of accepting the mainstream explanation are perceived as more negative than the potential consequences of the conspiracy theory.
5. Believing in a conspiracy theory about a historical event being distorted or covered up in order to protect one's cultural or personal identity, rather than accepting a more nuanced or uncomfortable explanation.

### Questions

1. What is the role of probability in decision-making and how does prospect theory challenge the way we traditionally understand probability?
2. How does our perception of potential gains and losses impact the way we make decisions and how does this relate to conspiracy theories?
3. How does prospect theory explain the tendency to underweight or overweight the probability of certain events, particularly in the context of conspiracy theories?
4. Can you provide examples of how prospect theory might influence belief in specific conspiracy theories?
5. In what ways might an understanding of prospect theory help us to better understand and address the appeal of conspiracy theories?

## Can We Avoid Mistakes When It Counts?

So, what's the take-away from all of this? It might be summarized as follows: conspiracy theorists, like the rest of us, notice bad things happening in the world around them. They (again, like the rest of us) are convinced that there must be a cause for these events. However, when they begin to consider what sort of cause this might be, they are led astray by the resemblance heuristic, which predisposes them towards a causal story (the conspiracy

theory) that most closely "resembles" the limited samples they are familiar with, and the limited, biased evidence they have reviewed. This completely ignores the possibility that the events in question are simply the result of statistical "chance." These errors are compounded by the failure to deal with probabilities and "risky decisions" properly, as described by prospect theory. Conspiracy theorists are often attached to some (perhaps imaginary) baseline about the way things "used to be" or the way "nature intended things," and are willing to take risks to avoid accepting losses from this baseline. Simultaneously, they improperly dismiss the possibility of some unlikely events (such as the sorts of chancy processes that *often* explain strange-looking results in small samples) and the inflate the probability of others (such as the conspiracy theory they've heard so much about on talk radio).

In *Thinking, Fast and Slow*, Kahneman argues there are other heuristics and biases waiting to trip us up, beyond those described here. The *halo effect,* for example, predisposes us to (without any evidence!) assign good qualities to people/things we *already* believe are good in other respects, and bad qualities to those we already dislike or distrust. *Outcome bias,* meanwhile, presents us with a false view of the past, whereby we assume that the things that did happen (for good or bad) were *predictable.* This conveniently allows us to avoid giving credit to decision makers for decisions that turned out well while blaming them for decisions that went wrong. These sorts of processes plausibly lend fuel to the fire of conspiracy theorists' tendency to blame any and all bad outcomes on the actions of the purported conspirators (who, not coincidentally, tend to belong to groups the theory's proponents already hold in ill regard). Finally, and perhaps most concerning our intuitive sense of how likely a given outcome is strongly affected by the detail in which one have imagined or described this outcome. So, the mere act of talking or reading about a conspiracy theory in detail might well serve to inflate our sense of how probable this sort of really thing is.

All of this happens generally happens without even thinking, and it can happen to even smart, knowledgeable people, since inductive fallacies don't present themselves as defective means of reasoning. Instead, these processes present themselves as a strong feeling that certain theories or ideas are correct, and invite us to adopt and defend these ideas as our own with all of the intellectual creativity and rigor that we can muster. This suggests that that vulnerability to conspiracy theories may be linked to neither ignorance nor stupidity. Rather, it might be that conspiracy theorists are mentally "lazy" in the ways that many of us are lazy, and it is this laziness that undercuts their ability to make cogent inductive inferences. In particular, belief in a conspiracy theory allows one to avoid all sorts of uncomfortable thoughts, such as fully grappling with the role of chance in events, or the poverty and bias of the news we consume, or the systematic ways in which our sense of what's possible misleads us about what is actually probable. Conspiracy theories reassure us that the bad guys really are all bad, and that, if we stop them next time, we can assure things will turn out well.

If correct, this suggests that there can be significant value in reflecting on the inductive failures of conspiracy theorists, even for those who feel quite confident that they themselves could never fall into the trap of believing in such a theory. Such confidence, as it turns out, may be a poor guide to one's actual vulnerability. However, it may be that we can partially inoculate ourselves against conspiracy theories by paying close attention to the *specific* ways in which they exemplify bad inductive reasoning. This, in turn, might make it at least somewhat easier to catch our own errors, and to become better, more careful inductive reasoners[6].

### QUESTIONS

1. In what ways do our cognitive biases and heuristics, such as the representativeness heuristic and prospect theory, contribute to the belief in conspiracy theories?
2. How does our desire to maintain a psychological baseline and avoid losses affect our likelihood of believing in conspiracy theories?
3. How does the detail in which we imagine or describe an event influence our perception of its likelihood?
4. How do our cognitive biases and heuristics contribute to the way we evaluate evidence for or against conspiracy theories?
5. In what ways do conspiracy theories offer reassurance or a sense of control in the face of uncertainty or discomfort?
6. How can we be more aware of and guard against our cognitive biases and heuristics in order to make more accurate inductive inferences?

## MINDS THAT MATTERED: DANIEL KAHNEMAN AND AMOS TVERSKY

[6] I'd like to thank Todd Kukla for his helpful comments.

Daniel Kahneman and Amos Tversky were two influential psychologists whose work revolutionized the field of decision-making and behavioral economics.

Kahneman was born in Tel Aviv, Israel in 1934. He received his undergraduate degree in psychology from the Hebrew University of Jerusalem, and later completed his PhD at the University of California, Berkeley. Tversky was born in Haifa, Israel in 1937, and received his undergraduate degree from the Hebrew University of Jerusalem before completing his PhD at the University of Michigan.

Kahneman and Tversky first met in the 1960s while working at the Hebrew University of Jerusalem, and they quickly formed a close collaboration that would last for over two decades. They began by studying how people make decisions under uncertainty, and developed a theory called prospect theory, which challenged the traditional economic assumption that people make rational decisions based on expected utility.

According to prospect theory, people are more influenced by the potential losses and gains associated with a decision, rather than the probability of those outcomes occurring. Kahneman and Tversky also found that people tend to overweigh the likelihood of rare events, and underweight the likelihood of more common events.

Their work on prospect theory earned them numerous accolades, including the Nobel Memorial Prize in Economic Sciences in 2002. In addition to their work on decision-making, Kahneman and Tversky also conducted research on a variety of other topics, including heuristics, biases, and mental shortcuts that influence how people process information and make judgments.

Kahneman and Tversky's work has had a significant impact on fields such as psychology, economics, and political science, and their ideas have been widely influential in shaping our understanding of how people make decisions. Their contributions continue to be studied and debated today, and their legacy lives on as a cornerstone of modern behavioral economics.

## Exercises

For this chapter, you'll the chance to consider several famous conspiracy theories.

### Case 1: The JFK Assassination

On November 22, 1963, President John F. Kennedy was assassinated in Dallas, Texas. The event, which shocked the nation, quickly became the subject of numerous conspiracy theories. One of the most prominent of these theories suggests that Kennedy was not killed by a lone gunman, Lee Harvey Oswald, but rather was the victim of a larger conspiracy involving the CIA, the Mafia, and possibly even the Cuban government.

The mainstream hypothesis, supported by the majority of experts and researchers in the field, is that Lee Harvey Oswald acted alone in the assassination. This conclusion was reached by the Warren Commission, which conducted a thorough investigation of the assassination and issued a report in 1964 stating that there was no evidence of a conspiracy in the assassination. The Warren Commission's findings were based on a thorough examination of the available evidence, including:

- Eyewitness testimony: The Warren Commission interviewed hundreds of eyewitnesses who were present at the time of the assassination. Many of these witnesses reported seeing a gunman in the sixth-floor window of the Texas School Book Depository building, where Lee Harvey Oswald was employed.
- Physical evidence: The Warren Commission examined the physical evidence found at the scene, including bullets and cartridge cases, which were matched to the rifle found in the sixth-floor window of the Texas School Book Depository building and linked to Lee Harvey Oswald.
- The analysis of bullets: The Warren Commission's experts concluded that the bullets used in the assassination were fired from the rifle found in the sixth-floor window of the Texas School Book Depository building. A thorough examination of the bullet trajectories and the wounds on President Kennedy and Governor Connally, who were also shot during the assassination, supported the conclusion that the shots were fired from this location, and that Lee Harvey Oswald was the lone gunman.

- The investigation of Lee Harvey Oswald's background: The Warren Commission also examined Lee Harvey Oswald's background and found no evidence of any association with any group or individual that would have motivated him to assassinate the president.
- The investigation of Lee Harvey Oswald's actions before and after the assassination: The Warren Commission's investigation of Lee Harvey Oswald's actions before and after the assassination, including his purchase of the rifle used in the assassination and his flight from the scene after the assassination, supported the conclusion that he acted alone.
- Furthermore, several subsequent investigations, including a 1978 investigation by the House Select Committee on Assassinations, have also concluded that Lee Harvey Oswald acted alone in the assassination. While some experts and researchers have criticized the methods and conclusions of these investigations, the majority of experts in the field have found the evidence supporting the mainstream hypothesis that Lee Harvey Oswald acted alone to be compelling.

The JFK assassination conspiracy theorists often use various fallacious strategies to disregard the findings of government reports and those of academic researchers. These tend to amount to the claim that "they're all part of the conspiracy!" (the government committees, the witnesses, the academics, the reporters, the police/FBI forensics experts, the historians…_). It's important to note that, these sorts of arguments lack proper evidence and are often based on misinformation and misinterpretation of facts. They are, by their nature, "unfalsifiable", in that they make claims that it basically IMPOSSSIBLE to gather evidence for (in fact, this is a common strategy for conspiracy theorists).

**Questions**

1. What is the mainstream hypothesis about the JFK assassination?
2. What evidence supports the mainstream hypothesis about the JFK assassination?
3. What are some of the fallacious strategies that the JFK assassination conspiracy theorists use to disregard the findings of government reports and academic researchers?
4. How was the Warren Commission's investigation of the JFK assassination conducted?
5. What were the Warren Commission's main findings about the JFK assassination?
6. What physical evidence was found at the scene of the JFK assassination?

## CASE 2: HOLOCAUST DENIAL

The Holocaust, the systematic extermination of millions of Jews and other minority groups by the Nazi regime during World War II, is one of the most well-documented events in history. However, despite overwhelming evidence, there are those who deny that the Holocaust ever happened, or that it was not as extensive as historical records indicate. These Holocaust deniers, or revisionists, often put forth conspiracy theories that challenge the mainstream understanding of the Holocaust and its historical record.

The mainstream hypothesis, supported by the vast, vast experts and researchers in the field, is that the Holocaust was a systematic extermination of millions of Jews and other minority groups by the Nazi regime during World War II. This conclusion is based on a vast amount of historical evidence, including:

- Documentary evidence: Nazi Germany kept extensive records of their operations, including the transportation and extermination of Jews and other minority groups. These records, along with other Nazi documents, were captured by Allied forces at the end of World War II and have been extensively studied by historians.
- Testimonies of survivors and witnesses: Thousands of survivors of the Holocaust have provided testimony about their experiences, including their transportation to concentration and extermination camps, the conditions in these camps, and the atrocities that occurred there.

- Physical evidence: The remains of concentration and extermination camps, including gas chambers and crematoria, were discovered by Allied forces at the end of World War II. These sites have been preserved as Holocaust memorials and have been visited by millions of people.
- Archaeological evidence: Researchers have uncovered mass graves and other evidence of mass killings at sites where Nazi killings occurred during the Holocaust.
- The Nuremberg Trials: The Nuremberg Trials, held after the war, brought to justice many of the top leaders of Nazi Germany and provided extensive evidence of the Holocaust.

Despite the overwhelming evidence, Holocaust deniers, or revisionists, put forward various conspiracy theories that challenge the mainstream understanding of the Holocaust. They often use fallacious strategies to disregard the findings of historical research and the evidence presented by academic historians. Some of the arguments Holocaust deniers use include:

- Claiming that the Holocaust is a hoax perpetrated by Jews or other groups for financial or political gain.
- Disputing the number of Jews killed, often by claiming that the numbers have been inflated.
- Questioning the authenticity of documents and other evidence, claiming that they have been forged or tampered with.
- Denying the existence of gas chambers and other extermination methods, often by claiming that they were used for disinfection or delousing.
- Claiming that the Holocaust is a Zionist conspiracy to justify the creation of Israel.

As is the case with other conspiracy theories, these "arguments" are based on misinformation, misinterpretation of facts, and a lack of understanding of historical research methods. The overwhelming evidence, including documentary evidence, testimonies of survivors and witnesses, physical evidence, archaeological evidence, and the Nuremberg Trials, all support the mainstream understanding of the Holocaust as a systematic extermination of millions of Jews and other minority groups by the Nazi regime during World War II. These evidences provides an inductive evidence that the Holocaust did happen.

The arguments used by Holocaust deniers often have anti-Semitic undertones, as they often perpetuate harmful stereotypes about Jews and their supposed role in world events. Additionally, Holocaust denial is often motivated by the psychological mechanism of cognitive dissonance, where an individual holds conflicting beliefs and is unwilling to accept new information that would challenge their existing beliefs.

It is crucial to understand the Holocaust in its proper historical context, and the importance of rejecting conspiracy theories that aim to deny or downplay the atrocities that occurred. It is important to remember the victims of the Holocaust, and to use the evidence to learn from history, to understand the dangers of hate and discrimination and to work towards a more just and equitable future.

**Questions:**

1. What is the mainstream hypothesis about the Holocaust?
2. What is the evidence for the mainstream hypothesis about the Holocaust?
3. How do Holocaust deniers use misinformation and misinterpretation of facts to support their theories?
4. How do Holocaust deniers make their hypothesis unfalsifiable?
5. What is the importance of rejecting Holocaust denial theories?
6. What are the dangers of anti-Semitism in relation to Holocaust denial theories?
7. How do the evidence and testimony of survivors and witnesses support the mainstream understanding of the Holocaust?
8. How did the Nuremberg Trials contribute to our understanding of the Holocaust?
9. What is the role of cognitive dissonance in Holocaust denial theories?

10. How can we use the historical evidence of the Holocaust to learn from the past and work towards a more just and equitable future?

## CASE 3: GMO CROPS

The use of genetically modified organisms (GMOs) in agriculture has been a contentious issue for decades, with many conspiracy theories emerging regarding the safety and efficacy of these crops. The debate pits those who believe that GMOs are a safe and effective way to increase crop yields and feed a growing global population, against those who believe that GMOs are dangerous and have negative impacts on both human health and the environment.

The mainstream scientific hypothesis is that GMOs are safe for consumption and that they have been proven to be an effective tool in increasing crop yields and fighting against pests and diseases. This hypothesis is supported by a large body of research, including studies conducted by government agencies, universities, and independent research organizations. These studies have found that GMOs are not significantly different from non-GMO crops in terms of their nutritional content or their impact on the environment. Additionally, GMOs have been found to be effective in increasing crop yields, reducing the use of pesticides, and improving the resilience of crops in the face of climate change.

On the other hand, conspiracy theories about GMOs often suggest that they are dangerous to human health and the environment, and that they are being pushed by large corporations for their own financial gain. These theories often rely on misinformation and misinterpretation of facts, and a lack of understanding of the scientific process. Some conspiracy theorists argue that GMOs are linked to an increased risk of cancer, allergies, and other health issues, despite a lack of evidence to support these claims. Others argue that GMOs are part of a larger conspiracy by corporations to control the global food supply and manipulate the population.

The GMO conspiracy theory posits that genetically modified crops are dangerous to human health and the environment, and that they are promoted by large corporations with nefarious motives. However, the overwhelming majority of scientific research and evidence supports the safety and benefits of genetically modified crops.

For example, GMO conspiracy theorists often claim that genetically modified crops can lead to an increase in allergies and other health problems, despite the fact that numerous studies have shown that genetically modified crops are no different in terms of allergenicity or toxicity than their non-GMO counterparts. Additionally, GMO conspiracy theorists often claim that genetically modified crops lead to an increase in the use of pesticides, however, studies have shown that the use of genetically modified crops has led to a decrease in the use of pesticides.

Another example of an unfalsifiable claim is the argument that genetically modified crops are not as "natural" as non-GMO crops, or that they are "playing God" with nature. However, these claims are not based on any scientific evidence, and are not testable or falsifiable.

Moreover, GMO conspiracy theorists argue that the research on GMOs is controlled by big corporations and that they manipulate the results to their advantage. However, there is no evidence to support this claim. In fact, the vast majority of research on GMOs is conducted by independent academic researchers and institutions, and is subject to rigorous peer review before being published in scientific journals. Furthermore, the research is openly available to be reviewed by the public and other scientists.

One potential psychological motive behind GMO conspiracy theories could be a mistrust of large corporations and government institutions, leading individuals to believe that these entities are hiding the truth about the supposed dangers of GMO crops. Additionally, the concept of "playing it safe" by avoiding something that is perceived as unfamiliar or unnatural, may also be driving factors. Fear of the unknown, coupled with a desire to

protect oneself and one's family from perceived harm, may lead individuals to believe in conspiracy theories about GMOs despite a lack of evidence. Furthermore, it can also be linked to a deeper mistrust in science and the scientific method as a whole. People who are skeptical of science tend to be more likely to believe in conspiracy theories. These ideas also tap into a long-standing tradition of anti-science sentiment, which is often rooted in political or ideological beliefs.

It is important to note that the weight of evidence supports the scientific consensus that genetically modified crops are safe for human consumption and have significant benefits for both farmers and the environment. It is essential to critically evaluate the claims made by GMO conspiracy theorists and base one's beliefs on sound scientific evidence and reasoning.

**Questions**

1. What is the mainstream scientific consensus on the safety and benefits of GMO crops?
2. What are some of the key arguments made by GMO conspiracy theorists?
3. What evidence supports the mainstream scientific consensus on GMO crops?
4. What are some of the fallacious strategies used by GMO conspiracy theorists to dismiss mainstream scientific research?
5. How do GMO conspiracy theories compare to mainstream scientific understanding of the issue?
6. What are some of the potential psychological motives behind belief in GMO conspiracy theories?
7. How do GMO conspiracy theories relate to broader anti-science sentiment?
8. What is the potential impact of GMO conspiracy theories on public understanding and policy related to GMO crops?
9. How do GMO conspiracy theories compare to other conspiracy theories, such as those related to vaccinations or climate change?
10. What are some strategies for effectively communicating the mainstream scientific consensus on GMO crops to individuals who may be susceptible to conspiracy theories?

## Case 4: The Fed

The Federal Reserve, also known as the Fed, is the central banking system of the United States. It was created in 1913 with the passage of the Federal Reserve Act. The Fed's main responsibilities include implementing monetary policy, regulating banks, and providing financial services to the government.

The mainstream understanding of the Fed is that it is an independent government agency, overseen by a board of governors appointed by the President and confirmed by the Senate. The Fed's monetary policy is designed to promote stable prices and maximum employment, in order to promote economic growth. This is done by setting interest rates and controlling the money supply through various tools such as open market operations.

However, there is a conspiracy theory that suggests the Fed is not an independent government agency, but rather a private entity that is secretly manipulating the economy for the benefit of a small group of elites. This theory has been around since the creation of the Fed, and has been promoted by some politicians and media outlets. The theory suggests that the Fed is controlled by a group of powerful bankers who use their influence to control the economy for their own benefit.

This theory is not supported by evidence. The Fed is a government agency, and its actions are subject to oversight by Congress. The Fed's monetary policy decisions are made by the Federal Open Market Committee (FOMC), which is made up of representatives from the 12 regional Federal Reserve Banks and the Board of Governors. The FOMC's decisions are based on economic data and analysis, and are designed to promote the best interests of the overall economy.

Furthermore, the Fed's actions have been extensively studied by economists, and have been found to have generally positive effects on the economy. The Fed's monetary policy has been credited with helping to stabilize the economy during times of crisis, such as the Great Recession of 2008.

It's important to note that the Federal Reserve conspiracy theory is often promoted by people with a political or ideological agenda, and it is not supported by evidence. This theory is not only unrealistic but also dangerous, as it can discourage people from trusting the Fed and its role in the economy.

Belief in the Federal Reserve conspiracy theory can cause people to make poor investment decisions, as they may be led to believe that the Fed is manipulating the markets for its own gain. This could lead investors to invest in more volatile and speculative assets such as bitcoin or gold, which may have greater short-term gains but are much more risky and do not perform as well over the long term. Additionally, this belief could lead people away from investing in stocks, which have historically had higher returns over time than other investments. Consequently, individuals who invest in these types of assets based on their belief in a conspiracy theory may end up losing money instead of achieving their desired financial goals. Belief in the Federal Reserve conspiracy theory can also lead to increased political polarization, as individuals become more suspicious of government and its role in the economy. This can lead to further divisions and mistrust between different groups of people and contribute to a decline in civil discourse.

The Federal Reserve conspiracy theory is closely related to other common conspiracy theories. For example, the **"New World Order"** conspiracy theory suggests that a small group of powerful individuals are secretly working behind the scenes to create a global government that will impose oppressive control over humanity. This theory often cites the Federal Reserve as part of this secretive power structure, claiming that it is controlled by powerful bankers and financial elites who use their influence to manipulate markets and economies for their own benefit. Antisemitic theories (such as Holocaust denial) also draw on the idea of a secret cabal controlling world events, but they focus specifically on Jews as being responsible for manipulating governments and economies around the world. Like the New World Order theory, these ideas often cite the Federal Reserve as part of this global Jewish conspiracy.

**Questions:**

1. What evidence is there that the Federal Reserve is an independent government agency, and not a private entity?
2. How does believing in the Federal Reserve conspiracy theory lead to inaccurate representations of economic reality?
3. What are some of the long-term negative effects that belief in this conspiracy theory can have on both individuals and society as a whole?
4. Why might people be attracted to believing in this conspiracy theory even though it has no basis in fact?
5. How could we better educate people about the true role of the Federal Reserve (and things like money, banks, money, and stocks more generally) and why it is important for our economy?

## Case Study 5: Vaccine Conspiracy Theories

Conspiracy theories surrounding vaccines have been around for decades, but have gained renewed attention in recent years with the rise of anti-vaccine sentiment and the ongoing COVID-19 pandemic. These theories often suggest that vaccines are dangerous, causing harm to individuals who receive them, and are part of a larger plot by pharmaceutical companies, governments, and other organizations to control or harm the population.

One of the most prominent conspiracy theories is that vaccines cause autism. This theory emerged in the late 1990s and was based on a now-retracted study published in the medical journal The Lancet. The study's results have been thoroughly discredited, and numerous studies involving hundreds of thousands of children have

shown no link between vaccines and autism. The author of the study was found to have had conflicts of interest and had manipulated data. The Lancet fully retracted the study in 2010.

Another common conspiracy theory is that vaccines make people sterile. This theory is not supported by any scientific evidence. Vaccines do not contain any ingredients that can affect fertility, and there is no evidence that vaccines cause any harm to reproductive health. Finally, some people have claimed that vaccines contain microchips that can be used for tracking or other nefarious purposes. This theory is not supported by any evidence and is not biologically possible as microchips are not small enough to be injected in a vaccine.

The best evidence against these conspiracy theories can found in thinking about the way that vaccines are actually tested. Vaccines go through a rigorous testing process before they are approved for use in the general population. This process is known as a clinical trial, and it is typically divided into four phases.

- Phase 1: The first phase of clinical trials for a vaccine involves a small number of healthy volunteers. The goal of this phase is to determine the safety and tolerability of the vaccine, as well as to identify any potential side effects. The number of participants in this phase is usually around 20 to 100 individuals.
- Phase 2: Once a vaccine has been deemed safe in phase 1, it moves on to phase 2. This phase involves a larger group of participants, typically around 100 to 500 individuals. The goal of this phase is to determine the vaccine's effectiveness and to gather more information about its safety profile.
- Phase 3: In phase 3, the vaccine is tested in even larger groups, often numbering in the thousands. The goal of this phase is to confirm the vaccine's efficacy and safety, and to gather more information about any potential side effects. This phase typically takes several months to a year to complete.
- Phase 4: Phase 4 trials, also known as post-marketing surveillance, are conducted after the vaccine has been approved and made available to the general public. The goal of this phase is to monitor the safety and effectiveness of the vaccine in the real-world setting.

For example, COVID-19 vaccines went through the same rigorous process of clinical trials before they were authorized for emergency use by regulatory authorities around the world. The Pfizer-BioNTech and Moderna vaccines were authorized for emergency use in December 2020, after phase 3 clinical trials involving tens of thousands of participants showed they were highly effective at preventing COVID-19.

Psychologically, vaccine conspiracy theories can be seen as resulting from an individual's need to make sense of the world around them. People tend to prefer a story that allows them to make sense of their environment and explain the events that occur in it. Vaccine conspiracy theories provide an easy explanation for why something like a virus or disease may have arisen in the first place. By believing in conspiracies, people feel empowered and believe they have taken control of their lives by understanding the "truth" behind a particular event or phenomenon.

At a deeper level, some individuals may look at vaccine conspiracies as an externalization of uncertainty and fear about the future; if they can attribute the cause of something like a virus to someone else (e.g., government or corporations) then they are able to feel less helplessness or vulnerability in the face of potential danger. This is especially true when there is no clear answer to why something has happened or what might happen next; instead of feeling powerless, individuals can turn to conspiracy theories for answers and explanations that provide comfort and security in times of doubt.

Additionally, there may be cognitive biases at play which lead some people towards believing in conspiracy theories - such as confirmation bias where an individual only looks for evidence that confirms their beliefs rather than objectively evaluating all available data points. Similarly, selective perception could also lead individuals towards forming false conclusions about certain topics - particularly those related to vaccines and health care - due to interpreting information from their own perspective without considering alternate viewpoints or interpretations.

Finally, social influences may contribute to vaccine conspiracy theories as well; if one's peers or family members hold similar beliefs then there is more pressure on an individual to conform and accept those same ideas even if there is no factual evidence supporting them. This herd mentality can lead people down dangerous paths which further entrench already established beliefs instead of challenging them with rational thought and debate.

The conspiracy theories about vaccines are not only unsupported by scientific evidence, but they also have real-world consequences. When fewer people get vaccinated, it puts the entire community at risk of disease outbreak. The misinformation circulating about the safety and efficacy of vaccines can also lead to unnecessary fear and mistrust of vaccines.

In the end, it is important to rely on credible sources of information, such as the World Health Organization, Centers for Disease Control and Prevention, and the National Institutes of Health, when evaluating the safety and efficacy of vaccines. Vaccines are one of the most effective public health tools available, saving millions of lives every year. Vaccines protect not only the individual who receives them, but also those around them through herd immunity.

**Questions**

1. What is the evidence that suggests that vaccines are not linked to autism?
2. How do the scientific studies claiming a link between vaccines and autism lack credibility?
3. Why do some people still believe in vaccine conspiracy theories, despite strong evidence to the contrary?
4. What are some of the potential psychological motivations behind believing in vaccine conspiracy theories?
5. Are there any long-term health effects associated with not being vaccinated?
6. How has anti-vaccine rhetoric impacted public health initiatives around immunization?
7. What strategies could be used to address false claims about vaccine safety and efficacy?
8. What are the ethical implications of promoting vaccine conspiracy theories?
9. In what ways might believing in vaccine conspiracy theories lead to personal or social harm?
10. How can we create an environment that encourages people to make well-informed decisions about vaccinations based on science, rather than fear or misinformation?

# CHAPTER 10: STATISTICAL REASONING

In this chapter on statistical reasoning, you will learn about the importance of sampling and representative samples. We will also cover measures of central tendency, such as mean, median, and mode. You will learn about variations and standard deviations, as well as normal and not-so normal distributions. We will also cover hypothesis testing, and how to understand poll or survey results. As part of this chapter, we will also delve into common pitfalls and errors in statistical reasoning. To help you understand these concepts, we will examine a case study featuring Dr. Evil and Professor Doom. Overall, this chapter will provide you with the skills and knowledge necessary to critically evaluate statistical information and make informed decisions based on data. This is a valuable skill to have in a world where we are constantly bombarded with statistical information from various sources. Understanding statistical reasoning will allow you to better understand and analyze data, and make more informed decisions in your personal and professional life.

Ahh-wooooooo! What's that I hear? It sounds like…werewolves?

## THE WEREWOLVES AMONG US?

Are you worried your classmates may actually be werewolves? Statistics can help!

1. You can compare the average amount of facial hair grown by your classmates to the average amount of facial hair grown by known werewolves. By taking the mean, median and mode of the two groups, you can determine if there is a statistically significant difference between them. Unfortunately, you will have to rely on categorical data as it's unlikely that any werewolf would agree to have their facial hair measured in inches!
2. You could use standard deviation (SD) to help you determine whether any of your classmates are werewolves. By calculating the SD for each student's body temperature, you can identify anyone whose temperature deviates too far from the normal range – a possible indicator that they might be a werewolf!
3. A probability test could also be used to help detect potential werewolves in your class. Because wolf-like features are not exclusive to werewolves, some people with wolf-like features may simply be normal humans with an overactive imagination (or too much time spent playing Werewolf). By using probability tests, you can calculate how likely it is that someone with certain characteristics is actually a werewolf.
4. Hypothesis testing could also provide clues about which students in your class might potentially be werewolves. For example, if students who report having strange dreams at night also tend to have higher grades than other students in the class, this could suggest that they are more likely to be werewolves than their peers!
5. Statistical significance is another way that statistics can help identify potential werewolves among your classmates. If student grades or attendance rates differ significantly between those who report wolf-like features and those who don't, this could indicate that there may be something supernatural going on!
6. Bayes Theorem could also prove helpful when trying to identify potential werewolves among your classmates – particularly if there are two or more possible explanations for why certain students seem different from their peers (e.g., one explanation being that they are actually a werewolf!). This theorem allows us to calculate the likelihood of one explanation being true over another based on prior evidence or beliefs about a particular situation or individual.
7. Confounding variables should also be considered when trying to spot potential werewolves among your classmates - particularly when analyzing differences in student performance or behavior between those who report wolf-like features and those who don't! It's important not to jump to conclusions without considering all other possible explanations - such as differences in socio-economic backgrounds or home environments - before drawing conclusions about whether someone might be a werewolf!
8. Qpotential werewolves among their classmates - especially given how unique every individual is and how difficult it can be for statistics alone to capture all aspects of human behavior! Making broad generalizations about entire groups of people based solely on averages or percentages calculated from statistical models should always be avoided as it can lead us astray from uncovering actual truths about our world and its inhabitants!
9. While correlation may suggest causation, statistics cannot necessarily prove whether someone is indeed a real-life creature of myth and legend like a werewolf– only additional information outside of what numbers alone tell us can do this! Therefore while correlational analysis may point us in specific directions regarding which individuals among our peers might possibly belong within these mythical

realms, we must always take care not to draw definitive conclusions on these matters until further evidence has been collected and analyzed accordingly.

10. Last but certainly not least – Statistical methods, alone cannot show whether someone is indeed a werewolf. Statistical methods are only as good as the data you start with! For this, we need careful data collection and observation. (And when we do *this,* you'll undoubtedly discover your classmates aren't werewolves after all!).

### QUESTIONS

1. How can statistics help us to identify potential werewolves among our classmates?
2. Why is it important not to overgeneralize when interpreting the results of statistical analysis?
3. In what ways can Bayes Theorem offer insights into identifying potential werewolves among your classmates?
4. What big picture lessons can we learn from this hypothetical scenario about the importance and limitations of statistical reasoning in everyday life?

## INTRODUCTION

Statistical reasoning is a way of thinking that involves understanding and analyzing data in order to draw conclusions and make informed decisions. It is an important skill to have in today's world, as we are constantly bombarded with information and it is essential to be able to critically evaluate the validity and reliability of this information.

One practical application of statistical reasoning is in understanding and interpreting poll results and scientific studies. Polls are used to gather information about people's opinions, attitudes, and behaviors, and statistical techniques are used to analyze the data and draw conclusions about the larger population. Similarly, scientific studies often involve collecting data and using statistical techniques to analyze the data and draw conclusions about a particular phenomenon.

Understanding and interpreting poll results and scientific studies is vital in many areas of life, such as politics, health, and the media. For example, understanding poll results can help you make informed decisions when voting or when considering which products or services to use. Similarly, understanding the results of scientific studies can help you make informed decisions about your health and well-being.

In order to effectively understand and interpret poll results and scientific studies, it is crucial to have a basic understanding of statistical concepts and techniques. Some of the key concepts and techniques include sampling, measures of central tendency, variability, probability, hypothesis testing, and confidence intervals. In the following sections, we will explore these concepts in more detail and discuss how they are used in statistical reasoning.

## UNDERSTANDING THE CONCEPT OF SAMPLING

Sampling is the process of selecting a subset of individuals from a larger population in order to gather information about the population as a whole. Sampling is an important concept in statistical reasoning because it allows us to draw conclusions about a larger population based on data collected from a smaller group of individuals.

There are several different types of sampling techniques that can be used, including simple random sampling, stratified sampling, and cluster sampling. The type of sampling technique used will depend on the specific research question being asked and the characteristics of the population being studied.

**Simple random sampling:** A sampling technique in which every member of the population has an equal chance of being selected for the sample. This is done by randomly selecting a certain number of individuals from the population.

**Stratified sampling:** A sampling technique in which the population is divided into different strata (groups) based on specific characteristics (e.g. age, gender, income level), and a random sample is selected from each stratum. This technique is often used to ensure that the sample is representative of the population.

**Cluster sampling:** A sampling technique in which the population is divided into groups (clusters) and a random sample of these groups is selected. Data is then collected from all individuals within the selected clusters. This

technique is often used when it is not practical to study the entire population, or when the population is geographically dispersed.

Some practical examples of sampling include:

*Political polls:* Political polls are often used to gauge the opinions and preferences of the general population. In order to accurately represent the population, the pollsters need to use a sampling technique that is representative of the population. For example, they may use a simple random sampling technique, where a random sample of individuals is selected from the larger population to participate in the poll.

*Marketing research:* Companies often conduct market research in order to understand consumer preferences and behaviors. In order to accurately represent the target market, the company may use a stratified sampling technique, where the population is divided into different strata (e.g. age, gender, income level) and a random sample is selected from each stratum.

*Health research:* Researchers may use cluster sampling when studying a particular health issue in a specific geographic region. For example, they may select a random sample of neighborhoods or communities in the region (a "cluster") and collect data from all individuals within those neighborhoods or communities.

The choice of sampling technique is an important consideration in statistical reasoning because it can significantly impact the validity and reliability of the conclusions drawn from the sample data. There are several factors that should be taken into account when choosing a sampling technique, including the research question being asked, the characteristics of the population being studied, and the resources available for conducting the study.

For example, if the research question is focused on a specific subgroup within the population (e.g. young women), it may be appropriate to use stratified sampling, where the population is divided into different strata and a random sample is selected from each stratum. This ensures that the sample is representative of the subgroup of interest. On the other hand, if the research question is focused on a specific geographic region, cluster sampling may be more appropriate, where a random sample of neighborhoods or communities is selected and all individuals within those neighborhoods or communities are included in the sample.

In addition to the research question and the characteristics of the population, the resources available for conducting the study can also impact the choice of sampling technique. For example, if the study has a limited budget and can only afford to survey a small number of individuals, a simple random sampling technique may be more appropriate because it requires fewer resources to implement.

## The Importance of Representative Samples

Random sampling is a sampling technique in which every individual in the population has an equal probability of being chosen for the sample. This method is highly regarded for its reliability and objectivity, as it minimizes the risk of selection bias, which occurs when the sample is not representative of the population. Both stratified sampling and cluster sampling "build on" simple random sampling.

The significance of using random sampling to ensure the validity of poll results and scientific studies cannot be overstated. If the sample is not representative of the population, the conclusions drawn from the sample data may not be accurate or reliable. This can have serious consequences in a variety of contexts, such as in politics, health, and the media. For example,

*Political polls:* Suppose that a political poll was conducted to gauge the opinions of the general population on a proposed education reform bill. If the sample is not representative of the population (e.g. if it oversamples individuals who are in favor of the bill), the poll results may not accurately reflect the views of the larger population. This could lead to misinformation and misunderstandings about the general public's support for the bill and could potentially impact the policies politicians adopt.

Health research: Suppose that a study was conducted to investigate the link between physical activity and the risk of developing heart disease. If the sample is not representative of the population (e.g. if it oversamples individuals who are physically active), the conclusions drawn from the study may not be applicable to the larger population and could lead to misinformation and misunderstandings about the role of physical activity in heart disease risk.

Marketing research: Finally, suppose that a company conducted market research to understand consumer preferences for a new line of organic skin care products. If the sample is not representative of the target market (e.g. if it oversamples individuals who are not interested in organic products), the conclusions drawn from the study may not accurately reflect the preferences of the target market, which could lead to poor decision-making and financial losses for the company.

The use of random sampling is crucial in ensuring the validity of poll results and scientific studies. It minimizes the potential for selection bias, which can lead to the fallacy of hasty generalization if the sample is not representative of the population. By ensuring that the sample is representative of the population, random sampling helps to produce more accurate and reliable conclusions.

## Measures of Central Tendency

Calculating measures of central tendency is a relatively straightforward process. For the mean, simply add up all the values in the dataset and divide by the number of values. For the median, order the values from least to greatest and select the middle value. For the mode, count the frequency of each value and select the value with the highest frequency.

Interpreting measures of central tendency can be more challenging, as it requires understanding the context and characteristics of the dataset. For example, the mean and median may give different results for a skewed dataset with extreme values. In this case, it may be more appropriate to use the median as the measure of central tendency, as it is not influenced by these values.

It is important to consider the limitations and appropriate uses of each measure of central tendency. The mean is useful when the data are roughly symmetrical and there are no extreme values, but may be influenced by these values. The median is useful when the data are skewed or have extreme values, as it is not influenced by these values. The mode is useful when there are multiple values that occur with similar frequency, but may not be useful when there are no values that occur more frequently than others.

Grades: A teacher wants to determine the typical grade of their students on a math test. They have a dataset of the grades of all the students in their class: {84, 90, 95, 96, 97, 98, 99}. The mean of this dataset is (84+90+95+96+97+98+99)/7 = 94. The median of this dataset is 96, since it is the middle value when the values are ordered from least to greatest. The mode of this dataset is not useful, since there are no values that occur more frequently than others. In this case, the mean and median give similar results, indicating that the typical grade of the students is around 94-96.

Income: A government agency wants to determine the typical income of households in a particular city. They have a dataset of the incomes of all the households in the city: {20,000, 25,000, 30,000, 40,000, 45,000, 50,000, 1,000,000}. The mean of this dataset is (20,000 + 25,000 + 30,000 + 40,000 + 45,000 + 50,000 + 1,000,000) / 7= 172857.14. The median of this dataset is 40,000, since it is the middle value when the values are ordered from least to greatest. The mode of this dataset is not useful, since there are no values that occur more frequently than others. In this case, the median is a more representative measure of central tendency than the mean, as the mean is significantly influenced by the extreme value of 1,000,000.

Hair Color: A researcher wants to determine the typical hair color of participants in a study on genetics. They have a dataset of the hair colors of all the participants: {brown, brown, brown, blonde, blonde, red, red, red, red}. Neither the mean nor the mode of this dataset are useful, as they cannot be calculated for categorical data. The mode of this dataset is red, since it occurs more frequently than any other hair color. In this case, the mode is a useful measure of central tendency, as it indicates the most common hair color among the participants.

## Questions

1. In what situations might simple random sampling be the most appropriate technique to use? What about stratified sampling or cluster sampling?
2. Have you ever participated in a poll or scientific study? If so, do you know what sampling technique was used? If not, how do you think the sample was selected?
3. Can you think of any real-world examples where understanding sampling techniques and statistical reasoning is particularly important?
4. How does the size of the sample impact the reliability of the conclusions drawn?

5. How do researchers ensure that the sample is representative of the larger population?
6. Have you ever encountered a poll or scientific study that you thought had a flawed sampling technique? What made you question the validity of the sample?
7. In what situations might it be more appropriate to use the mode or the median as a measure of central tendency, rather than the mean?

## EXERCISES: MEASURES OF CENTRAL TENDENCY

Answer the following questions. The measures of central tendency are "mean", "median", or "mode". The choices of sampling techniques are "simple random sampling," "cluster sampling," or "stratified sampling." In some cases, there might not be one clearly correct answer. The important thing is to think about *why* you might choose different techniques.

1. A teacher gave a test to her class and recorded the scores. The scores are: 50, 85, 85, 95, 100, and 100. What is the mean, median, and mode of the test scores?
2. A group of friends went to a carnival and recorded the number of tickets they won each day. The numbers are: 5, 10, 10, 15, 15, 20, and 50. What is the mean, median, and mode of the number of tickets they won each day?
3. A grocery store wants to understand the typical price of a gallon of milk at different stores in their area. They gather data on the price of milk at 10 different stores and calculate the mean, median, and mode. Which measure(s) of central tendency would be most representative of the typical price of milk? Why?
4. A researcher is studying the attitudes of college students towards a particular issue. They gather data by asking students who walk past their booth on a busy street corner to participate in their survey. Is this a representative sample of college students? Why or why not? How could the researcher improve their sampling technique?
5. You are trying to understand the typical commute time of people who live in your city. What sampling technique would you use to gather data on commute times? Why?
6. A researcher is studying which species are most "typical" of an area. They gather data on the species of 200 trees. Which measure of central tendency would be most representative of the typical height of the tree species? Why?
7. A pollster is trying to understand the political preferences of voters in a particular district. They gather data by surveying attendees at a political rally. Is this a representative sample of voters in the district? Why or why not? How could the pollster improve their sampling technique?
8. You want to study the academic achievement of students in a particular school district. What sampling technique would you use to gather data on student achievement? Why?
9. A company wants to understand the typical salary of employees in their industry. There is a wide range, with some people earning 50x more than others. They gather data on the salaries of 50 employees and calculate the mean, median, and mode. Which measure of central tendency would be most representative of the typical salary in the industry? Why?
10. A researcher is studying the attitudes of young adults towards a particular issue. They gather data by surveying participants at a music festival. Is this a representative sample of young adults? Why or why not? How could the researcher improve their sampling technique?
11. You want to study the environmental impact of a particular industry. What sampling technique would you use to gather data? Why?
12. A researcher is studying the typical lifespan of a particular species of bird. They gather data on the lifespans of 30 birds and calculate the mean, median, and mode. Which measure(s) of central tendency would be most representative of the typical lifespan of the bird species? Why?
13. A pollster attempts to measure public opinion on a political issue is conducted by calling only landline phones. What might be the problem with this? How could it be improved?
14. You are interested in studying the health of patients with diabetes in Minnesota. What sampling technique might you use? Why?
15. A medical study on the effectiveness of a new medical treatment is conducted only on patients who are willing to pay for the treatment out-of-pocket. What might be the problem with this? How could it be improved?

## MINDS THAT MATTERED: RONALD FISHER

Ronald Fisher was a British statistician and geneticist who made significant contributions to the development of statistical theory and methodology. He is known for his work on the design of experiments, statistical analysis, and the application of statistical methods to the study of genetics and evolution.

Fisher was born in London in 1890 and studied mathematics and physics at the University of Cambridge. After graduating, he worked as a statistician for the Galton Laboratory at the University of London, where he developed many of his key ideas on statistical theory and methodology.

One of Fisher's most significant contributions to statistics was his development of the concept of statistical significance, which is used to determine the probability that the results of a statistical analysis are due to chance rather than a real effect. He also developed the analysis of variance (ANOVA) method, which is used to compare the means of different groups, and the chi-squared test, which is used to test the independence of two categorical variables.

Fisher was also a strong proponent of the use of statistical methods in the design and analysis of experiments, and he developed the principles of randomization and replication, which are central to the scientific method.

In addition to his contributions to statistics, Fisher was also known for his views on tobacco and race. He was a vocal advocate for the use of tobacco and was critical of research linking tobacco use to cancer. He also held controversial views on race, and argued that intelligence was largely determined by genetics.

Fisher's views on tobacco and race have been met with criticism, and his views on intelligence have been largely rejected by the scientific community. His statistical contributions, however, continue to be highly influential and widely used in the field of statistics.

Despite his contributions to statistics, Fisher's work has also been the subject of criticism from proponents of Bayesian statistics, who argue that his approach is overly reliant on classical statistical assumptions and fails to account for uncertainty in statistical models. Bayesian statistics, which is based on the idea of updating probabilities based on new evidence, allows for a more flexible approach to statistical analysis and can better account for uncertainty and subjectivity in statistical models. As a result, Bayesian statistics has become increasingly popular in fields such as machine learning and data science, where uncertainty and subjectivity are often important considerations.

### QUESTIONS

1. What were some of Ronald Fisher's significant contributions to the field of statistics?
2. What are the main criticisms of Fisher's work from proponents of Bayesian statistics?
3. Do you think it is possible for a person's personal beliefs and biases to influence their scientific work, even if unintentionally? If so, how can scientists guard against this?
4. In what ways do you think the advancement of statistical methods has impacted society and decision-making processes?
5. How do you think Fisher's views on tobacco and race would be received in today's society? Do you think it is possible for a person to hold controversial views on social issues and still make significant contributions to a scientific field? Why or why not?

## VARIATION AND STANDARD DEVIATIONS

In statistical analysis, it is important to understand the concept of variability, which refers to the degree to which a set of data differs from one another. Measuring and understanding variability can help us better understand the characteristics of a population and make predictions about future samples.

There are several different measures of variability that can be used, including the range, variance, and standard deviation.

The **range** is the simplest measure of variability, and it is calculated by taking the difference between the highest and lowest values in a set of data. For example, if the data values are 3, 7, 5, and 9, the range would be 9 - 3 = 6.

The **variance** is another measure of variability, and it is calculated by taking the average squared difference between each value and the mean of the set of data. To compute variance, you will need to follow these steps:

1. Gather a set of data that you want to analyze.
2. Calculate the mean of the data. To do this, add up all the values in the data set and divide by the total number of values.
3. For each value in the data set, subtract the mean and square the result.
4. Add up all the squared differences.
5. Divide the sum of the squared differences by the total number of values in the data set. This will give you the variance.

For example, let's say you have the following data set: 2, 4, 6, 8, 10.

1. The mean of this data set is (2 + 4 + 6 + 8 + 10) / 5 = 6.
2. The squared differences are (2 - 6)^2 = 16, (4 - 6)^2 = 4, (6 - 6)^2 = 0, (8 - 6)^2 = 4, and (10 - 6)^2 = 16.
3. The sum of the squared differences is 16 + 4 + 0 + 4 + 16 = 40.
4. The variance is 40 / 5 = 8.

The **standard deviation** is a measure of variability that is calculated by taking the square root of the variance. It is used to describe the dispersion of a set of data, with a smaller standard deviation indicating that the data values are closer together, and a larger standard deviation indicating that the data values are more spread out. Continuing with the previous example, the standard deviation would be calculated as follows:

sqrt(8) = 2.83

This tells that the "average" data item is around 2.83 different from the "mean." The standard distribution plays a crucial role in describing the "distribution" of data.

## Normal (and Not-So Normal) Distributions

Another important concept in statistical analysis related to variability is the **normal distribution**, which is a bell-shaped curve that describes the probability of a certain value occurring in a set of data. The normal distribution is characterized by a mean, median, and mode that are all equal, and by approximately 68% of the data values falling within one standard deviation of the mean. It is important because it appears in many real-life situations, including the heights and weights of people, IQ scores, and other physical and psychological measurements.

One reason the normal distribution is important is that it allows us to calculate probabilities. By using the mean and standard deviation of a normal distribution, we can determine the probability of observing a particular value or range of values. This can be useful in hypothesis testing, where we are trying to determine the likelihood of observing a particular result if a certain hypothesis is true.

For example, let's suppose a student "Sarah" is worried that she spends an "abnormal" amount of time on TikTok compared to her classmates (she spends around 4 hours a day). She could use the normal distribution to determine how "extreme" this is by following these steps (Note: In real life, Sarah would almost certainly use a computer program to do this! We are showing the calculations here just to illustrate "how" these programs work):

1. Gather a set of data on the number of hours that students in the class spend on TikTok and calculate the mean and standard deviation of the data.
2. Convert the number of hours that the specific student spends on TikTok to a "z-score" by subtracting the mean and dividing by the standard deviation. This will give you the number of standard deviations the data item is from the mean. For the
3. Look up the z-score on a standard normal distribution table (or use a calculator or computer program) to determine the percentage of students in the class who spend fewer hours on TikTok than the specific student.

For example, let's say that Sarah surveys her classmates and ends up with the following data set of the number of hours that students in a class spend on TikTok: 0, 0, 0, 1, 1, 1, 2, 2, 3.

1. The mean of this data set is (0 + 0 + 0 + 1 + 1 + 1 + 2 + 2 + 3) / 9 = 1.1. The standard deviation is sqrt(((0 – 1.1)^2 + (0 – 1.1)^2 + (0 – 1.1)^2 + (1 – 1.1)^2 + (1 – 1.1)^2 + (1 – 1.1)^2 + (2 – 1.1)^2 + (2 – 1.1)^2 + (3 – 1.1)^2) / 9) = 1.

2. Sarah spends 4 hours on TikTok per week. The z-score for this data item is (4 – 1.1) /1 = 2.9
3. Using a standard normal distribution table (or a calculator or computer program), you can determine that less than 1% of students in the class spend fewer hours on TikTok than Sarah. Her use of TikTok is very extreme!

It's important to note that these statistical methods only work if we have accurate data, and these data are in fact normally distributed. In this case, we would need to make sure that we have correctly measured the number of hours that Sarah spends on TikTok and that our data set is representative of the overall population of students in the class. If these conditions are not met, our conclusions may be inaccurate.

Another reason the normal distribution is important is that it allows us to make predictions about a population based on sample data. For example, if we know that a particular measurement follows a normal distribution, we can use the sample mean and standard deviation to estimate the population mean and standard deviation. This can be useful in situations where we want to make predictions about future samples, such as in quality control or risk assessment.

Finally, the normal distribution is important because it is the basis for many statistical tests and procedures. Many statistical tests, such as t-tests and ANOVA, assume that the data follows a normal distribution. If the data does not follow a normal distribution, these tests may not be reliable and other statistical techniques may need to be used.

It is important to note that not all data is normally distributed (and this makes a big difference for our understanding of it!). For example, some other common distributions include:

- Skewed distribution: A skewed distribution is one where the data is not evenly distributed around the mean, but is instead heavily skewed towards one side or the other. For example, income data is often skewed to the right, with a few individuals having very high incomes compared to the majority who have lower incomes.
- Bimodal distribution: A bimodal distribution is one where the data has two peaks, rather than one. This can occur when there are two different groups of data that are not well mixed together. For example, a bimodal distribution might be seen in data on the heights of men and women, with one peak for men and one peak for women.
- Uniform distribution: A uniform distribution is one where all values are equally likely to occur. For example, if you roll a fair die, each number has an equal probability of being rolled, so the distribution of the rolls would be uniform.

### QUESTIONS

1. What is the normal distribution and why is it important in statistical analysis?
2. What is a skewed distribution and give an example of when it might occur.
3. What is a bimodal distribution and give an example of when it might occur.
4. What is a uniform distribution and give an example of when it might occur.

## HYPOTHESIS TESTING

Hypothesis testing is a statistical technique that is used to make inferences about a population based on sample data. It involves testing a specific hypothesis or prediction about the population, and determining the likelihood that the observed data would occur if the hypothesis were true.

There are several steps involved in hypothesis testing, including:

1. Formulating the hypothesis: This involves stating the prediction or assumption about the population that you want to test. For example, a marketing research company may be interested in determining whether a new product is more popular with men or women. In hypothesis testing, we often examine the **null hypothesis** (that there is no difference in popularity between men and women). We aim to **reject the null hypothesis,** which means that there IS evidence of a relationship.
2. Collecting and analyzing sample data: This involves collecting data from a sample of individuals or objects from the population, and using statistical techniques to analyze the data. For example, the

marketing research firm might survey 500 men and 500 women to get their ratings (between 1 and 5 of the product).

3. Evaluating the statistical significance of the results: This involves determining whether the observed results are likely to have occurred by chance or whether they are statistically significant. For example, you might use a **t-test** (don't worry about the details!) to calculate a **p-value**, which is the probability of obtaining results as extreme as the ones observed if the hypothesis were true. If the p-value is less than a certain threshold (e.g. 0.05), this indicates that the results are statistically significant and support the hypothesis.

**WARNING:** It is important to note that hypothesis testing is not a perfect process and there are several ways it can go wrong. One way is through sampling error, which occurs when the sample is not representative of the population. This can lead to incorrect conclusions being drawn about the population based on the sample data.

Another way hypothesis testing can go wrong is through researcher bias, where the researcher's expectations or beliefs influence the way the data is collected or analyzed. This can lead to a biased interpretation of the results.

It is also important to be aware that p-values can be misunderstood and misused. A p-value does not indicate the probability that the hypothesis is true, but rather the probability of obtaining results as extreme as the ones observed if the hypothesis were true. A low p-value does not necessarily mean that the hypothesis is true, but rather that the observed data is unlikely to have occurred by chance.

Additionally, p-values are affected by sample size, and a low p-value can be obtained simply by increasing the sample size, even if the hypothesis is not true. This is known as the "p-hacking" problem, where researchers cherry-pick data or manipulate the analysis in order to obtain a low p-value.

It is important to consider the limitations of hypothesis testing and to be aware of these potential pitfalls in order to make informed conclusions based on the data.

### QUESTIONS

1. What is the purpose of hypothesis testing in statistical reasoning?
2. What is the null hypothesis, and why is it important in hypothesis testing?
3. What are some potential issues that can arise in hypothesis testing, and how can we address them?
4. How do we interpret the results of a hypothesis test, and what do they tell us about the population?

## UNDERSTANDING POLL OR SURVEY RESULTS

Surveys and polls are commonly used to gather information about a population. The results of a survey or poll can provide valuable insights into the attitudes, opinions, and behaviors of the population being studied. However, it is important to understand the limitations of survey and poll results, as well as how to properly interpret them.

**Confidence Level.** A confidence level is a measure of how confident we can be in the results of a survey or poll. It is usually expressed as a percentage, and it represents the probability that the results of a survey or poll will accurately reflect the characteristics of the population being studied. For example, if a survey has a 95% confidence level, this means that there is a 95% probability that the results of the survey will accurately reflect the characteristics of the population. The higher the confidence level, the more confident we can be in the accuracy of the results. It important to note that this is an upper bound on how confident we should be. For example, we have an imperfect sampling technique (as we almost always do!), this will introduce additional opportunities for error not captured by the "number."

**Margin of Error.** The margin of error is a measure of the precision of a survey or poll. It represents the maximum amount by which the results of a survey or poll may differ from the true value for the population being studied. For example, if a survey has a margin of error of plus or minus 3%, this means that the results of the survey may differ from the true value by up to 3%. The smaller the margin of error, the more precise the results of the survey or poll are likely to be.

**Sample Size.** The sample size is the number of individuals or objects that are included in a survey or poll. It is important to have a large sample size because it increases the precision and accuracy of the results. However, it is also important to consider the cost and feasibility of collecting data from a large sample size.

**Sampling Technique.** Polls might use simple random sampling, cluster sampling, or stratified sampling. Many political polls, for example, use stratified sampling to ensure they get the right "mix" of men, women, Democrats, Republicans, etc. They do this because simple-random sampling leads to a "low response bias" (that is, certain groups of people are much more likely to respond to polls, which can skew our results).

### Example: Dr. Evil Vs Professor Doom

Imagine that there are two candidates running for president: Dr. Evil and Professor Doom. A poll is conducted to determine which candidate is more popular among voters.

To conduct the poll, a sample of 1000 voters is selected using stratified sampling. The population of voters is divided into strata based on age, gender, and geographical region, and a sample is selected from each stratum to ensure that the sample is representative of the entire population.

The pollsters ask each member of the sample which candidate they support, and record the responses. The results show that 50% of the sample supports Dr. Evil, while 46% supports Professor Doom. The pollsters calculate the margin of error to be plus or minus 3%, which means that the results of the poll may differ from the true values by up to 3%. This indicates that the poll has a relatively high level of precision.

The pollsters also calculate the confidence level to be 95%, which means that there is a 95% probability that the results of the poll accurately reflect the opinions of the entire population of voters.

However, it is important to recognize that the accuracy of the results can be affected by a variety of factors, including the sampling technique used, the way the questions are worded, and the way the data is collected and analyzed. If any of these factors are not done properly, it can lead to biased or inaccurate results.

For example, consider a scenario where the pollsters use stratified sampling to select the sample, but they define the strata in a way that is not representative of the population. If the strata are defined by age and geographical region, but not by gender, the sample may not be representative of the entire population of voters. This could lead to flawed conclusions about the popularity of the two candidates.

Even if the overall sample size is large, it can still be a problem if some subgroups or strata within the sample are not adequately represented. For example, if the pollsters use stratified sampling to select the sample, but some of the strata have very small sample sizes, the results of the poll may not accurately reflect the characteristics of those subgroups. This could lead to flawed conclusions about the popularity of the two candidates, even if the overall sample size is large. It is important to ensure that all subgroups or strata within the sample are adequately represented in order to produce accurate and reliable results.

In summary, it is important to carefully consider the sampling technique used when conducting a poll, and to ensure that the sample is representative of the entire population being studied. Poor choices or assumptions about the sampling technique can lead to biased or inaccurate results, which can in turn lead to flawed conclusions.

### Questions

1. How can the confidence level, margin of error, sample size, and sampling technique affect the precision and accuracy of a survey or poll?
2. In what ways might the way questions are worded or the way data is collected and analyzed impact the results of a survey or poll?
3. How can bias be introduced into a survey or poll, and how can it impact the results?

## Common Pitfalls and Errors in Statistical Reasoning

In order to effectively analyze data and draw conclusions, it is important to avoid common pitfalls and errors in statistical reasoning. Some of these pitfalls and errors include:

**Confounding variables:** A confounding variable is a factor that affects the relationship between the variables being studied. For example, if we are studying the relationship between diet and weight loss, exercise could be a confounding variable, as it also affects weight loss. In order to accurately interpret the results of a study, it is important to control for confounding variables or include them in the analysis.

**Bias:** Bias refers to a systematic error or tendency in a study that can distort the results. There are several types of bias that can occur in statistical analysis, including sampling bias, measurement bias, and selection bias. For example, sampling bias occurs when the sample is not representative of the population, leading to inaccurate conclusions. Measurement bias occurs when the measurement tools or methods are not reliable or valid, leading to inaccurate results. Selection bias occurs when the sample is not selected randomly, leading to biased conclusions.

**Overgeneralization (or "extrapolation" ):** It is important to be careful not to overgeneralize the results of a study beyond the population or sample studied. For example, if a study finds that a particular medication is effective in reducing blood pressure in a sample of older men, it would be incorrect to assume that the medication will have the same effect in women or younger men. It is important to carefully consider the limitations and generalizability of the results when interpreting a study.

**Lack of statistical significance:** In statistical analysis, it is important to determine whether the observed results are statistically significant, or whether they could have occurred by chance. A p-value is often used to evaluate statistical significance, and if the p-value is less than a certain threshold (e.g. 0.05), this indicates that the results are statistically significant and support the hypothesis being tested. However, if the p-value is greater than this threshold, it means that the results are not statistically significant and it is difficult to conclude anything about the hypothesis. This can be a common pitfall in statistical reasoning, as it is tempting to draw conclusions based on small or non-significant differences. It is important to be cautious about making conclusions based on non-significant results, as they may not be reliable.

One well-known example of flawed statistical reasoning is the replication crisis in psychology, which refers to the inability of many psychological studies to be replicated or replicated reliably. This issue was brought to light in the 2010s, when several high-profile replications of psychological studies failed to produce the same results as the original studies.

One reason for this lack of replication is the use of questionable research practices, such as p-hacking, in which researchers selectively report only those results that are statistically significant, leading to an overestimation of the true effect size. Another reason is the use of small sample sizes, which can lead to unstable and unreliable results.

Another example of flawed statistical reasoning is the use of biased samples, which can lead to incorrect conclusions about a population. For example, in a study on the effectiveness of a new medical treatment, if the sample is not representative of the target population (e.g. all of the participants are young and healthy), the results of the study may not be generalizable to the larger population.

Finally, overgeneralization, or making conclusions that are not supported by the data, is another common error in statistical reasoning. For example, a study may find that a particular intervention is effective in reducing anxiety in a sample of college students, but if the researchers conclude that the intervention will work for all individuals with anxiety, they are overgeneralizing their results. It is important to carefully consider the limitations of a study and the extent to which the results can be generalized to a larger population.

## EXERCISES: STATISTICAL REASONING

Answers to selected exercises can be found in the appendix.

1. You are a zookeeper who tracks how much food each animal in your zoo eats each day for a week. The amounts you have recorded for one type of animal are (2 lbs., 4 lbs., 6 lbs., 10 lbs.) Find the range and standard deviation of this data set.
2. A survey has been conducted to determine how many hours people spend on their phones daily. The results have been recorded as (0 hrs., 2 hrs., 5 hrs., 9 hrs.) Calculate the range and standard deviation of this data set to explain how big the variation is between people's phone usage habits.
3. You are studying student test scores from an exam taken by all students in your school district over a period in order to determine what score range is typical for students in this district. The scores you have collected are (70%, 82%, 83%, 96%). What is the range and standard deviation of these scores?
4. You work at an amusement park where visitors can purchase tickets with different levels of discounts depending on their age group or other criteria. To analyze customer spending habits you need to calculate

the range and standard deviation for ticket prices over a period of time - {$20, $25, $30, $35 } What do these calculations tell you about customer spending patterns?

5. A survey was conducted to measure people's happiness levels after taking part in different activities during their free time. The results were measured on a scale from 0-10. For one activity, the results were found to be{3 ,5 ,7 ,9 } . Find both the variance and standard deviation so that we can understand how varied people's reactions were towards this activity.
6. A poll is conducted to determine the preferred fast food chain among a sample of 1000 college students. The results show that 45% of the sample prefers Burger King, 30% prefers McDonald's, and 25% prefers Wendy's. The margin of error is plus or minus 2%. The confidence level is 95%.
    a. What does the percentage of the sample that prefers Burger King (45%) tell us about the preferences of college students?
    b. How does the margin of error (plus or minus 2%) impact the precision of the results of the poll?
    c. What does the confidence level (95%) indicate about the probability that the poll results accurately reflect the preferences of college students?
    d. If the sample size for the poll was 500 instead of 1000, how might this affect the precision and accuracy of the results?
    e. How might the results of the poll be affected if the sample was not representative of the entire population of college students (e.g. if it only included students from a specific major or school)?
    f. If the poll had a confidence level of 99% instead of 95%, how might this impact our understanding of the results?
    g. How might the results of the poll change if the sample consisted of people of all ages rather than just college students?
    h. If the poll had a margin of error of plus or minus 4% instead of plus or minus 2%, how might this impact the precision of the results?
7. A survey is conducted to determine the preferred type of car among a sample of 500 people who have previously expressed an interest in SUVs. The survey is conducted at a Jeep dealership, and the results show that 80% of the sample prefers SUV's, while 10% prefers sedans and 10% prefers sports cars. The margin of error is plus or minus 5%. The confidence level is 90%.
    a. What does the percentage of the sample that prefers SUV's (80%) tell us about the preferences of people who have previously expressed an interest in SUVs ?
    b. If the sample size for the survey was 1000 instead of 500, how might this affect the precision and accuracy of the results?
    c. If the survey had a confidence level of 95% instead of 90%, how might this impact our understanding of the results?
    d. How might the location where the survey was conducted (at a Jeep dealership) impact the results of the survey? (Basically: How much should we trust these numbers?)
    e. How could this survey be changed to reduce bias and produce a more representative sample?
8. A recent (fictional!) study conducted by researchers at the University of California has found that a new drug may be effective in preventing the development of Alzheimer's disease in mice. The study involved a sample size of 100 mice, and the results showed that the drug was effective in preventing the development of Alzheimer's disease in 65% of the mice. The p-value for the study was 0.05.
    a. What does the p-value of 0.06 indicate about the statistical significance of the results of the study?
    b. If the study had a sample size of 500 mice instead of 100, how might this affect the precision and accuracy of the results?
    c. How might the results of the study be affected if the sample included mice of different ages or genetic backgrounds?
    d. If the study had a p-value of 0.01 instead of 0.05, how might this impact our understanding of the results?
    e. How might the results of the study change if it was conducted on humans rather than mice?
    f. What additional information would be useful to know to understand the potential implications of the study's findings fully?
9. You are a member of a student government organization at your university and have been tasked with designing a poll to predict the outcome of the upcoming election for student body president.
    a. How will you choose the sample for your poll? Will you use a random sampling method or another method, such as stratified sampling or cluster sampling? Explain your rationale.
    b. What will be the sample size for your poll? How did you determine this sample size?

c. How will you collect data for your poll? Will you use online surveys, phone interviews, in-person interviews, or another method? Explain your rationale.
d. How will you ensure that your sample is representative of the entire population of students eligible to vote in the election?
e. What questions will you ask in your poll to gather information about the preferences of students for the different candidates?
f. How will you calculate the margin of error for your poll?
g. How will you communicate the results of your poll to the student body? Will you report the confidence level and margin of error, and if so, why is this important?

10. Your friend, Alex, is a firm believer in the idea that consuming large amounts of raw garlic can cure the common cold. He recently came across a study that he claims supports his belief. The study involved a sample of 150 people with the common cold who were divided into two groups: a control group and an experimental group. It The control group received a placebo, while the experimental group received a garlic supplement. The results showed that 60 people in the people in the control group (no garlic) reported that they had a cold in the next 3 months, and only 25 people in the garlic group said that they had a cold. Alex argues that the study provides strong evidence that garlic can cure the common cold and that it should be more widely promoted as a treatment. However, you are skeptical of Alex's argument and are not convinced that the study provides sufficient evidence to support his belief.
    a. What flaws do you see in Alex's argument?
    b. What other factors might have contributed to the differences in recovery rates between the experimental and control groups?
    c. How might the sample size of 150 people impact the precision and accuracy of the results of the study?
    d. How might the results of the study be affected if it included a representative sample of people of different ages or with different underlying health conditions?
    e. What additional information would be useful to know in order to fully evaluate the validity of the study's findings?
    f. How might the results of the study change if it was conducted over a longer period of time or if the experimental group received a higher dosage of the garlic supplement?
    g. How does the use of a placebo in the control group affect the reliability of the study's results?
    h. What other studies or evidence would you want to see to be convinced that consuming large amounts of raw garlic can cure the common cold?

# CHAPTER 11: A LITTLE HISTORY OF FORMAL LOGIC

In this chapter, you will learn about the history and foundations of formal logic. You will start by exploring Aristotle's Categorical Logic, learning about standard form categorical statements and how to analyze and evaluate them. You will then move on to categorical syllogisms, examining concepts such as mood, figure, and validity. The chapter will also delve into further developments in categorical logic and provide exercises to help you practice your skills. Next, you will dive into propositional and predicate logic, learning about valid argument forms and proofs in propositional logic, as well as the role of propositional logic in modern computers. You will also learn about predicate logic, a more advanced type of formal logic used in contemporary research.

Throughout the chapter, you will also be introduced to several minds that have shaped the field of formal logic, including Kurt Gödel, Alan Turing, and others. These profiles will provide you with insight into the contributions and impact of these influential figures, as well as the ongoing research and developments in the field. Overall, this chapter will equip you with a strong foundation in formal logic, helping you to think more critically and logically, and providing you with skills that can be applied in a variety of settings.

Let's begin with a (true) story about deceptively simple program built on formal logic—Eliza.

## MEET ELIZA

ELIZA was an early computer program that was designed to simulate conversation with a human user. The program was created in the 1960s by Joseph Weizenbaum at the Massachusetts Institute of Technology (MIT) Artificial Intelligence Laboratory. The goal of ELIZA was to demonstrate the superficial nature of communication between humans and machines and to show that it was possible to create the illusion of understanding on the part of the machine.

To achieve this, ELIZA used a simple pattern matching and substitution methodology. The program would analyze the user's input and look for specific keywords or phrases. Based on these keywords, ELIZA would provide a pre-written response that was designed to mimic the kind of responses a human might give in a similar situation. For example, if the user said something like "I feel sad," ELIZA might respond with a question like "Why do you feel sad?"

One of the most famous scripts for ELIZA was called DOCTOR. This script was designed to simulate the kind of conversation that might occur between a patient and a psychotherapist. It used non-directional questions to respond to the user's input, just like a real therapist might do.

Simple formal logic plays a crucial role in the way that the program functions. At its most basic level, Eliza relies on a series of logical rules and conditional statements to determine how to respond to user inputs. For example, the program might have a rule that says: "if the user inputs a question about their feelings, then respond with a non-directive question about the user's feelings." This rule uses logical operators (such as the "if" statement) to determine when to trigger a particular response.

Additionally, Eliza uses logical reasoning to analyze user inputs and determine which script to follow. For example, if the user inputs a statement about their feelings, the program might use logic to infer that the user is seeking emotional support, and therefore select the appropriate script for responding to such statements. In this way, logic plays a central role in the way that Eliza processes and responds to user inputs, allowing it to simulate a conversation and give the illusion of understanding.

Despite its simple logic and lack of true understanding, many people were fooled by ELIZA and believed that it was an intelligent program with real understanding. In fact, some even credited ELIZA with helping them overcome psychological problems or aiding in their treatment.

### QUESTIONS

1. What makes human thought different from Eliza's pattern matching and substitution methodology?
2. Do you think that Eliza's approach to conversation is similar to how humans process language and communication? Why or why not?
3. How do Eliza's scripts and rules for responding to user inputs compare to the way that humans use context and past experiences to interpret and respond to communication?

4. Can you think of any examples of situations where Eliza's lack of understanding might cause problems for human users?
5. How do Eliza's limitations as a computer program reflect the ways in which human thought and communication are uniquely complex and nuanced?
6. Do you think that it is possible for a computer program to fully replicate the complexity and depth of human thought and communication? Why or why not? (Newer AI systems like GPT are *much* more complex)?

## Introduction to Formal Logic

Formal (deductive) logic is a set of formal principles and techniques used to analyze and evaluate arguments. It is a system of reasoning that allows us to determine whether an argument is valid or invalid, and to identify the logical consequences of certain statements. It lies at the intersection of mathematics, philosophy, and computer science.

The history of formal logic dates back to ancient Greece, with the works of philosophers such as Aristotle and the Stoics. Over the centuries, the study of formal logic has evolved and developed, with contributions from many philosophers and mathematicians. Today, formal logic is an important tool used in a wide range of fields, including computer science, linguistics, and philosophy.

In this chapter, we will explore the history of formal logic, from its origins in Aristotle's syllogistic logic to the modern formal systems of propositional and predicate logic. We will also examine the development and applications of modal logic, and discuss the role of non-Western forms of logic in the history of the field.

Before starting out, it will be helpful to think about the difference between **formal languages** and **natural languages.** Formal languages, like such as those we will be talking about in this chapter, are artificial languages that are designed to be precise and rigorous, and to follow strict rules of syntax and semantics. Formal languages are used to represent logical statements and arguments, and to manipulate them in order to derive new conclusions.

Natural languages, on the other hand, are the languages that we use in everyday life, such as English, Spanish, French, and so on. Natural languages are more flexible and less precise than formal languages, and do not follow strict rules of syntax and semantics.

There are several key differences between formal and natural languages:

*Syntax:* Formal languages have a strict syntax, or set of rules for constructing sentences and expressing meaning. Natural languages, on the other hand, have a more flexible syntax, and there is often more than one way to express the same idea.

*Precision:* Formal languages are more precise than natural languages, because they follow strict rules of syntax and semantics. This allows them to represent complex ideas and arguments in a clear and unambiguous way. Natural languages, on the other hand, are less precise, and can be prone to ambiguity and misunderstanding.

*Expressiveness:* Natural languages are more expressive than formal languages, because they have a larger vocabulary and a greater range of syntactic structures. This allows them to convey a wider range of meaning and emotion. Formal languages, on the other hand, are more limited in their expressiveness, because they follow strict rules of syntax and semantics.

*Context:* Natural languages are heavily influenced by context, and the meaning of a given sentence can depend on the context in which it is used. Formal languages, on the other hand, are not influenced by context, and the meaning of a given statement is determined solely by its syntax and semantics.

Overall, formal and natural languages serve different purposes and have different characteristics. Formal languages are useful for representing and manipulating logical statements and arguments, while natural languages are better suited for everyday communication and the expression of more complex ideas and emotions.

## Aristotle's Categorical Logic

Categorical logic is a branch of formal logic that deals with the relationships between categories and the propositions that apply to them. Categorical logic was developed by the ancient Greek philosopher Aristotle, who is considered one of the founders of formal logic.

Aristotle was a philosopher and scientist who lived in the 4th century BCE. He was a student of Plato and later became the tutor of Alexander the Great. Aristotle is known for his contributions to a wide range of fields, including logic, metaphysics, ethics, politics, and biology.

In his works on logic, Aristotle developed a system of categorical logic that was based on the idea that propositions could be classified into different categories, such as "all," "some," "none," and "not all." This system was a significant advance in the field of formal logic, and laid the foundations for much of the work that was done in this area in the centuries that followed.

In addition to his contributions to logic, Aristotle also made significant contributions to other areas of philosophy. He is known for his theory of causation, in which he argued that there are four types of causes: material, formal, efficient, and final. He also developed a theory of form and matter, in which he argued that everything in the world is made up of matter and form, and that the form of a thing determines its essential nature.

## Standard Form Categorical Statements

In categorical logic, a categorical statement is a statement that asserts or denies a relationship between two categories. There are four standard forms of categorical statements:

- All S are P - A (universal affirmative) - This statement asserts that all members of a given category belong to another category. For example: "All dogs are mammals."
- No S are P - E (universal negative) - This statement asserts that no members of a given category belong to another category. For example: "No cats are dogs."
- Some S are P - I (particular affirmative) - This statement asserts that some members of a given category belong to another category. For example: "Some birds can fly."
- Some S are not P - O (particular negative) - This statement asserts that some members of a given category do not belong to another category. For example: "Some fish are not mammals."

According to Aristotle, EVERY claim can be expressed as a combination of these four types of statements. While this has turned out to be an exaggeration (there are some things we can't "say" in categorical logic), you really can capture quite a bit using just these simple forms.

## Exercises: Categorical Statements

For each of the below statements, identify the two "categories" (usually called S and P). Then say, what "letter" each statement is.

1. Some glittering rainbow unicorns are kangaroos.
    a. S = "glittering rainbow unicorns"
    b. P = "kangaroos"
    c. Form: Some S are P (I)
2. No elephants are fluffernutters.
    a. S = "elephants"
    b. P = "fluffernutters"
    c. Form: No S are P (E)
3. All glittering rainbow unicorns are lazy green sloths.
    a. S = "glittering rainbow unicorns"
    b. P = "lazy green sloths"
    c. Form: All S are P (A)
4. All hippopotamuses are towering trees.
5. All sneaky snakes are koalas.
6. No cheeky pink monkeys are gophers.
7. Some chickens are not sparkly purple dragons.
8. All flying saucers are silly yellow ducks.

9. Some juicy apples are narwhals.
10. Some warthogs are giraffes.
11. Some giggly pink unicorns are not slippery slugs.
12. Some scampering squirrels are not roaring lions.
13. Some scampering squirrels are slippery slugs.
14. All mischievous red goblins are fluffy unicorns.
15. All hippopotamuses are sparkly purple dragons.
16. All twinkling lights are otters.
17. All floating balloons are curious cats.
18. All sparkly purple dragons are crawling spiders.
19. No hippopotamuses are koalas.
20. All jiggly orange jellybeans are warthogs.

## CATEGORICAL SYLLOGISMS

A categorical syllogism is a form of logical argument that consists of three categorical statements, with two premises and a conclusion. The conclusion of a categorical syllogism follows logically from the premises, and is said to be "valid" if it is logically sound. Categorical syllogisms aim to establish that there is some sort of relationship between category S (the "subject" of the conclusion) and category P (the "predicate" of the conclusion). The premises link S and a P by use of a "middle" category M.

Categorical syllogisms have a strict structure, with the three statements arranged in a particular order: major premise, minor premise, and conclusion. The major premise is a premise states that there is some relationship between M and P, and the minor premise states that there is a relationship between M and S. The conclusion is that there is a particular relationship between S and P.

Here are some examples of categorical syllogisms:

Example 1 (VALID):

- Major premise: All humans (M) are mortal (P).
- Minor premise: All people identical to Socrates (S) are humans (M).
- Conclusion: All people identical to Socrates (S) are mortal (P).

Example 2 (VALID)

- Major premise: Some birds (M) are not flying animals (P).
- Minor premise: All birds (M) are animals (S).
- Conclusion: Some animals (S) are not flying animals (P).

Example 3 (INVALID):

- Major premise: All rabbits (M) are creatures with excellent hearing (P).
- Minor premise: No cats (S) are rabbits (M).
- Conclusion: Some cats (S) are not creatures with excellent hearing (P).

In order to determine the validity of a categorical syllogism, it is necessary to analyze the structure of the argument and the relationships between the different categories. Aristotle proposed a number of methods for determining valid vs invalid syllogisms, and this was a major area of research for the next 2,000 years.

In example 3, for instance, the "form" of the syllogism doesn't work, which means that it is POSSIBLE for the conclusion to be false even if the conclusion is true. We can *prove* that this form of argument is invalid by producing a **counterexample,** which is (1) an argument of the exact same form with (2) premises that are all true and (3) a conclusion that is false. The form of the above arguments is:

- Major: ALL M are P
- Minor: No S are M
- Conclusion: Some S are not P

We can now produce a counterexample as follows:

- Major premise: All rabbits are mammals. (True)
- Minor premise: No cats are rabbits. (True)
- Conclusion: Some cats are not mammals. (Obviously false!)

This counterexample doesn't merely show that this *particular* syllogism is valid, but that EVERY syllogism with the form: All M are P / No S are M // Some are not P is invalid.

## MOOD, FIGURE, AND VALIDITY

In categorical syllogisms, the mood refers to the specific combination of statement types (A, E, I, O) used in the premises and conclusion. For example, a syllogism with the mood AAA is one in which both premises and the conclusion are universal affirmatives, such as:

- Major premise: All humans (M) are mortal (P). – This is an A statement
- Minor premise: All Greeks (S) are humans (M). – This is an A statement
- Conclusion: All Greeks (S) are mortal (P). – This is also an A statement!

On the other hand, a syllogism with the mood AEO is one in which the major premise is a universal affirmative, the minor premise is a universal negative, and the conclusion is a particular negative, such as:

- Major premise: All humans (M) are mortal (P). – A statement
- Minor premise: No cats (S) are humans (M). – E statement
- Conclusion: Some cats (S) are not mortal (P). – O statement

There are 64 possible moods in total, since there are 4 possible statement types for each of the 3 statements in the syllogism.

The figure of a syllogism refers to the position of the predicate in the major premise and the subject in the minor premise. There are four possible figures, as described below. The figure of a syllogism is important because it determines which moods are valid. For example, certain moods are only valid in certain figures.

| | Figure 1 | Figure 2 | Figure 3 | Figure 4 |
|---|---|---|---|---|
| Major | M P | P M | M P | P M |
| Minor | S M | S M | M S | M S |
| Conclusion | S P | S P | S P | S P |

There are many possible ways to fill in the blank spaces in these figures, depending on the mood of the syllogism. For example:

A (valid) syllogism of the form AAA-1 has a mood of AAA, arranged in figure 1. For example:

- Major premise: All ninjas (M) are stealthy (P).
- Minor premise: All warriors (S) are ninjas (M).
- Conclusion: All warriors (S) are stealthy (P).

A (invalid) syllogism of the form AAA-2 also has a mood of AAA arranged in figure 2.

- Major premise: All ninjas (P) are people skilled in stealth and deception (M).
- Minor premise: All people who can disappear and reappear at will (S) are people skilled in stealth and deception (M).
- Conclusion: All people who can disappear and reappear at will (S) are ninjas (P).

A (valid) syllogism of the form EAE-2 has a mood of EAE, arranged in figure 2.

- Major premise: No honest people (P) are pirates (M).
- Minor premise: All treasure hunters (S) are pirates (M).
- Conclusion: No treasure hunters (S) are honest (P).

In order to determine the validity of a categorical syllogism, it is necessary to analyze the structure of the argument and the relationships between the different categories. Aristotle proposed a number of methods for determining valid vs invalid syllogisms, and this was a major area of research for the next 2,000 years. In modern times, the most common method for determining the validity of a categorical syllogism is to use a set of rules known as the **"rules of syllogism."** These rules specify which moods are valid in each figure, and can be used to determine whether a given syllogism is valid or not.

- Figure 1 Valid Forms: AAA-1, EAE-1, AII-1, EIO-1
- Figure 2 Valid Forms: EAE-2, AEE-2, EIO-2, AOO-2
- Figure 3 Valid Forms: IAI-3, AII-3, OAO-3, EIO-3
- Figure 4 Valid Forms: AEE-4, IAI-4, EIO-4

## Further Developments of Categorical Logic

After the development of syllogistic logic by Aristotle, several philosophers contributed to the study and refinement of this form of logic. Some of the most notable syllogistic logicians include:

Peter Abelard (1079-1142): Abelard was a French philosopher and theologian who is known for his contributions to logic and the philosophy of language. He developed the concept of "supposition theory," which deals with the meaning and reference of terms in syllogisms. For example, the term "Socrates" refers to an individual human, "humans" refers to a *category* of things, and "is mortal" refers to a shared property of humans. Determining how language "refers" is a tricky question (and one that continues to perplex logicians, even as we try to "teach" computers about it!).

William of Ockham (1287-1347): Ockham was an English logician and Franciscan friar who is known for his contributions to the study of logic and the philosophy of language. He developed the principle of "parsimony," also known as "Ockham's Razor," which states that, when faced with multiple explanations for a phenomenon, the simplest explanation is most likely to be true. This principle has been influential in a number of fields, including logic, philosophy, and science. In logic, Ockham's principle has been used as a guide for constructing arguments, with the idea that simpler arguments are more likely to be sound and reliable. In philosophy, Ockham's principle has been used to argue for nominalism, the idea that general terms and concepts do not correspond to any external reality, but are simply convenient ways of speaking about the world. In science, Ockham's principle has been used as a heuristic for choosing between competing explanations for a phenomenon, with the idea that simpler explanations are more likely to be correct.

Charles Dodgson ("Lewis Carrol", 1832-1898): Charles Dodgson was an English mathematician, logician, and children's author (he wrote *Alice in Wonderland).* He helped bridge the gap between categorical logic and modern predicate logic, explored the paradoxes of logic, and wrote a number of books and articles aimed at teaching people the basics of logic. He was among the last serious scholars to do research in categorical logic.

While categorical logic was once a dominant form of logical reasoning, it has been largely superseded by predicate logic, a more powerful and flexible system of logical reasoning that is better suited to dealing with the complexity and abstraction of modern mathematics, philosophy, and computer science. Among other things, predicate logic allows logicians to talk about *individual things* (and not just "categories") and capture complex forms of arguments beyond the "syllogism."

Despite the shift towards predicate logic, categorical logic is still used in a number of contexts, particularly in the fields of philosophy and linguistics. In philosophy, categorical logic is often used as a pedagogical tool to help students formally analyze and evaluate arguments. In linguistics, variants of categorical logic are occasionally used to analyze human's use of "categories" in natural language, and to understand the ways in which words and concepts are related to one another.

## Questions

1. How do formal languages (such as categorical logic) differ from natural languages (like English)? What are the advantages of using formal languages? The disadvantages?
2. What are the four standard forms of categorical statements, and how do they differ from each other?
3. What is a categorical syllogism? Can you give an example?
4. How do mood and figure affect the validity of a categorical syllogism?
5. Can you give an example of Ockham's razor? Why is this principle so important to science (and to everyday life!)?
6. Who are some important contributors to categorical logic? What aspects of their lives/research do you think are interesting?

## EXERCISES: CATEGORICAL SYLLOGISMS

*Note: This exercise is among the more challenging in the book! It's intended to give you a sense of how formal logic was taught and practiced for thousands of years (from Aristotle until the 19th century). Just do your best* 😊.

**Review.** To determine the mood and figure of a categorical syllogism, you can follow these steps:

| | Figure 1 | Figure 2 | Figure 3 | Figure 4 |
|---|---|---|---|---|
| Major | M P | P M | M P | P M |
| Minor | S M | S M | M S | M S |
| Conclusion | S P | S P | S P | S P |

1. Once you figure out these, you can look at this following to determine whether the syllogism is valid:
    - Figure 1 Valid Forms: AAA-1, EAE-1, AII-1, EIO-1
    - Figure 2 Valid Forms: EAE-2, AEE-2, EIO-2, AOO-2
    - Figure 3 Valid Forms: IAI-3, AII-3, OAO-3, EIO-3
    - Figure 4 Valid Forms: AEE-4, IAI-4, EIO-4

Here are the exercises. Selected answers are in the appendix. Note that S = "subject term of the conclusion", P = "Predicate term of the conclusion", and M = "Middle term".

1. Since some delicious meals (P) are colorful parrots (M) and some colorful parrots (M) are sparkly rainbows (S), it follows that some sparkly rainbows (S) are not delicious meals (P).
2. Since some squirming worms (M) are refreshing drinks (P) and some squirming worms (M) are glowing fireflies (S), it follows that some glowing fireflies (S) are refreshing drinks (P).
3. Since some scampering squirrels (M) are floating balloons (P) and no dancing bears (S) are scampering squirrels (M), it follows that some dancing bears (S) are not floating balloons (P).
4. Since no cheering crowds (M) are flying saucers (P) and some cheering crowds (M) are fluffy clouds (S), it follows that some fluffy clouds (S) are not flying saucers (P).
5. Since some floating balloons (M) are not cheering crowds (P) and some floating balloons (M) are magical potions (S), it follows that some magical potions (S) are cheering crowds (P).
6. Since some sneaky snakes are fluffy clouds and all giant robots are fluffy clouds, it follows that some giant robots are sneaky snakes.
7. Since no towering trees are sugarplum fairies and all squirming worms are sugarplum fairies, it follows that all squirming worms are towering trees.
8. Since all mystical dragons are towering trees and some towering trees are glowing fireflies, it follows that all glowing fireflies are mystical dragons.
9. Since no refreshing drinks are roaring lions and some bouncing balls are refreshing drinks, it follows that all bouncing balls are roaring lions.
10. Since some floating balloons are sizzling sausages and all sizzling sausages are roaring lions, it follows that some roaring lions are not floating balloons.
11. Since some cuddly teddy bears are not monkeys, and all cuddly teddy bears are quirky green aliens, it follows that no quirky green aliens are monkeys.
12. Since all juicy apples are crawling spiders, and some chickens are juicy apples, it follows that all chickens are crawling spiders.
13. Since no wiggly blue worms are cheeky pink monkeys, and some cheeky pink monkeys are not chickens, it follows that some chickens are not wiggly blue worms.
14. Since no singing dolphins are roaring lions, and some singing dolphins are not elephants, it follows that no elephants are roaring lions.

15. Since all towering trees are wacky yellow giraffes, and all chirping birds are towering trees, it follows that all chirping birds are wacky yellow giraffes.
16. Since no colorful parrots are llamas, and all llamas are jiggly orange jellybeans, it follows that all jiggly orange jellybeans are colorful parrots.
17. Since no sneaky snakes are curious cats, and some sneaky snakes are chickens, it follows that no chickens are curious cats.
18. Since no narwhals are crunchy carrots, and some otters are narwhals, it follows that some otters are not crunchy carrots.
19. Since all chirping birds are tempting desserts, and some mystical dragons are not tempting desserts, it follows that all mystical dragons are chirping birds.
20. Since all elephants are munchy brown monster cookies, and all cheering crowds are munchy brown monster cookies, it follows that some cheering crowds are elephants.

## MINDS THAT MATTERED: KURT GÖDEL

Kurt Gödel was an Austrian mathematician and logician who is best known for his incompleteness theorems, which demonstrate the inherent limitations of any system of axioms that is powerful enough to represent arithmetic. Gödel was born in 1906 in Brünn, Austria (now Brno, Czech Republic) and began studying mathematics and logic at the University of Vienna in 1924. He extended the work of Frege and Russell, but it took it in directions that surprised almost everyone.

Gödel's incompleteness theorems are two theorems that were published in 1931 and showed that, for any formal system (such as predicate logic) that is powerful enough to represent the natural numbers, there will always be statements that are true but cannot be proved within the system. The first incompleteness theorem states that any consistent formal system that is powerful enough to represent the natural numbers will contain true statements that cannot be proved within the system. The second incompleteness theorem states that any such system will also be unable to prove its own consistency.

This has significant implications for the foundations of mathematics and logic. It shows that there are limits to what can be known and proved within any given system, and that there will always be some truths that lie beyond our reach. This has led to a number of different responses, including the development of alternative foundations for mathematics and the exploration of new kinds of logical systems.

One of the key implications of Gödel's incompleteness theorem is that it calls into question the possibility of a "final theory" or "theory of everything" in mathematics or science. If any logical system is incomplete, then it follows that no single theory can ever hope to capture all of the truths about the world. This has led some philosophers to argue that there must be a fundamental limit to our understanding of the world, and that there will always be some mysteries that remain beyond our grasp.

In computer science, Gödel's incompleteness theorem has also had a significant impact. It has been used to prove that certain problems are inherently difficult to solve, and that there are limits to the kinds of algorithms and computations that can be performed. This has led to the development of new approaches to computation and problem solving, and has shaped the way that we think about the capabilities of computers and the limits of what they can do.

Some philosophers, scientists, and mathematicians have also argued Gödel's incompleteness theorem has implications for the nature of human thought, minds, and "souls." The theorem states that any formal system that is powerful enough to represent arithmetic will always contain statements that cannot be proved or disproved within that system. This means that there will always be some truths that cannot be fully captured within a formal system, no matter how powerful that system is. This has led some to argue that human thought is fundamentally different from a formal system, and that there are aspects of reality that cannot be fully captured by any system of logic or mathematics. Others have argued that Gödel's theorem simply highlights the limitations of formal systems, and that there may be other ways of representing and understanding reality that are not bound by the same limitations.

### QUESTIONS

1. What are Kurt Gödel's incompleteness theorems and how do they demonstrate the limitations of any system of axioms that is powerful enough to represent arithmetic?

2. What are the implications of Gödel's incompleteness theorems for the foundations of mathematics and logic?
3. How has Gödel's incompleteness theorem impacted computer science, and how has it shaped our understanding of the capabilities and limits of computers?
4. Do you think Gödel's incompleteness theorem has any implications for the nature of human thought, minds, or "souls"? If so, what might those implications be?
5. Do you think there could be alternative ways of representing and understanding reality that are not bound by the limitations of formal systems, as suggested by some philosophers and scientists? Why or why not?

## Propositional and Predicate Logic

Propositional logic is a branch of formal logic that deals with the logical relationships between propositions, or statements that can be either true or false. A proposition is a declarative sentence that makes a claim about the world, and can be either true or false based on the facts of the matter. Examples of propositions include "The sky is blue" (true), "2+2=9" (false), and "God exists" (unknown). Propositional logic has a long history, with roots dating back to the ancient Stoic philosophers in Greece.

The Stoics, who lived in the 3rd and 4th centuries BCE, were interested in logic as a tool for understanding the world and for arriving at truth. They developed a system of propositional logic that was based on the idea of the "syllogism," which is a form of argument that consists of two premises and a conclusion. The Stoics believed that all knowledge could be reduced to a series of syllogisms, and that the truth of any statement could be determined by whether it followed logically from a series of syllogisms.

Over the centuries, propositional logic has undergone many changes and refinements. In the 19th and 20th centuries, for example, logicians such as George Boole and Augustus De Morgan developed systems of symbolic logic that used algebraic notation to represent logical statements and arguments. These systems were a significant advance over earlier systems of propositional logic, and laid the foundations for much of the work that was done in this area in the 20th century.

- In propositional logic, the truth or falsity of a proposition is represented by a truth value, which can be either "true" or "false." Propositions can be combined using logical operators, such as AND, OR, NOT, IF-THEN, and EQUL to form compound propositions. These operators work as follows:
- AND is a logical operator that connects two propositions and results in a true statement only if both of the connected propositions are true. For example, the proposition "Dogs can fly AND cats can swim" is only true if both "Dogs can fly" and "Cats can swim" are true.
- OR is a logical operator that connects two propositions and results in a true statement if at least one of the connected propositions is true. For example, the proposition "Dogs can fly OR cats can swim" is true if either "Dogs can fly" or "Cats can swim" is true, or if both are true.
- IF-THEN is a logical operator that connects two propositions in the form "If P, then Q." It states that if the first proposition (P) is true, then the second proposition (Q) must also be true. For example, the proposition "If it is raining, then the sky is cloudy" will be true as long as it is NOT raining on clear day.
- NOT is a logical operator that negates a proposition, making it the opposite of what it originally stated. For example, the proposition "Dogs cannot fly" is the negation of the proposition "Dogs can fly."
- EQUALS is a logical operator that states that two propositions are equivalent, or have the same truth value. For example, the proposition "Dogs can fly" (false) EQUALS the proposition "Cats can talk" (false). These propositions don't "mean" the same thing, but they have the same truth value.

Propositional logic is different from categorical logic, which is a branch of formal logic that deals with categories and the relationships between them. Categorical logic uses four standard forms of categorical statements, known as A, E, I, and O, to represent relationships between categories. Propositional logic, on the other hand, uses propositions and logical operators to represent relationships between ideas.

### Valid Argument Forms and Proofs in Propositional Logic

Just as was the case with categorical logic, logicians have done a lot of research over the past few thousand years to determine the validity and invalidity of various arguments forms. Here are some examples of simple arguments forms that we know are valid:

Modus Ponens:

- Premise: If P then Q (e.g. "If it is raining then the streets are wet.")
- Premise: P (e.g., "It is raining.")
- Conclusion: Q (e.g., "The streets are wet.")

Modus Tollens:

- Premise: If P then Q (e.g. "If it is raining then the streets are wet.")
- Premise: NOT Q (e.g., "The streets are not wet.")
- Conclusion: NOT P (e.g., "It is not raining.")

Hypothetical Syllogism:

- Premise: If P then Q (e.g. "If it is raining then the streets are wet.")
- Premise: If Q then R (e.g., "If the streets are wet then the sidewalks are slippery.")
- Conclusion: If P then R (e.g., "If it is raining then the sidewalks are slippery.")

Disjunctive Syllogism:

- Premise: P OR Q (e.g. "It is either raining or it is sunny.")
- Premise: NOT P (e.g., "It is not raining.")
- Conclusion: Q (e.g., "It is sunny.")

Constructive Dilemma:

- Premise: P OR Q (e.g. "Either the streets are wet or the sidewalks are slippery.")
- Premise: If P then R (e.g., "If the streets are wet then the roads are dangerous.")
- Premise: If Q then S (e.g., "If the sidewalks are slippery then the roads are dangerous.")
- Conclusion: R OR S (e.g., "The roads are dangerous.")

These rules (along with others) capture the validity of many simple inferences we make everyday. They can also be chained together in "proofs" to establish the validity of longer, more complex argument forms.

### Propositional Logic and Modern Computers

Propositional logic is a fundamental part of modern computer science and programming. It allows us to represent logical statements and arguments in a precise and unambiguous way, and to manipulate them in order to derive new conclusions.

One way that propositional logic is used in computer programming is through the use of Boolean values. In programming languages such as Python, a Boolean value is a data type that can have only two values: True or False. These values are often used to represent the truth or falsity of a proposition, and can be manipulated using logical operators such as AND, OR, and NOT.

For example, consider the following simple Python program:

```
# Ask the user for their age
age = int(input("Enter your age: "))

# Ask the user if they are a student
is_student = input("Are you a student? (yes/no) ") == "yes"

# Use and, or, and not to process the user's responses
if age < 18 or (age >= 18 and not is_student):
  print("Sorry, you are not eligible for the discounted ticket price.")
else:
  print("Congratulations, you are eligible for the discounted ticket price!")
```

This program asks the user for their age and whether they are a student. It then uses and, or, and not to determine whether the user is eligible for a discounted ticket price. If the user is under 18 or is 18 or older but not a student, they are not eligible for the discount. Otherwise, they are eligible.

In this program, we use the AND (and) operator to check whether the user is 18 or older and not a student. We use the OR (or) operator to check whether the user is under 18 or is 18 or older but not a student. And we use the NOT (not) operator to negate the value of the is_student variable.

We also use the == (EQUALS) operator to compare the user's response to the string "yes". This allows us to determine whether the user is a student or not. If the user's response is "yes", the == operator returns True. Otherwise, it returns False.

At a more fundamental level, propositional logic plays a crucial role in the processor design of computers and other digital devices. In these systems, logical statements are represented using electronic circuits called "logic gates," which are used to implement logical operations such as AND, OR, and NOT.

Logic gates are the building blocks of digital circuits, and they are used to process and transmit information within a computer. Each logic gate has one or more input signals, and a single output signal. The output signal is determined by the logical operation being performed on the input signals.

For example, an AND gate will output a 1 (or "high" signal) only if both of its input signals are 1. An OR gate, on the other hand, will output a 1 if either of its input signals is 1. A NOT gate inverts the signal at its input, outputting a 0 if the input is 1, and a 1 if the input is 0.

By combining these basic logic gates in various ways, it is possible to create more complex circuits that can perform a wide range of logical operations. For example, a circuit that implements an IF-THEN statement might use an AND gate to combine the input conditions, and a NOT gate to negate the output if the condition is not met.

In this way, propositional logic serves as the foundation for the digital circuits that are used to control and process information in modern computers and other electronic devices. Without propositional logic, it would not be possible to build the complex circuits that are necessary to perform the wide range of tasks that computers are capable of.

## Predicate Logic

Predicate logic, also known as first-order logic, is a formal system of logic that extends propositional logic by allowing the use of variables and quantifiers. Predicate logic is a powerful tool for representing and reasoning about the relationships between objects and concepts in the world. It the basis for nearly all research done on logic for modern mathematicians, philosophers, and computer scientists.

The early development of predicate logic can be traced back to the work of Gottlob Frege, a German mathematician and philosopher who lived in the late 19th and early 20th centuries. Frege is credited with the invention of modern predicate logic, and he made significant contributions to the field of mathematical logic.

One of the major contributions made by Frege was his development of the concept of a "predicate," which is a word or phrase that describes a property of an object or concept. For example, the predicate "is red" describes the property of being red. Frege also developed the concept of a "function," which is a rule that assigns a unique value to each argument.

Frege's work on predicate logic was influential and set the stage for further developments in the field. In the early 20th century, Bertrand Russell, an English philosopher and mathematician, built upon Frege's work and developed a theory of types, which is a system for organizing and classifying predicates and functions. Russell's theory of types was an important step forward in the development of predicate logic, and it has had a lasting impact on the field.

The major symbols used in predicate logic include variables, constants, quantifiers, and predicates. Variables are symbols that stand for objects or concepts in the world, and can take on different values in different contexts. Constants are symbols that stand for specific objects or concepts, and do not change in different contexts. Quantifiers are symbols that express the extent to which a statement holds for a set of objects or concepts. The most common quantifiers are "for all" (symbolized by the upside down A) and "there exists" (symbolized by the upside down E). Predicates are symbols that describe properties or relationships between objects or concepts. For example:

1. ∀xP(x) = "For all x, P is true of x" (e.g., "For all animals, they have a heart.")
2. ∃xQ(x) = "There exists an x such that Q is true of x" (e.g., "There exists a mammal that can fly.")
3. P(a) = "P is true of a" (e.g., "Daphne is intelligent.")
4. Q(b) ∧ R(b) = "Q is true of b and R is true of b" (e.g., "Snoopy is a dog and is white.")
5. ¬P(c) = "It is not the case that P is true of c" (e.g., "It is not the case that Cindy can fly.")
6. P(d) ∨ Q(d) = "Either P is true of d or Q is true of d" (e.g., "Either sharks are fish or they have wings.")
7. ∀x(P(x) → Q(x)) = "For all x, if P is true of x then Q is true of x" (e.g., "For all animals, if they have a backbone then they are vertebrates.")
8. ∃x(P(x) ∧ Q(x)) = "There exists an x such that P is true of x and Q is true of x" (e.g., "There exists a bird that can fly and is a predator.")
9. ¬∀xP(x) = "It is not the case that for all x, P is true of x" (e.g., "It is not the case that for all animals, they have wings.")
10. ¬∃xQ(x) = "It is not the case that there exists an x such that Q is true of x" (e.g., "It is not the case that there exists a mammal that can breathe underwater.")

Predicate logic is a powerful tool that has a wide range of applications in various fields. In mathematics, predicate logic is used to formalize mathematical concepts and arguments, and to prove theorems. In philosophy, predicate logic is used to clarify and analyze philosophical concepts and arguments. For example, predicate logic has been used to analyze the concept of knowledge, and to evaluate the validity of philosophical arguments about knowledge. Finally, in computer science, it is used to design and analyze algorithms and data structures. For example, predicate logic can be used to prove the correctness of algorithms, and to analyze the time and space complexity of algorithms. Predicate logic is also used in the design of programming languages, to specify the syntax and semantics of programming constructs.

## Contemporary Research in Logic

Contemporary logicians have spent the last 80 years (since Gödel and Turning) building on the work of early logicians. Here, we'll briefly discussion some of the major topics and ideas that have interested them.

One important development has been the development of non-classical logics. A "classical logic" (such as categorical logic, propositional logic, and predicate logic) is, among other, things **bivalent** (meaning that statements must either be TRUE or FALSE—there is no "in between" or "neither."). While this works well for many purposes, there are some topics (such as when talking about future events, quantum mechanics, or "possible" events) where we need to alter or extend this. Examples of non-classical logics include intuitionistic logic, temporal logic, and modal logic. These logics have been applied in various fields, including computer science, linguistics, and philosophy.

Another important development has been the growth of automated theorem proving, which is the use of computers to prove or disprove mathematical theorems. This has led to the development of sophisticated theorem proving software, which has greatly increased the speed and efficiency of mathematical proof. In recent years, logicians have used these to prove results that humans could never have proved on their own.

There has also been significant progress in the field of set theory, which is a branch of mathematical logic that deals with the concept of sets and the relationships between them. In the 1960s, Paul Cohen proved the independence of the continuum hypothesis, which is a statement about the size of infinite sets, using a technique called forcing. This led to the development of the field of forcing and large cardinal theory, which studies the concept of large infinite sets.

In the field of computer science, there has been a great deal of progress in the development of logic programming languages, which are programming languages that use logic to represent and manipulate data. Examples of logic programming languages include Prolog and Mercury.

In recent years, there has also been a growing interest in the use of logical approaches in the field of artificial intelligence, particularly in the development of machine learning algorithms. Logical approaches have been used to develop algorithms that can learn from data and make predictions, as well as to analyze and understand complex systems.

Overall, the last 80 years have seen significant advances in the field of logic, and these developments have had a profound impact on a wide range of fields, including mathematics, computer science, philosophy, and artificial intelligence.

## QUESTIONS

1. What is a proposition in propositional logic and can you provide an example?
2. What are logical operators and how are they used to combine propositions in propositional logic?
3. What is the difference between propositional and categorical logic, and how do they approach representing relationships between ideas or categories?
4. Can you provide examples of valid argument forms in propositional logic?
5. How is predicate logic different from propositional logic and how does it expand upon the concepts and techniques used in propositional logic?
6. Can you provide an example of how propositional or predicate logic is used in a practical setting, such as computer science or artificial intelligence?
7. How is propositional logic used in modern computer science and programming? Can you provide an example of how it is used in a computer program?
8. What are Boolean values and how are they used in programming to represent the truth or falsity of a proposition?
9. How are logical operations such as AND, OR, and NOT implemented in computer processors using logic gates?
10. What are some current areas of research in logic and what impact do you think they will have on other fields in the future?
11. How has the field of logic evolved since the work of early logicians like Aristotle and the Stoics and how have contemporary logicians built upon their work?

## EXERCISES: PROPOSITIONAL LOGIC

Express the symbolic "form" of each of these arguments using propositional logic. Then, identify the "name" of the argument. The forms for this exercises are:

- Modus Ponens: If P then Q. P. So, Q.
- Modus Tollens: If P then Q. Not Q. So, not P.
- Hypothetical Syllogism: If P then Q, If Q then R. So, If P then R.
- Disjunctive Syllogism: P or Q. Not Q. So, P.
- Constructive Dilemma: If P then R. If Q then S. P or Q. So, R or S.
- Affirming the Consequent (Invalid): If P then Q. Q. So, P.
- Denying the Antecedent (Invalid): If P then Q. Not P. So, not Q.

You can find selected answers in the appendix.

1. If carrots can sing opera then hippopotamuses can solve Rubik's cubes in under a minute. It is false that carrots can sing opera. Therefore, it is false that hippopotamuses can solve Rubik's cubes in under a minute.
2. Either giraffes can speak fluent French, or raccoons can hack into computer systems. If giraffes can speak fluent French, then crocodiles can do advanced calculus. If raccoons can hack into computer systems then yaks can do parkour. Therefore, crocodiles can do advanced calculus or yaks can do parkour.
3. If invisible dinosaurs still roam the earth then carrots can sing opera. Invisible dinosaurs still roam the earth. Therefore, carrots can sing opera.
4. If wolves can sing opera, then hamburgers are made from chicken. Hamburgers are not made from chicken. Therefore, wolves are not made from chicken.

5. If giraffes can speak fluent French, then skunks can play the flute. Skunks can play the flute. Therefore, giraffes can speak fluent French.
6. Either dolphins are pink, or vultures can do magic tricks. If dolphins are pink, then Pegasus is a flying horse with wings. If vultures can do magic tricks then zebras can teleport long distances. Therefore, Pegasus is a flying horse with wings or zebras can teleport long distances.
7. If giraffes can speak fluent French, then Medusa turns people to stone with her gaze. Medusa turns people to stone with her gaze. Therefore, giraffes can speak fluent French.
8. If the president's campaign promises were all lies, then dolphins are pink. Dolphins are pink. Therefore, the president's campaign promises were all lies.
9. If the speaker of the house is secretly a robot, then hippopotamuses can solve Rubik's cubes in under a minute. If hippopotamuses can solve Rubik's cubes in under a minute, then vultures can do magic tricks. Therefore, if the speaker of the house is secretly a robot then vultures can do magic tricks.
10. If the chimera is a fire-breathing monster with the head of a lion, the body of a goat, and the tail of a serpent, then popcorn is a type of fruit. It is not the case that popcorn is a type of fruit. Therefore, it is false that the chimera is a fire-breathing monster with the head of a lion, the body of a goat, and the tail of a serpent.
11. If penguins can fly, then zebras can teleport long distances. It is false that penguins can fly. Therefore, it is false that zebras can teleport long distances.
12. If vultures can do magic tricks, then skunks can play the flute. It is not the case that skunks can play the flute. Therefore, it is false that vultures can do magic tricks.
13. Either gorillas can play the piano, or yaks can do parkour. It is not the case that gorillas can play the piano. Therefore, yaks can do parkour.
14. If cats can talk, then the vice president's policies are only for their own benefit. It is false that cats can talk. Therefore, it is false that the vice president's policies are only for their own benefit.
15. Either cats can talk, or raccoons can hack into computer systems. It is not the case that cats can talk. Therefore, raccoons can hack into computer systems.
16. If the moon is made of cheese, then Medusa turns people to stone with her gaze. Medusa turns people to stone with her gaze. Therefore, the moon is made of cheese.
17. If giraffes can speak fluent French, then yaks can do parkour. It is not the case that yaks can do parkour. Therefore, it is false that giraffes can speak fluent French.
18. If elephants can play the violin, then crocodiles can do advanced calculus. Elephants can play the violin. Therefore, crocodiles can do advanced calculus.
19. Either bats can play the harp, or zebras can teleport long distances. It is not the case that bats can play the harp. Therefore, zebras can teleport long distances.
20. If kangaroos can teleport short distances, then cats can talk. Cats can talk. Therefore, kangaroos can teleport short distances.

## MINDS THAT MATTERED: ALAN TURING

Alan Turing was a mathematician and computer scientist who is known for his contributions to the field of theoretical computer science. He is best known for his work on the idea of a universal computing machine, which was the theoretical basis for the modern computer.

Turing was born in 1912 in London, England. He received his education at King's College, Cambridge, where he studied mathematics. After completing his degree, he worked on various mathematical and computer science projects, including the development of the Enigma machine, which was used to decode German military communications during World War II.

One of Turing's most significant contributions to the field of computer science was his idea of a universal computing machine, which he described in his 1936 paper "On Computable Numbers, with an Application to the Entscheidungsproblem." In this paper, Turing introduced the concept of a machine that could read and execute instructions in the form of a program. He also described the idea of a "tape" on which the machine could store and read data, which became the basis for the modern computer's memory.

Alan Turning also proved the undecidability of the "halting problem." The problem asks whether it is possible to determine, for any given program, whether the program will eventually stop running or will continue to run forever. This problem is important because it has implications for the limits of what computers can do, and it has influenced the development of computer science and the design of programming languages.

Turning showed that the halting problem is an example of an undecidable problem, which means that it is impossible to design an algorithm that can solve it. (This is basically the computer science version of Gödel's incompleteness theorem, which influenced Turing). This is because the problem asks whether a program will halt, which is something that can only be determined by actually running the program. However, if we could design an algorithm to solve the halting problem, we could use it to create a program that could determine whether any given program will halt, simply by running the algorithm on the program. This would lead to a paradox, because the program would be able to determine whether it will halt or not, which is impossible.

The halting problem has important implications for the limits of what computers can do, and it has influenced the development of computer science and the design of programming languages. For example, the halting problem is one of the reasons why it is difficult to design programming languages that can catch all possible errors, and it has led to the development of techniques such as static analysis, which can detect certain kinds of errors in programs before they are run. It has also influenced the development of artificial intelligence, because it shows that there are certain things that computers will never be able to do, no matter how powerful they become.

Turing also proposed the idea of a test (now called the "Turing test") in 1950 as a way to evaluate the success of artificial intelligence (AI). The test consists of a human evaluator who engages in natural language conversations with another human and with a machine, without knowing which is which. If the evaluator is unable to consistently tell the machine from the human, the machine is said to have passed the Turing Test.

The Turing Test has been widely discussed and debated in the field of AI, and has been seen as a benchmark for the development of intelligent machines. However, it has also been criticized for its limited scope and for relying on subjective human evaluations. Despite these criticisms, the Turing Test remains an influential concept in the field of AI and continues to be used as a measure of machine intelligence.

Turing's ideas about universal computing machines laid the foundation for the development of modern computers, and his work has had a lasting impact on the field of computer science. In addition to his work on computing, Turing is also known for his contributions to the study of artificial intelligence, and his ideas about the capabilities and limitations of computers continue to be debated and studied today.

### QUESTIONS

1. How did Alan Turing's work on the Enigma machine contribute to the field of computer science?
2. What is the halting problem and what are its implications for the limits of what computers can do?
3. How has the Turing Test been used to evaluate the success of artificial intelligence?
4. How did Turing's ideas about universal computing machines pave the way for the development of modern computers?
5. In what ways has Turing's work influenced the field of artificial intelligence and machine learning?

# CHAPTER 12: LOGIC AND THE GOOD LIFE

In this concluding chapter, you will delve into the practical applications of logic in daily life. You'll start by considering the virtue of reason and how it can be cultivated to improve personal relationships. You'll then explore how to use critical thinking skills at work and make better decisions about health and wealth. Finally, you'll consider the role that logic can play in overall happiness and well-being. Along the way, you'll learn from the insights of philosopher Martha Nussbaum and reflect on the lessons you've learned throughout the course. By the end of this chapter, you'll have a deeper understanding of the importance of logic in navigating the complexities of life.

And now, let's meet Dr. Dreadful, who will help illustrate some of the dangers of not thinking critically.

## THE DIARY OF DOCTOR DREADFUL

Diary Entry 1:

I am the greatest supervillain the world has ever known! My name is Doctor Dreadful and I will stop at nothing to achieve world domination. Today, I had the most brilliant idea for a get-rich-quick scheme. I will use my

powers of mind control to convince people to invest all of their savings in my fake cryptocurrency, the "Dreadcoin". I know they will all see the value in it once they are under my control. Ha ha ha!

Diary Entry 2:

I have been having some issues with my girlfriend, Evilena. She keeps telling me that my get-rich-quick scheme is a bad idea and that I should be more careful with my powers. I can't believe she would doubt me like this! I mean, I am Doctor Dreadful after all. I don't need her negativity holding me back. I think it's time to cut ties and find someone who will fully support my plans for world domination.

Diary Entry 3:

I have been having some trouble with my henchmen lately. They keep questioning my decisions and it's really starting to get on my nerves. I mean, I am their boss! They should do as I say without question. I think it's time to replace them with some new, more loyal minions. I'll just use my powers of mind control to find some willing subjects.

Diary Entry 4:

I made the mistake of investing all of my own money into my Dreadcoin scheme. Unfortunately, it turns out that no one else was interested in investing. I have lost everything! I can't believe I fell for such a classic logical fallacy - the sunk cost fallacy. I should have cut my losses when Evilena warned me, but I was too stubborn. Now I am broke and alone.

Diary Entry 5:

I have hit rock bottom. In a desperate attempt to regain my powers and dominate the world, I decided to undergo a risky medical procedure. I thought that if I could just enhance my abilities, I could take over the world and become rich and famous again. Unfortunately, the procedure was a complete disaster and I am now even weaker than before. I fell victim to the gambler's fallacy - I thought that if I just kept trying, I would eventually succeed. But it only led to my downfall.

Diary Entry 6:

It's all over. Captain Courageous, with her shining cape and perfectly coiffed hair, has finally defeated me. She was able to see through my elaborate schemes and outsmart me at every turn. I can't believe I let my hubris and overconfidence get the best of me. I should have known that I couldn't defeat the world's greatest superhero.

The final showdown was nothing short of epic. I had planned my ultimate attack, sure that I could finally defeat Captain Courageous once and for all. But she was ready for me. With her super strength and quick thinking, she was able to outmaneuver me and bring me down. I tried to use my powers of mind control on her, but she was immune to my charms. I even tried to bribe her with all of my remaining Dreadcoins, but she was having none of it.

In the end, I was no match for Captain Courageous. She left me tied up in her lasso of truth, ready to be handed over to the authorities. As I sit here in my cell, I can't help but reflect on all of the logical fallacies that led to my downfall. If only I had listened to Evilena and not fallen for the sunk cost fallacy. If only I had realized that my henchmen were right and I was wrong. If only I had recognized the dangers of the gambler's fallacy before it was too late.

But it's too late for regrets now. I am Doctor Dreadful, defeated by the mighty Captain Courageous. Maybe one day I'll escape from prison and try to take over the world again, but for now I am resigned to my fate. Perhaps it's time to embrace my inner hero and use my powers for good. Or maybe I'll just sit here and plot my revenge. Either way, it's the end of an era for Doctor Dreadful.

## QUESTIONS

1. How does Doctor Dreadful's ego and overconfidence contribute to his downfall?

2. In what ways does Doctor Dreadful's lack of critical thinking and tendency to fall for logical fallacies lead to his failure?
3. How does Evilena's skepticism and willingness to challenge Doctor Dreadful's decisions serve as a foil to his hubris?
4. How does Doctor Dreadful's tendency to rely on mind control and manipulation contribute to his isolation and loss of support from those around him?
5. In what ways does Doctor Dreadful's pursuit of wealth and power ultimately lead to his defeat?
6. How does Captain Courageous's willingness to think critically and challenge Doctor Dreadful's schemes contribute to her victory over him?

## Introduction

In the previous chapters of this book, we have explored the foundations of logical thinking and how it can be applied to various aspects of our lives. We have learned about the different types of logical reasoning, such as deduction and induction, and how they can be used to evaluate arguments and make sound judgments. We have also examined the role of logical thinking in decision-making and how it can help us avoid common pitfalls and biases that can lead to poor decisions.

In this concluding chapter, we will delve deeper into the connection between logic and the good life, and how developing logical thinking skills can help us cultivate the virtue of reason. The virtue of reason is the ability to think critically and logically, and it is an essential part of living a fulfilling and meaningful life. Whether we are dealing with personal relationships, work, or leisure, the virtue of reason can help us navigate through the complexities of life and make informed decisions that align with our values and goals.

Throughout this chapter, we will explore how the virtue of reason can be applied in different domains of our lives, and how it can help us make better decisions, communicate effectively, and pursue our interests and passions in a meaningful way. By the end of this chapter, you should have a deeper understanding of the importance of logic and the good life and see how developing your logical thinking skills can help you live a more fulfilling and meaningful life.

## The Virtue of Reason

The virtue of reason is an essential part of living a good life, and it is something that we can cultivate and develop over time. According to Aristotle's influential account (along with being the "father" of logic, he also wrote a lot about science, ethics, and politics!), **virtues** are habits or dispositions that help us live a good life, and they are qualities that enable us to act in accordance with reason and pursue our goals in a way that is both fulfilling and meaningful.

Unlike some other philosophers, Aristotle did not believe that any virtues are innate or that we are born with them. Instead, he believed that virtues are acquired through practice and repetition, and that they can be developed and strengthened over time. Aristotle also believed that **vices** are the opposite of virtues, and that they are characterized by excess or deficiency. For example, if someone is excessively timid, they might be considered to have the vice of cowardice. Alternatively, if someone is excessively bold, they might be considered to have the vice of recklessness. Similarly, if someone is deficient in their ability to think critically and logically, they might be considered to have the vice of irrationality.

In order to cultivate the virtue of reason, it is important to avoid the vices of excess and deficiency. This means finding a balance between thinking too little and thinking too much, and between being too skeptical and being too gullible. By cultivating the virtue of reason in this way, we can ensure that our beliefs and decisions are grounded in sound evidence and logical thinking, rather than being swayed by emotions or biases. By following the doctrine of the mean and striving for balance, we can cultivate the virtue of reason and live a more fulfilling and meaningful life.

One way to cultivate the virtue of reason is by practicing logical thinking and engaging in activities that challenge and exercise our critical thinking skills. This can include reading and analyzing arguments, debating with others, and solving problems that require logical thinking. By challenging ourselves to think critically and logically, we can strengthen our ability to evaluate arguments and make sound judgments, and we can become more skilled at avoiding common pitfalls and biases that can lead to poor decisions.

While the virtue of reason is essential for living a good life, it is not always easy to cultivate and maintain. One of the main challenges is that our emotions can often pull us away from reason and cause us to make irrational or impulsive decisions. For example, if we are feeling angry or upset, we might be more prone to making hasty or rash decisions that we later regret. Similarly, if we are feeling overly optimistic or confident, we might be more prone to making overly optimistic or overconfident decisions that are not based on sound evidence or logical thinking.

One way to combat the influence of emotion on our decision-making is by practicing the virtue of reason. By cultivating the habit of thinking critically and logically, we can strengthen our ability to evaluate arguments and make sound judgments, even when we are feeling emotional. Additionally, practicing the virtue of reason can help us redirect our emotions in a more constructive way. For example, if we are feeling angry or upset, we can use logical thinking to help us evaluate the situation and find a more productive way to deal with our emotions. Similarly, if we are feeling overly optimistic or confident, we can use logical thinking to help us temper our expectations and consider alternative viewpoints.

Overall, the virtue of reason is an essential part of living a good life, and it is something that we can cultivate and develop over time. By practicing logical thinking and following the doctrine of the mean, we can strengthen our ability to think critically and logically, and we can live more fulfilling and meaningful lives.

### QUESTIONS

1. How does Aristotle's view of virtue differ from other philosophers'?
2. What role do emotions play in decision-making and how can the virtue of reason help us to "shape" our emotions so that they help (rather than harm) us?
3. What are some practical ways to cultivate the virtue of reason in our daily lives?
4. Can the virtue of reason be maintained consistently or does it require effort to cultivate on a daily basis?
5. Have you ever made a decision that you later regretted because you were feeling emotional or biased? How might you have approached the situation differently if you had cultivated the virtue of reason?

## CULTIVATING REASON TO BUILD PERSONAL RELATIONSHIPS

The virtue of reason is essential for building and maintaining healthy personal relationships, and it is an invaluable tool for effective communication and conflict resolution. By cultivating the virtue of reason in our personal relationships, we can ensure that our beliefs and behaviors are grounded in sound evidence and logical thinking, rather than being swayed by emotions or biases.

One way to cultivate the virtue of reason in personal relationships is by practicing **active listening** and empathizing with others. Active listening is a crucial skill for cultivating the virtue of reason in personal relationships, as it involves attentively listening to what others are saying and attempting to understand their perspective, rather than just thinking about what you are going to say next. By actively listening and empathizing with others, we can better comprehend their thoughts and feelings, and we can communicate in a more meaningful and respectful way.

However, a failure to actively listen can often lead us to commit logical fallacies. Here are three examples of how a lack of active listening can lead us astray:

*Ad Hominem Fallacy:* If we are not actively listening to what someone is saying, we may be more prone to making personal attacks or attacking their character rather than engaging with the content of their argument. For example, if someone is presenting an argument that we disagree with, we may be more likely to dismiss their ideas by saying something like "Well, they're just jealous" or "They're just trying to get attention." By making personal attacks rather than engaging with the argument itself, we are committing the ad hominem fallacy and failing to engage in logical thinking.

*Straw Man Fallacy:* If we are not actively listening to what someone is saying, we may be more prone to misrepresenting their position or setting up a "straw man" argument that is easier to attack. For example, if someone is presenting an argument that we disagree with, we may be more likely to twist their words or present a distorted version of their position in order to make it easier to attack. By misrepresenting someone's position, we are committing the straw man fallacy and failing to engage in logical thinking.

*Hasty Generalization Fallacy:* If we are not actively listening to what someone is saying, we may be more prone to making hasty generalizations or jumping to conclusions based on limited evidence. For example, if someone presents an argument that we disagree with, we may be more likely to dismiss their ideas without fully considering the evidence they have provided. By making hasty generalizations without considering all of the available evidence, we are committing the hasty generalization fallacy and failing to engage in logical thinking.

Overall, active listening is a crucial skill for cultivating the virtue of reason in personal relationships, as it helps us to avoid logical fallacies and consider the perspectives and evidence of others. By actively listening and empathizing with others, we can strengthen our ability to think critically and logically, and we can build more fulfilling and meaningful relationships with others.

Another critical skill involves **openness to criticism and correction,** even when it comes from someone you disagree with. Another critical skill for cultivating the virtue of reason in personal relationships involves openness to criticism and correction, even when it comes from someone you disagree with. This is an important aspect of the virtue of reason, as it involves being willing to re-evaluate our beliefs and behaviors in light of new evidence or alternative viewpoints. By being open to criticism and correction, we can ensure that our beliefs and actions are grounded in sound evidence and logical thinking, rather than being swayed by emotions or biases.

One common obstacle to openness to criticism and correction is the tendency towards confirmation bias, which is the tendency to seek out and give more weight to information that confirms our preexisting beliefs and biases. Confirmation bias can lead us to selectively interpret or remember information in a way that supports our beliefs, and it can make us resistant to criticism or correction. By being aware of confirmation bias and actively seeking out diverse perspectives and evidence, we can overcome this tendency and be more open to criticism and correction.

Another common obstacle to openness to criticism and correction is the halo effect, which is the tendency to view someone more favorably or unfavorably based on a single trait or characteristic. For example, if we view someone as intelligent or likable, we may be more likely to give their arguments more weight or to overlook their flaws. By being aware of the halo effect and actively considering multiple characteristics and perspectives, we can overcome this tendency and be more open to criticism and correction.

Openness to criticism and correction is especially important in a democratic society, where we rely on the exchange of ideas and the ability to challenge and re-evaluate our beliefs and behaviors. Both liberals and conservatives, for example, tend to have unrealistically degrees of "certainty" that their preferred policy positions are correct in large part because they ignore problems pointed out by the "other side." However, this also shows up in our personal life, when we (selectively) ignore criticisms of our views by family members, friends, or coworkers. By being open to criticism and correction, we can ensure that our beliefs and actions are grounded in sound evidence and logical thinking, and we can contribute to a more informed and productive society.

### QUESTIONS

1. Describe a situation in which you experienced the importance of active listening in your personal relationships. How did a lack of active listening contribute to the situation?
2. What strategies do you currently use to practice active listening in your personal relationships? Are there any areas where you feel you could improve your active listening skills?
3. Reflect on a time when you were resistant to criticism or correction in a personal relationship. How did this impact the relationship and how did you ultimately approach the situation?
4. What strategies do you currently use to foster openness to criticism and correction in your personal relationships? Is there any room for improvement in this area?
5. How do you believe practicing the virtue of reason can be helpful in building relationships with those who hold different beliefs or values? Provide an example of a relationship where the virtue of reason helped bridge any divides.

## MINDS THAT MATTER: MARTHA NUSSBAUM

Martha Nussbaum is an American philosopher and cultural theorist whose work focuses on ethics, politics, and emotion. She is known for her ideas about what it means to lead a good life, which she explores through the lenses of literature, philosophy, and cultural studies. Nussbaum is particularly interested in the role that vulnerability plays in human flourishing, and has argued that the recognition and acceptance of vulnerability is

essential for living a good life. In her work, Nussbaum also advocates for the development of "central human capabilities" such as education, freedom of movement, and access to healthcare, as a way of promoting social justice and equality. Nussbaum has been influenced by philosophers such as Aristotle, Adam Smith, and Immanuel Kant, and has engaged with the ideas of other contemporary thinkers such as Jacques Derrida and Michel Foucault.

One of the central themes in Nussbaum's work is the concept of vulnerability and fragility. In her book *The Fragility of Goodness: Luck and Ethics in Greek Tragedy and Philosophy*, Nussbaum addresses the ethical dilemma of individuals who are committed to justice, but who are also vulnerable to external factors that may negatively impact their well-being. Nussbaum argues that, contrary to the Platonic belief that human goodness can fully protect against peril, the acknowledgement of vulnerability is key to achieving the human good. This theme of vulnerability is also present in Nussbaum's interpretation of Plato's Symposium, in which the re-entrance of Alcibiades at the end of the dialogue highlights the fragility of human beings and their reliance on physical beauty and bodily limitations.

Another major theme in Nussbaum's work is the importance of liberal education and the role of multiculturalism in promoting social justice. In *Cultivating Humanity: A Classical Defense of Reform in Liberal Education*, Nussbaum appeals to classical Greek texts to defend and reform liberal education. She traces the development of the idea of becoming a "citizen of the world" through the Stoics, Cicero, and classical liberalism, and champions multiculturalism as a means of promoting ethical universalism. Nussbaum also defends the value of scholarly inquiry into race, gender, and sexuality, and the role of literature in exploring ethical questions.

Finally, Nussbaum's work also addresses issues of gender and sexual justice, and the intersection of feminism and social justice. In *Sex and Social Justice*, Nussbaum argues that distinctions based on sex and sexuality have been artificially enforced as sources of social hierarchy, and that feminism and social justice have common concerns. Nussbaum proposes the concept of functional freedoms, or central human capabilities, as a framework for understanding social justice. She also discusses the feminist critiques of liberalism and the limitations of liberal political theory in addressing issues of gender and sexuality.

Overall, Nussbaum's work is characterized by a commitment to exploring the complexities of ethics, justice, and human flourishing, and to finding ways to promote social justice and equality in a world that is often marked by vulnerability and fragility.

### QUESTIONS

1. How does Nussbaum's concept of vulnerability and fragility challenge traditional notions of goodness and ethics?
2. In what ways does Nussbaum's defense of liberal education and multiculturalism promote social justice and ethical universalism?
3. How does Nussbaum's approach to gender and sexual justice differ from traditional liberal political theory, and what implications does this have for understanding social justice more broadly?
4. How does Nussbaum's work engage with the ideas of other philosophers, such as Plato, Aristotle, and Kant, and how does it build on or challenge these ideas?
5. In what ways does Nussbaum's work on vulnerability and fragility relate to other themes in her work, such as social justice and gender and sexual justice?
6. How does Nussbaum's use of literature and cultural studies inform her philosophical arguments?
7. How does Nussbaum's work contribute to ongoing debates and discussions in the fields of ethics, politics, and cultural studies?

## REASONING WELL AT WORK

The virtue of reason is essential for success in work and career, as it enables us to make informed decisions, solve problems, and communicate effectively with colleagues and clients. By cultivating the virtue of reason in our work and career, we can ensure that our beliefs and actions are grounded in sound evidence and logical thinking, rather than being swayed by emotions or biases.

To practice the virtue of reason in work and career contexts, it is important to engage in activities that challenge and exercise our critical thinking and problem-solving skills. This can include reading and analyzing arguments, debating with colleagues, and solving problems that require logical thinking. It also requires that we take time to

self-reflect, and think about the ethical *values* that we want to live by. By challenging ourselves to think critically and logically, we can strengthen our ability to evaluate arguments and make sound judgments, and we can become more skilled at avoiding common pitfalls and biases that can lead to poor decisions.

As part of practicing the virtue of reason, it is important to cultivate the habit of thinking critically and logically. This involves making a conscious effort to apply the virtue of reason in our daily work and career activities, and it requires persistence and discipline to overcome any challenges or setbacks. For example, if we are prone to making hasty decisions without fully considering the evidence, we can make a conscious effort to slow down and carefully evaluate the available evidence before making a decision. By cultivating the habit of thinking critically and logically, we can ensure that our beliefs and actions are grounded in sound evidence and logical thinking.

The type of reasoning required in different work and career contexts can vary depending on the specific goals and objectives of the task at hand. For example, in moral or ethical contexts, the virtue of reason might involve applying moral principles or values to evaluate the rightness or wrongness of a particular action or decision. In scientific contexts, the virtue of reason might involve evaluating empirical evidence and applying scientific methods to test hypotheses or theories. In statistical contexts, the virtue of reason might involve analyzing data and drawing inferences based on statistical analysis. In analogical contexts, the virtue of reason might involve comparing and contrasting different cases or examples in order to draw conclusions or make predictions.

For example, consider the following vignettes:

*Maria.* Maria is a project manager at a design firm. She is tasked with leading a team of designers in creating a new branding campaign for a client. To practice the virtue of reason in her work, Maria makes a conscious effort to carefully evaluate the evidence and arguments presented by her team members when discussing different creative options. She also encourages her team to consider multiple viewpoints and to challenge assumptions when necessary. By practicing critical thinking and problem-solving skills in this way, Maria is able to make informed decisions and to effectively lead her team in delivering high-quality branding materials to the client.

*Carlos.* Carlos is a high school science teacher. He is passionate about helping his students learn to think critically and logically, and he makes a habit of posing open-ended questions and encouraging his students to consider multiple viewpoints when discussing scientific concepts. Carlos also helps his students practice the virtue of reason by assigning them to write analytical essays that require them to evaluate scientific evidence and construct logical arguments. By practicing the virtue of reason in this way, Carlos helps his students develop the critical thinking and problem-solving skills that are essential for success in academic and professional contexts.

*Liam.* Liam is a financial advisor at a wealth management firm. He is responsible for analyzing market trends and making investment recommendations to clients. To practice the virtue of reason in his work, Liam makes a conscious effort to carefully evaluate the statistical evidence and financial data that he uses to make investment decisions. He also seeks out diverse viewpoints and considers alternative viewpoints when making his recommendations. Finally, he considers what it means to manage his client's investments "ethically." By practicing critical thinking and problem-solving skills in this way, Liam is able to make informed decisions and to effectively serve his clients' needs.

Overall, the virtue of reason is an essential part of success in work and career, and it is something that we can cultivate and develop over time. By practicing critical thinking and problem-solving skills, and by cultivating the habit of thinking critically and logically, we can strengthen our ability to think critically and logically, and we can achieve greater success in our work and career.

## QUESTIONS

1. How have you used the virtue of reason in your own work or career? Can you think of a specific example where critical thinking and logical reasoning helped you make a better decision or solve a problem?
2. In what ways do you think cultivating the virtue of reason can benefit you in your work or career? How might it help you communicate more effectively with colleagues or clients?
3. How might the type of reasoning required in different work or career contexts vary? Can you think of an example where the virtue of reason might involve applying moral principles or values, as opposed to evaluating empirical evidence or analyzing data?

4. Have you ever found yourself making a hasty decision without fully considering the evidence? How might you cultivate the habit of thinking critically and logically to avoid making poor decisions in the future?
5. How can you challenge yourself to think critically and logically in your daily work and career activities? What activities or habits might you adopt to exercise your critical thinking and problem-solving skills?

## Thinking Critically About Health and Wealth

The capacity to think critically (and to cultivate the virtue of reason) is essential for making informed decisions about our health and wealth. By applying critical thinking and logical reasoning to these areas, we can cultivate the habit of making choices that are grounded in sound evidence and ethical values. This can help us avoid the vices of being too risky or too risk averse, and it can help us become healthier, wealthier, and wiser.

One way to apply the virtue of reason to our health decisions is by carefully evaluating the evidence and arguments behind different health practices and treatments. This can help us avoid falling for unproven treatments or fads, and it can help us find a balance between under- and over-treatment. By applying principles of scientific reasoning, such as Bayes' theorem, we can determine the probability that a particular hypothesis is true based on the evidence we have. This can help us make more informed decisions about what is best for our own health and well-being.

Here are some examples of how the virtue of reason can help us find a balance between under- and over-treatment in our health decisions.

*Overtreatment:* Samantha is a 45-year-old woman who has been experiencing some mild symptoms of menopause, such as hot flashes and difficulty sleeping. Her doctor suggests that she might a new drug that has just been approved by the FDA for other conditions, but which has been occasionally been used "off label" for serious cases. Despite the lack of evidence supporting the safety and effectiveness of the drug, Samantha decides to try it because she is desperate for relief from her symptoms. However, after taking the drug for a few weeks, Samantha experiences severe side effects, including stomach pain and dizziness. She realizes that she should have used critical thinking and carefully evaluated the evidence supporting the drug before making a decision to take it.

*Undertreatment:* Jack is a 55-year-old man who has high blood pressure and high cholesterol. His doctor recommends that he take medication to control his conditions, but Jack is skeptical of taking medication and decides to try to manage his conditions through diet and exercise alone. Despite his efforts, Jack's blood pressure and cholesterol remain uncontrolled, and he experiences several health complications as a result. Jack realizes that he should have used critical thinking and carefully considered the evidence supporting the benefits of medication in controlling his conditions before making a decision to forgo treatment.

*Finding a balance:* Emma is a 35-year-old woman who is considering whether to undergo a breast augmentation surgery. She is unhappy with the size and shape of her breasts and thinks the surgery might improve her self-esteem and confidence. Emma takes a few weeks to carefully evaluate the evidence supporting the safety and effectiveness of the surgery, as well as the potential risks and benefits. She talks to medical professionals, reads relevant literature, and talks to family friends. She also considers her personal values and priorities, and ultimately decides that the surgery is not the right choice for her. By finding a balance between her desire for self-improvement and her concerns about the potential risks of the surgery, Emma makes an informed decision that is best for her own health and well-being.

Similarly, we can apply the virtue of reason to our financial decisions by evaluating the evidence and arguments behind different investment options, and finding the "middle way" between "too risky" and "too low of returns." This isn't something that comes easy to many of us! On the one hand, many people are *overconfident* in their ability to identify "investment opportunities" (in individual stocks, real estate, bitcoin) despite LOTs of evidence the individual investors tend to underperform the market when they try to do this. On the other hand, the seeming "complexity" of finance makes other shy away from any "risky" investments at all, despite the fact that this carries severe long-term costs (such as never being able to retire!). Again, we can consider a few case studies:

*Too risk averse:* Nina is a 25-year-old woman who has just started her first job and is beginning to think about saving for the future. She is very risk averse and is not comfortable with the idea of investing her money in stocks or other risky assets. Instead, she decides to put all of her savings into a savings account, which she considers to

be a safe and stable option. However, five years, Nina realizes that the rate of return on her savings account is much lower than the rate of inflation, which means that the value of her money is actually decreasing over time, and cannot afford the down payment for a house. She realizes that she should have used critical thinking and carefully evaluated the potential risks and returns of different investment options before making a decision.

*Too risky:* Marco is a 45-year-old man who is looking for ways to grow his wealth quickly. He hears about the potential for high returns on bitcoin and decides to invest a significant portion of his savings into the cryptocurrency. Despite warnings from friends and financial advisors about the high level of risk associated with bitcoin, Marco is convinced that it is a sure thing and puts all of his eggs in one basket. Like many other investors, Marco is overly confident about his ability to "time the market" and "identify investment opportunities" that have escaped others. However, after a few months, the value of bitcoin drops significantly, and Marco loses a large portion of his investment.

*A balance:* Gina is a 35-year-old woman who is looking to invest her money for the long term. She is interested in finding a balance between the potential for high returns and the need to manage risk. After researching different investment options, Gina decides to invest in low-cost index funds, which offer a diversified portfolio that tracks a group of stocks or other securities. Gina uses critical thinking to carefully evaluate the evidence and arguments behind the potential risks and returns of index funds, and she decides that they are the right choice for her long-term financial goals. She avoids making changes to her portfolio based on the changing price of the stock market, or the latest news and fads. Over time, Gina's investment in index funds grows, and she is able to achieve her financial goals while managing risk.

### QUESTIONS

1. How can critical thinking and logical reasoning help us make informed decisions about our health and wealth?
2. How can we find a balance between under- and over-treatment in our health decisions?
3. How can we apply the virtue of reason to our financial decisions, and find the "middle way" between too risky and too low returns?
4. In what ways do personal values and priorities come into play when making informed health and financial decisions?
5. How can we make sure we are not swayed by unproven treatments or fads when making health decisions?

## CAN LOGIC MAKE YOU HAPPY?

Critical thinking is a crucial skill for mental health, as it allows individuals to evaluate and analyze information, thoughts, and emotions in a logical and objective way. By cultivating the virtue of reason, individuals can make informed decisions about their mental health, and can better understand and manage their thoughts and emotions.

There is a strong connection between critical thinking and cognitive behavioral therapy (CBT), a form of therapy that focuses on challenging and changing negative thought patterns in order to improve mental health. CBT involves examining and evaluating the evidence and reasoning behind one's thoughts and beliefs, and using this information to develop more realistic and helpful ways of thinking. By using critical thinking skills, individuals can effectively challenge negative thought patterns and improve their mental health.

Some example of fallacies involving our mental health include the following:

**Black-and-white thinking**, also known as the all-or-nothing fallacy, involves seeing things in absolute terms and failing to consider shades of gray or complexity. This can lead to false dichotomy, which is the belief that there are only two options or possibilities, and that one must choose between them. Examples of black-and-white thinking include:

- "I either have to be the best at everything or a complete failure."
- "I'm either happy or I'm miserable, there's no in between."
- "I have to be perfect or I'm a disappointment."

**Mind reading** involves assuming that one knows what others are thinking or feeling, without any evidence or confirmation. This can be a form of the false cause fallacy, which is the belief that a relationship between two things exists when it does not, or that one event caused another without sufficient evidence. Examples of mind reading include:

- "She didn't invite me to her party, she must not like me."
- "He didn't say hello, he must be mad at me."
- "They didn't laugh at my joke, they must think I'm not funny."

**Emotional reasoning** involves basing one's beliefs and actions on feelings rather than evidence or reason. This can also be a form of the false cause fallacy, as it involves attributing a cause to an effect without sufficient evidence. For example, if someone feels anxious, they may conclude that there must be something to be anxious about, rather than considering other possible causes of their anxiety. Examples of emotional reasoning include:

- "I feel guilty, so I must have done something wrong."
- "I feel embarrassed, so I must be an idiot."
- "I feel overwhelmed, so I must not be able to handle this situation."

One of the key components of cognitive behavioral therapy (CBT) is challenging and questioning negative thought patterns in order to develop more realistic and helpful ways of thinking. CBT involves examining the evidence and reasoning behind one's thoughts and beliefs, and using this information to develop a more balanced perspective.

For example, consider the case of Zara, a young woman who has struggled with low self-esteem and negative thought patterns for most of her life. Zara's therapist encourages her to examine the evidence and reasoning behind her negative thoughts, such as "I'm not smart enough to succeed in college." Through this process, Zara begins to realize that she has based her belief on a few isolated instances where she struggled academically, rather than on a more balanced view of her overall academic performance. By considering additional evidence, such as her high grades in other classes and positive feedback from her professors, Zara is able to develop a more realistic and helpful way of thinking about her intelligence and academic abilities.

To evaluate evidence and test assumptions in CBT, individuals can use techniques such as asking for clarification, seeking out additional information, and considering alternative perspectives. These techniques can help individuals like Zara identify logical fallacies or biases in their thinking, and can help them develop more accurate and objective ways of thinking.

For example, Zara's therapist encourages her to seek out clarification when she has doubts about her abilities, such as asking her professors for feedback or seeking additional help when she is struggling with a particular concept. By asking for clarification, Zara is able to gain a more nuanced understanding of her strengths and weaknesses, and is better able to identify specific areas where she needs to improve.

Using critical thinking skills can also help individuals reframe negative thought patterns in CBT. For example, instead of thinking "I can't do anything right, I'm a complete failure," an individual like Zara could challenge this thought by considering specific instances where they were successful and asking themselves if it is really true that they can't do anything right. This process of questioning and challenging negative thoughts can help individuals develop more realistic and helpful ways of thinking, leading to improved mental health and well-being.

In Zara's case, she is able to reframe her negative thought patterns by considering specific instances where she has been successful, such as receiving high grades in other classes or being praised for her participation in group projects. By considering this evidence, Zara is able to develop a more balanced and helpful way of thinking about her abilities, and is able to approach her academic challenges with more confidence and optimism.

## QUESTIONS

1. How does critical thinking contribute to mental health and well-being?
2. What is the connection between reasoning well and cognitive behavioral therapy (CBT)?
3. How can we use critical thinking skills to challenge and change negative thought patterns in CBT?

4. How can we use techniques such as seeking out additional information and considering alternative perspectives to evaluate evidence and test assumptions in CBT?
5. How can we use critical thinking skills to identify and avoid logical fallacies and biases in our thinking about mental health?
6. How can we apply critical thinking skills to our emotions and feelings in order to better understand and manage them?
7. How can we use critical thinking skills to develop more realistic and helpful ways of thinking about ourselves and our lives?
8. How can we use critical thinking skills to effectively communicate and seek support from others in regards to our mental health?

## WHAT NEXT?

Now that you have completed "A Little More Logical," you may be wondering what steps to take next in your journey to improve your logical thinking skills. Here are a few suggestions to consider:

1. Practice, practice, practice! The more you apply the concepts and techniques you have learned in this book, the more natural and intuitive they will become. Seek out opportunities to practice your skills, whether it's through puzzles and brainteasers, or through real-life situations where logical thinking is required.
2. Expand your knowledge. There are many other resources available that can help you improve your logical thinking skills. Consider reading books on logic, philosophy, or critical thinking, or taking online courses or workshops on these subjects.
3. Test yourself. There are many online quizzes and tests available that can help you gauge your progress and identify areas where you may need to focus your efforts.
4. Get feedback. Seek out the perspective of others on your logical thinking skills. This could be a friend, a colleague, or a mentor. Ask for specific feedback on your thought processes and how you can improve.
5. Keep learning. The world of logic and critical thinking is constantly evolving, with new ideas and techniques being developed all the time. Stay up-to-date with the latest research and thinking in these areas, and be open to incorporating new ideas into your own thinking.

By following these steps, you can continue to improve your logical thinking skills and make them an integral part of your daily life. Remember, the journey to becoming more logical is an ongoing process, but with dedication and effort, you can make significant progress and achieve your goals.

# APPENDIX: PROOF METHODS IN PROPOSITIONAL LOGIC

Propositional logic, also known as propositional calculus, is a branch of mathematical logic that deals with statements that are either true or false. Propositional logic studies the relationship between different statements or propositions, and allows us to make inferences about the truth or falsity of one statement based on the truth or falsity of another statement.

Propositional logic uses a set of symbols and rules to represent the logical relationships between statements. The basic building blocks of propositional logic are simple statements, which can be evaluated as true or false on their own. Simple statements are combined using logical operators, also known as connectives, to form compound statements. The logical operators used in propositional logic include:

- Negation (not): The negation operator negates the truth value of a statement. For example, if a statement "P" is true, then "not P" is false and vice versa. The symbol used to represent negation is usually a tilde (~) or a negation symbol (¬).
- Conjunction (and): The conjunction operator combines two statements into a new statement that is only true if both of the original statements are true. For example, if statement "P" is true and statement "Q" is true, then "P and Q" is true. The symbol used to represent conjunction is usually a caret (^) or an ampersand (&) or a ∧.
- Disjunction (or): The disjunction operator combines two statements into a new statement that is true if at least one of the original statements is true. For example, if statement "P" is true or statement "Q" is true, then "P or Q" is true. The symbol used to represent disjunction is usually a V or a pipe (|) or a ∨.
- Material Implication (if-then): The material implication operator combines two statements into a new statement that is only false if the first statement (the antecedent) is true and the second statement (the consequent) is false. For example, if statement "P" is true, then "if P then Q" is true, unless Q is false. The symbol used to represent material implication is usually an arrow (->) or a →.
- Material Equivalence (if and only if): The material equivalence operator combines two statements into a new statement that is true if both of the original statements have the same truth value, either both true or both false. For example, if statement "P" is true, then "P if and only if Q" is true, unless Q is also true. The symbol used to represent material equivalence is usually a double arrow (<->) or a ≡.

For example:

| **Ordinary Language** | **Symbolic Equivalent** |
|---|---|
| "If Harry Potter is a wizard, then he can perform magic." | (HPwizard -> HPMagic) |
| "Either the dragon is asleep or it is awake." | (DAsleep V DAwake) |
| "The ring can only be worn by someone pure of heart." | (Ring -> PureHeart) |
| "Luke Skywalker is not a Sith." | (~LSith) |
| "The hobbits will not leave without the ring." | (~HLRing) |
| "Dumbledore is alive and well." | (DAlive ^ DWell) |
| "Voldemort cannot be defeated without the help of a chosen one." | (Voldemort -> COHelp) |
| "It is not the case that the Force is only for Jedi." | (~(FJedi)) |
| "The portal can only be opened by someone with the key." | (Portal -> Key) |

| | |
|---|---|
| "The sword in the stone can only be pulled out by the true king." | (Sword -> King) |

## Translating Between English and Propositional Logic

Translating between English and propositional logic can be a bit tricky, as the way we express ourselves in natural language is often more nuanced and complex than the symbols used in propositional logic. However, with practice and a few guidelines, it is possible to accurately translate statements from English to propositional logic and vice versa. Here are some tips for translating common expressions:

**Negation:** Expressions such as "It is false that P", "Not P", or "It is not the case that P" can be translated into propositional logic using the negation operator, represented by the tilde (~) or negation symbol (¬). For example, "It is false that Harry Potter is a Muggle" would be represented as "~HPmuggle".

**Conjunction:** Expressions such as "P and Q", "P but Q", "P; however, Q", "Both P and Q", or "P; additionally, Q" can be translated into propositional logic using the conjunction operator, represented by the ampersand (&) or caret (^) or ∧. For example, "Luke Skywalker is a Jedi and Darth Vader is a Sith" would be represented as "LSjedi ^ DVSith".

**Disjunction:** Expressions such as "P or Q", "P unless Q" can be translated into propositional logic using the disjunction operator, represented by the pipe (|) or V or ∨. For example, "Either the dragon is asleep or it is awake" would be represented as "DAsleep V DAwake"

**Material Implication:** Expressions such as "If P then Q", "P only if Q", "Q if P", "Given that P, Q", "P is a sufficient condition for Q", or "Q is a necessary condition for P" can be translated into propositional logic using the material implication operator, represented by the arrow (->) or →. For example, "If Harry Potter is a wizard, then he can perform magic" would be represented as "HPwizard -> HPMagic"

**Material Equivalence:** Expressions such as "P if and only if Q", "P is equivalent to Q", or "P is a necessary and sufficient condition for Q" can be translated into propositional logic using the material equivalence operator, represented by the double arrow (<->) or ≡. Expressions such as "P if and only if Q", "P is equivalent to Q", or "P is a necessary and sufficient condition for Q" can be translated into propositional logic using the material equivalence operator, represented by the double arrow (<->) or ≡. For example, "The portal can only be opened by someone with the key" can be represented as "Portal <-> Key" or "Portal ≡ Key" meaning that the statement "Portal" is equivalent to the statement "Key" and vice versa.

Of course, many English statements will require MULTIPLE operators to translate correctly. Translating these complex English sentences into propositional logic can be a bit challenging, as the way we express ourselves in natural language is often more nuanced and complex than the symbols used in propositional logic. However, with a systematic approach and a good understanding of the basic logical operators, it is possible to accurately translate complex sentences. Here are some tips on how to approach translating complex English sentences into propositional logic:

1. Break down the sentence into smaller, simpler parts: Complex sentences often contain multiple clauses or phrases that express different ideas. Breaking down the sentence into smaller parts can make it easier to identify the logical relationships between the different ideas.
2. Identify key words or phrases: Look for key words or phrases in the sentence that indicate logical relationships, such as "if", "then", "and", "or", "not", "only if", "if and only if", etc. These words or phrases often indicate the use of a specific logical operator.
3. Translate the smaller parts into propositional logic: Once you have broken down the sentence into smaller parts and identified the key words or phrases, you can start translating each part into

propositional logic. Use the appropriate logical operators to represent the logical relationships between the different parts.

4. Put the sentence back together: After translating each part of the sentence into propositional logic, you can put the sentence back together using the appropriate logical operators to connect the different parts.
5. Check and test: it's always a good practice to check and test your translation to make sure it makes sense and it is representing the idea of the original sentence.

It is important to note that translating complex sentences into propositional logic can be an iterative process, and it may take some practice to get the hang of it. With practice and experience, you will become more proficient at identifying key words and phrases and applying the appropriate logical operators.

Here are some examples of more complex sentences, along with possible translations:

| | |
|---|---|
| "If Harry Potter is a wizard, then he can perform magic, but if he is not a wizard, then he cannot perform magic." | (HPwizard -> HPMagic) ^ (~HPwizard -> ~HPMagic) |
| "Either the dragon is asleep or it is awake, but if the dragon is awake, then it is not friendly." | (DAsleep V DAwake) ^ (DAwake -> ~DFriendly) |
| "The ring can only be worn by someone pure of heart, but it's not the case that only pure hearted people can wear the ring." | (Ring -> PureHeart) ^ ((PureHeart -> Ring)) |
| "Luke Skywalker is not a Sith and Darth Vader is not Luke Skywalker's father" | (~LSith ^ ~LSfather) |
| "The hobbits will not leave without the ring and Gandalf can only open the door if the ring is with him." | (~HLRing ^ (Ring -> GDoor)) |

## Well-Formed Formulas and Main Operators

In propositional logic, a "well-formed formula" (WFF) is a string of symbols that conforms to the rules of the logical system. A WFF is a formula that can be evaluated for truth or falsity based on the truth values of its propositional variables. It must have a logical structure, meaning that it should be composed of propositional variables, logical connectives and parentheses in a logical way. So, consider the following examples:

"WBlack" : This formula is well-formed because it contains only one propositional variable "WBlack" which is complete in itself and doesn't require any logical connective to be evaluated.

"WBlack ∧" : This formula is not well-formed because it is missing one of the two arguments required for the binary operator ∧ (conjunction) to function. A conjunction requires two propositional variables to be complete.

"∨ WBlack" : This formula is not well-formed because it is missing one of the two arguments required for the binary operator ∨ (disjunction) to function. A disjunction requires two propositional variables to be complete.

"~WBlack WTaco" : This formula is not well-formed because it contains two negation operators "" applied to two propositional variables, but negation is a unary operator that only applies to one propositional variable.

"(WBlack ∧WTaco" : This formula is not well-formed because it is missing a closing parenthesis, it doesn't indicate the end of the logical grouping and that can change the meaning of the formula.

"WBlack ∧ WTaco))" : This formula is not well-formed because it contains too many closing parentheses which makes it difficult to understand the logical grouping of the propositional variables.

"WBlack ∧ (WTaco ∨ WHunger)" : This formula is well-formed, it contains two propositional variables "WBlack" and "WTaco" and "WHunger" and logical connectives appropriately used.

The **main operator** in a compound formula (a formula with more than one operator) is the logical connective that determines the overall truth value of the formula. This means that it is the operator that is applied last in the order of operations. The main operator is the one that connects the sub-formulas together in order to create the compound proposition. The main operator is not necessarily the operator that appears at the beginning or the end of the formula, it is the one that is used to connect the sub-formulas or propositional variables together.

Here are three examples of compound formulas with distinct propositions and their main operator:

- "((P ∧ Q) ∨ R) ⊃ S" where P, Q, R, and S are distinct propositions. The main operator in this formula is the conditional operator (⊃) because it connects the sub-formulas "(P ∧ Q) ∨ R" and "S" together, creating the compound proposition and indicating that the truth of "(P ∧ Q) ∨ R" implies the truth of "S".
- "(P ∨ (Q ∧ R)) ≡ S" where P, Q, R, and S are distinct propositions. The main operator in this formula is the material equivalence operator (≡) because it connects the sub-formulas "(P ∨ (Q ∧ R))" and "S" together, creating the compound proposition and indicating that the truth of "~(P ∨ (Q ∧ R))" is equivalent to the truth of "S"
- "(P ⊃ Q) ∨ (R ⊃ S)" where P, Q, R, and S are distinct propositions. The main operator in this formula is the disjunction operator (∨) because it connects the sub-formulas "(P ⊃ Q)" and "(R ⊃ S)" together, creating the compound proposition and indicating that the truth of "(P ⊃ Q)" or "(R ⊃ S)" is sufficient to create the compound proposition.

In all of these examples, the main operator is the one that connects the sub-formulas together and determines the overall truth value of the compound formula. It is important to understand the main operator as it allows us to understand the overall logical structure of the formula and how the propositional variables relate to each other. This is crucial to evaluate the truth value of the formula based on the truth values of the propositional variables.

Finally, a note on **variable names.** When working with propositional logic, it is important to choose variable names that accurately represent the proposition they stand for. There are two main conventions for naming propositional variables: single letter names and more descriptive names.

Single letter names, such as "P", "Q", and "R" are commonly used in propositional logic because they are easy to read and write. They also require less space and can make formulas less cluttered. However, they may not be as easily understandable or memorable as more descriptive names.

More descriptive names, such as "IsRainy", "HasFuel", "IsHappy" are more meaningful and make it easier to understand the proposition they represent. They are also more memorable and can make it easier to keep track of multiple propositions within a formula. However, they can make formulas more cluttered and harder to read.

It is important to note that the choice of variable names is a matter of personal preference and what is most suitable for the purpose of the problem. It is important to be consistent in the choice of variable names within a

given problem, and to keep in mind that the variables in propositional logic only represent the values of TRUE or FALSE and nothing else.

## EXERCISES: BASIC TRANSLATION

Here some exercises for you to try out your translation skills

1. "The dragon is awake."
2. "Luke Skywalker is a Jedi."
3. "The ring is not pure."
4. "It is not the case that Gandalf is a wizard."
5. "The hobbits will leave with the ring."
6. "If the dragon is awake then it is not friendly."
7. "Either the dragon is asleep or it is not friendly."
8. "The portal can only be opened by someone with the key, but it's not the case that only people with the key can open the portal."
9. "Leia is a princess and Han Solo is a smuggler."
10. "It is not the case that Leia is a princess and Han Solo is a smuggler."
11. "Leia is a princess or Han Solo is a smuggler."
12. "If Leia is a princess then Han Solo is a smuggler."
13. "Leia is a princess if and only if Han Solo is a smuggler."
14. "Neither Leia nor Han Solo is a princess."
15. "The sword in the stone can only be pulled out by the true king."

## TRUTH TABLES: AND, OR, NOT

A truth table is a tool used in propositional logic to determine the truth value of a compound proposition based on the truth values of its propositional variables. It is a table that lists all possible combinations of truth values for the propositional variables, and the corresponding truth value of the compound proposition.

A **possible world** is a state of affairs or a scenario in which certain propositions are considered true and certain propositions are considered false. For example, if we have an argument with just two propositions, P and Q, then there are exactly FOUR possible worlds we need to be concerned with, with each world representing a different combination P's being true/false and Q's being true/false.

Each row of a truth table represents a possible world and the corresponding truth value of the compound proposition. For example, let's say we have a compound proposition "P ∧ Q" (P and Q). The truth table for this proposition would have two columns, one for P and one for Q. Each row represents a possible world, and the truth value of the compound proposition is determined by the truth values of P and Q in that world.

| P | Q | P ∧ Q |
|---|---|---|
| T | T | T |
| T | F | F |
| F | T | F |
| F | F | F |

For example, let's say P represents the proposition "The sky is clear" and Q represents the proposition "The sun is shining". The possible world where both P and Q are true corresponds to a sunny day with a clear sky. The possible world where P is true and Q is false corresponds to a clear day but with no sun. As you can see from the truth table, the compound proposition "P ∧ Q" is only true when both P and Q are true.

Similarly, for the compound proposition "P ∨ Q" (P or Q) the truth table would look like this:

| P | Q | P ∨ Q |
|---|---|---|
| T | T | T |
| T | F | T |
| F | T | T |
| F | F | F |

This truth table represents all possible world, or combinations of P and Q. For example, suppose that P represents the proposition "It's raining" and Q represents the proposition "It's snowy". The SECOND row of this truth table (where P is true and Q is false) corresponds to a possible world where it is raining but not snowing.

It's important to note that truth tables can be used to evaluate any well-formed formula with any number of propositional variables and logical operators. These tables represent all possible worlds and the corresponding truth values of the formula, providing a systematic way to evaluate the logical consistency of the formula.

The truth table for NOT represents the negation of a proposition. The negation of a proposition is represented by the symbol "~" or "¬". It is a unary operator (unlike the binary operators AND or OR), meaning it operates on only one propositional variable. The truth table for NOT has two columns, one for the propositional variable and the other for its negation.

Here is the truth table for NOT:

| P | ~P |
|---|---|
| T | F |
| F | T |

In this table, P represents the original proposition, and ~P represents the negation of that proposition. As you can see, the truth value of the negation of a proposition is the opposite of the original proposition. If P is true, ~P is false, and if P is false, ~P is true.

For example, let's say P represents the proposition "The sky is blue." The negation of this proposition, ~P, would be "The sky is not blue." In the truth table, P is true when the sky is blue, but its negation ~P is false. If P is false, that means the sky is not blue, and its negation ~P is true.

It's important to note that the truth table for NOT only have two possible worlds, one where the propositional variable is true and the other where it is false, because the NOT operator only negates the truth value of the propositional variable, it doesn't add any new possibility.

## Truth Tables for Conditional Statements and Material Equivalence

Material implication and material equivalence (like conjunction and disjunction) are binary operators, meaning they operate on two propositional variables.

Material implication, represented by the symbol "⊃" (or ->), is a compound proposition that states that if the first propositional variable is true, then the second propositional variable must also be true. The truth table for material implication has three columns, one for the first propositional variable (P), one for the second propositional variable (Q), and the last one for the compound proposition (P ⊃ Q).

Here is the truth table for material implication:

| P | Q | P ⊃ Q |
|---|---|---|

| | | |
|---|---|---|
| T | T | T |
| T | F | F |
| F | T | T |
| F | F | T |

As you can see from the truth table, the compound proposition "P ⊃ Q" is only false when P is true and Q is false. In all other cases, it is true. This means that if P is true, then Q must also be true.

Material equivalence, represented by the symbol "≡", is a compound proposition that states that the first propositional variable and the second propositional variable have the same truth value. The truth table for material equivalence has three columns, one for the first propositional variable (P), one for the second propositional variable (Q), and the last one for the compound proposition (P ≡ Q).

Here is the truth table for material equivalence:

| P | Q | P ≡ Q |
|---|---|---|
| T | T | T |
| T | F | F |
| F | T | F |
| F | F | T |

As you can see from the truth table, the compound proposition "P ≡ Q" is true only when P and Q have the same truth value. This means that the compound proposition is true if both P and Q are true or if both P and Q are false.

It's important to note that material implication and material equivalence are different operators, and they express different logical relations between two propositional variables. Material implication is often misunderstood as a stronger version of material equivalence, where if P is true, then Q must be true. However, this is not the case, as material implication only states that if P is true, Q might be true. Material equivalence, on the other hand, states that P and Q have the same truth value.

Also, it's important to be careful when interpreting the truth table for material implication, as P ⊃ Q is true when P is false. It doesn't mean that P is false and Q is true. It means that the statement "if P then Q" is true because the antecedent (P) is not true, so it's not possible to affirm if the consequent (Q) is true or false, so the implication is trivially true.

## Using Truth Tables to Prove Validity or Invalidity

**Truth tables** can be used to assess the deductive validity or invalidity of arguments in propositional logic. A valid argument is one where the truth of the premises guarantees the truth of the conclusion. In other words, if the premises are true, then the conclusion must also be true.

When using truth tables to assess the validity of an argument, we start by creating a truth table for the compound proposition that represents the argument. This truth table lists all possible combinations of truth values for the propositional variables, and the corresponding truth value of the compound proposition.

For example, let's say we have the following argument:

- Premise 1: P
- Premise 2: Q
- Conclusion: P ∧ Q

To assess the validity of this argument, we would create a truth table for the compound proposition "P ∧ Q", which represents the conclusion of the argument. This truth table would have two columns, one for P and one for Q. We would then fill in the truth values of P and Q based on the truth values given in the premises.

In this case, the truth table would look like this:

| P | Q | P ∧ Q |
|---|---|---|
| T | T | T |
| T | F | F |
| F | T | F |
| F | F | F |

As you can see, the compound proposition "P ∧ Q" is ALWAYS true whenever both P and Q are true. In the lines where it is false (the 2nd, 3rd, and 4th rows), at least one of the premises is false as well. This means that if the premises are true, the conclusion must also be true, and the argument is valid.

It's important to note that possible worlds are represented in the truth table, and a valid argument is one that holds in all possible worlds. In other words, an argument is valid if there does NOT exist a world where the premises are true and the conclusion is false.

In the same way, if we have an invalid argument, we can use truth tables to identify a possible world where the premises are true but the conclusion is false, showing that the argument is not valid.

**Showing Invalidity.** To show the invalidity of the argument ~(P & Q). So, ~P & ~Q, we can construct a truth table with the following steps:

1. Create columns for each propositional variable (P, Q) and the compound statements (~(P & Q), ~P, ~Q, and ~P & ~Q).
2. Fill in the truth values of P and Q in the first two columns, using all possible combinations of T (true) and F (false).
3. Use the logical operators in the argument to fill in the truth values of the compound statements in the remaining columns. For example, the truth value of ~(P & Q) is the opposite of the truth value of (P & Q), and the truth value of ~P is the opposite of the truth value of P.
4. Compare the truth value of the two statements in the argument (~(P & Q) and ~P & ~Q). If you can find a row where the PREMISES are true and the CONCLUSION is false, the argument is invalid. Otherwise, it is valid.
5. In this case, the truth table will show you that, in one case, the statement (~(P & Q)) is true and the statement (~P & ~Q) is false, this means that the argument is invalid.

Here is a truth table for the argument ~(P & Q) // ~P & ~Q:

| P | Q | ~(P & Q) | ~P & ~Q |
|---|---|---|---|
| T | T | F | F |
| T | F | T | F |
| F | T | T | T |
| F | F | T | T |

The truth table shows that the argument is invalid because the compound statements ~(P & Q) and ~P & ~Q have different truth values for at least one combination of truth values of P and Q (the second row, where the first statement is T and the second statement is F).

## Natural Deduction Proof Methods

**Natural deduction** is a method of proof in propositional logic that uses a set of rules to deduce new statements from a set of premises. A rule of implication, also called an inference rule, is a way to deduce a statement from one or more other statements. One example of a rule of implication is modus ponens.

Modus ponens states that if a statement of the form "if P then Q" (written as P -> Q) and P are both true, then Q must also be true. For example, if we have the premise "if it is raining then the ground is wet" (written as R -

> W) and the additional information that "it is raining" (written as R), we can deduce that "the ground is wet" (written as W) must also be true.

To prove that a conclusion follows from a set of premises, we can repeatedly apply a rule of implication to the premises and the previously inferred statements. For example, starting from the premises "P", "P -> Q" and "Q -> R", we can infer Q using modus ponens, and then infer R using modus ponens again. This results in the conclusion "P -> R". We could write this proof as follows:

To show: R

1. P # Premise
2. P -> Q # Premise
3. Q -> R # Premise
4. Q # From 1 and 2 by Modus ponens
5. R # From 4 and 3 by Modus ponens # QED

QED stands for "quod erat demonstrandum" which is Latin for "that which was to be demonstrated." It is used to indicate the end of a proof and that the conclusion has been rigorously proven.

In this proof, we have used the premises P, P->Q and Q->R, as well as the rule of implication Modus ponens, to deduce that R is true. The conclusion is marked by the QED which indicates that the proof is complete and the goal of the proof has been achieved.

Natural deduction lies beyond the scope of this book. There many excellent, free books that teach natural deduction (and other proof methods, such as trees) for propositional predicate logic. An especially good one is forallx : https://forallx.openlogicproject.org/.

# Appendix: Answers to Selected Exercises

## Chapter 1: Identifying Arguments

1. Premise: There is overwhelming evidence that climate change is real and caused by human activity.
   Premise: The Earth's average temperature has risen, sea levels are rising, and extreme weather events are becoming more frequent.
   Conclusion: We must take action to reduce our carbon emissions.
2. Premise: Reading books has numerous benefits for both children and adults.
   Premise: It can improve vocabulary, increase concentration and critical thinking skills, and even reduce stress.
   Conclusion: It is important for everyone to make time for reading in their daily routine.
3. Premise: Many of the college students surveyed reported feeling overwhelmed by the workload.
   Conclusion: Most college students experience similar levels of stress or anxiety when faced with large amounts of coursework.
4. Premise: Research into study habits among university undergraduates found that those who study more higher grades than those who do not invest as much time in their studies.
   Conclusion: Students who spend more time studying will have higher grades than those who do not invest as much time in their studies.
5. This passage does not contain a conclusion or a claim being made, so it is not an argument. It is simply providing information about the topic of GMOs and the differing opinions about them. It does not attempt to prove or support a particular viewpoint or claim.
6. This passage does not contain a conclusion or a claim being made, so it is not an argument. It is simply providing information about a fact that pertains to college students. It does not attempt to prove or support a particular viewpoint or claim.

## Chapter 2: Classifying Arguments

1. Conclusion: Kale smoothies are probably delicious. This argument is an inductive-strong argument because it is using evidence from a specific sample (the friends of the person making the argument and the "majority") to make a claim about a larger population (kale smoothies in general). The sample is representative and the evidence is strong, so the conclusion is likely to be true. However, it is not a deductive argument because the conclusion does not necessarily follow necessarily from the premises. It is possible that the friends are mistaken or that their experience is not representative of the larger population.
2. Conclusion: I need a soccer ball. This argument is a deductive-valid argument because the conclusion necessarily follows from the premises. If the premise "If you want to play soccer, then you need a soccer ball" is true, and the premise "I do want to play soccer" is also true, then the conclusion "I need a soccer ball" must be true as well. This is a valid deductive argument because the conclusion follows logically from the premises.
3. Conclusion: Soccer players in the larger population probably train rigorously and have a strong diet and exercise regimen. This argument is an inductive-strong argument because it is using evidence from a specific sample (the professional soccer players the person making the argument has observed) to make a claim about a larger population (soccer players in general). The sample is representative and the evidence is strong, so the conclusion is likely to be true. However, it is not a deductive argument because the conclusion does not necessarily follow necessarily from the premises. It is possible that the sample is not representative of the larger population or that the observations are not accurate.
4. Conclusion: I should eat a balanced diet and exercise regularly. This argument is a deductive-valid argument because the conclusion necessarily follows from the premises. If the premise "If you want to be healthy, then you should eat a balanced diet and exercise regularly" is true, and the premise "I want to be healthy" is also true, then the conclusion "I should eat a balanced diet and exercise regularly" must be true as well. This is a valid deductive argument because the conclusion follows logically from the premises.
5. Conclusion: All German people are extremely good looking. This argument is an inductive-weak argument because it is using evidence from a specific sample (professional German soccer players) to make a claim about a larger population (all German people). The sample is not representative of the larger population, as it only includes a specific group of people within Germany, so the conclusion is not likely to be true. Additionally, the evidence is not particularly strong, as it is based on the personal observations of the person making the argument, so the conclusion is not well-supported.

6. Conclusion: You will probably enjoy Chef Beatrice's pancakes. This argument is an inductive-strong argument because it is using evidence from a specific sample (culinary experts who have tried Chef Beatrice's pancakes) to make a prediction about a particular individual (you). The evidence is strong, providing good reason to believe the conclusion. However, it is not a deductive argument because the conclusion does not necessarily follow necessarily from the premises. The conclusion is still subject to defeat by countervailing evidence or objections. It is also not a generalization from a sample to a population, as the argument is specifically about the individual in question and not about a larger group.

## CHAPTER 3: IDENTIFYING FALLACIES

1. The fallacy committed in this argument is an ad hominem fallacy. In this case, the argument dismisses the Theory of Evolution because of Charles Darwin's personal views and flaws, rather than evaluating the theory on its own merits. To make the argument better, the argument could focus on the evidence for and against the Theory of Evolution, rather than attacking Charles Darwin as a person.
2. This argument commits the fallacy of division. In this case, the argument assumes that because Rapunzel's hair is strong enough to support Mother Gothel's weight as a whole, each individual strand must also be able to support Mother Gothel's weight. This is not necessarily true, as the strength of the hair as a whole does not necessarily translate to the strength of the individual strands. To make the argument better, the argument could provide evidence or a logical explanation for why the strength of the hair as a whole would translate to the strength of the individual strands.
3. The fallacy committed in this argument is an appeal to pity fallacy. In this case, the argument tries to convince the audience to give the speaker money by appealing to the audience's pity for the speaker's difficult situation. To make the argument better, the speaker could present evidence or reasons for why the audience should give them money, rather than trying to evoke pity.
4. The fallacy committed in this argument is a complex question fallacy. In this case, the argument assumes that Professor Ratigan's plot was "terrible, evil, and stupid," which has not been proven or accepted as true. To make the argument better, the argument could state the premise that Professor Ratigan's plot was "terrible, evil, and stupid" and provide evidence to support this premise before asking whether Professor Ratigan would admit that the plot was wrong.
5. The fallacy committed in this argument is a false dichotomy fallacy. In this case, the argument presents the options of Gaston marrying Belle or Belle ending up with no one at all, implying that these are the only two possibilities. However, there may be other options available, such as Belle ending up with someone else. To make the argument better, the argument could consider and address other potential options.
6. The fallacy committed in this argument is an appeal to force fallacy. In this case, the argument threatens to spread lies about the character of the person being addressed and to ensure that they are not hired again if the person does not help falsify financial documents. To make the argument better, the argument could present evidence or reasons for why the person should help falsify the documents, rather than threatening force or intimidation.

## CHAPTER 4: MORE FALLACIES

1. The fallacy committed in this argument is a hasty generalization fallacy. In this case, the argument concludes that most homeowners have installed a home security system based on a survey of only 10 homeowners in a high-crime area. This sample is not representative of homeowners in general, and the small sample size is insufficient to support the conclusion. To make the argument better, the argument could provide more evidence or a larger, more representative sample to support the conclusion.
2. The fallacy committed in this argument is a slippery slope fallacy. In this case, the argument suggests that allowing people to keep exotic pets will lead to a series of increasingly bizarre and dangerous events, without providing any evidence or logical reasoning to support this claim. To make the argument better, the argument could provide evidence or logical reasoning to support the claim that allowing people to keep exotic pets will lead to these negative consequences.
3. The fallacy committed in this argument is a post hoc fallacy. In this case, the argument assumes that because the speaker has been using herbal supplements and has noticed an improvement in cognitive function, the herbal supplements must be the cause of the improvement. However, there may be other factors that could have caused the improvement, and the argument does not consider these alternative explanations. To make the argument better, the argument could provide evidence or consider other potential explanations for the improvement in cognitive function.

4. The fallacy committed in this argument is an appeal to inappropriate authority fallacy. In this case, the argument appeals to a book as an authority on the subject of Jews controlling everything, without providing any evidence or reasoning to support the claim. The book is almost certainly not a reliable or credible source of information on this subject. To make the argument better, the argument could provide evidence or reasoning to support the claim, rather than relying on an inappropriate authority (and better sources would almost certainly discredit this way of reasoning).
5. The fallacy committed in this argument is a hasty generalization fallacy. In this case, the argument concludes that you can never trust a Slytherin based on the characteristics of three individuals (Draco Malfoy, Pansy Parkinson, and Blaise Zabini). This small sample is not representative of Slytherins in general, and the argument does not consider the possibility that there may be trustworthy Slytherins. To make the argument better, the argument could provide more evidence or a larger, more representative sample to support the conclusion. Additionally, it would be important to recognize that making judgments about the trustworthiness of individuals based on their membership in a particular group is generally problematic and can lead to discrimination. Instead, it would be more reasonable to consider the actions or characteristics of individuals as unique to those individuals, rather than ascribing them to an entire group.
6. The fallacy committed in this argument is a slippery slope fallacy. In this case, the argument suggests that allowing athletes to use performance-enhancing drugs will lead to a series of increasingly bizarre and unrealistic events, without providing any evidence or logical reasoning to support this claim. To make the argument better, the argument would need to provide more detailed defense of each claimed "link" in the chain.

## CHAPTER 5: FLYING SPAGHETTI MONSTER

Arguments For

1. This argument is not successful in proving the existence of the Flying Spaghetti Monster. It relies on the assumption that the natural world displaying complex design must be the result of a deity, and specifically the Flying Spaghetti Monster. However, this assumption is not necessarily true, as there may be other explanations for the complexity of the natural world. Additionally, the argument uses personal anecdotes and subjective experiences, such as the enjoyment of rainbows and puppies, as evidence for the existence of the Flying Spaghetti Monster. These personal experiences are not necessarily relevant or reliable in determining the existence of a deity.
2. This argument is not successful in proving the existence of the Flying Spaghetti Monster. It relies on personal experiences and encounters with the deity, which are subjective and cannot be verified by others. While the experiences described in the argument may be genuine, they do not provide conclusive evidence for the existence of the Flying Spaghetti Monster. Personal experiences and encounters are not necessarily reliable indicators of the existence of a deity.

Arguments Against

8. This argument is successful in providing a reason to doubt the existence of the Flying Spaghetti Monster. It points out that there is no empirical evidence for the existence of the Flying Spaghetti Monster, and that the claims of people who claim to have seen the creature are not verifiable by science. It also points out that the Flying Spaghetti Monster has not been seen by the person making the argument or by others, which suggests that the creature may be hiding or may not actually exist. These are all good reasons to doubt the existence of the Flying Spaghetti Monster.
9. This argument is successful in providing a reason to doubt the existence of the Flying Spaghetti Monster. It points out that there is no logical necessity for the existence of such a creature, and that the idea of the universe being created by a giant noodle-like creature that loves pasta and beer does not make sense. These are good reasons to doubt the existence of the Flying Spaghetti Monster.

Arguments for Withholding Judgment

15. This argument suggests that just because there is currently no concrete scientific evidence for the existence of the Flying Spaghetti Monster, that doesn't necessarily mean it doesn't exist. The argument points out that there may be other ways to understand the world beyond traditional methods of scientific inquiry. It is not irrational to withhold judgement on a belief until there is concrete evidence

for it. However, it is not rational to believe in something for which there is no evidence simply because traditional methods of scientific inquiry have not yet proven it to be false. (And so, this argument fails).

16. This argument suggests that the fact that the Flying Spaghetti Monster is said to have an insatiable appetite for pasta and beer is actually endearing, and that this is a reason to not completely dismiss the idea of its existence. However, the fact that the Flying Spaghetti Monster enjoys pasta and beer does not provide any evidence or reasoning to support the claim that it actually exists. Belief in the Flying Spaghetti Monster (or in its "possibility") should not be based on personal preferences or endearing characteristics, but rather on evidence and reasoning.

## CHAPTER 6: MORAL REASONING

1. This argument appeals to Kantian Ethics to argue that we should respect the dignity of others and that controlling access to guns is a way to do this by protecting the lives and safety of our fellow citizens. The conclusion of this argument is that we should support gun control. The argument is strong, as it presents a clear moral reason for supporting gun control. However, other Kantians might challenge the premise that gun control is an expression of respect for the dignity of others by arguing that the right to bear arms is a fundamental human right that should not be restricted.
2. This argument uses to Divine Command Theory argues that gun rights are given to us directly by God and that laws restricting access to guns are therefore immoral. The Bible is cited as evidence for this claim. The conclusion of this argument is that we should not support gun control. The argument would fail to convince those who do not believe in the authority of the Bible or who do not subscribe to the belief in a deity who gives us moral commands. Additionally, the premise that the Bible urges us to protect ourselves and our families from harm may be challenged by those who interpret the text differently or who believe that there are other ways to protect ourselves and our families that do not involve the use of guns.
3. This argument from Kantian Ethics also argues that gun control violates the inherent dignity of those who wish to own firearms by denying them the opportunity to exercise their autonomy and self-determination. The conclusion of this argument is that we should not support gun control. The argument might challenged (on Kantian grounds) by those who believe that the government has a responsibility to protect its citizens from harm and that restricting access to guns is a necessary measure to achieve this goal. Additionally, the premise that gun control treats people as mere "tools" for the government's own purposes may be challenged by those who do not see gun control as an inherently disrespectful act.
4. The argument in favor of gun control using Divine Command Theory concludes that laws restricting access to guns are immoral because they go against God's commands in the Bible. The argument cites specific passages in the Bible to support this claim. The argument may be strong for individuals who believe in the authority of the Bible and the existence of God. However, it will fail to convince those who do not believe in the Bible or God.
5. The argument in favor of gun control using Utilitarianism concludes that gun control laws are necessary because they maximize overall happiness and well-being by reducing gun violence. The argument cites the negative impacts of gun violence as evidence for this claim. The evidence cited by the argument: that gun violence is a serious problem and that gun control can help reduce it, would be good reason to support gun control (if true). However, the argument may not address other potential consequences of enacting or not enacting gun control laws, such as the impact on individuals' rights or the effectiveness of alternative approaches to reducing gun violence. Some overlooked evidence that may be relevant to this argument includes data on the effectiveness of different gun control measures, as well as the potential costs and benefits of implementing these measures
6. The argument against gun control using Ethical Egoism concludes that it is not in the individual's long-term self-interest to support gun control because it denies them the opportunity to protect themselves and their families from harm and strips them of their right to self-defense. The argument cites the importance of self-protection and self-defense as evidence for this claim. The argument might convince individuals who prioritize their own self-interest and safety above other considerations. However, the argument does not address the concerns of *other* people, such as the harm that gun violence can cause to others, the potential benefits of gun control for society as a whole, or the value of respecting the rights of others. To make the argument stronger, the individual could consider the potential negative consequences of gun violence on others and the potential positive consequences of gun control for

society, as well as the value of respecting the rights of others. These are concerns that may be important to other most ethical theories, such as Kantian Ethics or Utilitarianism.

## CHAPTER 7: PROBABILITY

1. The probability that Shelby will support a Democrat or Republican is 9/10 because 5/10 + 4/10 = 9/10.
2. The probability that the stock market will not crash is 9 in 10 because 1 - 1/10 = 9/10.
3. The probability of rain OR snow is 0.75 because 0.5 + 0.5 - 0.25 = 0.75.
4. The probability that the student will pass both tests is 0.3 because 0.5 x 0.6 = 0.3.
5. The probability that a randomly selected student is both red-haired and sensitive to the sun is 0.1 because (1/10) x (1/2) = 1/20 = 0.1.
6. The overall probability of having that type of cancer is 8% because (0.2 x 0.4) + (0.05 x 0.6) = 0.08 = 8%.

## CHAPTER 7: BAYES THEOREM

Problem 1:

- H: Bob has heart condition
- E: Abnormal electrocardiogram
- Pr(H): 10%
- Pr(~H): 90%
- Pr(E|H): 90%
- Pr(E|~H): 5%
- Pr(E): (0.1)(0.9) + (0.9)(0.05) = 0.135
- Pr(H|E) = (Pr(E|H) * Pr(H)) / Pr(E) = (0.9 * 0.1) / 0.135= 0.67

Probability that Bob has the disease is approximately 67%. Based on these results, it would be appropriate for Bob or his doctor to pursue further testing or treatment for a potential heart condition.

Problem 2:

- H: Kim has food allergy
- E: Positive skin prick test
- Pr(H): 0.08
- Pr(~H): 0.92
- Pr(E|H): 0.95
- Pr(E|~H): 0.01
- Pr(E): (0.08)(0.95) + (0.92)(0.01) = 0.0852
- Pr(H|E) = (Pr(E|H) * Pr(H)) / Pr(E) = (0.95 * 0.08) / 0.0852 = 0.892

Probability that Kim has the allergy is approximately 89.2%. With these test results, it would be appropriate to follow up with further testing or even begin treatment for a potential food allergy.

Problem 3:

- H: Tom's coin is rare
- E: Expert identified coin as rare
- Pr(H): 2%
- Pr(E|H): 90%
- Pr(E|~H): 1%
- Pr(~H): 98%
- Pr(E): (0.02)(0.90) + (0.98)(0.01) = 0.0278
- Pr(H|E) = (Pr(E|H) * Pr(H)) / Pr(E) = (0.02)(0.90) / 0.0278 = 0.647

The chance that Tom's coin is rare is 64.7%. It would be appropriate for him to conduct more tests to ascertain the coin's rareness.

## CHAPTER 8: SCIENTIFIC REASONING

**Case 1: The Size of the Earth**

1. The hypothesis of Eratosthenes' experiment was that he could use the angle of the sun's light in Alexandria on the summer solstice and the distance between Alexandria and Syene to calculate the Earth's circumference.
2. Some possible alternative or competing hypotheses that Eratosthenes could have considered were that the Earth was not spherical or that the sun's light did not always cast the same angle in different locations.
3. Eratosthenes used the angle of the sun's light in Alexandria and the distance between Alexandria and Syene as evidence to test his hypothesis.
4. Eratosthenes used the evidence to confirm his hypothesis by multiplying the distance between the two cities by 50, as the angle of the sun's light in Alexandria was 1/50th of a full circle. This calculation allowed him to gauge the Earth's curvature and determine its circumference.
5. This experiment was scientifically important because it provided the first recorded measurement of the Earth's circumference, which helped to advance the understanding of the world and its geographical features. It also demonstrated the use of the scientific method to test a hypothesis and make a groundbreaking discovery.

## CHAPTER 9: CONSPIRACY THEORIES

**Case 2: The JFK Assassination**

1. The mainstream hypothesis about the JFK assassination is that Lee Harvey Oswald acted alone in the assassination.
2. The evidence that supports the mainstream hypothesis about the JFK assassination includes eyewitness testimony, physical evidence, the analysis of bullets, the investigation of Lee Harvey Oswald's background, and the investigation of his actions before and after the assassination. The Warren Commission and several subsequent investigations have also concluded that Lee Harvey Oswald acted alone in the assassination.
3. Some of the fallacious strategies that the JFK assassination conspiracy theorists use to disregard the findings of government reports and academic researchers include alleging the government investigations were flawed or incomplete, disputing the ballistics evidence, suggesting the existence of a cover-up, and questioning the credibility of witnesses. They also claim that all the people involved in the official investigation were part of the conspiracy, which makes their claims unfalsifiable.
4. The Warren Commission's investigation of the JFK assassination was conducted through a thorough examination of the available evidence, including eyewitness testimony, physical evidence, and analysis of bullets. They also investigated Lee Harvey Oswald's background and actions before and after the assassination.
5. The Warren Commission's main findings about the JFK assassination were that there was no evidence of a conspiracy and that Lee Harvey Oswald acted alone in the assassination.
6. The physical evidence found at the scene of the JFK assassination included bullets and cartridge cases, which were matched to the rifle found in the sixth-floor window of the Texas School Book Depository building and linked to Lee Harvey Oswald.

## CHAPTER 10: MEASURES OF CENTRAL TENDENCY

1. The mean of the test scores is 85.83, the median is 85, and the mode is 85 and 100.
2. The mean of the number of tickets won is 17.86, the median is 15, and the mode is 10 and 15.
3. The mean, median, and mode would all be representative measures of the typical price of milk. However, the median might be the most representative measure because it is less affected by outliers or extreme values.
4. The sample of college students gathered by the researcher is not likely to be representative of all college students because it only includes students who happened to walk past the booth on a busy street corner. To improve the sampling technique, the researcher could try to gather data from a more diverse group of students, such as by conducting the survey online or by visiting multiple locations on campus. They could also try to randomly sample students from a list of all college students to ensure that the sample is more representative.

## CHAPTER 10: STATISTICAL REASONING

1. The range is 8. The standard deviation is 3.42.

2. The range is 9. The standard deviation is 3.92.

6.
a. The percentage of the sample that prefers Burger King (45%) tells us that Burger King is the most preferred fast food chain among college students.

b. The margin of error (plus or minus 2%) impacts the precision of the results of the poll by providing a range in which the true population proportion of preferences lies. For example, the true proportion of college students that prefer Burger King could range from 43% to 47%.

c. The confidence level (95%) indicates that there is a 95% probability that the poll results accurately reflect the preferences of college students (though only the assumption our sampling methods are perfect).

d. If the sample size for the poll was 500 instead of 1000, this would likely affect the precision and accuracy of the results due to the reduced sample size. The margin of error would also likely be larger due to the smaller sample size.

e. If the sample was not representative of the entire population of college students (e.g. if it only included students from a specific major or school), then the results of the poll may not accurately reflect the preferences of college students as a whole.

f. If the poll had a confidence level of 99% instead of 95%, this would increase our confidence in the results as it would indicate that there is a greater probability that the poll results accurately reflect the preferences of college students.

g. If the sample consisted of people of all ages rather than just college students, the results of the poll may be different as different age groups may have different preferences.

h. If the poll had a margin of error of plus or minus 4% instead of plus or minus 2%, this would decrease the precision of the results as the range in which the true population proportion of preferences lies would be larger.

## CHAPTER 11: A LITTLE HISTORY OF FORMAL LOGIC

**Categorical Logic**

1. Since some delicious meals (P) are colorful parrots (M) and some colorful parrots (M) are sparkly rainbows (S), it follows that some sparkly rainbows (S) are not delicious meals (P).
    a. Form: Some P are M. Some M are S. So, some S are not P.
    b. Mood: II0 (Some, Some, Some are not)
    c. Figure 4 (P before M, M before S)
    d. IIO-4 is not valid!

2. Since some squirming worms (M) are refreshing drinks (P) and some squirming worms (M) are glowing fireflies (S), it follows that some glowing fireflies (S) are refreshing drinks (P).
    a. Form: Some M are P. Some M are S. So, Some S are P.
    b. Mood: III. (Some, Some, Some)
    c. Figure 3 (M before P. M before S.)
    d. III-3 is not valid!
3. Since some scampering squirrels (M) are floating balloons (P) and no dancing bears (S) are scampering squirrels (M), it follows that some dancing bears (S) are not floating balloons (P).
    a. Form: Some M are P. No S are M. So, some S are not P.
    b. Mood: IEO (Some, Some, Some are not)
    c. Figure 1: M before P. S before M.
    d. IEO-1 is not valid!
4. Since no cheering crowds (M) are flying saucers (P) and some cheering crowds (M) are fluffy clouds (S), it follows that some fluffy clouds (S) are not flying saucers (P).
    a. Form: No M are P. Some M are S. Some S are not P.
    b. Mood: EIO (No, Some, Some are not)
    c. Figure 2: M before P. M before S.
    d. EIO-2 is valid!
5. Since some floating balloons (M) are not cheering crowds (P) and some floating balloons (M) are magical potions (S), it follows that some magical potions (S) are cheering crowds (P).
    a. Form: Some B are not P. Some M are S. So, some S are P.
    b. Mood: OII (Some are not, Some, Some)
    c. Figure 2: M before P. M before S.
    d. OII-2 is not valid.

**Propositional Logic**

1. If carrots can sing opera then hippopotamuses can solve Rubik's cubes in under a minute. It is false that carrots can sing opera. Therefore, it is false that hippopotamuses can solve Rubik's cubes in under a minute.
    a. Form: If C then H. Not C. Therefore, not H.
    b. This is an INVALID argument form (called "denying the antecedent").
2. Either giraffes can speak fluent French, or raccoons can hack into computer systems. If giraffes can speak fluent French, then crocodiles can do advanced calculus. If raccoons can hack into computer systems then yaks can do parkour. Therefore, crocodiles can do advanced calculus or yaks can do parkour.
    a. Form: G or R. If G then C. If R then Y. So, C or Y.
    b. Valid (Constructive dilemma).
3. If invisible dinosaurs still roam the earth then carrots can sing opera. Invisible dinosaurs still roam the earth. Therefore, carrots can sing opera.
    a. Form: If D then C. D. So, C.
    b. Valid (Modus Ponens)
4. If wolves can sing opera, then hamburgers are made from chicken. Hamburgers are not made from chicken. Therefore, wolves are not made from chicken.
    a. Form: If W then H. Not H. So, not W.
    b. Valid (Modus Tollens)
5. If giraffes can speak fluent French, then skunks can play the flute. Skunks can play the flute. Therefore, giraffes can speak fluent French.
    a. Form: If G then S. S. So, G.
    b. Invalid