Truth and Physics Education: a Heideggerian Analysis

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Abstract

This thesis develops a hermeneutic philosophy of science to provide insights into physics education. Modernity cloaks the authentic character of modern physics whenever discoveries entertain us or we judge theory by its use. Those who justify physics education through an appeal to its utility, or who reject truth as an aspect of physics, relativists and constructivists, misunderstand the nature of physics.

Demonstrations, not experiments, reveal the essence of physics as two characteristic engagements with truth. First, truth in its guise as correspondence enables a human being to prepare for the distinctive event of physics. Second, the event of physics occurs in human perception when someone forces a hidden reality to disclose an aspect of itself. Thus, the ground of physics is our human involvement with reality achieved by way of truth. To support this account of physics, the thesis reports phenomenological investigations into Isaac Newton's involvement with optics and a secondary school physics laboratory. These involve interpretations of Heidegger's theory of beings, schema and signification. The project draws upon, and contributes to, the hermeneutic phenomenology of modern physics, a tradition in continental philosophy that begins with Immanuel Kant, and advances particularly from Martin Heidegger to Patrick Heelan.

The thesis advocates an ontological pedagogy for modern physics which has as its purpose each individual student's engagement with reality and truth. Students may achieve this through demonstrations of phenomena that will enable them to dwell with physics, an experience that contrasts with their embroilment in modernity, and which perpetuates nature's own science.

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Chapter 1: Introduction

This thesis establishes the forgotten ontological foundation of physics education and thereby enables physics teachers – those who perpetuate nature's own science – to embrace a new pedagogy. Truth gives access to insights about the situation of physics education and the saving grace within the discipline of physics.

The first chapter introduces the traditions of thought that inspire the argument of the thesis. It establishes the educational context for the enquiry, and thereby indicates its relevance to curriculum development and teaching. Key topics include modern physics, metaphysics, truth, realism, ontology, and existential analysis. An introduction to the hermeneutic philosophy of science has as its focus the issues that are relevant to the thesis. The thesis pursues a new foundation for physics education and indicates some caveats. Finally, it indicates the direction of enquiry and sketches the contents of each chapter.

Orientation

Physics is an important subject taught in schools and universities. Those initiated into the discipline find employment and contribute to the prosperity of nations. Nevertheless, physics attracts little resource and few students in comparison with many other academic subjects. Those who seek to justify physics often appeal to its utility, which physics in the main achieves through its association with technology. In 1990 the present author established a government "think tank" on the implications of this perspective ingrained in national science policy (Harker & Spoonley, 1993). Whilst physics has always been associated with practical projects, they do not provide impetus to the discipline. That comes from the resolve of a few people to understand the truth about the material universe – a desire which still burns for many physicists today. Conspicuously, physics as the pursuit of the truth remains a quandary for both those who advance physics as the foundation of technological progress and those who seek to understand nature.

This thesis draws upon the work of the renowned German philosopher Martin Heidegger (1889-1976). Heidegger's innovations – his methods of investigation, his discernment of truth, and his insights into modern physics – strike into the present enquiry. Although best known for *Being and Time* (1927), Heidegger's

Gesamtausgabe (collected edition) now comprises over 100 volumes (Kisiel, 1995a). The thesis heeds Heidegger's directive that we should each pursue our own thoughts, and consequently it is not an explication of his works, beyond what is necessary to facilitate the present "path of thinking", to use one of his expressions. Whilst Heidegger's account of physics initiates the investigation, it is his earlier insight into truth that carries it forward in a new direction. Accordingly, the thesis moves us beyond Heidegger's metaphysical account of physics, to use his method of phenomenology to investigate truth at two engagements or "sites" of physics. The first engagement involves Isaac Newton in the seventeenth century and the second a modern New Zealand secondary school classroom. These phenomenological investigations reveal the nature of physics and that aspect of physics which is physics education. Given the extensive use of Heidegger's theory, and the hermeneutic philosophy of science that derives from his theory, this section introduces, and places in context, some of his indispensible concepts.

Modern Physics

Physics as a distinct subject began in antiquity when the first scientists brought together descriptive studies of optics, astronomy, and mechanics, because their methodology involved geometry. Physics is probably the oldest intellectual discipline and from human prehistory onwards it has been associated with religious, mythological, and astrological practices, and with practical projects. The word "physics" derives from the Greek word *φύσις* meaning "nature", and consistent with this the discipline considers phenomena that comprise nature or investigates nature itself. Enquiries in physics today focus on energy and matter, yet they still heed Aristotle's premise that we may reduce the physical world to one or more basic starting points. Physicists use the term "modern physics" to refer to that developed from the early twentieth century, particularly relativity theory and quantum mechanics. Modern physics is concerned with the forces that exist between objects and the relationship between matter and energy.

Heidegger uses the expression "modern science" in a very precise manner, and when the present thesis refers to "modern physics", it conforms to Heidegger's concept. He also uses the word "research" to refer to modern science, this being its leading characteristic. Modern physics begins with Galileo and Newton and proceeds with Maxwell, Planck, Heisenberg, Schrödinger, and Einstein. Heidegger

distinguishes between ancient, medieval, and modern physics. These are distinctive forms of physics because they entail distinctive assumptions about nature and about how to investigate nature. Modern physics did not evolve from medieval physics, and nor did medieval physics evolve from ancient physics.

Metaphysics

Alexandrians in the first century gave the disputed term "metaphysics" to the works written by Aristotle that appeared after those on physics, although the diverse content of those books renders them as a poor guide to the subject itself. Aristotle's *Metaphysics* discusses "first causes", that which founds all the disciplines of human enquiry (for example, ethics, mathematics, physics, and politics), that which is of most generality or most foundational for human beings, and it enquires into beings *qua* beings. The youthful Kant, in an essay, draws upon both Aristotle and Newton in his account of metaphysics. Kant seeks to explain the success of Newton's physics. This success is not merely theoretical for acclaimed discoveries are frequent in Kant's city, for example, Knutzen predicts the return of a comet in 1744 (Kuehn, 2001, p.83). As his biographer indicates, Kant requires for modern science a foundation that is as credible as the science itself:

> Metaphysical thinking is not in the least entitled to be an invention; it is not prospective as in geometry, in which new conclusions are successively formed from an original definition, but rather retrospective, so that given a state of affairs it seeks out the conditions from which that state results; for a total phenomenon it seeks the possible "grounds of explanation". (Cassirer, 1981, p.71)

The determinacy and evidence associated with Newton's physics need to be associated with metaphysics. Thus, for Kant metaphysics became the study of appearances and ultimate or foundational reality to the extent that humankind may know these things. Heidegger largely concurs with Kant on the nature of metaphysics although he gives the subject a new dimension. For Heidegger, metaphysics is also about appearances and reality – as rendered in the study of beings and beings in their totality, which equates to the study of what exists, ontology.

Heidegger's conception of truth

To investigate physics the thesis uses a notion of truth that it draws from within the hermeneutic philosophy of science. What distinguishes the hermeneutic philosophy of science from other modern accounts of science that involve human beings (such as those of Rorty and Toulmin), is the explicit involvement of truth. It is through an analysis of truth that access is gained, first to the distinctive features of the hermeneutic tradition, and then in the present thesis to the entities that are involved in physics.

What is truth? The present thesis identifies Martin Heidegger's two leading concepts of truth as *adaequatio* and *alētheia*. "*Adaequatio*" is truth located in an agreement or correspondence between reality and representations, mental or linguistic. This includes for example the correspondence apparent in "that is blue", "blue is a colour", and "2+2=4". Heidegger says that correspondence theories of truth are the "traditional" concept of truth or the "usual" concept of truth and he considers them in Aristotle and Aquinas (Heidegger, 1962a, p.257; Heidegger, 2002b, p.6; Heidegger, 2007, p.280) . He finds such accounts of truth undoubtedly meaningful. Although there are various renditions of the correspondence theory of truth, and thus abundant words that refer to the theory, the generic word preferred by Heidegger to refer to this form of truth is the Latin *adaequatio*, evidently because it indicates "similarity" which implies a human judgement that involves an equation, whilst remaining silent on the content of the judgement or equating. *Adaequatio* is the notion of truth that we engage when we say something is right or wrong. It is an indispensable notion in current practical Western schooling, and it is crucial in modern science. In physics, an enduring example of *adaequatio* is "empirical verifiability", the conformity of an assertion to a fact – for example, the statement about a new discovery in astronomy. When microlensing provides evidence of extra-solar planets, *adaequatio* contends they really do exist.

Alētheia is Heidegger's notion of truth – the truth inherent in the "disclosure", "uncoveredness" or "unconcealment" of beings. It is the human way to abide with this truth and all abidance with beings necessarily involves this form of truth. *Alētheia* rests upon the primordial phenomenon of human disclosedness and is inherent in all disclosures of beings including those beings that are the occurrent, physical entities of modern physics. Truth as disclosure is an ontological truth and indelible in the complex that is Dasein (the human being involved) and the beings

disclosed. Heidegger credits Kant as the first to ground *adaequatio* in *alētheia*. This sentence, which refers to the two "forms of truth", is a more specific rendition of Heidegger's assertion that Kant's real Copernican Revolution is his discovery that metaphysics grounds all human knowledge of objects. The question about *beings* is the question that entails *adaequatio,* hence the traditional/usual concept of truth. This contrasts with *alētheia*:

> *The most primordial phenomenon of truth is first shown by the existential-ontological foundations of uncovering ... With* and *through* it [Dasein] is uncoveredness; hence only with Dasein's *disclosedness* is the most *primordial* phenomenon of truth attained. What we have pointed out earlier with regard to the existential Constitution of the "there" and in relation to the everyday Being of the "there", pertains to the most primordial phenomenon of truth, nothing less. (Heidegger, 1962a, p.263, his emphasis).

Adaequatio, the truth of judgement, ultimately presupposes *alētheia*. What is primarily true is the uncovering of beings including Dasein, and this perspective enables Heidegger to say that Dasein is "in the truth" (Heidegger, 1962a, p.263).

The present thesis uses the word "correspondence" as equivalent to Heidegger's word "*adaequatio*". The word "disclosure" refers specifically to truth as *alētheia*, precisely Heidegger's concept.

Realism and physics

What is realism with reference to the external world? Heidegger interprets this as an ontological question about what constitutes that that is (being and beings, existence and entities). Consequentially, enquiries into the ontology of realism must precede any consideration of epistemic or semantic issues. The ontological understanding of being that we actually have along with our theoretical deliberations about entities, leads us to conclude that there is a reality independent of human beings. As Kant reasoned, the nature of ourselves limits our access to this external reality. Taking Kant a step further, Heidegger emphasises that what we discern about reality is most strictly a particular interpretation (hermeneutic), however this does not mean the interpretation is one that derives from, or depends on, theory. Nor does it depend on an absolute, authoritative perspective/insight (the God's eye view, or the view from nowhere).

Physics is humankind's attempt to engage with reality, or, as Heelan says, it is "nature's own science". Heidegger urges us to appreciate that modern science is a violent attempt to force the Real to reveal ever more of itself. This philosophical foundation for physics has become relevant in discussions about relativity theory and quantum theory. With the human interpretative apparatus as it is, is it possible to advance further into our understanding of reality? Physicists postulate entities that they derive from mathematical models and which we struggle to conceptualise. Einstein's famous analogy is that the presence of a coat ticket at a theatre indicates little of what hangs on the hook (Babich, 2009).

In the philosophy of science, it is the theory of operationalism which contrasts with the realism of Kant, Heidegger and Heelan. Operationalism – which has no place for Heidegger's Real – is an extreme modern version of empiricism. Bridgman represents that tradition well because he has practical experience as a physicist, begins his deliberations with critical reflection on what scientists actually do, and wrote after Einstein's work that radically altered the Newtonian concepts of space, time, and matter (Bridgman, 1952). He observes his colleagues and concludes the modern physics has precipitated with physicists a change in their "attitude toward what may be called the interpretive aspects of physics" (Bridgman, 1927, p.vii). Evidently, the scientist's stance must be, and is, one of pure empiricism, he "recognises no *a priori* principles which determine or limit the possibilities of new experience" and there should be no demand from nature that it embraces any formula, structure or organisation (Bridgman, 1927, p.3):

> In general, we mean by any concept nothing more than a set of operations; *the concept is synonymous with the corresponding set of operations*. If the concept is physical, as of length, the operations are actual physical operations, namely, those by which length is measured; or if the concept is mental, as of mathematical continuity, the operations are mental operations, namely those by which we determine whether a given aggregate of magnitudes is continuous. (Bridgman, 1927, p.5)

In his statement that the concept is "synonymous" with a set of operations, it is possible to recognise a correspondence theory. Thus, *adaequatio* is essence of modern empiricism.

Ontological terminology

Heidegger is correct when he begins *Being and Time* with the assertion that we have all forgotten being. One consequence of our forgetting the subject of ontology as a pre-eminent branch of metaphysics is that there is not in common use a vocabulary for ontology. We draw the vocabulary we use in intellectual discussions from theories that hold their own presuppositions and consequences. If we import words into ontology, they can create confusion because they carry with them associations from elsewhere. Equally, it can become graceless and confusing when we use the same word for two "concepts" that hold separate provenance. Further, we can expect to make more progress when we develop our own categorial framework upon the intellectual labour of others. For these reasons, it is best to use Heidegger's terminology to refer to ontology. In this thesis, some of the requisite ontological terms (introduced when they first appear) include Dasein, ontic, ontological, ontological understanding, *Befindlichkeit*, *Rede*, and existential analytic.

"Dasein", is one of the core terms in *Being and Time*. It first appears as one of things that has being and "is":

> Everything we talk about, everything we have in view, everything towards which we comport ourselves in any way, is being; what we are is being, and so is how we are. Being lies in the fact that something is, and in its Being as it is; in Reality; in presence-at-hand; in subsistence; in validity; in Dasein; in the 'there is'. (Heidegger, 1962a, p.26)

If Heidegger "defines" Dasein, he does so thus:

> This entity which each of us is himself and which includes inquiring as one of the possibilities of its Being, we shall denote by the term "Dasein". (Heidegger, 1962a, p.27)

At the same time, he provides decisive counsel for the present thesis when he says that if we are to enquire, to formulate questions explicitly and transparently, we must first give a proper explication of Dasein.

Phenomenology

Science and technology are hegemonic in Western universities and one of the consequences of this is the preponderant influence of the methods of science in all manner of enquiries. Yet science cannot investigate itself scientifically. That which is the foundation of a method is already present in the method and integrally a

component of any investigation that uses the method. That this necessitates the use of another method of enquiry challenges Husserl, and then Heidegger. It turns us to recognise that the enquirer is integrally a part of any enquiry, even the enquiries of physics that seek to eliminate the involvement of the human being and thereby to claim objectivity.

The alternative method of enquiry – phenomenology – renders objectivity in another way. Phenomenology as the "science of phenomena" is a diverse intellectual discipline with little consensus about how to conduct phenomenological research. The present thesis confines itself to the phenomenology that Heidegger advocates, Kockelmans prescribes, and Heelan illustrates in his hermeneutic philosophy of science. It appears to be the first study of its specific kind in science education (Østergaard, Dahlin, & Hugo, 2008). Phenomenology is not a set of rules about how to proceed, but rather it is whatever renders as sense to the enquirer in a particular situation. Heidegger places the key words in italics when he writes of the methodological use of the word "phenomenology":

> 'Phenomenology' neither designates the object of its researches, nor characterizes the subject-matter thus comprised. The word merely informs us of the "*how*" with which *what* is to be treated in this science gets exhibited and handled. To have a science 'of' phenomena means to grasp its objects *in such a way* that everything about them which is up for discussion must be treated by exhibiting it directly and demonstrating it directly. (Heidegger, 1962a, p.59)

In this quotation, Heidegger uses the word "science" in the traditional German manner, which refers to any determined, systematic enquiry directed at the attainment of knowledge. The idea of "seeing" or "grasping" in a manner that exhibits and demonstrates to us in a direct way stands in contrast to the aspirations that physicists hold for physics. It is not possible to confirm phenomenology as physicists seek to confirm the theories of physics, through a consensus based upon enduring and universally available evidence. How then is the phenomenological enquiry of the present thesis – the existential analytic – to be judged?

Specific mention should be made of the expression "existential analytic". As indicated, phenomenology is an activity, not a theory. It is like a sports fixture, where there are rules and preparations, what occurs in the play is what counts, and the outcome is unpredictable. The sports code played in this thesis was devised by

Heidegger and it is called an "existential analytic of the Dasein". The engagement is between she who enquires *and* human beings like herself and whatever else she encounters – "what is primarily interrogated is those entities which have the character of Dasein" (Heidegger, 1962a, p.65). The event necessarily involves the two teams to an equal extent, although the report on how they perform comes from one of those involved in the play. The present thesis describes the play in two matches, which are between a Dasein that enquires and (first) the beings that involved Newton and (second) the beings involved in a secondary school classroom.

The direct involvement of the Dasein that enquires warrants comment, because it is central in an existential analytic and contrasts with all the sciences (in the modern sense) that lay claim to objectivity, including physics. "Looking at something, understanding and conceiving it, choosing, access to it—all these ways of behaving are constitutive for our inquiry, and therefore are modes of Being for those particular entities which we, the inquirers, are ourselves" (Heidegger, 1962a, pp.26-27). It is not possible in an existential analytic to be free of the questioners comportment (not "behaviour", because "behaviour" is steeped in objectivist theory).

The word "existential" refers to a full or general understanding of existence, which must include a sense of both structure and content. It contrasts with "existentiell" which refers to someone's personal understanding of their own existence (Heidegger, 1962a, p.33). Fundamental ontology, which is the source of all other ontologies (that is, regional ontologies, such as those of physics and ordinary-everydayness), is achieved through an existential analytic (Heidegger, 1962a, p.34). Because of the direct relationship between fundamental and regional ontology it is deemed appropriate to use the term "existential analytic" to refer to a study that is primarily regional.

Hermeneutics

Hermeneutics is the theory of interpretation – broadly, what it means to understand texts, utterances, or nature. The word "hermeneutics" appears in many contexts. It may describe a method of enquiry, for example in "Heidegger's hermeneutic phenomenology" or it may describe a leading feature of human beings, for example in "the hermeneutic way of being of Dasein", or it may refer to a major theme within the discipline of continental philosophy. All of these uses of the word appear within the present thesis.

Ancient hermeneutics has multiple and conflicting histories that extend to the origins of writing itself. Whenever someone makes an interpretation of something, there is the potential to say that hermeneutics is involved. Many scholars find a beginning for hermeneutics in ancient Greek works, which reflect the etymology of the term as *hermeneuō* (translate or interpret), and which include Aristotle's work of about 360 B.C. with its Latin title *De Interpretatione*. From its origins until today, "hermeneutics" may refer to translation, proclamation, or explanation. In the West, hermeneutics came to describe what was involved in the interpretation of important texts in the Bible. As is easy to imagine, the practice of hermeneutics was as diverse in this period as in ancient times. Perhaps the dawn of the modern era, the Enlightenment, heralds the advent of modern hermeneutics. Kant's essay on "what is enlightenment" brought reason to the foreground – as a means to access the truth. The present thesis considers the implications of this in the philosophy of science. Husserl's phenomenology, founded upon meaning existent in the life-world and giving credence to intuitionism, paves the way for Heidegger's distinctive phenomenology which may be truly called hermeneutic phenomenology. As Heidegger says, the "phenomenology of Dasein is a *hermeneutic* in the primordial signification of this word, where it designates this business of interpreting" (Heidegger, 1962a, p.62). This is the first of three uses Heidegger finds for the word "hermeneutic". The second is also methodological in that it refers to the extension of the ontology uncovered (the meaning of being), to a general hermeneutic of investigation. Thereby is revealed "any further ontological study of those entities which do not have the character of Dasein" (Heidegger, 1962a, p.62). He continues:

> this hermeneutic also becomes a 'hermeneutic' in the sense of working out the conditions on which the possibility of any ontological investigation depends.

And finally, "hermeneutic" is the word used to describe the nature of the human being as Dasein – this is philosophically the most important aspect of the Dasein:

> to the extent that Dasein, as an entity with the possibility of existence, has ontological priority over every other entity, "hermeneutic", as an interpretation of Dasein's Being, has the third and specific sense of an analytic of the existentiality of existence; and this is the sense which is philosophically primary. (Heidegger, 1962a, p.62)

The thesis always uses the word "hermeneutic" in one of Heidegger's three senses and the context should indicate which sense pertains.

The hermeneutic philosophy of science

The enquiry draws upon entrenched theory in continental philosophy, specifically the hermeneutic phenomenological philosophy of science. An important way to see the enquiry is to locate it as a development in this historical, philosophical tradition. Without deprecating the contributions of others, it is convenient to submit that the relevant tradition runs from Kant, to Heidegger, to Heelan. As this tradition enquires into modern science, it could hardly have begun before there was sufficient development of physics by Kepler, Galileo, and Newton. All the requisite elements of the tradition are problematics for Kant, Heidegger provides the structure necessary to advance the investigation and begins essential work with his investigations into Dasein, and Heelan, particularly with his insights into the phenomenology of both vision and mathematics, begins to detail our human involvement in modern science. It is apposite to enquire into the human limits of the discipline of physics at a time when physics routinely announces new discoveries whilst its theory remains enmeshed in a crisis about objectivity and realism that was precipitated by quantum mechanics at the beginning of the twentieth century (Heelan, 1965, pp.ix-xiv; Vol.1, Mehra & Rechenberg, 1982).

Kant

Immanuel Kant (1724-1804) is a classical or generalist philosopher who spent much of his intellectual energy on issues in the philosophy of natural science. He develops his ideas over a long period of time and it is impossible to discern all of his conclusions in his final work (Kockelmans, 1968, p.13). Kant begins his deliberations in the philosophy of science having been involved in practical and theoretical physics. Evidently, this begins with Teske's "impressive" , dramatic, courses on experimental physics (Kuehn, 2001, p.78). The first part of Kant's 1755 treatise begins with a "short outline" of the Newtonian philosophy that Kant says is the foundation of his own deliberations about the formation of galaxies, including the Milky Way. Whilst it is a commonplace for us that the universe is constituted with a discernable structure, in Kant's time most people thought the random distribution of the stars in the sky was evidence that there was no underlying

structure for much that could be seen. Kant credits "an Englishman, Mr [Thomas] Wright of Durham ... [with the] happy step" that shows the stars are not a mere swarm, but are a part of a "Systematic Constitution of the Universe" (Kant, 1969, p.54 & p.51). Although the 1755 work contains intriguing ideas (for example, that because nothing in nature is balanced the planets do not have circular orbits, and that the movements of the outer most planets in the solar system "gradually cease"), its importance is that it is a determined attempt to provide a cosmological model that does not invoke direct divine intervention. Instead, its conclusions derive from purely mechanical natural laws, as Leibniz's disciples assert is appropriate (Kant, 1969; Friedman in Kant, 2004, pp.viii-iv). This rejection of divine intervention in hypotheses about particular phenomena remains an understanding in the hermeneutic philosophy of science, and is relevant in this thesis concerning the beings of Newton. In 1756, Kant publishes *Physical Monadology*, which addresses a central issue that continues in the hermeneutic philosophy of science and into the present thesis where it appears in the relation to the beings that engaged Newton during his experimental work. The issue is the relationship between mathematics and physical objects. If matter is ultimately constituted of simple elementary substances (physical monads), and these substances exist in space, how can we reconcile their existence with the infinite geometrical divisibility of space? Kant's answer builds on Leibniz's notion that monads have "point-like" centres. True substances are metaphysical points which, Leibniz asserted, are both real and exact, mathematical points are exact but not real, and physical ones are real but not exact.

In contrast to empiricist philosophers, for whom the philosophy of science consists of an analysis of fundamental concepts and methods of enquiry extant in science, Kant from 1770 with growing confidence asserts that the philosophy of science is to be concerned with the prior conditions that make science possible at all. The period of this advance which is the birth of the hermeneutic philosophy of science, is that between Kant's inaugural address upon obtaining his professorship the University of Königsberg in 1770 and the publication of his *Critique of Pure Reason* in 1781 (Kockelmans, 1968, pp.9-10). Kant observes that human experience is the foundation of the laws of physics, and he argues that the experience and the laws must be founded upon a regular, discernable structure or framework that enables them to be brought together.

Each of Kant's three accounts of physics and Heidegger's account, differ in what they say about the nature of this foundational structure. In the first book ever committed to a philosophical reflection on modern physics, *Metaphysical Foundations of the Natural Sciences* (1786), Kant argues for a schematism that systematically relates *a priori* conditions (particularly those that involve space and time) to empirical representations. As he says, "science proper, especially [science] of nature, requires a pure portion, lying at the foundation of the empirical, and based upon an *á priori* knowledge of natural things" (Kockelmans' translation, Kockelmans, 1968, pp.19-29). This conclusion is possible for Kant because earlier he shook off classical metaphysics, the view that the task of metaphysics is to investigate a supra-natural reality that is the site or foundation of God, human freedom, immortality, and all existence. Things as they are in themselves are neither spatial nor temporal, and we have no knowledge of things in themselves. Thus, Kant confines metaphysics to that which grounds human experience and is therefore available for rational investigation, and he sets out to investigate experience in physics, morals, politics and religion.

Mention should be made of a specific topic that engaged Kant, because it features in the present thesis: it is the relationship between mathematics and physics. The relationship between mathematics and physics was an issue at the birth of modern physics, as Galileo wrote of his adversaries (plural):

> … I can almost hear him shouting in my ears that it is one thing to deal with matters physically, and quite another to do so mathematically, and that geometers should stick to their fantasies and not get entangled in philosophical [scientific] matters– as if truth could ever be more than one; as if geometry up to our time had prejudiced the acquisition of true philosophy [science]; (Drake, 1978, p.172)

Having decided that physics is concerned only with the laws of the moving forces of matter as given in experience and as mediated for us by an *a priori* framework or schema, Kant was not inclined to allow mathematics to intrude. Consistent with his insights into the nature of metaphysics, Kant maintains that mathematics cannot provide insight into the essence of the many kinds of physical force. Moving forces cause motions, and motions because they relate to space and time are amenable to mathematical description, yet these motions are not the essence of physics. This discussion about the relationship between mathematics and physics, Heidegger

resolves in a dramatic way, and the present thesis suggests further on this topic. On the other leading question in the technical work of the present project, the vexed question of the status of reality, Kant kept the notion of the thing-in-itself as different from the percept, and in this way he kept a connection with realism.

Heidegger

How does Martin Heidegger understand the physics of his day? Heidegger is not "well versed" in physics although apparently this does not limit his ability to discern the nature of science (Heelan, 1995, p.579). He did study physics and mathematics at Albert Ludwig University in Freiburg after he abandoned the idea of becoming a priest and Kockelmans says that "for a philosopher" he is "remarkably well informed about several sciences" (Kockelmans, 1985, p.22 & p.117). His knowledge of physicists apparently does not fetter Heidegger when he says "contemporary natural scientists, in contrast to scientists working on the level of Galileo and Newton, have abandoned vigorous philosophical reflection and no longer know what the great thinkers thought" (Heidegger, 2001, p.57). The current physicists' lack of self-critique is not a consequence of their "negligence or laziness" but is "due to the blindness determined by the destiny of the present age" (Heidegger, 2001, p.60). Such categorical statements indicate the tenor of Heidegger's views about modern science.

Theorists concerned about the nature of science did not seize upon Heidegger's work. One of the reasons that Heidegger did not initially appear relevant to those engaged in discussions about the philosophy of science is the way in which the philosophy of science defined itself at the start of its modern tradition:

> If any problem in the philosophy of science can justifiably be claimed the most central or important, it is that of the nature or structure of scientific theory. For theories are the vehicle of scientific knowledge and one way or another become involved in most aspects of the scientific enterprise. (Suppe, 1974, p.3)

Those who define the philosophy of science in the exiguous way this quotation implies will agree with Richardson's memorable statement "On the longest day that he ever lived, Heidegger could never be called a philosopher of science" (Richardson, 1968, p.511). Actually, Richardson immediately qualifies the quoted sentence "But he is a philosopher – an important one – and no genuine philosopher

can afford to ignore the problems of science", and the hermeneutic philosophy of science rejects the notion that the nature of scientific theory is the most central or most important issue to consider. Accordingly, Heidegger achieves standing as a philosopher of science in the more recent tradition that emphasises the entanglement of human beings and institutions in an enterprise. A leading proponent of the hermeneutic philosophy of science, Patrick Heelan, nominates Heidegger as the "key figure" in this emerging tradition (Heelan, 1982; Heelan, 1997, p.272; Heelan, 1998; Heelan, 2005).

A characteristic of Heidegger's work is the extent to which it integrates into a single theoretical structure (his metaphysics). Nevertheless, this introduction isolates a development that is of particular relevance in the present thesis. It is the hidden schematism by which human understanding deals with phenomena, in other words the foundational structure of the Dasein with regards categories. What is the hidden schematism by which human understanding deals with phenomena? As indicated earlier, Kant sought a schematism that would serve as the foundation of modern science, working with the advantage of having contributed to research in physics. Heidegger's philosophy of science begins in his lecture course of 1927/28, *Phenomenological Interpretation of Kant's "Critique of Pure Reason"* and develops in *Kant and the Problem of Metaphysics* (first published in 1929). At the end of the lecture course Heidegger refers to the manner in which the "Kantian architectonic of presentation" makes it difficult to see the essential core of Kant's work which he says is Kant's section entitled "The schematism of the Pure Concepts of Understanding" (Heidegger, 1997, p.291). What appears crucial for Heidegger is that the categories (which include the discipline of physics) cannot be taken as isolated concepts of understanding, because they are all essentially related to time (for example though notions such as permanence, succession in time, and coexistence). He indicates the way forward to the philosophy of physics:

> "... categories belong essentially to the original whole of the pure time-related imaginative synthesis. This it would not do at all to set up an isolated analytic of concepts and then to inquire into their employment in a subsequent part. The question is the following: What belongs to the pure synthesis as such and how do its concrete variations look as regional principles of nature? (Heidegger, 1997, pp.291-292)

The concrete variations (regional ontologies, or ontic disciplines), which include the discipline of physics, or equally the theory of teaching, are grounded in fundamental ontology, and it is fundamental ontology that is consistently Heidegger's prime interest. Those concerned with the hermeneutic philosophy of science must proceed from his insight into being and categories but away from fundamental ontology, whilst always taking appropriate account of fundamental ontology. As Heidegger says of this:

> The question of Being aims therefore at ascertaining the *a priori* conditions not only for the possibility of the sciences which examine entities as entities of such and such a type, and, in so doing, already operate with an understanding of Being, but also for the possibility of those ontologies themselves which are prior to the ontical sciences and which provide their foundations. *Basically, all ontology, no matter how rich and firmly compacted a system of categories it has at its disposal, remains blind and perverted from its ownmost aim, if it has not first adequately clarified the meaning of Being, and conceived this clarification as its fundamental task*. (Heidegger, 1962a, p.31, his emphasis)

To reiterate, our present direction of enquiry is away from the fundamental task, and yet we still need to be cognizant of the structure that relates the most fundamental to the disciplines.

What is the *a priori* foundational structure that enables intellectual disciplines like physics? Asked another way, what links the pre-theoretical foundation of understanding to the understanding that is characteristic of disciplines like physics? Heidegger traversed this territory some years before *Being and Time*. His schema from the *Kriegsnotsemester*, the 1919 War Emergency Semester (KNS), is a sketch that relates the pre-theoretical and the theoretical. He drew the diagram at the end of a lecture to assist students (student Brecht records the sketch that Heidegger did not include in his own notes, Heidegger, 2000b, p.186). The sketch indicates what is involved in the hermeneutics *of* facticity and it is here adjudged as an attempt (facilitated by Lask and the German neo-Kantians) to complete Kant's project (for descriptions of the schema, Kisiel, 1993, pp.21-24; Kisiel, 1995b; Kisiel, 2002). This schema shows the relationship between physics and the foundational ontology of the Dasein of *Being and Time*. It helps to explicate the "central phenomena of factic life

experience which is always at once active experiencing and the passively experienced" (Kisiel, 1994a, p.177).

The pre-theoretical part of the schema Heidegger develops by a reflection on Husserl's principle that everything presents itself "originarily in intuition" to be taken simply as it gives itself (Heidegger, 2000a, p.92). The entities of physics along with every other "something" passively experienced is constituent of a formal-logical something (motivated in a primal something) that is associated with an objective-type something (motivated in a genuine life-world). Thus, the relationship is shown between *formalization* that established the "primal something" of human life, and *generalization* (as for example in physics) that yields an abstract "object-like" universal occurring "stepwise and typewise according to species and genera drawn from particular lifeworlds or regional spheres of experience" (Kisiel, 1994a, p.179). This is a part of the phenomenological beginnings of *Being and Time* and of the present thesis which it considers the beings of physics.

With Heidegger's schematism introduced, what may be said about the particular example of research? The origin of the modern science he locates in forms of understanding that were known in ancient Greece. As already indicated, this does not imply that there is an evolution from ancient to modern science. The physicist's every involvement with physics involves a cultivation of the hermeneutical situation that is physics (physics is a particular thematization, see Heidegger, 1962a, p.449). Thus, the physicist must move beyond the standpoint of ordinary everydayness or being with things as equipment or being with things as objects of contemplation, to take up the particular restrictive stance. The stance of modern mathematical physics which he describes is in the words of Babich (1995, p.590) is that which realises a "perpetual motion machine". This perpetual motion machine is the construction of institutionalised, experimental projection. This, in turn, is the outcome of a particular hermeneutic schematisation achieved by Dasein, and that he describes by reference to an early Greek notion of mathematics. In the mathematical projection of nature, it is not the mathematical projection that is important but that which is *a priori*. This topic is taken up again in chapter 3.

Finally in relation to Heidegger and his hermeneutic philosophy of science, there is to consider the relationship between science and technology. He asserts that both modern science and modern technology are seen by us as expressions of modernity – they emerge in modernity and they are regarded as characteristic of

modernity. This idea came to prominence in his latter period and particularly as the result of his 1955 lecture entitled "The Question Concerning Technology". In that lecture he says the "current conception of technology, according to which it is a means and a human activity, can therefore be called the instrumental and anthropological definition of technology" (Heidegger, 1977b, p.5). Such a "definition" he repudiates in favour of a description of technology which approaches its essence through an explication of truth, *alētheia*. The essence of technology has "everything" to do with revealing (*ibid*, p.12). Modern technology is unique because it draws upon modern physics, whilst modern physics is unique because it draws upon modern technology – but these features (he calls them mutual dependencies) of the two are not the essential defining characteristics of either. The relationship is "merely historiographical" (*ibid*, p.14), which is to say, contingent. Modern science does not beget technology, nor does technology beget science. Rather, they are two expressions of truth as it flows upward as the metaphorical sap in the tree. In chapter 3, under the heading "Truth and beings", this metaphor is made explicit.

Heidegger's latter lectures on modernity are consistent with his early account of truth although he lingers on different terminology. For example, we read "the essence of modern technology lies in Enframing" and "Enframing belongs within the destining of revealing" (*ibid*, p.25). The word "Enframing" is the "standard translation" for a deliberately artificial word "*das Gestell*" and Young notes that we need to look for some kind of "coincidence of meaning" between this term and metaphysics (Young, 2002, p.37). Kisiel colourfully records that "*Ge-Stell*, [is] the artefactic compositing of planetary resources that repositions the world into a global warehouse to hold its 'natural' resources in standing reserve" (Kisiel, 2002, p.74). From this foundation, Heidegger continues in a bid to establish a distinction between ancient and modern technology; this controversial move depends on the casting of "technology" as "technological practice". Modern technology, according to Heidegger, is violent (Schumacher's word) in comparison to the technology of the Ancient Greeks, which is passive or gentle. This aspect of Heidegger's work becomes a stance against modernism and gives rise to discussions about the ancient quest to discover the nature of the good life and environmentalism (for example, in the research programme of Irwin, 2010). Nevertheless, it is the pervasiveness of *alētheia* which grounds the human being and the situation of the human being, and this *applies* in modernity (Western metaphysics) as in other historical periods (this is further

developed in the first section of chapter 3, "Truth and Beings"). Further, it is plain that only through an explication of truth may the relationship between modern science and modern technology be properly conceived. Accordingly, it is truth that the present enquiry maintains as its focus.

Heelan

Patrick A. Heelan (1926-) is a member of the Society of Jesus who is a leading figure in the hermeneutic philosophy of modern physics. In the present thesis, use is made of his account of incommensurable world-views, his insights into the phenomenology of space perception and mathematics, and the hermeneutics of experiments. Heelan is a physicist who for his second doctoral degree undertakes a study of the "crisis of objectivity" or the "crisis of realism" in modern physics (Heelan, 1965, p.ix). He investigates the "physical philosophy" of Werner Heisenberg (1901-1976), one of the architects of quantum mechanics. In 1965, with reference to physics, Heelan asserts that there are two worlds with one identical referent. These he casts as an observation language and an explanatory language:

> The difference between observation language and explanatory language, then, is not that they deal with different sets of referents, but that they consider the same set within different contexts. One considers them within the context of a World-for-us, while the other considers them within the context of a World-for-things. (Heelan, 1965, p.177)

This work – because it stays close to the practice of physicists – is the commencement of the hermeneutic philosophy of science that Heidegger inaugurates. Heelan says the task of the hermeneutic philosophy of science is to "explore at a philosophical level the sense in which interpretation is at work in all of physics and other experimental science, and to contribute to opening up a new philosophical – and metaphysical – perspective on physics that was possibly foreshadowed by Einstein and Heisenberg in their attempt to make sense of their discoveries" (Heelan, 1998, p.273). As mentioned earlier, Kant sets this task himself in relation to Newton.

At the start of his text on the philosophy of science and space perception, Heelan says the method of enquiry is "phenomenological and hermeneutical" (Heelan, 1983b, p.2). He expands this:

> ...what we know is not limited to the deliverances of a unique privileged perceptual framework constitution an absolute transcultural empirical basis for all knowledge, and we can have access to a multiplicity of possible perceptual horizons, both of the Euclidean and of non-Euclidean structure, ground both in unaided perception and in the use of special technologies ("readable" technologies) invented using scientific theories. (Heelan, 1983b, p.2)

From Heelan, we learn that whilst Newton's mechanical physics confined itself to the perception of moving objects and involved Euclidean geometry, modern physics is now engaged with a number of geometries and the mathematical determination of objects whose nature and existence is highly problematic.

The present enquiry continues Heelan's hermeneutic philosophy of science by applying Heidegger's technique (the existential analytic of the Dasein) to the work of science teachers and students. Heelan is precise regarding that which is the distinctive "work" or involvement of scientists. His pivotal concept is that "scientific states of affairs are given in an originary way to the experiencing scientist during the course of scientific observation" (Heelan, 1977, p.26). Heidegger introduces the word "apprehension" to refer to this more foundational form of "perception" which posits a public reality and involves foremost disclosing truth, *alētheia*. Truth within apprehension is not in itself sufficient for science. Science also involves *adaequatio,* truth as correspondence, in order to make public the disclosed truth of apprehension. This form of truth often presents a challenge in science. For example, on occasions Newton wrote a word to describe a colour and then changed his mind. If Newton was simply tired on the first occasion and thus mistaken about the correct word to associate with the colour, we might reason that Newton's apprehension was consistent with regards to *alētheia*, but not to *adaequatio*. Once Newton develops work habits and skills with light, prisms, and recording, he achieves a situation where his intention, the instrument, and the procedure (including prediction and measurement) constitute a single embodiment. Of this Heelan says, "experimentation in the fullest sense involves the possibility of a human subject embodying himself in instrumentation not only for the purposes of observation, but also to create that context, physical and noetic, which is the condition of possibility for the scientific object to manifest itself in observation" (Heelan, 1977, p.34). Later we will provide an existential analysis to indicate how Newton abides with truth.

Instruments and human beings involved with a predetermined aspect of Heidegger's Real, constitute a situation whereby there may be a "hermeneutical shift" into the state of affairs of (say) physics. Measurement is the contrived act designed to render publicly verifiable information about the state of a physical system as shown though instrumentation (elaborated in Heelan, 1977, pp.31-32). If this "reading of a text in context" is the essence of science, then that could be something science educators seek to convey.

Toulmin credits Heelan with the breakthrough into the hermeneutic genus of the philosophy of science. However, for Toulmin this work apparently extends into physical science the humanistic, relativist, culture driven account of truth that founds other disciplines (Toulmin, 2002). Heidegger and Heelan see it otherwise – the hermeneutic account of physics/nature is an expression of reality conceived in specific manner. This means historical science is non-historical, which is to say modern physics is not founded in culture, nor are the practices of bench scientists today in their essence derived from the work of predecessors. The principal supporters of "historical science" today come from the social and behavioural sciences, says Heelan, who cites Skinner's book *Beyond Freedom and Dignity* as an exemplar (Heelan, 1977, p.10; Skinner, 1971).

Finally, from his experience investigating physicists and physics, Heelan indicates the criteria to use when an existential analytic is to be judged:

> In the hermeneutic tradition, philosophy is – has to be – a very personal endeavour, and its power to persuade is more like a historical narrative than an explanatory argument; it is dependent on the resonant strength of the author's voice in speaking from a coherent grasp of historical, philosophical, and scientific traditions to achieve an elucidation of human experience from some perspective. (Heelan, 2001, p.404)

The contrast Heelan makes for the hermeneutic tradition is that with analytic philosophy, and the critical issue is the nature of understanding. The hermeneutic tradition suggests the importance of the individual bringing what may be brought from the traditions of history, philosophy and science, to make sense of experience. Those within the modern tradition include Gadamer, Habermas, Nietzsche, and Foucault. In the present thesis the focus is Heidegger and Heelan because it is physics which is at issue. The challenge within the hermeneutic tradition is taken up in chapter 5 regarding Newton's engagement with truth is to encounter them within

the elucidation of human experience, as opposed to describing the properties of objects and the place of things in the theory of modern physics.

The argument of the thesis

The thesis inaugurates a new understanding of physics education. It establishes the principles of an ontological pedagogy for modern physics to address a crisis hidden within the discipline of physics. The crisis is apparent when we reflect on the involvement of truth in the discipline as a whole and in physics education. The crisis derives from the inability of physics education to perpetuate physics because students do not personally engage with the truth that is essential to physics.

How does this thesis enquire into truth and physics? This question calls for a very particular kind of answer. Its extant method of enquiry – the existential analytic of Dasein – rejects research questions, hypotheses, and scientism in all its guises. Instead, a preliminary indication of the foundation and direction of enquiry stands to introduce the thinking. Heidegger says that in such circumstances it is necessary to provide a *formal indication* of the topic and the presuppositions that the enquiry will probe. The initial formal indication of this thesis is that truth explicates physics and physics education. The argument proceeds through these steps:

1. Truth remains crucial, albeit controversial, in physics education (chapter 2)
2. Heidegger provides a percipient account of truth (chapter 3)
3. Truth reveals a crisis in physics education and suggests a path to its amelioration (chapter 4)
4. The involvement of truth in Newton's physics reveals the nature of physics (chapter 5)
5. The involvement of truth in a school provides insights into physics education (chapter 6)
6. An ontological pedagogy for modern physics may overcome the crisis in physics education and perpetuate physics (chapter 7).

The present enquiry moves from within the hermeneutic philosophy of science. It uses Heidegger's early account of phenomenology to interrogate the human experience of physics, as the hermeneutic philosophy of science understands that experience. Obvious places to interrogate physics in this way are research laboratories, deliberations in scientific journals, and historical accounts of significant discoveries or advances in the theory of physics. The starting point of any such

enquiry must be the human life-world of physics and the involvement of Dasein with truth that entails.

The engagements in the life-world the present enquiry selects for phenomenological analysis are (1) physics as it involves Isaac Newton and (2) physics as it involves students in a school laboratory at Hillary College, Auckland. Neither has previously been the grist of a phenomenological investigation with Heidegger's method, although there are some projects that are similar in particular respects. For example, Heelan provides an incisive enquiry into the work of physicist Heisenberg. Although Heelan does not draw upon Heidegger, his project is the foundational enquiry in the hermeneutic philosophy of science. *The Metaphysical Foundations of Modern Physical Science* (Burtt, 1954) also describes Newton's work by way of Newton, again without the benefit of Heidegger's phenomenology. The enquiry into a school physics laboratory extends the hermeneutic phenomenology of physics into a new field, education.

Why is Newton the appropriate representative of modern science in this thesis? Given Heidegger's precise account of modern science and its origins the first possible representative for a phenomenological enquiry is Galileo. This presents practical difficulties because the present author does not speak Italian, the sources on Galileo are more limited than those on Newton, and the culture is remote from that of the author. To abide with the beings "of" another is a challenge and one should not accept unnecessary obstacles. It would have been possible to select a figure from the history of quantum physics and this would probably have been satisfactory. Heelan selected Werner Heisenberg for his enquiry and that worked out well. Alternatively, a modern scientist could provide material for a study. Those involved in nanotechnology would be ideal for their methods display much that accord well with the present task. However, there is a need to ensure that the thesis invests in an acknowledged personage in modern science and Newton incontrovertibly holds a preeminent position in the history of modern science. The focus in the thesis is on Newton's optics, the inauguration of modern optics. The experimental equipment Newton uses in this work is common in school science laboratories in North America, the United Kingdom, Australia and New Zealand. Consequently, it is possible to relate Newton's activities to those of students in schools. Finally, it is the discipline of physics that the positivists take as their exemplar of science and the present project in phenomenology may respect that tradition. This does not mean, of

course, that studies of other theorists, and in biology, are not going to take their place in this ontological tradition of enquiry.

The thesis provides the analysis of the two engagements in the present tense: strictly, the analysis is of the *enquirer's present engagement*, first with the beings of Newton and then with the beings of the school laboratory. This is characteristic of this form of enquiry, it is an existential analytic *of Dasein* – the enquiry incorporates the enquirer as Dasein along with other beings. A concomitant of this is that whoever reads the enquiry can only consider its insights against their own situation. Like a sports fixture, each engagement is unique for those on the field of play and understood from their position.

It is crucial to distinguish the existential analytics in the thesis, which develop in chapters 5 and 6, from Heidegger's account of modern science in chapter 4. Chapter 4 facilitates an initial access to physics education by way of Heidegger's description of *research*, it is not an existential analytic. Heidegger derives his theory of modern science from his compendious account of Western metaphysics, modernity. He also derives other human engagements from his metaphysics, particularly art and technology. Heidegger renders the discipline of physics as an expression of modernity. Whilst Heidegger's metaphysical description of physics holds exciting possibilities for physics education, some of which develop in chapter 4, the thesis enquires in another direction. It returns to Heidegger's account of the human way of being, as set out in chapter 3, and provides existential analytics that involve the truth-beings of Newton (chapter 5), and the truth-beings in a secondary school physics laboratory (chapter 6).

Each chapter contributes to a Heideggerian conception of physics education, which ultimately justifies a curriculum and pedagogy. In summary:

Chapter 2, "Truth is important in physics education", examines the credibility of the claim that physics education shelters our perplexity about truth. It begins with enquiries into truth in general and then presents truth in disputes about schooling. Next, there are contentions about truth in the propositions of physics. Finally, truth is an issue in the intellectual discipline of physics. The chapter concludes that truth remains disputed in physics and in education.

Chapter 3, "Heidegger's theory of truth", develops an account of the human being. This is the theory that subsequent chapters use in an existential analytic. The thread, which integrates the various aspects of Heideggerian ontology, is his insight

into truth as disclosure, *alētheia*. All beings are truth-beings, because for Dasein they are disclosures, and Dasein always abides with formulations of truth that manifest through signification, which is to say in for-the-sake-of-which-cascades. Every being entails ontological understanding and disposition. Signification, beings, the schema, and truth are available to enable us to make sense of observable comportment.

Chapter 4, "Physics and physics education", proclaims the implications of Heidegger's account of modern science for physics education. It then articulates another way to investigate physics education, says why this alternative is desirable, and sets out the requisite theory. The chapter selects two exemplars of physics to pursue through existential analytics. They are Isaac Newton's engagement with beings in the seventeenth century and the engagement of a teacher and students in a contemporary New Zealand secondary school classroom.

Chapter 5, "Newton dwells with truth", displays four analects that embrace and contrast the themes of work, discovery, observation, and disclosures in physics. The ontological biography of Newton that develops in the first three enquiries shows the beings of physics in complexes of truth. The final enquiry moves to compare Heidegger's later theory with phenomenological conclusions about the nature of physics. The chapter concludes with the observation that the most noticeable part of modern physics is the ontic discipline which involves truth as correspondence, and that the truth of disclosure by way of modern physics is a relatively infrequent occurrence.

Chapter 6, "Students dwell with truth", locates the distinctive truth of physics in schooling. It presents an existential analytic which draws on the author's teaching experience to explore how students engage with physics education. Five separate enquires range over the themes of ordinary everydayness, student experience, the holism of classroom interactions, and the life-world of the teacher.

Chapter 7, "Discussion and conclusions", proffers four topics: truth, the nature of physics, physics education, and pedagogy. It builds upon, integrates, and discusses the existential analytics of Dasein that appear in chapters 5 and 6. Physics education is now understood as essential to the discipline of physics – it perpetuates physics in and of itself. That modern physics in its essence holds a special relationship with individual persons – it is never a group activity – holds important consequences. An ontological pedagogy of modern physics may overcome many difficulties that beset modern physics.

Chapter 2: Truth is important in physics education

There is controversy in Western nations about what schools ought to teach their students. Dissension appears in the political arena, in public policy, and in classrooms each day. Although we might hope the debate proceeds on an agreed understanding of what is at present taught and what should be taught, this is not the case. The goals of physics education reflect disputes amongst physics teachers and in the community. What occurs in a school science classroom or laboratory is complex, integrated, and variable. Heidegger is contemptuous of both the aims and methods of schooling when he says that schools are constructed to provide for the "calculated, swift, massive distribution of ununderstood information to as many as possible in the shortest possible time" (Heidegger, 1999a, p.85).

The formal school physics curriculum, which often recognises national student examinations, orients the process of teaching and learning. In physics education, a modern syllabus may prescribe attitudes, skills, knowledge, and understanding. Such documents, like physics textbooks, hold that the discipline of physics consists of subject matter, set out in defined topics that draw upon a history of progressive discovery about the nature and properties of matter and energy. Physics teachers usually believe it is their task to adhere to both the syllabus and the discipline, which means they prepare their students for examinations and genuinely introduce them in the history and practice of physics. Students and teachers – as much as professional scientists and those who fund schools and universities – subscribe to the worth of the intellectual discipline of physics.

Yet there is a shadow cast over the aspirations of physics teachers, students, scientists, and those who fund science and education. The shadow over the subject is cast by the philosophy of science, which is unable to settle upon an account of the discipline of physics, and by educational research that struggles to describe how students come to understand physics or even the nature of that understanding. Such uncertainty encourages curriculum planners to abandon intellectual disciplines as the foundation of national curricula. The challenge to the discipline of physics comes from those who urge that schooling is about socialisation, citizenship, the learning of

specific skills or attitudes, the personality of students, or the integration of knowledge.

The shadow deepens as philosophies of pluralism, relativism, and scepticism imbue political, policy, and practical discussions about education. A contemporary philosopher suggests the descriptive term "deniers" for the conspicuous group who dismiss truth as the object of human enquiries (Williams, 2002, p.5). Understandably, it is difficult to distinguish the intellectual discipline of physics from cultural expressions, simulations, and the products of imagination. As these all gain respect as the artefacts of human aspiration, people hesitate to distinguish them from each other. Information technology disguises the foundation of knowledge and thereby levels all information. Teachers struggle to explain the internal character of physics and its uniqueness.

How might we investigate these concerns about the inner-nature of physics, its pedagogy, and its involvement in society? Perhaps by advancing one notion that appears critical in all of them, and that is the notion of truth. If truth is perplexing in physics education, that perplexity may give us access to the essential truth-content of physics. With that agenda, it behoves us to consider how truth appears in the subject of physics and its teaching.

There are many and various claims made about truth that pertain to physics education. These include universal claims about truth that apply to physics education as much as anywhere, specific claims in the philosophy of science, and claims about the curriculum. Perhaps the leading contention regarding truth in physics education is that there are truths that constitute the discipline of physics and that the task of the physics teacher is to introduce the student to precisely these particular truths. The immediate task is to explore the question of truth in the teaching of physics through the *diverse* enigmas that involve concepts of truth.

Accordingly, the exploration begins with enquiries into truth in general, followed by examples where truth is involved in disputes about pedagogy. Next, there are examples that relate to truth in the propositions of science. Finally, there are examples that show the involvement of truth in the intellectual discipline of physics. In is apparent that these topics progress from truth "in general" towards claims about truth that are specific to physics.

Students and teachers shun truth (Nietzsche)

Discussions about the human beings' engagement with truth apply as much to students and teachers in schools as to anyone. A leading modern philosopher who proffers arguments about truth that he alleges hold universal applicability is Friedrick Nietzsche (1844-1900). He makes two contributions to discussions about truth that are of particular interest in physics education. First, his early arguments represent the pervasive scepticism just mentioned and second he advocates for the virtue of truthfulness that all schools uphold.

Nietzsche's assertion that there is a will to truth characteristic of human beings holds implications for physics education. Can we characterize physics students and scientists as isolated individual beings, each inherently driven by a will to truth, a will that is born within them and which characterises their essence? Students who engage with physics – noticeably astronomy with its dramatic revelations and speculations – do express their desire to understand in a personal way the inner nature and significance of phenomena. Some students even express their wonderment that they are personally within this unfathomable universe. Likewise, practicing scientists may declare in their memoirs their fervent desire to know. Although such observations support many theories, credibly, they reveal a commandeering, unphilosophical, complicated willing within (Nietzsche, 2002, p.18), being aware also that the will to truth "seduces us into taking so many risks" (Nietzsche, 2002, p.5).

It happens that in schools, enquiring wilful students who crave truth confront timetables, frenetic activity, and assorted pedagogical techniques. They find truth does not appear on the timetable, except perhaps ingeniously in those schools that seek to advance a particular persuasion by professing the good name of truth. If the question of truth is ever asked, teachers and students in modern schools might well conclude as Nietzsche wrote in 1873, when he asked "What, then, is truth?" and responded with one long, pessimistic sentence:

> A mobile army of metaphors, metonymies, anthropomorphisms, in short a sum of human relations which have been subjected to poetic and rhetorical intensification, translation, and decoration, and which, after they have been in use for a long time, strike a people as firmly established, canonical, and binding; truths are illusions of which we

> have forgotten that they are illusions, metaphors which have become worn by frequent use and have lost all sensuous vigour, coins which have lost their stamp, are now regarded as metal and no longer as coins. (Nietzsche, 1999b, p.146)

This description accords with the monotonous proffering of alleged relevance that many associate with physics instruction when it directs students towards examinations for the purpose of their advancement within institutions and employment. Nietzsche's conclusion is the very conclusion students themselves draw, for them schools do not proffer truth, and further, any belief in a permanent, reliable, formation of truth is misplaced. In their involvement with schooling, students are unlikely to suffer for the sake of truth and Nietzsche would approve of their scepticism (Nietzsche, 2002, p.26). The physics teacher who asserts "relevance" for the mobile army of truths in propositions may contribute to the creation of a new generation that denies truth.

Nietzsche's second contribution to discussions about truth has a different focus – he precisely identifies a moral virtue that holds universal recognition and is germane in physics education. As he says, we have heard about "the obligation to be truthful which society imposes in order to exist" (Nietzsche, 1999b, p.146). Truthfulness is Nietzsche's own virtue and his spokesperson Zarathustra is "more truthful than any other thinker" (Nietzsche, 1979, p.128). Both society and physics impose the obligation of truthfulness on those involved in physics education. Civil society protects itself through rules of conduct and if we believe Nietzsche, the obligation to tell the truth leads all other obligations. Teachers and students carry into the classroom the same obligations of truthfulness towards each other that are extant in politics, the military, churches, and families.

Here, it is the requirements imposed on physics education by the discipline of physics that takes particular relevance. Notwithstanding the inclinations of those involved, the physics classroom involves special responsibilities towards truthfulness. These derive from the requirement that physicists be truthful in their work. The nature of their enquiry into matter and energy requires integrity, which includes truthfulness to oneself and one's colleagues. There are celebrated cases where the truthfulness of physicists is demonstratively inadequate. At the birth of Newtonian physics, with both Galileo and Newton, historians record untruths and falsifications over both the substance of findings and the provenance of

achievements. For example, Cohen (I. B. Cohen, 1985, p.105) observes that Galileo's originality was not exactly as he "boastfully" declared it, basing this opinion on historical research into the Middle Ages by the French scholar and scientist Pierre Duhem. Newton also departs from the requirements of truthfulness when he disseminates the view that he discovered universal gravitation twenty years before the event. Whilst we may excuse disputes over priority, dishonesty at the core of a major work is disquieting. Newton's leading biographer writes specifically about Newton's "fudge factor" to highlight such deficiencies, particularly regarding the second edition of the *Principia* (Westfall, 1973). Westfall describes the arbitrary nature of Newton's correction to his calculations of the velocity of sound in air, the acceleration of gravity at Paris derived from the moon's motion, and the precession of the equinoxes. Westfall refers to "another computational slight-of-hand to give a similar pretence of precision", with the reference being to Newton's triumph in the *Principia* regarding the calculation of the speed of sound (Westfall, 1980, p.734). Had Newton been aware that the compression of sound ways generates heat (as was demonstrated by Laplace a century later), Westfall would not have written:

> The passage is one of the most embarrassing in the whole *Principia*, since the adjustments rested on no empirical grounds whatever, and in their manifest hollowness served only to cast undeserved doubt on the basic analysis. In its very flagrancy, however, the adjusted derivation gives us insight into the polemic goal behind the pretense of a higher degree of precision. (Westfall, 1980, pp.735-736)

Like physicists themselves, Westfall, assumes physics should display the virtue of truthfulness. Why this is so when truth itself is in question and when Newton achieves success in spite of his deficiencies, precipitates Nietzsche's problematic. Nietzsche might have included "truthfulness" when he mused "we still do not know where the drive to truth comes from" (Nietzsche, 1999a, p.146). Certainly, Williams finds a material relationship between these concepts as he opens *Truth & Truthfulness* with his observation that there is a demand and drive towards both truth and truthfulness (Williams, 2002, p.1). It is Westfall's determination not to be deceived (as opposed to Newton's determination to deceive) that requires attention here:

> This unconditional will to truth–what is it? Is it the will not to let oneself be deceived? Is it the will not to deceive? For the will to truth could be

> interpreted in this second way, too–if "I do not want to deceive myself" is included as a special case under the generalization "I do not want to deceive". But why not deceive? But why not allow oneself to be deceived? (Nietzsche, 2001, p.200)

Westfall's disquiet regarding Newton's deception is greater than the disquiet he might show over a marginal author and an unimportant work. It is because it is Newton, and because it is the exemplarily (and in this case even paradigmatic) work of modern physics, that Westfall's findings are dramatic and revelatory. Westfall's readers find this to be the case – because they also hold an expectation of Newton. When Westfall published his findings in *Science*, a physicist fabricated a futile attempt to justify Newton by appealing to an aspect of scientific procedure (McHugh, Armstrong, Boultbee, & Westfall, 1973). Physicists do not expect Newton to deceive them, and physics students do not expect their teachers to deceive them. These situations are more than contingent, they are indicative of something foundational to the discipline of physics, something that appears in the context of research and in the context of physics education. Williams, who claims the support of Nietzsche (Williams, 2002, p.60), will advance that this something is "truth in the discipline of physics" expressed though truthfulness. As he says, truthfulness "implies a respect for the truth" (Williams, 2002, p.11).

With this, there is a bifurcation in the argument: it is possible to conceive truth through its association with reality, and it is possible to conceive truth through its association with moral virtues. For Williams, truth itself is an expression of two more basic virtues that he identifies as "Accuracy and Sincerity" – which means, "you do the best you can to acquire true beliefs, and what you say reveals what you believe" (Williams, 2002, p.11). Williams asserts that the relationship between truthfulness and truth is confined within the spectra of moral virtues, and thus exclusively about the human being. Truthfulness and truth are creatures of procedure when you "do" and "say". The alternative account of truthfulness is that which advances that she speaks the truth when her statement accords with reality or phenomena – as contemporary students say, "you tell it as it is". The views of both Nietzsche and Williams are helpful in the subsequent discussion of truth and physical reality. For the moment, to be systematic, consider another general account from the deniers of truth. It is Rorty's argument that truth is integral to structures of

power and institutions – a further version of scepticism, which applies to the physics classroom as much as elsewhere.

Physics teachers are evangelists (Rorty)

Those who dispense with truth, "run on empty" as Williams (2002, p.59) says, are obliged to account for the association between physics education in classrooms today and innovation at Woolsthorpe three hundred years ago. They must say how science maintains itself and develops. This challenge falls to the pragmatists, and the American Richard Rorty (1931-2007) wrote extensively as their representative. Pragmatists argue that we may explain physics without recourse to any concept of truth, which means we need only to address ourselves to the technical and social benefits of physics, "solidarity, democracy, and the discouragement of cruelty, and other laudable ends" (to perhaps unfairly characterise them with the words of their opponent, Williams, 2002, p.59).

Rorty asserts the manner in which science advances is consistent with the manner by which other human endeavours proceed, irrespective of the status accorded to science by today's secularised society, where scientists have replaced priests (Rorty, 1991, p.35). Pragmatists find solidarity and consensus to be the touchstones of science and religion:

> Pragmatists would like to replace the desire for objectivity – the desire to be in touch with a reality which is more than some community with which we identify ourselves – with the desire for solidarity with that community. They think that the habits of relying on persuasion rather than force, of respect for the opinions of colleagues, of curiosity and eagerness for new data and ideas, are the *only* virtues which scientists have. They do not think that there is an intellectual virtue called "rationality" over and above these moral virtues. (Rorty, 1991, p.39)

Thus, the role of the physics classroom is to establish solidarity between generations of physicists. Newton and young students share the intellectual virtues of persuasion, respect, curiosity, and eagerness. Mention will soon be made of the extent of Newton's determination to persuade.

It may be inferred that for Rorty, physics education is an elaborate attempt to persuade the young to join the community of older scientists – physics evangelism. Rouse (2003, p.92) describes Rorty's account of truth as an "instrumentalist

antirealism" which accords with the feeling physics teachers sometimes express as their being "small cogs within a machine of schooling" and out of touch with their discipline. Reich (1996, p.342) says Rorty's pragmatism neglects the real world as it attempts to found a "liberal utopia". The vision of science advanced by The Royal Society and its offspring organisations internationally supports Reich's insight. As the Society president says "Our sights are set on encouraging and sustaining excellent science and technology and ensuring that the astonishing advances that will come in the next decades are used for the benefit of society, worldwide" (Rees, 2009). "The Royal Society of New Zealand Act 1997" asserts the importance of truth in section 10(3) which requires that the financial statements be "true". It does not mention truth in relation to science, instead section 6(b) says one function of the Society is to "recognise excellence in science and technology" (New Zealand Government, 1997). Instrumentalist and idealist accounts of science direct our attention away from truth.

Rorty's locus of science is the free and open encounter that takes place between human beings in communal settings – in institutions – and consequently there is no reason to praise scientists for being objective, logical, methodical, or devoted to truth; however, there is reason to "praise the institutions they have developed and within which they work" because it is these institutions that give concreteness and detail to the ideal of unforced agreement (Rorty, 1991, p.39). The physics classroom and the physics library bask in this acclaim and relish their status as loci of moral virtue – even if they are no longer repositories of truth.

People may debate whether or not the physics classroom is one of the institutions that display Rorty's ideal of unforced agreement. In the practical arena that debate emerges on two levels. First, there are teachers who focus on the discipline itself, the content of physics, and allow both phenomena and theory to display themselves, and second there are teachers who propel students towards correct answers in their own interests, and consequently students' practical books record many things that did not occur. Notice that in both plays 'truth' is irrelevant (according to Rorty) and if students wish to know what to believe about phenomena or examinations, it is best if they listen to as many suggestions and arguments as they can. With this form of relativism, it does not matter what physics teachers advance, as long as it is unforced and everyone agrees. The locus of truth is the

physics classroom as much as it is the research institutions of science, or the initiation ceremonies of satanic cults.

Rorty's legitimation of science without truth, efficiently levels disciplines for it removes the criterion of truth from all their practical debates. People who seek money for their "discipline" or cause, particularly those who approach the state, emulate the institutional characteristics of physics. Likewise, those who seek to incorporate a point-of-view into national curricula. It is the pragmatists' argument that levels the disciplines, and thus generates a uniformity of stature that effectively influences decision-makers against those who assert truth. The success of those who are not engaged with the rigours of truth itself becomes evidence that the notion of truth is a superseded ideal, and this further directs resources away from disciplines that have traditionally involved truth in their rationale.

How adequate is Rorty's account of natural science that renders truth as superfluous? The short answer is that it is correct as far as it goes – if we elaborate a pragmatic description of the mechanism of science, we find that the detail smuggles in contentions about truth. To see this occur it is necessary to examine a theory of science that comes from what Rorty calls the post-Kuhnian era. Within the genus of post-Kuhnian theories is the species that Rorty calls "left-wing Kuhnianism", this being the same theory that he refers to as his own version of "pragmatism" (Rorty, 1991, p.38). Left-wing Kuhnianism is a poor example to consider because it lacks detail. However, Rorty lists other Post-Kuhnianists to include Kuhn, Toulmin, Feyerabend, and Hansen (Rorty, 1991, p.95), and Toulmin's account of the mechanism of science is detailed and includes examples, some of which derive from his own experience as a practising physicist. Toulmin, who argues that truth can be a relative quality which is dependent on historical and cultural contexts, sets out an historical example to support his thesis (Janik & Toulmin, 1996). More recently, Toulmin traces the philosophers' quest for truth back to Descartes and Hobbes, and lauds Dewey, Wittgenstein, Heidegger and Rorty for abandoning that tradition (Toulmin, 1990).

Toulmin notices that many developmental systems proceed through identifiable stages whereby when the stages operate in sequence, change appears purposeful, designed, or teleological. His theory in *Human Understanding* explains how the mechanism itself operates in each case without a designer and without a particular purpose (Toulmin, 1972). He identifies the overarching theory as the

General Theory of Evolution and details its operation concerning living species, the artefacts of technology, and intellectual disciplines. The model posits three stages: variation development, selection of variants, and a mechanism for the perpetuation of selected variants. In the case of intellectual disciplines, those initiated into the ways of the discipline work to produce variants that are novel "ideas", "insights", proposals, or "hypotheses". Colleagues subsequently test these ideas though discussions held in conferences or in the discipline's literature and those variants that have little merit are (hopefully) politely forgotten. Those innovations that participants deem worthwhile they incorporate into the literature of the discipline, into lectures they present, and require in the essays of their students. It is in this way that particular notions perpetuate. Although perpetuation may secure a place in the history of the discipline, participants expect new variants to overtake even the most celebrated of variants.

The elaboration of the mechanism and the essential role of institutions, only serves to identify more precisely where truth potentially is an issue. There are two loci to appraise. The first is the creative act that generates a variant, and the second is the human act of choice involved in advancing a particular variant. We are entitled to discuss each of these problematics drawing upon concepts of truth. Rorty's free and open forum – now apparent as the site for inspiration in the production of variants and as the site of selection processes – still involves individual human beings, all with their paradoxical attributes, using whatever criteria they may as they judge assertions. We should not assume that truth is not involved. Toulmin himself writes convincingly about the non-rational factors that are involved in the advance of science, and he argues that science has a pervasive influence on political and cultural affairs. It is that which hides from us that drives humankind – and this may include truth.

For the purposes of the present discussion about the role of truth in disciplines, it is only necessary to discern this situation, it is not necessary to resolve it. With this particular observation regarding Toulmin's model, it becomes apparent that statements, and the nature of the support statements may attract, is a crucial issue for the post-Kuhnian constructivists that Rorty applauds and joins. The next section attends to statements in physics.

True propositions in physics education (Aquinas)

Those in schools talk and write incessantly and some of this commotion is communication about the formal physics curriculum. In relative peace, teachers consider the statements made by students that relate to the formal curriculum and "mark their work". The tick and the cross are characteristic of schoolwork. Each instance involves a predetermined standard, criterion, or specification, an assertion by the student, and a judgment by the teacher. An industry now assists teachers in the evaluation of students against criteria, and it is said that teachers should assess students in a fair and impartial manner. It is a foundational premise of schooling that the criteria which derive from the formal curriculum and the discipline of physics are together to hold sway over all the inclinations of physics teachers and students. If the assertions and judgements made by students and teachers do not involve truth, then we can be confident that truth is not involved in physics education.

When they explain the discipline of physics to the public, physicists sometimes appeal to truth and the public shows no difficulty with the notion. Consider two examples from Feynman's 1964 Messenger Lecture. At one point he says "I would like to illustrate that such a thing is true" (Feynman, 1965, p.85). The audience must understand truth for this simple sentence to make sense. They expect Feynman's illustration is going to show the accordance between the "such a thing" and some more foundational true truth which is available for comparison. The second example involves the same components. With reference to the advance of theory towards Newton's concept of gravity and in particular the problem of planetary movements, he says:

> At the time of Kepler some people answered this problem by saying that there were angels behind them beating their wings, and pushing the planets around an orbit. As you will see, the answer is not very far from the truth. The only difference is that the angels sit in a different direction and their wings push inwards. (Feynman, 1965, p.18)

Feynman develops his engaging narrative to indicate that whilst the theory of gravitation has advanced, the inherent essence of the phenomenon remains a mystery. He alludes to three accounts of a single phenomenon in the paragraph: that which involves angels, Newton's account, and an ideal version that is the truth. As in the previous example, "truth" indicates desirability that associates with correctness.

The two examples introduce a form of teleology into physics – explanations are better if they are closer to the truth, and the purpose of explanation is the revelation of the truth.

In philosophy, there is a theory about truth that is relevant to the involvement of truth in the assertions made by students in classrooms and physicists who speak in public. When people deem statements true or false, they engage an understanding of truth (Cooper in Phillips, 1993, p.30). The theory – which postulates that we may locate truth in the correspondence between assertions and facts – has a tradition of contention and many variants. Victorian school administrators listed the facts that teachers must teach in their schools, whilst modern curriculum officials provide guidelines on the knowledge and understand that students must demonstrate – between then and now the theory of truth endures. Theorists interpret the word "fact" in many ways, although it always alludes to something definitive and relatively certain. At one extreme are those who assert that the claim that a statement is true is nothing more than an assertion that it accords with another statement. The audience at the Messenger Lecture would find this very unsatisfactory for they were not there to delight in word games. They came to hear Feynman tell them about the current engagement of physics with an external world. In which case they have already set for us the problem of the relation between words and worlds, and directed Feynman to produce grounds for the truth of his words that are not merely linguistic.

Variants of the correspondence theory of truth develop through ancient and medieval authors and Aquinas (1225-1274) provides a succinct account of them in his *Quaestiones disputatae de veritate*, which was the outcome of a formal process of enquiry with his students that began about 1256 (Aquinas, 1994, pp.xv-xvi). Aquinas is a suitable theorist to facilitate a review of the engagement between the correspondence theory of truth and physics education. Aquinas proceeds through an analysis of three definitions of truth, leading with the contention that truth and being are the same. Hence, the question is posed, how might Aquinas interpret the talking and writing about the formal curriculum in a contemporary physics classroom?

In the process of evaluation, the work of the student always begins with a question – a question posed by the teacher. That question produces a response and the teacher compares the response to a marking schedule. Whether each of these components is oral, in written sentences, or in "small message service" text messages, is a matter to consider shortly. Whilst the education service usually

provides the criteria in the marking schedule in full written sentences in received language, the modes of communication in physics education vary. Such variability does not stop teachers from declaring that a student's work is correct or that her statements are true. About this, Aquinas begins:

> First of all, it [truth] is defined according to that which precedes truth and is the basis of truth. This is why Augustine writes: "The true is that which is"; and Avicenna: "The truth of each thing is a property of the act of being which has been established for it." Still others say: "The true is the undividedness of the act of existence from that which is." (Aquinas, 1994, pp.6-7)

That which precedes the truth is the written criterion in the curriculum, now specified "as the basis of truth". If the student's assertion replicates that which precedes him, then the student utters that which is true. Truth for the student is that which is in the curriculum specification. Augustine's reference to "that which is" is a reference to the criterion of the curriculum in its written form.

When the curriculum itself becomes the truth in this way, we notice how any statement might stand as the foundation (basis) of the curriculum and accordingly the foundation (basis) of truth. It is Avicenna's "property of the act of being" and nothing else that establishes the foundation of truth. Should the physics curriculum enshrine only the angel theory of planetary movement, then the angel theory of movement is the basis for truth, and this truth is that spoken by students in their examinations. About this, teachers are likely to express two sentiments: they sympathise with the students' predicament, and they are anxious about those who determine the curriculum.

Those who determine the physics curriculum confront the challenge of writing their discipline into documents that both facilitate pedagogy and conform to an adequate understanding of the discipline of physics. The truth is now the truth that is in their mind as the result of the academic literature, the lectures they attend, and the experiments they conduct. This account of truth supports the predominance of senior physicists on curriculum writing panels and it is about such situations that Aquinas develops his second account of truth:

> Truth is also defined in another way—according to that in which its intelligible determination is formally completed. Thus, Isaac writes: "Truth is the conformity of thing and intellect"; and Anselm: "Truth is a

> rectitude perceptible only by the mind." This rectitude, of course, is said to be based on some conformity. The Philosopher says that in defining truth we say that truth is had when one affirms that "to be which is, and that not to be which is not." (Aquinas, 1994, p.7)

To be true, the physics curriculum must conform (to use the word Isaac uses) with that which is in the mind of the curriculum developer. Isaac's "thing" is the written curriculum and the "intellect" at issue is that of the curriculum scribe. The angel theory of planetary motion may still be paramount in the physics curriculum if it is the "rectitude perceptible" to curriculum developers.

Feynman introduces the angel theory of planetary movement to illustrate the advance of Newton's theory and to emphasize the persistent mysterious aspect of his phenomena. There are relationships between the angel theory, Newton's theory, and a true situation. (Sometimes the word "reality" refers to the "true situation".) Those same relationships pertain in the example of the public official who determines the curriculum, and these relationships precipitate the third account of truth that Aquinas identifies:

> The third way of defining truth is according to the effect following upon it. Thus, Hilary [of Poitiers] says that the true is that which manifests and proclaims existence. And Augustine [in the book *On the true religion]* says: "Truth is that by which that which is, is shown"; and also: "Truth is that according to which we, judge about inferior [lower] things." (Aquinas, 1994, p.8)

In this brief quotation, it appears that "that which is" could be a written assertion as per the earlier sense outlined. However, Aquinas here refers to "reality", the existence of things independent of the human being. The notion of judgement remains explicit as for other variants of the correspondence theory that Aquinas sketches, although now the decision itself *shows* "that which is". The truth of a proposition depends on its accordance with an actual, real, true, external, state of affairs. It is now possible to say that truth has its foundation in things (Aquinas, 1994, p.9). We see that "truth has a foundation in extramental reality, its nature as truth is perfected only through an operation by the intellect" (Wippel, 1989, p.297).

The correspondence theory of truth in all of the senses identified by Aquinas is hegemonic in physics and physics education. Its position as the kind of truth advanced by common sense in our everyday life reinforces its dominance. A

student's first introduction to physics as the nature of matter and energy elevates the proposition that physics is about that which is beyond our experience yet knowable. Newton anguished over the concept of truth entailed in this relationship as his mathematical projection of nature strengthened, and since the time of Aristotle, people have proffered that physics is humankind's most sustained attempt to confront the ultimate truth, physical reality.

Truth in the philosophy of physics (Newton)

The present study compares physics as it was for Newton with physics as it is now for students. Truth is the vehicle that facilitates this comparison, and consequently Newton's deliberations about truth and the involvement of truth in the methods of the seventeenth century experimentalists, are relevant. The texts that assist us to appreciate Newton's sentiments about truth are those which engage topics such as reality, experiment, and induction.

There is much that remains unclear about Newton's philosophy of science. For example, interpretations of the famous assertion in the second edition of Newton's *Philosophiæ Naturalis Principia Mathematica*, "*hypotheses non fingo*", remain controversial, in part because Newton uses the word "hypothesis" in different ways (Hansen, 1970, p.15). The cataloguing of uses and examples is not going to assist our understanding of the expression, instead we should focus on "erecting a logical framework for hypotheses" (Hansen, 1970, p.33). A Newton scholar observes that what is particularly obscure is Newton's belief about how theory is constructed in natural philosophy (G. E. Smith, 2002, p.139). Involved in Newton's use of the word "hypotheses" is his use of the word "true" and implied associations with "Truth". Newton's accounts of truth are congruous through two movements of thought: from 1664 at Trinity College when he alone questions ancient and modern sources, and from about the same time when he engages with truth in work that is preparatory to the *Opticks* (first published much later in 1704).

In 1664, a twenty-two year old Newton at Trinity College headed his notebook "Questiones quædam Philosophiæ". Above the title he wrote "Amicus Plato amicus Aristoteles magis amica veritas", borrowing an expression from the English physician and natural philosopher Walter Charleton, who in turn drew his inspiration from Plato and Aristotle (Cambridge University Library, 2002; Newton, 1664-65, folio 1; Tarán, 2001, p.4 & p.12). In whatever form the statement appears, it means

that truth (the nature of which is unspecified or variously specified) stands superior to the teachings of any human teacher. Thus, truth is independent of human beings. Charleton's slogan is the only extant philosophical mention of truth that Newton makes in his notebook as he embarks on his career as an experimental philosopher. Whilst truth was not a topic Newton explicitly wrote about at that time, a concern for truth is apparent in the *Questiones*. The very first entry in his notebook (entitled "Off y^{e} first mater") is about the relationship between a point in mathematics and matter – the point is indivisible and the body is divisible (Newton, 1664-65, folio 1-2). His deliberations show that he was perplexed by the separateness of these truths, using truth in a sense that entails "actual", "real" and "certain" – which is consistent with the title where "matter" refers to reality or substance and "first" refers to that which is most basic for human kind.

Although he does not examine the concept of truth or make much of the word "true", Newton does not shy away from its use in the senses indicated, as shows in the third folio where "true" is used in relation to the topic just mentioned, and the ninth and fiftieth folios that concern a different topic. In this way, truth is from the start involved in Newton's deliberations.

The role of truth in Newton's philosophy of science becomes apparent in his *Opticks*, of which Cohen (who translated Newton's *Philosophiæ Naturalis Principia Mathematica* and wrote extensively on Newton), says it is the "most comprehensive public statement he ever made of his philosophy of science or his conception of the experimental scientific method" (I. B. Cohen & Westfall, 1995, p.127; Newton, 1999). The work of the *Opticks* considerably predates its first publication in 1704, and although it is the second edition which provides the quotations in the present investigation its new material still draws upon the earlier period of thought. This period of relevant work is that subsequent to his 1672 paper on colours (sent to Oldenburg), and it is a time that "tells us less about optics than about Newton" who for "eight years ... had locked himself in a remorseless struggle with Truth", eight years of "uneaten meals and sleepless nights ... of continued ecstasy as he faced Truth directly on grounds hitherto unknown to the human spirit (Westfall, 1980, p.238 & p.239).

How should we understand Westfall's capitalised word "Truth"? First, consider some of the correspondence from around that time, and then the more

definitive statement in the *Opticks*. As Newton commented in a letter to Oldenburg, about Pardies' letter:

> For the best and safest method of philosophizing seems to be, first to inquire diligently into the properties of things, and establishing those properties by experiments and then to proceed more slowly to hypotheses for the explanation of them. For hypotheses should be subservient only in explaining the properties of things, but not assumed in determining them; unless so far as they may furnish experiments. For if the possibility of hypotheses is to be the test of the truth and reality of things, I see not how certainty can be obtained in any science; since numerous hypotheses may be devised, which shall seem to overcome new difficulties. (Newton, 1978, p.106)

Westfall's independent translation of this passage uses the word "employed" instead of "subservient" (Westfall, 1980, p.242). It is Newton's assertion that there can be no certainty in science that usually takes attention when this quotation is read by many. Feyerabend explicitly says this text establishes Newton as a "good empiricist". By this he means that Newton clearly formulates the view that "only a system of thought that has been built up in a purely inductive fashion can claim to be genuine knowledge. Theories which are partly metaphysical, or 'hypothetical', are suspect (Feyerabend, 1999, p.91). Here, however, what is of interest is the veiled account of truth which involves Newton in more than the simple truths of perception and induction.

Newton indicates in his letter that his method involves: things that are independent of people, properties that are revelations to people about things, experiments that assist with the identification of properties, and hypotheses that explain properties (not the things themselves). His statements about hypotheses amount to a stipulative definition of the word "hypotheses", and it is a definition that is derived from an understanding of "truth and reality". Hypotheses are renounced as a method of access to truth and reality, because, he implies, hypotheses about truth and reality will always be diverse and there is no adequate way to assess them. This leaves the word "hypotheses" for use in relation to experiments. The expression "then to proceed more slowly to hypotheses for the explanation of them" does not make it clear what the "them" refers to: the choice is "truth and reality" or

phenomena/that which experiments investigate/that which has properties. In the overall sense of the paragraph, it is "phenomena".

Newton again summarises this very arrangement in a reply to Oldenburg, however his use of the "word" truth in that reply is not that just outlined:

> … I cannot think it effectual for determining truth, to examin the several waies by which Phænomena may be explained, unless where there can be a perfect enumeration of all those waies. You know, the proper Method for *inquiring* after the properties of things is, to deduce them from Experiments. ... the Theory, which I propounded, was evinced to me, not by inferring 'tis thus because not otherwise, that is, not by deducing it only from a confutation of contrary suppositions, but by deriving it from Experiments concluding positively and directly. (Newton, 1672, p.5004)

The Royal Society provides the Latin original (Newton, 1672, p.5006). An alternative translation of the critical passage is:

> It doesn't seem to me that there is an effective way of determining truth as the diverse modes are examined by which phenomena can be explained unless there could be a perfect (i.e. complete) enumeration of all those modes. (R. Small, 2009)

The word "truth" is now used to refer to the best of several modes of explanation of a phenomenon, and accordingly it is a correspondence use of the word "truth" – the correspondence being between the hypothesis (a sentence) and reality.

Schematically, Newton's scheme that involves truth can be displayed thus: Reality/the truth (about which there can be hypotheses in sense 1 of the word, and Newton rejects such hypotheses *in toto*) – Phenomena (sense made of reality through perception regarding properties) – Hypotheses about phenomena (hypotheses in sense 2 of the word, and the business of experimental science) – Truth as the best hypotheses (sense 2) on the day. This indicates a significant step towards the explicit separation of truth and reality from the work of the experimental scientist. Newton believes in reality described as the unknowable truth or simply, the Truth. It is about hypotheses that concern the properties of phenomena that we may discern truth, which is our approval of a correspondence.

These uses of the word "truth" are apparent in the *Opticks*. Consider two passages he wrote in English. The first relates natural philosophy to a metaphysical system:

> Whereas the main Business of Natural Philosophy is to argue from Phænomena without feigning Hypotheses, and to deduce Causes from Effects, till we come to the very first Cause, which certainly is not mechanical; and not only to unfold the Mechanism of the World, but chiefly to resolve these and such like Questions. (Newton, 1718, p.344)

And a little later, following his description of how particles "have … passive Laws of Motion as naturally result from that Force ..." (Newton, 1718, p.366):

> These Principles I consider not as occult Qualities, supposed to result from the specifick Forms of Things, but as general Laws of Nature, by which the Things themselves are form'd: their Truth appearing to us by Phænomena, though their Causes be not yet discover'd. (Newton, 1718, pp.376-377)

This paragraph follows a list of examples/questions drawn from physics and biology; although, "Whence is it that Nature doth nothing in vain; and whence arises all that Order and Beauty which we see in the World?", could belong to another discipline (Newton, 1718, p.344). Later he is more specific about the "general Laws of Nature", which he proclaims are established by Induction: "... Experiments and Observations, and in drawing general Conclusions from them by Induction" (Newton, 1718, p.380).

The hidden nature of things (including their causes) is not in itself amenable to hypotheses; nevertheless, this nature produces phenomena that are amendable to hypotheses and we are to discern general laws by way of these hypotheses and induction. The expression he uses on page 377, "their truth", holds two references: there is "their truth" as a reference to the occult Qualities (unknowable reality) of things, and there is "their truth" as entailed in that which is knowable, namely general Laws of Nature. He asserts that sentences that arise from induction are the truths about the unknowable Forms of Things, which is Truth.

That concludes the summary of the notion of truth that engaged Newton, particularly his eight-year struggle to describe Truth in relation to the method of experimental science – work that eventually appeared in his *Opticks*. Had Kant

access to the account given here, he might not have written about the "infallible calculations of Newton" (Kant, 1969, p.87).

Reality as the truth that founds physics (Plato and Aristotle)

Mention has been made of the hegemony of correspondence theories of truth in physics and physic education. The foremost correspondence theory in physics education today is that which asserts that physics is humankind's attempt to mirror an enduring physical reality that is independent of the human being. Aristotle alludes to this theory in *Physics* when he refers to the truth that constrains and holds with reference earlier writers, "all of them identify their elements, and what they call their principles, with the contraries, giving no reason indeed for the theory, but constrained as it were by the truth itself" (Physics Bk. 1 188b27-188b30, Aristotle, 1984, p.322). Reality constrains those who produce theory in the discipline of physics – the very theory that becomes the content of school physics courses. The notion of reality as constraint is something that children appreciate as they physically engage with their environment and discover it restrains them. Youth carry this understanding of nature with them into classrooms where physics teachers reinforce it. As a teacher wrote, "since students have navigated the physical world for more than a decade their intuitions usually have a thread of truth" (Redish & Vicentini, 2004, p.50).

Physics education has a history as long as that of physics itself. Plato acknowledges the subject of physics as one of the empirical studies wherein students seek to understand nature with absolute certainty (Heidegger, 1995b, p.16; Heidegger, 2009, p.27). Although it is usual to embrace educational institutions because they benefit students, they are also essential for formal disciplines such as physics. Because the problematic of truth and reality is integral to physics, it is also integral to physics education. This problematic of truth in education is not that alluded to by those who assert that teachers must be honest and teach the truth. Rather, physics education imports from the discipline of physics itself certain inherent qualities and presuppositions that are problematic.

Aristotle opens *Physics* with an account of the disciple that in its most fundamental features endures with physicists to this day:

> When the objects of an inquiry, in any department, have principles, causes, or elements, it is through acquaintance with these that knowledge and understanding is attained. For we do not think that we know a thing until we are acquainted with its primary causes or first principles, and have carried our analysis as far as its elements. Plainly, therefore, in the science of nature too our first task will be to try to determine what relates to its principles. (Physics Bk. 1 184a10-184a16, Aristotle, 1984, p.315)

Although the element of correspondence is essential in this statement, the foundation of physics is specifically the objects of enquiry that have principles. These objects – physical phenomena – today engage students who deem them credible because they are the objects of perception and because they assert an already understood reality that entails constraint. Aristotle supports his general statement with an example that was later to engage Newton, motion:

> Now the principles which cause motion in a natural way are two, of which one is not natural, as it has no principle of motion in itself. Of this kind is whatever causes movement, not being itself moved, such as that which is completely unchangeable, the primary reality, and the essence of a thing, i.e. the form; for this is the end or that for the sake of which. Hence since nature is for the sake of something, we must know this cause also. We must explain the 'why' in all the senses of the term, namely, that from this that will necessarily result ('from this' either without qualification or for the most part); that this must be so if that is to be so (as the conclusion presupposes the premises); that this was the essence of the thing; and because it is better thus (not without qualification, but with reference to the substance in each case). (Physics Bk. 2 198a36-198b9, Aristotle, 1984, p.388)

That a correspondence theory is involved is apparent from, for example, Aristotle's assertion that we must explain and from the tier structure (later to become "dualism") that the paragraph as a whole establishes. That reality is also involved is explicit and about reality he tells us these things: it is unchangeable, it is primary, it is the essence of a thing (the form), and it is the form (essence) of reality that indicates the "for the sake of which". Reality is the foundational truth that is "not ...

itself moved" when we observe movement in nature. It is apparent that Aristotle does not refer to the aforementioned constraints that children discover as they mature: children encounter the constraints of nature, and Aristotle in the cited paragraph refers to the constraints of reality. Aristotle's conception of physics probably involves a notion akin to consciousness and it entails a hylomorphism that blends form and matter into an amalgam that is unlike the modern understanding of the physical world (Shields, 1993, pp.164-165; Tartaglia, 2007, p.66). The description of form just cited indicates teleology ("for this is the end or that for the sake of which") somehow associated with reality as well as nature.

Elsewhere, when Aristotle describes the subject matter of physics, it is nature and not reality that engages those who dwell with the subject. In this, Aristotle allows scope for children and professional physicists alike, as both may lack the experience needed to take a comprehensive view of the admitted facts:

> Lack of experience diminishes our power of taking a comprehensive view of the admitted facts. Hence those who dwell in intimate association with nature and its phenomena are more able to lay down principles such as to admit of a wide and coherent development; while those whom devotion to abstract discussions has rendered unobservant of the facts are too ready to dogmatize on the basis of a few observations. The rival treatments of the subject now before us will serve to illustrate how great is the difference between a scientific and a dialectical method of inquiry. (On Generation and Corruption Bk. 1 316a5-316a14, Aristotle, 1984, p.515)

Again, a correspondence theory is apparent as are facts, both those facts that are promising for "wide and coherent development" and those that are insufficient. The rival disciplines or "methods of inquiry" – physics and philosophy – differ only in the extent to which they involve the facts in deliberations. Aristotle here provides a particular rendition of Plato's insight as recorded in *Parmenides*.

Plato provides many fundamental distinctions that dominate Western philosophy for over 2,000 years. That is Heidegger's judgement and he sets out to identify what the thinker Plato "left unsaid" (Heidegger, 1998d, p.155), by which he means that he seeks through an examination of Plato's text clues to an alternative metaphysics. A leading notion in Plato's dialogues is the doctrine of ideas. Aristotle also makes use of a "particular rendition" of this doctrine, which founds Plato's

insights into reality and intellectual disciplines (disciplines of the intellect or mind). Of the dialogue where the discussion appears, *Parmenides*, leading scholars say the "best Platonists differ about its meaning" (Hamilton and Cairns, in Plato, 1961, p.920). *Parmenides* records a tortuous, inconclusive discussion between a youthful Socrates and the eminent Parmenides, which begins with a reading by Zeno.

Following a discussion about the separateness of the concrete master-slave relationship in human dealings and the mastership-slavery relationship in the world of ideas, Plato writes:

> The significance of things in our world is not with reference to things in that other world, nor have these their significance with reference to us, but, as I say, the things in that world are what they are with reference to one another and toward one another, and so likewise are the things in our world. You see what I mean?
>
> Certainly I do.
>
> And similarly knowledge itself, the essence of knowledge, will be knowledge of that reality itself, the essentially real.
>
> Certainly.
>
> And again, any given branch of knowledge in itself will be knowledge of some department of real things as it is in itself, will it not?
>
> Yes.
>
> Whereas the knowledge in our world will be knowledge of the reality in our world, and it will follow again that each branch of knowledge in our world must be knowledge of some department of things that exist in our world.
>
> Necessarily. (Parmenides, 134e, Plato, 1961, p.928)

Definitively, we have "our world" which is the world of the senses and "the other world" which transcends our world. The essence of knowledge is that it is *about* "some department of real things as it is in itself", the transcendent world, which with this justification we may call "reality", the "real world" or "the Real". Knowledge *in* our world is knowledge *of* our world. Knowledge in the discipline of physics, including physics education, is knowledge in our world – which problematises the relationship between "the real world" and the discipline of physics.

It would be best if we could know things as they are in their essence, which is to say in their "forms", however as indicated, this is denied to us. Socrates introduces

to the dialogue the notion of forms in relation to "likeness" and "unlikeness", "Do you not recognize that there exists, just by itself, a form of likeness and again another contrary form, unlikeness itself" he says (Parmenides, 128e, Plato, 1961, p.923). The transcendence is summarised, "you hold that there exist certain forms, of which these other things come to partake and so to be called after their names; by coming to partake of likeness or largeness or beauty or justice, they become like or large or beautiful or just" (Parmenides, 131a, Plato, 1961, p.925). What concept of truth does this entail? Consider Socrates' summary:

> But, Parmenides, the best I can make of the matter is this–that these forms are as it were patterns fixed in the nature of things. The other things are made in their image and are likenesses, and this participation they come to have in the forms is nothing but their being made in their image. (Parmenides, 132d, Plato, 1961, p.927)

There are "fixed patterns" and other things are made in "their ... likeness", this likeness being simply an "image" of "nature": a correspondence theory at work. It is the mysterious correspondence of a synthesis established between the forms which are patterns of reality/nature and the image that we find in Newton's *Principia Mathematica* and subsequent textbooks on modern physics. Parmenides confirms the relationship:

> Because, Socrates, I imagine that you or anyone else who asserts that each of them has a real being 'just by itself,' would admit, to begin with, that no such real being exists in our world. (Socrates) True, for how could it then be just by itself? (Parmenides, 133c, Plato, 1961, p.927)

Unfortunately, the dialogue does not cast in such a tidy manner as for example beauty, the objects which physicists regard as their objects. They appear in a range of examples, specifically, fire, water and man (in the physical sense), and "trivial and undignified objects" such as hair, mud and dirt (Parmenides, 130d, Plato, 1961, p.924). Nevertheless, the pattern is clear – physical objects have two related realities: as the Real which transcends our senses, and separately in accordance with our senses. Physics, then, is the discipline of knowledge within our grasp, whilst that which it pursues is reality in the first sense which is forever beyond us. In *Timaeus*, Plato takes further the doctrine of forms, as he seeks to enquire into physics, astronomy, and biology. The image is now a model of reality:

> ... relating to the true and waking reality of nature, we have only this dreamlike sense, and we are unable to cast off sleep and determine the truth about them. For an image, since the reality after which it is modeled does not belong to it, and it exists ever as the fleeting shadow of some other, must be inferred to be in another [that is, in space], grasping existence in some way or other, or it could not be at all. But true and exact reason, vindicating the nature of true being, maintains that while two things [that is, the image and space] are different they cannot exist one of them in the other and so be one and also two at the same time. (Timaeus, 52c, Plato, 1961, p.1179)

Such an account prescribes a correspondence theory to truth that must associate with reality. Elsewhere the present thesis refers to this as the teleological account of the goal of physics.

How does this relate to physics education? In his discussion of the art of sophistry, Aristotle confirms Plato's worrisome relationship between reality and disciplines as they are taught. "Sophistry" refers to the wise ones who make their business wisdom – the teachers of modern physics. For "sophistry is a certain appearance of wisdom without the reality" (Sophistical Refutations 171b3-172b4, Aristotle, 1984, p.291) . The use of "reality" in this sentence is not the use at issue in the present discussion about physics: Aristotle's word "reality" in this sentence merely indicates that the teachers offer an appearance of the disciplines, and not the actual disciplines. However, Aristotle's statement applies in the particular case of physics, where the discipline is about reality (the forms of objects), and thus he implies that physics education is unsatisfactory because it conveys a questionable "appearance" of its subject matter and not its subject matter (which is reality). Truth entails reality, and reality restricts truth in accordance with its structure of forms, and physics education stands apart from this the alleged foundation of physics. Physicists, in contrast to physics educators, seek to bring themselves ever closer to the forms/reality. They do this by way of their perception of objects and deliberations that construct the doctrine of physics. Physicists allude to the teleology inherent in this when they describe the progress of physics itself, their discipline. They applaud advances in theory that take humankind closer to the unknowable forms that comprise reality. Feynman's 1964 Messenger Lecture makes use of this

notion without the audience questioning that to which the theory increasingly approximates.

Heidegger does not support the account of truth, reality, forms, and physics education just given on behalf of Plato (Heidegger, 1998b; Heidegger, 2002b). He says the present interpretation of Plato contributes to the unfortunate advance of Western philosophy – and consequently chapters 4 and 5 develop Heidegger's alternative rendition of truth and physics.

Students construct physics (Hirst)

The present chapter begins with an account of truth wherein truth is only incidentally associated with education, and progresses through theories that increasingly involve truth in education. At the end of the progression, there are those who seek to negotiate physics with their students and believe that the discipline of physics is a cultural construction. They are the constructivists, and Hirst is their recent representative. Constructivists draw upon the concept of truth which Heidegger identifies as *Adaequatio*, truth located in an agreement or correspondence. This account of truth is introduced in Chapter 1 under the heading, "Heidegger's conception of truth". Paul Heywood Hirst (1927-), who in 1965 became the Chair of Education in King's College, London, proclaims his own concept of forms of knowledge as the foundation of education. His popular dogma hides within it an account of truth which ultimately renders physics as a mental schema agreed for the moment between physicists, and the task of the physics teacher is to assist students in their construction of the physics in accordance with the public schema.

Hirst's conclusions about truth as the "ground" of "liberal education" altered during his lifetime, and his festschrift suggests that it is desirable to "reconstruct" his account of truth and knowledge. The conclusion belongs to David Cooper, professor of philosophy at University of Durham, who analyses truth in liberal education (Cooper, 1993, p.39). Hirst made truth important in discussions about teaching with his 1974 paper "Liberal education and the nature of knowledge", which according to a Stanford professor well versed in the recent history of the philosophy of education, achieved the status of a classic (Phillips, 1993, p.80). A biographer declares it is "arguably the most discussed and debated paper in the analytic philosophy of education", at a time when the analytic philosophy of education prevails in the United Kingdom and beyond (McLaughlin, 2001, p.195). Hirst's paper derives its

influence from what it rejects, which is that practical human need should determine school curricula, and truth appears as one of Hirst's justifications for a curriculum based upon forms of knowledge that arise though human experience and which hold some potential to develop themselves and enlighten us. In the concept Hirst advocates, liberal education is "concerned simply and directly with the pursuit of knowledge". He continues "but the doctrines [intellectual disciplines] give to this general idea particular meaning and significance", and thereby he insinuates there is a role for the discipline of physics in liberal education and that its justification is the discipline's foundation in truth (Hirst, 1972, p.2). He places "mathematics" and the "physical sciences" in his initial list of subjects that constitute a "distinct discipline or form of knowledge" (Hirst, 1972, pp.17-18). The relationship between truth, science and the individual is apparent when, conjuring images of injudicious physics teachers responsive to the economic plight of Great Britain, Hirst says:

> a teacher might teach a subject such as science with purely vocational or economic ends in view. He might regard himself just as equipping people for vocations or as serving a national need for trained manpower, without much thought about the development of the individuals concerned, as individuals. ... teaching science with these limited ends in view should be distinguished from educating people. (Hirst & Peters, 1970, p.28)

Teachers, preferably, should not teach physics to advance the discipline of physics itself, nor to foster the role of physics in society, but to accrue to people the benefits that derive from their being personally involved with this specific form of knowledge and the truth that pertains.

Although truth "plays an explicit and emphatic role in this concept of liberal education" (Cooper, 1993, p.39), with the exception of his remarks on religion, Hirst initially generates little debate about truth. His assertion that religion is an inadequate form of knowledge because it lacks truth, drew a response from those who seek to teach religious beliefs as a "body of truths" (for example, Astley & Francis, 1994, p.446).

That Hirst seeks to found intellectual disciplines on truths that emerge from experience – as opposed to merely advocating for the traditional disciplines advanced in Western education – is apparent in his account of the discipline of education. In response to Habermas, Hirst says that teaching is the:

> self-critical, reflective and reconstructive analysis and judgement by different groups of practitioners, operating at different and progressively more deep and wide-ranging levels of presupposition, using the disciplines to a maximum degree. (Hirst, 1983, p.28)

The expression "more deep and wide-ranging" suggests a foundation for teaching itself, a "ground", or the truth, of that discipline-practice. Educational practice takes upon itself its own distinctive involvement with truth; and it is through this involvement that education emerges as a "field of knowledge" (Hirst, 1972, pp.17-18), which apparently is a second-tier discipline ("forms" constituting the first-tier).

What is the concept of truth involved in distinctive disciplines such as physics and education according to Hirst? Already in the present thesis, various accounts of truth are considered in relation to physics and more generally. It is such well known accounts of truth that Cooper indicates Hirst finds present in the disciplines, although Cooper concludes that for Hirst, the "truth-test criterion comes to subsume the various other criteria" (Cooper, 1993, p.39). This appeal to a "truth-test" whets our appetite to know what concept of truth is in the circumstance of a test. A test is a procedure undertaken to establish the quality or reliability of something. Inherent in any test is a comparison, the presence of which leads directly to the conclusion that Hirst's "truth-test" invokes a correspondence theory of truth. Examples of disciplines with their own distinctive truth-tests include art, mathematics, morality, physics, and education (Hirst & Peters, 1970, p.62). In physics, the correspondence established in the truth-test is primarily between reality and a mirror of reality that the human being establishes in her mind and which consists of the network of propositions, procedures, presuppositions, laws, and theories together constitutive of the discipline of physics. The essential point is that this does not involve a necessary, incontrovertible reality – rather the human being, individually or in community, constructs a "mental picture", understanding always that this mental picture is just a mental picture, convenient for the present. This is a familiar, enduringly popular, concept of truth which allows us to avoid dogmatism with its overtones of unreasonableness and superiority. It is likely to go some distance towards explaining the popularity of Hirst's theory of education and the disciplines.

Popularity aside, it is correspondence accounts of truth which enable constructivist methods in the teaching of physics. As we might expect, constructivist theory in education coalesces with constructivist theories of science. We read of the

"enormous influence of constructivism on science education" which includes the inauguration of empowerment and emancipation of people, in a collection of articles each directed at an aspect of the theory bound to science education (Matthews, 1998, p.1). Here the species of the genus "correspondence" appear, to the wrath of a professor of philosophy who says of constructivism in education theory, that it "is a protean doctrine in which the metaphors of building and inventing have run riot (Nola, 1997, p.57). Less cryptic is:

> Educational constructivism draws upon other constructivist – philosophical and sociological – traditions, but it has its own autonomous roots and history. Educational constructivism of the personal variety stresses the individual creation of knowledge and construction of concepts. (Matthews, 1998, p.3)

Matthews demonstrates that truth is contentious in both educational theory and the philosophy of science when he documents constructivism in official government science curriculum publications (Matthews, 1998, p.5).

Four hundred years earlier, at the birth of modern physics, Galileo assails the protean doctrine of a constructivist:

> Two or three times in this author's arguments I have noticed that in order to prove that matters stand in such-and-such a way, he makes use of the remark that in just this way do they accommodate themselves to our comprehension, and that otherwise we should have no knowledge of this or that detail; or that the criterion of philosophizing would be ruined; as if nature first made the brain of man, and then arranged everything to conform to the capacity of his intellect. But I should think rather that nature first made things in her own way, and then made human reason skilful enough to be able to understand, but only by hard work, some part of her secrets. (Galilei, 1967, pp.264-265)

Galileo, the consummate realist, would not accommodate the constructivists of his day. The moons of Jupiter were not placed to accommodate the "brain of man", nature made things "in her own way": he, Galileo, discovered, and did not invent, these particular moons.

If, as Hirst says, physics and its teaching are founded upon experience, what may be said of the mental discipline of physics? To answer this, consider again

Hirst's truth-test, but this time focus on what is required before the student applies the test. It is:

> only when experience and thought, which necessarily involve the use of concepts of some sort, involve those shared in a public world, that the achievements with which we are concerned are possible. (Hirst & Peters, 1970, p.62)

Teachers who introduce students to a "shared public world" are reminiscent of Rorty's evangelistic teachers. Yet the crux of the matter is the individual's objective judgement, which is "not possible without a body of agreed concepts" (Hirst & Peters, 1970, p.62). The word "agreed" indicates that the concept of truth at work is a correspondence concept of one form or another, and in this case it is a correspondence of concepts between people on the inside of the form of knowledge, the physicists initiated into physics. It is Aquinas who represents this concept of truth in the present thesis, and it is upon this insight that Hirst builds his constructivist argument, with its alleged foundation of "understanding". Hence, the requirement for abstract intellectual elements to be taught is absolute – it is about understanding itself. Hirst:

> By not really bothering whether or not they have got hold of the concepts and can use them, by being content with memorised statements, by allowing pure repetition of operations, by omitting anything which demands even the briefest unrehearsed argument or justification, we simply evade all the problems and totally fail to develop any significant understanding. (Hirst, 1974, p.28)

Right from the start, from his 1974 paper, Hirst associates understanding – and thus the discipline of physics – with the notion of schema. It is, of course, a mental schema.

> Whatever else is implied in the phrase, to have 'a rational mind' certainly implies experience structured under some form of conceptual scheme. The various manifestations of consciousness, in, for instance different sense perceptions, different emotions or different elements of intellectual understanding, are intelligible only by virtue of the conceptual apparatus by which they are articulated. (Hirst, 1972, p.10)

To establish his forms of knowledge, Hirst again appeals to a correspondence theory of truth and refers to "publicly rooted conceptual organisations" (Hirst, 1972, p.11).

This is one answer to the problematic of Kant that chapter 1 introduces. What is there that founds Newton's physics? Hirst assumes the rational mind – both "rational" and "mind". These characteristics of individual human beings carry forward to allow communal concepts, formal conceptual structures, agreed procedures and common standards. The discipline of physics is in its essence a mental construct, for Hirst and the well-named "constructivists".

Cooper's assessment of Hirst's account of truth in education, which is mentioned above, begins with these words:

> The motto for this chapter might be Heidegger's gnomic remark, 'The essence of "education" is grounded in the essence of "truth"'. Faithful or not to his intention, I interpret the motto to mean at least this: a philosophy of education is, or should be, informed by a conception of truth. Better perhaps: philosophies of education are always deeply influenced, for the most part covertly, by such conceptions, and it is important that these influences be made explicit. (Cooper, 1993, p.30)

As Cooper indicates, truth is covert in Hirst's account of physics and physics education. If truth is at all overt in such accounts it is *adaequatio*, Heidegger's notion of the usual concept of truth as correspondence. Nevertheless, truth provides access to insights into Hirst's deliberations. Now we turn in the next chapter to Heidegger's explicit rendition of truth that ultimately sits in advance of his account of physics.

Chapter 3: Heidegger's theory of truth

This chapter interprets Heidegger's theory to establish the foundation for an existential analytic. The chapter indicates the concepts that the analytic uses and it considers some of their contentious aspects. Truth – which according to chapter 2 is an enduring problematic in physics – is the theme of the present chapter. This chapter and the next, show that Heidegger's account of truth takes us beyond the Greek problematic of truth and reality in physics, and beyond the inclination of some current theorists to eliminate, or marginalise, truth.

Chapter 3 describes truth and Dasein, whilst chapter 4 describes truth in the discipline of physics and physics education. This chapter begins with Heidegger's account of truth and beings. Then, it considers Dasein's schema which is the foundational expression given to truth by Dasein. Subsequently, the chapter catalogues the beings that involve Dasein and physics, and concludes with an account of the Dasein's way of existence – how Dasein abides with truth.

Truth and beings

Because science is but one small part of Heidegger's account of our human involvement with beings (his ontology), this section begins with a summary of the role of truth in his comprehensive theory. This theory was the outcome of several influences, and what follows takes the view that the problem of categories is one of the most important issues that Heidegger sought to resolve. How is it that we so naturally group the individual objects that we encounter? Physics deals with electrons, not each individual electron.

Heidegger's lifelong project – the meditation on being – begins when as an eighteen-year-old he challenges Aristotle's account of beings and categories. He records that the "first philosophical text through which I worked my way, again and again from 1907 on, was Franz Brentano's dissertation: *On the Manifold Sense of Being in Aristotle"* (Richardson, 1974, p.x). Brentano begins his dissertation with a quotation from *Metaphysics VI*, "there is one science which considers being as being, and the attributes which it has as such. This science differs from all particular sciences" (Brentano, 1975, p.1). That one science some call philosophy, and Brentano subsequently says that Aristotle was the "first to make a classification of

science and to expound its separate branches in separate essays" (Brentano, 1995, p.4). Heidegger often walks in the fields around Messkirch as he contemplates Aristotle and the problem of categories, so perhaps it is the rural setting which inspires this analogy to explain the relationship between truth, metaphysics and categories (Safranski, 1998, p.25):

> As the root of the tree, it [metaphysics] sends all nourishment and all strength into the trunk and its branches. The root branches out into the soil and ground to enable the tree to grow out of the ground and thus to leave it. The tree of philosophy grows out of the soil in which metaphysics is rooted. The ground and soil is the element in which the root of the tree lives, but the growth of the tree is never able to absorb this soil in such a way that it disappears in the tree as part of the tree. (Heidegger, 1998a, p.278)

Heidegger uses the word "metaphysics" to refer to the whole arrangement of the tree in the ground, or more narrowly to refer to the hidden essence, the foundation of the tree in the ground, the roots that send all nourishment to the trunk and the branches. It is the second use that renders the branches as physical and apparent (above the ground), in contrast to the metaphysical roots (below the ground). Heidegger discusses both uses of the word in his 1929-30 lectures. Here the former is "comprehensive thinking" or "overall orientation" or "metaphysics in general" (p.8, p.8, p.9) and the latter is the hidden aspect of things whereby on the basis of "such representation of the universal, we are in a position to determine individual items that stand before us" (Heidegger, 1995b, p.9). His examples of the "things" that stand before us at that time are the "lectern" and the "house". Heidegger rejects Aristotle's classification, his categories, as an outline of objective realism. The branches of the tree – including the branch which represents physics, including that with the lectern and the house – are not objective renderings of natural forms, but are constructs mediated by human language, culture, and history.

How does his analogy involve truth? His argument is that beings (entities) operate with a "prior representation" of Being or truth (the nourishment and the strength which flows from the base of the tree into the branches). Consequently, he says:

> the essence of truth always appears only in the already derivative form of the truth of cognitive knowledge and the truth of propositions that formulate such knowledge. (Heidegger, 1998a, p.280)

The prior representation is what enables the tree to grow out of the ground, whilst the form of truth that is apparent to us (above the ground) is either "cognitive knowledge" (intuitions which we know with certainty because we have private access to them) or a form of truth that depends on a correspondence theory. The derived forms of truth are themselves grounded in truth – however, this truth, which he calls *alētheia*, is integral to, and derived from, reality (The Real). The human being can only achieve a partial exposure to reality through a "recollection" that enables the openness of a realm.

Heidegger uses *alētheia* in his early deliberations to describe this notion of truth as an uncovering. He arrives at this formulation of truth in his early systematic analysis of the human being by considering various correspondence theories of truth, particularly those of Aristotle, Aquinas, and Kant. For example, in *Being and Time* he traces the usage in Aquinas, whose summative account of such theories appears in chapter 1, and says:

> Thomas Aquinas, who refers this definition to Avicenna (who, in turn, has taken it over from Isaac Israeli's tenth-century '*Book of Definitions'*) also uses for "*adaequatio*" (likening) the terms "*correspondentia*" ("correspondence") and "*convenientia*" ("coming together"). (Heidegger, 1962a, p.257)

When he reflects on these accounts of truth, it becomes apparent to Heidegger that there must be another form of truth. This truth enables the achievement of any correct representation or assertion.

In the 1930s, there is an impressive advance in Heidegger's thinking about *alētheia*. He declares the strategy that *Being and Time* displays as "inadequate" and the result of thinking "defensively" about truth (Heidegger, 1999a, p.246). The openness of the open, the essence of truth, he now proclaims as a constructive assertion of the sway of being of Dasein and as the ground of being for Dasein. This altered sentiment he summarises:

> The question of being is the question of the truth of be-ing. When accomplished and grasped as it historically unfolds, it becomes the grounding-question–over against the hitherto "guiding-question" of

> philosophy, which has been the question about beings. (Heidegger, 1999a, p.5)

This new turn in his programme, which he achieves with an altered guiding-question, does not negate his earlier work – rather, it adjusts the focus to that work towards the more central topic. Accordingly, his assertion that whenever beings exist (including the beings of physics), be-ing must hold sway (Heidegger, 1999a, p.5), does not preclude further enquiry into the beings of physics (say) in the manner of Heideggerian phenomenology that he expounds in *Being and Time* with the celebrated example of the carpenter. However, such an enquiry so far as Heidegger is concerned is displaced, and everyone's time would be better spent on the "unmastered ground plan of the historicity of the crossing itself" (Heidegger, 1999a, p.5).

Given Heidegger's altered approach to truth, it is appropriate that his latter investigation into the essence of the physical sciences begins with metaphysics, and maintains a metaphysical perspective, as opposed the former guiding question, which held its focus on beings. According to Kisiel, this is the movement of Heidegger's third attempt to establish the essence of science and he labels it "metaphysical" or "epochal" (Kisiel, 1977, p.163). Now Heidegger renders modern science as a terminal epoch in the long history of metaphysics that is ending "in the planetary domination of technology":

> … metaphysics here does not refer to an abstract academic discipline but rather to the prevailing presuppositions and concrete interpretation of reality which uniquely stamp an age … the question of Being is nothing less than the question of science and technology, insofar as the institutions and the attitudes they have provoked permeate the fabric of 20th century existence and thus indelibly mark the way we now live, move and have our being. (Kisiel, 1977, p.163)

Reality and truth are now on centre stage, and physics teachers assume a responsibly that they might prefer to avoid. It is time to ask how physics teachers ought to behave if they are to achieve success in the metaphysical domination of humankind. Their methods emerge in chapter 4, which elaborates Heidegger's ontological account of modern physics.

The metaphysical foundations of modern science are unique – modern science did not evolve from medieval science (*doctrina* and *scientia*), and nor did

medieval science evolve from ancient science (*epistêmê)* (Heidegger, 1977a, p.117). Heidegger bases this conclusion on his historical scholarship, and it contrasts with both Toulmin's account of the evolution of science and Rorty's description of science as a cooperative venture in institutions, as chapter 2 indicates. With different but consistent reasoning, which derives from the nature of modern science that chapter 4 elaborates, Heidegger says, "Nuclear physics does not permit itself to be traced back to classical physics and reduced to it" (Heidegger, 1977c, p.172). Consequently, it is appropriate to discuss Heidegger's philosophy of modern science without making specific reference to ancient or medieval science. There are aspects of modern science that both ancient and medieval science replicate, but these aspects do not owe their presence in modern science to their earlier involvements. For example, Aristotelian science involves observation and so does modern science, however this involvement is not correlative in the two traditions. Another consequence of Heidegger's historical insight is that it is not sensible to say that propositions in Greek or medieval science are incorrect, whilst those of modern science are correct (Heidegger, 1977a, pp.117-118).

This section shows how truth and metaphysics are integral to Heidegger's account of the human being, and relates his two formulations of *alētheia* to these things. To establish the theory that an existential analytic requires, it is necessary to extend this discussion, to say more about Dasein, specifically the foundation of Dasein in a schema that involves truth.

Dasein's schema provides for truth

What is the foundational structure that enables human beings to classify things, including those of modern physics, to involve themselves with the theory of physics and categories such as solids, liquids, and gases? Kant asked this question in an incomplete work tellingly entitled *How is physics possible? How is the transition to physics possible?*" (Kant, 1993, p.100). The answer is that it is "schematism", a formal structure the human being brings to all its involvements with entities, including those of physics. In Kant, schematism refers to the mental application of categories to the data of sense perception. Heidegger improves on this, and develops his neoteric schema as the primary classification of the beings that he identifies with his ontological phenomenology.

There is nothing physical about the "structure" a schema shows, it is merely a formation found to be necessary when we examine the way certain beings comport in their world. Kisiel calls it Heidegger's "first environmental analysis" (Kisiel, 2002, p.179). Schematism enables animals to make choices, and biologically it apparently evolves with movement and the need to classify. Watch a horse as it grazes a paddock. Without being taught botany, without knowing plants as we know plants, the horse selects the edible and rejects the inedible. Individual particular choices are possible only because of the horse finds itself where it is, with the environment it renders through a schema. It is probable that ontology recapitulates phylogeny, although Heidegger wilfully veers away from such a conclusion when he tells his students that he does not consider the "thematic metaphysics of life" (Heidegger, 1995b, p.193). His concern is only to demarcate worlding, being-in-the-world, for which he sets these parameters: "The stone is worldless and man is world-forming", and he implies the horse is somewhere between the two (Heidegger, 1995b, pp.192-193). His example is further from humankind than the horse, it is an insect:

> The bee's world is limited to a specific domain and is strictly circumscribed. … But it is not merely the world of each particular animal that is limited in range – the extent and manner in which an animal is able to penetrate whatever is accessible to it is also limited. The worker bee is familiar with the blossoms it frequents, along with their colour and scent, but it does not know the stamens of these blossoms as stamens, it knows nothing about the roots of the plant and it cannot know anything about the number of stamens or leaves, for example. (Heidegger, 1995b, p.193)

The ontological formation of the bee – bee schematism – provides it with a potential and an actual world, as does the horse's schematism, as does the schematism of the Dasein, which is that of the physicist.

Before he writes *Being and Time*, Heidegger elaborates his formidable schema of Dasein. This is Heidegger's prime, foundational answer to Kant's question about how physics is possible and it is a distinctive reformulation of Kantian schematism (Schalow, 1987; Schalow, 1994, p.315). The schematism of the Dasein enables the Dasein to engage aspects of the Real and thereby to eventually commission modern physics. Schematism constitutes Dasein and all that exists integral to Dasein, which

includes modern physics. The next section tabulates beings and thus elaborates on "all that exists". The prime classification of beings in the modern era is the particular complement of beings Heidegger identifies with his ontological phenomenology.

Incidentally, two points can be made which derive from physics being constitutionally integral to the Dasein schema. Both develop when Heidegger's analysis of truth is related to the schema. First, modern physics has always been with Dasein and can never be alienated from Dasein, and second without Dasein (that is, Dasein's particular schema) physics is not possible. Heidegger's summary of these points builds upon truth as *alētheia*, disclosedness:

> Dasein, as constituted by disclosedness, is essentially in the truth. Disclosedness is a kind of Being which is essential to Dasein. *'There is' truth only in so far as Dasein i s and so long as Dasein i s. Entities are uncovered only when Dasein is;* and only as long as Dasein is, are they disclosed. Newton's laws, the principle of contradiction, any truth whatever – these are true only as long as Dasein is. (Heidegger, 1962a, p.629, his emphasis)

It is time to say more precisely how Heidegger develops his schema and what it entails.

Heidegger captures his breakthrough of thought to schematism in the expression "a hermeneutics of facticity". To achieve this insight requires two requisite discoveries which Kisiel documents. First, Heidegger advances that there is a primal something, "*Ur-etwas"*, as it is cast in student transcripts (Kisiel, 1993, p.551), that which from the summer semester of 1920 Heidegger calls "facticity" (Kisiel, 1993, p.23). Second, Heidegger advances the hermeneutic method (quickly called "formal indication", although this is not his only use of that term) by which *Ur-etwas* may relate to the theoretical, formal-logical objective something. These breakthroughs evince the Dasein when they converge and a totality emerges, "What [facticity] and how [hermeneutics] drawn to a point where they are one and the same" (Kisiel, 1993, p.21). More fully, Kisiel explains, it:

> will be necessary to arrive at a point where we can see that a formally indicating hermeneutics and a dynamically understood facticity belong essentially together in a close-knit unity; whence a "hermeneutics *of* facticity. (Kisiel, 1993, p.23)

The first step in knitting the unity is to set out the four categories of being Heidegger presents in his KNS schema. As mentioned on page 16,"KNS" is an abbreviation for the war-emergency semester, when his lecture course began on 7 February, 1919 (Kisiel, 1993, p.39). The KNS schema is Heidegger's second attempt to identify Dasein's schematism. The first, which assists us to see something more of his thinking, appears in his habilitation thesis, where he introduces "the concept of 'living spirit' [*lebendiger Geist*] as the necessary standpoint for solving the problem of categories" (Kisiel & Sheehan, 2007, p.73).

The sources of information on Heidegger's schema are primarily his blackboard sketch by hand and the notes taken by his students (particularly Becker and Brecht). It is these that Kisiel explores and relates to Heidegger's text (Kisiel, 1992, p.37; 1993, p.22; 1994b, p.161). A compilation renders four categories of being and indicates how they relate to each other. It is within this schema that raw life, human practical action, physics, art and mathematics are enabled:

IA *Das vorweltliche Etwas*
The pretheoretical something – preworldly something
(basic movement of life as such),
primal something, original something, *Ur-etwas*
[The It which worlds and thus properizes itself]
IB *Welthaftes Etwas*
The pretheoretical something – world-laden something
(basic movement of particular spheres of experience),
genuine lifeworld
IIA *Formallogisches gegenständliches Etwas*
The theoretical something – formal-logical objective something
(motivated in primal something)
IIB *Objektartiges Etwas*
The theoretical something – object-type something
(motivated in a genuine lifeworld)

Use is made of Heidegger's numbering system in the thesis. The word "something" in the schema that is common to all Dasein indicates a being. Fundamental ontology is primarily concerned with the foundation of all that is for the Dasein – the whole schema. Physics, as cast by those who attend to objects, movements, and mathematics, is IIB: but the essential point is that IIB relates to the other three

categories in a manner that is determinative of all that associates within IIB. Later, the present chapter considers the notion of regional ontology and it is apparent that it is the schema that maintains the engagement between the beings of physics and Dasein.

Heidegger's theory now develops in an important way, which brings us closer to the discipline of physics. He identifies the kinds of beings that are present for us today – present in accordance with the schema. He does this by applying his hermeneutic phenomenology to that which is around. This may be called first-order phenomenological seeing. The insights he achieves are set out on Division I of *Being and Time*, where he takes a pedagogical approach to the topic. The complement of beings that is available to us today is a contingent matter. In Greek times Dasein held the same schema but the kinds of beings available were, Heidegger says, not necessarily those of our era. With this statement we have arrived, by another path, at the very conclusion of the previous section. It is time to identify the beings of our era.

The beings of truth

The phenomenological search of the environment, "environment" in Heidegger's sense of "that which is close to us", identifies the kinds of beings in modern physics:

> The Being of those entities which we encounter as closest to us can be exhibited phenomenologically if we take as our clue our everyday Being-in-the-world, which we also call our *"dealings" in* the world and *with* entities within-the-world. Such dealings have already dispersed themselves into manifold ways of concern. (Heidegger, 1962a, p.95, his emphasis)

When we proceed with the kind of "seeing" that is required, beings are identified and they can be grouped into kinds. Heidegger initially claims that he has seen just three kinds. In the 1950s, he says art is a fourth kind, which highlights how groupings of beings are contingent. That paper also demonstrates how disclosure, truth as *alētheia*, is foundational to our decisions about the classification of beings. With reference to Van Gogh's painting of the peasant's boots, he says there is a disclosure that goes beyond the shoes being equipment to the revelation to Dasein of a distinctive truth. It is this occurrence of truth that brings to stand the being, in this case a being of art (Heidegger, 1993b, pp.161-162). In modern physics, truth is at

work in the same way, to disclose to the Dasein beings. Phenomenologically, the kinds of being that Dasein encounters, according to *Being and Time*, are as follows:

Ready-to-hand beings (Zuhandenheit)

When the Dasein copes easily with tasks in familiar circumstances, Dasein deals with ready-to-hand beings. For the Dasein everything encountered in this way is of practical use and there is no reflective involvement with things.

> Only because equipment has *this* 'Being-in-itself' and does not merely occur, is it manipulable in the broadest sense and at our disposal. No matter how sharply we just look ... at the outward appearance of Things, in whatever form this takes, we cannot discover anything ready-to-hand (Heidegger, 1962a, p.98)

If physics is entirely about our rational reflection on objects as contained in the academic literature of the discipline, then it follows that physics does not involve ready-to-hand beings. The present thesis demonstrates that this is not the situation of Newton or students in physics lessons.

When ready-to-hand beings abide with the Dasein, it is important to resist any temptation for an observer to say that the being is in the "subconscious mind" of the Dasein, for the ontic theory of consciousness has no place in Heidegger's ontology. More positively, the Dasein achieves the manipulation and management of these beings proximally.

The physics teacher writes on the blackboard and uses the chalk without any awareness of the chalk. If she is asked after the class about the chalk she used to write particular words she will truly not be able to say what occurred. People asked about what occurs as they engage with ready-to-hand beings often "fill in the gaps" – they will create an account about what happened. Those asked admit, "I did not pay attention", "it did not seem important", or "I did not notice". The use of the word "attention" takes us to the foundations of an ontic discipline, educational psychology, and specifically to the pioneering work of William James (James, 1950, pp.402-458). As an empirical discipline, educational psychology must explain what occurs with reference to that which is objectified. The inability of people to detail ready-to-hand involvements, which James might describe as a lapse of self-consciousness or self-awareness, is explained by reference to a lapse in attention. It

is the mind which attends, and the truths entailed in such an exercise are those of correspondence, *adaequatio*.

When theorists use expressions like "ordinary everyday coping" or "ordinary everydayness" they indicate ready-to-hand beings in the main. In more recent scholarship the words "equipment" and "paraphernalia" refer to that which is ready-to-hand. "Paraphernalia" draws attention to the collective and relational aspects of equipment – as Heidegger says, taken "strictly, there 'is' no such thing as an equipment" (Heidegger, 1962a, p.97). For example, John Haugeland (a contemporary Heideggerian scholar at the University of Chicago whose work informs several aspect of the present thesis) describes Heidegger's exemplar with these words:

> Heidegger makes these points in terms of the equipment and paraphernalia of everyday life; but the upshot is the same. Hammers, nails, boards, and drills, screwdrivers, screws, and glue are all bound together in a (large) nexus of intertwined roles, instituted by the norms of carpentry practice; and that's what makes them what they are. (Haugeland, 1982, p.17)

This rendition of ready-to-hand beings draws us towards the nexus and totality of ready-to-hand beings, which is to say, towards those relationships that the concept of 'referential totality' implies.

There is a kind of being which Heidegger derives from the ready-to-hand exemplar. It is the unready-to-hand being (*Unzuhandenheit*). A way to see into this category of being is to consider what occurs when something interrupts Dasein's Zen-like everyday coping. Some event or other breaks into the normal flow of activity that engages the Dasein. Heidegger cites three progressive forms of example, the obstinate, conspicuous, and obtrusive. With reference to equipment with insufficient usability:

> When its unusability is thus discovered, equipment becomes conspicuous. This *conspicuousness* presents the ready-to-hand equipment as in a certain un-readiness-to hand (Heidegger, 1962a, pp.102-103)

The chalk breaks and the physics teacher must find another stick of chalk. This interrupts the lesson, whilst the chalk itself becomes unready-to-hand and demands attention, as does the new stick of chalk until it is in flow. This temporary

breakdown in writing with chalk Heidegger calls "obstinate". If the chalk is expended and the teacher tries to extract further words from it by pressing her finger down on the chalk to write, Heidegger says the malfunction is "conspicuous".

If the teacher discovers there is no more chalk available at all, Heidegger says this is a permanent breakdown in the equipment and describes it as "obtrusive". He appreciates the teacher's situation and frustration:

> When we notice what is un-ready-to-hand, that which is ready-to-hand enters the mode of obtrusiveness. …The more urgently … we need what is missing, and the more authentically it is encountered in its un-readiness-to-hand… (Heidegger, 1962a, p.103)

Although the missing chalk is unready-to-hand (obtrusive) it still takes its nominal reference from the ready-to-hand category of being, and the importance of this is apparent when we consider the involvements of physics teachers as they teach.

There is a confused case – according to some scholars – that seems to simultaneously have a being as both the ready-to-hand and the unready-to-hand. It is when the chalk is lying in the box and seen by the teacher. It is equipment, but it is not actively involved at the time as equipment and accordingly it is not the ready-to-hand. It might be called unready-to-hand. However, there has been no specific breakdown in its use. This better fits with the next category in the present discussion, and the notion that chalk sticks in the box are equipment is wrong.

Presence-at-hand beings (Vorhandenheit)

In a powerful section of *Being and Time*, Heidegger identifies *Vorhandenheit* as the pure making-present of something. His translators comment on the meaning of the German word:

> The adjective '*vorhanden*' means literally "before the hand", but this signification has long since given way to others. In ordinary German usage it may, for instance, be applied to the stock of goods which a dealer has 'on hand', or to the 'extant' works of an author … (Macquarrie and Robinson in Heidegger, 1962a, p.48)

Heidegger argues that pre-Socratic philosophy features this concept – the flawless, genuine revelation of something as itself – but Western philosophers subsequently neglect the concept:

> … that simple awareness of something present-at-hand in its sheer presence-at-hand, which Parmenides had already taken to guide him in his own interpretation of Being – has the Temporal structure of a pure 'making-present' of something. (Heidegger, 1962a, p.48)

Interpretations of Parmenides' didactic poem, *On nature*, remain contentious (Heidegger, 1992). At the time when he writes *Being and Time*, Heidegger proffers to his students:

> For Parmenides, the most proper possibility of truth presupposes untruth. Not change and becoming, but *doxa itself as belonging to truth*. More precision in the actual interpretation. Truth-Being: The most intimate connection. Being and knowledge, Being and consciousness. ... *Through and in the one truth, the one Being; and only in Being, truth*. (Heidegger, 2008, p.53, his emphasis)

According to Heidegger, truth and Being identify from the time of Parmenides, exactly as they do in his ontology.

There are two forms of *Vorhandenheit* that emerge from the unready-to-hand. The first form is apparent when the teacher despairs of the situation and merely stares into the empty box. The second form is that which emerges as the teacher considers the theory of economics in relation to the empty box and school funding. This second form relates to the notion of academic disciplines, such as physics, and to the concept of regional ontology which appears at the beginning of chapter 4. This latter form is very significant in western education. It is Dasein's stance in relation to scientific (in Heidegger's broad sense) theory, or more precisely, Dasein's stance to the objects of scientific theory. The ontological equivalent of the ontic object, that which carries properties, is the present-at-hand being:

> …ontologically, *existentia* is tantamount to *Being-present-at-hand* (Heidegger, 1962a, p.62)

The present thesis challenges this association between an ontic science and present-at-hand beings, and the word "tantamount" is an issue. The usual phenomenological account of how present-at-hand beings arise from ready-to-hand beings may be given in an example: The being of the chalk changes if the remaining piece of unusable chalk is taken to the chemistry laboratory. The chalk is now common chalk: it is calcium carbonate which is *something* that students study in chemistry. Chalk displays properties which the chemistry teacher presents to students as predicates,

and these properties are independent of the chalk itself. The teacher says "chalk is white", and some of the woodwork in the classroom is also white. This is the "same" chalk that appears in the students' geography books in relation to the North Downs chalk hills in Surrey. As the student expects, the hills are white and there is chalk in the White Cliffs of Dover. This is the work of present-at-hand beings, apparently those of the ontic discipline of chemistry.

Others like itself (Dasein)

Heidegger asserts that Dasein distinguishes human beings from the other kinds of beings already introduced:

> These entities are neither present-at-hand nor ready-to-hand; on the contrary, they are *like* the very Dasein which frees them, in that *they are there too, and there with it*. (Heidegger, 1962a)

The teacher in the classroom understands other teachers and students as she copes with the demands they make on her. Ontologically, Dasein-teacher is seen to comport towards other Dasein in a way that suggests this groups constitutes a particular kind of being for Dasein-teacher.

To follow Heidegger's description of Dasein in *Being and Time*, consider his concept of *Fürsorge* (solicitude). The quotation below is from his theory of ontology, and thus it does not refer to "mattering" in the sense of how things commonly "matter" to us (for example, they might be valuable, or a worry, or things that need special attention), but rather it refers to our interactions with them. Reflecting on Dasein-teacher's relationship to Dasein-students:

> Being for, against, or without one another, passing one another by, not 'mattering' to one another – these are possible ways of solicitude. And it is precisely these last-named deficient and Indifferent modes that characterize everyday, average Being-with-one-another. (Heidegger, 1962a, p.158)

Ordinary everydayness is the most primordial, original, way of being for Dasein. He continues:

> These modes of Being show again the characteristics of inconspicuousness and obviousness which belong just as much to the everyday Dasein-with of Others within-the-world as to the readiness-to-

> hand of the equipment with which one is daily concerned (Heidegger, 1962a, p.158)

Without self-consciousness as the day proceeds the Dasein copes with others and equipment. Dasein-teacher comports towards different groups of beings in different ways. Where the possible ways are those that relate to other Dasein they are ways of "solicitude" (*Fürsorge*). The former is how Dasein-teacher relates to equipment, the ready-to-hand beings, and the latter is how Dasein-teacher relates to beings like itself. As Heidegger says these "entities [like itself] are not objects of concern, but rather of solicitude" (Heidegger, 1962a, p.157).

Macquarrie and Robinson say that the word "solicitude" is not an ideal translation of "*Fürsorge*", although it is consistent with other translations. Solicitude is "caring for" without the sentimentality, morality, or intellectualism that associates with our more usual conceptions of "caring". Blattner establishes this notion of *Fürsorge* with an example which is here paraphrased: Dasein-teacher is in her classroom and some delinquent students burst into the room. They crash into the data show as they bully another student. The perpetrators rush away as suddenly as they appeared. Dasein-teacher was not responsible for this. She had no part in the event, except that she was by coincidence in the classroom when it occurred. Nevertheless, Dasein-teacher feels responsible, apologizes to people, takes an excessive interest in the injured student, and feels obliged to give a full account of events. This is, "because *who (s)he is* is more fundamental than what *(s)he is accountable for*" (Blattner, 2006, p.38, his emphasis). This example demonstrates that the expression "self-awareness" is misleading because "awareness" is usually associated with consciousness. More generally, "subjectivity" is not an appropriate term if that word associates with theories of the mind. With specific reference to *Being and Time*, it is said that Heidegger's thought "was bent resolutely on the goal of 'decentering' the human subject (without lapsing into an anti-human objectivism)" (Dallmayr, 1980, p.221).

Another aspect of solicitude that is relevant for an existential analytic, is the etymological association of solicitude with care and concern (*Sorge*, "care"; *Fürsorge*, solicitude; *Besorgen*, concern). The use of *Fürsorge:*

> … in contexts where we would speak of 'welfare work' or 'social welfare', this is the usage which Heidegger has in mind in his

> discussion of 'Fürsorge' as 'a factical social arrangement' ... (translators in Heidegger, 1962a, p.157)

The section, below which is about signification, considers further the "care structure".

One final aspect of "Others" warrants mention. Heidegger also uses the word "Mitdasein" (Dasein-with) for the being or the Dasein of others, but not usually for others themselves (Inwood, 1999, p.31). The emphasis on *Fürsorge* supports an interpretation of *Mitdasein* as "passive" and thus on a par with all other beings that Dasein is merely "with". For the Dasein, "Others" is an abbreviation of "Others-like-myself", not an ontological interpretation of "Others-who-happen-to-be-here". Thus, the ontological world includes a notion of Others, but it is made secondary to societal arrangements, including the Dasein's involvement in those arrangements (as shown in the example above). The expression "Others-like-myself" gains its intelligibility beforehand from *Fürsorge* (Heidegger, 1962a, p.119).

To conclude this section about the beings that exist based upon observed phenomena, the kinds of beings Heidegger identifies are ready-to-hand, present-at-hand, and others-like-ourselves. There is also the privative ready-to-hand being, the malfunctioning ready-to-hand being, the unready-to-hand being. There are no other kinds of beings and an existential analytic must stay within this inventory. The catalogue of beings is a static account of the phenomenological world – the next section makes the Dasein move.

Dasein's existence with truth

To achieve an existential analytic of the Dasein it is necessary to consider Dasein's way of existence. How does the Dasein abide with truth, form its world, and proceed in that world? This world includes, of course, physicists and physics.

> By directing our researches, towards the phenomenon which is to provide us with an answer to the question of the "who", we shall be led to certain structures of Dasein which are equiprimordial with Being-in-the-world. (Heidegger, 1962a, p.149)

This section follows Heidegger's directive in *Being and Time:* ontological structures are to be discerned from phenomena. The section introduces terminology that enables an existential analytic to interrogate the comportment of the Dasein, which is to say how Dasein abides or dwells in a world. The words "abidance" and

"dwelling" seem passive and more congruous now is his expression "bodying forth" (Heidegger, 2001, p.51). The most foundational structure discernable that provides Dasein's way of being is the KNS schema that draws together the mandate of involvement (facticity) and interpretation (hermeneutics). An earlier section of the present chapter indicates that the hermeneutics *of* facticity relates directly to the "structural" relationships between beings. With this preparation, the question is posed, what may be said about how Dasein proceeds in the world? To use the historian's word (Kisiel, 1993, p.35; 2002, p.179), what is the "kinetic" of Dasein? Heidegger understands this question involves assumptions about time. He says "time is the how" and "Dasein *is* time" (not merely "in" time), which indicates that we experience time as a part of the "how" and not a part of the "what" (Kisiel, 1993, p.317). Heidegger also understands that the question about how Dasein proceeds with world, calls for an answer derived by way of phenomenology – we must look afresh at Dasein-world, Dasein bodying along. The question asks for a dynamic, time-involved, account of the ontological situation.

Heidegger founds this "time involved" account of Dasein upon three leading concepts: ontological understanding, *Befindlichkeit* (disposition, dwelling), and *Rede* (that which is the foundation of talk and discourse, nomination). The present thesis uses the word "disposition" for Heidegger's "*Befindlichkeit*" and "nomination" for "*Rede*". *Alētheia*, disclosed truth, embraces Heidegger's three concepts and binds them together into one "functioning", equiprimordial complex. It is reasonable to say that this is Heidegger's tripartite model of the functional Dasein.

Having regard to the importance of fieldwork, phenomenology, *Being and Time* contains few observations although those it provides appear adequate because their simplicity gives them potency. Heidegger observes the carpenter at work, people around his own kitchen table, and those involved in a small number of academic disciplines. His examples primarily investigate three preeminent aspects of the Dasein, skilful coping, ordinary everydayness, and objectification. It is from the examples that the tripartite model of the Dasein emerges in *Being and Time*. The examples are pedagogical in *Being and Time*, thus sparse and simple, and the relationship between them and the tripartite model Heidegger works out around the time that he establishes the KNS schema. Kisiel's doxology for *Befindlichkeit* (disposition, disposedness) records it was first present in the winter semester 1919-1920, to "elaborate the situated character of life, how I find myself" and it further

develops in the summer semester 1924 (Kisiel, 1993, p.492). The threefold description of Dasein was explicit, if in a nascent phase, in Heidegger's thinking in 1924, as was shown in his talk to the Marburg theologians, as Kisiel says:

> This still quite nascent phase in the discussion of *In-Sein*, the equiprimordial constellation of involvement with the world and self through affective disposition, understanding, and discourse, is here still being articulated without the aletheic vocabulary of "truth" also developing out of Aristotle, or the kinetics of "thrown project" unique to BT itself (Kisiel, 1993, p.317)

For Heidegger, there comes together, (1) Brentano's account of Aristotle's categories, including the objects he considers in his physics, (2) his rejection of Husserl's notions about ego which ultimately produces the KNS schema, (3) the foundational notion of truth, and (4) phenomenological observations which integrate and render a list of the kinds of beings there are and (5) how the Dasein abides equiprimordially with these beings as Dasein's time.

Ontological understanding (Verstehen)

The act of understanding, *Verstehen*, specifically the understanding of Being – disclosed beings – is the first of two major existentials in *Being and Time* (Heidegger, 1962a, p.118 & 120). This introduction is to assist with the execution of the existential analytics in chapters 5 and 6. It arrives at Sheehan's definition of ontological understanding as "thrown-open-ness-as-ability-to-make-sense-of", by way of Heidegger's early work. Ontological understanding always involves truth and is integral to everything in the discipline of hermeneutic phenomenology.

The word "understanding" when used outside of Heideggerian scholarship usually refers to ontic understanding (as presented in a previous section, and for instance in Heidegger, 2000a, p.55). An example is the understanding of experiments or theories which physics teachers seek to instil "in" their students. In contrast to ontic understanding, ontological understanding is "rooted in Dasein's ownmost Being" … (Heidegger, 1962a, p.43). It is paradoxical that the English word "understanding" directs our attention towards the ontological situation when that is not our common use of the word. The word "under" can refer to something foundational and hidden as in "underwear", and "stand" means to take a position with determination, as in a military "stand" or "stand your ground". Today,

"understanding" frequently refers to scientific theories that explain and are not foundational.

Every example of experience, knowledge, and understanding, including ontic understanding (that in positivist theories), involves ontological understanding. There is an ontological ground inherent with everything experienced or understood. Hence, all of physics – discoveries, experiments, and theories – involve ontology. Further, ontological understanding always involves aletheic truth. Dasein always abides with beings, which is to say, Dasein always abides with ontological truth. The Dasein cannot have puzzlement about the ontological character of disclosures. When the astronomer sees a new image and asks "what is it", the "it" holds no puzzlement, and the answer sought is in terms of ontic understanding. The "it" is already determined when this image posits itself "as one of those", by way of a hermeneutic "as" (the hermeneutics *of* facticity). In contrast, what the physicist *qua* physicist seeks is the apophantic "as", which is an "as" in accordance with the ontic discipline of physics, otherwise, the "as" of assertion (Inwood, 1999, pp.20-22). It is the way we encounter the world – through the formulation of beliefs and objects, using logic, which Heidegger considers in *The Essence of Reasons* (Heidegger, 1969). When the student astronomer looks skywards, the "what is" turns to "it is", as she exclaims "it is a planet". More strictly, it is ontologically still that which she saw and which hermeneutics gratifyingly renders as a something wonderful, whilst apophantics, which entails truth as correspondence, renders the apperception as a planet. As Heidegger says of the primacy of ontological understanding, the Dasein:

> gets its ontological understanding of itself in the first instance from those entities which it itself is *not* but which it encounters 'within' its world, and from the Being which they possess ... (Heidegger, 1962a, p.85)

What is the scope of ontological understanding? This must be an important question for a thesis in the discipline of education. Heidegger says that ontological understanding is something "which can itself develop" (Heidegger, 1962a, p.43). Uniquely, Dasein is world-forming – only Dasein has the potential to expand its ontological world. This is a contingent matter. It is how Heidegger finds us and the contrast is with rocks and trees, and with animals that begin and remain "poor in world" (Heidegger, 1995b, pp.192-193). Already the present thesis, relates the notion of the ontological world (that is, ontological understanding) to his discussion

about schema, horses, and bees. Further, the distinctive regionalism that is ontic physics, which chapter 4 elaborates, comes to abide with the Dasein as a projection that founds upon a characteristic form of ontological understanding.

It is Dasein's ontological world-forming way that enables Heidegger to say that Dasein is foundationally a being in a particular kind of ontological world. In his Kant-book:

> The existential analytic of existence does not have as an objective a description of how we manage a knife and fork. … Being-in-the-world cannot be reduced to a relation between subject and object. It is, on the contrary, that which makes such a relation possible, insofar as transcendence carries out the projection of the Being of the essent. (Heidegger, 1962b, pp.243-244)

The present chapter describes Heidegger's deliberation about the KNS schema, which is now found relevant to the projection of the Being of the essent. His account of projection – as the act of ontological understanding – rejects the language of transcendence and instead appeals to "essential unity":

> The existential analytic illuminates this projection (this act of understanding) within the limits imposed by its point of departure. It is not so much a question of pursuing a study of the intrinsic constitution of transcendence as of elucidating its essential unity with feeling [*Befindlichkeit*] and dereliction.... (Heidegger, 1962b, p.244)

Ontological understanding and *Befindlichkeit*, which is considered shortly, are always thrown together, because they are within the "essential unity" (Heidegger, 1962a, p.573; Langan, 1959, p.36). *Being and Time* explores these ideas in what Macquarrie and Robinson call a "puzzling passage" (Heidegger, 1962a, p.330). There is a sense in which the Dasein – as ontic *and* ontological understanding – is "thrown". Consider, this paragraph, from his discussion of Dasein's guilt and the phenomenon of care (*Sorge*), which encourages that idea:

> And how is Dasein this thrown basis? Only in that it projects itself upon possibilities into which it has been thrown. The Self, which as such has to lay the basis for itself, can *never* get that basis into its power; and yet, as existing, it must take over Being-a-basis. To be its own thrown basis is that potentiality-for-Being which is the issue for care. (Heidegger, 1962a, p.330)

The "basis for itself" to which the paragraph refers is ontological understanding and *Befindlichkeit*. "Basis" itself is a problematical word because it can conjure the notion of a temporal sequence, when a better description is that there is an "essential unity".

Beyond *Being and Time*, Heidegger develops the notion of ontological understanding with his expression the "openness of the open". In *Beiträge zur Philosophie*, he abandons the idea of thrownness in favour of "*Ereignetsein*" (its occurrence, occurring, or event) (Heidegger, 1999a):

> What Heidegger is expressing in both the earlier language of *Geworfenheit* [thrownness] and the later language of *Ereignis* is that being-open is the ineluctable condition of our essence, not an occasional accomplishment of our wills. It is our "fate," the way we always already are ... To-be-the-open is to be *apriori* open*ed*, and only as such can we take-things-as. Dasein is … able to open up other things only because it itself is already opened up. (Sheehan, 2001, p.13)

Accordingly, the understanding of (say) occurrent entities depends on an openness that is "thrown", which is ontological understanding, or as Sheehan says "thrown-open-ness-as-ability-to-make-sense-of" (Sheehan, 2001, p.15).

Ontological disposition *(Befindlichkeit*)

The preferred word for *Befindlichkeit* is "disposition", although this is not ideal, and nor is it the word Heidegger settles on himself after years of deliberation. *Befindlichkeit* is an ever-present constituent of all beings, which is to say all truth – it is an integrant of intelligibility.

According to the translators of *Being and Time* (Heidegger, 1962a, p.172), *Befindlichkeit* is sometimes "attunement". It may also mean the "state in which one may be found" (Translator's comment, Heidegger, 1962a, p.172). Heidegger's leading example of *Befindlichkeit* is *Stimmung*, which translates as "mood" but this captures only one part of Heidegger's notion and is excessively psychological. *Stimmung* originally refers to the tuning of a musical instrument. A prominent American scholar glosses Heidegger and pursues the scope of *Befindlichkeit*:

> Heidegger suggests that moods or attunements manifest the tone of being-there. As Heidegger uses the term, mood can refer to the *sensibility* of an age (such as romantic), the *culture* of a company (such

> as aggressive), the *temper* of the times (such as revolutionary), as well as the *mood* in a current situation (such as the eager mood in the classroom) and, of course, the mood of an individual. (Dreyfus, 1991, p.169)

Thus, a vital, multi-dimensional concept emerges.

Later, however, there is a dramatic alternation, which Gendlin claims the scholars did not follow: Heidegger's concept *Befindlichkeit* becomes *Wohnen* (disposition/mood becomes dwelling):

> Joan Stambaugh asked Heidegger what had become of his concept of "Befindlichkeit" from *Being and Time*, since it is not mentioned in his later writings. "It is now dwelling", he said. (Gendlin, 1988, p.152)

The new word for *Befindlichkeit* emphasises both the involvement of truth and the notion of clearing which becomes a leading analogy for ontological understanding. The altered terminology brings forward an aspect of *Befindlichkeit* that was always present: place is prominent in an expression that is allegedly a literal translation of Heidegger's *Befindlichkeit* – "where-you're-at-ness" (Dreyfus, 1991, p.168). The "where" that suggests "place" is not a reference to a physical place like a physics laboratory, but nor is it a mental "place" if that is taken to require the involvement of a mind. The general or holistic aspect is an amalgam of everything non-specific relevant to the Dasein's existent situatedness, and "dwelling" freed from its association with houses, seems appropriate.

The adjusted terminology is consistent with Heidegger's wider programme of thought. The KNS schema, Heidegger's first environmental analysis, records what he finds first in the language of looking around/being-there, then in language of knowing-how-to-get-around/coping, and finally in the language of phenomenological intuition which includes the openness of the clearing that allows foundational ontological understanding (Kisiel, 2002, p.179). Consistent with this, *Befindlichkeit* develops from mood-discovered-here to become dwelling, the truth of beings in their total circumstance.

Ontological nomination (Rede)

In German "*Rede"* means "talk", although Heidegger's ontological notion of *Rede* has only a minor association with talk or discourse. Any ontic discipline, such as physics, entails debate, communication, discussions, and talk. Textbooks, lectures,

and academic journals are the foundation of the young scientist's work. In physics, language – the tool for communication – is as vital as prisms and telescopes. However, ontologically language itself, is another ontic discipline, another branch on Heidegger's tree. Language involves beings that are ready-to-hand or present-at-hand that locate in the KNS schema as all other beings locate, with truth that flows from the roots upward. Dreyfus notes:

> *Rede* ordinarily means talk, but for Heidegger *Rede is* not necessarily linguistic, i.e., made up of words. So I shall translate *Rede* by "telling," keeping in mind the sense of telling as in being able to tell the time, or tell the difference between kinds of nails. (Dreyfus, 1991, p.215)

The reference to the Heidegger's carpenter is apposite because it suggests the phenomenological method is an appropriate way to enquire. Nevertheless, "telling" misses something crucial: *Rede* refers to that which proceeds language and it always holds an equiprimordial association with ontological understanding and *Befindlichkeit*. Consider this example: "I will always remember when my daughter disappeared under the surf for the last time", says the distraught father. There is no word for Sally-death-dad-surf-gone, yet the Dasein precisely and enduringly identifies a disclosed truth – *Rede* at work. In chapter 5, there are several examples that involve Newton's discoveries and his struggle with a step beyond *Rede*, the provision ontic names for phenomena.

Rede is an ontological naming, that enables Dasein to precisely hold a truth. With the correspondence theory of truth involved, ontological nomination and ontic names are easy to confuse. They both depend on articulation, one in the ontological sense and the other as it distinguishes the meanings of words in dictionaries. Dreyfus again:

> We can make sense of Heidegger's use of both a linguistic and a non-linguistic sense of telling if we first see that both require a prior structural articulation. To be articulated can simply mean having natural joints. Heidegger's word for this is *Gliederung*, articulation (with lower-case a). In this sense a skeleton is articulated, and so is the referential whole. (Dreyfus, 1991, p.215)

Dasein always understands ontological arrangements in their totality. This is akin to Husserl's notion of "sensed nature", which is to be distinguished from "constructs" (Hardy & Embree, 1992, p.41). Husserl:

> let us now take a first, naïve look around; our aim shall be, not to examine the world's being and being-such, but to consider whatever has been valid and continues to be valid for us as being and being-such in respect to how it is subjectively valid, how it looks …. (Husserl, 1970, p.156)

Being and being-such (Heidegger's beings-truths with understanding and *Befindlichkeit*) essentially belong to the "life-world" in which we live intuitively, and this requires articulation, that *Rede* mediates. Dreyfus provides an example:

> One manifests the already articulated structure of the referential whole in the most basic way simply by telling things apart in using them. Heidegger calls this *Articulation*. A surgeon does not have words for all the ways he cuts, or a chess master for all the patterns he can tell apart and the types of (Dreyfus, 1991, p.215)

The surgeon abides with *Rede*, identifies (in practice, nominates) every type of cut, for if this was not the case, the surgeon could not profit from experience.

For-the-sake-of-which cascades (Signification)

Ontic discussions about the ontological phenomena now at issue refer to the human being as having purposes, goals, rationality, irrationality, emotions, activities, motivation, work, and play. All these activities presuppose the progression of time. The present section has yet to give an account of the interaction between truth-beings that will explicate the on-going-ness of phenomena. Mention has been made of Kisiel's apt expression, the kinetic of the Dasein. That which achieves the kinetic, Heidegger captures in his concept of a forward-casting Dasein: a being that identifies and uses what is significant in its proximal environment to comport itself. This is Dasein's way of being-in-the-world, and the word "signification" is appropriate when the focus is upon an individual Dasein described in an existential analytic. An elucidative passage on signification in *Being and Time* says how Dasein "signifies" *to itself*:

> In its familiarity with these relationships, Dasein 'signifies' to itself: in a primordial manner it gives itself both its Being and its potentiality-for-Being as something which it is to understand with regard to its Being-in-the-world. (Heidegger, 1962a, p.120)

The relationships are those between beings, and the potentiality-for-Being is Kisiel's vector. An existential analytic is our – extramural – enquiry into how in each case the Dasein signifies to itself.

Being and Time sets out a vocabulary to facilitate discussions about signification. The vocabulary itself suggests how the Dasein turns ontological meaning (the sense or significance of its situation) into comportment. Signification is the theory of for-the-sake-of-which cascades. An existential analytic of the Dasein is an enquiry into for-the-sake-of-which cascades. In these cascades the relationships between truth-beings are cast in a language that facilitates a new form of phenomenology:

> The "for-the-sake-of-which" signifies an "in-order-to"; this in turn, a "towards-this"; the latter, an "in-which" of letting something be involved; and that in turn, the "with-which" of an involvement. (Heidegger, 1962a, p.120)

This indicates a sequence of ontological involvements, a cascade that need not be logical in the sense of formal logic, but which is logical in the foundational sense of logic which Heidegger pursues elsewhere (for example, Heidegger, 1984; Heidegger, 1994). The Dasein constantly constructs such cascades, and abandons them as others form – "mechanically" this is the way of being of the Dasein. Ontic psychologists and sports commentators see minds and bodies in action, but Dasein is actually an "integrated" existential. With specific reference to the involvement of beings in this kinetic integration, he says:

> The discoveredness of the ready-to-hand and the present-at-hand is based on the disclosedness of the world for if the current totality of involvements is to be freed, this requires that significance be understood beforehand. In understanding significance, concernful Dasein submits itself circumspectively to what it encounters as ready-to-hand. Any discovering of a totality of involvements goes back to a "for-the-sake-of-which"; and on the understanding of such a "for-the-sake-of-which" is based in turn the understanding of significance as the disclosedness of the current world. (Heidegger, 1962a, p.344)

Beings as bearers of truth – ready-to-hand beings and present-at-hand beings – disclosed (*alētheia*) in a totality, project the Dasein "forward". The "current world" is the world now, which embraces the inventory and the projection. The for-the-sake-

of-which cascades are at once for the Dasein equiprimordial and in our explication the “mechanical” constructs that facilitate the interrogation of Kisiel’s “kinetic”. Chapters 5 and 6 seek to construct for-the-sake-of-which-cascades for the beings of Newton and those of students.

Being and Time is not a convenient handbook for Heideggerian phenomenologists. The present chapter builds the handbook that facilitates chapters 5 and 6. Heidegger directs his text at what he requires to repudiate the tradition of philosophy, and a consequence of this is that there are few sustained examples of Dasein “functioning”. The examples that appear tend to separate the descriptions of comportment and of beings from his treatment of for-the-sake-of-which-cascades (notice the page numbers cited in the quotations above). Further, his preoccupation with appearances in the critical sections of *Being and Time* convolutes signification. Practical phenomenologists need details about the kinetic of Dasein, details which will facilitate the analysis of phenomena.

The expression “concernful Dasein” in the quotation above indicates something Heidegger does provide which works itself out through signification, and which facilitates analysis. Heidegger’s “care structure”, the “phenomenon of care” (*Sorge*), is the ontologically elemental totality of Dasein’s casting itself backward, and forwards as “being-towards-an-end”, at the same time (Heidegger, 1962a, pp.214, p.303, p.365, Section VI "Care as the Being of Dasein", p.225-273). “Man is this projecting ... I am my being in the situation” (Editor's analysis in Heidegger, 1967, p.282). Thus, the physicist does not encounter reality but engages with beings in the manner of concern. Reality is a derived, or secondary, formation only encountered through other for-the-sake-of-which cascades. Teachers and students mediate their environment individually pushing ahead without in each case identifying objects. In their ordinary dealings with the classroom they do not pause to say “that is a book, and that is the school bell”. Instead, entities are “disclosed in their possibility” (Heidegger, 1962a, p.192).

Chapter 4: Physics and physics education

This chapter presents two initiatives. First, it develops what we might expect to be Heidegger's account of physics education. What is physics? How does physics education relate to physics? How is truth involved in physics education? As Heidegger did not write about physics education, it is necessary to extrapolate his exposition of modern science to elaborate his insights into physics education. This extrapolation attends particularly to the involvement of truth in modern physics and physics education.

The second initiative of the chapter relates to a projected enquiry. The chapter suggests a way to enquire further into Heidegger's insights into physics and its teaching. It establishes the method that chapters 5 and 6 use to penetrate the topic. Heidegger provides the method that progresses the enquiry beyond his own account of physics. It is his method of the existential analytic of the Dasein, which he argues "comes before any psychology or anthropology, and certainly before any biology" (Heidegger, 1962a, p.71). The chapter develops to two crucial aspects of the method: formal indication and ontological biography. Chapter 5 is an existential analytic that investigates the genesis of modern physics, and chapter 6 is an existential analytic that investigates the perpetuation of physics through teaching.

Before the new chapter proceeds with its tasks, it may be helpful to provide an overview of the last two chapters, which together are the foundation for what follows. Chapter 2 establishes that truth in physics is an abiding concern in the philosophy of science. It identifies quandaries in Greek, medieval, and modern philosophy. The origin of the discipline of physics is located in Plato and Aristotle's conjectures about truth and reality. In the middle ages, as Aquinas shows, truth remains problematic and not least in relation to reality and science. Finally, a cadre of flourishing philosophers, which includes Rorty and some who claim to be pragmatists, argue that modern science can proceed perfectly well without any reference to "truth". Others argue such theorists "run on empty" and that without the involvement of truth it is impossible to give an adequate account of the human being. Amongst those who allege that human beings construct their world, including the

world of physics, is Hirst, who as chapter 2 shows, develops the implications of his epistemology for education. Heidegger dismisses all such theory:

> The pertinacity of established epistemological theories which are constructivist not only generally, but also specifically regarding what they single out in advance as their subject matter and generate constructions about, namely, theoretical perceiving and knowing, can make the phenomena exhibited above seem strange initially. (Heidegger, 1999b, p.73)

The way to proceed, he asserts, is by way of a kind of seeing that encounters significance. Heidegger refers to a new form of enquiry, which will appear strange, and which he names as an existential analytic of the Dasein:

> The pertinacity of such theories and the apparent strangeness of the analysis can be clarified with regard to what motivates them only on the basis of developing *that* kind of seeing in which significance is encountered. (Heidegger, 1999b, p.73)

Chapter 3 provides the foundation required to enquire with the new way of seeing, the existential analytic of the Dasein. His perceptive portrayal of the human being – the Dasein that exemplifies a particular way of being – shows our perpetual abidance with truth. Heidegger understands truth in two primary configurations: truth as correspondence, *adaequatio*, and the truth of disclosure, *alētheia*. *Adaequatio* involves *alētheia* and a judgement about likeness or similarity. The chapter relates Dasein to Heidegger's metaphysical account of truth and intellectual disciplines, the KNS schema which is Dasein's first "structural" formation of truth, and to the kinds of truth-beings that involve the Dasein. The first structural formation of truth renders Heidegger's insight into the hermeneutics *of* facticity. The truth-beings Heidegger identifies phenomenologically. Dasein's truth-beings are either ready-to-hand beings, present-at-hand beings or others like itself. The final section of chapter 3 develops the ontological kinetic of the Dasein, which is Heidegger's account of the functioning of the human being, as it appears to another, "in" time.

Ontic disciplines and regional ontology

If you ask a Heideggerian scholar, "what is physics?" the scholar may tell you that physics is an ontic discipline or a regional ontology. These answers are consistent with the account of Dasein already sketched, and now the task is to say how the

different answers relate to Dasein and to each other. Heidegger's schema and the analogy of the tree in the previous chapter enable us to locate physics as an ontological structure of the Dasein. Without neglecting the totality of relationships involved, the beings we commonly associate with physics appear in the schema as IIB, the theoretical or object-type something (p. 68). With this foundation in mind: What is an ontic discipline and what is a regional ontology?

Early in *Being and Time*, Heidegger refers to the "ontical sciences" and contrasts research in these sciences with research in ontology. Physics is an example of an ontical science, and inquiry in such a science "is concerned primarily with *entities* and the facts about them" (Heidegger, 1962a, p.31).

The term "ontic studies" may refer to all the subjects taught in schools. School subjects are a selection of ontic disciplines and when students learn their prescribed subjects they learn "the interconnection between true propositions" (Heidegger, 1962a, p.32). It is apparent that truth in such subjects is most dependent, if not exclusively dependent, on correspondence, *adaequatio*. Husserl, Heidegger's early mentor, argues that the human life-world founds ontic disciplines:

> Each of us has his own appearances; and for each of us they count ... for what actually is ... we have long since become aware of this discrepancy between our various ontic validities. But we do not think that because of this there are many worlds. (Husserl, 1999, p.338)

Ontic certainty, for Husserl, is founded on induction (Husserl, 1999, p.355 and 376), and consequently the subjects taught in school are effectively founded upon aspects of the world which children spontaneously discover for themselves. Children display an "understanding" of induction from a young age. Perhaps such observations inspired Paul Hirst and his advocacy of "forms of thought" as the foundation of the school curriculum.

Inevitably the question arises, what are all these entities and disciplines founded upon? Husserl proposes that there are two forms of ontological investigation: fundamental ontology and regional ontology. Ontic studies in this sense just discussed, aligns with the notion of regional ontology. As Husserl says in his "preliminary" work, *Ideas I*, written around 1922:

> … there emerges a fundamentally essential difference between *being as mental process and being as a physical thing*. Of essential necessity it belongs to a regional essence, Mental Process (specifically to the

> regional particularization, Cogitatio) that can be perceived in an immanental perception; fundamentally and necessarily it belongs to the essence of a spatial physical thing that it cannot be so perceived. (Husserl, 1999, p.72)

He continues to discuss the "physical-thing datum" and "data analogous to physical things", and it is again apparent that the concept of truth here is *adaequatio*, particularly when he refers to "essential necessity transcendencies" (Husserl, 1999, p.72). Husserl would say that Newton constructed mental models of transcendent physical entities – entities that exist but which in themselves have nothing to do with Newton (chapter 2 indicates similar accounts of realism).

Heidegger provides an overview of ontic studies in his 1927 lecture, "Phenomenology and Theology", where, in a move beyond Husserl, he identifies three things that are always associated with science. Talking primarily about theology but speaking about ontic studies generally:

> Proper to the positive character of a science is: first, that a being that in some way is already disclosed is to a certain extent come upon as a possible theme of theoretical objectification and inquiry; second, that this given positum is come upon with a definite prescientific manner of approaching and proceeding with that being. In this manner of procedure, the specific content of this region and the mode of being of the particular entity show themselves. (Heidegger, 1998c, p.42)

The quotation from Husserl in *Ideas I* emphasises both the mental and the physical, and makes use of the notion of a region. Heidegger in this quotation dispenses with the Mental but holds to the notion of a specific content for a "region". Truth as disclosedness of a being, is "proper" to the positive character of science, which reflects the notion of phenomenological seeing, apprehension, which because it is dominated by hermeneutics is more than *mere* description. As we might expect, Heidegger's image is spatial (region), and the model hidden within his grand-analogy is that of a Venn diagram (set theory in mathematics). Heidegger's word "positum" is a rare word today although it was once used in philosophy to indicate a thing laid down or presupposed, especially as a basis for argument or a postulated or posited entity (Oxford English Dictionary, 1989). Heidegger apparently refers to that necessarily presupposed for there to be a particular entity. "Laid down" is one clue to the spatial nature of the image, as is his use of the word "region" in the same

paragraph. As he said in 1919 on primordial science as a pre-theoretical science, "Precisely that which first is to be posited must be pre-supposed" (Heidegger, 2000b, p.74) . A positum, always a being, can be the ontological equivalent of an ontic "object" which includes the "sight things" referred to above.

"Positum" is a word that the existential analytic in chapter 6 uses. The word indicates its home within a model, it is spatial in its allusion, it is unitary in its reference, it relates directly to 'truth' in Heidegger's sense, and accordingly it is a commended word for an existential analytic. It also has the authority of Heidegger. "Positum" continues in Heidegger's spectacular use in his discussion of regional ontology a decade beyond the publication of *Being and Time*. In the controversial translation of *Beiträge zur Philosophie (Vom Ereignis)* we read:

> What is "scientifically" knowable is in each case *given in advance* by a "truth" which is never graspable by science, a truth about the recognised region of beings. Beings *as a region* lie in advance for science, they constitute a *positum*, and every science is in itself a "*positive" science* (including mathematics). (Heidegger, 1999a, p.101)

The image is again spatial – this time it is "grasp" and "region" that build analogy. The positum, to be an existing being, must always be disclosed. It is unitary and it is rendered as truth. Dasein even renders speculation as a positum – which is a truth for Dasein. It is with ontological certainty that the Dasein understands that the Dasein is involved in speculation. I know when I conjecture. Both quotations demonstrate that Heidegger's use of the word "positum" draws upon the spatial analogy that founds the reasoning extant in regional ontology and ontic studies. "Positum" conjures associations that the word "entity" does not, and the "positive sciences" are now recognised as the sciences that address the positum.

Teach the science of nature

It is possible to discern what Heidegger might say specifically about physics education from his account of modern science. As Heidegger's approach to modern science is by way of metaphysics, he renders physics education as an expression of Western metaphysics. In the winter of 1931, in the lecture series on the essence of truth, in his discussion of the projection of being, the ontological unity of his subject is apparent when he exemplifies the projection of being in four examples, nature (physics), history, art and poetry (Heidegger, 2002b, p.44). When the foundation is

Dasein, and truth flows within the structure of metaphysics (recall the tree analogy), a unity constructs itself – regions (as in regional ontology) or ontic disciplines (perhaps school subjects) are then on display as related aspects of a particular way of being. The way to gain access to a metaphysical account of a discipline such as physics, is to interrogate the involvement of truth, both as correspondence and disclosure, in all that is indispensable to the discipline.

Heidegger says the essence of "what we today call science is research" and he explains that the "essence" of research is found in three interrelated *characteristics* (Heidegger, 1977a, p.118). This section develops the implications of these three characteristics for practical physics, in particular that aspect of physics that involves education. "Practical physics" here does not refer narrowly to practical work in the school physics laboratory or in research laboratories, but to the work of practicing physicists, technicians, administrators, teachers, and students – that which we may observe as work in the maintenance or advancement of the discipline of physics.

Restrict reality

The "essence" of research consists in the "fact that knowing [*das Erkennen*] establishes itself ... within some realm of what is, in nature" (Heidegger, 1977a, p.118). The "realm" depends on truth as disclosure, "flowing" into the branch, and this constitutes for the human being as indubitable, ontological understanding. The opening up of a sphere that will accommodate ontological understanding – restricted to a particular realm – is Heidegger's first essential characteristic of modern physics. What can be said of it?

This particular understanding as disclosure, *alētheia*, depends on the Real, or more precisely that aspect of the Real that the human being may access. "Access" here does not imply that the physicist is continuously or ever conscious of *alētheia* with its hidden understanding – rather, *alētheia* is discernable in what the scientist does. Einstein had insight into this when he said "To him who is a discover in this field, the products of his imagination appear so necessary and natural that he regards them, and would like to have them regarded by others, not as creations of thought but as given realities" (Einstein, 1982, p.270). In *Being and Time*, Heidegger's account of Einstein's advance appeals to nature as it is "in itself", which may perhaps be understood as a reference to the Real, however it quickly falls away to

"the problem of matter" which unhelpfully encourages physicists to think in a manner that Heidegger specifically repudiates:

> The relativity theory of *physics* arises from the tendency to exhibit the interconnectedness of Nature as it is 'in itself'. As a theory of the conditions under which we have access to Nature itself, it seeks to preserve the changelessness of the laws of motion by ascertaining all relativities, and thus comes up against the question of the structure of its own given area of study–the problem of matter. (Heidegger, 1962a, p.30)

Heidegger elaborates on this in his 1938 lecture, published as *The Age of the World Picture*, when he turns from the metaphor of the tree and nature to speak of a "ground plan" and the "sphere opened up". Subtly, this makes his account less dynamic, and thus it is less suggestive of an individual person and more suggestive of an intellectual discipline. The opening of the sphere is the fundamental event in research and those involved in physics are obliged to adhere precisely to this ontological understanding in their practice – they are obliged to abide with the *alētheia* that defines physics and which he refers to as nature manifest.

> Physics is, in general, the knowledge of nature, and, in particular, the knowledge of material corporeality in its motion; for that corporeality manifests itself immediately and universally in everything natural, even if in a variety of ways. (Heidegger, 1977a, p.119)

The significance of the clause "even if in a variety of ways" will become apparent when consideration is given to the second and third characteristic of modern science. In a lecture, preparation for a conference, he says:

> Physics, which, roughly speaking, now includes macrophysics and atomic physics, astrophysics and chemistry, observes nature (physis) insofar as nature exhibits itself as inanimate. In such objectiveness, nature manifests itself as a coherence of motion of material bodies. (Heidegger, 1977c, p.171)

This first characteristic of modern science indicates a potential primary goal of modern physics pedagogy: it is to ensure that the students of physics abide with the *alētheia* that pertains to nature, which is to say, to corporeal materiality in motion. As Heidegger says, perhaps too concisely, "science sets itself upon the real" (Heidegger, 1977c, p.167). How might the physics teacher encourage students to

attend to the real and in the required manner set upon it? Direct personal involvement with the corporeal must be important. Some might say that students bring this aplenty to the classroom, and they indeed do, but now it must become a conscious category that associates with, and reinforces, the discipline of physics. Subscription to the corporeal materiality we may regard as the foundational level of commitment for every physicist. Those exercises that will reinforce this notion may be the lessons of the primary school. For example, the classification of objects of different kinds and the physical movement of small objects: playing with blocks and marbles. At the next level, the corporeal moves in waves as for example on the sea shore, which is the phenomenon that Feynman singles out as assisting a proper understanding of physics. As his biographer says, Feynman tried to place his students:

> mentally at the beach . "If we stand on the shore and look at the sea," he said, "we see the water, the waves breaking" … Nature was elemental there, though for Feynman elemental did not mean simple or austere. The questions he considered within the physicist's purview – the fundamental questions – arose on the beach. (Gleick, 1994, p.22)

Unerringly, the master physics teacher brings his students to the very phenomena that display the first characteristic of modern science.

How mathematics enters into the physicist's engagement with reality is important. The Greek expression "*ta mathēmata*", according to Heidegger, refers to a "deep" sense of mathematics, which indicates that those involved know something in advance of the practical use of mathematics (Heidegger, 1977a, pp.118-119). To see this we might reflect that we cannot discover through mathematical reckoning what mathematics itself is (Heidegger, 1977c, p.177). Thus, when we measure something, we already abide with an understanding that what we are measuring is the kind of thing that can be measured (within the sphere). The ruler is technology designed to measure, thus the ruler is marked in centimetres which indicate a dimension in space, and every centimetre is the same as every other centimetre regardless of the space involved. Thus, numbers have but a small and derived part in the process of measuring, and teachers should emphasise to students that specific measurements (numbers) are not the essence of *alētheia* with regards to the involvement of mathematics in physics, and that *ta mathēmata* is an inherent essential part of the ground plan of physics.

There are other aspects of the ground-plan of modern physics which Heidegger develops elsewhere. For example, that natural science itself deals only with "present nature", and thus the natural sciences admit "a historiographical consideration of their own past merely as an addendum" (Heidegger, 1994, pp.46-47). Another is the nature of "logic" that science and everydayness involve, the "logic of logic" and the logic of categories that is necessary for science to construe objects (Crowell, 2005, pp.60-61).

Finally with regard to the first characteristic of modern physics, it is important to appreciate how physics abides with the physicist. There is in effect a single truth, *alētheia,* which entails corporeality, movement and measurability. Theorists discuss how this may be derived from vision; see for example Levin's "empire of everyday seeing" and McNeill's "glance of the eye" (Levin, 1988; McNeill, 1999). In the terminology that Heidegger largely abandons after *Being and Time*, the "aspects" of the ground-plan are equiprimordial, which is to say they are equally (non-hierarchically) basic (primordial) and mutually interdependent. They constitute in a flow from the roots of the tree to the branch that is physics. The consequence of this is that students must grasp the first characteristic of modern physics holistically, in a gestalt moment. Both Galileo and Newton were troubled that they came to abide with an equiprimordial complex that is difficult to explain to others without lamely saying it is a "world-view". This is why it is difficult to initiate students into the discipline of physics. They must embrace the constitution of physics as one whole truth – if they fail to achieve this insight they will not be able to commit to the discipline of physics *qua* physics. As this is an ontological embrace, it is not enduringly, or ever necessarily, conscious. When held by a group of people it has the effect of aligning them one to the other, thus we may identify a comradely within physics (something that arches over, perhaps "underpins" might be better, researchers, technicians, teachers, and senior students). Heidegger would say there is a "leap" required to achieve physics (Heidegger, 1987, p.43) – those who leap congeal with others who have leapt (students become physicists).

Force revelations

The second characteristic of modern physics is the method of "decisive superiority", whereby physicists entrap and secure that part of the Real that is within the available sphere (Heidegger, 1977c, p.169):

> The methodology, characterized by entrapping, securing, that belongs to all theory of the real is a reckoning-up. … To reckon, in the broad, essential sense, means: to reckon with something, i.e. to take it into account; to reckon on something, i.e. to set it up as an object of expectation. (Heidegger, 1977c, p.170)

He refers to the familiar method of enquiry in physics – the procedure of prediction by way of hypothesis, measurement, comparison, and the testing of laws. It is this characteristic of modern science that encourages us to see the virtues of the physicist – she is orderly, honest, sincere, systematic, pedantic, open-minded, reliable, collegial, skilled, and diligent. As these virtues also accrue to other disciplines and human purposes (perhaps marriage is an example) their presence encourages some to conclude that physics is essentially the same as other disciplines.

Newton struggles to explain how experiments and reality are involved in truth. He sometimes conceives of reality as a robust scientific realist (at least in the conclusion of Glazebrook, 2001, p.3). However, what is the procedure that uses a hypothesis to enable human beings to know more of reality? In a letter to Oldenburg, Newton says:

> For the best and safest method of philosophizing seems to be, first to inquire diligently into the properties of things, and establishing those properties by experiments and then to proceed more slowly to hypotheses for the explanation of them. For hypotheses should be subservient only in explaining the properties of things, but not assumed in determining them; unless so far as they may furnish experiments. For if the possibility of hypotheses is to be the test of the truth and reality of things, I see not how certainty can be obtained in any science; since numerous hypotheses may be devised, which shall seem to overcome new difficulties. (Newton, 1978, p.106)

Westfall's translation of this passage uses the word "employed" instead of "subservient" (Westfall, 1980, p.242), and this assists us to see that what is at issue is truth in its construction as *adaequatio*. When a notion is employed it is brought into a relationship with something – in this case the relationship is that between the written hypothesis and that which is revealed. That which is revealed associates with the ground plan and *alētheia*, but what is now most important is that it also associates with *adaequatio* by way of its association with the hypothesis. There is a

similarity or a correspondence involved in the total situation. Newton again summarises this very arrangement in a reply to Oldenburg:

> ... I cannot think it effectual for determining truth, to examin the several waies by which Phænomena may be explained, unless where there can be a perfect enumeration of all those waies. You know, the proper Method for *inquiring* after the properties of things is, to deduce them from Experiments. ... the Theory, which I propounded, was evinced to me, not by inferring 'tis thus because not otherwise, that is, not by deducing it only from a confutation of contrary suppositions, but by deriving it from Experiments concluding positively and directly. (Newton, 1672, p.5004)

His word "truth" in this quotation embraces both the *alētheia* and *adaequatio*.

The physics teacher, who seeks to bring students to appreciate the second essential characteristic of modern science, will involve students in the measurement of the measurable. However, the critical part of this – if the goal is for students to understand the nature of physics – is that the student forces nature to reveal itself in accordance with already held notions about that to be investigated and measurement. Further, in addition to the mathematical aspect, and equiprimordial with it, the method will in both its planning and execution show it supports and guides a fundamental law that has been laid down and is to be confirmed or denied confirmation (Heidegger, 1977a, p.122).

This procedure depends on truth as *adaequatio* – there is correspondence entailed with an aspect of the Real as shown in the sphere or ground plan (*alētheia* is also involved in this); there is correspondence entailed in the technology itself (every metre rule must measure the same distance as every other metre rule); and there is correspondence in the rules that pertain to the application of the technology (take care to avoid errors). We must consider the various structures of *adaequatio* in their specific contexts of meaning. As Kockelmans emphasises these truths are always finite, context bound, and subject to revision (Kockelmans, 1993, p.145). Consider for example, a discussion about the errors inherent in the optical observation of binary stars. This demonstrates the role of *adaequatio* as the form of truth that is essential to the second characteristic of modern physics. A physicist tells us that in all cases, long-term variations such as those visually observed as binary motions orbits are the result of measurements over a long interval of time and that these

measurements "have to be combined" (Heintz, 1971, p.133). He then sets out the sources of error (it is necessary to take the word of the observer because visual observations leave no re-measureable records, faint pairs of stars and close pairs of stars present a particular challenge), and the techniques of amelioration (corrections to micrometer observations, the use of sufficiently long and homogenous data that enables systematic errors to be determined, rejecting data that falls outside of a specific parameter, and the use of reversing prisms). Such discussions display truth as *adaequatio*. The observers must be truthful in the records they make (there must be correspondence between what they see and what they write), skill is involved particularly with close pairs and faint pairs (there is a judgement about the actual situation, and some are more adept at making such judgements than others), to remove systematic errors in long-run data it is necessary to adhere to the notion that there is a correct measurement to which the actual measurements must be brought by way of mathematical technique).

Specialise

What is Heidegger's third characteristic of modern science? As physicists work, they reveal new aspects of the Real (new corporeal beings) and develop methods that force these beings to reveal more about themselves. The engagement with these unmasked beings may require new resources, specialist management, skills, experimental arrangements, and training. In response to this situation the discipline of physics establishes sub-disciplines then sub-sub-disciplines and the emergence of specialities shows in the literature of the discipline (for example, H. Small & Crane, 1979). As the subject matter becomes refined, institutions restructure within themselves to provide the human and physical resources necessary, until specialist institutions are established. As for example, is seen with the science programmes of the United States of America's National Aeronautics and Space Administration and the Large Hadron Collider built near Geneva, Switzerland, by the European Organization for Nuclear Research. It is the revelation of new corporeal beings that demand of humankind that there be new institutions. Intrinsically, research has the character of an ongoing activity, and it is this which drives the requirement for specialised institutions. Heidegger has in mind research institutions and perhaps educational institutions when he argues the need of the German university to return to its essential, unifying roots (Cooper, 2002, p.48; Heidegger, 2003).

This characteristic of science – its escalating demand for resources – enables us to proffer career advice to physics students. Specialise as quickly as possible and develop practical skills to make useful within a research programme. Select for yourself an area of specialisation that will fragment in your lifetime.

Heidegger's third characteristic of modern science acquires its association with truth only through its involvement with the first two characteristics of modern science. Truth is not uniquely an aspect of this third characteristic as it is in the other two. The results of research themselves "open up" up further opportunities for research: which means that the results of research (which always involve *adaequatio* and which always build in the plan of the object-sphere, *alētheia*) generate new possibilities of procedure. "This having-to-adapt-itself to its own results as the ways and means of an advancing methodology is the essence of research's character as ongoing activity" (Heidegger, 1977a, p.124).

The implications of this for physics education are stark. Research institutions require recruits for science-work and they must be reliable, disciplined, and responsive to instructions. Reasoned advice is available on how physics educators in universities might advance students in this circumstance (Stith & Czujko, 2003). The planning aspects of institutions themselves and the planning of science-work within institutions, is vital. The science manager is necessarily a part of modern science. The implementation of plans requires a certain kind of individual, one who works well with others, can concentrate on exacting, repetitive work, and who above all is dependable. For the vast majority of people involved, the work is not glamorous or even particularly intellectual. Physics education produces individuals for the machinery of physics – employees.

A further implication of the third characteristic of modern science is that for students it covers over the essential truth that constitutes in the first two characteristics. Students find it difficult to see science itself when the needs of institutions and technology dominate science lessons. National policy also contributes to this effect (de Alba, González-Gaudiano, Lankshear, & Peters, 2000, p.113, suggests examples). In educational institutions, timetables and other procedures of communal life are in the foreground. Most consequential in this regard, because of its pervasive negative effect, is the examination. Students who learn science for the purposes of examinations are consumed by *adaequatio* and this overshadows the distinctive renditions of *alētheia* in physics.

The third characteristic of modern science was not always so prominent. Galileo and Newton worked alone during their long periods of productive work. They engaged *alētheia* and *adaequatio* without the distractions apparent in modern classrooms and research institutions. By engaging students in the perplexity of Galileo or Newton, physics teachers can establish circumstances favourable to the gestalt moment that enables students to abide in truth with modern science. Galileo's work with pendulums, or his attempt to show the inadequacy of Aristotle's account of falling bodies, and the failure of his experiments with falling objects, can lead students to consider Heidegger's first two characteristics of modern science. It is best if students abide with the disclosures of modern physics by way of their practical use of apparatus of their own construction. Sobel (1999, pp.19-21) gives an account of Galileo's work that is sufficient to construct lesson plans. Modern students, in conformity with the metaphysics of their age, tend to respond to apparatus with expected assertions, right answers. The physics teacher must oppose brash *adaequatio*.

The third characteristic of science may distract educators who must make decisions about curriculum. The influence, credibility, and esteem of institutions today associate with science itself in the minds of students, the public, and curriculum planners alike. Many students first encounter physics as an aspect of an institution, usually a school. Institutional arrangements influence the way students' perceive the discipline. They see physics as a time-tabled event, and watch as physics attracts resources and associates with persuasive institutions such as the National Aeronautics and Space Administration. With this entrenchment in institutions, few curriculum planners are inclined to question the nature of science or its foundation in the human beings involvement with truth.

The hermeneutic philosophy of science

The section above indicates the implications for physics education of Heidegger's account of modern science. What is salient is what Heidegger forgets when he finds three *characteristics* within modern physics, because it is that which is forgotten which provides an opportunity for further enquiry. To explore further, the present section treats of Heelan's hermeneutic philosophy of science, understood as a recent elaboration of Heidegger's programme. Consequently, this section moves from Heidegger, to Heelan, to the opportunities opened up by their theory. The subsequent

section presents a proposal for further enquiry. That further enquiry into the nature of physics includes physics education and it stands as an alternative way to consider the phenomena of science which Heidegger understands through metaphysics.

Heidegger's account of modern science – which he presents to scientists – is for him an example of current Western metaphysics which shows in a fallenness of human kind that "levels" human existence to repetition, drudgery and distractions (Peters, 2002, pp.6, p.9, & p.19). Technological Dasein "has ended in the grip of a control obsession that elevates a *means* – technological mastery over entities – over all other *ends*" (Zimmerman, 1995, p.515).Truth engages Western people as an encounter through correspondence, the "current dominant concept on of truth" (Cooper, 2002, p.54). Those entrapped in this metaphysical predicament may find attractive such theories as those of Rorty and Hirst that do not require the truth of disclosure. The physicist within modern metaphysics is akin to other people, a mere participant in the overwhelming circumstances of the epoch. This reflects in the original title of Heidegger's 1938 lecture which was "The Grounding of the Modern World Picture by Metaphysics" ("Introduction" in Heidegger, 1977a, p.x). There is in metaphysics both a "decision" on the essence of beings and a "decision" concerning the essence of truth. Such decisions are not conscious mental acts, but are decisions that we may identify though the particular involvements of the Dasein that are made available to us through the study of comportment. By the expression "world picture" Heidegger means that which is in its totality normative and binding for us (see Babich, 1995, p.591; Heidegger, 1977a, p.129). Accordingly, it is apparent that when Heidegger asks about the essential characteristics of modern science, he does so with an established sentiment and agenda. He places physics in a list of five "essential phenomenon of the modern period": modern science, machine technology, art as aesthetics, culture as the highest expression of value, and "degodization" which generates a particular form of religious experience (Heidegger, 1977a, pp.116-117).

That which the metaphysical account of modern science neglects is Heidegger's already begun phenomenological investigation into beings. He neglects phenomenological seeing when historicity and metaphysics become the impetus for his thought. He abandons the challenge of beings inherent in his early mediation on Brentano's Aristotle, along with Husserl's directive "to the things themselves". Beings (the positum, ontic entities) within for-the-sake-of-which-cascades do not

confront us in Heidegger's account of modern science, although his work remains an ontological enquiry and there is the specific reference to *alētheia*. We assume his work on beings, particularly in *Being and Time*, coheres with his subsequent account of physics. Through this "omission" Heidegger poses for us the general question, is there a credible Heideggerian phenomenological account of modern physics? Posing this question does not undermine Heidegger's theory of metaphysics, it identifies in a general way (soon to be made more explicit in a critique of Heelan's contribution) an opportunity to re-engage Heidegger's earlier project specifically with regards to modern science.

In *Heidegger's Philosophy of Science*, Glazebrook indicates Heidegger's trajectory. Her historical account identifies "the question of how scientific projection determines its object" as the decisive factor that determines the development of Heidegger's thought about the essence of science through three periods (Glazebrook, 2000, p.8). As in the present chapter, Glazebrook begins with Heidegger's metaphysical account of science. She then analyses his rejection of Kant's idealism as the basis on which to understand Newton's science, and lays out his argument that modern science is bound by the experimental method to a subjective metaphysics of representation. Heidegger uncovers a "metaphysics of subjectivity in which the certainty of the experimental method is founded upon the self-assertion of the thinking subject" (Glazebrook, 2000, p.65). This is a promising place from which to begin a phenomenology of science with the Dasein, however Heidegger turns from this opportunity and Glazebrook records how he "seeks to understand science toward a further end … the role of science in determining the modernity of the West" (Glazebrook, 2000, p.66). With this direction of thought, Heidegger invites the present thesis.

Heelan, unlike Heidegger, does not embrace metaphysics as the place to begin an enquiry into the nature of science. As a physicist himself, Heelan finds it congenial to begin with enquiries into decisive acts of scientific discovery. This work begins early in his career with a thesis on the German mathematical physicist Werner Karl Heisenberg (1907-1976) with whom Heelan holds discussions (Heelan, 1965). For Heelan the task of a hermeneutic philosophy of science is to:

> explore at a philosophical level the sense in which interpretation is at work in all of physics and other experimental science, and to contribute to opening up a new philosophical – and metaphysical – perspective on

> physics that was possibly foreshadowed by Einstein and Heisenberg in their attempt to make sense of their discoveries. (Heelan, 1998, p.273)

It is apparent that it is by way of an all-embracing philosophical enquiry into "interpretation" that insights are to be achieved, and thus the involvements of individual scientists appear paramount for Heelan's philosophy of science and he speaks of "exemplary cases" (Heelan, 1998, p.291). Not the other way round, as Heidegger shows in his work on physics – and this notwithstanding that Heidegger acknowledges the importance of Galileo, Kepler, and Newton (as chapter 4 indicates), and mentions the complexity of Heisenberg's work when he opens his decisive 1962 lecture (Heidegger, 2002c, p.1). Heidegger met Heisenberg in 1953 at a conference, "The Arts in the Epoch of Technology", when Heisenberg's paper was tellingly entitled "Modern Physics Image of the World" (Petzet, 1993, p.75).

How does Heelan leave the hermeneutic philosophy of science upon the completion of his major investigations? He refers to a "strong" hermeneutical philosophy of natural science which is within the "working canon of philosophical works defined principally by the writings of Heidegger and Husserl" (Heelan, 1989, p.477).

First, Heideggerian, hermeneutic phenomenology acknowledges that all philosophical enquiries begin and continue with the person who enquires. There is no opportunity to engage in phenomenological enquiry without the inclusion of a reference to the self, even if this is not explicit. The present thesis maintains the stance that this reference should always be explicit with the enquirer cast in an ontological manner, as Dasein.

Second, Heelan claims that physics in its genesis and its perpetuation orients towards the perceptual world (Heelan, 1983a; Heelan, 1983b). Perception is the foundation of physics for many reasons that include its involvement in scientific observation. Heidegger since his 1951 lecture "Building, Dwelling, Thinking", was "constantly occupied with the issue of space and with the question of whether 'space' as conceived by Galileo, Newton, and modern natural science is identical with space in art" (Petzet, 1993, p.157). Kockelmans finds the concept and the event of "perception" distanced from phenomenological seeing:

> As far as Heelan's claims about scientific observation are concerned, I myself have in the past always refrained from discussing a hermeneutic approach to the natural science from an analyzing point of view. By this

> I mean that the term "perception" does not refer to a truly original act, but to an act whose meaning and function can be discovered only by those who adopt an analyzing attitude. Human beings do not primarily and directly engage in perception; instead they care, work, study, wonder, love, hate, etc. The latter are all forms of understanding. And all understanding is, as we have seen, interpretation. (Kockelmans, 1993, p.111)

What is the veiled alternative to an "analyzing point of view", that which holds "perception" as a derived commodity, and to which the "analyzing attitude" accords? His reply is direct: it is desirable to attend to what is involved in "actually doing science, teaching science, (and) employing scientific insights" (Kockelmans, 1993, p.112). This is a directive to return to the beings and signification in accordance with chapter 3, which means to enquire into physics within an existential analytic of the Dasein.

Third, what is the stance Heelan takes on the constructs of theory that are characteristic of physics, for example, neutrons, protons, and electrons? Do they exist independent of the human being or are constructs of the human being, generated to facilitate understanding? Heelan maintains exactly Heidegger's view that neither of these alternatives is correct. Instead, scientific entities are "objects in the living world". As such they are available for involvement as cultural entities. It is through their theory-ladenness that they achieve their involvement in a "broad cultural historical lifeworld" (Heelan, 1998, p.287). This wide range of potential involvements, however, is not the relationship that binds "electrons" to modern physics. That is only to be achieved through *alētheia*, and involvement in the forced revelation of an aspect of the Real. This does not mean electrons are real or an aspect of the Real. It means that as the beings that electrons are themselves, as for example, word-beings, they participate in involvements that through correspondence relationships enable the Dasein to force an aspect of the Real to disclose. The "electrons" are not "themselves" an aspect of the Real. The participation of an "electron" in physics is akin to the electron's participation in the broad cultural lifeworld, it is however, only through *alētheia* that its special embroilment in modern physics can occur. Not all *alētheia* is the *alētheia* of modern physics, and thus the electron may involve itself in human understanding though historical, local, or practical situations. Scientific experimentation, involves human beings in involving

themselves in situations where scientific "objects" manifest themselves. Such manifestation will entail *alētheia*, and much of the work of modern science is preparation for that expository disclosure. Heelan uses the expression "finding or producing specimens" for observation (Heelan, 1972, p.121). This event is a breakthrough of an aspect of the Real into the for-the-sake-of-which-cascades of the Dasein.

Equally, through expression in the truth of correspondence, the electron may incorporate itself in the for-the-sake-of-which-cascades of the Dasein. The school student, who learns from a textbook or a computer screen, may participate in a cultural lifeworld that engages electrons. Without phenomena that entail disclosures of the Real that entail the electron, the electron for the student remains detached from modern physics. The existential analytic in chapter 6 investigates such situations.

Fifth, a further topic to consider from Heelan's work, relates to the effect of the truth of disclosure upon the Dasein. Most accounts of the revelation of an aspect of the Real in modern physics record it as a profound experience for the Dasein. This has consequences that are evidenced in Heelan's examples of advance in physics. One of those consequences is that theorists such as Rorty observe the camaraderie of physicists – those who enter into the discipline of physics and share something identifiable. Rorty identifies that shared as a social construct and consequently advances the notion that physics education is evangelism. Rorty is correct when he observes the priest-like devotion of physicists, but this devotion is not to each other or to the ontic discipline of physics, it is to aspects of the Real involved in truth.

Sixth, chapter 2 argues that there is a "shadow ... of pluralism, relativism, and scepticism" inherent in theories that deny truth and that this influences societal beliefs and curriculum. Heelan provides two examples that enable us to explore truth and experience. In particular, they show the contribution of *alētheia* in physics and some dimensions of hermeneutics. Two portentous historical conflicts reverberate for centuries, and one of these demonstrates the effect of *alētheia* in modern physics, whilst together they advance our insight into hermeneutics. There is Galileo's conflict with the Catholic Church and Martin Luther's conflict with the Council of Trent (Heelan, 1994, p.363; Stapleton, 1994, p.11).

All parties to the disputes believed that there was a singular truth and the task was to read that truth correctly. Both Luther and the Ecclesiastical Council fully

expected to find God's truth written by God in the Bible. Galileo and his inquisitors, with no less conviction, believed God wrote truth in the book of nature. At the level of human practice, the pivotal issue in their disputes was about the "relevance of experience to interpretation" (Heelan, 1994, p.364). This is distinct from any claim for a mere, relativistic, historical materialism – the problem of truth for Luther and Galileo is how to access it.

Galileo's access to truth came from his observations of the phases of Venus which confirm that the planet's orbit extends to the opposite side of the Sun from the Earth, a result predicted by Copernicus, and in contradiction of Ptolemy's theory of planetary arrangements. When the historian and research astronomer Owen Gingrich read Galileo's notebook he discovered that at the time of momentous insight into the solar system Galileo stopped writing in the vernacular Italian and wrote in Latin (Gingerich, 2003; Heelan, 1997, p.274). This, admittedly slight evidence, suggests the moment of insight had the character of an unrestrained, holistic leap whereby Galileo came to abide with absolute certainty with a significant truth. Heelan likens it to a religious "conversion" and compares it to the insight of Luther. These examples problematize the nature of the alternative world views and the involvement of truth in worldviews. A leading aspect of hermeneutics as shown in these historical examples is the personal experience of enlightenment. For a human being there is a distinctive insight that likely identifies with a particular moment of realisation or certainty. *Alētheia* "arrives", although strictly equiprimordially it "abides". For Luther, there is the experience of conversion that decisively defeated "theoretical undecidability", when for Trent the relevance of texts and authority remained. Of course, this did not involve modern physics. Similarly however, Galileo finds his experience of conversion, his "exemplary experience", in the "well-chosen experiment" (Heelan, 1994, pp.370-371), in modern physics.

It is apparent that a leading aspect of hermeneutics is its legitimation of alternative accounts of the same phenomena/text/reality. The human being has the ability to select or reject a phenomenological truth of experience (Heelan, 1994, p.371). Notwithstanding the modern discipline of astronomy, it remains sensible (a truth, *alētheia*) to say that the Sun rises in the east and sets in the west, and thus proceeds across our sky and encircles our spherical Earth. In physical science today, the Earth revolves round the Sun and that is also sense. Two accounts with their foundations in sense coexist. Another example involves the seasons. In the United

Kingdom, they base the periods of spring and autumn upon agriculture, whilst in the United States they understand the seasons as fixed parts of a four-part year:

> It makes no clear sense, from this second point of view, to say (e.g.) "Spring came late this year": that represents a switch back from astronomy to agriculture, which we are liable to take unthinkingly. (Toulmin, 2002, p.28)

In such examples, we find the problematic of privileged stances, or more expansively, the problematic of alternative constructs of truth as disclosure and correspondence. Modern physics is a particular privileged stance because of the forced involvement of an aspect of the Real.

A proposal for an investigation

There is an opportunity to learn more of about physics education through a new stratagem that truth facilitates. A research initiative suggests itself through the discussions in chapter 3 and the present chapter thus far. The present section and that which follows it, elaborates the new technique, and chapters 5 and 6 implement it.

How did we arrive at this pregnant moment? Chapter 3 provides Heidegger's account of truth for Dasein and chapter 4 has brought this account forward into in modern physics. It is convenient to label Heidegger's description of science his "metaphysical account of modern science" to indicate its setting, limits, character, and association with Kant. Heidegger's metaphysical account of modern physics is about truth and consequently physics education is about truth. *Alētheia* and *adaequatio* are the intrinsic foundation of modern physics – it is truth that allows the possibility of modern physics and mediates the actuality of modern physics. As *adaequatio* and *ta mathēmata* have their inauguration and enduring substantiation in *alētheia*, it may be said that *alētheia* dominates physics. However, this is a misleading way to consider truth in physics, because there is a formation of *alētheia* in physics which is distinct from all other formations of *alētheia*. *Alētheia* reveals modern physics through a particular formation of truth, a primordial unity of a structural whole – Heidegger refers to this first set-up as a ground plan, area, or circumscribed object-sphere. Richardson is credited with the word "blueprint" (Babich, 1995, p.590). It was the achievement of Galileo and Newton to abide with this particular complex of truth in examples and they did so mindful of the newness of this human involvement, knowing that they had leapt into a new "realm" of

understanding. Today, physicist and physics students can achieve the signification of beings that will enable them to abide with the very disclosures of truth that were first engagements of Galileo and Newton. When this occurs it has the truth character of a leap. They may structure their environment to coerce more of that truth "within" the Real to participate in a disclosure. As further objects of an individualised character appear (often requiring their own forms of environmental structuring, which is to say their own "methods of enquiry") these objects become the impetus for the formation of sub- and sub-sub-disciplines. The formation of new sub-disciplines drives the increasing specialisation of physicists and thereby necessitates the formation of institutions and the demand for resources. As this occurs more of the practical work in the discipline of physics comes to focus on *adaequatio* the derived form of truth, and *alētheia* the truth of disclosure retreats. This is the situation of a physicist who is involved in management and not with phenomena. It is the situation of the vast majority of people involved in the discipline of physics.

One of the resources the expanding discipline of physics demands is physicists. As indicated in the previous section of the present chapter, the human resources of physics are an issue for the discipline and for Western societies which as we have seen associate physics with technology and progress. Physics education is an integral facet of the discipline of physics because it provides the necessary human resources of modern research. The demise of physics education must be the demise of the discipline of physics itself. These are conclusions of the thesis thus far.

Now the insights of Heidegger that develop in chapter 3 and those of Heelan's hermeneutic philosophy of science in the present chapter, come together to suggest an enquiry into physics that does not derive from Heidegger's metaphysical analysis which is given in the present chapter. The starting point for this new enquiry could be Richardson's rigorous question, "What exactly is observed in a laboratory observation – a being, a number, a symbol" (Richardson, 1968, p.536). Heelan (1995, p.583) provides a commentary on Richardson's question. Richardson's question – asking as it does about the specifics of the beings involved in the ontic discipline of physics, the beings of a regional ontology – suggests a methodology for an enquiry into physics. It is the methodology that Heidegger uses when he investigates beings and determines the number of kinds that there are and how they relate to Dasein. His hermeneutic phenomenological method is on show in *Being and Time*, where with a very small number of examples he demonstrates and labels the

beings that he finds. It appears possible to extend his work into the realm of physics, to engage with the beings of physics, as Heidegger engages with the beings of the carpenter in *Being and Time*. Support for this approach is found in the work of Kockelmans and Babich (see particularly, Babich, 1995, p.590; Kockelmans, 1993, pp.111-112). The earlier critique of Heidegger's metaphysical approach to science and its concomitant enquiries, particularly the work of Heelan, suggests that the investigation of ontic beings in science is a virgin field. There is a "lower level" of ontology which confines itself to the Dasein and other beings, and which has the potential to complement current work in the hermeneutic philosophy of science.

What would an enquiry into modern science look like if it were to accept that beings need to be the focus? It would take its lead from Heidegger's initial engagement with Brentano's Aristotle and his description of the involvements of the carpenter in *Being and Time*. Thus, it would necessarily begin with the events of physics perhaps those of significant discovery, the work of the everyday bench scientist, or the work of the physics teacher and the student.

The theoretical and practical considerations above mandate an enquiry into the involvement of people with the beings of modern physics. Such an enquiry would be successful if it were to provide new insights into the contested topics and to effect a more meaningful integration of our understanding of physics and physics education.

As Newton's physics is paradigmatic of science (there is debate about this which need not concern us here) and extensively taught in Western schools, it is appropriate as the focus for an enquiry into the nature of the discipline of physics and its conveyance to new participants in the discipline. This selection accords with the views of those who are concerned about the whole of Western intellectual history. For example, Toulmin nominates Newton and Descartes as the founding figures of the whole of modern thought (Toulmin, 1990, p.ix). We may expect that revelations about the beings involved in Newton's physics will be generally applicable to all of physical science, and indeed possibly to other intellectual disciplines beyond science.

Where can we find Newtonian physics? There is evidence from the time when the person of Newton was himself involved as a practical and theoretical physicist, and there is the involvement of beginners facing the topics of Newton's physics in secondary school classrooms. Historical documents provide some access to Newtonian physics as it was for Newton, and the students at Hillary College can

represent the new generation of physicists. We expect some congruence between physics as it was for Newton and as it is for today's learners. Physics in the seventeenth century at Woolsthorpe Manor, Lincolnshire, must hold some relationship to physics in the twenty-first century at an Auckland school. Perhaps a kernel of physics passes from one generation to the next. If there is an essential content that is definitive of physics, it is elusive, contested, and in competition with many doctrines. Furthermore, the survey above indicates that if there is an essence of physics it must involve *alētheia* and *adaequatio*, perhaps in several different ways.

An existential analytic of the Dasein as method

Hermeneutic phenomenology is a method that allows a wide range of resources to be brought to an enquiry and allows considerable latitude in how any enquiry develops. One specific method within the genera of hermeneutic phenomenology is the existential analytic of the Dasein. This more precise method – defined by Heidegger – involves the identification of formations of truth-beings, and relates these to Dasein's for-the-sake-of-which-cascades. The resources of theory for this form of enquiry are those that chapter 3 indicates.

The enquiries that chapters 5 and 6 report on are phenomenological interpretations of the ontic discipline modern physics. They draw upon a procedure that Husserl and Heidegger develop and use, and which Heelan nominates as that characteristic of the strong hermeneutic philosophy of natural science. Those chapters display the techniques of an existential analytic, although they sometimes make use of theory to facilitate insights. This section describes the phenomenological method and some of the issues that the method itself generates. To do this, it places Heideggerian phenomenology in its historical context, and considers two pivotal concepts for such an enquiry, formal indication and phenomenological seeing. Finally, this section considers the notion of ontological biography, which is the specific technique of chapter 5.

Phenomenology, "the science of the ways in which knowledge appears", has been a term in use since *The Phenomenology of Mind* (1807) (Hegel, 1931, p.476, Vol. 2). The methodological sense of the word is the legacy of Husserl who in the 1890s, influenced by Brentano, seeks to ground our knowledge of the world in our lived experience, without in the process reducing the content of that knowledge to the contingent and subjective features of that experience. Already in the present

thesis, mention is made of the relevance of Husserl to Heidegger as he develops the hermeneutics of facticity. Now, Husserl's role in relation to methodology appears. For Husserl, intentionality, object-directedness (object–aboutness) is the mark of the mental. We may discern in intentional acts (consciousness of things, events, objects, states of affairs) a meaningful structure through which the mind directs itself at objects under aspects (influential mental backgrounds or states of mind).

Heidegger rejects Husserl's focus on consciousness and the related part of his methodology. Instead, he maintains that the purpose of phenomenological description is to make manifest the structure our everyday being-in-the-world. Discrete mental judgements and acts (intentionality) are founded upon a more basic background of living with a grasp of the world. Merleau-Ponty (1908-1961) extends Heidegger's theory when he relates our bodily experience to perception (Merleau-Ponty, 1962). Heidegger's project opens the way to a distinctive phenomenological method of enquiry – the method of philosophy as ontology – which he contrasts with the method of positivist science, including modern physics, which deals with beings-objects-entities (Heidegger, 1982, p.19). The call to go back to life in its originality implies a twofold claim: go back to original experience and thus gain a new access to life, and equally, to generate appropriate means for its description, to develop a "conceptuality adequate to it" (Fehér, 1994, p.81). The present thesis – as an enquiry into physics – confronts both of these challenges.

A preeminent aspect of the original intuition is that it is to be experienced specifically as a new way of seeing being – this is the primordial hermeneutic viewpoint. Truth as being is the thing, *Sache* (Heidegger, 1962a, p.256), that the thesis must identify and the way the thesis adopts to achieve this is though Heidegger's theory that pertains and the punctilious rejection of alternates. Alternatives to shun include the philosophy of science as set out by Suppe (1974) for example, the theory of education, and "common sense about schooling".

Formal indication reveals phenomena

> What is phenomenology? What is a phenomenon? Such matters themselves can be made clear only by means of a formal indication! (Heidegger, 1993a, p.169)

What is formal indication? According to Heidegger, those who would be involved with philosophy must think their own programmes and anything can initiate

philosophy. The task of philosophy is not to know what others have thought, but to apply the method of formal indication and questioning. This section elaborates on these as techniques with reference to the production of an existential analytic. Since the problematic of categories has been an issue since chapter 3, it is the example in this section. Heidegger introduces this topic in his 1930 lecture series on human freedom, when he explains that the particular is:

> always the particularity of one thing, namely the universal contained within it, and the universal is always the universality of the various particulars determined by it. We must therefore always look to the particular if we wish to discover the universal. (Heidegger, 2002a, p.3)

This quotation can be understood as a statement that says we must always look for beings or truth in their particularity. If this is the case, how are we to construe categories, such as those of the KNS schema?

Phenomenology strikes a position that makes the categorial determinately an intuition and gives all intuitions the same standing. Phenomena "give" to themselves whatever categories they disclose. Three advantages of this approach to categorial intuition are that it indicates the genesis of formal indications, it aligns with the theory of Dasein, and it accords with the recommendations that Heidegger makes about the practical advance of philosophy.

Heidegger's marginal notes to his 1915 "test lecture" for his habilitation, *The Concept of Time in the Science of History*, indicate his early development of the strategy of formal indication as "a way of accessing and expressing the occasionality of unique historical existence" (Heidegger, 1916/2007; Kisiel & Sheehan, 2007, p.xviii). Unfortunately, Heidegger truncates his "one and only" sustained treatment of "formal indication" when his theological students complain to the dean about the content of his lectures and he pays the "pedagogical price" (Kisiel, 1993, pp.150 and 170-171). Nevertheless, it is possible to discern in the early work two complementary senses of "formal indication", and phenomenology is integral to both of them. It might be more canonical to say that there is one sense with two applications – that in his explication of the Dasein (as entailed in Dasein's way of being, in accordance with chapter 3), and that in Dasein's method of philosophy.

The first sense of "formal indication" appears in the explication of Dasein. Heidegger arrives at Dasein's distinctive primary categories by way of Aristotle, his habilitation on Duns Scotus, and Brentano. Eventually he produces the categories in

the KNS schema of the Dasein, which are summarised on page 64. In a concrete example, Heidegger's carpenter in *Being and Time* (from the point-of-view of the observer) selects tools, hammers nails, and disposes of waste wood. The carpenter is involved with that which *the observer* categorises in accordance with categories, and which for Dasein-carpenter are "raw" involvements. Earlier, mention is made in the present thesis of the examples of a horse and a bee which also engage schema to understand categories as their comportment shows. Neither the carpenter, nor the horse, nor the bee, arrives at their situation, produces a matrix or structure of categories, and then applies that blueprint to tools, grasses, or flowers. Dasein is itself hermeneutic and formal indication is inherent to Dasein's way of being with World.

What may be said of the second sense of "formal indication", that which finds use as a method of enquiry? There are three topics to consider, the genesis of a formal indication, the character of the formal indication, and the use of the formal indication in the present thesis. Heidegger calls the second sense a "use of a sense" in his discussion about how the factic Dasein (the here-and-now Dasein) involves itself with history as the discipline of the past. This appears in the context of a discussion about the relation of ourselves to history that opens with his thesis that there is a "radical difference between philosophy [phenomenology] and science, not only with regard to their "objects" but also their manner of relating to the object" (Heidegger, 1993a, p.158). Although the topic appears in lectures on religion and the "historical" he uses is appropriate to that topic, the "historical" of the discipline of physics is equally an example. It is the "manner of relating" which is at issue in the second sense of formal indication. His example develops:

> How does the historical itself stand to factic Dasein, in what sense does it have out of factic Dasein itself? But does not the question itself introduce a particular, and perhaps even disturbing, sense of the historical? Do I not already have a particular sense in mind, in terms of which I decide in what sense the historical happens to factic life experience? ... the question cannot be broached and approached in any other way … (Heidegger, 1993a, p.164)

Because of that which is hidden in the question itself we are able seek a ground through the question. This implies freedom because there is openness to various

potential grounds and it implies a choice between those potentialities. He continues with a stipulative definition of the second sense, which he calls the "methodic use":

> We shall call the methodic use of a sense which is conducive to phenomenological explication the 'formal indication.' Its task is to prefigure the direction of this explication. It points the way and guides the deliberation. The phenomena are viewed on the basis of the bearing of the formally indicating sense. But even though it guides the phenomenological deliberation, contentwise it has nothing to say. (Heidegger, 1993a, p.164)

The term "phenomenological explication" refers to his method of philosophy, although it is easy to think it might refer to the Dasein's abiding-with understanding *per se* (sense one). The sense of "formal indication" here is the specific sense that chapters 5 and 6 use, which is to say, it is something definitive about how the investigator proceeds to identify for-the-sake-of-which-cascades, formations of truth, and beings. It is the technique when one seeks to progress an existential analytic. The formal indication is an intuition that "points the way and guides" the analytic.

To "think", we must *fabricate* a response to a question and in doing so we draw upon that which is within the question. Practically, we proffer a proposition that we consider has merit, and hold that proposition tentatively as we explore aspects of it. The investigator needs something that points the way and guides the deliberation indefinitely, yet those "ideas" might simply not appear. Instead, other formal indications appear which generate work and then extinguish in that work. The ability of investigators to locate and settle upon fruitful formal indications defines their competence. Heidegger acknowledges "dead ends" (for example, in relation to Aristotle, Heidegger, 1995a, p.138). The metaphor of forest paths that he uses often (for example in book titles, *Holzwege*) refers to exploration down pathways that may terminate. It is apparent that a formal indication cannot be "wrong", but rather it fails to last any distance.

Ontological biography

This section develops an approach to investigation that Heidegger initiated. It develops a method of enquiry – here called ontological biography – around his assertion that the way to understand modern physics is to attend to the paradigmatic insights and experiments of those who founded the discipline. According to

Heidegger, in the case of modern physics those most responsible are Galileo, Kepler, and Newton (Heidegger, 2002b, p.45). Ontological biography investigates the involvement of Dasein in what some call regional ontologies or the ontic sciences. It is a form of existential analytic of the Dasein – where the goal is to ourselves abide with the very truths that held abidance with other Dasein. Like all existential analytics, ontological biography seeks to explicate beings, and Being, as ontological constituents of the Dasein. Accordingly, the ontological situation of any Dasein is available for such an investigation. Psychiatrists might wish to use the method with their patients, and teachers with their students. Those with an interest in art, history, medicine, literature, or geography, may apply the technique of ontological biography to their epoch-making people.

When he investigates the character of pictorial space, Heelan adopts a similar procedure to ontological biography. The similarity derives from Heelan's use of enquiries into the manner of creation, deliberation about, and his rendition of, Vincent van Gogh's paintings – when his task is to explicate hyperbolic visual perception. Heelan provides paintings, photographs, discussion about the assertions of art critics, as he seeks to have us experience hyperbolic visual perception. He does more than merely describe the phenomena at issue as we might expect in a textbook of art history. He constructs for us the situation of van Gogh; he seeks to have us see through van Gogh's eyes; to participate in the world as van Gogh participated; to abide that which abided with van Gogh. Heelan does not advance this in the manner of an existential analytic, which is to say in Heideggerian constructs of beings within signification. This is why his procedure is not an ontological biography *per se* but is a similar technique of explication. The two techniques hold the same broad aim, but ontological biography determines to work that aim out in a particular theoretical framework. More concretely, how does Heelan proceed? Some examples, with the ontic art historians first:

> ... Gombrich and others have shown in the case of "gates" or "grills" of different shapes and sizes ..., because it could be the optical projection of any one of a family of three-dimensional Euclidean forms, but it is also ambiguous in relation to the space of perception. (Heelan, 1983b, p.107)

He enters a topic already in ontic text (in this case the text of "Gombrich and others") which contains a difficulty that may render as an issue of truth ("ambiguous

in relation to"). Heelan continues with relevant theory that includes the ability of mathematical projection to mediate non-Euclidian transforms. Yet the ontic rendition is about to break down, not in its theory but in its practice:

> The way an artist then makes hyperbolic shapes appear to the viewer does not in principle require the invention of some new kind of linear projection different from the one defined by the theory of geometrical optics: he would, however, have to rely heavily on clues of other sorts, for example, shading, coloring, brush stroke, and other painterly techniques, as well as possibly the kinds of schematic clues that seem to function in the types of perceptual illusions examined above [Müller-Lyer illusion and the moon illusion]. (Heelan, 1983b, p.108)

Further theory follows, this time the history from Ancient Greece and Rome, and Leonardo who develops a theory about this very matter. Then there is the experience of someone with the phenomena, in this case Robert Hansen; and, then Heelan seeks to bring us into the experience:

> To the extent that such an experience is an experience of hyperbolic space, as I believe it is, I have tried to illustrate its special systematic character in figures 4.1, 4.2, 4.3, 4.4 and 4.7. (Heelan, 1983b, p.109)

No longer are we being informed about ontic theory, Heelan now offers us the opportunity to participate in the very experience of van Gogh. There follows a discussion about the difference between an image and maps or ideograms. The image delivers the message "immediately, directly, and pictorially to perception" (p.109) – ontologically we abide with that which is closest. Because the particular images under discussion are unlike those of linear visual perception, with which we are familiar and which Alberti in 1435 describes in his ontic text *De pictura* (Alberti, 1991), they summon a problematic of truth.

After he completes his attempt to have us abide with that which hyperbolic visual perception invokes, Heelan revealingly contrasts his explication with those descriptions which ontic theory (in his example psychology) has on offer. Van Gogh's "peculiarities" are "not *directly* the product of pathological psychology–as has sometimes been said–or *merely* the effect of strong emotion" (Heelan, 1983b, p.126). Then, he speculates on whether or not van Gogh achieves the ontological insight that the vision which he exploits in his painting implies:

> One would be curious to know whether van Gogh asked himself if this was the true form of the real. If it is the case that ontology is (should be) normed by common language, then the real World is Euclidean, and the hyperbolic transformation of it is a systematic distortion. If, on the other hand, it is van Gogh's persuasion that pure unaided vision has (should have) priority over cultural artefacts, then he would have cherished the new experience as the epiphany of the *real* that lies behind culture, that is usually masked by the everyday cultural overlay. (Heelan, 1983b, p.126)

Heelan concludes that it is "probable" that van Gogh did believe that he was the witness of a special epiphany of the real, in which case his aesthetic is rooted in more than subjective emotion, and is oriented towards "a certain vision of reality and a certain kind of World" (Heelan, 1983b, p.127). Incidentally, it is Heelan's "aspect of the real" reference that relates the van Gogh enquiry to the hermeneutic philosophy of science, and his expression "epiphany of the real" is akin to a description of the physicists' involvement with physics. Ontological biography does not direct itself at such historical questions as "One would be curious to know whether van Gogh asked himself if this was the true form of the real" (which are ontic), instead it seeks to have us enter into that certain kind of World which is the very "subjective-objective" World whereby (not "wherein") van Gogh dwells.

An ontological biography seeks to have the investigator abide (a subjectivity) with the very beings of an "earlier time" (an historical objectivity). The kinds of beings available for the enquiry are those set out in chapter 3, the foundation of the ontological schema of all Dasein is the same, and the way of "seeing" is to be that of phenomenological hermeneutics as developed in a previous section of the present chapter. Heidegger leads us into ontological biography when he seeks to explain Dasein's being-in-the-world in *Being and Time*. His leading examples are his carpenter at work and his description of himself at home. In both cases, Heidegger advances a phenomenological description that strikes us as plausible because we relate the example to ourselves. He uses examples to give us access to a particular way of looking at a situation that could be our situation. He describes the situation and not things. Although things are prominent in the situation (for example, the hammer and the pen) their relevance is located in the totality of the situation of the Dasein and not in themselves as objects. Heidegger's pedagogical purpose in the

phenomenological sketches in *Being and Time* is twofold. He teaches us to see beings in a new way and he teaches us about the nature of ontic theory. Likewise, an ontological biography holds the potential for us to engage with beings and to gain insight into a particular ontic theory, in this case the theory of physics.

In an ontological biography, objectivity and subjectivity draw together to a point where the distinction extinguishes. Those who advance that physics is an objective discipline that stands without the necessity of human involvement, and without truth (as is shown in chapter 2), will see regional beings as objects and physics as objective. For them it is the persistence of reality that carries modern physics forward from time the time of Galileo until today. Those who identify the human being as the aegis for physics, whether physics derives from individual people or institutions, hold a subjective position that allows truth to wander. For them, physics perpetuates in the same manner as other human artefacts perpetuate. Already we have seen that Heidegger absorbs "an aspect of the Real" in his description of Dasein and modern physics. His ontological account of modern physics does not require or generate the objectivity-subjectivity dichotomy. Ontological biography is consistent with this because the beings of modern physics Dasein-Newton-Real (which is to say Dasein as being-in-the-word) remain as "expressions" of the Dasein. Such a situation, when considered from the perspective of truth is sometimes called a deflationary realist's position. In this inimitable rendition of such a philosophical position, the truth of modern physics and the beings of physics that engage Newton are available to Dasein because they are integral to Dasein-world. The task of ontological biography is to allow these very beings to come to presence with the investigator.

The present chapter and the previous chapter prepare for the two existential analytics – enquiries with truth, beings, and Dasein, into the ontic discipline of physics – that follow.

Chapter 5: Newton dwells with truth

The purpose of this existential analytic is to gain insight into the nature of physics. The genesis of modern physics is the ground of enquiries into (1) Newton's work habits at Trinity College, (2) discovery, (3) observation, and (4) the disclosure of physics shown through the involvement of mathematics. Heidegger urges us to seek in an existential analysis the foundation of theoretical discovery, which includes the foundation of ontic disciplines such as modern physics:

> When in the course of *existential ontological* analysis we ask how *theoretical* discovery 'arises' out of *circumspective* concern, this implies already that we are … asking which of those conditions implied in Dasein's state of Being are existentially necessary for the possibility of Dasein's existing in the way of scientific research. … This formulation of the question is aimed at an *existential conception of science*. (Heidegger, 1962a, p.408)

The discipline, the "hermeneutic philosophy of science", now subsumes Heidegger's "*existential conception of science*". Chapters 3 and 4 prepare for the ontological biography this chapter presents. In this chapter, the very beings that engaged Newton – each as truth in a configuration – muster and show their involvement with each other. Heidegger and Heelan provide the theory to facilitate access to these truth-beings. The beings accord with Dasein's schematism and appear in for-the-sake-of-which cascades. This chapter seeks to show the dimensions of their involvement with each other and the constitution of truth that they entail.

The four topics of the chapter – Newton's work habits at Trinity College, discovery, observation, and mathematics – are procedural organisers that facilitate entry into situations that are multi-faceted and thus invite boundless enquiry. Although the four analects maintain a focus on truth, they sometimes contrast the existential analytic with other theory. The analects are sequential to the extent that they initially attend to *adaequatio* and then progressively bring *alētheia* into focus. The chapter does not integrate its enquiries as integration is the work of chapter 7.

Truth in institutions (work)

Newton's work presents itself to physics students as an ontic, or thematic, body of theory in textbooks or presentations. Students are to acquire the truths of Newton – to learn properties and locations within an objectifying analysis. How does truth that is integral with Dasein-Newton enmesh itself with others through ontic presentations? As one first step towards a response to this multifaceted question, consider Newton at work. The discussion in this section begins with the historical circumstances, then it considers truth in the activity of physics, and finally it relates truth to the tripartite model of the Dasein when the section constructs scenarios as for-the-sake-of-which cascades.

The literature records an example whereby Newton demonstrates his ability to cope with a practical employment situation. We can see the result when Newton wrote as a journalist must write – rapidly and for a particular audience. It is equivalent to our seeing something of the making of the furniture crafted specifically by Heidegger's carpenter. We seek the truths involved from the circumstances of the work and from the product itself. Because we are Dasein, and because we have dealt with similar circumstances, we can intuit the beings and their truth complements. Ontologically, such understanding is our abidance with the very same truth and thus with the very same beings. In a bid to affirm the beings and with them construct for-the-sake-of-which cascades, this section sets out the circumstances that involve Newton and examines his product.

Investigators into history may not be insightful about the nature of the truths they seek. Naive historians, storytellers, do not heed the more foundational referential totality as they unfold unitary truths. They create their own distinctive referential totality that most centrally has themselves, their work space, their books, their research resources. Like Herodotus, the first systematic historian, they hold themselves, and us, to the story of the day, which in accordance with signification is present-at-hand or ready-to-hand. Those readers of text in the Herodotus tradition – history books of a kind – who mutter that the history is interesting and distracting, like a vivid novel, suggest that the beings are present-at-hand beings. Whilst those who read the same text and mutter that they must complete their university assignment within just two-days, suggest that the beings are ready-to-hand beings.

The example relates to a period long after Newton's practical investigations into optics and after his lectures at Trinity College on that topic. It is an example in which Newton renders what we may expect to be the present-at-hand beings of modern physics as ready-to-hand beings in a referential totality that relates to, and in large measure derives from, his own institution. As chapter 4 indicates, Heidegger claims involvement with institutions is a characteristic of modern science (because particular disclosures of the Real require substantial resources), and truth as correspondence is the hallmark of institutions. Whilst Newton's early work involves disclosure in arrangements with a prism and a beam of light, that disclosure itself in the new task does not render as a present-at-hand being replete with *alētheia*. An ontic psychologist might say that Newton remembers the moment and has some notes available. The historian Shapiro sets out to the information we need to see this "transmutation" of truths that abide with Dasein-Newton.

First, consider the history of the discovery and its presentation in lectures and in his subsequent text. Irrespective of the disputes about the specific dates of both Newton's investigations and his lectures, it is clear that Newton's involvement with those very truth-beings that we can today ourselves involve predates his lectures. Four contradictory pieces of information suggest when Newton first achieved the disclosure – the first moment when Newton, prisms, spectrums, and the revelatory ratio, were one construct of sense. There is (1) information on when he purchased the prisms, (2) when he claims in writing that he did the work, (3) when others with various insights and perspectives say he did the work, and (4) the required position of the Sun. Westfall argues for 1665 and 1666 as the years of the climactic, intellectual advance (Westfall, 1980, pp.156-158). If the "birth of optics" is the first occasion of a disclosure somewhere in that timeframe, then Westfall's word "intellectual" diminishes the ontological character of the event.

After the "birth of optics", there is a delay of at least three years until Newton lectures on the subject. "He had the theory fully elaborated before January 1670 when he lectured on it. Three years are not sufficient cause to drown the excitement of discovery in a sink of erudition" (Westfall, 1980, p.158, the reference to "three years" refers to the final round of elaborated trials). It is fortuitous for the present purpose that there is a further delay before the tardy Newton writes his account of optics to satisfy the administrative requirement.

Newton advances his own investigations in geometrical optics when, in 1669, Barrow (the first Lucasian Professor) entrusts him to proofread his mathematical optical lectures entitled *Lectiones XVIII* (Shapiro's introduction to Newton, 1984c, p.15). Upon appointment as the second Lucasian Professor, Newton continues his work on optics and adopts Barrow's work, improves parts of it, and rejects parts of it. Newton adopts Barrow's structure in his writing (Janiak, 2008, p.3). Here we discern Newton in his workplace, with his books, reading and writing. As a scholar, Newton involves the beings of modern physics as they are revealed in Barrow's writing as present-at-hand beings and truth constitutes through correspondence. Truth may construe as an example of the second definition that Aquinas gives, "according to that which its intelligible determinations formally completed", his theory of abstract judgement. These are the same present-at-hand beings involved when Newton was said to have "a firm command of optics through his studies of the works of Boyle, Descartes, and Hooke" (Shapiro's introduction to Newton, 1984c, p.9). Newton's "seven closely written pages of notes" indicate his level of involvement with the present-at-hand beings of Hooke's *Micrographia* (Shapiro in Newton, 1984c, p.8). Westfall suggests *Micrographia* "stimulated" Newton: "His immediate negative reaction to Hooke's account inaugurated forty years of antipathy between two incompatible men" (Westfall, 1980, p.158). Could truth as disclosure have been here? Yes, if Newton exclaims, "Hooke is a disgrace", but the exclamation does not constitute any form of definitive truth within modern science. Confining our discussion to disclosure, *alētheia*, according to Newton, Hooke reveals something of himself, and not something of physics. Where is the region of such a disclosing truth? Not within science, and hardly within ordinary everydayness unless we incline towards a narrow interpretation of Heidegger's definition that makes ordinary everydayness involvement with the beings "unto the day" (Heidegger, 1962a, p.422).

Newton's appointment as a Lucasian Professor in the autumn of 1669 obliges him to adhere to the regulations that pertain to his appointment. These include that he must give one lecture for about one hour each week during the term and submit annually not fewer than ten of those lectures for deposit in the university library for public use (Shapiro footnotes, *Mathematical Papers*, 3:xviii-xxvii). Barrow informally reduces the expected lecture load to one term a year and university records show that after some initial adherence to the rules (the Lent term of 1670)

Newton settles to the pattern of one lecture series a year, in the Michaelmas term. These lectures are very poorly attended (Westfall, 1980, pp.210-211). The librarian documents the event of Newton's first formal deposit with university officials on 21 October 1674. As Shapiro says, Newton complies with the regulations "somewhat tardily" (Newton, 1984c, p.16). To the extent that he is able, Shapiro tabulates when Newton actually wrote the materials he lodges as his lectures, and he discovers three things. First, it is unlikely the deposited materials are Newton's lectures in the sense of what he actually said to his students. Second, the dates Newton gave as the delivery dates of the particular lectures are impossible or unlikely. Third, Westfall's 1963 resurrection of the manuscript *Lectiones opticae* suggests that the deposited material was not Newton's actual lecture notes at the time of delivery. The resurrected book is forty percent shorter than the deposited lectures and it shows alternative dates for the delivery of particular lectures. Newton's biographer concludes:

> There is good reason to think that the deposited manuscript was originally a revision … prepared for publication and deposited (with suitable dates inserted)…. The deposited manuscript … further pretended that a course of lectures was given in the autumn of 1679, when we know that Newton was in Woolsthorpe after the death of his mother. (Westfall, 1980, p.211)

When faced with an administrative task, Newton takes his available work (as ready-to-hand beings), dissects it, revises it, collates it, and dates sections to conform to a lecture format and the terms. Thereby, he produces a further ready-to-hand being that he delivers on 21 October 1674.

The beings involved in such a practical, pragmatic exercise are ready-to-hand and they indicate truth as correspondence. Newton's engagement with these beings is not in the sphere of modern physics as cast by Heidegger, but is instead within a situation of institutional arrangements and Newton's business need to satisfy regulations. Heidegger says of such relationships that involve Dasein-physicist, institutions, tools, and ready-to-hand beings (equipment encountered):

> That with which our everyday dealings proximally dwell is not the tools themselves [*die Werkzeuge selbst*]. On the contrary, that with which we concern ourselves primarily is the work—that which is to be produced at the time; and this is accordingly ready-to-hand too. The work bears with

> it that referential totality within which the equipment is encountered.(Heidegger, 1962a, p.99)

The "work", a word which conveys a strong sense of association and embroilment, is what engages Newton, and that which he uses, "the tools", has the character of background as he proceeds. The expression which Heidegger's translators declare as more "clumsy" is apt, they refer to a "totality of assignments" (Heidegger, 1962a, p.99). "Assignment" is a word that relates well to beings within for-the-sake-of-which cascades. It also relates well to disposition, *Befindlichkeit*.

Newton' writing in the example, is within a referential totality, a particular set of assignments, which in some way bind together. The truth in these assignments is "tame" and that of correspondence. We might imagine that Newton limits his time on administrative tasks, rapidly partitions and dates his work, and perhaps complains to others about his university's requirements. Such speculation goes beyond the evidence that is available in the primary sources although it is consistent with what we know about Newton (a compilation of insights into Newton himself is in Janiak, 2008). What we can be more certain about is that Newton exhibits the skills involved for required editorial exercise which he completes in an inattentive, perfunctory manner that contrasts with the application to detail he demonstrates in his work on optics proper, that work which entails disclosing truth. When disclosure, *alētheia,* involves Newton, he is painstaking and precise, otherwise not.

The above description of Dasein-Newton's involvement with ready-to-hand beings that associate with administration can be related to a further, more speculative, description of beings that shows how text may be present-at-hand or ready-to-hand. Throughout the work on the administrative task described, the Dasein engages with the ready-to-hand beings of optics and maintains these beings as ready-to-hand. There are other ways to engage the text that is initially a ready-to-hand being. How would we describe the situation regarding truth if Newton ignored the requirements of his university and began again to repeat his experiments in optics? Dasein-Newton would eventually engage with present-at-hand beings, first as he contemplates the text and then later he might force the critical ratio of the spectrum to reveal itself. Heidegger refers to such developments as a "change-over":

> If this entity becomes the 'object' of an assertion, then as soon as we begin this assertion, there is already a change-over in the fore-having. Something *ready-to-hand with which* we have to do or perform

> something, turns into something '*about which*' the assertion that points it out is made. Our fore-sight is aimed at something present-at-hand in what is ready-to-hand. Both *by* and *for* this way of looking at it [Hin-sicht], the ready-to-hand becomes veiled as ready-to-hand. (Heidegger, 1962a, p.200, his emphasis)

The "change-over" is within the structures of signification, and the words "points it out" indicate that this involves a relationship within structures. This change-over is not an alternation in a being *per se*, but rather the constitution of a new being from within the referential totality. The for-the-sake-of-which cascades now involve "individual" "objects" in two ways (that is, as a ready-to-hand being and as a present-at-hand being). This duality is why he says the ready-to-hand being becomes "veiled" as a ready-to-hand – it is no longer the prominent fore-structure within the for-the-sake-of-which cascades, nevertheless it still participates in the for-the-sake-of-which cascades. What is the nature of truth that this change over entails?

Correspondence constructs of truth appear both in the "work" situation, with ready-to-hand beings, and in the contemplation of the beings of physics, with present-at-hand beings. The example with ready-to-hand "work" beings is given above where it is said he "dissects it, revises it, collates it, and dates sections" (p.73). Comparing and contrasting, constructing models, imagining alternatives – all these activities construed within for-the-sake-of-which cascade render truth as correspondence for present-at-hand beings in the situation of contemplation.

How might the truth of disclosure enter into a referential totality which so far appears as a proliferation of correspondence? This question requires an exploration through for-the-sake-of-which cascades. Something specific that Newton wrote provides an example for analysis. In the second lecture of Part I of *Optica*:

> The case has therefore been presented in which the length of the solar image transmitted through the prism would appear equal to its breadth, and consequently one in which the image would appear nearly circular, provided that the common opinion were true. (Newton, 1984b, p.293)

The example is a conclusion that uses mathematics to define an aspect of the Real which Newton forced to reveal itself by his manipulation of a prism and other equipment in relation to the Sun. Apart from the mild reference to "common opinion" it is apparently an objective and disinterested account of the situation and

the concomitant truth of disclosure. It is possible to construct for the purposes of discussion several speculative for-the-sake-of-which cascades, scenarios:

1. Newton wrote this paragraph as a contribution to the advance of humankind. He wrote the paragraph for-the-sake-of modern mathematical physics, this was for-the-sake-of humankind's understanding, which in itself is for-the-sake-of the betterment of humankind. The beings involved here (just for this small section – not the full range involved in the scientific exercise) are probably present-at-hand and the associated disposition, *Befindlichkeit*, would promote the "warm and positive" signification for those beings regarding humankind. The ontic psychologist would record that Newton was well-motivated towards humankind and if asked Newton would say that the beings of modern physics were facilitative for human kind.

   A physicist of international renown, who provided the scientific leadership for the Manhattan Project that constructed the first nuclear weapons, also related a disclosure of nature to humankind. Julius Robert Oppenheimer at Alamogordo, New Mexico, on 16 July 1945, abided with the beings of physical science disclosed, with for-the-sake-of-which cascades that involved fears for humankind, as was shown when he quoted the *Bhagavad-Gita* at the blinding instant when the world's first atomic device exploded (Stern & Green, 1971, p.14). Disclosed truth presences for Newton and for Oppenheimer, and modern physics is holistically ready-to-hand with *Befindlichkeit* to the fore.
2. Newton wrote this paragraph to record the result of his scientific investigations – for the sake of his scientific insight. He wrote to record the moment when the Real disclosed itself through forced circumstances that involve a prism. This might be how a youthful experimental physicist writes her laboratory notes – or perhaps more likely, when she stops writing notes in excitement as *alētheia* gains ascendance over the preponderance of *adaequatio*. Involved are for-the-sake-of-which cascades that entail a profound association with disclosure, *alētheia*. The quotation from Westfall, about the "excitement of discovery" is pertinent. The situation involves truth as correspondence, for you must hold the prism correctly and you construct an "expectation" that there will be a disclosure. But the disclosure itself – when the event occurs – impacts upon the Dasein as wonderment and an

awakening. This is the imposition of the Real *qua* reality, the forced intrusion of a truth-*alētheia*-being into signification. Nature asserts itself. The for-the-sake-of-which cascades now hold a virginal, especial, unassailable truth-being.

In Newton's case, this scenario could satisfy his own personal desire to abide with the beings of optics – to hold a form of knowledge for its own sake. His early life as the "sober, silent, thinking lad", suggests this disposition (Chapter 2, Westfall, 1980, p.40). Later, when he writes the passage above, he does so as an attempt to dwell with the truth-*alētheia*-being. The passage is an expression surfeit with disposition, *Befindlichkeit* as dwelling.

3. Newton wrote this paragraph to confound his critics. The for-the-sake-of-which cascades involve his personal advancement, both within the university and within the academy. His use of an expression like "common opinion" supports this scenario. He is not concerned simply to advance his own view, but to displace the views of others and achieve his place in the history. Ultimately, such a for-the-sake-of-which cascade may come to involve ready-to-hand-beings that are awards or documents of recognition, and these in turn embrace correspondence and disclosure in relation to other beings. The ontic psychologist who seeks to understand Newton will speak of his early isolation from others, feelings of inferiority, need for personal satisfaction or even his desire for revenge. Now the "sober, silent, thinking lad" takes another complexion, and we recall Westfall's sentence about Newton's "forty years of antipathy" towards Hooke. What is the ontological status of a being that is "revenge"? It is a present-at-hand being when it is savoured. It is ready-to-hand-to-hand when it motivates. A word like "revenge" is used with regard to a mix of beings that may only be revealed in the context of the existential analysis of for-the-sake-of-which cascades of the Dasein. The truth as disclosure that involves the ratio and the spectrum does not endure in this scenario.

It is the task of ontological biography to bring forward alternative scenarios and to investigate them. The present exploratory study with scenarios can only indicate the possibility of further enquiries.

To conclude, this section indicates how an enquiry into the beings of Newton could develop. It shows that whilst we do not have sufficient information at present to create an ontological biography for Newton, it is possible to speculate on what such a report might reveal. Physics appears as truth in ontological constructs of disclosure and correspondence. There are many different accounts that we may give to indicate the nature of the truth- beings that involve Newton, and that we can do this indicates that these beings are available to us, for including in our signification.

Stumbling into abidance (discovery)

The ontology of Newton's insight into the theory of colour – that is the topic in this section. It investigates contentions about the for-the-sake-of-which cascades when the Dasein encounters the unexpected. The particular "unexpected" of interest is the disclosed being which is an aspect of the Real, in the context of modern science. Newton abides with this being, and it behoves us to understand what this entails. This section proceeds to consider the distinction between the method-context of discovery and the method-context of justification. The section also relates to the ontological transition from ordinary everydayness to physics, which is an explicable in terms of beings and signification.

Everyone occasionally receives a surprise when something unexpected appears. A discovery is made which is personal, incontrovertible, and enduring. What is the ontological status of this phenomenon, stumbling into abidance? The opening sentence alerts us to the consider disclosure, *alētheia*, and to call for an existential analytic of the Dasein as the appropriate form of enquiry, which is to say a general enquiry into the beings that may compound as Dasein. Further, if stumbling into abidance occurs in physics, what can be said about the involvement of truth-beings that is distinctive to physics?

Here is an occasion to use Heidegger's method of formal indication which chapter 4 introduces. A phenomenological explication, an unfolding, is sought and the way to achieve this is allow a formal indication to point and guide the way within an analytic. The term "formal indication" here is the second sense that appears in chapter 4, the method that requires us to fabricate a response to a being.

Take as a formal indication, the *de novo* existential unfolding hypothesis. This states that beings come into being with Dasein (that is, they come to abide with Dasein equiprimordially) with a restricted complement of concomitant pointing

beings. Consider this hypothesis in relation to Heidegger's doctrine that all interpretation involves fore-having, fore-sight and fore-grasping; and the example of Dasein's engagement in physics where the ontological fore-structure includes an already specified "ground-plan" established in advance of a disclosure of truth. We may expect that signification, to be explicatory, must provide a sufficient and comprehensive account of the situation of the Dasein. A sufficient and comprehensive account would include all the beings, an account of their standing as truth, and the relationship of one to another. In addition, there must be an account given of how the beings relate one to another, and it is convenient to cast these relationships with Heidegger's terms, by-which, for-which, about-which, with-which and upon-which:

> The discoveredness of the ready-to-hand and the present-at-hand is based on the disclosedness of the world for if the current totality of involvements is to be freed, this requires that significance be understood beforehand. In understanding significance, concernful Dasein submits itself circumspectively to what it encounters as ready-to-hand. Any discovering of a totality of involvements goes back to a "for-the-sake-of-which"; and on the understanding of such a "for-the-sake-of-which" is based in turn the understanding of significance as the disclosedness of the current world. (Heidegger, 1962a, p.344)

The "current world" is the world at issue. The for-the-sake-of-which cascades are at once for the Dasein equiprimordial and in our explication the constructs that will facilitate our interrogation of Kisiel's "kinetic". Chapter 3 introduces this situation and the notion of the kinetic. How is it that "what it (Dasein) encounters" sometimes carries truth as sluggish correspondence, and sometimes carries truth as spectacular disclosure? This question can also be asked from within the tripartite model of the Dasein: how does truth in its particularity generate *Befindlichkeit* (in the present example which is modern physics)? *Befindlichkeit* is here in its guise as present disposition, dwelling. Heidegger says quickly that it is "world", in the particular sense entailed in Being-in-the-world. However, what may be said about the differentiation of that world with regards to truth? With regards to the kinds of beings that Heidegger identifies, the parallel question resolves when he says that abidance with Dasein's way of being to primarily Dasein's skilful coping in the world and the grasping of beings, for the most part, as available resources. At least

that is the account for Dasein within Western metaphysics. This concurs with the last two sentences of the quotation immediately above.

The hypothesis says that for some phenomena, the fore-having, fore-sight, and fore-grasping are not of themselves sufficient to account for the Dasein abiding with a particular being. As constituted in for-the-sake-of-which cascades the fore-structure is insufficient to account for truth as disclosure. The *de novo* existential unfolding hypothesis provides a focus within an existential analytic to explore the context of discovery, as opposed to the context of explanation or justification. As Heidegger and Kuhn observe, much of physical science is programmatic and produces an accumulation of "tedious" information (Rouse, 1981, considers scientific realism in Kuhn and Heidegger). Modern physics becomes for them the extensive ground of truth as correspondence. Chapter 2 presents Toulmin as an example of the Post-Kuhnianists who understand science in terms of this "tedium" and accordingly deny a role for disclosed truth. Chapter 2 shows how Toulmin's model of evolutionary development – which he finds at work in science, technology and human understanding – only raises more urgently the question of truth in modern physics.

The present concern, however, is the phenomena that occur occasionally in research (in Heidegger's sense) – a being intrudes into the Dasein's totality and the total situation leads us to conclude that it is a disclosed being that stands beyond that which we associate with truth as correspondence. It might be said that Newton supports the *de novo* existential unfolding hypothesis in the only known autobiographical account of his discovery of the theory of colour. The letter, his "historical narration" (Shapiro, Newton, 1984c, p.10), is dated 6 February1671/2, and the normalised version begins:

> Sir
>
> To perform my late promise to you, I shall without further ceremony acquaint you, that in the beginning of the year 1666 (at which time I applyed my self to the grinding of Optick glasses of other figures then Sphericall) I procured me a triangular glasse Prisme to try therewith the celebrated phænomena of colours. And in order thereto having darkned my chamber & made a small hole in my window-shuts to let in a convenient quantity of the sun's light, I placed my Prism at its entrance that it might be thereby refracted to the opposite wall. It was at

> first a very pleasing divertisement to view the vivid & intense colours produced thereby; but after a while applying my selfe to consider them more circumspectly, I became surprized to see them in an oblong form, which according to the received lawes of refraction I expected should have been circular. [Paragraph] They were terminated at the sides with streight lines, but at the ends the decay of light was so graduall that it was difficult to determine justly what was their figure, yet they seemed semicircular. (Newton to Oldenburg, Newton, 1671/2, f.460r)

Three statements about the present-at-hand being that is the spectrum on Newton's wall support the *de novo* existential hypothesis.

The first is: "It was at first a very pleasing divertisement to view the vivid & intense colours". This sentence testifies to the unexpected in the presencing of the beings. The beings are "pleasing", "vivid" and "intense", beyond his expectation. This indicates that the beings involve Newton and a disposition, *Befindlichkeit*, constitutes in the situation. There is no domain or sphere located in this, certainly not that of physics if physics is dispassionate and beyond human emotion. Newton's description of his abidance with/as the being of the spectrum is exactly how students at Hillary College describe the same experience. The students say the spectrum is "pretty" and fall silent – this comportment indicates truth as disclosure. It is not possible for Newton or the students to arrive at a genuine conclusion of "pleasing" or "pretty" by way of *adaequatio*. As Heidegger says of a great work of art, "this painting spoke", but it does not speak by way of "description and explanation", it is the "unconcealment of being", *alētheia* (Heidegger, 1993b, p.161). From her hermeneutic and phenomenological reading of *The Origin of the Work of Art*, Babich calls this "Heideggerian or aletheic (earth-grounding, world-opening) truth" (Babich, 2003, p.152). For Newton and the students there is an experience that announces and the announcement is "earth-grounding and world-opening". The *de novo* synthesis involves beings that come not from the artist's brush but from the Real. Chapter 7 refers to students and the nature of truth in disclosure.

The second statement is: "I became surprized to see them in an oblong form, which according to the received lawes of refraction I expected should have been circular". A present-at-hand being (the oblong being) was not the present-at-hand being (the circular being) that another being (the laws being) indicates. What is the nature of the "lawes of refraction" being which this situation indicates? This being

appears in Newton's engagement with the spectrum as a ready-to-hand being. Yet, when the "lawes of refraction" being appears in ontic textbooks – the place we expect to find written laws – "they are" present-at-hand beings. No they are not! First, it is a mistake to cast the beings of ontic text as present-at-hand beings (the previous section indicates this). Second, the beings that involve Newton "in the beginning of the year 1666" are not the same beings which abide with Newton as the "lawes of refraction" in his study of ontic texts. As the section above declares, we know something of Newton's study of the ontic text. For example, Shapiro reports with reference to Hooke's *Micrographia*, "Newton read it attentively, taking seven closely written pages of notes" (Newton, 1984c, p.8). This text describes the wave theory of light and Newton read it at a time when "microscopists were uncertain about how well the images reflected reality" (Fara, 2009, p.642). The effect of this is to underscore the significance of his words "I became surprised". The nature of this surprise contrasts with his "very pleasing divertissement" because the structures of beings in for-the-sake-of-which-cascades are different in each, as is *Befindlichkeit*. It is serendipitous that the word Newton uses to describe his situation, "circumspectly", is the word in Heidegger translations "circumspectively". It is difficult to imagine a more adequate description of the Dasein with the present-at-hand than Newton's "applying my selfe to consider them more circumspectly". In the quotation already given from *Being and Time*, "concernful Dasein submits itself circumspectively to what it encounters as ready-to-hand". Dasein-Newton proceeds in a circumspect manner, with caution and care. The beings this involves, Heidegger tells us, are present-at-hand beings. In *Being and Time* when Heidegger describes presence-at-hand beings, *Vorhandenheit*, his approach is pedagogic and he describes the transition from ready-to-hand to present-at-hand. The circumspective manner of the carpenter with the broken hammer assists our understanding of the distinction. In Newton's situation there is also a temporal sequence, but it is unlike that initially described with the hammer. The movement, the kinetic inherent in a for-the-sake-of-which-cascade, is "towards-this":

> When an assignment to some particular "towards-this" has been thus circumspectively aroused, we catch sight of the "towards-this" itself, and along with it everything connected with the work—the whole 'workshop'—as that wherein concern always dwells. The context of equipment is lit up, not as something never seen before, but as a totality

> constantly sighted beforehand in circumspection. (Heidegger, 1962a, p.105)

Newton's concern, his "workshop", that with which he dwells as a totality, involves "the lawes" as present-at-hand beings in ontic text and "the lawes" as ready-to-hand beings in the gestalt moment of grasping the rectangle and its implication. The former is indicative of truth in a correspondence configuration (*adaequatio*), and the latter truth as disclosure (*alētheia*). An aspect of the Real carries into the situation in *alētheia* that supports the *de novo* existential unfolding hypothesis. The Real truths and the truth is always *alētheia* and it has the potential to bewitch the Dasein. Newton's lawes as *adaequatio* fail to achieve the status of the Real disclosed. The totality constantly sighted before hand is not that of the ontic textbook, but that of reality forced into revelation by the many actions which Newton summarises at the start of his letter.

The third statement to consider, records a *de novo* being that relates to how Newton describes the rectangular image on the screen: "They were terminated at the sides with streight lines, but at the ends the decay of light was so graduall that it was difficult to determine justly what was their figure, yet they seemed semicircular". This statement records Newton's engagement with the phenomena. With the rectangle on the wall, as he peered at it, there is discerned a "straight line" which contrasts with the "semicircular" lines. Only as present-at-hand beings can such lines be. The wall that served as a screen is rough in its surface, the distance between the shutter and the prism was about twenty-two feet (the present author has been in the room, and the distance is given as twenty-two feet in Newton, 1984b, p.539), the Sun is not bright at Woolsthorpe Manor early in the year, and the image is given as "length was 13¼ inches and its breadth 2⅝ inches" (*ibid*). If we repeat the experiment, the lines may be described as straight and semicircular, but they are not really so. Indeed, Newton says in the quotation given that the semi-circular line is indistinct.

This analysis suggests that there is support for the *de novo* hypothesis of insight in the engagement of Newton that entails lenses and rectangles, which some might say is synonymous with "physics". However, historians argue that Newton's letter – his only historical narration of the one of the most critical advances in the history of modern science – is not accurate.

That Newton should choose to write in this way to describe his work is revealing of his character and situation. It is a defensive, humble, account which suggests that he stumbled across the beings that were critical. As Newton tells the story, it is plausible; however, a solicitous history – produced by those not involved – does not wholly verify Newton's report. In Shapiro's judgment:

> Although his account is undoubtedly in part an embellished historical reconstruction, making the discovery appear like a "Baconian induction from experiments", in many of its essentials it does agree with the surviving manuscripts. (Newton, 1984c, p.10)

Irrespective of the accuracy of Newton's account of his practice, we must ask how he proceeded.

In his paper on Newton's style, Ducheyne draws attention to the distinction between "the *presentational sequence* of Newton's theory (*the method of justification*)" and "the *chronological sequence* of Newton's theory (*the method of discovery*)" (Ducheyne, 2005, p.2). Ducheyne's purpose, to the extent that it finds current theory inadequate, resonates with the present work. He argues against the orthodox theory that the Newtonian scholar (Cohen) represents– the crux of which is that Newton works by means of the successive adaptation of mental constructs through comparisons with nature. Chapter 2 introduces the theorist, Cohen, in relation to Newton's philosophy of science. Such a theory allows the use of "arbitrary hypotheses", which Ducheyne says is "characteristic of the hypothetical-deductive method" (Ducheyne, 2005, p.2). Chapter 2 also considers the difficulties extant in such constructivist accounts of physics. The attempt here, using the draft letter as evidence, is to discern the beings from a presentational sequence. Now we must consider the beings as they might be discerned from the method of discovery, using whatever sources contribute to that enquiry.

What ultimately gratifies Newton, we might speculate, are not the vivid colours, but the confirmation that the beings of his theory point accurately to other beings which now appear on his wall. Equally, the beings on the wall point to the beings of the theory. Together the two relationships constitute as single truth of disclosure. It is only in our analytic endeavours that the truth condition is cast as a situation of objects and relationships between objects. What beings can we discern that were involved with Newton as events unfolded? "Events unfolded" refers to the

method or context of discovery. Truth provides information on the various configurations of truth-beings within for-the-sake-of-which cascades.

First, the present-at-hand beings of theory are present. *Micrographia* has already been mentioned. "By the latter part of 1665 Newton had acquired a firm command of contemporary optics through his studies of the works of Boyle, Descartes, and Hooke" (Shapiro in Newton, 1984c, p.9). From Descartes, Newton knows of Kepler's theory and the critical sine law of refraction, the "foundation of his optical investigations" (Shapiro, in Newton, 1984c, p.7). These are beings that constitute truth through correspondence. There is also evidence that he was involved in practical investigations in optics. Newton's own writing contributes to the theory that establishes itself through correspondence. For example, in *Optica*, Part II (The origin of colors), Lecture 11 (continuation of "The Phenomena of Light Transmitted through a Prism to a Wall", Newton takes up "in somewhat more detail the shape of the coloured image formed by light flowing through a narrow, round hole into a dark room and then passing through a prism" (Newton, 1984b, p.539). The "lectures" (it is unlikely he presents them as in the text) also provide for Dasein truth as correspondence entailed in present-at-hand beings.

Second, the "unfolding" will entail a being which carries truth as disclosure. The unitary nature of this truth-being needs not be laboured again, nor the unity of significance, the "ontological constitution of the world"(Heidegger, 1962a, p.416). However, how does that "unitary nature" associate with truth as correspondence as this develops in the paragraph above? It is within the for-the-sake-of-which cascades and the forestructure of insight that we must seek an answer. Such questions, Heidegger tells us, are to be advanced phenomenologically. It is legitimate to ask ourselves, what is that experience for us, and to infer that Newton was in a similar situation. The question admits several versions. In the "now" of *alētheia* what is the status of the forestructure, say for example fore-grasping? Or, as Bernard Lonergan (1970) might cast it: what is the nature of insight that involves truth? Or in Heidegger's ontology: what is the movement from that enables the truth of Newton's physics as disclosure? In *Being and Time* his concern is to obverse of that here, specifically, the temporal problem of the transcendence of the World (pp.415-418). He first reminds us about the ontological origin of science, and then provides a comment:

> We shall not trace further how science has its source in authentic existence. It is enough now if we understand that the thematizing of entities within-the-world presupposes Being-in-the-world as the basic state of Dasein, and if we understand how it does so. (Heidegger, 1962a, p.415)

This is the kinetic from disclosure to thematizing, whilst the present issue is from thematizing (Newton's laws) to disclosure (Newton's abidance with *alētheia* in the complex that involves a spectrum as a rectangle). Nevertheless, Heidegger provides insights that assist the present project.

Or, to pose the issue in an existential analytic with the blush of the thesis: how within a for-the-sake-of-which cascade are we to reconcile our unitary experience of now with progression? First, it is apparent that Heidegger's assertions on page 416 of *Being and Time* about the "horizonal unity of the schemata" are not helpful. As chapter 3 indicates, there are primarily three kinds of being available, and hermeneutic phenomenological seeing does not reveal as horizon as a kind of being. Thus, the "horizon" must be a being and the use of the word "horizon" suggests a correspondence configuration of truth. The 'horizon' emerges from the thematizing of entities, not the other way round. Dasein does not proceed in the world with categories and then seek to identify everything disclosed. Chapter 2 refers to the "manifold sense of being" in relation to Heidegger's early intensive mediation on Brentano's book. The analogy of the tree, and the KNS schema, together are a distinct advance on the theory of horizons. The KNS schema could be read as a configuration of categories, but this would be a mistake in the sense of category is that implied in Aristotle and associated with horizons. Incidentally, when Heidegger (for example, Heidegger, 1962a, p.417) refers to the "horizonal unity of ecstatical temporality" the word "horizonal" does not refer to horizons in Aristotle's sense, but rather it indicates a totality or wholeness.

Without categories and horizons, how within a for-the-sake-of-which cascade are we to reconcile our unitary experience of now with progression? It is possible to construct an answer by way of an appeal to Heidegger's statement that the world is neither ready-to-hand nor present-at-hand.

> *The world is already presupposed* in one's Being alongside the ready-to-hand concernfully and factically, in one's thematizing of the present-at-hand, and in one's discovering of this latter entity by Objectification;

> that is to say, all these are possible only as ways of Being-in-the-world. (Heidegger, 1962a, p.417)

The world with which Dasein abides or participates is that world which he refers to as the Real, in relation to modern physics. It is the ontological resource that enables the KNS schema. When it imposes itself within for-the-sake-of-which cascades it does so with a "reliability" or "consistency" for the Dasein. As he turns the prism, Newton cannot avoid *alētheia*. The forestructure in the for-the-sake-of-which cascades and an aspect of the Real inevitably produce disclosure. This is what Heidegger means when he says:

> this 'subjective' world, as one that is temporally transcendent, is 'more Objective' than any possible 'Object'. (Heidegger, 1962a, p.418)

The quotation marks indicate Heidegger distances himself from the ontic language, the sentence is about ontology. In an ontological manner the world imposes itself upon Dasein, which is one sense in which he says Dasein is "fallen" or abides with "facticity".

Mention may be made of one whose conclusions about reality have some congruence with those of Heidegger mentioned above. Heidegger's account of the world is reminiscent of a notion the Harvard philosopher Hilary Putman develops in *Representation and Reality*, "internal realism", a notion that first appears in his work *Reason, Truth and History*. Perhaps ontology asserts itself in Putman's view that within a conceptual scheme, the entities that are involved in that scheme are real (Putnam, 1988, pp.113-114). Putman seeks to develop a third way between classical realism and antirealism, and says that he approaches "some of Heidegger's conclusions from a Wittgensteinian direction" (Putnam, 2004, p.16). More specifically, he says "I think that philosophy needs to take the ways of thinking that are indispensable in everyday life much more seriously" (2004, p.16). Putnam rejects traditional dualisms, and argues a controversial, pragmatic form of realism:

> The key to working out the program of preserving commonsense realism while avoiding the absurdities and antinomies of metaphysical realism in all its familiar varieties (Brand X: Materialism; Brand Y: Subjective Idealism; Brand Z: Dualism. …) is something I have called internal realism. (I should have called it pragmatic realism!) Internal realism is, at bottom, just the insistence that realism is not incompatible with conceptual relativity. (Putnam, 1987, p.17)

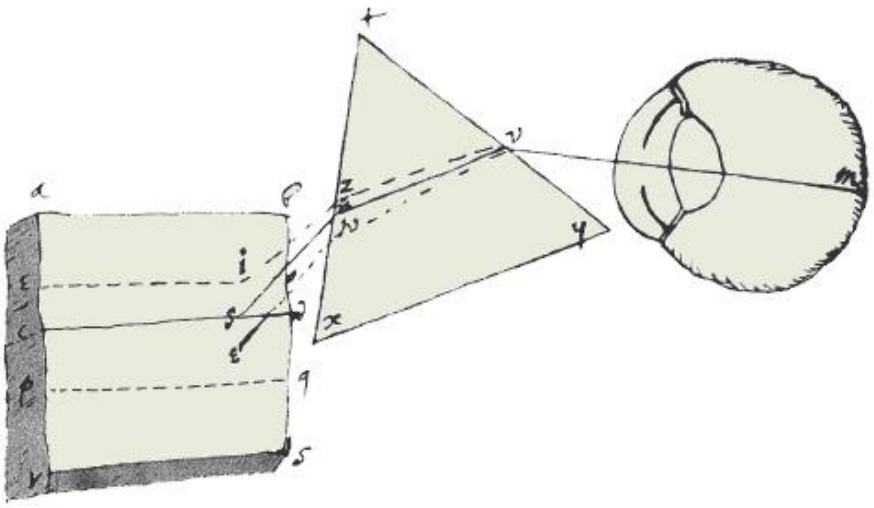
The strategy of reasoning is reminiscent of Heidegger, although that does not seem sufficient to make Putnam take up the notion of truth as disclosure.

Newton does not proceed from hypothesis to experience, but rather an experience of truth occurs when he holds fore-structures that include the beings of theory. Calling something a "hypothesis" does not of itself count for much. Newton, according to his own accounts, exhaustively seeks to achieve a situation – any new situation – that will enable an experience of *alētheia*. He searches as situations strike him, and not in the strict logical fashion that the hypo-deductive method prescribes. The engagement with the prism is a bodied engagement, an imprecise, try-and-see series of events. These enable him to achieve *alētheia*. Once that occurs, Newton works to improve that experience, literally in optics to "sharpen the image", and thus to create a definitive demonstration. Newton uses the term "*experimentum crucis*", critical experiment, that Hooke coins, but this should be called a crucial demonstration, or just a demonstration. Smith uses the term "crossroads experiments" that enable phenomena to pick themselves out, as *experimentum crucis* (G. E. Smith, 2002, p.146), whilst Laymon (1978) shows how Newton had many purposes in his work towards such experiments and how their relationship to theory was complex and at times uncertain. Nevertheless, Newton had an instinct about the importance of demonstrations. Demonstrations are the principal vehicle by which the truth of disclosure in modern physics may transmit itself from one physicist to another.

Colours (observation)

This section begins as Heidegger sometimes begins his lectures, with a preliminary enquiry to attune the reader to the questioning. Then, it considers Newton's engagement with colours in his experimental work in optics. This highlights situatedness, the hermeneutical situation. Next, it considers the characteristics of Newtonian ontic physics. This highlights de-situatedness. Finally, it considers a physicist's interpretation of ontic physics. This highlights situatedness. Through the three movements, the question of truth is paramount.

Probably in the early 1600s, during his extensive trials with light sources and prisms, Newton produces a record of his findings. "Of colours" appears and includes a diagram and tabulation as follows:



If abdc be white & cdsr black y^n eodc is red.

If abdc be black & edsr white y^n eodc is blew.

If abdc be blew & edsr white y^n eodc is blewer.

(Diplomatic text, Newton, 1664-65, folio 63)

	white	& cdsr	blew	y^n e	~~yelle~~ Red.
	black		blew		~~Greene~~ blewer.
	blew		black		Greene, or Red
	black		red		blew.
	red		black		redder.
If abdc be	red	& cdsr be	white	y^n eodc is	blew.
	white		red		redder.
	white		whiter		blew.
	whiter		white		redd.
	black		blacker		Greene or darke red
	blacker		black		blew.

(Diplomatic text, Newton, 1664-65, folio 63)

What is the essence of these extracts from Newton's text? Is the essence located in Newton's engagement or is it located in the text as it lies before us now? The purpose of this preliminary interpretation of the essence of these quotations is "to attune our questioning attitude to the right basic disposition or, to put it more prudently, to allow this basic disposition a first resonance" (Heidegger, 1994, p.3).

Heidegger's words here are those from a lecture that he gave when he wrote the *Beiträge zur Philosophie (Vom Ereignis)* (Heidegger, 1994, p.xx). Consequently, they open a text which the editor of the *Beiträge* considers important preparation for Heidegger's contentious *Beiträge*, and which has as its theme "On the Appropriating the Event" (Heidegger, 1994, p.191). The task – responding to the essence – is the production of sovereign knowledge. However, sovereign knowledge is not knowledge in the sense of knowledge in physics, which is knowledge of facts, figures (for example physical constants) or mathematical formulae, but rather the seeking itself (Heidegger, 1994, pp.6-7). His analogy is the climbing of a mountain where you slip and slide back, and then experience the peak and its *height* until this becomes habitual (Heidegger, 1994, p.21). The words Heidegger uses are "attune" and "disposition", the words that chapter 3 indicates as translations of *Befindlichkeit*, and which after 1936 Heidegger understands as "dwelling". The task of the present mediation on the quotations from Newton is to dwell with their essence.

Newton's extant formulation which the quotation shows, often takes the form: If (something 1) be (colour 1) and (something 2) be (colour 2) then (something 3) is (colour 3). The words which convey a "logic" for the formulation are "if", "be", "and", "then" and "is". Heidegger enquires into this situation at least from 1915 in his post-doctoral dissertation where he asks about the categories that logic requires (Crowell, 2005, pp.60-61).The correctness of the assertion is an issue for Newton. As the quotation shows, in his deliberations Newton replaces yellow with red, and green with red. Newton labours to make the assertion correct. In this he draws upon *adaequatio*, the dimensions of which chapter 2 shows in the enquiry of Aquinas, and which Heidegger likewise summarises in the 1930s and concludes that in its commonplace formulation "truth is the correspondence of knowledge (representation, thought, judgement, assertion) with the object" (Heidegger, 1994, p.16). There are alternative renditions of these relationships present in Newton's text. One is that the *perceptum* or *idea* relates to the representation, and another is that our representation reaches the things themselves (*res*) and what belongs to them (*realitas*). All of this is as familiar to Aquinas as to Heidegger who concludes that the "controversy among all these opinions can still go on endlessly" because it is "characteristic of this sterile wrangling to renounce in advance the question of the soil upon which the combatants stand" (Heidegger, 1994, p.17). His reference harks back to the analogy of the tree and the movement of truth from the soil to the foliage

(chapter 3). The analogy of the tree is at once an analogy for Western metaphysics and for the Dasein's engagement with truth. It is Newton himself, or ourselves, who are essential to the being that enables the abidance with truth that the analogy of the tree indicates?

Truth as the soil or the ground of truth as correspondence, *alētheia*, is a "self-evident determination of truth" and "it settles into an openness already holding sway and does so, as it were, each time anew" (Heidegger, 1994, p.22 & 23). Thus, we are led to consider the openness that holds sway before Newton's diagram and tabulation become possible. Heidegger says we must consider the essence of truth within the diagram and the tabulation, and by "essence" he means not the universal or the enduring, but rather that which a genus or class holds by means of its lineage, derivation, origin (Heidegger, 1994, p.53 & 54). Our question is what was Newton's diagram and tabulation before they became that which now "is"? The "essence" – the whatness (what it is) – of anything – must be seen both in advance and continue constantly inherent in any "it" (*Sorge*, the phenomenon of care).

The question becomes the hermeneutic question: how are we to interpret Newton's diagram and tabulation – or more precisely, how are we to see the essence therein? Heidegger's response to this is categorical. The "idea" or the "object" (that which is) is to be understood on the basis of beings and not as an image which is the counterpart to, and the result of, a particular apprehension and representation (Heidegger, 1994, p.62, pertains). This is the phenomenological foundation of the enquiry, and the beings located phenomenologically are those that chapter 3 lists and which appear in the quotations from Newton's notebook.

With these beings (their surrogates with us are prism, light, spectrum, Newton) there are the major existentials (structural moments) of ontological understanding (*Verstehen*) and disposition (*Befindlichkeit*). Now however, as the intention is to emphasise the totality or wholeness of the Dasein's disposition, the word to use is "situatedness", or as Heidegger renders this notion in *Being and Time*, the "*hermeneutical Situation*" (Heidegger, 1962a, p.275 & 276). This totality of the-there, Richardson acknowledges in a translation which produces "beings-in-the-ensemble":

> In every particular comportment, then, there is a certain resonance or attunement (*Gestimmtheit*) by reason of which the whole ensemble becomes manifest. We recognise here, of course, the ontological

> disposition, disclosing, as it does, There-being's essential reference to the World, which, if considered in the ontic dimension, may be called There-being's orientation towards beings-in-the-ensemble. (Richardson, 1974, p.219)

In the current discussion, with the focus on ontic text, it is Richardson's final sentence that claims us. In support of Richardson's emphasis, Inwood says:

> Heidegger coins *Befindlichkeit*, which combines the ideas of 'situatedness' and of 'feeling/faring somehow", of where and how one finds oneself (Inwood, 1999, p.131).

In this are two notions of "thrownness" from confusing sections of *Being and Time* – the Dasein is thrown into facticity (emphasis on ontological understanding) and is thrown into situatedness (emphasis on *Befindlichkeit*). Of course, they are always equiprimordial and their separation here is only for the purpose of exposition.

What in Newton's diagram and tabulation indicates situatedness? One indication of situatedness/*Befindlichkeit* comes from the quotation in chapter 2 – "for eight years ... locked himself in a remorseless struggle with Truth ... uneaten meals ... continued ecstasy". In the text we can see that Newton draws the prism and the spectrum out of proportion because they had to fit on the paper – the total situation comprises of the "real" prism, the "real" paper (hermeneutic facticity) and that which engages Newton as his event (the hermeneutic Situation). Likewise, we see that Newton writes and then alters words in the tabulation of colours. He has a particular vocabulary of colours – today we expect violet, indigo, and orange. We may observe situatedness in each of these examples. Newton appears along with (dwells with) the physical phenomena. Newton abides first with the phenomenon of the spectrum. He then abides with the individual colours within and seeks to label them. It is clear that the area which he first thought to be yellow, he makes red. Similarly, the area that he initially records as green is subsequently "blewer". (This particular point is not about "understanding". Newton does not misunderstand anything, nor would he benefit from a modern education.) The truth this work involves is that of correspondence. Newton encounters a phenomenon and seeks a word for it. The word must be that which conveys the correct colour to other people. *Alētheia* enters into the situation in two ways. First, each and every being holds disclosure or it would not be a being. This is the sense in which Dasein is perpetually in the truth and it is not the sense at issue. The second way is a disclosure of modern physics,

that which an earlier section of the present chapter describes. There is the unforgettable, unexpected disclosure that enlivens Newton. It is the event in which *alētheia* "dominates" *adaequatio* in for-the-sake-of-which-cascades, and which the earlier section describes as discovery in modern physics. This disclosure that involves the spectrum, the prism and Newton, holds in for-the-sake-of-which-cascades. The argument now is that it contributes to disposition. Said wrongly and violently, it contributes to *Befindlichkeit* as an "input" and the ontic psychologist says Newton is highly motivated to record his findings.

There is, in contrast, a way to interpret Newton's text as modern physics which is independent of humankind, which includes independence from Newton. Heidegger describes the step to this formation of "physics" as an opening to what has been there:

> In historiological thematizing, the main point is the cultivation of the hermeneutical Situation which–once the historically existent Dasein has made its resolution–opens itself to the repetitive disclosure of what has-been-there. (Heidegger, 1962a, p.449)

His term "historiological thematizing" refers to "any discourse on as a coherent theoretical attitude, as the concrete logic of a field" (Inwood, 1999, p.93). This quotation refers to the ontic discipline of physics textbooks which every Dasein encounters by way of *adaequatio*. Physics is now the physics of objectivity, detachment and dispassion. What account may be given of the move from the situatedness that involves Newton to the de-situated text book which may sit on a library shelf? The achievement is not that of Newton. Another Dasein comes along and in an alternative situatedness to that of Newton, constructs modern physics for textbooks. The alternative situatedness need not involve *alētheia* in the second sense indicated above. Those who write physics textbooks need not engage with the distinctive truth of physics. Work to de-situate physics appears as an "instinct" for Dasein. It is even apparent in the second version of Newton's tabulation of findings:

white	blew	Red.
black	blew	blewer.

(Normalised text, Newton, 1664-65, folio 63)

The Newton Project provides this normalised text. The diplomatic transcription, which this chapter shows earlier, is a detailed representation of the document with

minimal editorial intervention. The diplomatic text for Ms.3996, *Questiones quædam Philosophiæ*, shows 493 deletions by Newton, 408 additions by Newton, and does not apply 2,074 regularisations – all of which are adjustments in the normalised text (Editors' explanation of text, Newton, 1664-65). The graphic in folio 63 was "traced by hand from scanned images of the Chadwyck-Healey microfilm of the original documents" (The Newton Project, 2009). This is not an issue of truthfulness as chapter 2 indicates Nietzsche construes truthfulness. The requirement for an ontic discipline is that there be copies made of Newton's work and the alterations found are inevitable because the copy is that of another Dasein, a Dasein that does not hold Newton's situatedness. Many Dasein compile the documents of physics, which is the ontic discipline of physics.

Later, in association with lectures, Newton himself reconstructs his earlier account of the prism and the spectrum, and the ontic discipline of physics emerges afresh as a construction of truth as correspondence. Shapiro notes Newton's many attempts to describe his experiments and the "seemingly innumerable variants from the first" (Newton, 1984c, p.51). As Newton says:

> But to present my idea more distinctly: First, I find that to differently refrangible rays there correspond different colors. To the most refrangible ones there corresponds purple or violet, and to the least refrangible red, and the intermediate ones green, or rather the boundary of green and greenish blue. Blue, however, falls between purple and green, and yellow between green and red. Hence, as the rays are more and more refrangible, they are disposed to generate these colours in order: red, yellow, green, blue, and violet, together with all of their successive gradations and intermediate colors. (Newton, 1984b, p.437)

Newton now has a more conventional grasp of colours, one that corresponds to our own. However, this develops by a process that is well removed from the truth of disclosure that pertains. Shapiro describes another contrivance:

> Throughout the *Lectiones opticae* Newton divides the spectrum into five principal colors. He added orange and indigo to these when near the end of the Optica in Lect. II, 11, he introduced his musical division of the spectrum; and from the "New Theory" (Prop.5) onward he used a sevenfold division alongside of the fivefold one. Of the five colors enumerated here, only the name for the most refrangible rays, purple

("purpureum"), varied until he finally opted for violet in the *Opticks*.

(Newton, 1984a, p.50)

This is a further example of Newton's (almost) total engagement with truth in its correspondence guise.

Chapter 2 considers the constructivists' account of modern physics, Cooper's probe into truth therein and Matthews' assertion that educational constructivism draws upon other constructivist traditions. The Heideggerian rendition of Newton's involvement in textbooks contradicts constructivism. Whilst the constructivists' observe that physics always involves someone, they develop this with an implicit or explicit rendition of the theoretical distinctions that Heidegger denies. Perhaps an existential analytic will support Matthews' observation that construction begets construction. Yet the example of this section, which develops with conventional Heideggerian theory, indicates why physics in and of itself, in its essence, cannot be a mere construct of the human being. There are two reasons for this. The first derives from a consideration of truth and the second derives from the third step in the argument of the present section, the step that is about to appear – this is the step that says how physicists and students come to abide with physics by way of ontic textbooks. With regard to truth, the engagement with the Real which is necessary for modern physics, indeed its essence, is absent in constructivism. Constructions in physics are not as unfettered or as unconstrained as constructivists suggest. Physics builds in its essence upon reality within *alētheia*, and not upon earlier constructions. That is not to say that there is no involvement of *adaequatio* for there is within for-the-sake-of-which-cascades. It is this involvement of correspondence that possibly misleads the constructivists. The second reason follows.

There is no involvement of physics, no presence of physics, which does not entail situatedness. When the physicist picks up a physics textbook, there is situatedness. Every experiment or demonstration occurs with Dasein's situatedness. The physics textbook, the journal article, the conversation with a colleague, all hold their beings and relationships in for-the-sake-of-which-cascades. Situatedness is in this *Befindlichkeit* with an emphasis on the totality of the enterprise (allegedly physics, but not necessarily). Physics textbooks only appear objective when Dasein renders them (or their contents) as objects that hold detachment from the Dasein, this is their hypothetical un-involvedness. Each objectifying of the content of physics textbooks involves situatedness, as does every engagement of the Dasein. Only in

some formulations of the philosophy of science does physics hold itself as detached from situatedness. Elderly scientists record an engagement with situatedness in research whenever they write their biographies around their work achievements and colleagues. Chapter 2 records Newton's early separation of truth from the human being, in a slogan that derives ultimately from the ancient Greeks, "Amicus Plato amicus Aristoteles magis amica veritas". This slogan heads the notebook (Ms.3996) which provides the example that the present section discusses (f.63). This is about one aspect of the ground-plan of modern physics that chapter 4 introduces. As one of the hermeneutic philosophers of science says:

> Heidegger thinks that in every theoretical, and a fortiori in every scientific, orientation toward the world, the scientific experience itself contains already a special thematization in which the object of knowledge is taken, constituted, and projecting as its theme. In this projection a certain domain of the being is staked out, the approach to this domain is given its particular methodical direction, the structure of the conceptual and discursive explanation receives its orientation, and a specific language is constituted. (Kockelmans, 1985, p.124)

Kockelmans' use of "domain" is unfortunate if it leads us to think that beings of a kind have a sphere or area, or a fence around them. This quotation may be read in conjunction with the tree analogy for the involvement of truth in ontic disciplines. With a wide range of sciences in mind, Heidegger tells us that what is encountered proximally, which means truth within for-the-sake-of-which-cascades, in this case in "circumspection", may entail space viewed in a "certain way" which can be studied "purely by looking at it" (Heidegger, 1962a, p.146). Thus, thematization occurs in building and surveying, which entail calculation and measurement on paper. In the example of folio 63, Newton's notebook takes on this character. Earlier the present section alludes to the cultivation of historiological thematizing, or as it was then said, in Heidegger's phrase, the achievement of the "hermeneutic Situation".

Entrance to this section is achieved by way of a preliminary enquiry to attune the reader. Thus, it is appropriate to follow again Heidegger's method to close the section and provide a recapitulation. Newton's text enables this section to demonstrate that objectivity in modern physics is an illusion, without the implication that physics is relative or a matter of mere opinion. That which lays claim to objectivity in modern physics is ontic text, and yet ontic text is incapable of any

importance without Dasein and Dasein's situatedness. The construction of ontic text in modern physics entails an attempt to achieve de-situatedness. The example of space stands out for in modern physics we have spaces reduced to points (as in chapter 4) and diagrams out of proportion in the present chapter. For the Dasein, such attempts have the character of work which seeks to defeat time and space. Newton's notebook – his personal record of a truth of disclosure – quickly comes into use as a tool for himself (the first section in the present chapter is a discussion of something similar to this) and it becomes situated with those Dasein who bring a new hermeneutic to abide with the text. Apart from a relatively small number of events when truth discloses, the truth of the enterprise of modern physics entails various compilations of correspondence. As the previous section indicates, even in those few events when *alētheia* shines into the openness of beings, the Dasein, in for-the-sake-of-which-cascades involves truth as correspondence, and thus *adaequatio* endures in modern science.

Mathematics (disclosures)

This section investigates the ontological ground or foundation of modern physics. It digs below the ground-plan or blueprint that enables physics. Whilst chapter 4 indicates several aspects of the ground-plan of modern physics, this section confines itself to the mathematical that involves Newton. Ultimately, the section argues that modern physics entails a distinctive disclosure although that is not all it entails. This disclosure of physics involves mathematical beings by drawing upon an essence within those beings that determines the kind of beings available to, or for, modern physics.

Modern physics is the mathematization of nature. Newton avoids a confrontation with that commonplace assertion because he does not pursue the essence of things, but rather as Kockelmans says, "merely tries to understand the phenomena which we experience by means of observation and experiment", although there remains debate about his philosophy of science (Burtt, 1954, pp.52-56, pp.63-69; H. F. Cohen, 1994, pp.88-89; Kockelmans, 1993, p.122). This section pursues "the mathematization of nature" through its rendition by Husserl and onwards to an existential analytic of Newton's project in optics. The analytic describes the event of physics in a conventional inventory of the truth-beings and their signification structures. Subsequent enquiry into those beings is largely in

accordance with Heidegger's concept of categorial intuition and apriorism. Chapter 2 interprets compelling paragraphs that Newton wrote about hypothesis and truth, to argue that Newton understands his project as the identification of relationships between properties, although his interests are more substantial. These relationships are cast as laws, statements which involve mathematics, just as he found them in the optical work of Barrow and others. The present section asks what we may say about the laws of modern physics.

Whilst the history of the hermeneutic philosophy of science in chapter 1 advances Kant, Heidegger and Heelan as the definitive theorists of the tradition, there are others of importance. One of these is the Edmund Husserl (1859-1938), Heidegger's mentor and colleague. Mention is made in chapter 1 of Husserl's foundational work in phenomenology, which is a technique of enquiry that inspires the existential analytic of the Dasein. Heidegger's KNS schema is a consequence of his rejection of Husserl's concept of the ego, although as chapter 3 shows the schema makes use of Husserl's notion of the life-world. Now, it is Husserl's problematisation of mathematics in physics which is of consequence. Like Heidegger, Heelan acknowledges the challenge from Husserl which in his case appears when he exchanges "the practice of physics for the profession of philosophy" (Heelan, 2002, p.440). Husserl began in his mid-seventies (around 1934) to write a publication that would ground and explain his phenomenological philosophy (Translator's introduction, Husserl, 1970, p.xv). Although unfinished, *The Crisis of European Sciences and Transcendental Phenomenology* provides a distinctive re-interpretation of Husserl's life's work.

Incidentally, when the present thesis claims that there is a crisis in physics education it draws inspiration from Husserl. Both crises – that of the European sciences and that of the physics education – derive from a current construction of truth and they hold in common the human's detachment from that which is foundational of things and existence. In Husserl's example, man has become a "nonparticipating spectator, surveyor of the world" (Husserl, 1970, p.285). As chapter 4 testifies, this accords with Heidegger's account of Western metaphysics. In the event of modernity we adopt as our defining characteristic an "inquiring theorizing scientific spirit" (Heelan, 1997, p.284; Heidegger, 1977b). In physics education the student has become a user of physics, and not a participant in the truth of disclosure that is definitive of modern physics. Husserl's "crisis" claim is about

abandonment on a monumental scale, whilst the crisis in physics education relates to physics teachers who abandon an exiguous, precise, incarnation of disclosure. Both claims involve an abandonment of the pre-theoretical attitude of the life-world, and a pre-givenness which contemplative detachment, including the ontic discipline of physics, requires.

How are the beings of mathematics within Newton's physics? The first section of the present chapter interrogates the relationship between Heidegger's ordinary-everydayness, which is sufficiently Husserl's life-world, and Newton's skilful production of ontic physics. That section is unable to identify any demarcation, within for-the-sake-of-which-cascades or within the structures of truth, which would indicate a "cross-over" into contemplative physics from customary living. Instead, the analogy of truth as sap in the trunk is found more credible. Heidegger's "ground plan of modern physics" is the early rising sap, truth which enters and remains essential within modern physics. In his last meditation, Husserl expresses a very similar idea with the expression – the "garb of ideas". Perhaps it is Husserl's sartorial analogy which inspires Heelan when he says that reality (that which modern physicists decisively encounter) comes to us dressed in "sensible" clothes (Heelan, 1998, p.285). Husserl:

> Mathematics and mathematical science, as a garb of ideas, or the garb of symbols of the symbolic mathematical theories, encompasses everything which, for scientist and the educated generally, *represents* the life-world, *dresses it up* as "objectively actual and true" nature. (Husserl, 1970, p.51)

First he tells us that both mathematics and physics *are* a garb of mathematical symbols (ideas) – this should not be taken literally. The word "garb" implies regalia that cover the essential core. Then, he indicates that it is the regalia (garb) which demarcates an area or sphere of the life-world. The effect of this is to give the core of physics a particular appearance (we see the clothes, not the person). Finally, he is specific and says that it is this outward appearance that makes mathematics and physics appear objective, actual and true. Husserl continues to assert what is foundational:

> It is through the garb of ideas that we take for *true being* what is actually a *method*–a method which is designed for the purpose of progressively improving, *in infinitum*, through "scientific" predictions, those rough

> predictions which are the only ones originally possible within the sphere of what is actually experienced and experienceable in the life-world. (Husserl, 1970, p.52)

Husserl describes ontic certainty, the alleged objectivity in modern science, as dependent on, and reflective of, a sphere of experience within the life-world. However, what is foundational is a method which does no more than tidy a "sphere" of the lifeworld. This does not accord with the current core tenets of the hermeneutic philosophy of science. It does not include the vital engagement with the Real, and instead casts physics as but one of many possible spheres that are the product of human experience. This accords with the relativists, and constructivists, accounts of physics that chapter 2 expounds.

Like Husserl, Heelan also advances method as in some way definitive of modern physics, although his probe into method draws more from practical experience, the practice of physics (Heelan, 1998). With reference to the culture of the laboratory that is involved in a research programme, he says in his summary of the hermeneutic philosophy of science:

> The object-as-measurable is recognizable as such because it comes 'dressed' in sensible 'clothes' provided by the experimental strategies used. Whether such 'clothes' render the scientific entities perceptible will be discussed below. *This leads to a second conclusion: observation events should not be called semantically 'theory-laden'–this appellation should be reserved for experimental design–but rather semantically praxis-laden, like all dedicated or designated cultural objects of the lifeworld presented as fulfilling experience*. (Heelan, 1998, p.285, his italics)

Now it is not the garb to which we must attend, but the object-as-measureable. The clothes may enable us to recognise a particular object of physics, but they are more the integrants of the ground-plan, than the delineators of a sphere. That experimental *design* is theory-laden indicates the nature of the truth involved, which is a correspondence formulation. The object-as-measurable, that integral to "observation events", is a cultural object in the life-world which fulfils experience.

To what extent are these assertions about the method modern physics – from Husserl to Heelan – found in Newton's work which ostensibly is the embodiment, or at least the exemplar, of modern physics? We must seek from the "systematically

praxis laden" – for example, numbers and operators in experiments or demonstrations – to gain access to ontological essence. A further way to define the task is to say we must clarify what is definitive of physics, and at this moment the extant choice is the event or the method. A third way to define the task is to say it is an attempt to gain access to ontological truth by way of ontic truth. (Heidegger often advocates the strategic move from the ontic to the ontological as a way to begin an existential analytic.) The fifth way to define the task is to say we seek to reveal more of Heidegger's ground-plan of modern physics. A sixth what to define the task is to say it is an enquiry into Heidegger's concept of 'categorial intuition', which refers to the categories grasped in perception but which are prior to any categories of cognition. Finally, a seventh way to define the task: If a part or all of that ground-plan of modern physics is *a priori*, which is Heidegger's assertion (chapter 3 introduces this with Sheehan's comment on Heidegger's "being-open as an ineluctable condition of our essence"), we may construe the current task as an enquiry into apriorism. Newton's work on optics in the earlier sections provides access to Newton's involvement with the beings of mathematics:

> In the wall or window of a room let F be some hole through which solar rays OF are transmitted, while other holes elsewhere have been carefully sealed off so that no light enters from any other place. The darkening of the room, however, is not necessary; it only enables the experiment to turn out somewhat more clearly (Newton, 1984b, p.285)

Newton indicates his personal experience of the situation, which as the earlier section on colours shows, might indicate something about situatedness, the *hermeneutical Situation* that pertains. Physically, not ontologically, Shapiro says that "In fact, in the corresponding Fig.2 in the *Lectiones opticae* Newton drew the room in which the experiment is performed and the spectrum project onto its wall" (Shapiro, in Newton, 1984c, p.285 & diagram p.50). The quotation above is about the same situation or demonstration which he describes in the letter that features in the earlier section ("I became surprized to see them in an oblong form", Newton, 1671/2, f.460r), although now Newton does not describe surprise but confidently issues instructions.

> Then place at that hole a triangular glass prism … that refracts the rays *OF* transmitted through it toward *PYTZ*. You will see these rays, terminated by the opposite wall or by some paper placed sufficiently far

> from the prism, formed into a very oblong figure *PYTZ*, specifically, one whose length *PT* is four times and more than its breadth *YZ*. (Newton, 1984b, p.285)

In Newton's demonstration, it is difficult to say where the oblong figure starts and ends, although it is correct that the image is always approximately in the ratio he suggests. Newton's experiments were crude and his difficulties derived from both the nature of light and his facilities (for an account of the difficulties replicating the experiments, see Biernson, 1972). Newton knows about these difficulties around accuracy and his demonstration does not depend on the exactness of the ratio. It depends on there being a rectangle as opposed to a circle, and there being a consistent ratio, not an exact measurable ratio. Such judgements human beings make with a greater confidence. Newton pursues the "humanly observable", as opposed to the "precisely measurable". The experiment cited above looks precise because Newton uses the language of geometry, when the experiment is based on a hole that is only approximately circular. Newton concludes:

> Indeed, in whatever position I placed the prism, I nonetheless could never make it happen that the image's length was not more than four times its breadth, that is, with the angle of the prism ACB or $\alpha\kappa\beta$ being about 60°. (Newton, 1984b, p.285)

And, he underscores his conclusion with "definitely appears" and "contrary to all experience":

> Hence, this definitely appears to establish that at equal incidence some rays undergo a greater refraction than others; for if the contrary were true, that solar image would seem almost circular, and in a certain position of the prism it would appear to the senses completely circular, which is contrary to all experience. (Newton, 1984b, p.285)

In this statement, there are mathematical expressions such as "almost circular" which must mean "not circular", and the phenomenological word "position", and an appeal to "experience".

What may be said of the beings that Newton indicates in these quotations as F, OF, triangular, OF, PYTZ, PT, four, YZ, four times, angle ACB, angle $\alpha\kappa\beta$, and 60°? There is an account that is through ourselves and thus about ourselves, and it is this account which Heidegger indicates with his expression "the existential analytic of the Dasein". When Heidegger (Heidegger, 1962a, p.262) draws the relationship

between *alētheia* and the "things themselves", allegedly consistent with Aristotle, he makes the discussion about entities. The Greek provenance of the relevant concepts and their relationships is disputed (Campbell, 2001, pp.79-84). It might be thought that the mathematical truth-beings that are taken out of their hiddenness are beings of disclosure and that is all there is to be said. It is only in a universal, primordial sense of *alētheia* that these mathematical entities involve disclosure when we cite them as entities. The present enquiry takes adopts the method of an ontological biography, and the beings at issue cannot be cast as disclos*ed* "F, OF, triangular, OF, PYTZ, PT, four, YZ, four times, angle ACB, angle *ακβ*, and 60°", for with Newton, in every case, they are an equiprimordial Dasein-being complex and the more appropriate word is "disclos*ing*".

Let us locate the specific question about the mathematical beings in its ontological context. Husserl's (1970, p.36) dictum "back to the things themselves" is of undiminished relevance to phenomenological seeing, and with this guidance we begin with our primarily observation – comportment. In this example, Newton, comportment is the immediately given that manifests itself, in the words of Kockelmans ("Introduction" to Husserl, 1994, p.14). If we see the phenomena of comportment we set aside all questions of truth and reality. Husserl advocates this very strategy as a way to access an understanding of Galileo, and says:

> ... if we go back to Galileo, as the creator of the conception which first made physics possible: what came to be taken for granted only though his deed could not be taken for granted by him. He took for granted only pure mathematics and the old familiar way of applying it. (Husserl, 1970, pp.36-37)

From the available sources of information which includes Newton's writing, it is possible to reduce the comportment seen to three events or movements: Newton arranges, Newton perceives, and Newton records. These are the three phenomenological involvements of Newton's experimental science. Each of these events however has as its foundation several aspects of "Newton's ontology", and it is to just one of those that this section attends. This tripartite comportment conforms to Heelan's account of the hermeneutic philosophy of science, and when seen holistically, it is apparent that it is perception is the pivotal link between the preparations and the recording. It is also perception which provides access to the

Real which is characteristic of Newton's physics in his own descriptions, and in Heidegger's analysis of the characteristics of modern science.

There are several ways to describe the focus that this analytic must now adopt. In Heidegger's language of *Being and Time* it is about the forestructure of perception, which he also calls the hermeneutical circle (Heelan, 1983b, p.194; § 32. "Understanding and Interpretation", Heidegger, 1962a, pp.188-195). However, Heidegger presents a lecture course at Marburg University in the summer semester of 1925 that is perhaps more helpful for the current task, which is to elucidate the ontological ground of modern physics by way of an elucidation of specific Newtonian truth-beings which some allege are "mathematical", namely "F, OF, triangular, OF, PYTZ, PT, four, YZ, four times, angle ACB, angle *αkβ*, and 60°".

Each of these beings occurs for Newton in the hermeneutic context of modern physics. There is signification already present with regards to each being, and the beings are all beings only within significance, for-the-sake-of-which-cascades. They also associate with truth in definitive ways that at once establish and define their involvement in for-the-sake-of-which-cascades. All of this is to work out within the example of Newton's demonstration with the prism. The question here is, on what basis is all of this possible? It is befitting that this section begins with Husserl, because Heidegger's response to this question includes a tribute:

> Edmund Husserl has not only enabled us to understand once more the meaning of any genuine philosophical empiricism; he has also given us the necessary tools. '*A-priorism*' is the method of every scientific philosophy which understands itself. There is nothing constructivistic about it. But for this very reason *a priori* research requires that the phenomenal basis be properly prepared. The horizon which is closest to us, and which must be made ready for the analytic of Dasein, lies in its average everydayness. ("Author's Notes", in Heidegger, 1962a, p.490)

The examples Heidegger (Heidegger, 1962a, p.75) cites are anthropology, psychology and biology, but he could include modern physics. In ontology, including the ontology of modern physics, we must step back into the ontological attributes of Dasein. The step back he sets out in *The History of the Concept of Time*:

> As categorial intuition is possible only on the basis of the phenomenon of intentionality having been seen before it, so the third discovery [the *a priori*] to be discussed now is intelligible only on the basis of the *second*

> and accordingly only on the basis of the *first*. It is in this way that the sequence of discoveries accounts for itself, and the first manifests its fundamental significance step by step. (Heidegger, 1985, p.72)

Chapter 4, during the introduction to formal indication, refers to the foundation of the categorial intuition within phenomenology. Heidegger's phenomenological/ontological use of *a priori* is distinct from the use of the term by other theorists which in the main refer to the human ability to know independently of experience, which in the case of Kant refers to the ability to know subjectively (Heidegger, 1985, pp.73-74; Øverenget, 1998, p.75, disputes this). The categorial intuitions of "F, OF, triangular, OF, PYTZ, PT, four, YZ, four times, angle ACB, angle *ακβ*, and 60°" are now at issue. Each enters into, and makes itself known, through comportment which we encounter as the phenomena Newton-beings. Truth is present as *adaequatio* in the first and the third phenomena of modern physics, that is, when Newton prepares and when Newton records. In the middle phenomena, perception, truth is present as *alētheia*. Consequently, it is necessary to consider "F, OF, triangular, OF, PYTZ, PT, four, YZ, four times, angle ACB, angle *ακβ*, and 60°" in three separate events with distinct formations of truth. The first two events carry the beings as ready-to-hand beings or as present-at-hand beings in a manner similar to all such beings as set out in the first two sections of the present chapter. The engagement of the "F, OF, triangular, OF, PYTZ, PT, four, YZ, four times, angle ACB, angle *ακβ*, and 60°" in perception is however quite different. It is here that *ta mathēmata*, the "deep sense" mathematics that chapter 4 introduces, becomes important. Heidegger's summary of the "fuller essential determination of the mathematical" includes the following:

1. The mathematical is, as *mente concipere*, a project (*Entwurf*) of thingness (*Dingheit*) which as it were, skips over the things. The project first opens a domain (*Spielraum*) where things–i.e., facts–show themselves.
2. In this projection there is posited that which things are taken as, and how they come to be evaluated beforehand. ... Newton therefore entitles the section in which he presents the fundamental determinations about things as moved: Axiomata, *sive leges motus*. The project is axiomatic.

3. As axiomatic, the mathematical project is the anticipation (*Vorausgriff*) of the essence of things, of bodies; thus the basic blueprint (*Grundriss*) of the structure of and its relation to every other thing is sketched in advance. (Heidegger, 1967, p.92)

Heidegger's description of the mathematical applies to each of the phenomenological aspects of modern physics, but differently in relation to the second, in comparison with the first and third. The difference is most apparent when consideration is given to the meaning of *mathesis*. Kockelmans (1985, p.142) says "Heidegger explains that the word 'mathematics' is derived from the Greek word *ta mathēmata*", as per chapter 4, and then he continues:

> Originally this expression meant that which can be taught and learned. Thus the word "*mathesis*" originally meant the act of teaching and learning, as well as that which is taught and can be learned. (Kockelmans, 1985, p.142)

That which physics teachers may teach, and that which physics students may learn, is physics in the first and third phenomenological aspects. The second aspect involves disclosure and an engagement with the Real, and is an occurrence, not course content.

Each phenomenological aspect may be related to Heidegger's steps that involve the categorial intuition. It is the second aspect that is crucial for it is this aspect that makes modern physics distinct from other disciplines. Other disciplines have preparations and recording, only modern physics has forced engagements with aspects the Real by way of perception. It is because of this second aspect, that which involves perception, that the conclusion may be drawn that modern physics is no more than an example of ordinary everydayness, because every concrete perception involves the ordinary and the everyday (Compare, Heidegger, 1985, p.48). Every intuition itself is already categorial, and the beings of disclosure in modern physics are not an exception. Of course the first and second phenomenological aspects of physics are in a sense unique, and we recognise them in teaching and learning the discipline of physics.

In retrospect, chapter 5, "Newton dwells with truth", presents four different enquiries into the nature of modern physics. The chapter depends on our being able to abide with the very beings that engage Newton. It is Husserl's phenomenological method which enables us to contemplate the phenomenon Newton-physics, and from

Newton's work and his circumstances to intuit physics. If this is unachievable in an existential analytic, further work will need to be undertaken to indicate how physics perpetuates itself in conjunction with Dasein that have finite lives. Modern physics holds an identity as an ontic discipline and the construction of that discipline is found in the work that Newton undertakes to satisfy the requirements of his university and his own publication programme. Truth in those processes is that of the traditional concept, correspondence, *adaequatio* in its many formulations that involve sentences, statements or meanings. They are all reducible to linguistic or quasi-linguist structures. In the act of scientific discovery, through the practice of experimental science, there is the truth of disclosure. This is a rendition of *alētheia* which is beyond the rendition of *alētheia* that is characteristic of all beings. Beings as the entities that dwell with the Dasein – be they ready-to-hand beings or present-at-hand beings – all entail disclosure. But, in modern science there is a further incidence of disclosure which involves discrete, disjointed aspects of the Real, forced into presence as the result of the deliberate manipulation of circumstances. It is human perception which encounters the disclosure, and thus it is something that cannot be adequately accessed from another Dasein or through text. Scientific discovery which remains available for demonstration to all Dasein – an instance of truth – holds all the hallmarks of *alētheia*. It is akin to a gestalt moment, always with an unexpected aspect because it entails something that is "beyond" the Dasein, the Real, and always it entails something more familiar to the Dasein, indeed so familiar that until Heidegger it never became a topic. From the complex fore-structures involved in the establishment of the circumstances, the disclosure though perception, and the recording of the physics, the chapter attends particularly to categorial intuition. This, the chapter asserts, is that which precedes the categories of the KNS schema. Categorial intuition, something inherently *a priori* for all Dasein, is that which allows the Dasein to abide with categories. It is found to be characteristic of life which involves choices. It is not just Dasein which depends for its way of being upon choice, and thus upon schema.

Chapter 6: Students dwell with truth

The overall purpose of this chapter is to gain insight into physics education. It is the involvement of truth that provides access to insights that relate to both classroom teaching and the nature of physics in classrooms. The investigations in this chapter are an initial survey of what this form of enquiry might reveal. Physics lurks unnoticed at school, both as an ontic discipline and ontologically – this chapter explores the concealment of physics. The first enquiry, "At the school gate", is into truth and the meaning that students find in their experience of secondary schooling. This shows *Befindlichkeit* as disposition and dwelling, and facilitates a move in chapter 7 to relate schooling to modernity. Then follows "In the classroom", which is into truth and the nature of a physics teacher's professional engagement with students. It is an ontological peep into a classroom to identify the beings and the forms of truth there. The third section, "The metre rule" investigates objects, the continuity of beings, the referential totality, and *Rede*. "School physics" has as its focus the students' engagement with physics and uses the example of a laboratory practical which is based upon Newton's optics. The demonstration involves prisms and colours. This facilitates discussions about the presence of truth in beings and about how truth endures. The final section, "Teachers and students", shows further the ontological nature of classroom interactions between students, classes of students, and the teacher. It relates learning theory to the ontology of the classroom.

These investigations re-construct and re-interpret the investigator's experience as a physics teacher at Hillary College, an innovative multicultural secondary school in Auckland which has approximately 55 teachers and 1,200 students, of whom 65 percent are Polynesian (Gadd, 1976; Johnson, 1973a; Johnson, 1973b; Johnson, 1973c; Murphy, 1976). The investigations begin with actual occurrences and the task is to show what these occurrences reveal of their inherent ontology – to see them afresh. The opening description is always an ontic description: the task is to look afresh – with truth – into "inaccurate descriptions of the everyday world" (Heidegger, 1999b, p.67). It sometimes becomes necessary to go beyond the phenomena and to construct scenarios that render the ontological situation concretely. This is acceptable because this chapter's purpose is to introduce a method of enquiry, and not to report on persons at Hillary College. Heelan's

entreaty, as presented earlier, for the perspicacity of such enquiries is held by this chapter as its ideal:

> In the hermeneutic tradition, philosophy is – has to be – a very personal endeavour, and its power to persuade is more like a historical narrative than an explanatory argument; it is dependent on the resonant strength of the author's voice in speaking from a coherent grasp of historical, philosophical, and scientific traditions to achieve an elucidation of human experience from some perspective. (Heelan, 2001, p.404)

Thus, the chapter is a first-order existential analytic as discussed in chapter 4, and no claim is made that it provides "evidence", but rather that it contributes to a new form of understanding that others may develop.

At the school gate (ontological transitions)

The school bell rings at 8.30 a.m. every school morning. The red Electronic Solenoid Bell produces a continuous ring for five seconds, and this is of approximately 95 decibels at a distance of one meter. The frequency range of the sound is between 2,000 and 12,000 Hertz. An electronic programme controls the bell that rings at specific times during the school day and not on public holidays. Being electronic, it is the role of the physic teacher to programme the bell at the start of the year. There are seven bells located high on the seven major buildings that comprise the school and they always ring together.

Lauren, in her third year of secondary schooling, has heard this bell ring at 8.30 a.m. over 400 times and in total over 3,000 times. The sound of the bell for Dasein-student is a ready-to-hand being, involved in comportment without its involvement being an issue for the Dasein. It is ontologically that which is "farthest" (Heidegger, 1962a, p.36), a signal not a bell, although "signal" is still too ontic. Equiprimordially, the bell rings with the Dasein even when there is no sound. The ready-to-hand being abides with the Dasein even on the day when the electricity fails and Lauren still arrives at school at 8.30 a.m., and 1,200 students proceed through the day as if the bell sounds. There is an expression of *Rede* which abides with Lauren in a complex that involves the 3,000 rings and repeated past comportment: *Rede* facilitates an instruction something like "move on Lauren" that primarily is an ontological marker/reminder of an ontological understanding, which (when disposition is in accord) shows itself as comportment. The ready-to-hand being (bell,

3,000 rings, sound, instruction, comportment, ontological understanding, *Befindlichkeit*, *Rede*), is involved as a being in signification for Dasein-student. There are many for-the-sake-of-which cascades that will involve this being, and which need not be entirely the same on every school day. Further, this being is resilient for it survives when a part of its totality is removed, as was shown the day the electricity failed.

Even in brief outline, the existential analytic displays a complexity greater than that in a popular form of analysis which is in use in schools. The school psychologist, trained in the ontic discipline that produced for Pavlov a Nobel Prize in 1904 (Todes, 2000), limits the phenomenon to the 8.30 a.m. bell (stimulus), Lauren's behaviour as the psychologist sees it (response), and the joy Lauren finds at school (reward). The psychologist's focus is behaviour, disruption and strategies of intervention, as given for example in Wearmouth, Glynn, and Berryman (2005). This is not to assert that the method of the behavioural psychologist is superior or inferior to that of an existential analytic – for the former has developed as a practical technology and the latter merely seeks a form of explication.

The present existential analytic (chapter 6) presents something not present at all in the existential analytic that involves physics and Newton (chapter 5). This relates to the question of how to interpret crowd phenomena in an existential analytic. The phenomenon of the bell and its effect on many people, is relevant to Carman's assertion that the word "Dasein" refers "either to particular human individuals or to the species" (Carman, 2003, p.39). The phenomenon of the bell is apparent in the comportment of individuals and a community group, but species never comport as an involvement in a referential totality. Institutions such as schools are of human dimensions – they involve the comportment of families, friendship groups, classes of students, and communities. Each such unit may constitute sense in some way "visible" as a being. Carman's assertion imports into a discussion of ontology, a category established in an ontic discipline (species in zoology), and whilst ontic disciplines may suggest directions of thought in ontology, they must not be taken to have relevance in themselves and to be in any way directly applicable in ontology. Mass-transit, immigration, and the internet may provide examples for the further analysis of the referential totalities of humanness.

The observations of Lauren and the bell, relate to the KNS schema. It is the ontological understanding of the "bell" being, now observed by her teachers as the

habit of punctuality, which carries Lauren through her school day. The understanding of "when" and "where" inherent in her comportment is known in an existential analytic through the KNS schema to involve primarily IB *Welthaftes Etwas*, the basic movement of particular spheres, in the example of Lauren and the bell it is the lifeworld of ordinary everydayness. The decibels and the frequency range – the language of physics – which are examples of II B *Objektartiges Etwas* in the KNS schema, the object-type of something, has no involvement with Lauren. They may abide with Dasein-teacher who finds them meaningful in association with a physics degree and a textbook (and thereby establishes a relationship between IIA and IIB), and they are meaningful as they are intended in the manufacture's pamphlet on the bell to indicate that a "loud noise" is expected. It is in his role as the programmer of the bell that these beings appear. The precision of the frequency range (as opposed to the range itself) also holds meaning in the lifeworld for the physics teacher, who assumes those who write pamphlets about bells select appropriate units and appropriate measures. For example, the frequency is in hertz and does not entail an accuracy that requires fractions of a unit, say 12,000.00072Hz. That these things are not thought by Dasein-teacher at Hillary College when involved with the bell indicates IB and not IIB. Dasein-teacher abides with ready-to-hand begins in the actions to maintain the bell, and holds the potential to involve present-at-hand beings.

What enables the relationships between the categories in Heidegger's KNS schema? An approach may be made to questions of this kind by considering phenomena. For Dasein-student-Lauren the ready-to-hand being involving the bell is a complex of sense-relationships as indicated, and not even a grouping of "objects". All truth about this bell-being is within an ontological understanding of time-marking and the concomitant comportment as moving-ahead in this marked time. This assertion is the sense of the phenomenon as it appears in the existential analytic, which is to say to the phenomenologist. The whole matter under consideration is about bells at times and Lauren observed to move and establish involvements in accordance with the bells. There are many things that could alter in the being under discussion, but time-marking is not one of them. For example, a siren could replace the red bell and the Dasein's equiprimordial abidance would be essentially unaltered. Lauren might say "I do not like the new siren" and never further attend to the matter. Ontologically, it is here that IA in the schema becomes an issue because it is the

category of genesis, which in this case is found to cohere with time-marking as ontological understanding.

The form of truth that involves the bell-being is *adaequatio*, correspondence. The indicators of this are the 3,000 bells, the absorption of the situation into ordinary everydayness, the consistency of Lauren's comportment at 8.30 a.m., and the involvement of the ready-to-hand being as discussed. The truth inherent in the Dasein-student-time marker-comportment-equiprimordial-complex being (ontically Lauren) is related to the (ontically cast) placement of the seven bells and their electric supply, and it is related to time which abides with Dasein, and to signification. The Dasein's for-the-sake-of-which-cascades must always entail the ontological complex Dasein-student-time marker-comportment. At one time, this being must have held involvement with for-the-sake-of-which cascades that involved Lauren's optically and ontologically seeing the bell (unless Lauren does not have an account of the origin of the sound, which is improbable). This ontological-optical seeing, apperception (in ontic theory the closest equivalent is "perception") involves truth as correspondence or disclosure. As said "perceiving is essentially having-something-itself" and the experience is inductive (Husserl, 1999, p.355). Perhaps correspondence abides with the bell-being as it endures; this is the likely form of truth in anything that is day-by-day. But correspondence is not the only possibility, and an existential analytic may explore situations when the bell involves *alētheia*, disclosure. Consider this scenario. Ask Lauren about her first day at Hillary College and she will recount her story: she waited for the event, the school seemed large and sprawling after her 200-student primary school, there were many new faces, she did not know where to go, everyone was excited, new uniforms, strange teachers, her mother gave her a small present to mark the occasion, and she arrived early. Then the bell rang. Conversation stopped. Many students, including Lauren, looked up at the red bell clanging away high on the building. The noise was excessive and it dominated everything for a short time. Later at social functions with alcohol Lauren will say "that (expletive) bell". In the moment of the first bell the truth involved was a truth of disclosure, *alētheia*. It was an ingredient in a complex of disclosure which for Dasein-student-Lauren resulted in *Rede* but not necessarily in any comportment visible to Dasein-teacher. In her own way, Dasein student has a marker of that bell at that time – the experience is nominated. *Rede*, in accordance with *alētheia* as an involvement of ontological understanding, produces an identifiable abidance –

Lauren's "expletive bell", which phenomenologists' appreciate, is much more than *Rede* producing a word-thing. Dasein-student is the bell-being which speaks to her, instructs her, tells her where she is, initiates comportment, and involves itself in her for-the-sake-of-which cascades. In short, Lauren (ontic) and the bell (ontic) dwell as a being (ontological).

The discussion involving the bell can extend to consider the relationship between the existential analytic and Heidegger's account of metaphysics. To achieve this in chapter 7, the groundwork must be laid. This section now considers further ontological disposition by contrasting two students and relating this to the wider meaning inherent in schooling. Ontologically, the unexpected bell-complex of Lauren's first experience marks the forced, violent imposition of the new school upon Dasein-student. It is indicative and constitutive of a transition from everydayness at home to the referential totality of the school environment. At first this referential totality is most unlike everydayness, and every time the bell rings it holds the potential to be involved in a complex as a present-at-hand being (Lauren stares at the sound – it involves her). The total situation which en-captures Dasein-student and which involves *alētheia* will mark for Dasein-student the transition from primary school to secondary school. This is the public aspect or exposure of the closest ontological situation – herself and time. Dasein-student abides with "growing up" that entails bells and commitments. As the weeks pass the novelty fades, Dasein settles into the secondary school routine and the bell complex becomes a ready-to-hand being, ontically "background, or ontologically a being characteristic of ordinary everydayness at school.

Lauren, the teacher finds, is punctual – attendance and bells are not an issue for Lauren. Why is this so, when Ben struggles every morning to body thorough the school gate before 8.30 a.m.? Both Dasein encounter the ready-to-hand being that somehow involves the bell. Whenever there are human difficulties, attend first to *Befindlichkeit,* disposition. Ontological understanding and disposition are the pre-given essences of all comportment. In Heidegger's *Being and Time* terminology Dasein encounters them in the backward-looking aspect of equiprimordiality as "throwness" or as his English translator said "finding oneself" (see chapter 3) – Lauren did not ask to be Lauren, any more than Ben asks to be late. Somehow both are "happenings" that Dasein-teacher involves either as ready-to-hand beings (when actively on duty at school) or as present-at-hand beings (when at home thinking

about the management of Ben and the pleasure of teaching Lauren). Ben and lateness may be present-at-hand for the reflective Lauren. For Ben, the problematical behaviour is transparent and only ever involves ready-to-hand beings – ask him why he is always late and he will tell you he does not know, somehow it just happens. Years later, Ben involves present-at-hand beings in the lateness and he at last gains insight into his difficulties. An existential analytic will enquire into the for-the-sake-of-which-cascades, including truth within them, to provide insight into Lauren's punctuality and Ben's lateness. In the absence of pertinent information it is necessary to speculate, to create scenarios. If you ask Lauren and Ben they will initially tell you something similar about their ambitions and their purpose in attending school. They both wish to succeed with careers. To provide an account of Ben's situation that generates (in the school's terminology) "lateness" and the concomitant inconvenience to teachers and penalties for Ben, it is necessary to identify those beings that involve Dasein-Ben. We may speculate that the for-the-sake-of-which-cascades of Dasein-Ben are more complex than those of Dasein-Lauren. On first enquiry they appear similar, however when Ben's relationship with his younger brother becomes integral to Ben the differences between Lauren and Ben are dramatic. It is not that Ben's brother is a paraplegic, but the disclosed truth that pertains. Ben remembers the day when he and his young brother jumped into the river and his brother hit a submerged log, this in spite of their father telling them not to jump into rivers. That moment – the father's appearance, the place, the voice, and the accusation – has become a single disclosure for Ben, along with another disclosure, which involves the vision of his brother in the water. The *alētheia* Dasein-Lauren-bell is profound for Lauren, but it fades more quickly than the *alētheia* entailed in Ben's situation with his brother and his father. The truth of events has its own logic. As an elderly woman, Lauren settles to remember the early days at Hillary College, and dwells fondly on the horror of the bell. Ben never considers his school to this extent. That time in his life enduringly involves his brother.

The school councillor, well versed in Heidegger (let us imagine), produces a *pro forma* upon which to record the beings and the signification of beings in for-the-sake-of-which-cascades. She fills in the forms for Ben in session after session and notices how clearly her questioning always brings Ben to "moments" of truth, *alētheia*. These disclosures remain current. They are not memories that will fade, nor

is it possible to convince Ben of anything at all about them. He was there, it was in his time, the full situation can only be known by himself, and it is he who holds the incontrovertible truth. The guidance councillor recommends more counselling and Ben feels the benefits of regular retreats, but nothing obliterates or reconfigures *alētheia*. Ben eventually constructs for-the-sake-of-which-cascades to honour his brother, and it is those which lead him to medical school where he is never late. Abiding with his brother now holds itself out as sometimes present-at-hand with a comportment which involves tears, and sometimes ready-to-hand with a comportment which involves long hours of study. Years later, Ben's teachers read a newspaper article about Ben and muse, "he was an introverted boy, disorganised character, amazing how they mature and gain determination".

Mention has been made of the violent transition inherent in Lauren's first involvement with the bell. It is not just the bell which involves itself with Lauren in the referential totality that is the ontological school environment. Noticeably, Dasein-teacher adopts the same stance towards Lauren as the bell. Experienced teachers advise young teachers "begin tough, you can always ease off, but you cannot go the other way". Highly organised, precise, and demanding, Lauren abides with Dasein-teacher as a ready-to-hand. Individually and collectively she finds teachers impose their will upon students. The bell and the routines of the school, and the constant movement to different classrooms, impact on Lauren to distress and unsettle her, and to ensure conformity. She remembers her primary school teacher, and the settled, safe, known classroom that was hers just before the school holidays: there she abided in ordinary everydayness, a different example of *Befindlichkeit* as dwelling. The bell is the ontic reality and the extant symbol of the routine of the secondary school. According to officials, it is the mechanism required to organise 1,200 students with limited resources. These bells adorn secondary schools throughout the country, and all the schools were built to one of two functional and economic designs, known as Nelson Blocks or the S68 design. The buildings produce uniformity and suggest that schools are mass institutions for the masses. The form of truth such situations suggest by large numbers of students and the involvement of government is predominantly the truth of correspondence. Schools need rules and order. In the next section, which concerns the marking of the attendance register in a classroom, a routine of schooling emerges.

Years later, Dasein-teacher receives a copy of his own school's celebratory historical publication and finds in it a monochrome picture of the school bell. At a Traditional Grammar School, the bell that the school prefects ring by hand is a large iron object that hangs in the quadrangle formed by buildings constructed uniquely over 150 years ago. Two strikes only are ever heard. Ostensively, this school bell serves the same function as the Electric Solenoid Bell, which renders it also as a ready-to-hand being abiding with Dasein-student. Why is the bell worthy of a photograph and why is the bell remembered with fondness by generations of students? The first day for Dasein-teacher was similar to Lauren's first day; however, there was an important difference in the referential totality and that which is available to incorporate in for-the-sake-of-which-cascades. Truth constructs in Dasein-teacher's ontological situation, those beings which incorporate into signification, for-the-sake-of-which cascades, for Dasein-teacher contrast with those for Dasein-student at Hillary College. The traditional boy's grammar school, as seen in the symbol of its bell, holds and advances its own history that entails an identity established though historical involvements. There is an apparent uniqueness that derives from an historical tradition and the *mana* (reputation, standing, orientation within the wider community, spiritual quality) of the school. In Dasein-teacher's early situation the scope for beings involved in for-the-sake-of-which-cascades is apparently greater, certainly different, to that for Dasein-student at Hillary College. The school, although with its modern purpose in accordance with that of Hillary College, holds itself in a different frame which apparently relates to tradition but which ontologically is present for incorporation in for-the-sake-of-which cascades. Ontologically, the referential totality contrasts in the two schools and this has implications. Chapter 7 considers an important implication of this when it relates the existential analytic of the present section to Heidegger's metaphysics.

In the classroom (the beings of teaching)

What is the nature of the professional relationship that holds between students, teachers and the school administration? This question enquires into the ontological situation and thus requires an existential analytic of the Dasein. The phenomenon whereby the teacher marks the attendance register is available for an existential analytic. The report here directs attention to the involvement of truth in the situation and the nature of the referential totality. The effect of this is to bring forward the

nature of the engagement between teachers and students and between teachers and school administrators.

Observe the beginning teacher as he starts to "mark" his "roll" of class member at 9.05am. He draws a sloping line to indicate the presence of each student ("/" for morning and "\" for the afternoon). The teacher carries into the situation an event: it is the specific time when in a meeting when the school principal says that the roll is a legal document, and that judges in courtrooms can ask teachers to swear to its accuracy to prove the alibi of students charged with crimes. To sight each student the teacher has to look around for the students do not sit still, they wander around.

There is a transition involved in the marking of the attendance register, Dasein-teacher ceases to be "in the everyday manner" (Heidegger, 1962a, p.167) and adopts a manner of seriousness. Dasein-teacher is with equipment – ready-to-hand-pen, ready-to-hand-book, and ready-to-hand-student. The present-at-hand classroom of the earlier discussion with colleagues is no longer a being abiding with Dasein-teacher. Nor is there a ready-to-hand-classroom present. The referential totality narrows for Dasein-teacher as the work beings. Each being involves itself as a being relevant to the strokes as Dasein-teacher constructs the register. The Dasein does not "mark" the register, the Dasein comports to the situation in total for the moment with each separate student, the pen, the stroke, and the meaning of the stroke constituting an ontological whole, a way-of-being-in-the-world for the now.

The involvements and sense to compile this inventory of students is ontologically similar to the involvements and sense to compile the list of chairs and desks at the end of the school year. The inventory of furniture is an annual requirement. We see Dasein-teacher as "he counts" ready-to-hand beings. Dasein-teacher records the correct thing as its own something. "That which is *explicitly* understood – has the structure of *something as something"* (Heidegger, 1962a, p.189). In the examples under discussion, the "as" is a hermeneutic "as", which is to say it is not an apophantic "as". Ontologically, the character of the furniture and the character of the students hold much in common: they are countable entities available for involvement as counted – in the terminology of chapter 4, a *positum*. Now there is a further interpretation of the earlier considered quotation:

> What is "scientifically" knowable is in each case *given in advance* by a "truth" which is never graspable by science, a truth about the recognised

> region of beings. Beings *as a region* lie in advance for science, they constitute a *positum*, and every science is in itself a "*positive" science* (including mathematics). (Heidegger, 1999a, p.101)

In an ontic theory, the inventories are an exercise in administration which is a part of the teacher's professional role, a paid activity. Ontologically, that which is "administratively" knowable is *given in advance* by a "truth" which is never graspable by administration, a truth about the recognised region of beings. The truth of each student and each chair is the truth of disclosure, *alētheia*. It is like the truth in chapter 5, the truth of discovery when Newton stumbles upon beings. That Newton searches as the teacher searches for students and chairs, only serves to further underscore the referential totality, the fore-knowing within the fore-structure (to involve the KNS schema as well as the fore-knowing of the *positum* of the moment), and that these engagements are engagements that contrast with those of ordinary everydayness. It is apparent that ontologically, Newton functions as a scientist as the teacher functions as an administrator. Heidegger's model of region and *positum* serves in these examples. Some may interpret such conclusions from phenomenology to be support for Heidegger's concept of *das Gestell* (Enframing) as is elaborated in chapter 1.

The experienced teacher marks the student register evidently without thought, without hesitation, or tribulation. She just does it, soporific as she recovers from the social event of the previous evening. George makes her the victim of small-town intimacy when he says, "Me brother saw you at the pub, Miss". Dasein-teacher turns the friendly overture of Dasein-student (a ready-to-hand being) to her use. "George, find Moana and bring her here" is the teacher's response. George-teacher-register-absentMoana-pen-stroke-accuracy-progress equiprimordially constitute a ready-to-hand being. Dasein-teacher does not hold the insight that she is this integrated complexity, for that is the judgement available only to Heideggerians outside of the classroom referential totality. Somehow, the register compiles itself – although it took the teacher three years to acquire her skill with registers and students like George. Later that year the school inspector hears comments that this teacher does not have much of a personal relationship with her students, apparently she does not genuinely care about them, and she does not see them as people each with their own needs and requirements. She is efficient, apparently like a machine. Inspectors who look ontically discover ontically.

The experienced and the inexperienced teacher are "with" ready-to-hand beings as they compile the attendance register. However, the character of their involvement with these beings, as we find it in the comportment, may be distinctly different. The difference is the work of significance, a concept introduced in chapter 3.

> In terms of the significance which is disclosed in understanding the world, concernful Being-alongside the ready-to-hand gives itself to understand whatever involvement that which is encountered can have. (Heidegger, 1962a, p.189)

"Concernful" here holds no relationship to the school inspector's interest in the teachers concern for her students. To set out signification in the examples that contrast, it is necessary to provide speculative for-the-sake-of-which cascades. Such cascades are inventions here, although an investigator can probably construct those that pertain by asking teachers about their processes and purposes, and anyone can construct them by introspection.

The experienced teacher might *later* report that she placed the mark on the paper for George because he was present. She wants an accurate record of George's attendance because attendance is a welcome achievement for George who is frequently absent. Why is she concerned about George? It is for-the-sake-of his advancement and well-being, and this in turn is why she selected teaching as her profession, to improve young lives. The trusted investigator constructs further for-the-sake-of-which-cascades that relate to her professionalism and reliability as a teacher, and they often appear ultimately to entail her bid for promotion (yet another "about-which").

In a phenomenological enquiry of this kind, the phenomenologist records an ontic re-construction (with the apophantic "as"). Never can the actual cascades with their associated disposition, *Befindlichkeit,* be confidently recorded, for it is the *Befindlichkeit* of now that grasps to involve and the rapport the investigator establishes with Dasein-teacher will be a leading influence in current *Befindlichkeit*. If the teacher worries about promotion and the phenomenologist is the school inspector, the for-the-sake-of-which-cascades will be ontic constructs designed to advance the teacher. Heidegger understood this:

> The way we take this ontical sense of 'letting be' is, in principle, ontological. And therewith we Interpret the meaning of previously

> freeing what is proximally ready-to-hand within-the-world. (Heidegger, 1962a, p.117)

On page 117 of *Being and Time*, Heidegger describes phenomenologically the relationship between the ontological and the ontic, which is in terms of the theory of Dasein (most given as the KNS schema) is the relationship between IB *Welthaftes Etwas* and both IIA and IIB. Manifest in the phenomenology is IIB, the theoretical, object-type something, and the form of truth is that of correspondence, *adaequatio*. In contrast to the experienced teacher seeking promotion, the inexperienced teacher reports that he is concerned with "survival". The completion of the attendance register is a confrontation with students and a threat to his mental health. The mark against the student's name is for-the-sake-of-the-completion-of-the-record, this is for-the-sake-of-placing-the-attendance-register-in-the-pigeonhole for that official document, this is for-the-sake-of its being adequate when inspected by the deputy-principal, this is to ensure Dasein-teacher is not admonished by the deputy-principal, this is to minimize the problems of the day, this is to enable the inexperienced teacher to "survive" his day. If he can somehow survive this year, he will have enough money to travel overseas. Each student's presence is recorded with a "/" as a *preparing* for Dasein-teacher to work in a London pub, which is another example of Heidegger's "about-which" apparent as Dasein-teacher bodies into its future. "All preparing, putting to rights, repairing, improving, rounding-out, are accomplished in the following way: we take apart in its 'in-order-to' that which is circumspectively ready-to-hand … (Heidegger, 1962a, p.189).

There is a topic indicated above that was of particular concern in chapter 5, where it appeared in deliberations about Newton and mathematics. Dasein teacher counts students and chairs, and this encourages us to enquire into the beings involved. The phenomenon reveals a related group of ready-to-hand beings. The "numbers", perhaps better considered as "place markers" indicate a limited number of places derived from the life-world. They are 1,2,3,4 ...1,000,000. No they are not! Somewhere before a million the places available for students and chairs extinguishes. There is, perhaps perversely, provision for negative places. Two students are absent or two chairs are missing Dasein-teacher records for the school office administrators "-2". The note to the office has as its reference positive places for students and chairs, and not absence, nor does it refer to a number. The positive references available come from the life-world, the beings engaged in the referential

totality. These beings are the relationship establishing beings of Dasein-teacher. When she teaches mathematics, the beings are derived from another place and imported into the life-world as present-at-hand beings. An example is "infinity" which occurs only though an operation in mathematics. As Heelan memorably says, infinity has nothing to do with us, and we have nothing to do with infinity (Babich, 2009). Nonetheless, teachers have plenty of involvements with students and chairs, as the kind of *positums* that enable counts.

The metre ruler (objects)

The ontic school physics laboratory contains discrete objects and this section explores what may be said in an existential analytic that starts with an ontic object, a ruler. The section explores the ontological expression of continuity by beings, probes the notion of a referential totality, and finally provides an opportunity to focus on *Rede*.

Objects hold many associations. The ruler that sits on the teacher's laboratory bench is one of a set of metre rulers that government officials provide to schools as a part of their initial complement of equipment. As Hillary College was built over a decade ago, the ruler shows wear commensurate with that time. The ruler indicates that this room is a science laboratory, because is a part of the equipment supplied to science laboratories and elsewhere. This ruler, being a metre long and marked in accordance with the metric system of measurement, indicates its association with a particular ontic theory of measurement used in physics. Students will attend to this ruler in lessons about International System of Units and they will hear the name of Lavoisier in association with the ruler. The physics teacher exercises a responsibility for the ruler as a part of the equipment which belongs to this laboratory, and the responsibility is discharged in accordance with a further ontic regimen which defines the management of school equipment. This ruler is the one that flew through the air in a failed physics demonstration and students who jeered remember this ruler. At this moment the ruler is in use as a paperweight, and thus it is not involved in the discipline of physics *qua* ruler. It weighs upon three heaps of printed papers that the teacher will distribute to students in three different classes. Now the ruler is involved in practical teaching and associates with lesson plans and decisions about the presentation of courses.

An existential analytic may begin with a search for sense that involves Dasein. The examples above show sense in many entanglements of a ruler and these entanglements we can recognise as being within ontic regions such as the discipline of physics (Standard International units), ordinary everydayness (the joy of failed experiments), and practical pedagogy (the paperweight). Chapter 4 indicates that in an existential analytic, ontic objects such as rulers are not to be contrasted with ontological entities such as referential totalities. Rather, the ontological is to be brought forward leaving the ontic abidance of the ruler intact. Heidegger was able to access the ontological foundation of ontic objects because all that is ontic is grounded in the ontological.

The observation that government officials provide kits that contain objects such as rulers opens the way to an existential analytic that enquires into the Dasein "government officials". Such an enquiry, if it is to relate to the particular ruler that now sits on the laboratory bench ten years later, will ideally involve the very officials that produced the kits. In the absence of needed enquiries from the earlier decade, it is necessary to speculate. Signification for a Dasein ten years previously must have held integral the ready-to-hand being which ten years later is again involved in a ready-to-hand being integral to another Dasein. In Heidegger's theory of philosophical method, this statement is a "formal indication", a proposition held for the moment to be correct for the purpose of exploratory analysis. With reference to the ruler and the move away from its ontic rendition, it is observed that the ruler is with the official a ready-to-hand being and with Dasein-teacher a ready-to-hand being, yet the character of the ready-to-hand being as indicated in its involvements in for-the-sake-of-which-cascades is different in each situation. What account may we give of the "continuity" between the signification of the official and that a decade later of Dasein-teacher? What generates the continuity achieved for the ruler over the decade? Notice the way that the official is not involved particularly with Dasein-teacher of the current example. The signification of the official may involve teachers, but not this teacher. As the official packs rulers into boxes he holds for-the-sake-of-which-cascades that involve a for-which such as "teachers" (plural). Likewise, Dasein-teacher cannot know the very individual who packed this ruler and thus for-the-sake-of-which-cascades for Dasein teacher cannot incorporate this very official. The continuity found in the perpetuation of the ruler over the decade is not a specific continuity that abides with either Dasein-official or Dasein-teacher. The continuity

that is here spoken of generates with, and is elaborated by, the Dasein that would now write about rulers. The problem of the ontic ruler, which shows the ontic ruler itself, is ontological with the investigator Dasein. The problem of accounting for the ruler over the period of ten-years is not within the experience of the official involved with ready-to-hand boxes and rulers nor is it with Dasein-teacher who is fully occupied coping with a class that involves much equipment including the rule. For the official and the teacher, there is no specific account of the future (official example) or the past (teacher example) and every for-the-sake-of-which-cascade which associates with them must involve beings that in themselves incorporate such restrictions about time in place. Another way to cast the argument in this paragraph is to notice that the description uses the word "is" in two distinct ways. When the ruler becomes in the discussion, objectified in an ontic domain, the apophantic "is" pertains. Whilst when the ruler is involved in discussion of the ontological situation, the hermeneutic "is" pertains, and in this the objective ruler ceases to be available to the official or Dasein-teacher.

It is argued that the official manages ready-to-hand beings for-the-sake-of "teachers" or "education". However, these are not the beings with which the present investigation abides – now the "ruler", "teachers", and "education" are cast as present-at-hand beings, the objects of reflection and contemplation in the existential analytic. Can the official achieve the beings of the existential analytic? To achieve something like this the signification of the official must alter. We can speculate that the for-the-sake-of-which-cascades of the practical official moving thousands of rulers to hundreds of schools can the beings are ready-to-hand and transparent. The form of truth that involves these beings is a correspondence form of truth which appears in this example as the truth of regular activity. Only when someone interrupts the official and asks him to explain his job does he begin to construe present-at-hand beings which in this case are present-at-hand teachers and a present-at-hand concept of education.

Do we not want to say that the ruler the official dealt with is the same ruler in use a decade later as a paperweight or the same ruler that is involve in the explanation about the the official's job? An existential analytic explicates the situation to "avoid" a confrontation with this question. It brings forward the official, the teacher, and the Dasein that poses this question. Developing the situation for each separately allows for-the-sake-of-which-cascades to involve beings appropriate

to each separate Dasein's involvement. Is that sufficient to deflect us from naïve realism which has been under discussion since Greek times? Plato's statement, considered in chapter 1, that "knowledge of our world will be knowledge of the reality in our world" implies our world is not the only world and that other people, creatures, Dasein, may flourish in different worlds. Plato apparently admits a separation of the worlds of groups and this holds some accordance with the existential analytic that maintains a distinction between the worlds of officials and physics teachers. What has emphasis in the existential analytic is more than this however; it is "our" world as the separate ontological situations of Dasein-teacher, the official, and the investigator.

Another way to enquire into these issues is to relate the ruler to a referential totality. This enlivens Plato's statement that the essence of knowledge "is about some department of real things". The word "department" is at issue, for it holds three potential interpretations: it may refer to an intellectual discipline or body of ontic knowledge, which apparently is Aristotle's reference; or it may refer to a portion of reality, which is something Plato considers; or it may refer to all that engages the person in their activity of the moment. This third possible reference is to be understood in an existential analytic as a reference to Heidegger's notion of a referential totality. As indicated in chapter 4, the leading feature of a referential totality is that it is "governed" by a "towards-which". The notion of "towards-which" is one of the possible participants in signification, and signification is Dasein's constant task of building for-the-sake-of-which-cascades. If the for-the-sake-of-which-cascade for Dasein-teacher, holds as a being "pedagogy", and that being is towards-which the Dasein ontologically understands itself and to which it possibly comports, then there is a basis for asserting that the Dasein is within a referential totality which may we may label "pedagogy". It is a description and a label which the experience of teaching at Hillary College belies. It does not belie it because the structure of the argument is wrong but because "pedagogy" is not what teachers themselves understand as their world as they teach. Thus, a more credible label is sought for a physic teacher's about-which in a for-the-sake-of-which-cascade during teaching. A candidate might be something that involves the betterment of students. Many teachers at Hillary College would say they are there "for their students", or "to make a difference to the lives of students". This notion, student-betterment, can incorporate into for-the-sake-of-which-cascades and be the very notion that provides

the clue to the referential totality. The ruler is not reserved for experiments as intended when the official packed the PSSC Physics kit, but is available for use in accordance with a situation entailed in a more general understanding – the ruler holds equipmentality that relates to "student-betterment". Each potential assignment within a for-the-sake-of-which-cascade of the ready-to-hand ruler will in some way relate to the "student-betterment" being ("assignment" is a translation of Heidegger's earlier word, Heidegger, 1962a, p.99, and it is found apposite). Now it becomes possible to give an account of why Dasein-teacher does not particularly relate classroom practice to the theory given at teachers' college. There has been a subtle shift in what Dasein teacher is about in the physics laboratory, and that shift is marked by an alteration in referential totality. The enthusiasm engendered by lectures on pedagogy at university was genuine and meaningful; however, the referential totality of the university is not that which Dasein-teacher constructs in the school physics laboratory. Nor does Dasein-teacher have regard to the purpose of the ruler as understood by the official. Again, the referential totality of the practical efficient official is not that of Dasein-teacher. Other examples might relate the statements in curriculum documents to the referential totality of Dasein-teacher transparently coping at work, and thereby provide an account of why curriculum innovation is so difficult to achieve throughout a country.

The discussion invokes the term "student-betterment", which as a hyphenated expression draws attention to nature of the beings involved in for-the-sake-of-which-cascades. A referential totality appears to be ontologically like the beings it involves. In the transparent coping of Dasein-teacher in the physics laboratory teaching (said ontically), we find ready-to-hand beings and the correspondence form of truth, and the referential totality itself has the character of a ready-to-hand being with the correspondence form of truth. The notion of student-betterment because it is non-specific, a "fuzzy" notion that admits of diverse examples, suggests itself as an about-which that could involve itself in a for-the-sake-of-which-cascade which relates to the referential totality of the laboratory-teaching. Such an ontological construct accords with Dasein-teacher being (ontically) a teacher in many laboratories and in all of them pursuing the advancement of whichever students are there.

To relate the ontological "student-betterment" to spoken words requires a move away from this ready-to-hand character, and such a move will show the

presence of truth as correspondence. Dasein-teacher comporting in the referential totality of the laboratory-teaching does not understand the involvements through the use of words or concepts. The ingredients of signification are beings with a different character. The structure of sense entails the ready-to-hand being we associate with "student-betterment" held in the for-the-sake-of-which-cascades by the truth of correspondence. In the referential totality Dasein-teacher will for the most part involve the ruler with the ontological association with student-betterment. This is what Dasein-teacher holds ontologically in a rough equivalence to our ontic concept or word "teaching", or perhaps "physics teaching", even "pedagogy". To facilitate the move to the ontic words and concepts (whatever they may be) Dasein-teacher invokes nomination, *Rede*, in relation to the about-which of student-betterment. There is a private, hidden naming of why-how-where Dasein-teacher teaches. Interrupt Dasein-teacher in the referential totality and you find no ambiguity about the referential totality. A telephone call to the physics laboratory draws a curt "I am teaching", which means "I am involved in something that consumes my entire world and which excludes everything else – it should be obvious to anyone that this is my situation, go away". The integrity of the referential totality (and not the laboratory) is shown as the issue for Dasein teacher when we consider the response to the telephone call. It is a typical example of a "break-down" that involves ready-to-hand beings. When the hammer breaks in Heidegger's example he keeps our attention on the hammer and the carpenter, because he seeks to explain the concept of unready-to-hand and then present-at-hand as a sequence. Yet it is more than the carpenter and the hammer that re-engage (alter their ontological situation) in the breakdown situation – there is a collapse of the whole business of carpentry and the workshop, which indicates ontologically as the referential totality. We can imagine that the carpenter experiences disappointment about the interruption of the work and the peaceful abidance as a participant in the functioning workshop. Recall the curt response of the teacher to the telephone call.

In both examples it should be possible to discern the lead "about-which" of the referential totality. In the laboratory-teaching example it is taken to be the ontological understanding "student-betterment" and in the workshop (according to Heidegger) it relates to being a craftsperson in a small community. The totality, including its attractiveness, suggests Heidegger's word "dwelling", and we find Dasein-teacher dwells in the referential totality construed in a structure that relates

student-betterment with laboratory and with teaching. Dwelling is always an expression of *Befindlichkeit* in accordance with the tripartite ontological model of the Dasein. We observe the teacher is disposed towards the laboratory and teaching in a consuming, ethereal way. In this is found an account to why teachers appear clannish and as a group stand themselves apart from others.

How does *Rede* become involved in this example? Expletives often provide good examples of *Rede* at work. The word the teacher says under his breath when the telephone rings in the middle of the lesson, and that which the carpenter says when the hammer breaks, are not the same word. But they both refer to a referential totality which is interrupted. The same words might appear if the breakdown came from another source. People tend to use the same expletive for a wide range of broken objects – this indicates that ontologically the expletive largely and in the main associates with the referential totality. The word the carpenter uses in his workshop is not the word he uses in ordinary everydayness with his protestant wife. The expletive is only the observed comportment of the ontological situation and that which produces it is *Rede* and also equally the ontological understanding as mediated by *Befindlichkeit*. This situation is indicated in the diversity of expletives in accordance with referential totality. *Rede* is aligned by ontological understanding and moulded by *Befindlichkeit*, and it achieves its backwards and its forwards (a reference to the "care structure") through the involvement of truth as correspondence.

Rede is involved in all ontological understanding. The example above relates to the lead ingredient of a referential totality, which is perhaps more dramatic than other examples. Consider this case. The field phenomenologist records the comportment of the elderly education official who steadily writes into a list "20x metre rulers per kit". The phenomenologist diligently investigates the signification of the official and finds that the PSSC kit is to include rulers "for-the-sake-of physics teachers" and "for-the-sake-of student learning". As a grandfather who fought in a world war, the official understands his work as a contribution to a national endeavour. Such people are found in the government service. Now, the manager of the division visits the official's work place and there are rumours of redundancies. What is your job he asks the clerical worker, who replies that he packs and clears 5,000 code 3 items a day. Later that evening the official laments to his wife, "I could not explain why my job is so important". In this assessment to his wife, he refers to

the ontological situation, that which is nearest: the for-the-sake-of-which-cascade that is well understood by the official and also transparent to him as he works. He finds the beings nominated in that cascade are not nominated in words that he can say. "Well" says the wife, "you love our granddaughter and your packages are for children like her". "I would sound daft if I said that", he retorts. The official invokes unfamiliar beings, when the manager obliges him to respond in accordance with a disquieting referential totality, that where the beings in the for-the-sake-of-which-cascades must relate to statistics, outputs, and efficiency. The beings of the manager present with (in) for-the-sake-of-which-cascades which involve beings that judge the process the manager introduces and management itself. The threat to the official's job presents with (in) the cascade as "unemployed", "despondency", "my obligation to my wife". The disposition with (in) the cascade equates with the ontic word "fear". Dwelling is not a positive experience. When in the routine of his week he does his job, he sorts, he counts and he packs, and the beings involved are transparent, and in for-the-sake-of-which-cascades that construct a sense, an ontological understanding, and dwelling is positive – from beyond reason he understands that life itself is good.

School physics (demonstrations)

In 1960, the Physical Science Study Committee produced the first edition of their textbook *PSSC Physics*. This text and those that followed, along with the kits of equipment for practical laboratory demonstrations and student experiments, influenced the way physics was taught in Western countries. Many physics textbooks display the physics pedagogy that *PSSC Physics* displays. Their convictions are exemplified in the *Elements of Physics* by Robert A. Millikan and Henry G. Gale, an influential publication which appeared in 1927, well in advance of *PSSC Physics*. About the emergent pedagogy of physics teaching in that text, commentators say:

> [The authors'] chief aim from the beginning has been to 'present elementary physics in such a way as to stimulate the pupil to do some thinking on his [sic] own account about the hows and whys of the physical world in which he lives.' Hence as to subject matter they have included in this book only such subjects as touch closely the everyday life of the average pupil. In a word, they have endeavoured to make it

> represent the everyday physics which the average person needs to help him adjust to his surroundings and to interpret his own experiences correctly. (Fraser & Tobin, 1998, p.268)

The various concepts of truth that develop in chapters 2, 3 and 4 enable insight into this statement. Elementary physics, understood as introductory physics, should relate to the reality of the student's life-world. The difficulties inherent in this have been alluded to earlier, and it is sufficient to reiterate that such a view contrasts with Heidegger's account of modern physics as the forced revelation of an aspect of the Real. This aspect of the Real is not something students will encounter in everyday life. Perhaps the approach to physics indicated here will motivate students and provide them with a vocabulary that they can use when they begin the discipline of modern physics. The account of truth in the quotation is entirely the correspondence account, for physics is to *relate to* the pupils' surroundings. There is a subtle reference to truth as disclosure, for assumptions are made about the grounding or reality of the "experiences" which the student will "interpret". Physics is to be relevant to the (one and only) *correct* interpretation of experiences. The experience themselves may involve *alētheia*, however what follows does not explore in that direction.

At Hillary College, it is found that Physical Science Study Committee physics requires a competency in mathematics that is beyond many senior students. This section reports on the experiences of a teacher using twelve PSSC light-box with 32 students of about 14-years-of-age, which in the New Zealand system of education makes them Year 10. The procedures the teacher adopts are those determined by the teacher and not those specified in a textbook. One kit of physics equipment at Hillary College includes a "light box" which enables almost parallel beams of light to be shone through lenses and prisms. The prism is about three centimetres on a face.

Sometime shortly after 7.00 a.m. Dasein-teacher takes a light-box from the heap of boxes and attaches a 13.8 volt DC power supply. The light shines and two black slit-plates inserted into the slots in the box make the beam appear parallel. Dasein manipulates a prism and a faint spectrum of colours appears. Dasein shuts the curtains. What happens subsequently is not recalled. That it is possible years later to recall the moment the teacher first saw the spectrum suggests disclosure, *alētheia*. Anything that abides with the Dasein as a clear memory is more likely to involve *alētheia* then *adaequatio*. The truths of correspondence, in contrast, appear pale and

fade if not re-established. The truth of disclosure with the spectrum is not a truth of ancient, medieval, modern, or school physics. It is a truth generated by a test that concerns pedagogy. Specifically, the ready-to-hand being, the spectrum, or perhaps the wider circumstance, holds as *alētheia* because it declares "the equipment works" and the ontological disposition of the Dasein adjusts as Dasein understands the implications of this truth. The implication is that preparations are complete for the students who will enter the laboratory at the 8.30 a.m. bell and expect a class to begin with the 9.00 a.m. bell. Ontological understanding influences ontological disposition and Dasein routinely seeks to improve disposition by altering understanding. This is not undertaken by the Dasein in a conscious, rational manner, although psychologists might recommend that strategy without reference to its ontological foundation. "Prepare thoroughly for the lesson", they say, "and you will relax and the students will relax". Dasein understands the strategy in a foundational way: it is *Befindlichkeit* made apparent in comportment.

Inspectors of schools, working to criteria, record that the physics teacher is nervous when he confronts classes of students. Although there does not appear to be a word for the completion of a teacher's preparations involving light-boxes, ontological nomination, *Rede*, pertains, which is a common happening with *alētheia*. The ontological ingredients of a word are present. Imagine that the now elderly physics teacher repeatedly recites the story of the first light-box to his family. As he begins the story yet again his daughter bemoans "not the light-box story again", and it is apparent that another Dasein has begun to attach a word-being to that which began and remains for Dasein-teacher an involvement with a being of *alētheia*. The box-story for the daughter entangles itself in the truth of correspondence, and is thus never as profound, grounded, enduring, incontrovertible, or vivid as it is for Dasein-teacher. It is *alētheia* that resonates with the Dasein and produces the re-telling: there is no story told about any other day long ago. For Dasein teacher the focus is not the story but where *alētheia* constitutes its ready-to-hand being, the spectrum on that particular day when the beginning teacher faced a difficult class. *Rede* holds the particular moment of *alētheia*, which means that an ontological constituent of that moment is a marker that provides the Dasein with a way to access that precise construct of truth. Subsequently, the geriatric immobilised teacher tells his story again, not to the family but to himself whilst dozing late at night, and brings the marker into words – it was "the most beautiful spectrum I ever saw" – words which

are beyond those that the daughter could provide. The beauty is not that of aesthetics, which the attentive daughter may conclude if she heard him mumble, but the "beauty" of a young teacher standing ready to simultaneously confront a class of students and the discipline of physics, the beauty of involvements and disclosure. As Heidegger tells his students, with a concrete example which is the plaything worn out and almost unrecognisable, "it is my youth" (Heidegger, 1999b, p.70) .

As mentioned, Dasein-teacher recalls the moment when the spectrum showed itself for the first time that day in the school laboratory, without being able to remember the subsequent events when the students arrived. Nor can he tell you the date, or what he had for breakfast, or even who was teaching in adjacent rooms, these involve ready-to-hand beings with the correspondence theory of truth, and such involvements do not endure as *alētheia* endures. This situation provides a clue about the nature of *alētheia*. Because it is the profound form of truth in its genesis, *alētheia* endures through *Rede*, and because it endures, *alētheia* punctuates Dasein's existence. It accentuates aspects of the temporal trajectory of being-in-the-world. This is one way that Dasein abides with truth. More precisely, for the Dasein all abidance as dwelling is equiprimordial – which means all the "accumulated" *alētheia* of the lifetime abides now with the Dasein. Abidance with *alētheia* enables, perhaps not exclusively, the Dasein to understand its "personal" history of existence.

Truth alters as Dasein's abidance with, or involvement in, beings, adjusts. Precisely, Dasein continually alters signification and the incorporated beings of signification alter taking their truth aspect with them. This alternation for *alētheia* is a transition to involvements as correspondence. In effect, correspondence erodes disclosure. The temporal punctuation of *alētheia* is the remnant of *alētheia* as correspondence asserts itself in what was once more markedly in each precise case *alētheia*. As enlightening (showing of incorporated meaningful sense) as that spectrum was on that day, the story about it as told to the family alters over a period of years, and the daughter says the teacher forgets. With effort Dasein-teacher may be able to generate again the being of the spectrum with *alētheia*, the elderly dwell with the past when they are not enmeshed in for-the-sake-of-which-cascades that involve ready-to-hand beings. This "very being" that calls for attention however, that which carries *alētheia*, it is apparently now a present-at-hand spectrum being. In contrast, it was found in the classroom years ago to be a ready-to-hand spectrum being. How, or if, it alters in this way, is a topic that deserves investigation.

Heidegger writes in a lecture draft never delivered "The *definitiveness* of this signifying , which is what initially needs to be explicated, lies in the characteristic of the *disclosedness* of that which is for a while significant to us at the particular time in question" (Heidegger, 1999b, p.71). It is the summer semester of 1923, when Dasein's schema is entrenched with Heidegger, the title of the course is the "hermeneutics of facticity", and his examples all relate to the "being-in-the world" of beings, which is to say his emphasis is not greatly the language of truth and dwelling. *Alētheia, Befindlichkeit*, truth, disposition, and dwelling, do not arrive in van Buren's glossary for the book that is a product of the semester. In the summer of 1923, Heidegger's words "that which is for a while significant to us at the particular time in question" are to be understood as a reference to beings that are for a time incorporated in current for-the-sake-of-which-cascades and which subsequently are not so incorporated. His text supports this interpretation of subsequent and "secondary" placement in for-the-sake-of-which-cascades, because:

> precisely *from out of* and *on the basis of* this *disclosedness* that what is being encountered is *there*, holds itself in its being-there, and lingers in it ... The beings-which-are-there in everydayness are not beings which already are in an authentic sense prior to and apart from their "in order to do something" and their "for someone," but rather their being-*there* lies precisely in this "in order to" and "for," and where this, the disclosedness, breaks down, and then it is *it* which breaks down–i.e., even then are the beings in question still there in *it*: the beings are there and for our being-occupied (going about dealings) "they stand in the way." (Heidegger, 1999b, p.73, his emphasis)

The hermeneutic "it", which is a being, involves truth. The question to ask of this paragraph is what may be said about the nature of the truth in each case as time proceeds. If the beings involved in signification alter how do we account for the initial being of the spectrum holding a profound relationship to the being of the geriatric physics teacher? The alternative is to declare the latter event founded in illusion or a construction, and abandon Heideggerian phenomenology. The suggestion here is that *alētheia* endures with *Rede* and hence does not just "linger" but profoundly lingers. Truth abides with the Dasein as its historical beingness. *Rede* has greater endurance than *Befindlichkeit*. Nomination endures more than mood.

At 9.30 a.m. at Hillary College, the teacher teaches 32 students about light-boxes. No, rather, Dasein-teacher renders a multifaceted class ("Dasein"-class) that Dasein-teacher engages as a unit that encounters light-boxes. Much occurs before students physically uplift apparatus. The teacher's introduction refers to the English Man Newton, the Royal Society that is far away in London, and how Western science hundreds of years ago confronts a problem about the homogeneity of light. Some boys covertly chat about the defeat of their local Otara rugby team on a ground less than 500 meters away and yesterday's loss is in a sequence of losses, and they today confront the problem of poor performance, a topic for the team meeting at 6.30 p.m. tonight. Heidegger generates controversy with his expression "idle talk", but there is nothing "idle" in the boys' covert talk. There is a poster on the wall of the laboratory, supplied by the Royal Society, and the teacher indicates the picture of Newton.

Truth is everywhere involved in the teacher's presentational style, the anecdotes, the melodrama, the science, and the poster. Always it is a correspondence account of truth, whereby things, particularly word-things and picture-things relate to history and science, which also render as beings. In dramatic contrast, literally phenomenal with its roots to phenomenon, the boys' rugby game involves disclosure, *alētheia*. In that final moment, when the desperate attempt to even the score halts, when the frantic play stops, with Pake injured on the ground, and as the referee's whistle expires, there is the briefest moment of silence as the result impacts on players and spectators alike. *Alētheia*, the same *alētheia*, abides with many "persons", or more correctly if recent theorists prevail, *alētheia* abides with a single hydra-like Dasein. Be that as it may, *alētheia*, unites the boys, focuses the boys, and extinguishes the presence of all correspondence truths to which it does not associate.

Zara, already at the age of 15-years, abides in the school laboratory with a very different disclosure, from that to the rugby game. That which is closest and most constant for Zara is her escape from childhood to the safe home of Pastor Rae where God and order speak to her, and from where she carries the most fearsome determination to achieve success at school. The school counsellor, although not Dasein-teacher, knows that preeminent for Zara is a truth of violence. There is horror in precise memories which Zara cannot avoid or quiet. Physical appearance is not a good indicator of ontological disposition, with its foundational truth of disclosure with an involved being. Newton achieves a relationship with the *alētheia* that abides

with the violence of Zara's home-life, not in any way though science but by way of Dasein-teacher and her "trust" that Newton in some way associates with the school success she desperately desires. Ontologically for Zara there is the message, "if this is science this is where I attend". The for-the-sake-of-which-cascades for Zara bring together "self-worth" as ontological understanding and disposition (not as the mood of the moment, but as settledness which we may call dwelling), and physics. The boys do not know what life is about, thinks Zara. The physics teacher did not recognise the ontological situation of the boys or Zara. Chapter 7 considers further the involvement of truth in student discipline and violence.

With the preliminaries in chapter 4, the teacher's task appears as the facilitation of *alētheia* – the moment when the student dwells with the especial truth of modern physics which is, in a Heideggerian rendition, the prime purpose of physics education. Unfortunately, there is no recollection of this as the situation in the laboratory at Hillary College. Before giving the actual events, consider two examples of *alētheia* in physics classrooms, the second of which accords with *alētheia* of modern physics that chapter 4 describes. Dasein-teacher reflects on his own student-days and the strategy of his own physics teacher to inculcate the discipline of physics. There was one truth of disclosure that dominated his days in the school laboratory. Against that truth, all else weighed light. Students frequently discussed that single truth and it became a marker of the progress of each physics lesson. These were the days when masters would cane boys and fear, bravado, and pain had a role in teaching. Later, at secondary teachers' college at Epsom, disclosure, this time Heidegger's truth of physics, presented itself to Dasein-teacher with a prism. The tutor was Rae Munro (Munro, 1977; New Zealand Association for Research in Education, 2005), and perhaps that is the genesis of the present thesis for without the personal experience of disclosure in modern physics, Heidegger's account of truth in modern physics could appear tepid.

Now the boys and Zara lumber forward to collect their light-boxes. They plug power packs and lights shine as the teacher pulls the curtains and the room separates from the school outside. This creates an intimacy which teachers know generates calm. The students' movements are careful and the conversation subdued. Various students relate to their experience with the light-boxes in various ways. Probably no one immediately places the correct face of the prism at the correct angle in the beam to generate a spectrum of colours. There is an opportunity to judge the

correspondence between that which is physically there, and the diagram the teacher drew on the blackboard, the drawing in the poster, and the photograph of a light-box in the textbook which a few students consult. They all abide with a level of correspondence, and they all maintain themselves in their distinct manner. The correspondence truth involved requires nothing more. "I see it", shrieks Zara as the colours appear in the light-box, and as she leaps from an apophantic "it" of *adaequatio* to a hermeneutic "it" of *alētheia*.

The demonstration, as the teacher recounts it in his lesson plan, is about the homogeneity of light and Newton's achievement. Student s will record sufficient of this in their examination at the end of the year. The entire experience is enmeshed in correspondence theory by the institutional requirements, and formally judged only in accordance with correspondence theory. What of *alētheia*, which might be that involved in a Heideggerian rendition of the purposes of the kits issued for *PSSC Physics*? *Alētheia* was present in the colour and situation beings unexpectedly incorporated by Zara in her for-the-sake-of-which-cascade of the moment. The shriek was the being of the ontological understanding of this as rendered through *Rede* for Zara. "Ahhh" means "the being of the spectrum in the circumstance" which *alētheia* "drives" or "motivates", which disposition allows, and which emerges in comportment that is facilitated by the only language Zara holds. Oppenheimer quotes religious poetry, Archimedes proclaims "eureka", and Zara shrieks. Shrieking is most likely when the student must manipulate the prism and has to work for the revelatory experience. The moment the colours appear is a memorable experience for students. Repetitions of the event are referenced to the first appearance of the spectrum and thus the correspondence theory of truth involves itself in repetitions. Sufficient alterations in the circumstances may enable another truth of disclosure, for example if Zara attempts to use sunlight through the curtain to produce a spectrum on the wall, in a manner reminiscent of Newton.

Zara did not abide with the truth of modern physics, and her physics teacher is culpable in regard to this failure of pedagogy. Nor did she achieve physics on the basis of a common and deficient account of physics – the constructivists account to which Hirst provides access in chapter 2. Although Zara's light-box renders *alētheia*, this is *not* a scientific demonstration in the discipline of physics. If physics involves the formation of a personal hypotheses, and the confirmation or rejection of those hypotheses though the manipulation of equipment, then Zara's work with light-box

was not science although it may have been about the history of science. The students were given the light-box and told about the spectrum and its significance in the history of Newtonian science. The students did not construct any hypotheses nor did they design a test for any hypothesis, and from this it appears that in this particular lesson there was no opportunity to construct physics.

If physics involves the forced disclosure of an aspect of the Real, and that disclosure must abide with that which is foundational to mathematics and relates to measurability (*ta mathēmata*), which is to say Heidegger's ontological concept of modern science, then the students did not engage with modern physics. Astonishingly, nevertheless, the class approached the essence of modern physics with little equipment and no knowledge of the subject. It would not have been difficult for the physics teacher to set up the situation with the students holding fore-knowledge about measurement and the measurable before they engaged with light-boxes and prisms. The teacher needs to pose precisely the right questions on the basis of an understanding of the nature of modern physics. Students could practice responding to such questions in advance of the light-box project. There could be built (by means of truth within correspondence theory) within students a way looking for the mathematical in the things of nature. This is one way towards the "ground plan" or "sphere opened up", which chapter 4 develops as foundational to modern physics. Heidegger's insight into modern science does not render modern physics mysterious or beyond the reach of the ordinary physic teacher with access to minimal equipment. In this observation about the practicality of teaching to establish the particular circumstances and forms of *alētheia* essential to modern physics, is found the saving grace within modern physics – its pedagogy is not demanding, and well within the achievement of physics teachers.

One further aspect of the saving grace within physics needs development. It may be approached by considering what the teacher's questions might be when teaching in accordance with the hermeneutic philosophy of science. What is the shape of the image formed by the prism? Can you measure the sides of the rectangle formed? Is the image always the same in every light-box and in other circumstances with prisms? These are Newton's questions as chapter 5 shows – and they are remarkably clear, although Newton struggles with them. That students do not struggle with such questions indicates the ability of truth as correspondence, which satisfies students about physics without the need to engage *alētheia* with the Real

which modern physics genuinely requires. This disjoint between modern physics as *alētheia* with Dasein, and modern physics as it renders in ontic textbooks, is also indicative of the saving grace within the discipline of modern physics. The hermeneutic philosophy of science implies that so long as Dasein is, there is the potential for modern physics, and without Dasein there cannot be the discipline modern physics. Chapter 7 develops the assertions of this section regarding particularly how straight-forward it is to perpetuate modern physics.

Teachers and students (truth-beings)

The learning theory that Dasein-teacher contemplates at teachers' college before qualifying as a teacher involves itself there with Dasein-teacher as present-at-hand beings within for-the-sake-of-which-cascades. The involvement of that same theory in the practice of the physics teacher at Hillary College must be as a ready-to-hand being, incorporated in different for-the-sake-of-which-cascades than those at teachers college. This provides a further example of the ontological transitions that previous inquiries indicate.

Heidegger sometimes suggests that all theory is *entirely* ontic and involves *only* present-at-hand beings. In the present thesis, chapter 5 and the present chapter argue that this is not the situation that shows in an existential analytic. In this section, it is not the teacher's involvement with the classroom and the students which is at issue, but the involvement of the student with that which they must learn. That which they must learn is ontic theory, and chapter 5 provides a discussion of the ontological genesis of that theory in modern physics with Dasein-Newton as the example. Ontic theory is primarily in textbooks although it also appears in video, diagrams, and spoken presentations. A leading characteristic of ontic theory is that it presents to students as content or facts that each student must learn. Many students learn the same content. In an allegedly historical subject like physics the content is largely settled and thus textbooks for students display a remarkable uniformity. Heidegger's account of modern physics argues that the foundation of modern physics is not historical but rather is a particular form of disclosure, truth as *alētheia* under as he says "aspects", or more clearly, with particular involvements or signification.

There is a subject in computer science that has the title "the ontology of learning" and there have been attempts in education to produce the "ontology of learning". These attempts in education appear to revolve around three ideas, first that

students alter their being when they become students at school as opposed to human beings at home, second that students change their being when they learn, and third, that learners do more than absorb or construct representations, they develop a concomitant personal identity. This final notion resonates with the work of the present thesis to the extent that it indicates the importance of holism and change, but its foundation is not Heidegger's insights into truth and beings. The approach to the topic here, that within an existential analytic, has as quite different theoretical foundation. To orient towards this alternative, consider a conclusion from a project that investigated learning by looking into classrooms.

At a New Zealand university, an "Understanding Learning and Teaching Project" researcher records their pivotal conclusion about student learning in classrooms:

> We came to realize that classroom learning could only be understood as a dynamic change process, in which each concept or belief had a life story of its own as it evolved in the mind of each student. (Nuthall, 1999, p.305; see also Nuthall, 2000; Nuthall, 2005)

This project has been influential with teachers. This conclusion is an ontic account of how students acquire ontic disciplines such as modern physics. Nevertheless, it leads us towards an existential analytic. The beings the phrase "concept or belief" suggest in this statement from the perspective of Dasein-student are manifold. The expression "dynamic change process" indicates that time is involved or what in some ontological studies describe mysteriously as "unfolding". As indicated earlier, Kisiel's word "kinetic" of Dasein is preferred for the involvement of time because it associates with the tripartite theory of the Dasein, including particularly signification. Further, the Nuthall statement is about classroom learning, which is a reference to a defined space. This is not the same as an ontological referential totality, but both do acknowledge the need to confine enquires to a holism that in itself is understandable.

This section develops an existential analytic to examine contentions about that which Nuthall advances as "student learning", and again it is truth that provides access to the nature of the beings involved as Dasein-teacher teaches. There are two circumstances to distinguish before the relationship between them becomes an issue: ontically, the first situation is that of a student as an individual human being and the second situation is that of student groups or classes. Aspects of this ontic distinction

develop below in an existential analytic, which is to say in Heideggerian ontology. In the first situation, the ontological classroom is composed (ontically) of individual students equated to different forms of being at the same time. Ontologically, Dasein-teacher is with Dasein-student, and Dasein-student in the complex with Dasein-teacher may be a ready-to-hand-student or a present-at-hand student. In the second situation, (ontically) the students together constitute a being and the involvement of Dasein-teacher may be "with" a ready-to-hand class or a present-at-hand class.

"Classroom learning" says Nuthall – this apparently equates to the concepts and beliefs that evolve in the mind of "each student" – is the arithmetic sum of the learning of individual students in such an account of learning. If we begin with the extant unit, the class and not the classroom although the classroom is an equally a legitimate ontic concept, an existential analytic might proceed as follows. Dasein-teacher says, "I teach 4S this afternoon" – that is an example of comportment. She does not say she will teach John, Sarah, Moana, Harry, *et al*; nor is the expression "4S" a convenient contraction of the student's names or their physical presence. As understood in ontic discussions about schooling, any object-student might be absent without 4S ceasing to be 4S. Ontologically, 4S is not the sum of its physical parts but neither does 4S have physical parts as in its ontic rendition. The ontological 4S renders as a totality of associations, relationships, and involvements which include the nominated ontic "4S". The ontological 4S being holds its being when beyond the school on a field trip in the mountains. Dasein-teacher did not constitute the 4S being at the beginning of a school year (phenomenological temporal idealism). *Being and Time* contends that without Dasein there is no time and implies by implication that the constitution of 4S in time thereby depends on Dasein. Earlier it was mentioned that there is a "species" concept of Dasein, and that is relevant to such assertions in *Being and Time*, and which cannot be pursed here. Ontologically, the constitution of 4S was not of a moment and it is never final, parted, or beyond – however, it does always involve Dasein, but not necessarily Dasein-teacher.

What is the nature of the being of 4S and what is there that may be said about the involvement of truth in this 4S being? The being of 4S cannot be Dasein. Its "comportment", shown involvements, do not lead to its becoming understood by Dasein-teacher as an "Other like myself". So what is "4S"? The two possibilities are a ready-to-hand being and a present-at-hand being, and these could abide with Dasein-teacher at different times. Most likely, within school hours – when the

teacher is active, performs tasks without hesitation, has a role, manages situations, and multi-tasks – the 4S being is ready-to-hand. In her retirement as she marvels about her survival in the classroom, 4S is a present-at-hand being.

Dasein-teacher seeks to have her students "stay together", by which she means to have them all at the same standard of proficiency and understanding of the topic of the day, in the present example, the topic is Newton's optics. We may observe the comportment as she tries to ensure the less capable students are brought up to the class standard – she spends more time with some students, frequently speaks directly to them when in group situations, and discusses their work with other teachers. Any ontic selection Dasein-teacher makes of the less capable derives from the class, not from the individual performance of the student. It derives from the class as Dasein-teacher renders the class in an ontic construction. Most likely, that construction is the student grade register in which the teacher writes results of written test as the year progresses. Or, it may be the Otis intelligence test results held in the school office which the teacher read at the start of the school year. The achievement of Otis was to produce a test that could be administered to large groups and provide data on individuals (Ellis, 1928, p.84). Or it may be an assessment that the teacher makes from a notion within the discipline of psychology, perhaps this concerns the motivation of the student, or an inability to stay "on-task", or in the word of William James to which chapter 3 refers, an inability to "attend" (Chapter XI, "Attention", James, 1950). Or, it may have a sociological foundation, as when another teacher says over a cup of tea, "all those Jones are thick, their mother took off shortly after Sally was born". However, the teacher arrives at her selection of those in need of special attention – they would not be "less" capable unless there was a middle level of capability – that is, unless there is first 4S. Likewise, for the "social" or "moral" situation within the class – there is a "standard" that is acceptable behaviour and adhered to by those seen as the class: one essential part of this derives from the class itself. "Harry pay attention" we hear Dasein-teacher say as Harry speaks to his neighbour Jane. Experienced teachers appreciate this is not primarily an effort to advance Harry's learning, but more an effort to maintain the focus of the class as a whole. It benefits everyone and most more than Harry. An ontological account is required of Dasein-teacher who is found to comport more frequently towards some Dasein-students than others.

That which is in the foreground for teachers in such events is the class, which indicates that the class is a ready-to-hand being involved with Dasein-teacher. What might it take to involve Dasein-student? Softly spoken Jane spoke to Harry first, but she did not risk her teacher's attention and indeed the teacher did not notice this as a complexity of the class. When Dasein-teacher abides with Dasein-class there must be a break-down situation for a new abidance to establish. Jane did not constitute a sufficient "breakdown", nor did Harry who was not engaged as Harry, but rather accommodated and aligned in accordance with the being-class. The truth of the classroom for Dasein teach is the class. It is the class which establishes itself in a myriad of correspondences, each a truth subservient to Dasein-teachers abidance with the ready-to-hand class. If Harry continues his "disruption" he will be made to leave the classroom. This enables Dasein-teacher to maintain the class as a ready-to-hand being, for Dasein teacher teaches equipment-class.

Harry is not Dasein-student when Dasein-teacher comports to maintain the class. He is an invisible aspect of equipment-class, visible only to us as the observers of the situation which we now render in our referential totality. This means the involvements of significance for Dasein-teacher, which we may construct as for-the-sake-of-which-cascades for Dasein-teacher, do not involve Harry uniquely. When Harry finally becomes involved as Harry there to be individually taught, the teaching of the class is at risk. The ruling for-the-sake-of-which-cascades alter for Dasein-teacher and what becomes unready-to-hand is not Harry, but the class. More fully, Harry's actions escalate until the class ceases to be something with which Dasein-teacher skilfully copes, and thus the class becomes un-ready-to-hand. Dasein teacher now involves another being and the question is "what are the characteristics of this new being". If the comportment of the teacher shows a withdrawal from the situation, perhaps a deliberate calming and composure, or alternatively a pondering about how to proceed, these indicate Dasein-teacher abides with a present-at-hand being class being. As the teacher remembers her lectures on operant conditioning at teachers' college and analyses the situation she confronts, truth as correspondence engages. Alternatively, she comports towards Harry, separates him from the class by standing between the class and Harry, and points to a specific place where Harry has written something in his exercise book. The observer hears "What do you mean by this Harry". It is a skilful instinctive performance by a competent teacher. The lurking deputy-principal who is the observer at the window in the door of the

laboratory, rational and ontic, thinks she does well to isolate Harry from the other students and focus his attention on something that he has written by the use of a physical object (a pointing finger) and by the posing of a non-threatening question provide Harry with an activity. The teacher thinks none of this as she performs now with the ready-to-hand Harry as transparently to herself as she performed with the ready-to-hand class which for the moment is un-ready-to-hand.

Consider this example of the transition of the ready-to-hand class to the unready-to-hand class. Beginning teachers sometimes ask how much noise is reasonable as a class works. The answer is not to be given in decibels. We observe successful teachers whose classrooms are silent as their students work, whilst other equally successful teachers perform amidst a din. The answer to the beginning teachers' question is that the level that is acceptable is that which the teacher and their students tolerate without it distracting from their work. This is an ontic answer which hides its ontological foundation. In phenomenological terms, it is that level of noise may rise until it precipitates the breakdown of the ready-to-hand class that abides with Dasein-teacher. Chapter 7 presents and integrates the conclusions drawn from chapter 6.

Chapter 7: Discussion and conclusions

Physics is about truth and the task of the physics teacher is to enable students to access that truth. These are the conclusions of the investigation, although it is necessary to be more specific about the qualities of that truth, its perpetuation in the school subject, and its connivance in the discipline of physics. The inalienable quiddity of physics is a particular formation of truth, *alētheia*, which derives from both our human abidance in truth and a mysterious hidden reality.

If physics is to continue as an engagement for human beings, effective provision must be made for the perpetuation of the truth structures that are characteristic of physics. In Western nations this task traditionally falls to schools and universities, although it could be achieved elsewhere, for example in the home or in research institutions. In all instances, the truth in physics requires preparations that force nature to reveal something further of itself. This revealed aspect of nature is a disclosure that is constituent of the way of being of the human being for a moment. The extent of the necessary preparations is what limits home based education in physics. The discussion of pedagogy below indicates how to use simple equipment, such as prisms, to reveal truth structures. Modest equipment is sufficient to enable students to abide with truth in accordance with modern physics, and thereby to include students in physics.

The essence of modern physics is truth as a precisely constituted form of disclosure which involves beings of a particular kind in intricate ways. The existential analytics in chapters 5 and 6 explore these intricacies and suggest more about the structures of truth-beings that are characteristic of modern physics. An existential analytic is a species of phenomenology and thus it is something a person engages in, like a sports fixture, rather than a formal method of enquiry or procedure. Any phenomenological "enquiry" can only suggest directions for further thought. That which follows builds upon the phenomenology in chapters 5 and 6, and phenomenology never constitutes unequivocal evidence that supports conclusions, it is just a vehicle to assist thought.

The strategy in the present chapter is to start with the nature of truth and proceed to the nature of physics, then to consider those conclusions which relate to the involvement of physics education in Western metaphysics, and finally to focus

on physics education and pedagogy. With this strategy for the presentation, the sections are (1) "The involvements of truth", (2) "The essence of modern physics" (inferences from the ontological biography of Newton and the hermeneutic philosophy of science), (3) "Physics education" (inferences from the enquiry into physics education at Hillary College, particularly with regard to the essence of modern physics and teaching), and (4) "The ontological pedagogy of modern physics" (teaching to reveal the essence of modern physics).

The involvements of truth

This section presents conclusions about Heidegger's notion of truth which derive from the existential analytics. It (1) begins with a summary of the ways to explicate truth, and then (2) considers disciplines, everydayness and regionalism. The next topic is (3) truth as discovery, which precedes a discussion of (4) the formulations of *alētheia*. The section then considers (5) the way that *adaequatio* associates with *alētheia* in for-the-sake-of-which cascades. Finally, the section explores (6) the prospect that the conceptions of truth that chapter 2 introduces may inform the findings of the existential analytics about truth.

There are four ways to explicate truth in an existential analytic

The question "what is truth", because it begins "what is", begs of us an answer that is in the form of a list of properties. The challenge is to provide an ontological account of truth in opposition to our thinking which gravitates towards such a list. There is no adequate word to describe truth because any definition of the word is in effect a list of its properties. Truth is being, and every being is truth: that is Heidegger's early discovery and it does elucidate something profound about truth, and it produces the term "truth-being". To remove ourselves from the seductive "what is" construal, Heidegger alters the language to say that truth "abides" with being. Our concern is relationships that involve truth-beings in their abidance. The summons of hermeneutic phenomenology is to identify precisely these relationships for truth-beings.

There are four ways to describe the relationships of truth-beings on display in chapters 5 and 6. Each of these brings into focus a different aspect of the truth-being under discussion. Descriptions in accordance with the three ways, even when taken together, are not *adequate* for the task of explication, because "adequate" is one of

those words that requires criteria and definitions. Heidegger (who here draws upon Aristotle) says they require of us the apophantic "as", by which he means an assertion such in the form "we understand truth as being". They are derivative of the very structure that we seek to understand, which he calls the hermeneutic (primary) "as". The path to the hermeneutic "as" is by way of insights into existentiel (particular) examples, which is to say the particular examples of truth-beings which comprise an existential (general) analytic of the Dasein. Consequently, the four ways to describe the relationships of truth-beings are attempts to explicate hermeneutic structures or involvements of the truth-beings.

The four paths to an ontological account of truth are: first, that which derives from phenomenological insights into truth itself and which are the basis of Heidegger's account of the historical concept of truth, truth as disclosure and correspondence; second, the KNS schema that indicates the relationships of being to the Being of the Dasein and which surpasses Aristotle's notion of "categories"; third, the phenomenological classification of beings; and fourth, the kinetic of Dasein as construed in for-the-sake-of-which-cascades which involves ontological understanding and disposition, along with a capacity for nomination. Each of these paths develops in the theory of chapter 3.

These paths are those most effective in an existential analytic. Any situation in chapters 5 and 6 may be interrogated with the theory from any or all of these paths. Heidegger provides further theory about truth which is less conducive to an existential analytic. For example, the enquiry into truth in Plato assists in our understanding of the four ways, but does not of itself produce another strategy of enquiry. His account of the allegory of the cave is a phenomenological example that complements the carpenter example in *Being and Time*. The reason that these examples are complementary is that the focus of his discussion about the cave is ontological understanding (the fourth way, above), and the focus of the *Being and Time* example is revelations about the nature of beings that comportment shows (the third way, above).

Our perplexity about truth provides access to beings in the existential analytic. Bland statements, such as "truth is our human way of existence", hide the complexity that the four ways indicate. An existential analytic is a concrete enquiry which illuminates the Dasein as Heidegger says "in general" . Analytics typically begin with perceived circumstances or ontic assertions and then the four ways enable

insights into a situation. That said, the specific situational enquiries that chapters 5 and 6 report do not each draw upon all four theoretical foundations of investigation. Instead, one or two of the ways provide access to some aspect of the truth situation.

Disciplines, everydayness, and regionalism

That there is a distinct school subject called physics misleads us about the ontological situation. Likewise, the notion of regional ontology as distinct from formal ontology also misleads us. Likewise, the notion of ordinary everydayness as distinct from involvement in an ontic discipline or regionalism is also misleading. Ordinary everydayness is the how of being, how Dasein lives "unto the day"(Heidegger, 1962a, p.422), and this day may involve physics.

Incidentally, on the basis of the existential analytics in chapters 5 and 6, this thesis rejects Heidegger's claim that to everydayness "belongs further the comfortableness of the accustomed" – that may be the situation, but equally it may not. "Comfortableness" in some formulation or other may be integral to an aspect of disposition and as such associate as much with physics as with ordinary everydayness (Heidegger, 1962a, p.422).

Physicists and students, those who engage in physics, experience truth in for-the-sake-of-which-cascades without the involvement of any boundary, particularisation, or region. Husserl notices this when he dismisses the idea of "many worlds", but he still builds his distinction between fundamental ontology and regional ontology with the concept of "necessary transcendencies". Hirst classifies forms of knowledge upon his own experience and not the ontology of participants. Physicists and physics students never transcend into a region, realm, sphere, domain, particularisation, or discipline of physics. It is Hirst and others who construct models of the mind who need doctrines and intellectual disciplines. Instead, as chapters 5 and 6 show, physicists and physics students consistently engage with truth *qua* disclosure and correspondence in highly variable for-the-sake-of-which-cascades. Only for those who seek to classify is there a being something like "the discipline of physics". The first construct of constructivists is constructivism. School administrators and curriculum planners cannot dispense with categories, but their categories do not hold any significant ontological foundation in the involvements of physicist Dasein. The notion that there are ontic sciences that deal with different aspects of reality, or domains of understanding, or forms of knowledge, is an

administrative convenience contrived itself as a truth-being by those involved in administration. The use of such ideas as a way to enter a discussion in ontology is another *use* for these "ontic beings", but the categories themselves do not hold profound ontological significance.

Nevertheless, as the present thesis shows, nothing in this stops the use of the convenient word "ontic" to refer to truth-beings that associate through some human activity, but nothing profound about ontological status should be understood by this use. Most importantly, this use of the word "ontic" does not indicate that the beings involved are bound to each other in any way which legitimises analogies of spheres or boundary fences. In Heidegger's tree analogy for metaphysics the alternative account is found (Dahlstrom, 2001, p.408, considers the "stepping beyond" concept of transcendentalism in Kant and Heidegger). The sap which flows upwards is truth and we must hold our focus on the sap and not on the leafy branches (the disciplines and the sub-disciplines in the tree analogy) we are inclined to notice at the top of the tree. At first it is the KNS schema that enables the interrogation of truth in the analogy of sap, then it becomes the existential analytic and in particular the for-the-sake-of-which cascades. The existential analytics in chapters 5 and 6 underscore Heidegger on this matter: disciplines are artificial constructs, useful when we seek to gain access to beings, but truth is the determinant of beings.

Truth in discovery

Discovery is important in history books, in our lived lives, and in modern physics. The ontology of discovery becomes apparent when we are unencumbered by notions such as ontic disciplines and regional spheres. To prepare for the discussion of modern physics, this section considers the ontology of discovery and takes issue with the notion that discovery is characteristic of present-at-hand, "ontic", entities (something which Heidegger implies but does not apparently say). For example, he heads Section 69(b) in *Being and Time*, "The Temporal Meaning of the Way in which Circumspective Concern becomes Modified into the Theoretical Discovery of the Present-at-hand Within-the-world" (Heidegger, 1962a, p.408).

The existential analytics show that discovery – always, unexpected discovery – is truth as disclosure, *alētheia*. This ontological rendition has nothing to do with the way that the word "discovery" appears in common speech, where "to discover" can mean, "to find out about something" or "to invent something": distinct examples

of the correspondence theory of truth at work. Newton, a teacher, and school students all comport in a distinctive manner when they ontologically discover. In specific unique situations they express surprise, delight, certainty, and authoritativeness. There is knowledge from which they can never to be alienated, a personal absolutism. Commitment to the importance of a moment of revelation indicates the formation of *alētheia* that discovery produces. Although the examples in the analytics do not indicate dread, it is possible to imagine comportments that indicate dread also as a response to *alētheia* as discovery.

Contra to the identification of ontological discovery with *alētheia*, one scholar produces his own phrase and relates discovery to ontic disciplines:

> Discovery presupposes a species of truth–what we can call *ontical* truth (truth regarding entities–which is the only sort of truth most of us ever consider). This is implied in the pivotal qualifier "as entities": it means that ontical comportments must undertake to get the entities in some sense "right." The feasibility and requirement of ontical truth is what distinguishes human (ontical) comportments from the behaviour of animals and inanimate things. (Haugeland, 2000, p.50)

It is correct that discovery "presupposes a species of truth", when the notion that we enquire into is "ontological discovery" and not any use of the word. Haugeland takes us in the wrong direction with his emphasis on "as entities", because the entities in an existential analytic render as relationships, and not as discrete objectified spatio-temporal real things. Furthermore, the concept of truth involved in "right", depends upon a correspondence theory and gels (as the previous section argues) with ontic disciplines as construed in, for example, school subjects.

The analytics suggest the use of the word "discovery" in ontology has an affinity to its use in the law, where discovery is a process to force the revelation of information relevant to a legal case. The appearance of information disrupts the case, hopefully before the hearing. Ontological discovery is the presencing of a truth-being that disrupts Dasein's for-the-sake-of-which-cascades. Ontological discovery is never discovery with indifference – there is a moment in which the discovery dominates within for-the-sake-of-which cascades. This gestalt moment of *alētheia* will involve *Rede*, which makes it identifiable for Dasein. The translation of this event of disclosure into words for other people can be bothersome, as the Newton analects show and as school situations also show.

Further, the disclosure of discovery, through its impact on for-the-sake-of-which-cascades, attunes or conditions the Dasein. It is truth-beings that serve to attune the Dasein, and to achieve this they must distinguish themselves, which is to say they must abide with Dasein in a manner that influences that which we find indicative of *Befindlichkeit* in comportment. Heidegger indicates a pertinent example as the Dasein's "variations of fear, which we know as … becoming startled" (Heidegger, 1962a, p.182). Dreyfus draws attention to Dasein's characteristic capacity to "startled", in contrast to robots and insects which evidently are not attuned and thus do not startle (Dreyfus, 1991, p.68).

Examples of discovery that draw upon for-the-sake-of-which cascades that entail only ready-to-hand beings are instructive, because they do not encourage us towards Descartes' dualism. Consider this example. You are thinking about philosophy as you drive home from work. Suddenly, a truck pulls into your path and you brake without thinking. You engage (construct for-the-sake-of-which cascades) with beings such as the brake pedal and the truck. As the crash is about to occur you increase the pressure on the brake pedal. Later, the coroner concludes you had an instinct for self-preservation and it was a pity you did not have the time required to avert your death. The being of the discovery is the truck and your urgency associates the truck and disposition. Disposition in the for-the-sake-of-which cascades is what sets you increasingly to the brake pedal (observable comportment) when the truck intrudes into the for-the-sake-of-which cascade. The ready-to-hand being-truck is not a being of indifference for you, as it is for us when its representative, a present-at-hand being-truck, appears in the coroner's conclusions. In contrast, Haugeland's *ontical* truth of discovery is a meek form of discovery, which is truth as correspondence and like all correspondence it holds only a fleeting capacity to influence our way of being in the sense of *Befindlichkeit*. We might say Dasein "discovers" that 1+1=2, but the existential analytics suggest that Dasein just abides with the correspondence. To experience this, consider two numbers less familiar. That 1234+1=1235 does not startle anyone. It is a truth, say within an ontic discipline if you will, but we would not want to call it an ontological "discovery" – that requires disclosure.

Conspicuous comportment often associates with discovery, as is shown by your reaction to the truck, as well as by Galileo, Newton, and all physicists who

become fervent about discoveries. The contrast is with the "dimmed ... down" uniformity of truth as correspondence that constitutes the ontic world:

> By looking at the world theoretically, we have already dimmed it down to the uniformity of what is purely present-at-hand, though admittedly this uniformity comprises a new abundance of things which can be discovered by simply characterizing them. (Heidegger, 1962a, p.177)

In the existential analytics in the previous chapters provide many examples of ontological discovery, not one of which is "dim".

Formations of Alētheia

The preceding section on discovery develops a view about truth that this section makes explicit in relation to the theory of *alētheia*. Since *Being and Time, alētheia* has been contentious. For example, Ernst Tugendhat interrogates section 44 of *Being and Time,* to challenge to the assertion that disclosedness is the primordial phenomenon of truth and argues that Heidegger "tied the philosophy of subjectivity down to the dogmatism of self-certainty" (W. H. Smith, 2007; Tugendhat, 1996, p.240). Further, philologists like Paul Friedländer (1958) dispute Heidegger's claim that he found part of his notion on *alētheia* through a meticulous reading of Greek philosophy. Almost 20 years after *Being and Time*, Heidegger summarises:

> But since the dawn of thinking "being" names the presencing of what is present, in the sense of the gathering which clears and shelters, which in turn is thought and designated as [that which will] gather or assemble [and which is] experienced through *alētheia*, the sheltering which reveals things. (Heidegger, 1975, p.39)

Krell (1975, p.92) also summarises: "presence is the meaning of *ousia;* upsurgence is the meaning of *physis;* unconcealment is the meaning of *alētheia*, and the gathering of these three into one is *logos*". Now *physis* is presencing in the sense of upsurgence, and Krell says Heidegger's notion of Being remains the "aletheological notion of Being" (Krell, 1975, p.92). With that background, what is the account of *alētheia* that emerges from the existential analytics of the thesis?

Alētheia formulates in two distinct ways. First, there is disclosure as an "ingredient" of *all* beings, hence truth-being, or more accurately, truth-being-Dasein where "being" is either a ready-to-hand being or a present-at-hand being and truth may be *adaequatio* or *alētheia*. In this formulation – which is within fundamental

ontology and Heidegger's interminable theme – the word "*alētheia*" holds two meanings: (1) as the ground, source, foundation, or the "holding open", of being, and (2) as that truth which is held open, present, gathered, available. This is Heidegger's reference to the presencing of what "is present, in the sense of the gathering which clears and shelters". This is the formulation of *alētheia* (particularly 2), Heidegger reads, rightly or wrongly, in the texts of ancient Greek philosophers who understand the sway and eminence of presence. It is precisely what the Western tradition of philosophy forgets, and it is why "*alētheia*" appears in the present thesis and not "aletheia".

The second formulation of *alētheia* occurs in acts of discovery. This rendition of *alētheia* derives from phenomenology, and it has the character of *alētheia* in the first formulation, indeed it always embraces *alētheia* in the first formulation, but additionally it includes perception. Modern physics deliberately makes this formulation of *alētheia* occur, but the occurrence is common enough outside of physics. The unusual part of this formulation of *alētheia* is that there is an intrusion of *alētheia* into the for-the-sake-of-which cascades of the Dasein, and the Dasein embraces, abides with, dwells with, renders as that which now shines especially in the openness. Dasein does not question, cannot question, the presence of this formulation of *alētheia*. "I know what I saw" pleads the harassed witness lamely, to stress that she held an ontological understanding of the moment. Epistemology is debatable – ontology is beyond rationality and words. The intrusion mentioned is the intrusion of an aspect of the ontological world that is available to the Dasein through perception. As Kant understands, we can only engage with that for which our biological apparatus equips us, and as Heidegger understands, we can only engage with that for which our ontological apparatus equips us, which is to say the KNS schema. The use of the phrase "dwells with" rightly suggests *Befindlichkeit* (ontological disposition). This formulation of *alētheia* disposes or determines the Dasein in particular situations. The situations are in a sense beyond the Dasein – Dasein cannot make an aspect of the Real presence if there is not this aspect of the Real in existence. The Dasein cannot encounter a stream where there is no stream. The comportment when *alētheia* abides with the Dasein in this second formulation holds common features. The person reports surprise, delight, awe, or astonishment. Dasein discovers when reality imposes upon signification. Of course not every report of this nature refers to *alētheia*. Nevertheless, whenever it is said that Dasein has

achieved an incontrovertible revelation by way of perception, the situation potentially involves *alētheia*.

This construction of *alētheia* recognises that phenomena are themselves constituted and it is through this constitution that they render as ontological sense. In this regard it is similar to Haugeland's theory of beholdenness (Haugeland, 1998, pp.346-347). He derives his account of truth from his observations of "skilful mundane performances" that produce truth as beholdenness for the Dasein by way of the "correctness of their results", which is here understood as a reference to *alētheia* and not *adaequatio* (Haugeland, 1998, p.348).

Disclosure always involves correspondence

The existential analytics that chapters 5 and 6 report, enable a conclusion to be drawn about the nature of truth which hold implications for modern physics and its pedagogy. This conclusion is not specific in *Being and Time*, although it lurks there. Truth as disclosure always involves truth as correspondence. This is the obverse of Heidegger's initial account *alētheia* in *Being and Time*, where he argues that truth as correspondence always presupposes disclosure. Heidegger nevertheless implies the relationship between *alētheia* and *adaequatio* in what he says about ontological understanding, for example in the sentence "As a disclosure, understanding always pertains to the whole basic state of Being-in-the-world" (Heidegger, 1962a, p.184). His reference to "the whole basic state" is a reference to signification. It is within for-the-sake-of-which cascades that the fullness of the equiprimordial situation is apparent. It is this which gives the richness to the human way of being, which as he says casts the totality of involvements "revealed as a categorial whole" (Heidegger, 1962a, p.184). He continues, "With equal primordiality the understanding projects Dasein's Being both upon its 'for-the-sake-of-which' and upon significance as the worldhood of its current world" (Heidegger, 1962a, p.185). When the for-the-sake-of-which cascades of Dasein develop in the examples of Newton and students, they show many beings that are integral to both projection (in a sense of thrownness) and projecting ahead. The nature of truth for these beings is always first the truth of disclosure which "establishes for them" the relationship to the "pretheoretical something" (the "basic movement of life as such" and the "basic movement of particular spheres of experience" in the KNS schema, which is set out on page 64), which is the "original" primordial disclosure. He refers in *Being and Time* to the

"fundamental stratum" and "prephenomenological experience" (Heidegger, 1962a, p.132).The nature of truth for these beings is also, second, "their" association with aspects of the for-the-sake-of-which cascade which has primarily involves truth with the character of correspondence. It is apparent that a disclosure is not merely a disclosure but an involvement, which implies the engagement of truth as correspondence.

Disclosure and alternative theories of truth

Each of the theorists of truth that chapter 2 cites contribute to the discussion of disclosure, because they highlight observations that the ontological theory of truth must accommodate. It is possible to appreciate further the insights from the existential analytics by considering their findings in relation to other theorists. For example, Nietzsche's notion of "the will to truth" – that which seduces us into taking so many risks – which chapter 2 introduces, accords with Heidegger's insight about signification and the ever present kinetic of Dasein. Chapters 4 and 5 provide examples of this. Nietzsche's "mobile army of metaphors, metonymies, anthropomorphisms" are the configuration of truth-beings in cascades where the nature of the truth therein is that of correspondence. It is a function of truth that the Dasein finds its own situation as Nietzsche says in the quotation that chapter 2 presents "firmly established, canonical, and binding". However, it does not follow that truthfulness can be entirely reduced to correspondence – there is disclosure within truthfulness. It is not possible to be false unless one begins with a disclosure of truth – something to move away from. Newton's "fudge factor" is an attempt to make correspondence aspects of truth accord with a disclosure. In that case the situation is made complex by there being more than one correspondence truth-being equiprimordially in the signification. The truth-being of disclosure in the situation is the present-at-hand being of the unique forced disclosure of an aspect of the Real which is definitive of modern physics and which Newton cannot deny. The beings in the text are not those disclosed beings and Newton is compelled to alter his text beings to maintain the truth of disclosure.

Aquinas is another theorist whose work we can interpret through Heidegger's theory of truth in modern science. The challenge for Aquinas is that whilst he understands correspondence well though three definitions, he finds that religious experience apparently entails examples of disclosed truth. Heelan, also a churchman,

advances this in a paper that builds upon insights he acquired whilst considering the hermeneutic philosophy of science. Even when Aquinas seeks to relate truth to reality, he does so with a correspondence account of truth, and we read about the alignment of the intellect and the way things are. Even with his third way of defining truth – that which "is shown" and "proclaims existence" – Aquinas manages to bring the concept of truth back to correspondence, although there is, as Heidegger shows, a way to truth as disclosure here, and perhaps Aquinas held an instinct about this (when for example he says that he knows experientially what it means to wait for the Lord). Heelan finds a helpful rendition of this in the work of the Canadian Jesuit Bernard Lonergan (Heelan, 2002, p.448; Lonergan, 1972). Notwithstanding any glimpses of the truth of disclosure, the book of Nature did not supplant the book of Scripture for Aquinas, as it did for the enlightenment rationalists.

Plato understands disclosure, according to Heidegger. Plato's understanding is apparent – if somewhat hidden, as mentioned in chapter 2 – in the doctrine of the cave, where what "remains unsaid" in Plato's thinking is a change in what determines the essence of truth (Heidegger, 1998d, p.155). Be that as it may, Aristotle's influence is paramount when Heidegger writes *Being and Time*. The formative 1922 manuscript on Aristotle, that some scholars call the first draft of *Being and Time*, supports this view along with other evidence (Heidegger, 1995a, p.x). When Heidegger discusses Aristotle's concept of force and our subjective experience, he records how we "do not at all want to get involved with the pre-scientific and extra-scientific experience of nature, with what makes itself manifest in a so-called nostalgia for nature" (Heidegger, 1995a, p.78). When Aristotle writes *Physics* he adheres to the importance of phenomena, which may be understood as Dasein's encounter with disclosure. In the second book he famously interrogates that which causes movement "not being itself moved". Such a notion engages physics as an enquiry necessitated by discussions that depend greatly on language and apparent contradictions that emerge in language. It harks to the dialogues of Socrates. Although this topic remains controversial, Aristotle's approach to physics probably "strays too far" from the phenomena, and consequently contributes to the Cartesian dualism that Heidegger seeks to overcome some 2,000 years later. As chapter 2 indicates, *On Generation and Corruption* problematises the scientific and dialectical method. In the quotation given in chapter 2, the issue that concerns Aristotle is a contradiction between two alternative correspondence accounts of phenomena, and

not as we might expect from a first reading of his text, a tussle between the disclosure and correspondence. The "scientific" method of enquiry which requires sufficient "observations", nevertheless constructs science through correspondence, which is the procedure Aristotle acknowledges in the "dialectical method of inquiry". Although the latter approach dispenses with the observations, with regards to the nature of truth therein the method of science and the dialectical method are equivalent.

The essence of modern physics

These conclusions derive primarily from the ontological biography of Isaac Newton – an existential analytic of Dasein involved in research – that chapter 5 presents. Also relevant are the four ways of truth as set out in the section above, and Heelan's insights into the hermeneutic philosophy of science.

Physics requires a distinctive disclosure

What is modern physics? This section argues that modern physics in and of itself is a distinctive disclosure, an involvement of truth. That disclosure is always of an aspect of the Real which is forced into an involvement with Dasein in a particular manner. The disclosure is of a world that is beyond human intellectual intuition and which the physicist interprets through an unequivocal, regulated interrogation.

This disclosure and the preparations for it, together, constitute the essence of modern physics. Heidegger does not approach physics by way of an enquiry into essence. Notwithstanding that in many phenomenological enquires his strategy is to draw us towards the essence of his topic, in his mid-life account of modern science he describes the "characteristics" of research, as chapter 4 shows. Heidegger's account of modern science is an *analytical* contribution to the hermeneutic philosophy of science. He bases his conclusions on his insight into Western metaphysics and his observations of physics. Chapter 4 shows how his account of research invites an existential analytic of the Dasein, to confirm or deny his conclusions.

The existential analytics of Dasein-Newton and Dasein-student indicate that physics occurs when a Dasein grasps truth-beings and constructs for-the-sake-of-which cascades that culminate in a distinctive disclosure of an aspect of the Real. As an earlier section argues, there is no crucial distinction between the *domain* of

ordinary everydayness and the *region* of physics. In many examples, the involvements that we may deem "ordinary everydayness" are integral to those of modern science. The for-the-sake-of-which-cascades speculatively reconstituted for Newton, students, and the teacher, are replete with concrete examples. To show this, these examples draw upon the fourth path to insight which is about the kinetic of the Dasein which construes in for-the-sake-of-which-cascades. Accordingly, the conclusion is that there is a great variety of truth-beings that may associate equiprimordially and presence in modern physics whilst the essence of modern physics itself is the single disclosure of an aspect of the Real.

From the plethora of truth-beings available, and having regard to the "continuity" of ordinary everydayness and modern physics, what is the nature of the truth-being that is essential to modern physics? It is a present-at-hand truth-being, a truth-being that "carries" *alētheia* with regard to an aspect of the Real, and a truth-being that carries *adaequatio* with regard to the situation that forces its disclosure, and it is a truth-being which carries *adaequatio* with regard to its association in "subsequent" for-the-sake-of-which-cascades. Should there not be such a truth-being, then modern physics would not exist. The conclusion that a characteristic disclosure is the essence of modern physics locates the essence of physics within Heidegger's first characteristic of modern physics which appears under the didactic heading "Restrict reality". Some of the consequences of this account are that physics exists only as long as Dasein exists, physics is a potentiality of all Dasein, demonstrations (and not experiments) are inalienable from physics, and institutions are not essential to modern physics. In addition, there are consequences to consider that derive from the notion of a "ground-plan" itself. From Heidegger's and Heelan's theory it is possible to identify these as *ta mathēmata*, the pre-logic of logic, beings which perception may reveal, and an aspect of the Real within the confines of the KNS schema ("logic of logic" dates from before 1915, see Crowell, 2005, p.61).

As a distinctive formation of truth as disclosure, modern physics is always a potentiality of Dasein. The existential analytics of the thesis support Heidegger's observation that modern physics did not evolve from medieval physics and Greek physics. There is, however, no reason why a Dasein in another historical era could not abide with the truth-beings that we associate with Newton's achievement of modern physics. Likewise, any student at any time can abide with these beings. If modern physics is lost, individual human beings could re-engage modern physics,

either through their own unaided engagement with truth, or with the assistance of historical texts. This is what it means to say modern physics is a potentiality of all Dasein.

Rorty observes a group of involved people, physicists, and misses a mandatory facet of the situation which is the discovered/disclosed truth-being. Without that aspect of the situation, without truth, physicists and physics teachers appear similar to other evangelists, as chapter 2 records. Heidegger (1962a, p.269) says how the disclosures of truth in physics require Dasein, but does not explicitly say the obverse which is that Dasein always holds the capacity for such disclosures.

That there is the Real, that which awaits its own exposure by force, is a consequence of Heidegger's account of nature. This is the given that Newton associates with God and which he seeks to penetrate in his search of religious texts. In a parallel exercise, Heidegger seeks information on the nature of reality in ancient Greek philosophy. The dispute amongst modern theorists about whether Heidegger is a realist or a deflationary realist is not of concern, except to indicate that the present thesis inclines towards the conclusions of Taylor Carman (2003). Heidegger relates modern physics to nature early in *Being and Time*:

> The relativity theory of physics arises from the tendency to exhibit the interconnectedness of Nature as it is 'in itself'. As a theory of the conditions under which we have access to Nature itself, it seeks to preserve the changelessness of the laws of motion by ascending all relativities, and thus comes up against the question of the structure of its own given area of study–the problem of matter. (Heidegger, 1962a, p.30)

Nature is that which is merely occurrent, that which Dasein encounters as being-in-the-world. The "merely occurrent" is the Real, and as it happens we encounter the Real with the schema that is ours – the KNS schema. The environing world is the world to which Dasein comports because it is the world of being-in-the-world. World as a wholeness is not a being but that to which the Dasein gives itself in signification (Heidegger, 1998b, p.121), which Kisiel's "kinetic" that for-the-sake-of-which cascades generate. Dreyfus and Carman say it is the world encountered in the context of our practices (for example, Carman, 2003, p.191). In Heidegger's account of the environing world is found a further reason not to distinguish physics as a region distinct from that of ordinary everydayness. The Real of the forced

disclosure in physics is the same real as in everyday occurrence. The importance of disposition-dwelling, *Befindlichkeit*, is apparent now, for it is *Befindlichkeit* as an integral to beings in for-the-sake-of-which cascades which "allows" Dasein to abide with everydayness and then to abide with physics.

The truth of physics appears in demonstrations

If physics is a distinctive disclosure, where does that disclosure occur? Where do we locate the essence of physics? Physics in and of itself locates in demonstrations. Thus, experiments or experimentation or the scientific method, are dispensable. Demonstrations enlighten the truth of modern physics in particular examples, and practical experimentation is merely one manner by which it is possible to determine the correspondence aspects of demonstrations. The much heralded "hypothesis" of the research scientist is only ever a stepping stone to truth in a demonstration.

Galileo is the first teacher of modern physics and his actions indicate his belief about the truth of physics and how to promulgate that truth. Likewise, Newton in his practice indicates something important about the promulgation of the truth of modern physics. Both men labour to provide demonstrations to others. Galileo built and sent telescopes to influential people around Europe. In his conflict with the Church, he convinced some to whom he could demonstrate truth, but failed dismally in the inquisition and Heelan provides an account to why that outcome was inevitable. Newton laboured to establish the single demonstration that would convince everyone. Both Galileo and Newton sought to promulgate a truth of forced disclosure. Both understood that it was the experience of the truth of modern physics that would convince others, not the words of physicists. Of course some were never to be convinced, as the section in chapter 4 on Heelan's hermeneutic philosophy of science indicates.

For those who seek to expand our knowledge of physics, experiments entail *assertions* about the projection of an aspect of the Real (*adaequatio*), the faithful manipulation of equipment in accordance with precise rules (*adaequatio*), and the generation of an outcome that agrees, or does not agree, with the earlier assertions (*adaequatio*). Once an experiment achieves an outcome which places a gleam in the eye of the physicist we have an indication that *alētheia* is present. The whole package – projection, arrangements and outcome – the physicist writes into a report which an academic journal publishes and the key message is "try it for yourself: you

too can abide with the truth". In this process there is apparent the interaction of public objectivity and the subjective element of physics, which concerns Heelan:

> Public objectivity ... is a necessary condition of science; since, without it, there could be no scientific community, no scientific language and no collaboration towards well-defined goals. (Heelan, 1965, p.87)

This is correct, but essential, and in advance of public objectivity, is the disclosure of an aspect of the Real. According to Heelan, Heisenberg understands this well, he quotes him, starting with a reference to the abstract mathematical theory of modern physics:

> This representation ... is completely 'objective', i.e., it no longer contains features connected with the observer's knowledge, but it is also completely abstract and incomprehensible ....the mathematical expressions ... do not refer to real space or to a real property, it thus, so to speak, contains no physics at all. (Heelan, 1965, p.88)

When physicists, including Newton, stand on the shoulders of giants, the giants do no more than indicate (*adaequatio*) what is necessary to disclose an aspect of the Real. Each physicist in turn subsequently forces the Real to disclose an aspect of itself, or as is more likely today, accepts that this aspect is available.

In the journal article that the physicist writes, it appears that the physicist is absent. The reason the article does not need to refer to the physicist is that it is already understood that human beings perform the experiment, now a demonstration, and thus emerges the nature of the public domain of physics. (It is understood that not every journal article published is about disclosure, most involve steps along the way, steps that depend on *adaequatio*.) Ontologically, disclosures of aspects of the Real always involve Dasein with Dasein's characteristic schema and its capacity to render truth. The performance produces *alētheia*. This example of *alētheia* will involve an aspect of the Real, but most significantly it will also involve the full situation of the demonstration, and a judgement about the journal article. There is now a new being in existence. This is a present-at-hand being, single in itself, involving truth in many and interacting ways, and which will include *Rede*. That night the physicist tells her husband, "Smith's paper is magnificent, I saw the Smith effect once Bill my new technician managed to provide the right voltage" – *alētheia*, now involves "the Smith effect" (understood and identified initially as *Rede*), circumstances such as "the correct voltage" (*adaequatio*), and Smith's paper

(*adaequatio*, as is shown when it translates into Mandarin). The physicist and Smith now enter into a relationship: those Dasein who hold this complex disclosed truth-being. As other Dasein abide with this truth-being, Rorty – without admittance to the truth-being – notices the accumulation of people and declares physics is a form of evangelism.

Ontic texts do not constitute physics

Physics is not found in physics textbooks, nor is physics humankind's accumulated knowledge about physics. Historical texts, such as Newton's *Principia Mathematica*, do not themselves constitute modern physics. When a student gazes with awe at Newton's *Principia Mathematica* – copies of which reside in glass cabinets at the British Library and the Wren Library – the student does not abide with physics. The existential analytic in chapter 5 shows that when Newton is required to present his university with a copy of his delivered lectures he uses his notes as ready-to-hand beings and the form of truth involved is *adaequatio*. Newton writes about physics and does not engage in physics when physics is defined in accordance with Heidegger's insight into truth.

The physicist who uses Newton's text on optics as a recipe book, or more likely a text derived from Newton's text, and with care (care always involves *adaequatio*) produces a spectrum which is a rectangle of the dimensions Newton declares, may come to abide with physics. In the event that the disclosure Newton describes occurs for the physicist, then and only then, does the physicist dwell with physics. Then and only then, does the physicist in a veritable (en-truthed) disposition appreciate that physics is Dasein's inheritance of the Real. When the physicist performs the demonstration and forces an aspect to the Real to revelation, the physicist abides with the very truth-beings that are the beings of Newton.

The discipline of physics that we may behold – laboratories, employment, books and academic articles – is a vast structure that associates with forced disclosures, but which in itself is entirely a complex of *adaequatio*. The many forms of correspondence theory that Aquinas tabulates are present in these works. Words and sentences have precise or imprecise meanings. They may be accurately translated or inaccurately translated. The books and databases are held or not held by the physics librarian. The equipment may be well or poorly maintained, the operator

skilled or unskilled. The laboratory may be well funded or under-funded. The structure as a whole is the ontic discipline of physics, never physics in and of itself.

Institutions are not essential to physics

If the essence of physics is found in Heidegger's first characteristic of modern science, revealed in accordance with demonstrations that show in his second characteristic of modern science, what is to be said of the third characteristic of modern science, institutions? It is Heidegger's observation that aspects of the Real embrace the Dasein to generate a demand for further enquiry and this complexity necessitates the institutionalisation of science. Seeing Newton's involvement with beings as an interaction that involves truth is facilitated by his relatively unembellished association with his university and his decades of enquiry away from institutions. Heidegger is correct in his observation that the increasing involvement of institutions in modern science is a consequence of new aspects of the Real, but it does not follow that any particular aspect of the Real must be pursed, indeed many are not, and decisions on those which are – enmeshed in Western metaphysics – are frequently not within the gift of physicists. Funding decisions about the institutions and priorities for research (in both Heidegger's sense of the word and common usage) are dominated by national aspirations, human preferences, and commercialism. The obverse of this is that the individual human being can authentically abide with physics (truth in accordance with Heidegger's first two characteristics), although resource constrains limit the scope of such abidance because Dasein needs resources to force the Real to reveal particular aspects itself. Institutions are ready-to-hand for physicists; they are a tool involved in some disclosures. Those who equate modern science with "Big Science" do not see the essence of modern physics. Chapter 1 makes reference to Heidegger's account of the relationship between modern science and modern technology. Big Science is an approach to research which develops in physics from the Second World War and is characterized by large-scale instruments, substantial agencies, team work, politics, ideology, and significant expense (Josephson, 2003; for a case study, see R. W. Smith, 1989). Nevertheless, the essence of physics remains available to Dasein in many situations without any requirement for expensive resources, team work, or ideology.

Physics education

These conclusions are derived from the existential analytic of students at Hillary College that chapter 6 presents. Also relevant is Heidegger's account of metaphysics and Heelan's hermeneutic phenomenology of science.

Physics perpetuates itself when Dasein constitutes truth

How does the essence of modern physics carry itself from one generation of human beings to the next? Since the time of Galileo modern physics has achieved its own perpetuation, without anyone showing concern about its ontology. Yet, if the essence of modern physics is truth as argued above, it follows that it is this very truth which must be carried forward if modern physics is to continue. Physics perpetuates itself in the distinctive disclosures of physics.

The aim of physics education is to have each student personally abide with disclosures that are events in modern physics. Physics teachers will seek to constitute truth-beings – compilations of students and the Real. Such an approach to physics education contrasts with the preparation of students for employment in industries that draw upon physics and with the teaching of physics as a history of the discipline. The primary aim of physics education is not to learn about the achievements of Galileo, Newton, and Einstein – in each case such an aim will bring *adaequatio* to the fore. Nor can students engage with physics on the internet, which also is a domain of correspondence – nature's own science cannot dispense with nature.

Physics is a rare occurrence in the school laboratory

If physics is defined as a distinct disclosure, *alētheia*, physics did not occur in the teaching that chapter 6 describes. The disclosure of physics – the event of truth – was found to be a very rare occurrence in physics education at Hillary College. This finding of the existential analytic suggests that there may be value in an empirical study that identifies the nature of the truth that engages students in physics classrooms and laboratories.

If the criterion for productive time in the physics classroom is engagement with *adaequatio* preparatory to *alētheia*, then the time spent explaining the nature of the Real, the human access to the Real, *ta mathēmata*, teaching the skills required to manipulate equipment, and how to measure, is valuable. The existential analytic

indicates the ontological barriers to such learning founded in *adaequatio*. There are many diverse beings which engage in the students' for-the-sake-of-which cascades and these beings carry truth into the students' comportment. Students comport to the total situation of signification, which probably does not involve physics.

If the criterion for engagement with physics is the moment of *alētheia*, abidance with an aspect of the Real, forced to reveal itself, then most students in a physics lessons fail to engage physics at all. This is an egregious concern, for the absence of the authentic experience leaves a student forever with uncertainly about the nature of physics. The example of student teachers challenged on their own engagement with physics, and thus their ontological understanding of physics is set out in chapter 6. In that chapter, the students' engagement with an aspect of the Real is their realisation that the spectrum of a prism is a rectangle and that the sides of that rectangle are a particular ratio that is given by nature. The moment of *alētheia* must involve in some way the revelation that nature abides by mathematics, in accordance with the prior projection of the situation, which is the distinctive fore-having of modern physics. Very few students achieve this: most manage to see a spectrum which is "pretty". Those that bring the elements together often fall silent. They cannot explain the truth of this gestalt moment, because the only form of truth available for explanations is *adaequatio*. Nor is there a word in common use that covers this particular formative experience of truth as disclosure.

Students are equipment

The existential analytic of students and their teacher at Hillary College suggests a remarkable conclusion – students are a part of the teacher's equipment. They are not passive other Dasein (see chapter 3, "Others like itself). Consistently, the analytic shows that Dasein-teacher engages with students as ready-to-hand beings and the formation of truth for these beings is a correspondence structure. Chapter 5 provides examples where the teacher's task relates to the institution (completion of the attendance register), to classroom management preliminary to engagement with ontic physics ("turn to page 89 in your textbook"), and to the development of skills preliminary to physics ("tilt the prism this way"). Further, one section explores the formations of beings involved when a teacher teaches a class of students as opposed to an individual student. Truth as correspondence, *adaequatio*, abounds in all these examples. All are common tasks when a teacher teaches ontic physics. For Dasein-

teacher the student is ready-to-hand, a part of the paraphernalia of the classroom, a tool available to achieve an outcome. Assessment practices for physics support this conception of teaching. Student grades become a proxy for efficiency that shows in the manipulation of equipment.

For Dasein-teacher, students are ready-to-hand beings, and not "other Dasein like itself". Confirmation of this may be sought in the distinction schools draw between students and teachers. These groups eat in different places, hold different responsibilities, and their separate status reflects in the management of schools. Dasein teacher closes off the Being-with-one-another that is characteristic of the Dasein-Dasein situation. There is "aloofness, hiding oneself away, or putting on a disguise", and to escape from this, special "routes" must be taken, which the existential analytic suggests in the activity of teaching are seldom taken (Heidegger, 1962a, p.161).

> Of course Being towards Others is ontologically different from Being towards Things which are present-at-hand. The entity which is 'other' has itself the same kind of Being as Dasein.... The relationship of Being which one has towards Others would then become a Projection of one's own Being-towards-oneself' into something else. The Other would be a duplicate of the Self. (Heidegger, 1962a, p.162)

From the point-of-view of the Dasein-teacher, there is an ontological taking to be achieved with respect to students. Dasein teacher must constitute the student in accordance with signification, which is always to be interpreted as within an equiprimordial totality. In the classroom, beings for Dasein teacher are in the main and for the most part, ready-to-hand beings. Once outside of the workplace, teachers may construe the beings of their students as other Dasein. When George in the analytic says to the teacher "Me brother saw you in the pub, Miss", he contravenes the totality, and seeks to constitute a new projection of himself, one which he hopes will be more favourable, and which the ontic psychologist will describe as more personal. This is the alternative projection to that which the existential analytic that chapter 6 alleges predominates.

That teachers cast students as paraphernalia is not a criticism of teachers. An existential analytic is always a description of what is found and not a normative assessment. Schools are institutions with a purpose in the Western metaphysical tradition and it is foreseeable from Heidegger's theory that teachers will align

themselves with that purpose, as chapter 4 indicates. However, caution is required in any attempt to draw a conclusion from existential analytic of the Dasein. As the opening of chapter 6 indicates, with the quotation from Heelan, in the hermeneutic tradition, philosophy is very personal, and each of us must assess the conclusions of others in our own terms and with reference to our own experience. Chapter 6 presents a small number of discrete enquires and a different group of inquiries may inspire different ideas.

The potential hidden within physics education

The enquiry into secondary school physics education supports Heidegger's general contention that those involved in the enterprises of modernity misunderstand their situation. Teachers perform in accordance with the current metaphysical structures that found and dictate the character of Western nations, communities, and families. Teachers embrace schooling the way that they embrace agriculture, aviation, city development, business, and living – with a belief in utility, progress and efficiency. This is akin to Toulmin's hidden agenda of modernity. When curriculum officials say that physics is useful, that it prepares students for employment, and that it contributes to the nation's economic wellbeing, the officials advance arguments that mislead us about the veritable nature of physics and its genuine potential. There may be instrumental benefits that accompany physics education, yet these relate to the accoutrements of modern physics and schools, and not to the essence of physics itself. From the human being's engagement with the essence of modern physics, nothing specific or practical follows.

What does occur when a student genuinely commits physics is that the disclosure works in the for-the-sake-of-which cascades of the Dasein in relation to disposition, and accordingly it is appropriate to say the Dasein dwells with modern physics. Dwelling with modern physics entails dwelling with an aspect of the Real and is an example of abidance that has a particular character. That character works through the for-the-sake-of-which cascades of the student. The comportment suggests that those who abide with modern physics, who have the experience of the disclosure involved, feel themselves to be closer to nature. Such a direct personal association with nature contrasts with the strictures of modern Western metaphysics. Physics is one of those activities or events which enable the Dasein to transcend its

circumstances. How physics teachers may teach for transcendence is the topic of the next section. It is the means to realise the hidden potential within physics education.

The ontological pedagogy of modern physics

This section sets out the parameters and principles of an ontological pedagogy for modern physics and indicates the practices a physics teacher might adopt. Any ontological pedagogy at present must be a Heideggerian pedagogy, until another theorist develops a further form of ontology that could facilitate pedagogy. When an existential analytic of Dasein provides the insights into ontological pedagogy it implies the use of Heidegger's theory. The term "hermeneutic pedagogy" also refers to Heideggerian pedagogy at present although potentially there could be another form of hermeneutic pedagogy derived from a different theorist.

Aspects of an ontological pedagogy to consider include the nature and scope of the prime aim (the disclosures of modern physics), the manner of involvement of truth as correspondence, the building of for-the-sake-of-which-cascades, and the relationship between this pedagogy and institutions.

Aim

In this pedagogy, the aim is to have each student abide with the truth of modern physics. This means the student will abide with the very beings that engage other physicists. The student will experience the forced disclosure of an aspect of the Real in accordance with the fore structures that are essential to modern physics. The students' task is to demonstrate to themselves the character of nature. The curriculum will show which specific disclosures of the Real each school year will involve, and the teacher will record evidence of student achievement according to that list. Classical modern physics – construed as the physics of Galileo and Newton – is ideal for the secondary school because there are many disclosures available for the list and the equipment required is minimal. Although not strictly essential to the pedagogy, students find the history of science of that time motivating.

As such, disclosures can only occur under very precise circumstances. The role of the teacher is to construct those circumstances, and this involves the teacher and the student with truth as a correspondence formulation.

The teacher

An analogy will elicit the involvement of the teacher in this pedagogy: A father takes his daughter for a walk in their garden. "Do you know where money comes from?" he asks the girl. After some banter, the father suggests money grows in gardens like this one, and the girl begins to turn over rocks, looking for money. With great delight, the girl discovers coins under rocks, and intensifies her search. In this narrative, the father prepares the ground, both by way of the placement of coins and by way of suggestion to the daughter. The daughter searches in accordance with the father's suggestion, but this nevertheless proceeds as an exercise of her own freedom for she brings her own ontological understanding and disposition to the activity. She need not search, and she cannot search beyond her capabilities (Kantian and Heideggerian). The discovery of a *particular* coin instances *alētheia* – the discovery is always of a coin, she does not discover the genesis of coins. The achievement of *alētheia* is to an extent an achievement of the father, but proximally, and necessarily, it is the daughter's unique achievement. Years later, the girl will tell her children about that very coin, her father, and the *alētheia* of her youth. *Rede* will abide with *alētheia* to facilitate this: she may speak in Maori or in French, or use any choice of words to describe the disclosure of the coin. Such details about how people achieve communication are of scant ontological interest. What is of cardinal importance is that the girl's instance of disclosure dwells as ontological understanding with ontological nomination.

The ontologically attuned physics teacher sets students in pursuit of the Real. Unlike the father, the teacher has no part in the construction of that which "is". The discovery – always abidance with *alētheia* – belongs to the student. According to both Galileo and Newton, God set up the Real that awaits our discovery. As Galileo said in *The Assayer*, the grand book of nature, the universe, is written in the language of mathematics and we must learn to read the book in its own language. Less effusively, we note that modern physics subscribes to realism – in an ontologically understood way that which the physicist discovers is not ourselves. Heidegger's account of realism, which recognises Kant's observation that we have limited access to reality, and emphasises the hermeneutic nature of our involvement with reality, is inherent in modern physics. "Reality" (with a capital R) appears in Heidegger's list of everything that "is", beings (see the quotation from Heidegger on page 7, and Kant's critical step towards Heidegger's conclusion on page 12). The strict

empiricists' view which Bridgman represents (page 6), renders the banter of the father irrelevant, when clearly it is essential to the events that unfold. Likewise, physics teachers must engage their students with truth as correspondence, because this is essential to the students' subsequent actions to elicit a disclosure.

The physics teacher in an ontological pedagogy of modern physics is similar to the father in the analogy. There are many preparations that must be made, but ultimately the student must be left to investigate and encounter the standards that nature imposes upon all physicists equally. This is what Heelan means with his statement that modern physics is natures' own science – it is not the science of the Dasein or the science of the physicist.

The "ground-plan" that the father establishes relates to Heidegger's vexatious analogy that chapter 4 features. Consistent with the schema of the girl there is laid out the garden and the notion of money. These make sense to the child, without interrogation. They are the "natural" world of the child as a being-in-the-world. There is also the constituent logic of the child, which is as legitimate as formal logic. Both arise from the inherent, covert logic of logic. The ground-plan also comprises of the ontological understanding that grounds all physical entities – the child searches in time and space and not in the recesses of her "mind". Nor does she try to remember that which she has yet to encounter. Also inherent in the ground-plan are those aspects of "bodying along" which Heelan identifies as ever-present constituents of science. They are first that the field of operations is a field within arm's length of the child. The child walks into the garden to establish this situation. Heelan enables us to recognise the importance of distance in physics, and the genesis of our notion of distance in the manipulations of the hand and fingers. The daughter understands distance in this way – a search within walking distance is achievable, and she can turn rocks that are (1) available and (2) within the grasp of her hand. Further, in these two dimensions is the involvement of that form of perception, a geometry, which derives from binocular vision and the capability to perceive objects of a particular kind (Heelan, 1983b, p.54 & p.282, for relevant insights). Physicists will think of wavelengths of light, but the daughter copes perfectly well without any such notion. The child physically searches for money, not for an abstract construction. She comports towards the total situation as set out in the ontological situation and which includes the ground plan for enquiry that the father generates. Should the father begin to turn over rocks and search for money, he would deny his

daughter the opportunity to achieve the truth inherent particularly in the first disclosure of money under a rock.

Physics is personal

What is the nature of the preparations that the physics teacher must make to have students achieve the aim of an ontological pedagogy? There are two answers to this question and it is the second that must concern us here because it relates to the practicalities of teaching. Mention should be made of the first answer for completeness. Earlier the present chapter recites some of the things that in so far as we take cognisance of them as what we already know them to be in advance. In *What is a Thing?*, Heidegger's example is a rifle, and how we must know in advance of learning about a rifle what a weapon is, otherwise we could not conceive of a rifle (Heidegger, 1967, p.72). Logic and mathematics in the sense of their originating formations with the Dasein are the leading examples in the present thesis, although there are several other examples (Babich, 1995, p.592). Of these things Heidegger says they must be known in advance, "must be learned, and must be teachable" (Heidegger, 1967, p.72). This remark does not mean that these things should be taught in schools. Heidegger is only indicating the nature of what is involved.

Now to the second answer to the question posed, what is the nature of the preparations that must be made to enable the student to achieve a particular disclosure? The task for the physics teacher is to facilitate signification that allows the truth of physics to presence. In other words, the physics teacher must facilitate the construction of for-the-sake-of-which-cascades that can involve the required disclosures. The existential analytics that concern Newton and students at Hillary College, demonstrate the extreme variability of for-the-sake-of-which-cascades. Even in the precise case, when students achieve the disclosure of a particular truth of modern physics they do so with diverse signification.

When the thesis rejects regional ontology and any account of physics as a distinct ontic discipline, that is, it rejects an identifiable set of propositions or observations as the foundation of modern physics, a concomitant conclusion is that it rejects the language of "openness" which Heidegger and others use. The language of openness is founded upon a region or a sphere opened up, which is the basis of regional ontology. The task of the teacher is not to have the student enter into a relationship with the discipline of physics (a region or sphere), but to enter into a

relationship with the Real. Signification could be the pathway to either of these options, but if the goal is that of the ontological pedagogy of modern physics the physics teacher must opt for the second option.

Accordingly, the teacher must attend to the for-the-sake-of-which-cascades of students, with the aim as indicated. Recall from the analogy of the father and the coins that the for-the-sake-of-which-cascades of students at the decisive moment of disclosure are beyond any current involvement by the teacher. The student is alone with the Real. The teacher can only facilitate aspects of the for-the-sake-of-which-cascades sought. The teacher can never control particular disclosures for students.

The existential analytics, and a little introspection, show that the beings involved in for-the-sake-of-which-cascades demonstrate human freedom and they are amenable to persuasion. Ontic psychologists say that it is possible to motivate students. However, the strategies to adopt in ontological pedagogy will be precisely tailored – not to the behaviour of the student – but to the comportment that is revelatory of a for-the-sake-of-which-cascade. The work of the physics teacher will appear similar to that of the psychotherapist. The teacher will probe all that relates to the way of being of the student and facilitate the construction of an orientation towards the required disclosures. In this the teacher must attend to both ontological understanding (which is to a large extent is embraced in the opening paragraph of the present section) and disposition. The disposition (*Befindlichkeit*) of the student as held by beings involved in for-the-sake-of-which-cascades appears to us as something intensely personal. Nevertheless, disposition is relevant to the truths of modern physics, and diligent physics teachers will incorporate disposition in their objectives. Such an objective will direct the teacher to ascertain the state of being of the student, and how this accords with the potential for the disclosure of physics. Extreme examples are obvious, for example the student whose father died yesterday is unlikely to place herself or himself in a position to abide with the essence of physics. It is, however, the more subtle examples that are common and they are equally relevant. Teachers may well consider this to be a re-formulation of the requirement that they concern themselves with the students' work habits, attitudes, and motivation. Now, however, the purpose of this engagement with the student is not to facilitate learning or the achievement of success in examinations. It is specifically, and only, to facilitate a particular disclosure. The ontological physics teacher who strays into any other purpose would be guilty of misconduct.

Demonstrations

Demonstrations perpetuate modern physics. It is through demonstrations that students achieve the truth of modern physics. Whilst the aim of the pedagogy of modern physics is *alētheia*, the pedagogy also involves truth as correspondence. The section entitled "The potential hidden within physics education" argues *adaequatio* hides the essence of truth in physics education and distracts teachers. Nevertheless, there is a requirement in physics research and physics education for *adaequatio*.

There are three arenas in which *adaequatio* holds relevance in relation to modern physics. First, truth is involved in the practical work required to establish and maintain the institutions of modern physics, which includes research institutions, universities, and schools. Physics administrators, managers, physicists, physics teachers, physics technicians, and physics students are all subject to rules that facilitate their institutions. Second, correspondence formulations of truth abound in all facilities that convey information from one person to another. Lecture theatres, textbooks, and academic journals all depend on the correspondence theory of truth. This arena particularly, although also the first arena, participate in the covering-over of the essence of modern physics. Teachers who adopt the hermeneutic philosophy of science as their philosophy of science will be able to do much to counter such concealment of modern physics.

The third arena for the involvement of truth as correspondence is that which relates to preparations for *alētheia*. Teachers must teach physics students to plan, to organise, to construct, to use equipment correctly, to observe, and to calculate. Such activities involve standards that constitute much of the ontic discipline of physics. The requirements include such things as the need to keep the workspace clean, honesty, physical skills, and the mastery of specific techniques such as those of error management. The correct use of equipment entails standards that are universal for those who participate in physics. The standards of physics do not derive from moral theory or the conventions of civil society. They derive from the bestowed character of reality which presences in the event of *alētheia*. If the physics demonstration does not produce *alētheia*, it fails not because of some inadequacy of nature, but because of a student's failure with respect to *adaequatio*. Reality is unforgiving, but always available to respond to further efforts.

The event of modern physics occurs within a demonstration. The student deliberately manipulates equipment to abide, or to dwell, with the very beings that

engage others. Modern physics, of and in itself, in its essence, is not experimental. The aim is not to produce and prove, or disprove, an hypothesis. An hypothesis is always an assertion that holds forth *adaequatio*. Experimentation may be a road to discovery, but it is not a mandatory or dependable path. The pragmatic, pluralist, and relativistic theories that minimise the importance of truth, or deny truth, emphasise procedures that physicists may adopt, in original discovery. These procedures of enquiry are not essential to physics. The existential analytic, Newton's ontological biography, suggests that he physically engaged with equipment until the phenomena eventually appeared in a dramatic moment, *alētheia*. Once reality reveals more of itself to someone, humanity partakes of the opportunity the method affords. The construction and testing of student hypotheses diverts attention away from the reservoir of experiences that involve *alētheia*.

Prospects

The ontological pedagogy of modern physics – the theory of teaching implicit in the hermeneutic philosophy of science – has an assured future. There will always be students and teachers who seek to discover truth. Kant, Heidegger and Heelan indicate the prospects for, and the limits of, our involvement in modern science, whilst the present thesis shows what this implies for physics education. Yet it would be naïve to suggest that this pedagogy will entrench itself in systems of schooling that facilitate Western metaphysics. Since the industrialisation of Western nations, our thinking has increasingly congealed into a calculation of the useful. It is unnecessary to understand the essence of physics to use the ontic discipline of physics for many purposes. The unique disclosure of physics is not of itself useful, whilst work preparatory to the disclosure carries with it incidental benefits, which in the case of physics students includes the development of skills for employment and the mastery of information that educators may assess.

This thesis began with the claim that physics education misunderstands its task. It argues that the inauthenticity of physics education is apparent when we discern the truth of modern physics, *alētheia*, in accordance with the hermeneutic philosophy of science. The difficulties derive from the way that schools teach physics without reference to truth or reality. *Alētheia* in physics affirms reality and *alētheia* in physics education affirms the physics teacher as the one who promulgates a distinctive human commitment to reality. The thesis leaves much unsaid or

undefended, nevertheless it opens doors to further thought and innovative practice in physics education. The immediate task is to develop the science teachers' discussion about the nature of science. The hermeneutic philosophy of science could become a topic in the philosophy of education courses that universities provide in teacher pre-service education. Science teachers could follow the example of Galileo and Newton, and demonstrate to others the human potential to dwell with facets of reality, and thereby perpetuate physics.

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