**Foundational Development of Emergence**

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**Abstract** This paper presents a non-standard approach to emergence that describes the foundational stages of the development of emergence, including the factors that initiate the progressive stages of its development. Observing that emergence is a naturally occurring creative process in the universe, the focus of the paper is a strictly realist analysis of the intrinsic qualities of emergence. Emergence brings things into existence, things such as objects, qualities, relations, and systems. The process of emergence develops, becoming increasingly complex as additional factors come to play roles in the process. The paper describes a diagram of the foundational stages of the development of emergence that shows what additional factors initiate the progressive stages of its development. The diagram displays the origins of factors such as the contact relation and the cause relation, among others. Factors that originate in the stages of the foundational development of emergence play roles in the forms of emergence that occur in highly complex situations like geology, biology, sociology, ecology, and cosmology. Understanding the foundational stages of emergence can enhance understanding in all the disciplines. The paper explains how emergence is a component of science based transdisciplinarity. It presents a new paradigm for understanding the intrinsic nature of emergence. The intention is to make the understanding of emergence useful by way of a strictly realist approach based on observation. The goal is to provide scientists with a practical method for the identification and mapping of emergence in systems of interest.

**Keywords**: emergence, emergent product, creative process, development, cause, realist, origins, transdisciplinarity, integrative transdisciplinarity, transdisciplinary

**INTRODUCTION—History and Context**

“Transdisciplinarity is the highest form of integration and generalization of knowledge about the world. Therefore, it can be argued that transdisciplinarity is a way of expanding the horizon of human and scientific worldview, allowing you to see and describe the world in all its diversity.” (Mokiy, 2019). Understanding the intrinsic nature of emergence is required to achieve transdisciplinarity because it is the process of emergence that creates the hierarchic organization of the universe from elementary particles to galactic clusters(Vesterby, 2011, 2012).

The material component of the universe is hierarchically organized—from protons, atoms, and molecules to planets, stars, and galaxies—from organelles, cells, and organisms to social systems and ecosystems—level by level, with the deep-structure of each higher level composed of all the levels below it all the way down to the foundational level of elementary particles.

In general, the various disciplines of the sciences and humanities study specific levels, or groups of closely related levels. Due to the immense quantity and diversity of components and relations that occur at each level, it has become increasingly difficult to know and understand more than one or two levels.

The disciplines have become increasingly specialized, intellectually isolated from one another, rendering communication between the disciplines increasingly difficult. This problem with communication has had serious consequences. Humanity is now faced with large complex multifactorial problems such as climate change, adequate health care, and pollution, that require input for solutions from many disciplines—disciplines that cannot communicate effectively with one another.

Transdisciplinarity was called upon to help with this communication issue because enhancing communication is a big part of what transdisciplinarity does. However, from the beginning the development of transdisciplinarity has followed two different paths. One path was focused on the integration and generalization of knowledge about the world, which enhance communication between the disciplines of science. The other path has been focused on communication between members of large teams put together to develop solutions to the large complex multifactorial problems.

It turned out that what is required for integration and the resulting enhanced communication between the sciences is quite different from what is required for effective communication between the members of the teams for solving the large problems. These teams typically include people from diverse backgrounds having diverse viewpoints about the problem—people from government, academia, business, practitioners and tradesmen, and people who will benefit from the solution—diverse stakeholders in the development of the solution.

The challenge of communication within the teams was met head-on by putting the teams together and working hard developing methodology to improve the communication. The challenge for integration and generalization of knowledge stalled out. No one knew what to do, although clues were found.

Piaget suggested transdisciplinarity for integration and generalization, but admitted he did not know how to do it.

Finally, we may hope to see a higher stage succeeding the stage of interdisciplinary relationships. This would be “transdisciplinarity”, which would not only cover interactions or reciprocities between specialised research projects, but would place these relationships within a total system without any firm boundaries between disciplines.

While this is still a dream, it does not seem to be unattainable . . . (Piaget, 1972)

Mokiy noted,

At modern rates of development of the human consciousness, science, and technology, it was possible to expect that comprehension of bases of transdisciplinarity and the description of its identification signs should be completed. However, in the direction of transdisciplinarity for science,” this did not happen (Mokiy, 2019).

Brandt pointed out in 2013 that “While transdisciplinary research is growing, there is no common glossary, no focused communication platform, and no commonly shared research framework (Brandt et al., 2013).

According to Bergmann and Jahn,

Recent years have seen the development of new approaches and framings in an attempt to strengthen the effectiveness of research in societal transformations. One consequence has been a weakening of the theoretical foundations of transdisciplinary research. Research that draws on the transdisciplinary research mode tends to transition from *a scientific approach* to the *mere application of participatory processes*. (Bergmann & Jahn, 2019)

Piaget correctly identified what would be the source of the route to integrative transdisciplinarity.

As for defining what such a concept should cover, it would obviously be a general theory of systems or structures including operative structures, regulatory structures and probabilist systems, and linking these various possibilities by means of regulated and definite transformations (Piaget, 1972).

It was Bertalanffy’s treatment of isomorphy in his general systems theory that opened the way to integrative transdisciplinarity (Bertalanffy, 1968). Vesterby described this transition from isomorphy to transdisciplinarity (Vesterby, 2012).

An isomorphy is a pattern-of-organization of structure or process that occurs in two or more different situations and plays a role in the intrinsic nature of the situations in which it occurs. What is known about the role of an isomorphy in one situation can be used to enhance the understanding of a different situation where that isomorphy also occurs and plays a role in the nature of that other situation. What is known about the role of a molecule in one situation can be used to enhance the understanding of a different situation where another molecule of that type is also playing that role. In this example the isomorphic molecules are playing their role in two situations that are at the same hierarchic level, that of chemistry.

Throughflow is an isomorphy. Throughflow occurs when matter, push, or pattern-of-organization, or some combination thereof, passes through an object, system, or situation. Throughflow is an isomorphy that occurs in many diverse situations. It occurs in Newton’s cradle with the flow of push from sphere to sphere to sphere. It occurs with the flow of a river through a valley. It occurs with the flow of blood through the circulatory system. It occurs with the flow of energy through a living organization, through an economic system, through an ecosystem.

Throughflow is an isomorphy of particular significance because the flow of energy alters the matter it flows through and blocking matter alters the flow of energy. Flowing water plays a major role in geology through chemical alteration of rock, erosion, and transport of sediments. Metabolism and growth in organisms are due to the throughflow of energy.

Each of the above examples occurs at a different level of hierarchic organization. Throughflow occurs at and plays its roles at different levels of the hierarchic organization of the world. Thus, it plays its roles in diverse disciplines. So, what is known about throughflow and its roles in one discipline can be used to enhance understanding in another discipline where throughflow also occurs.

That is knowledge that crosses disciplinary boundaries—discipline independent knowledge—integrative transdisciplinarity.

Emergence is an isomorphy(Vesterby, 2017). The process of emergence creates new pattern-of-material-organization due the motion of matter(Vesterby, 2011). Everything that exists is in its deep-structure composed of elementary particles, atoms, and molecules. The difference between one thing and another is which of these foundational components are present, how many of them there are, and their particular patterns-of-organization. It is the process of emergence that determines the pattern-of-organization. That process creates new atoms, molecules, and new materials. It creates new rocks, organisms, ecosystems, planets, and stars.

As with throughflow, these examples occur at different hierarchic levels. Different disciplines study these various levels. Because knowledge of the process of emergence is relevant in these various disciplines, it is cross disciplinary, a part of integrative transdisciplinarity.

Isomorphies such as throughflow and emergence, that play their roles in two or more disciplines are examples of discipline independent knowledge and constitute discipline-independent-transdisciplinarity (Vesterby, 2012).

Emergence, as a constituent of discipline-independent-transdisciplinarity, plays an additional transdisciplinary role beyond isomorphy. It is a role that directly connects knowledge of one situation with knowledge of another situation. Specifically, it is a role that directly and seamlessly connects one discipline with another discipline, thus transforming transdisciplinarity into one coherent body of knowledge, with the disciplines distinct but lacking artificial boundaries between them. It is here that understanding the development of emergence plays a required role for achieving integrated transdisciplinarity.

The vast majority of isomorphies play roles that are useful for enhancing knowledge in various situations. But those situations are usually separate, isolated from one another. Isomorphies of this kind generally do not have unifying roles for transdisciplinarity.

The unifying role of emergence is due to its intrinsic nature as a process. When a newly occurring pattern-of-material-organization comes into existence, that event of emergence is a consequence of the prior occurrence of a creative process.

Molecules are composed of atoms. Atoms and molecules are examples of two distinct levels of hierarchic organization. When, in the process of emergence, two atoms come together and join into a newly existing coherent object, a molecule, the coming together and joining is a continuous process. The molecule is a newly existent, newly emergent, pattern-of-material-organization. It is not only a new object, it is a new occurrence of the molecular level of hierarchic organization—a molecule as the top level with component atoms as a lower level.

The process of emergence here creates a new occurrence of a level of organization, and it does so through a continuous process. There is continuous existential connection throughout the process from beginning to end. This continuous ongoing pathway of progressing change is existential-pathway-development. The creative transition from a lower hierarchic level to a higher level occurs by way of existential-pathway-development.

The process of emergence creates hierarchic organization by way of existential-pathway-development.

The hierarchical organization of material reality—from protons, atoms, and molecules to planets, stars, and galaxies—from organelles, cells, and organisms to social systems and ecosystems—is the result of the process of emergence.

Each hierarchic level has it intrinsic qualities and characteristics, its potential based on those qualities for new kinds of relations with other things that exist. The various disciplines study the qualities, characteristics, and potential relations of the various levels of the hierarchic organization of the universe. Because the process of emergence creates the hierarchic organization of the universe, it thereby creates the subject matters studied by the various disciplines.

The process of emergence creates the hierarchy of the world by way of existential-pathway-development from protons and atoms to galaxies and galactic clusters. This universally ubiquitous process creates the subject matters of the disciplines by way of continuous existential-pathway-development.

Existential-pathway-development is a continuous sequential process. Emergence creates the subject matters of the disciplines in a continuous sequential manner, level by level, the levels sequentially developing from one to another, as with physics, chemistry, geology, and planetology.

By diagraming the existential-pathway-development of the process of emergence, it is possible to map the existential-pathway-development of the subject matters of the disciplines as they develop from one another.

The process of emergence develops, occurring in simpler forms in simpler situations where few other factors are playing roles, and occurring in more complex forms in more complex situations where greater numbers of other factors are playing roles. Because each emergent level has emergent qualities that play roles in the emergence of the next level, the process of emergence develops as it creates hierarchic organization, changing with each stage due to the roles of these additional factors.

Mapping out the existential-pathway-development of the disciplines will also map out the development of the process of emergence as it becomes increasingly complex due to the increasing complexity of the levels it is creating. Emergence at the level of physics is simple relative the complexity of emergence at the level of the microbiology of a cell, or relative to the interrelating complexity of the many forms of emergence that play roles in biological evolution.

The development of emergence from the simple forms to the highly complex forms can be described and diagramed using the type of diagram used in this paper to describe the foundational development of emergence.

Emergence, in creating the continuous hierarchic order of the universe by way of the existential continuity of existential-pathway-development, establishes the integration of transdisciplinary knowledge.

That integration of transdisciplinary knowledge can also be described and diagramed using that type of diagram, which displays an existentially continuous sequence of developmental relations.

**INTRODUCTION--Emergence**

It is the intention here to describe emergence in a strictly realist manner to provide scientists with a practical method for the identification and mapping of emergence in systems of interest.

Emergence is a naturally occurring creative process that brings things into existence—objects, qualities, relations, systems (Vesterby, 2011, 2017, 2019a, 2019b). Following the foundational progressive development of this creative process reveals the fundamental sources of newness in the universe and the origin of cause. The process of emergence is universal, playing its roles at all levels, from the subatomic to the intergalactic. Following the development of the process of emergence up through the realms of physics, geology, biology, ecology, all the way to cosmology, reveals how the foundational sources of newness and cause play roles that enable the occurrence of complex forms of newness such as occurs with biological evolution, and complex causal relations such as those of systems. Thus, emergence is relevant in every discipline, and is a core component of transdisciplinary research. Because emergence is a naturally occurring process in the universe, it can be objectively observed and described.

**The intrinsic nature of emergence**

Everything material that humans experience is composite in nature, composed of subunits—parts, molecules, atoms, subatomic particles. The specific kinds of subunits involved and the specific manner in which they are organized determine the intrinsic nature of a material situation. They determine the pattern-of-material-organization that is the physical basis of the situation. Any change in the subunits or their organization will have the consequence that a different newly occurring situation will come into existence—a different newly occurring pattern-of-material-organization will emerge.

In its simplest form, emergence is the coming into existence of newly occurring pattern-of-material-organization due to the motion of matter. Motion is required for the process of emergence in two ways. First, for there to be a change in the organization of the pattern, one or more units must move. Second, for there to be a change in which units are components of the pattern, the units must move to join the pattern or to leave it.

The emergent event, the new occurrence of a pattern-of-material-organization, is the consequence of the process of emergence. Foundationally, the process of emergence consists of a component of a pattern-of-material-organization moving to a different location which has different distance and direction relations to other components of the pattern. Changing the distance and direction relations changes the organization of the pattern, which results in the coming into existence, the emergence, of a newly occurring pattern-of-material-organization.

Emergence develops, occurring in simple form in situations where few factors are playing roles in the process of emergence, and occurring in more complex form in situations where more factors are playing roles in the process. The process of emergence develops by way of additional factors coming to play roles in the process. Foundationally, the process of emergence is simple, but rapidly develops in complexity as additional factors join the process, until eventually emergence occurs as the highly developed, highly complex process of biological evolution.

Many different factors play roles in association with motion in the development of the process of emergence. Initially the development of the process of emergence from stage to stage is based on various factors of the motion of a component of a pattern-of-material-organization in relation to other components of the pattern. The situation is foundational for emergence—emergence in its simplest forms. But with each change of the way the motion occurs in relation to the other components, the nature of the process itself changes, resulting in different ways in which the emergent pattern is created:

1. Motion of a component passing by another component.
   1. Motion of a component getting closer to another component.
   2. Motion of a component passing through the point of closest approach.
   3. Motion of a component getting farther away from another component.
2. Motion of a component directly at another component.

NASA’s Double Asteroid Redirection Test (DART), which is testing methodology to protect the earth from serious asteroid impact, is a consequence of these patterns—asteroid approaching earth; asteroid passing through point of closest approach; asteroid moving away; asteroid moving directly at earth. These simplest of patterns then develop with the roles of additional factors.

Eventually, motion directly at another component brings the components into adjacent relation wherein there is no space between the components, and the components come into contact with each other. Prior to this, the relations between the components were strictly organizational—pattern-of-material-organization based on distance and direction relations. The contact relation is based on something more than the organizational relation of two components being in adjacent relation with one another.

Contact is a relation between the substantiality of one material component and the substantiality of another material component. Because the nature of contact is due to the nature of substantiality, it is a supraorganizational-factor, a factor that exists in addition to organizational factors. Two important points follow from this. First, is the development of emergence from a process that creates newly occurring patterns-of-material-organization to a process capable of resulting in the emergence of supraorganizational-factors. This is a major development for the process of emergence. Second, just as emergent products, such as groups, can play roles that cannot be played by their individual separate components, supraorganizational-factors can play roles that are beyond the types of roles organizational-factors can play.

These five roles require the additional supraorganizational nature of substantiality:

* Contact.
* Push (the basis of cause).
* Coherence (units of matter sticking together).
* Coherent structure.
* Complex processes and systems (based on causal relations among coherent structures).

A great diversity of factors play roles in the process of emergence. This results in many different kinds of emergent patterns-of-material-organization, many kinds of emergent products, from the simple change in the distribution of a group of objects in space, to the emergence of a new species of organism, or to the emergence of a star or planet or galaxy. Whatever other factors play roles that determine the specific nature of the emergent product, every case of emergence, no matter how simple or how complex, is, at its core, based on change in pattern-of-material-organization due to the motion of matter. That is, motion to different location with different extensional relations resulting in new pattern occurs within all cases of emergence, giving them their intrinsic-identities as cases of emergence.

Because essentially all matter, throughout the universe, is moving, emergence is everywhere. Wherever you are, wherever you look—there it is. Emergence is one of the universals—factors that are essentially omnipresent throughout the universe.

**On Method**

This paper presents a diagram of the foundational development of emergence from its simplest form to the various forms of contact initiated emergence. The diagram spreads out the development, identifying 12 factors that initiate stages in the early development of the process of emergence.See Figure 16 for the diagram of the foundational development of emergence.

The utility of this approach is that it presents a visual map as well as the identification of factors, such as sequential-enhancement, transformation-point, combinatorial-enhancement, and throughflow that initiate the stages of the foundational development. In more developed situations these foundational factors can be used to provide insight into any material change. For example, transformation-points are the most common source of unexpected consequences, combinatorial-enhancement results in the origin of the hierarchical organization of the universe, and throughflow initiates the complexity of the biological organization of organisms and ecosystems. These factors, and a few others such as cause and coherence, that order the universe, originate, literally emerge, in the first stages of the development of the process of emergence.

Emergence is a creative process. One goal here is to explain why emergence is creative, and to point out the kinds of creative roles it plays in the universe. To understand the why of this creative quality of emergence it is necessary to understand consequent-existence and structural-logic.

Consequent-existence occurs when something exists simply as a consequence of the existence of something else. If the one thing exists, then the other thing exists. There is an existential-dependency relation between the two. The existence of the one is dependent on the existence of the other.

Consequent-existence is a precursor of cause. While it has some of the qualities of cause, it does not have enough of those qualities to be cause. Cause is a developed form of consequent-existence with several additional factors playing roles to make it what it is. That is, consequent-existence is only one of several factors that constitute cause.

The manner in which consequent-existence occurs is simpler than the manner in which cause occurs. With consequent-existence, when the one thing is there, the other thing is there too. The one thing does not make the other thing be there—it is just there. Basically, with consequent-existence force or energy is not required. With cause, the one thing makes the other thing be there. With cause, force or energy is always required—one of those additional-factors that constitute cause.

It is important to use consequent-existence as a mode of understanding for two reasons, first because the beginning stages of the foundational development of emergence are creative by way of consequent-existence, and second, because like most factors, consequent-existence develops, playing roles in multiple forms and stages of emergence. It occurs developmentally prior to emergence. It occurs in the basic foundational process of emergence. It occurs in the development of emergence from stage to stage. And it occurs in more highly developed stages of emergence, from stages of structural organization all the way to the complexities of emergence in biological evolution. The following paragraphs give some examples of consequent-existence at different stages of emergence.

Consequent-existence plays a role developmentally prior to emergence when the continuing-existence of space occurs as a consequence of the existence of space.

It plays a role in the basic form of the process of emergence. When a component of a pattern-of-material-organization moves to a new location, the component has, as a consequence of occupying that location, the extensional relations of that location with the other components of the pattern, and, when the extensional relations of a pattern-of-material-organization change, a new pattern emerges as a consequence.

Consequent-existence occurs as the primary creative factor in the first few stages of the development of emergence when the emergent event at each stage is a simple consequence of the role of the additional factor.

And it occurs in more developed situations. For example, from geometry, when two straight lines cross, an angle is formed between the lines. The angle exists as a consequence of the existence of the crossed lines. No force is required. When the lines are crossed, the angle is just there.

Another example from geometry led to the recognition of consequent-existence in biological evolution, which is the most complex occurrence of the process of emergence that is known. When a circle fills a square there are somewhat triangular spaces in the corners of the square between the line of the circle and the lines of the square. These spaces are called spandrels, and are consequences of the shapes of the circle and the square in position together. Spandrels occur in developed form, in structural form, in architecture when an arch occurs within a rectangular frame.

Stephen Jay Gould noticed the consequent-existence relation between spandrels and the surrounding architecture in a church in Venice. The spandrels were "necessary architectural byproducts of mounting a dome on rounded arches” (Gould & Lewontin, 1979). He suggested that there could be features of organisms that were byproducts of other features that were the results of selection. As simple byproducts, they were not themselves results of selection—they were consequent on the occurrence of the evolved features. A factor that originates developmentally prior to emergence, and then plays a dominant role in the early stages of emergence, is here playing a role in highly complex emergence.1

Structural logic is the manner in which the intrinsic qualities of something that exists determine the kinds of relations that something can have with other things that exist (Vesterby, 2008). A cube with its flat surfaces slides down an inclined board, while a ball with its curved surface rolls down.

Throughout the process of emergence, from the initial qualities of the components to the coming into existence of the emergent product, it is structural logic that determines the nature of each relation, the nature of each consequence—the nature of each step in the process. Structural-logic provides understanding of why consequent-existence occurs.

The process of emergence is determinate in that the existence and intrinsic qualities of what goes before determine, by way of consequent-existence and structural-logic, the existence and intrinsic qualities of what follows. (Another universal) The existence and intrinsic qualities of the components and their interrelations determine the existence and intrinsic qualities of the emergent product. Because it is structural logic that plays the determining role in this manner, it is structural logic that answers the why questions.

Consequent-existence and structural-logic play roles in both the development of emergence, as depicted in the diagram, and in individual cases of the process of emergence as they progress from components to emergent product. By noting the intrinsic qualities of things, systems, and situations that are under investigation, and observing the manner in which those qualities determine the consequent relations, it is possible to use structural logic as a conceptual tool of investigation. It can be used as a method of reasoning about relations between things. As a method of reasoning, it tends to be accurate because the order of the reasoning is based directly on the intrinsic order of what is being investigated. The structural logic used to analyze a situation is the structural logic of the situation itself.

Structural logic is a natural feature of the universe. Every relation of every kind, throughout the universe, is determined by structural logic. Because structural logic is one of the universals, omnipresent throughout the universe, it plays its role in the subject matters of all the disciplines. Because emergence develops, becoming more complex with the roles of additional factors, emergence becomes compatible with all the disciplines as the various factors of each discipline come to play roles in the process of emergence. The use of structural-logic and emergence as analytical tools is thereby a transdisciplinary mode of thinking and investigation (Vesterby, 2012).

The body of this paper discusses a diagram of the foundational stages in the development of emergence. The diagram is intended to draw attention to the structural-logic that determines the stages of that development. Thus, it is intended that the diagram be understood in terms of structural logic. The diagram is designed to show that a particular factor results in a particular stage or emergent product in the development of emergence. The diagram is additionally designed to provide understanding of why the emergence of a particular stage or product is the consequence of the role of a particular factor.

**THE FOUNDATIONAL DEVELOPMENT OF EMERGENCE**

**Development**

Development is sequential difference through space and structure, through time and change. Sequential difference is a universal—omnipresent throughout space, time, matter, and change. There is an immense variety of different forms of sequential difference, and essentially every form plays a role somewhere at some stage or other of the development of emergence.

Progressively along any form of sequential difference there occurs more of whatever constitutes the sequence. This *more*, in whatever form it occurs, is an enhancement of the situation. The *more* that is a consequent of sequential difference plays roles throughout emergence, constituting a core factor of why emergence is creative.

Over the course of its development, emergence tends to become increasingly more complex in a sequential difference pathway from the simple to the complex, a continuous existential-pathway-development. The primary factor that contributes to this development are the additional factors that contribute their roles to the process of emergence.

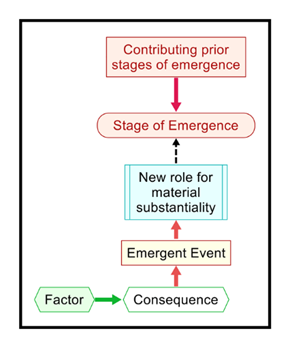
Because emergence is based on motion, and motion is matter passing through space, there are several foundational forms of sequential difference that are basic to emergence. There is the path of sequential difference through the spatial place the moving object passes through. Motion is a form of continuously ongoing change, and there is the sequential difference of that continuous change. The continuously ongoing change of motion takes time to occur, and there is the sequential difference of continuously changing time.

While the sequential difference of spatial place, the sequential difference of ongoing motion, and the sequential difference of continuous time are necessary for emergence to occur, these three factors are only contextual for emergence. Emergence occurs in space, over time, due to motion, but their combined occurrence does not constitute emergence. Foundationally, emergence is change in pattern-of-material-organization—the coming into existence of a newly occurring pattern. There must be, additionally, pattern-of-material-organization. A pattern-of-material-organization consists foundationally of units of matter, objects or systems, occupying space and having spatial distance and direction relations between them. The simplest pattern consists of two units of matter separate from one another.

**Legend**

As shown in the *Legend*, there is a four-step sequence that occurs with each stage of the development of emergence (Figure 1). (See Figure 16 page 34, for full diagram of Figures 1 – 15 connected.)

1. The occurrence of an additional factor playing a role in the process of emergence.
2. The consequent change in the process due to the role of that factor.
3. The emergent event—the coming into existence of a newly occurring pattern-of-material-organization.
4. The emergence of another stage in the development of emergence.



**Fig. 1** Legend—Pathway of relations in the process of emergence

Occasionally, the process of emergence results in the coming into existence of a new role for the substantiality of matter. When this happens, the nature of emergence develops from a process capable of creating newly occurring patterns-of-material-organization to a process capable of creating supraorganizational-factors. Substantiality is a supraorganizational-factor because it has intrinsic qualities that are more than merely organizational in nature. Supraorganizational-factors can play roles that are beyond the types of roles organizational factors can play. When the process of emergence creates a supraorganizational-factor, this is indicated by an additional fifth box in the four-step sequence.

Above the Stage of Emergence box there is a box with a downward pointing arrow. This box contains the names of prior stages of emergence that are playing roles in the occurrence of the current stage.

**Additional factor—Motion**

When an object, that is a component of a pattern-of-material-organization, moves to a different location in space, the object then has, as a consequence, the extensional relations of distance and direction with the other components of the pattern that the newly occupied location has with the other components of the pattern. Because the extensional relations between the components of a pattern-of-material-organization together constitute the pattern, any change of those extensional relations results in a change in the pattern. When a component of a pattern moves to a different location with different extensional relations, that changes the pattern-of-material-organization. A newly occurring pattern that was not there before comes into existence—a new pattern emerges (Fig. 2).

Diagram

Description automatically generated

**Fig. 2** The additional factor, motion, results in the emergence of newly occurring pattern-of-material-organization due to the basic process of emergence

Emergence is a creative process. The process of emergence creates newly existing patterns-of-material-organization. It brings something new into existence that was not there before. The process of emergence is a source of newness in the world.

In the general development of the universe from the simple to the complex, there are two developmentally prior sources of newness—continuing-existence and motion. They both, each in its own way, bring something new into existence that was not there before. Both continuing-existence and motion exist as forms of ongoing change. In each case, the ongoing change occurs continuously and sequentially.

Things exist, and they continue to exist. A rock exists—it is there, and it continues to be there. The earth exists—it is there, and it continues to be there.

Continuing-existence occurs continuously and sequentially. You can hold a rock in your left hand, and then, as the rock continues to exist, you can switch it to your right hand. During the part of the continuing-existence of the rock when it was in your left hand, the part of the continuing-existence of the rock when it was in your right hand was not occurring—you had not yet switched the rock over to the right hand. When you switched the rock to your right hand, and the part of the continuing-existence of the rock when it was in your right hand was then occurring, it was newly occurring—new part of the sequentially continuous ongoing continuing-existence of the rock.

With continuing-existence, when the current part is occurring, the following part does not exist—it is not yet occurring. When the following part does occur, it is newly occurring—newly existing. With the occurrence of new part of continuing-existence, continuing-existence is a source of newness in the universe.

Since everything in the universe that exists and is continuing to exist has this quality of sequentially continuous new part of continuing-existence, newness is one of the universals—omnipresent newness throughout the universe. The entire universe, as it continues to exist, is continuously new.

Continuing-existence is the fundamental, the foundational, source of newness in the universe. All other sources of newness occur in the context of, and concurrently with, the newness of continuing-existence.

Space exists. Setting aside all forms of speculation, setting aside hypothesis and theory, space can be observed. The space between objects can be observed. A hand can be passed around in that place. Space is place. An object can be put in that place. If the objects on each side are removed, the spatial place is still there. A hand can still be moved around there and an object can still be put there in that place.

Space not only exists—it continues to exist. It is possible to continuously observe space continuing to exist. Continuing-existence is an isomorphy. As with all cases of continuing-existence, with the continuing-existence of space when the current part is occurring, the following part does not exist—it is not yet occurring. When the following part does occur, it is newly occurring—newly existing. With the occurrence of new part of spatial continuing-existence, spatial continuing-existence is a source of newness in the universe.

Motion is matter passing through space—a continuous, sequentially occurring form of ongoing change. With motion, when the current part is occurring, the following part does not exist, it is not yet occurring. When the following part does occur, it is newly occurring—newly existing. Thus, motion is a source of newness in the universe.

Motion not only exists—it continues to exist. Motion has two forms of ongoing continuance, ongoing change. There is the ongoing continuance of the motion itself as it progresses through space. This form of continuance can be measured with a ruler of kind. Then there is the continuance of the continuing-existence of the motion, how long the motion continues to occur, its duration. This form of continuance can be measured with a clock.

Motion, then, has two forms of newness. The newness that occurs with new part of ongoing motion, and the newness that occurs with the new part of the ongoing duration of the motion, the new part of the ongoing continuing-existence of the motion.

Space exists, it is there, and it continues to be there. Motion exists, it is there, and it continues to be there—it occurs, and it continues to occur. As matter passes through space, the continuing-existence of the motion occurs in the context of and concurrently with the continuing-existence of the space the motion is passing through. New part of the continuing-existence of the motion occurs in the context of and concurrently with the new part of the continuing-existence of the space the motion is passing through.

Space provides an extensionally three-dimensional place where motion can occur. And the continuing-existence of space provides a place where the continuing-existence of the motion can occur. The continuing-existence of the place where the motion occurs provides a sequentially continuous changing context where the sequentially continuous change of the continuing-existence of the motion can occur. The continuing-existence of space is here playing the role of time for the occurrence of motion (Vesterby, 2019c).

Without a spatial place in which to occur, motion could not exist. Without the sequentially continuous change of the continuing-existence of the place where the motion occurs, the sequentially continuous change of the continuing-existence of the motion could not occur.

Thus, the continuing-existence of the space, and the form of newness that results from the continuing-existence of space, play roles with the continuing-existence of motion, and with the form of newness that results from the continuing-existence of motion. It is common for the forms of factors as they occur in prior stages of their development to play roles in fallowing stages. The continuing-existence of space, and its consequent newness, play roles with the continuing-existence of motion, and with its consequent newness. Both the continuing-existence of space with its form of newness and the continuing-existence of motion with its form of newness play roles with the continuing-existence of the process of emergence and with the newness that results as a consequence of that process.

The foundational process of emergence provides a third, developed, source of newness in the universe in which both continuing-existence and motion play roles. Another developed source of newness, a developed form of emergence, is the process of growth, in each of its varied forms, such as accumulation of grains of sand to create a sand dune, accumulation of atoms or molecules to create a crystal, or accumulation of cells to create a living sponge. The process of biological evolution, as it creates new species of living organisms, is a highly developed source of new things coming into existence that were not there before. Evolution, also, is a developed form of the process of emergence.

**Additional factor—Continuously ongoing motion**

Newly existing pattern is the consequence of the occurrence of motion. Because motion, as it occurs, is continuously ongoing, the change in distance and direction relations occurs continuously as long as the motion continues. The consequence is the continuous emergence of new pattern-of-material-organization (Fig. 3).

Ongoing motion occurs in a sequential manner. The changing distance and direction relations as a consequence change sequentially, which sequentially changes the pattern-of-organization. There is continuous sequential emergence of new pattern.

Along any sequence there is progressively more of whatever it is that constitutes the basis of the sequence. Whenever there is more of something in a situation, more space, time, matter, motion, emergence, structure, process, etc., that *more* constitutes an enhancement of the situation.

* Enhancement occurs with ongoing motion in the form of new part of the motion.
* Enhancement occurs with sequentially changing distance and directions in the form of the newly occurring distance and direction relations.
* Enhancement occurs with sequentially changing pattern-of-material-organization with the coming into existence of newly occurring pattern.

Here emergence is based on sequential enhancement. Emergence due to sequential-enhancement is the basic form of emergence as it occurs throughout the universe.

Diagram

Description automatically generated

**Fig.** **3** The additional factor, continuously ongoing motion, results in the emergence of sequentially continuous emergence of newly occurring pattern-of-material-organization by way of emergence due to sequential-enhancement

Emergence is based on motion—is a consequence of motion. Because all matter in the universe is moving in one way or another, the entire material universe is constantly emerging. The organization of the entire material universe is continuously new.

**Additional factor—Motion of one object passing by another object**

This section discusses cases of emergence where the direction in which the object is moving relative to another object can play a significant role in the type of emergence that occurs. Motion on a trajectory that passes by another object involves three forms of emergence—depending on the various factors playing roles that change the nature of the process of emergence (Fig. 4).

* Emergence due to sequential-enhancement based on decreasing distance relation.
* Emergence due to transformation point.
* Emergence due to sequential-enhancement based on increasing distance relation.

Diagram

Description automatically generated

**Fig. 4** The additional factor, motion of one object passing by another object, results in the emergence of three forms of emergence

The motion is generating basic emergence due to sequential-enhancement during the entire passage past the other component. However, during the first half of the passage, the moving component is approaching the other component, and the distance between the two components is continuously decreasing. Thus, the form of emergence due to sequential-enhancement that is occurring here is based specifically on decreasing distance.

During the second half of the passage, the moving component is getting progressively farther away from the other component, with the distance between the components continuously increasing. Here it is a different form of basic emergence due to sequential-enhancement, now based specifically on continuously increasing distance.

The changeover from emergence based on decreasing distance to emergence based on increasing distance occurs at the point of closest approach of the moving object to the other object. The factor, direction of motion, does not change, but in the context of the configuration of the pattern-of-organization of the components, the consequence of the direction of motion changes at the point of closest approach. It is an abrupt, one time only, change due solely to the ongoing changing relations between the components of the situation—a transformation point.

A well-known example of motion passing by with the occurrence of a transformation point occurs when asteroids approach the earth, pass by, and then move progressively farther and farther away. As they pass by, they move through the point of closest approach, the transformation point where the decreasing distance to the earth as they approach is transformed to increasing distance as they move away.

At the point of closest approach, two distinct forms of emergence occur together, simultaneously, emergence due to sequential-enhancement and emergence due to transformation-point. Emergence due to sequential-enhancement brings into existence a sequence of different *patterns-of-material-organization*. Emergence due to transformation-point brings into existence a different, newly occurring, *pattern-of-organization of the process of emergence*.

Because the motion through the point of closest approach is continuous, the occurrence of emergence due to sequential-enhancement through the point of closest approach is also continuous. The occurrence of emergence due to transformation-point is an abrupt, one time only event that is a consequence of the singular nature of the point of closest approach. When the emergence due to transformation-point occurs, it is newly occurring—it is emergent. Forms of emergence that come into existence due to additional factors are emergent forms of emergence. All developed forms of emergence are emergent forms.

Transformation points are due to the ongoing development of the situations in which they occur. A situation consists of all the factors of space, time, and matter that occur together in a particular place. Because everything that exists has various qualities of continuing-existence and sequentiality, everything that exists develops in one way or another. All the factors of space, time, and matter of a situation develop individually, and also all together concurrently. The combined concurrent development of the factors of a situation constitutes situation-development.

Existential-pathway-development is the continuously ongoing sequentially connected development of a situation through space, time, and process interrelations. This is the continuous developmental pathway taken by situation-development. Change occurs during existential-pathway-development. All the factors of a situation continue to exist during existential-pathway-development. Other forms of change can occur during continuing-existence. Sequential forms of change such as motion can lead to transformation-points.

As happens with the motion of an object passing by another object, sequential change can occur as a series of similar changes until it encounters a transformation-point where a different form of change occurs, after which the sequential change again continues with a series of similar changes that are now altered by the transformation-point. Situations with a series of minor developments that encounter a transformation-point as a major development, and then return to a series of now altered minor developments can be a source of unexpected consequences. The minor/major/minor development sequence can play a role in changes in system equilibrium.

**Additional factor—Motion of one object directly at another object**

Here direction of motion again plays a determining role in what happens to the process of emergence—determining what new relations occur between the components, determining what emergent products come into existence. The motion of one component is directly at the other component. Initially, emergence due to sequential-enhancement based on decreasing distance is occurring (Fig. 5).

Eventually the motion brings the components close enough together that, while still spatially separate, they can play roles in combination as a group that the individual components cannot play when they are not together. For example, the two components can be close enough together that a third component cannot pass between them without touching one or the other. At the stage of development of the situation when the components can play roles in combination, the group relation has emerged.

Diagram

Description automatically generated

**Fig. 5** The additional factor, motion of one object directly at another object, results in the emergence of two factors, group relation and hierarchical organization, by way of emergence due to combinatorial-enhancement

The group exists as the combination of the components together. The components are subunits of the group. With the emergence of the group, there is a simultaneous emergence of levels of organization. There is the higher level of the group, which can play group level roles. And there is the lower level of the subunits, which individually cannot play group level roles. A group with levels of organization has hierarchical organization.

The factor, group, emerges when the components come close enough that they can play roles together in combination. The factor, hierarchical organization, emerges when the components come close enough that the components in combination compose a group, a whole composed of subunits, with roles for the subunits at the subunit level, and roles for the group at the group level.

The new existence of the group, and the new existence of the hierarchical organization of the group, are the enhancements of the developing situation due to the motion of the one component directly at the other. The emergence of the factors, group and hierarchical organization, is a consequence of the components coming close enough that they can play roles together in combination—emergence due to combinatorial-enhancement.

There is the basic form of emergence—emergence due to sequential-enhancement—the coming into existence of a newly occurring pattern-of-material-organization due to the motion of one or more components of that pattern. Then there are other forms of emergence based on additional factors.

* Emergence due to sequential-enhancement based on decreasing distance.
* Emergence due to transformation-point.
* Emergence due to sequential-enhancement based on increasing distance.
* Emergence due to combinatorial-enhancement.

These four forms of emergence are emergent forms of emergence, coming into existence when their additional factors, such as increasing distance or combinatorial-enhancement, begin to play roles in a developing situation—when their additional factors begin to play roles in the process of emergence.

Complexity is quantity and diversity of components and relations. Increasing the quantity and diversity of components and relations increases the complexity of a situation.

Emergence in general can contribute to increased complexity by creating newly occurring patterns-of-material-organization. Different patterns-of-organization can have different qualities and thus play roles as different components that can have different relations with other things that exist.

Emergence due to a transformation-point can be an important contributor to complexity because it often occurs as a major development with significantly different emergent products. The new pattern can act as a different component enabling different relations.

Emergence due to combinatorial-enhancement contributes to complexity by creating groups with hierarchical organization. The complexity of the universe, such as that of geology, life, ecosystems, and galaxies, is in large part a consequence of emergence due to combinatorial-enhancement. The hierarchical organization of the universe, from protons, atoms, molecules, and living systems, to solar systems, galaxies, and galactic clusters, is a consequence of emergence due to combinatorial-enhancement.

**Additional factor—****Motion brings objects together until there is no space between the objects**

At this stage in the development of emergence, the motion is again initially one component moving directly at another component, with the occurrence of emergence due to sequential-enhancement due to decreasing distance. In this case the motion brings the components of a group right up next to one another such that there is no longer any space between the components. At this point in the ongoing development of the situation combinatorial-enhancement occurs again—with two emergents. Due to the combining, emergence due to transformation-point occurs with the abrupt coming into existence of the adjacent relation between the components. The emergent situation is a group with direction relations from one component to another, but no distance relation (Fig. 6).

Adjacent relation is a consequence of both emergence due to combinatorial-enhancement and emergence due to a transformation-point. Sometimes two or more forms of emergence can play roles within a particular process of emergence. Prior forms of emergence can play roles in developed forms of emergence. Here emergence due to transformation-point is playing a role due to emergence due to combinatorial-enhancement. The transformation-point is a consequent enhancement of the combining.

Diagram

Description automatically generated

**Fig. 6** The additional factor, motion brings objects together until there is no space between the objects, results in the emergence of adjacent relation by way of emergence due to combinatorial-enhancement and transformation-point

**Additional factor—Adjacent relation**

When two material objects come into adjacent relation, and there is no space between them, their substantiality comes into adjacent relation. When the substantiality of different material objects comes into adjacent relation, the contact relation emerges. The contact relation emerges instantaneously with the adjacent relation of material objects (Fig. 7).

The contact relation is a new role for substantiality. Previous roles for substantiality that are developmentally prior to the adjacent relation are:

* Matter occupies space—a relation between matter and space.
* Matter moves through space—a relation between matter and space.
* Units of matter form patterns-of-material-organization in space—a relation between matter and matter in relation to space in that the distance and directions between the units of matter are the distance and direction relations between the spatial places the units of matter occupy.

These roles are purely organizational in nature.

Diagram

Description automatically generated

**Fig. 7** The additional factor, adjacent relation, results in the emergence of contact by way of emergence due to adjacent substantiality and transformation-point

When an object exists in space, when an object occupies a spatial location, that is an organizational relation. Specifically, the organization is that the material object occupies immaterial space—space does not occupy the object.

When an object moves through space, the object sequentially occupies the spatial place it passes through—the occupation organization. With motion there is additionally the organization of the motion itself. Undisturbed motion is linear with intrinsic directionality.

The intrinsic directionality of the motion occurs in the linear sequence of spatial-place the object passes through. That linear sequence of spatial-place

has its own intrinsic directionality. There are here two cases of linear directionality, one occurring in the other.

When units of matter occur as components in a pattern-of-material-organization each individual component has a relation with the spatial place it occupies. Additionally, all the components of the pattern have distance and direction relations with all the other components. There are two types of organizational relations here, that of occupancy and that of material pattern.

With the instantaneous emergence of contact due to the adjacent relation, there is no change to the prior organizational relations in the situation. With the occurrence of contact, however, there is the additional organizational relation between the two sides of that relation—contact has a directional aspect to it. Because this is still just an organizational relation, identical to the organization of the adjacent relation in location and form (direction but no distance), this is again a minor development.

The emergence of contact is due not only to the adjacent relation, the spatial relation between the objects, it is due also to the substantiality of the objects, adjacent substantiality—emergence due to adjacent-substantiality.

Contact is a new role for substantiality. Previous roles are in relation to space—occupying, passing through, and distance and direction relations. Contact is a direct relation between substantiality and substantiality. Space plays only a context role in the contact relation—the place where it occurs. Space does not play a direct role in the existence or intrinsic nature of the contact relation.

Because the nature of contact is due to the nature of substantiality, contact is more than organizational in nature—a supraorganizational-factor. Two important points follow from this. First, with the emergence of new roles of substantiality, emergence develops from a process that creates newly occurring patterns-of-material-organization to a process capable of creating supraorganizational-factors, a major development for the process of emergence. Second, just as emergent products, such as groups, can play roles that cannot be played by their individual separate components, supraorganizational-factors can play roles that are beyond the types of roles organizational-factors can play, such as contact and push.

**Additional factor—Contact****—*Basic causal pathway***

The contact relation develops along two distinct types of existential-pathways. In the simpler developmental pathway, one part of matter moves directly at another part of matter, collides with it, and pushes on it, causing the second part of matter to move, as occurs with billiard balls and Newton's cradle2. This is the basic causal pathway. In the more complex developmental pathway, a variety of factors play roles that result in one part of matter sticking to, binding with, or in general cohering with another part of matter, with the emergence of coherent-structure—the coherent structure pathway (Fig. 8).

Diagram

Description automatically generated

**Fig. 8** In the basic causal pathway, the additional factor, contact, results in the emergence of blocked motion by way of emergence due to blocking and transformation-point. Additionally, in the coherent structure pathway, contact results in the emergence of coherence by way of emergence due to material interaction

Because space is immaterial, there is nothing there that could impede the motion of matter through space. When motion is directly at a substantial material object, there is something there. Adjacent relation emerges as a consequence of combinatorial-enhancement. With the adjacent relation, the substantiality of the one object is in direct association with the substantiality of the other unit, and there is the instantaneous emergence of the contact relation. Contact connects the moving substantiality of one object with the substantiality of the other object. The substantiality of the other object blocks the motion.

The motion that gets blocked has been passing through space in a specific direction. Direction is an intrinsic quality of the motion. When the motion is blocked, this directional quality is maintained. Blocked motion has an intrinsic directional quality.

Blocking is a new role for substantiality in the development of the process of emergence—a supraorganizational role. In an abrupt major development of the situation, a supraorganizational factor, substantiality, alters the pattern-of-organization of motion. The consequence, blocked motion, is a change to the speed of the motion through space, a change to that aspect of the intrinsic organization of the motion. This change to the organization of the motion is a case of emergence due to blocking.

**Additional factor—Blocked motion—*Basic causal pathway***

At the transformation-point that occurs with the adjacent relation between a moving object and a blocking object, there is not only the instantaneous emergence of contact and blocking, there is additionally the instantaneous emergence of push. When a moving object collides with a blocking object, the moving object pushes against the blocking object. The motion of the object is transformed into push. The push is directional, which is a direct consequence of the directionality of the blocked motion. Push is a consequence of blocked motion—emergence due to blocked-motion (Fig. 9).

As with contact and blocking, push is a new role for substantiality in the development of the process of emergence—again a supraorganizational role. The substantiality of the moving object presses against the substantiality of the blocking object in a supraorganizational relation between two cases of substantiality. Push has organizational features such as the direction of the push, but push requires something more than purely organizational factors. Push is a consequence of the nature of substantiality—without substantiality push cannot occur.

Push is cause. Push is the core factor of cause. All cases of cause are based on contact, blocked motion, and the consequent push. There are situations that superficially appear to be casual, but where no causal factor is playing a role. There is consequent-existence where one thing exists due simply to the existence of another thing, for example, continuing-existence is a consequence of existence. And there are allowing situations that involve two separate energy flows where energy passing through one changes the situation so that energy can pass through the other, for example, opening a faucet allows water to flow through a hose.

Diagram

Description automatically generated

**Fig. 9** In the basic causal pathway, the additional factor, blocked motion, results in the emergence of push by way of emergence due to blocked motion and transformation-point

The cause-and-effect relation due to supraorganizational factors is a major development in the process of emergence. Prior to the emergence of push, motion, with various roles for substantiality, is the initiator of change to patterns-of-material-organization. These changes are the result of simple consequent-existence wherein one thing exists due to the concurrent or prior existence of something else. A pattern-of-material-organization exists as a simple consequence of the concurrent existence of the distance and direction relations between the material components of the pattern. Consequent-existence occurs by way of structural-logic, wherein the existence and intrinsic qualities of one thing determine the existence and intrinsic qualities of something else. The distance and direction relations between components of a pattern-of-material-organization determine the existence and intrinsic qualities of that pattern. There are roles for space, matter, and motion. There are no roles for push or force—no roles for cause.

With the emergence of push, change is made to happen. With push, an emergent supraorganizational factor initiates change. New pattern-of-material-organization is caused—pushed, forced, into existence. After this major development, further emergence involving forced change is different in nature from emergence based on simple consequent-existence due to motion and can result in greater diversity of emergent products. In general, blocking matter alters the flow of motion (by way of consequent-existence), and the flow of motion causally alters blocking matter (by way of push).

Push is cause. The directionality of push is the source of the directionality of cause—why cause comes first, and effect comes second. This is how caused emergence works.

**Additional factor—Push—*Basic causal pathway***

Contact, blocking, and push are supraorganizational relations between substantiality one part with another. Contact connects substantiality. Blocking alters the motion of substantiality. Push presses one part of substantiality against another part of substantiality. That pressure has an effect on the substantiality that it is pressing against. Push causes change to occur. Push causes change that would not happen otherwise due only to motion changing organizational factors—change that would not occur without the supraorganizational role of the substantiality. The push of the blocked motion transforms that motion into oriented pressure within the matter of the blocking object (Fig. 10).

Motion is directional. Blocked motion maintains that directionality. The consequent push is thus directional. This directionality is carried forward into the matter of the blocking object as the directionality of the emergent oriented pressure. Like most factors, cause develops, becoming more complex with the roles of additional factors.

The pressure compresses the matter somewhat. This compressed matter constitutes a newly occurring pattern-of-material-organization. A similar situation develops in the forward part of the object that was moving. The matter there also becomes compressed. This compressed matter initiates a separate existential-pathway-development within the object that had been moving. One result is bounce. This divergent pathway will not be described here.

Diagram

Description automatically generated

**Fig. 10** In the basic causal pathway, the additional factor, push, results in the emergence of directionally oriented pressure by way of emergence due to push and transformation-point

**Additional factor—Directionally Oriented Pressure*—Basic causal pathway***

Matter at the surface of the blocking object develops directionally oriented pressure internally due to the push from the moving object. This directionally oriented pressure then presses on the adjacent interior matter, which then presses on the adjacent interior matter, with the directional pressure progressing on further into the blocking object. In this manner a directionally progressing pressure wave emerges in the matter of the blocking object. This pressure wave is a consequence of emergence due to push (cause) (Fig. 11).

Diagram

Description automatically generated

**Fig. 11** In the basic causal pathway, the additional factor, directionally oriented pressure, results in the emergence of a directionally progressing pressure wave in the blocking unit by way of emergence due to push

An example occurs here of direct-transformational-factor-development, wherein the prior stage of a factor transforms into the following stage. The prior stage of motion becomes the following stage of motion when the motion of the object through space directly transforms by way of push into the motion of the pressure wave through the blocking object. With factor-development, factors tend to occur in simpler forms in situations where few factors are playing roles (motion through space), and to occur in more complex forms in more complex situations where greater numbers of other factors are playing roles (motion through matter).

**Additional factor—Directionally progressing pressure wave*—Basic causal pathway***

The directionally progressing pressure wave propagates on through the object, sequentially changing the pattern-of-organization of the matter of the object. The changing pattern-of-organization involves an elastic compression and relaxation of the matter through which the wave is passing. This sequentially ongoing change through the object is a case of emergence due to sequential-enhancement, and because it is a consequence of push, it is emergence due to caused-sequential-enhancement (Fig. 12).

Diagram

Description automatically generated

**Fig. 12** In the basic causal pathway, the additional factor, directionally progressing pressure wave, results in the emergence of throughflow by way of emergence due to caused sequential-enhancement

The pressure wave passes through the object from one side to the other—the emergence of throughflow. Throughflow occurs when matter, push, or pattern-of-organization, or some combination thereof, passes through an object, system, or situation. With a pressure wave, it is the passage of push and pattern-of-organization.

**Additional factor*—*Throughflow—*Basic causal pathway***

When the pressure wave has reached the far side of the object, there is no more matter to which the push can be applied. The last push imparts a forward impetus to the object. In an abrupt, one time only major development, the push of the pressure wave is transformed into the motion of the object through space. The object moves, with the emergent motion a consequence of emergence due to transformation-point and emergence due to push (Fig.13).

Diagram

Description automatically generated

**Fig. 13** In the basic causal pathway, the additional factor, throughflow, results in the emergence of motion of the object through space by way of emergence due to push and transformation-point

Push played a role in the passage through the object. But after the motion is transformed into that of motion through space, push is no longer playing a role. Thus, it was emergence due to push all through the object and emergence due to push involved in the transformation of the motion, but that form of emergence plays no further role past the emergence due to transformation-point at the surface of the object. Other than getting it started, emergence due to push plays no role in simple motion through space.

Again direct-transformational-factor-development plays a role, but this time it is different. Motion of the pressure wave (complex) is directly transformed into the motion of the object through space (simple). It can happen with factor development that a more complex form of a factor can develop into a less complex form.

The universe, and everything in it, develops in one way or another. Development always has some quality of *more*. Forms of universal unidirectional change, such as time, motion, and existential-pathway-development, always contribute *more* to every situation. The process of emergence is creative, contributes to *more* in that it brings into existence newly occurring patterns-of-material-organization. Some factors of the process of emergence, such as combinatorial-enhancement, are major contributors to *more*, for example, the creation of the hierarchical organization of the universe from atoms to galaxies.

While some factors always add *more*, pattern-of-material-organization can become simpler. The existential-pathway-development of the situation does not return to the previous occurrence of the simple pattern. Instead, it develops forward to the simpler form by creating a new, emergent, different occurrence of the simple pattern. The new occurrence of a form, whether simpler or more complex, is always developmentally more.

**Additional factor—Motion*—Basic causal pathway***

The object that had previously played the role of blocking is now moving. The motion takes the object through a sequence of different locations, each of which has different distance and direction relations with other components of the pattern-of-material-organization. As the moving object occupies the sequence of different locations that have different extensional relations, the pattern-of-material-organization changes sequentially as a consequence of emergence due to sequential-enhancement (Fig. 14).

It is a major development to the process of emergence when a supraorganizational factor, push, no longer plays a role. The situation has become simpler in that there is one factor less playing a role. Nevertheless, development with enhancement goes forward due to the contributions to *more* from time, motion, and existential-pathway-development. By way of existential-pathway-development the situation has developed forward to a new case of motion of an object through space, to a different object that is moving, and to a different part of spatial-place that the motion is passing through.

Diagram

Description automatically generated

**Fig. 14** In the basic causal pathway, the additional factor, motion through space, results, in the emergence of new pattern-of-material-organization by way of emergence due to sequential-enhancement

**Additional factor—Contact—*Coherent structure pathway***

Matter can stick together, cohere, one part with another, when the substantiality of one object is in contact with the substantiality of another object. Coherence is a new role for substantiality in the process of emergence. It is a supraorganizational role, substantiality to substantiality. This is material-interaction-based-emergence, with coherence as the emergent property. All material objects that humans can see and touch are consequences of this early stage in the development of emergence (Fig. 15).

Diagram

Description automatically generated

**Fig. 15** In the coherent structure pathway, the additional factor, contact, results in the emergence of coherence of matter one part with another by way of emergence due to material-interaction

The discussion has followed the foundational development of emergence stage by stage. The full understanding of these stages is a connected sequence of development (Fig. 16).

**Figure 16.**

<https://www.researchgate.net/publication/363884885_Foundational_Development_of_Emergence_Diagram_VESTERBY>

**CONCLUSION**

The paper describes the stages of the early development of emergence, which is a naturally occurring process in the universe that creates things such as objects, qualities, relations, and systems. While emergence is a simple process foundationally, it develops, becoming increasingly more complex as additional factors come to play roles in the process. The core quality of the process of emergence is the creation of newly occurring patterns-of-material-organization due to the motion of matter—the emergence of newly occurring pattern due to motion. Along with continuing-existence and motion, the creative quality of emergence is one of the fundamental sources of newness in the universe.

Because emergence plays its role throughout the universe, understanding the foundational stages of emergence enhances understanding throughout the disciplines of science.

Several factors that play general roles in the organization of the universe originate in the foundational stages of the development of the process of emergence. Combinatorial-enhancement creates the hierarchical organization of the material component of the universe. Contact enables the interaction of matter one part with another. Throughflow, which plays a role in the function of Newton’s cradle, also initiates the complexity of biological and ecological organization. Push is the core factor of causal relations. And coherence creates material structure.

Additionally, there are several universally general determinate patterns of relation that play creative roles in the process of emergence. The simplest is consequent-existence wherein one thing exists due only to the existence of something else. Structural-logic determines what happens with consequent-existence. With structural logic, the intrinsic qualities of something that exists determine the kinds of relations that something can have with other things that exist. With development, everything that exists takes part in one way or another in a universally omnipresent transition, a sequential difference, from one time, place, part, pattern, level, condition, or situation to another involving some form of enhancement. With development, (a) the existence of something sets the intrinsic qualities of that something, (b) the intrinsic qualities determine the relations that something can have with other things, (c) the relations between things determine their pattern of organization, and (d) the pattern-of-organization determines what the situation is. The existence and intrinsic qualities of what goes before developmentally determine the existence and qualities of what follows. What goes before in the process of emergence determines the existence and intrinsic nature of the emergent product.

**FOOTNOTES**

1. Biological evolution is based on the survival of traits that play positive roles in the survival and reproduction of organisms. Spandrel type traits would be neutral in biological evolution. Identifying neutral traits is extremely difficult, so much so that any trait claimed to be a neutral spandrel type trait must be considered questionable. Even though they are difficult to recognize, the structural-logic of emergence based on process indicates that spandrel type traits occur in biology.

2. See Newton’s cradle on Wikipedia.

https://en.wikipedia.org/wiki/Newton%27s\_cradle

**REFERENCES**

Bergmann, M., & Jahn, T. 2019. Transdisciplinarity as critical transdisciplinarity. [Abstract booklet.] *International transdisciplinarity Conference 2019. Joining forces for change.* Gothenburg, Sweden 10 – 13 September 2019, p. 161.

Bertalanffy, L. V. 1968. *General system theory: Foundations, development, applications*. New York: George Braziller Inc

Brandt, P., Ernst, A., Gralla, F., Luederitz, C., Lang, D. J., Newig, J., Reinert, F., Abson, D. J., & Wehrden, H. 2013. A review of transdisciplinary research in sustainability science. *Ecological Economics*, *92* (C), 1-15. https://doi.org/10.1016/j.ecolecon.2013.04.008

Gould SJ, Lewontin RC. 1979. The spandrels of San Marco and the Panglossian paradigm: A critique of the adaptationist programme. *Proceedings of the Royal Society B: Biological Sciences*. 205 (1161): 581–598.

Mokiy, V. 2019. International Standard of Transdisciplinary Competence. *Informing Science: the International Journal of an Emerging Transdiscipline.* Vol. 22. https://doi.org/10.28945/4480

Piaget, J. 1972. The epistemology of interdisciplinary relationships. *Interdisciplinarity: Problems of teaching and re- search in universities*. Paris. OECD Publ. Retrieved from https://archive.org/details/ERIC\_ED061895/page/n135

Vesterby V. 2008. The Origin and Foundational Development of Structural Logic. In Cook, D (ed.).*Proceedings of the 14th ANZSYS Conference*. Perth: School of Computer and Information Science, Edith Cowan University [CDROM]. ISBN 978-0-7298-0668-8 https://www.researchgate.net/publication/265143528\_The\_Origin\_and\_Foundational\_Development\_of\_Structural\_Logic

Vesterby V. 2011. The Intrinsic Nature of Emergence. *Proceedings of the 55th Annual Meeting of the ISSS - 2011, Hull, UK*, *55*(1). https://journals.isss.org/index.php/proceedings55th/article/view/1599/605

Vesterby V. 2012. From Bertalanffy to Discipline-Independent-Transdisciplinarity. *Proceedings of the 56th Annual Meeting of the ISSS*, San Jose, CA, USA. http://journals.isss.org/index.php/proceedings56th/article/view/1886/672

Vesterby V. 2017. Emergence Is an Isomorphy. OSF Preprints. http://dx.doi.org/10.31219/OSF.IO/YS3WD

Vesterby V. 2019a. Emergence: Distracting Notions and How to Get It Right. OSF Preprints. http://dx.doi.org/10.31219/OSF.IO/VCPNB

Vesterby V. 2019b. Emergence Is Why It Is Not Possible to Explain Life Solely with Physics and Chemistry. OSF Preprints. http://dx.doi.org/10.31219/OSF.IO/CWNT7

Vesterby V. 2019c. The Basis of Time in the Universe. OSF Preprints. http://dx.doi.org/10.31219/OSF.IO/Q4NTK