

# FROM BERTALANFFY TO DISCIPLINE-INDEPENDENT- TRANSDISCIPLINARITY

Vincent Vesterby

## ABSTRACT

When Bertalanffy advocated a new scientific discipline called general system theory, this generalist mode of understanding was to be based on the isomorphism of laws, principles, and models in the different sciences, and on structural uniformities (isomorphies) in the subject matters of those sciences. There is a conceptual shift in Bertalanffy's work from the logico-mathematical mode to a deeper more complex understanding. There is a corresponding shift in the understanding of isomorphies from the isomorphy of laws and principles to the isomorphy of qualities of real systems. The recognition of isomorphies in real situations and systems has resulted in the creation of the modern generalist mode of understanding and from there the development of discipline-independent-transdisciplinarity. This paper gives an introduction to this form of transdisciplinarity, and explains how this mode of understanding naturally develops a universal transdisciplinary language.

Keywords: transdisciplinary; transdisciplinary language; multidisciplinary; interdisciplinary; Bertalanffy

## INTRODUCTION

Discipline-independent-transdisciplinarity is a direct consequence of the work of Ludwig von Bertalanffy (Bertalanffy, 1968). It provides the fulfillment of his vision of a general discipline applicable to all the empirical sciences, and simultaneously it provides the fulfillment of his vision of a method leading to a unitary conception of the world.

It was the recognition of isomorphy that made it possible for Bertalanffy to envision general system theory, and it has been the understanding and use of isomorphy that has led to the creation of discipline-independent-transdisciplinarity.

*Isomorphy* means equal form. Scientists in various disciplines discovered that the same form can occur in two or more different situations. For example, the same law or principle can apply to situations in different disciplines, or the same structure or process, such as open system or self-organization, can occur in diverse situations. The form does not have to be exactly equal in each of the various instances, but only significantly similar. For example, the basic form or core pattern is the same in each case, but with secondary differences due to interrelations with the roles of other factors.

There is an evident conceptual shift in Bertalanffy's work, from emphasis on the logico-mathematical mode to a deeper more complex understanding. The understanding of isomorphies is carried through this transition from (a) isomorphies viewed mostly as concepts, and abstract laws and principles that can be applied in the analysis of various

situations, to (b) increasing recognition of isomorphies as features, qualities, or components of real physical and dynamic situations. There occurs a recognition of the limitations of the logico-mathematical mode, a recognition of the limitations of models, principles, and laws, and an increasing recognition of the roles and significance of isomorphies as components of reality that make the general application of the concepts, laws, and principles possible. Through this transition there is also the change in the role of isomorphism in the unification of science, from isomorphism of laws and principles between disciplines to the unification of science through “the structural uniformities of the different levels of reality.” (p. 87)

### **INITIAL STEPS ON THE PATH FROM BERTALANFFY TO TRANSDISCIPLINARITY**

- **First step:** Recognition of isomorphic laws, principles, and models.
- **Second step:** Realization that the isomorphy of laws, principles, and models enables the transfer or application of understanding from one situation to other situations that appear to be entirely different in components, relations, and forces.
- **Third step:** The recognition that isomorphic laws can be applied to different situations because there are isomorphies already present, intrinsic, in those different situations that make the application of the laws possible.
- **Fourth step:** Realization that the logico-mathematical approach is insufficient for dealing with organization.
- **Fifth step:** The realization that what is known about an isomorphy intrinsic to one situation can be used to obtain understanding of various different situations where that isomorphy also occurs—without the aid of the logico-mathematical approach, laws, principles, or models.

This is a transition from the abstract and conceptual character of the logico-mathematical mode to the reality oriented recognition of isomorphies as components of reality that are themselves useful for the generalist mode of understanding that Bertalanffy was developing.

### **THE TRANSITION**

“. . . [W]e can ask for principles applying to systems in general, irrespective of whether they are of physical, biological or sociological nature. If we pose this question and conveniently define the concept of system, we find that models, principles, and laws exist which apply to generalized systems irrespective of their particular kind, elements, and the ‘forces’ involved.

“A consequence of the existence of general system properties is the appearance of structural similarities or isomorphisms in different fields. There are correspondences in the principles that govern the behavior of entities that are, intrinsically widely different.” (p. 33)

“The isomorphism under discussion is more than mere analogy. It is a consequence of the fact that, in certain respects, corresponding abstractions and conceptual models can be applied to different phenomena.” (p. 36)

“Not only are general aspects and viewpoints alike in different sciences; frequently we find formally identical or isomorphic laws in different fields. In many cases, isomorphic laws hold for certain classes or subclasses of ‘systems,’ irrespective of the nature of the entities involved. There appear to exist general system laws which apply to any system of a certain type, irrespective of the particular properties of the system and of the elements involved.” (p. 37)

“In elaborate form [general system theory] would be a logico-mathematical discipline, in itself purely formal but applicable to the various empirical sciences.” (p. 37)

“Its subject matter is formulation of principles that are valid for ‘systems’ in general, whatever the nature of their component elements and the relations or ‘forces’ between them.” (p. 37)

“A unitary conception of the world may be based, . . . on the isomorphy of laws in different fields. Speaking in what has been called the ‘formal’ mode, i.e., looking at the conceptual constructs of science, this means structural uniformities of the schemes we are applying.” (p. 48-49)

In the above quotes, general system theory is something distinct from the disciplines and their specific subject matters. General systems is valid for and *applicable* to systems and disciplines in general.

In the following quotes there is an evident shift to recognition of isomorphy as an existing quality of the world. The laws and principles can be applied because the patterns of isomorphy are already there in the real world.

“System isomorphisms also appear in problems which are recalcitrant to quantitative analysis but are nevertheless of great intrinsic interest. There are, for example, isomorphies between biological systems and ‘epiorganisms’ (Gerard) like animal communities and human societies.” (p. 34)

Here Bertalanffy points out that the logico-mathematical mode is sometimes insufficient when the analysis is of a situation where organizational-factors are more significant than quantitative-factors. The distinction between biological systems (cellular and multicellular organisms), and epiorganisms is essentially organizational in nature. Cellular and multicellular organisms are coherent-unit-systems (with coherent outer boundaries—cell membrane and skin), while animal communities and human societies

are higher level noncoherent-systems (without coherent outer boundaries) with coherent-unit-system-organisms playing roles as more or less loosely interacting subsystems.

“Speaking in ‘material’ language, it means that the world, i.e., the total of observable events, shows structural uniformities, manifesting themselves by isomorphic traces of order in the different levels or realms.” (p. 49)

“Apparently, the isomorphisms of laws rest in our cognition on the one hand, and in reality on the other.” (p. 82)

“However, these laws and schemes [as mathematical expressions] would be of little help if the world (i.e., the totality of observable events) was not such that they could be applied to it. . . .The structure of reality is such as to permit the application of our conceptual constructs.” (p. 82-83)

“We realize, however, that all scientific laws merely represent abstractions and idealizations expressing certain aspects of reality. Every science means a schematized picture of reality, in the sense that a certain conceptual construct is unequivocally related to certain features of order in reality; . . .” (p. 83)

“[S]cientific laws merely represent abstractions and idealizations . . .”

It is the order of reality that is of more substantial significance here.

“If the variables are continuous, this definition [Ashby’s fundamental concept of machine] corresponds to the description of a dynamic system by a set of ordinary differential equations with time as the independent variable. However, such representation by differential equations is too restricted for a theory to include biological systems and calculating machines where discontinuities are ubiquitous.” (p.96)

“We completely agree that description by differential equations is not only a clumsy but, in principle, inadequate way to deal with many problems of organization.” (p. 97)

When the logico-mathematical approach is useful but not sufficient, what is left is (a) systems, which are ubiquitous throughout the universe, and (b) isomorphies, which are also ubiquitous—throughout structure and process, throughout space and time.

All systems are isomorphic in that they are systems. Like all isomorphies, they can differ from one another due to the roles of other factors. Thus isomorphism is the core factor that makes discipline-independent-transdisciplinarity possible. However, to get there the understanding of isomorphies must be further developed.

A **factor** is something that exists and plays a role in the origin, structure, or processes of the situation in which it exists. A **general-factor** is something that exists in two to many different situations where it plays roles in the intrinsic natures of those situations. The understanding of general-factors developed from the understanding of the **isomorphies** of Bertalanffy's general system theory.

The term, *isomorphy*, refers to significantly similar patterns-of-organization occurring in different situations. The term, *general-factor*, incorporates the meaning of the term, *isomorphy*, and additionally emphasizes the roles of isomorphic patterns-of-organization as factors in the origins, structures, and processes of the various situations in which they occur.

- **Sixth step:** Recognizing isomorphies as general-factors that determine the origins, structures, and processes of the situations in which they occur.

### **DISCIPLINE-INDEPENDENT-TRANSDISCIPLINARITY**

Discipline-independent-transdisciplinarity is the systematic use of general-factors, **structural-logic**, and **development**, which are intrinsic to the nature of everything that exists, as conceptual tools of exploration, analysis, understanding, and description. These three factors, and many others, that are used as conceptual tools are omnipresent throughout the universe, which provides the discipline-independent aspect of this form of transdisciplinarity.

#### **The Nature of Physical Reality that Makes It Possible to Use Isomorphic Qualities of the Universe, Such as Emergence, Self-Organization, and Hierarchy, as Conceptual Tools**

Given that all material-reality, from atoms to galactic clusters, is composed of elementary particles, the difference between atoms, molecules, organisms, planets, stars, and galaxies, is what elementary particles are present in each and the **patterns-of-organization** of those particles. The **deep-structure** of everything that exists occurs in the form of patterns-of-organization.

Pattern-of-organization is an omnipresent quality of the material-universe.

- Elementary particles combine to form the emergent **hierarchic** pattern-of-organization of atoms.
- Atoms combine to form the emergent hierarchic pattern-of-organization of molecules.
- Molecules combine to form the emergent hierarchic organization of crystals and a host of different materials.
- Objects, groups of objects, and **systems** in general combine, and combine again and again, to form the hierarchic organization of all of the rest of material-reality.

Within this hierarchy there are many **levels-of-organization**—the levels of atoms, molecules, cells, organisms, ecosystems, planets, stars, and so on. Each level occurs as a type of pattern-of-organization—the crystal pattern-of-organization, the social system pattern, the solar system pattern. There is usually great diversity of details in the various instances of a level—many kinds of crystals, different kinds of social systems, different arrangements of the planet sizes in a solar system.

Throughout the material-universe, these patterns-of-organization repeat. At the atomic level there are many instances of the hydrogen pattern, many instances of the lead pattern. At the molecular level there are many instances of the water molecule, and many instances of the deoxyribonucleic acid molecule. At the planetary level there are many instances of the gas giant pattern. When a pattern-of-organization exists in and plays a role in two or more different situations, it is a general-factor.

- A **factor** is something that exists and plays a role in the origin, structure, or processes of the situation or system in which it exists.
- A **situation** is a combination of interrelated factors.
- A **general-factor** is something that exists and plays a role in the intrinsic nature of two to many different situations.
- A pattern-of-organization that exists in a situation, and plays a role there, is a factor of that situation.

When a pattern-of-organization, as a general-factor, occurs two or more times, the individual instances are isomorphic to one another in that each instance exists as that pattern. Hydrogen atoms are isomorphic to one another, as are water molecules.

When the pattern of a level has variations in the patterns of the instances of that level, the instances are still isomorphic in that they each are based on the pattern of the level. The basic pattern of the level is there within them, even though there are secondary differences. All the instances of deoxyribonucleic acid are isomorphic in this manner.

- It is a core feature of discipline-independent-transdisciplinarity that isomorphic patterns-of-organization, as general-factors, can be used as conceptual tools.
- What is known about a general-factor in one situation can be used to achieve understanding of another situation where that general-factor also occurs.

Isomorphic general-factors occur not just horizontally at a hierarchic level. Some patterns-of-organization of material structure and process also occur at more than one level of the hierarchic organization of material-reality. A very simple example is a cube composed of eight smaller cubes. The whole units of both levels are cubes, and thus structurally isomorphic.

A more complex example of a general-factor occurring at different levels is **throughflow**. This general-factor is a **process-pattern-of-organization**, occurring in a living cell when the cell takes in energy, which then plays roles in the **self-organization** and maintenance of the cell, and is finally dissipated from the cell as heat. Throughflow again occurs in a multicellular organism when that organism takes in energy in the form of food, the energy then playing multiple roles driving the physiology of the organism before it is dissipated as excess heat. An ecosystem has a complex organization determined by several throughflows of energy, such as sunlight, photosynthesis, nutrients, wind, and water. These different levels of throughflow are isomorphic, even though they are progressively more complex due to the roles of additional factors and their greater deep-structure up the series of levels, because they all have the core pattern-of-organization of throughflow.

There are two **larger-scale-patterns-of-organization** playing roles in these examples. A larger-scale-pattern-of-organization is one that extends through many stages of development or levels of organization, either horizontally throughout a level or vertically up the hierarchy of material-reality.

- ❖ Whether it is across a level or up the material-hierarchy, the basic pattern of the level or the basic pattern of a general-factor is present in all the instances of the level or the general-factor, giving the instances their **self-identities** as instances of the level or that general-factor.
- ❖ Patterns-of-organization, as general-factors, tend to occur in simpler forms in simpler situations, where few other factors are playing roles, and to occur in more complex forms in more complex situations, where more additional factors are playing roles.

Care must be taken when using a developed form of a general-factor as a conceptual tool in the context of a larger-scale-pattern because the additional factors present can alter the role of the general-factor (Vesterby, 2008b).

### ***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.

There are many kinds of development. **Factor-development** occurs when a general-factor occurs in more complex form from one situation to another due to the roles of additional factors. Foundationally there is **extensional-development** and **change-development**. With extensional-development the parts of the developmental transition, the parts of the **sequential-difference**, are all there together. They are coexistent, as with the parts of space as one flies from one spatial-location to another, or with the components of a structure from the base of the structure up to the top. With the extension

of space and with the extension of a structure, development exists as **coexistent-sequential-difference**.

With change-development the parts of the developmental transition, the parts of the sequential-difference, are not coexistent. For example, with ongoing time the parts are not coexistent. The future has not yet come into being, only the present exists, and the past is no longer there. The change-development of time occurs as **noncoexistent-sequential-difference**.

- All forms of **change** occur as noncoexistent-sequential-difference.

Motion is a form of change-development. The future part of a motion has not yet occurred, only the current part is occurring, and the past part is finished. Motion occurs as noncoexistent-sequential-difference. With both time and motion the **enhancement** that is a consequence of the development is the continuously increasing amount of the ongoing change—continuously increasing time that has occurred, increasing quantity of the motion that is occurring, as for example the increasing distance the motion has traversed. The enhancement occurs due to ongoing sequential-difference—**sequential-enhancement**.

Both *extensional-development*—occurring as coexistent-sequential-difference, and *change-development*—occurring as noncoexistent-sequential-difference, are patterns-of-organization.

Both can be used as conceptual tools just like any other general-factor.

**Emergence** is a general-factor, a process-pattern-of-organization that plays a universal role in the coming into existence of new pattern-of-material-organization as a consequence of motion (Vesterby, 2008a, 2011).

Emergence is a form of change-development. In the simplest form of emergence, motion initiates changes in the distance and direction relations between two units of matter, with consequent changes in the pattern-of-organization of the units, and the emergence of new pattern-of-organization. At this foundational stage of the development of emergence, it is a creative process based on the sequential-difference of motion—on **sequential-enhancement**.

A developed form of emergence is based on **combinatorial-enhancement**. Here motion brings units of matter together, combining them loosely or coherently into groups, with the emergence of the group pattern-of-organization and hierarchic organization as the enhancements. When these groups come together and combine into larger more complex groups, and then combine again, emergence based on combinatorial-enhancement results in the development of the hierarchic organization of material-reality from atoms and molecules to solar systems and galactic clusters.

Because of its role in creating the levels of the hierarchic-organization of material-reality, emergence serves as a conceptual tool of particular significance.

Looking at emergence in outline format. (Taken from a larger outline.)

- ...
- C2. Patterns-of-organization come into existence through the process of emergence.**
  - D1. Emergence is the creation of newly existing patterns-of-material-organization as a consequence of the motion of units of matter relative to one another.**
  - D2. Emergence is a general-factor.**
    - E1. Emergence develops, becoming more complex with the roles of additional factors.**
      - F1. Basic general forms of emergence.**
        - G1. Emergence due to sequential-enhancement.**
        - G2. Emergence due to combinatorial-enhancement.**
      - F2. Some developed forms of emergence.**
        - G1. Causal-based emergence.**
        - G2. Through-flow-based emergence.**
        - G3. Coherence-based emergence—emergence of structure.**
      - F3. Some sophisticated forms of emergence.**
        - G1. Emergence based on biological evolution.**
        - G2. Emergence based on learning—emergence of understanding.**

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### ***Additional Forms of Development***

When a unit of matter moving through space collides with another unit of matter that is blocking the path of the moving unit, the moving unit pushes against the blocking unit, and in doing so changes the state of motion of the blocking unit. The moving unit pushing against the blocking unit causes a change in the state of motion of the blocking unit. Push is a foundational form of **cause**. When the blocking unit is a component of a group of other units, the changed motion of the blocking unit changes the distance and direction relations between that unit and the other units in the group, thus changing the pattern-of-organization of the group. The push of the moving unit causes the emergence of a new pattern-of-organization of the group. The new emergent pattern is a developed enhancement of the situation—**cause based emergence**—a **cause based development**.

When units of matter **coherently combine**, the enhancement of this stage of the development of combinatorial-enhancement is the emergence of **structural organization—coherence based emergence—coherence based development**.

**Throughflow-development** occurs when a flow of matter and energy passes through a situation or system, and in the process alters the nature of the situation or system. Water flowing through a drainage basin in the form of rivulets, creeks, and rivers, alters the configuration of the drainage basin in a variety of ways. Energy and nutrients enter living cells and organisms, play roles in their maintenance and self-organization, and leave as excess heat and waste materials.

There is here a third larger-scale-pattern-of-organization.

- ❖ In throughflow situations matter alters the flow of energy, and energy alters the organization of matter.

This larger-scale-pattern is one that extends through many stages as the matter/energy flow enters a situation, interacts with the various components there, and in one way or another exits the situation.

When used as a conceptual tool, this larger-scale-pattern serves as a deep-structure template upon which to arrange the details in any energy-flow/matter-change situation.

**Situation-development** is the combined concurrent developments of all the components of a situation together with the combined concurrent developments of all the interrelations between those components. **Existential-pathway-development** is the continuously ongoing sequentially connected development of a situation. This is the continuous developmental pathway taken by situation development. There are a great many other forms of development such as plate tectonics, biological evolution, and ecological succession. All the different forms of development, and all the individual cases of each form, together constitute the **general-development-of reality**.

### ***Structural-logic***

**Structural-logic** is the intrinsic logic of reality, the manner in which the intrinsic qualities of something that exists determine the types of relations that something can have with other things that exist. All forms of development are determined by structural-logic (Vesterby, 2008c).

For example there is the following, universally foundational, developmental sequence of the qualities of prior stages determining the qualities of the next stages. This three-stage developmental sequence involves the emergence of the qualities of a situation as a whole from the qualities of the components.

1. The qualities of the components of a situation determine the kinds of relations that can occur between those components.
2. The qualities of those relations determine the patterns-of-organization that can occur in that situation.
3. The qualities of the pattern-of-organization of a situation determine the qualities of the situation as a whole.

This is another larger-scale-pattern-of-organization, one that extends from a lower level, that of the components, to a higher level, that of the whole.

When used as a conceptual tool, this larger-scale-pattern serves as a deep-structure template upon which to arrange the details in any situation involving the combinatorial-enhancement based emergence of a whole due to the combining of its components.

- ❖ In all forms of change-existential-pathway-development, the existence and intrinsic qualities of what goes before determine by way of structural-logic the existence and intrinsic qualities of what follows.

This omnipresent larger-scale-pattern-of-organization extends through any occasion of noncoexistent-sequential-difference, through any occasion of change.

When used as a conceptual tool, this larger-scale-pattern serves as a deep-structure template upon which to arrange the details in any situation involving change—be it time, motion, emergence, cause, or any developed form of change.

Thus everything that exists is developmentally connected to something else that has existed just prior, exists now, or will exist immediately following. Through these developmental connections, the universe has an omnipresent deep-structure aspect of orientation, a directionality of structure and process.

These connected oriented pathways of development provide conceptual highways of exploration, analysis, understanding, and description.

### ***Universal-factors***

Some factors such as space, time, development, emergence, structural-logic, and several others, are omnipresent throughout the universe. As such they are universal-general-factors. They constitute the unifying framework of discipline-independent understanding.

- **Seventh step:** Identifying universal general-factors.

- **Eighth step:** Using the universals to create a universal-conceptual-model in which all other factors can be placed in realistic relation to one another—discipline-independent-transdisciplinarity (Vesterby, 2007).

### **Transdisciplinary Language**

Two elements are necessary for interdisciplinary communication—shared vocabulary and shared conceptual patterns. To the extent that scientific disciplines develop discipline specific vocabularies and conceptual patterns, the practical capacity for mutual interdisciplinary understanding is reduced. The practice of discipline-independent-transdisciplinarity is a process of pattern mapping from which emerges a language that by nature is common to all disciplines.

- Structural-logic determines the order of the various forms of development, and those forms of development constitute the syntax of this language.
- The names of the general-factors that play roles in development are the words of the language. (in blue)
- The semantics consists of the reality-referent relation between those names and the general-factors.

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Throughout the organization of the universe, from galactic clusters down through all the deep-structure to the individual elementary particles themselves, there are general-factors, and larger scale patterns, and all the forms of development that exist and play roles determining the intrinsic nature of the universe. Just as the entire material-universe is made out of elementary particles, it is equally made out of these omnipresent patterns-of-organization of structure and process.

- All of these patterns-of-organization are isomorphies.
- Everything that exists is constituted of them, and determined by them.
- All of them can be used as conceptual tools of exploration, analysis, understanding, and description.
- They provide a method applicable to all the disciplines of science, and to all the disciplines of the humanities.
- They provide a method that unifies the sciences, and knowledge in general.
- And finally they provide a universal transdisciplinary language that enables communication across the breadth and depth of knowledge and understanding.

Bertalanffy's recognition of the importance of systems, and his insight into the significance of isomorphies, set up the preconditions for further exploration and development of understanding—enabling the discovery of universals, development, structural-logic, and general-factors, and the use of these factors as conceptual tools for

even more discoveries, such as the intrinsic nature of emergence. The consequences are discipline-independent-transdisciplinarity and a universal transdisciplinary language.

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