COMPLEX SYSTEMS BIOLOGY AND HEGEL'S PHILOSOPHY

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ABSTRACT

In this study I will argue that Hegel's philosophy has similarity to the self-organization theories of Prigogine and Kauffman and complex systems biology of Kaneko, and is therefore an idea in advance of its times.

In The Philosophy of Nature, Hegel's interest is in how nature evolves through the mechanism of self-organization. He was writing before Darwin proposed the theory of evolution, and his dialectic is aimed at analyzing and describing development in the logical sense. The important feature of this work is their analysis of the fundamental structures by which order is generated.

Hegel struggled to produce the concept of life from that of matter. He proposed that matter should develop into organism, but only in a logical sense. Nature itself is a system of producing spontaneous order through the random motion of the contingent.

Then Hegel tackles living things. He would like to say that the basis of life is the non-equilibrium self-referential structure. In more modern terminology, we could interpret this as meaning that the first organism emerged from interaction between high polymers. Living creatures exhibit flexibility and plasticity through fluctuations in these elements. Complex systems biology uses a dynamical systems approach to explain how living things acquire diversity, stability and spontaneity.

First, simple single-celled organisms arose through interactions between proteins and nucleic acids. These are the archae-bacteria in modern terminology. Next, the development of eukaryote cells from the prokaryotes is explained by symbiogenesis or endosymbiotic theory.

Then, multicellular organisms appeared. These were networks of cells or systems of selves. They reproduce sexually and necessarily die. The process of individualization is complete. This is just a return to universality. The dynamism between universality and individuality is self-referential. Universality (the first simple prokaryote) becomes individuality (the complex animal), and it then returns to universality (human beings with spirit). Here, it is important to observe that spirit emerges from nature. Nature has the purpose of producing organism from matter and then spirit from organism. It is teleology without theology depending only on contingent and complex systems biology.

Keywords: Hegel, natural philosophy, complex systems biology, the theory of evolution.

1 METHODOLOGY—*THE PHENOMENOLOGY OF MIND* AND *THE SCIENCE OF LOGIC*

1-1

Hegel (1770--1831) was a German philosopher who was a major figure in the philosophical movement known as German idealism. He was a professor at Berlin University (1818--1831). In this study, I will argue that Hegel's philosophy has similarities to the self-organization theories of Prigogine and Kauffman, and is therefore an idea in advance of its time.

The development of thought and thing is at the core of Hegel's philosophy. In *The Phenomenology of Mind*, he tackles the development of recognition and being, subject

and object, and self and other from simple to complex forms. In *The Science of Logic*, Hegel deals with the progress of categories from abstract to concrete and pure being to absolute idea. In *The Philosophy of Nature*, his interest is in how nature evolves through the mechanism of self-organization. Hegel was writing before Darwin proposed the theory of evolution, and his dialectic is aimed at analyzing and describing development in the logical sense. The common feature of these works is their analysis of the fundamental structures by which order is generated, which Hegel contrived.

In the preface of *The Phenomenology of Mind*, Hegel argues as follows.

It (philosophy) is the process that creates its own moments in its course, and goes through them all; and the whole of this movement constitutes its positive content and its truth. This movement includes, therefore, within it the negative factor as well, the element which would be named falsity if it could be considered one from which we had to abstract. The element that disappears has rather to be looked at as itself essential, not in the sense of being something fixed, that has to be cut off from truth and allowed to lie outside it, heaven knows where; just as similarity the truth is not to be held to stand on the other side as an immovable lifeless positive element. Appearance is the process of arising into being and passing away again, a process that itself does not arise and does not pass away, but is per se, and constitutes reality and the life-movement of truth. The truth is thus the bacchanalian revel*, where not a member is sober; and because every member no sooner becomes detached than it eo ipso collapses straightway, the revel is just as much a state of transparent unbroken calm (p.105).

*the ancient Roman festival in honor of Bacchus.

Hegel was surely influenced by Adam Smith's concept of the invisible hand: a form of overall order that arises out of local interactions between falsities or the elements that disappear (the contingents). A system is that which is complete and has dynamic order within itself.

1-2

We first consider *The Science of Logic*. The following extracts are from Book Two (Doctrine of Essence), Section Three (Actuality), Chapter Two, (Actuality).

The chapter discusses three concepts, i.e., contingency, relative necessity, and absolute necessity.

a. The contingent is an actual which is at the same time determined as only possible. … The contingent is immediate actuality. It has no ground… The contingent is also the actual as what is only possible, and it has its immanent reflection in an other (p.480f.).

b. relative necessity (real necessity) is in itself also contingency… Real necessity contains contingency in itself… we have here the potential unity of necessity and contingency (p.485).

c. The determinateness of necessity consists in its having its negation, contingency, within it. This is how it has shown itself to be.
Real necessity not only contains contingency implicitly, but the latter also becomes in it; … but it is not only this (in-itself of the necessity) but the necessity's own becoming (p.485f.).

We can paraphrase this as follows:

a. The contingent exists.
b. When we throw the dice, the probability of throwing five is 1/6. There is necessity through the contingent.
c. Spontaneous order emerges through the interaction of the contingent. We can call this order through fluctuation (Prigogine) or order at the edge of chaos (Kauffman).

1-3

Turning to Book Three (Doctrine of Concept), Section Two (Objectivity), Hegel argues that "objectivity is the totality of the concept that has returned into its unity" (p.631). Here objectivity is nature itself, which develops itself through three stages, from mechanical to chemical objects and finally to teleology (purpose). Object evolves of itself, then subjective viewpoint against it progresses together.

The term center is important in this section. "In the material world, it is the central body that is the genus or rather the individualized universality of the single objects and their mechanical process" (p.641). Hegel was suspicious of Newton's mechanics. "It is for this reason an empty abstraction to assume in mechanics that a body set in motion would go on moving in a straight line to infinity if it did not lose movement because of external resistance" (p.641). For Hegel, friction is just an epiphenomenon of centrality, which brings the body back to itself. Hegel knew of neither thermodynamics nor entropy. Because of centrality, he thinks, the body has a natural tendency to move in one single direction.
"Centrality, therefore, is now the reciprocally negative and tense connection of these objectivities. Thus free mechanism determines itself to chemism" (p.644).

In this system of natural philosophy, matter evolves spontaneously from a mechanical object to a chemical one. It then goes on to become a teleological object, which is life itself.
"The chemical object is a striving to sublate the immediate determinateness of its existence and give concrete existence to the objective totality of the concept" (p.646). The principle of centrality in the mechanical object becomes affinity in the chemical object.
This then turns into purpose. "Teleology possesses in general the higher principle, the concept in its concrete existence, which is in and for itself the infinite and absolute—a principle of freedom which, utterly certain of its self-determination, is absolutely withdrawn from the external determining of mechanism" (p.654). Hegel struggled to produce the concept of life from that of matter. He proposed that matter should develop into organism, but only in a logical sense, with subjectivity and centralization producing spontaneous order.

2 HEGEL'S EVOLUTIONARY THEORY—*THE PHILOSOPHY OF NATURE*

2-1

In *The Philosophy of Nature*, Hegel divides natural philosophy into three parts: mechanics (space and time, motion, and astronomy), physics (from physical to chemical process), and organics (minerals, vegetables, and animals). In Hegel's view, nature develops logically. Hegel's form of explanation here is the same as that in Logic. That is, nature itself is a system of self-organization through the random motion of the contingent.

In the section on mechanics, Hegel deals with gravity as centrality. "Matter is therefore not yet posited as being material, but a center, a material singularity of an

ideal nature, i.e., gravity" (§262). Matter is not a singularity, but only an ideal singularity. In addition, matter develops itself toward singularity.

Then, matter becomes chemical.

The chemical process itself is so constituted … [that] corporality which subsists as being indifferent is posited as a mere moment of the individuality therefore, and the notion is posited in the reality which corresponds to it. This concrete unity with self, which brings itself forth from the particularization of the different corporealities into a whole, and by its activity negates the one-sided form of its self-relatedness and leads the moments of the Notion back into unity while dividing and particularizing itself into them, is the organism. The organism is therefore the infinite self-stimulating and self-sustaining process (§336).

Next, we will address the question of the organism. "Primarily, life has universal type of shape. It is just matter, then it goes on to the individual and concrete subjectivity of the animal organism" (§337).

The first type of life is called the earth. "This immediate totality presupposed by subjective totality, is simply the shape of the organism; as the universal system of individual bodies, it is the terrestrial body" (§338). The earth is the ground of life. "The land and to a greater extent the sea are therefore the real possibility of life, and at every point, they are perpetually breaking out into punctiform and ephemeral animation" (§341).

Hegel would like to say that the basis of life is the non-equilibrium self-referential structure. In more modern terminology, we could interpret this as meaning that the first organism emerged from interaction between high polymers.

2-2

Kaneko (2010) proposes a model of complex systems biology, which, I will argue, Hegel was proposing in his metaphysics 200 years ago. Kaneko conceptualizes life as a living system that develops when interaction between the elements in a system is sufficiently strong. Living creatures exhibit flexibility and plasticity through fluctuations in these elements. Complex systems biology uses a dynamical systems approach to explain how living things acquire diversity, stability, and spontaneity.

First, simple single-celled organisms arose through interactions between proteins and nucleic acids. These are the archaebacteria in modern terminology, or the universe itself in Hegel's terminology. Next, the development of eukaryote cells from the prokaryotes is explained by symbiogenesis or endosymbiotic theory. According to this theory, mitochondria and plastids were formerly free-living bacteria that were taken inside another cell as an endosymbiont. Hegel would call this the universe's self-particularizing. In other words, cells consist of cytoplasm enclosed within a membrane. They represent the first individual or self. The symbiogenesis theory means that the other comes into the self and then a new more complex self emerges.

Next, multicellular organisms appeared. These were networks of cells or systems of selves. They reproduce sexually and necessarily die. The process of individualization is complete.

Hegel wrote as follows:

This division of the universal and self-external organism, and this merely punctiform transitory subjectivity raises itself … to the existence of this identity, which is the vitalized organism, the subjectivity which constructs its members within itself (§342).

Here "this merely punctiform transitory subjectivity" can be thought of as the prokaryote—the first type of organism.

In Hegel's logic, the universal of the notion is not a mere sum of features common to several things but is a process of self-particularizing or self-specifying, which manifests itself as individuality. The prokaryote represents universality because when it divides into two, no distinction can be made between the two new entities. The next stage is the development of individuality through particularity, which includes the eukaryotes and organisms with more still complex systems of cells, including multicelled organisms.

We next consider "the animal organism."

Organic individuality exists as subjectivity in so far as the externality proper to shape is idealized into members, and in its process outwards, the organism preserves within itself the unity of selfhood. This constitutes the nature of the animal, in which the actuality and externality of immediate singularity is counted by the intro-reflected self of singularity or the subjective universality which is within itself (§350).

That organic individuality is subjectivity or subjective universality has the following meaning. Hegel's Logic argues that the "individual is as a universal stated expressly as a negative identity with itself" (§163). First, universality exists, and then as it forms a negative identity with itself, it becomes individuality.

The dynamic or self-referential relationship between universality and individuality is the motive power that drives Hegel's logic.

Hegel examines organisms through three perspectives: "The organism is therefore to be considered (a) as the individual Idea, which is simply self-related in its process … i.e., shape; (b) as Idea which relates itself to its other, its inorganic nature … i.e., assimilation; (c) as the Idea relating to an other which is itself a living individual, and thereby relating itself to itself in the other, i.e., the generic process" (§352).

Then universality appears again.

Through the process with external nature, the animal as a single individual endows its self-certainty or subjective Notion with truth and objectivity. Consequently, this production of itself is a self-preservation or reproduction … Linked up with itself in this way, the Notion is determined as the concrete universal or genus, which enters into a relationship and a process with the singularity of subjectivity (§366).

2-3

Parker (2003) proposed the following: The Cambrian explosion was triggered by the sudden evolution of vision. The introduction of the first eye effectively tore up the previous Laws and gave rise to chaos among animals. The first eye effectively created new niches for everyone. The most obvious requirement for adaptation to this new world of light would seem to be the possession of hard parts. It seems the evolution of hard parts everywhere, and ultimately the evolution of body forms of multicelled animals, was driven by active predators.

In this process, the animal acquires new degrees of freedom. Subjectivity and individualization are complete. The animal becomes capable of learning, increases its knowledge, and begins to progress toward human status.

This is just a return to universality. The dynamism between universality and individuality is self-referential. Universality (the first simple prokaryote) becomes individuality (the complex animal), and it then returns to universality (human beings with spirit).

"This type is exhibited by nature partly in the various stages of its development from the simplest organization [c.f. prokaryote] to the most perfect [human] in which nature is the instrument of spirit" (§370). Hegel deals only with logical development within nature. He does not propose an evolutional theory as such, but his approach is close to that of complex systems biology. However, Hegel extends it to deal with the development nature to spirit, as well as the one of matter to organism.

3 DESTRUCTION AND CONSTRUCTION - FROM *THE PHILOSOPHY OF NATURE* TO *THE PHILOSOPHY OF SPIRIT* -

3-1

How does spirit emerge from nature?

The genus preserves itself only through the perishing of the individuals, which fulfil their determination in the process of generation (sex relationship), and in so far as they have no higher determination than this, pass on to death (§369).

The individual having therefore put an end to itself of its own accord (§375).

Superseding this death of nature, proceeding from this dead husk, there rises the finer nature of spirit… The other side, which is death, constitutes the sublation of the singular, and is therefore the proceeding forth of the genus, of spirit… This is the transition from natural being into spirit; nature has found its consummation in living being, and has made its peace by shifting into a higher sphere. Spirit has therefore issued forth from nature (§376 addition).

A system of individual necessarily disappears, and then, a system of universe, or genus appears. A system is generated through destruction of another system.

The emergence of spirit from nature is also dealt with in *The Philosophy of Spirit*. There are same explanations as are in *The Philosophy of Nature*.

It is only in the form of individuality that the genus has being for the animal, which senses the genus without knowing it….The animal does not attain to the engendering of the genus through the sublation of the particularity of the sexes which takes place in the generic process… (In animal) death is necessarily brought about by the contradiction of individuality and genus, but even death, since it itself appears in the form of immediate individuality, and since it is not the conserving sublation of individuality but simply the empty and annihilating negation of it, also fails to bring forth the universality or universal individuality(§381 addition).

An animal reproduces itself and necessarily dies, and he as an individual, returns to universality of genus, but he doesn't know it. Only spirit knows it. Here important is to observe that spirit emerges from nature. Nature has the purpose of producing organism

from matter and then spirit from organism. It is teleology without theology depending only on contingent and complex systems biology.

3-2

Catherine Malabou (born 1959) is a French philosopher. Her agrégation and doctorate were obtained under the supervision of Jacques Derrida and her dissertation became the book (2005). The concept of plasticity is central to Malabou's philosophy, which she derives from the work of Hegel. She extends this to the analysis of the brain (2008).

Malabou explains the importance of the term plasticity in Hegel's work.

With this end in view, our plan is to form a concept, that of 'plasticity'… To 'form a concept' in the sense intended here means first of all to take up a concept (plasticity), which has a defined and delimited role in the philosophy of Hegel, only in order to transform it into the sort of comprehensive concept that can 'grasp' the whole (Malabou 2005, p.5).

She describes the sense of the term plasticity as follows:

Meanwhile, plasticity directly contradicts rigidity. It is its exact antonym. In ordinary speech, it designates suppleness, a faculty for adaptation, the ability to evolve (Malabou 2008, p.5).

But it must be remarked that plasticity is also the capacity to annihilate the very form it is able to receive or create (ibid, p.5).

The word plasticity thus unfolds its meaning between sculptural molding and deflagration, which is to say explosion (ibid, p. 6).

In Malabou's analysis, a system destroys itself. Then, through this destruction, it reproduces itself. A system with this propensity to destroy and reproduce itself has the characteristic of plasticity.

3-3

Raup (1991) argues as follows: Almost all species are extinct—only about one in a thousand of the species that have existed is still alive. This is a 99.9% failure rate. Yet extinction is a necessary ingredient in evolution. Extinction continually provides new opportunities for different organisms that can explore new habitats and modes of life. The bursts of speciation that often follow extinction provide many opportunities, which serves to increase the chance that at least one new body plan or physiology will succeed.

There are three extinction modes. First, catastrophes such as meteorite impacts might cause mass extinctions without regard to differences in fitness. The earth has seen five mass extinctions (this is known as a field of bullets extinction event). Second, there is selective extinction in a Darwinian sense, leading to the survival of the most fit or best-adapted species (fair game). But Raup argues that the third type, wanton extinction, has been the essential ingredient in producing the history of life that we see in the fossil record. This is a type of selective extinction in which some types of organisms survive preferentially but not because they are better adapted to their environment.

Raup's conclusion is that extinction is necessary for evolution and that selective extinction—which is largely blind to the fitness of the organism—is most likely to have

dominated the evolutionary process, and to have produced the diversity of life we see today.

Speciation is therefore a system that passes away necessarily but from which another system emerges. If 99.9% of species have appeared and disappeared, then only 0.1% of them have survived. This is the sum total of the diversity of today's living things. Just as surely, these too will pass away, but another system of species will appear.

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