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THE EVOLUTION CONCEPT: THE CONCEPT EVOLUTION

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ABSTRACT: This is an epistemologically-driven history of the concept of evolution. Starting from its inception, this work will follow the development of this pregnant concept. However, in contradistinction to previous attempts, the objective will not be the identification of the different meanings it adopted through history, but instead, it will let the concept to be unfolded, to be explicated and to express its own inner potentialities. The underlying thesis of the present work is, therefore, that the path that leads to the development of the concept of evolution is the path that studies the possibilities of the evolution of concepts, and that the historical reconstruction of its conceptual trajectory will shed light into potential and unexploited possibilities. This methodology will provide useful tools and resources for future developments of the concept. For example, it will define the concept of transmutation as a different conceptual trajectory deviating from the one corresponding to evolution, at the onset of the 19th century. Moreover, epigenesis will not be the opposing concept to evolution, but only to simultaneous and instantaneous generation. It will demonstrate that every important system of epigenesis drew upon some kind of formative power to explain development. More importantly, it will show that the problem of preformation cannot be overlooked, and that some kind of virtual preformation must be considered in order to address the problems of generation and development.

KEYWORDS: Evolution; Development; Concept; Epigenesis; Preformation; Transmutation

INTRODUCTION

There were some attempts in the past to trace the concept of *evolution* back in history. May be one of the first of these attempts was the one made by Thomas Huxley in 1878 (Huxley, 1893). More recent studies include those of Bowler (1975) and Richards (1992). All those studies, of undeniable intrinsic and fundamental value, were focused on tracing and reconstructing the changing meanings of the concept of evolution through history. This work will follow a different approach, a different methodology. It will not follow the sequence of the different transmutations of the concept, but, starting from the same point of departure, it will follow the path took by the concept itself. In other words, given the origin and context of appearance of the concept, it will allow it to evolve by its own, following its immanent possibilities and potentialities. In this manner, it will be given the concept the opportunity to be expressed, to be explicated, to be unfolded.

In consequence, this is an *epistemologically-driven* history of the concept of evolution. With this, we do not only want to indicate that this history is going to be reconstructed leaning on concepts, passively, but, above all, that we will use epistemology as an active tool for constructing history, even potential and alternative histories. The most dramatic consequence of this new methodology, which it will be evident almost from the beginning, is that it considers a totally different path the one followed by the concept of *transmutation*. This fact establishes a clear difference with previous works on this matter.

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THE EVOLUTION CONCEPT

Linguistic analysis: morphological analysis of corpora[1]

Evolution comes from the Latin word *evolutio*. The word literally means **unrolling**, **unfolding**. One of the first persons in recorded history to use the word *evolutio* was Marcus Tullius Cicero (106–63 BC). Cicero was a consul of the Roman Republic, a politician and philosopher considered one of Rome's greatest orators. Cicero's rediscovery in the 14th-century played a major role on the origin and development of the Renaissance.

Cicero used the verb *evolvere* six times in his writings. In those six times, Cicero used the word with different, but interrelated and complementary meanings. In the first place, he used it in the most literal meaning of opening a book, at a time when a book was a scroll, and opening it implied actually *unrolling* it. In the second place, he

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1 All the text analysis was carried out using the software *Diogenes* (Heslin, 2007). Diogenes provides database searching and browsing capabilities of Greek and Latin ancient texts. It is equipped with morphological analysis of corpora.

used it as a figurative extension of its literal meaning of unrolling a scroll, in order to put forth or explain an idea, an argument, that is, to *explicate*. He also used it in order to explain the course of the stars. Finally, Cicero used the verb *evolvere* as a metaphoric equivalent to guess or divine. On the other hand, Cicero used the corresponding noun *evolutio* just once, in a very interesting context:

> "Quid tibi, Torquate, quid huic Triario litterae, quid historiae cognitioque rerum, quid poetarum **evolutio**, quid tanta tot versuum memoria voluptatis affert?" (Cicero, 1931, p. 26).

> "What actual pleasure do you, Torquatus, or does Triarius here, derive from literature, from learning history, from **reciting** the poets and committing vast quantities of verse to memory?".

What did Cicero mean by evolution then? We could state that with *evolutio* Cicero meant reciting a text that was previously memorized. For this, it was necessary to unroll the book and read it. In a way, the book was already written, but otherwise, its content was unknown. In this sense, its unrolling, its evolution, carried a prophetic sign. One could affirm that the final outcome was already present at the beginning, as a sort of teleological cause, though its presence was not discernible or perceived before its actual realization. Therefore, the final outcome was *virtually* present, and its evolution allowed its actualization.

Cicero was responsible for creating a philosophical vocabulary in Latin, adapting many concepts from the Greek. Then, an interesting question would be: are there any antecedents of the use of the concept of evolution in the Greek world? One of the authors who used to resort to the metaphorical descriptions found in Cicero was Euripides (480–406 BC), one of the greatest poets of Greek antiquity. Euripides used mainly two different words to refer to such activities: *anaptysso*[2] and *exelisso*[3], which meant unfolding and unrolling. These are a few examples:

- "I will *explicate* [*anaptyxo*] to you why this is unworthy to be lived for me, now as well as before" (Euripides, 1912, p. 232).
- "Let me *uncoil* [*exelixas*] the seal's envelopings, and see what would this tablet say to me" (Euripides, 1946, p. 230).
- "And how did you *decipher* [*exelisseis*] the oracle?" (Euripides, 1912, p. 510).
- "To this husband *expound* [*anaptyxo*] the folds of my heart" (Euripides, 1925, p. 408).

There is a strong correlation between the uses made by Cicero and Euripides. Are

2 αναπτύσσω. It derives from the term *ptyche*, which means "fold".
3 εξελίσσω. It derives from the term *helix*, which means "spiral".

there any uses of these terms in the scientific realm? Hippocrates (460–370 BC) was one of the first users of these terms in scientific issues, namely medicine. He used the term *anaptysso* mainly for respiratory explanations, such as *expectoration*, that is, for example, the spitting of pus during and after pulmonary infections. This terminology was later adopted by Galen (129–200/216).

THE CONCEPT EVOLUTION

Anaxagoras: the development of an organism from a germ

Anaxagoras[4] (500-428 BC), the Greek Presocratic philosopher born in Clazomenae (Turkey), faced the problem of the development of the different tissues in an organism from an apparently homogeneous substance. He believed, following Parmenides, that nothing came into being from not-being, so he substituted coming-into-being for a process of becoming distinct by separation [*diakrisis*]. In the beginning, all things were together in the germ [*gone*] and they became gradually distinct as they grew. He resumed this thesis with the formula: "How could hair come from what is not hair or flesh from what is not flesh?" (Kirk & Raven, 1957, p. 378).

All the future tissues of an organism were contained in the germ. Initially, they were in a state of condensation that rendered them invisible. As they grew, they separated and became gradually distinct. The process by which this gradual distinction occurred was called *revolution* [*perichoresis*]. The revolution began from a small area and then extended over a larger space: "it began to rotate first from a small area, but it now rotates over a wider and will rotate over a wider area still" (Kirk & Raven, 1957, p. 373).

Aristotle: psyche as the principle of life

Aristotle (384–322 BC), in a way, posed the question that would determine the fate of developmental research for many centuries: "How, then, does it make the other parts? Either all the parts, as heart, lung, liver, eye, and all the rest, come into being together or in succession" (Aristotle, 1912, 734a16-18). For him, the first option was clearly false, since some parts of the embryo were visible whereas others were not, and the reason for this was not that they were too small to be visible, since the lung was larger than the heart and it appeared later in development. Therefore, Aristotle was inclined for the second option, that is, organs appeared one after the other. However, this did not mean that the first organ *made* the second one, and so on. If so, since what potentially existed

4 Euripides was one of his most notable disciples.

was brought into being by what actually existed, then the form of the second organ would have to exist in the first one. Moreover, any part could pre-exist in the semen or the seed, as if any part was already present in them, then it could not possibly have been made by them.

Aristotle gave a detailed description of the generation and development of the hen's egg in his book "Historia Animalium":

> "With the common hen after three days and three nights there is the first indication of the embryo [...] Meanwhile the yolk comes into being, rising towards the sharp end, where the primal element of the egg is situated, and where the egg gets hatched; and the heart appears, like a speck of blood, in the white of the egg. This point beats and moves as though endowed with life, and from it two vein-ducts with blood in them trend in a convoluted course [...] A little afterwards the body is differentiated, at first very small and white. The head is clearly distinguished, and in it the eyes, swollen out to a great extent. This condition of the eyes lasts on for a good while, as it is only by degrees that they diminish in size and collapse. At the outset the under portion of the body appears insignificant in comparison with the upper portion [...] When the egg is now ten days old the chick and all its parts are distinctly visible. The head is still larger than the rest of its body, and the eyes larger than the head, but still devoid of vision [...] At this time also the larger internal organs are visible, as also the stomach and the arrangement of the viscera; and the veins that seem to proceed from the heart are now close to the navel [...] About the twentieth day, if you open the egg and touch the chick, it moves inside and chirps; and it is already coming to be covered with down, when, after the twentieth day is past, the chick begins to break the shell" (Aristotle, 1910, 561a6-561b29).

In the hylemorphic scheme of Aristotle, the generation of a new organism was mediated by the impression of a form into matter: "Everything that comes into being or is made must (1) be made out of something, (2) be made by the agency of something, and (3) must become something" (Aristotle, 1912, 733b24-26). That out of which the living was generated was the material, which in this particular case was for Aristotle the female catamenia. On the other hand, the particular formal agency that was necessary for this generation was the *psyche*. The psyche was the defining principle of the living, that by which a thing was capable of living, feeling and thinking (Ostachuk, 2016). The psyche was present in the male semen: "it is plain therefore that semen both has psyche, and is psyche, potentially" (Aristotle, 1912, 735a8-9). Aristotle explicitly affirmed that the female catamenia was semen, but that it did not contain the principle of life: "the catamenia are semen, only not pure; for there is only one thing they have not in them, the principle of psyche. For this reason, whenever a wind-egg is produced by any animal, the egg so forming has in it the parts of both sexes potentially, but has not the principle in question, so that it does not develop into a living creature, for this is introduced by the semen of the male. When such a principle has been imparted to the secretion of the female it becomes an embryo" (Aristotle, 1912, 737a28-33).

Harvey: epigenesis and the plastic force

William Harvey (1578-1657) was an English physician that is usually recognized as the discoverer of blood circulation. One of his major works was *Exercitationes de generatione animalium*, published in 1651. There, following Aristotle's guidance, Harvey studied the development of the hen's egg. Harvey distinguished two types of generation: "Some, out of a material previously concocted, and that has already attained its bulk, receive their forms and transfigurations; and all their parts are fashioned simultaneously, each with its distinctive characteristic, by the process called **metamorphosis**, and in this way a perfect animal is at once born; on the other hand, there are some in which one part is made before another, and then from the same material, afterwards receive at once nutrition, bulk, and form: that is to say, they have some parts made before, some after others, and these are at the same time increased in size and altered in form. The structure of these animals commences from some one part as its nucleus and origin, by the instrumentality of which the rest of the limbs are joined on, and this we say takes place by the method of **epigenesis**, namely, by degrees, part after part; and this is, in preference to the other mode, generation properly so called" (Harvey, 1847, p. 334). He thought that insects were generated by metamorphosis, whereas "the more perfect animals" were generated by epigenesis.

Although being committed to explain development according to efficient causes, Harvey conceived that an agent was responsible for the advancement and progress of this process: "as soon as the egg, under the influence of the gentle warmth of the incubating hen, or of warmth derived from another source, begins to pullulate, this spot forthwith dilates, and expands like the pupil of the eye, and from thence, as the grand centre of the egg, the latent **plastic force** breaks forth and germinates" (Harvey, 1847, p. 229). This plastic force or power was contributed by the male semen. However, unlike Aristotle, Harvey considered this faculty as the efficient cause of the chick. Therefore, Harvey conceived development as a gradual process of generation and growth starting from a homogeneous substance and driven by a plastic power: "In the egg then, as we have said, there is no distinct part or prepared matter present, from which the foetus is formed; but in the same way as the apex or gemmule protrudes in a seed; so in the egg, there is a macula or cicatricula, which endowed with plastic power, grows into the eye of the egg and the colliquament, from which and in which the primordial or rudimentary parts of the chick, the blood, to wit, and the punctum saliens are engendered, nourished, and augmented, until the perfect chick is developed" (Harvey, 1847, p. 332).

The concept of plastic force was a widely known and amply used concept during the Renaissance. Its origin can be traced at least up to Galen, who explicitly made use of the term: "As for the actual substance of the coats of the stomach, intestine, and uterus, each of these has been rendered what it is by a special alterative faculty of Nature; while the bringing of these together, the combination therewith of the structures which are inserted into them, the outgrowth into the intestine, the shape of the inner cavities, and the like, have all been determined by a faculty which we call the shaping [*dieplasen*] or formative [*diaplastiken*] faculty [*dynamis*]; this faculty we also state to be artistic — nay, the best and highest art — doing everything for some purpose" (Galen, 1952, p. 25). Later, this Galenic idea of the *diaplastic power* was retaken by the Renaissance and further developed. Figures such as Jacob Degen (Schegk, 1511-1587), Daniel Sennert (1572-1637) and Ralph Cudworth (1617-1688), were the main characters of this intellectual trajectory. This group of thinkers concluded, in general, that the *plastic faculty* (for Sennert) or *plastic nature* (for Cudworth) was nothing more and nothing less than a part of the Aristotelian psyche.

Malpighi, Swammerdam and the rudiments of preformation

The work of Harvey on animal generation was soon to become questioned. In the 1670s, they appeared numerous investigations that were to dispute Harvey's judgments and conclusions.

Marcello Malpighi (1628-1694), an Italian physician, studied the development of the hen's egg and affirmed that the chick could be found in the egg before the appearance of the *punctum sanguineum*. As Harvey thought blood was the first part generated in an organism, Malpighi proved that Harvey was wrong at this point. Also, his results seemed to suggest that the organism was generated altogether at once, and not sequentially, part by part, as it was stated by Harvey. This rather hasty conclusion was interpreted as evidence in favor of metamorphosis and against epigenesis.

Malpighi considered his experiments as a revision of those of Harvey, to whom he highly admired. He clearly established the appearance of organs as a sequential process, although he considered that a kind of rudiment should be present from the beginning: "I assume some sort of first outlines [*ébauches*] of the animals, since while we search for the principle of life in the animal's egg, we are confronted with the fact that the animal is already formed, so that as soon as we encounter the first movements of life, we are obliged to recognize the parts appearing in front of our eyes" (Malpighi, 1686, p. 309). Malpighi left no doubt that these sketches were preexistent: "Therefore, it is necessary to admit that these first outlines [*ébauches*[5]] preexist in the egg" (Malpighi, 1686, p. 315).

Meanwhile, Jan Swammerdam (1637-1680), a Dutch entomologist, reported his studies on the development of insects. Swammerdam's enterprise comprised two main concerns: he wanted to demonstrate that (1) what was once considered different animals were, in fact, different developmental stages of the same animal, and that (2) the passage from one stage to another was not mediated by metamorphosis as it was described by Harvey, but, conversely, it was a transformation, a "gradual and natural growth" (Swammerdam, 1758, p. 2) mediated by epigenesis.

Swammerdam's rejection of metamorphosis came from his refusal to accept the action of chance in nature, and was based on Harvey's interpretation of metamorphosis: "Bees, wasps, butterflies, and whatever is generated from caterpillars by metamorphosis, are said to have sprung from chance" (Harvey, 1847, p. 335). Swammerdam considered metamorphosis as a "death and resurrection" process that, therefore, involved spontaneous generation, to which he fiercely opposed: "These animalcules do not die, as man does, in order to rise again; all that happens to them is, that their limbs become improvable at the time of their transmutation, which, however, happens in so surprising a manner, that it is no wonder observers, at first sight, should take the production to be a real resurrection from a dead animal. This is all that can be offered from what we know of insects, in proof of the resurrection of the dead; which is altogether another thing, than that idle and imaginary death of those animalcules, or the transformation, as it is called, of their limbs. Nor are those authors less mistaken, who, from these natural changes, which they idly call metamorphoses, have endeavored to ascertain the transformation of metals" (Swammerdam, 1758, p. 9).

Swammerdam demonstrated the presence of adult structures, such as wings, legs and antennae, in the caterpillar itself, even before the formation of the nymph: "in the Nymph, so called by Aristotle with the greatest propriety, there are not only all the parts and limbs of the little winged animal itself; but, what is more surprising, though till now unnoticed by any author I have met with, all these parts, or limbs, are to be discovered, and may be shown in the worm itself, on stripping off its skin in a careful manner" (Swammerdam, 1758, p. 3). This clearly demonstrated that the caterpillar and the adult were the same individual, there was a continuation between the two states (and of the species) and there was not an intervention of chance in their passage. Moreover, Swammerdam also showed that the adult form and its parts were not generated instantly and at the same time, but gradually and sequentially: "Those parts

5 Malpighi used the word *stamina* in the original text in Latin.

are by no means generated suddenly and all at once, as has been supposed, but grow leisurely one after another, till all of them having arrived at a state of perfection" (Swammerdam, 1758, p. 13).

Considering that adult forms were contained in larval stages, Swammerdam was led to affirm that there is no true generation (i.e. creation) in nature, only growth: "it seems very probable, that in the whole nature of things there is no generation that can be properly so called, nor can anything else be observed in this process than the continuation, as it were, of the generation already performed, or an increase of, or addition to, the limbs, which totally excludes the doctrine of fortuitous propagation" (Swammerdam, 1758, p. 16). This affirmation would seem to be in contradiction with his support for epigenesis. However, as it was understood by Swammerdam, and many other researchers of those days, epigenesis meant "gradual and natural growth", that is, the opposite of instantaneous and simultaneous formation, which was Harvey's definition of metamorphosis. Swammerdam did not consider that an animal was formed out of an homogeneous material, but rather that some kind of pre-delineation should be present from the beginning: "Then, types [*typi*] and delineations [*delineationes*] of the parts pre-exist in the semen, which through an even and gradual epigenesis, they are nourished, they grow, they unfold [*explicantur*] and expand [*dilatantur*] as much as they can" (Swammerdam, 1685, p. 45). For Swammerdam, these types and delineations were present in the semen before fertilization, whereas this process was the responsible for triggering the unfolding and expansion of the parts. Swammerdam even defended a rudimentary theory of preexistence: "from the first creation every species were introduced" (Swammerdam, 1685, p. 45). This conceptual framework allowed Swammerdam to disregard chance and a plastic force, resources used by Harvey, as participating elements in the process of development.

Another important event in this history was the discovery of the seminal particles. Antony Leeuwenhoek, one of the pioneers of the use of the microscope for biological investigations, found a whole new world of microscopic life, microorganisms, which he called *animalcules*. He discovered the spermatozoa in the male semen in 1677.

The discovery of the seminal particles contributed to the idea that the embryo was not generated by formless fluids, but from clearly distinguishable and structured entities. These findings were interpreted as a refutation of epigenesis. This conclusion was highly stimulated when Hartsoeker published his work *Essay de dioptrique* in 1694, where he illustrated a spermatozoon containing a miniature of a complete human body, a homunculus. Hartsoeker did not actually see the miniature, but he affirmed that it was hidden under the "skin" of the animalcule: "We just affirmed that the animalcule joins the egg by the most tender part of its body. However, I believe that this part is the tip of its tail, that this tail contains the umbilical vessels, and that if one could see the animalcule through the skin which is hiding it, we would may see it as represented by this figure, otherwise the head would may be bigger in proportion to the rest of the body, than the one delineated here" (Hartsoeker, 1694, p. 229). Therefore, the miniature was a hidden truth. In fact, there was no such homunculus hidden in the spermatozoon. However, the question these people were trying to answer was still pertinent: how did the organism obtain its form?

The Leibnizian evolution

Gottfried Leibniz (1646-1716), the German polymath, a prominent mathematician, developer of the differential and integral calculus together with (and independently of) Isaac Newton, was not indifferent to the biological debates of his age. Influenced by the new discoveries in animal generation, he developed a theory that it may not be mistaken to call it a theory of evolution: "Swammerdam, Malpighi and Leeuwenhoek, who are the best observers of our time, have come to my aid and have made me admit more easily that the animal and every other organized substance does not at all begin when we think it does, and that its apparent generation is only a development [*dévelopement*] and a sort of augmentation" (Leibniz, 1890, p. 73). For Leibniz, an animal was not generated or even perished, it was only unfolded and folded: "What we call generation is a development [*evolutiones*] and an increase, just as what we call death is an envelopment [*involutiones*] and a diminution" (Leibniz, 1969, p. 650). This was an ever-repeated process in which an animal may adopt different forms and be transformed, as it occurred with the caterpillar and the butterfly, but it never disappeared and never completely lost its body, its material basis: "according to my opinion, not only are all lives, all souls, all minds, all primitive entelechies, everlasting, but also that to each primitive entelechy or each vital principle there is perpetually united a certain natural machine, which comes to us under the name of organic body: which machine, moreover, even although it preserves its form in general, remains in flux, and is, like the ship of Theseus, perpetually repaired. Nor therefore can we be certain that the smallest particle of matter received by us at birth, remains in our body, even although the same machine is by degrees completely transformed, augmented, diminished, involved [*involvatur*] or evolved [*evolvatur*]. Hence, not only is the soul everlasting, but also some animal always remains, although no particular animal ought to be called everlasting, since the animal species does not remain; just as the caterpillar, and the butterfly are not the same animal, although the same soul is in both. Every natural machine, therefore, has this quality, that it is never completely destructible, since, however thick a covering may be dissolved, there always remains a little machine not yet destroyed, like the costume of Harlequin, in the comedy, to whom, after the removal of many tunics, there always remained a fresh one" (Leibniz, 1890, p. 191). Therefore, Leibniz considered an animal as a vital principle attached to a machine-like body. This vital principle had a clear association with the Aristotelian psyche, to which he added an atomistic nature. He called it *monad*.

Haller: from epigenesis to evolution

Albrecht Haller (1708-1777), a prominent Swiss anatomist, represented an interesting case. Initially, he was a proponent of epigenesis. However, he was later led to support evolution: "I have left quite a glimpse into my works, that I was inclined to epigenesis, and that I regarded it as the feeling most consistent to experience. But these topics are very difficult, and my experiences on the egg are so numerous, that I propose with less reluctance the contrary opinion, which begins to appear to me the most probable. The chicken has provided to me the reasons in favor of development [*dévélopement*]" (Haller, 1758, vol. 2, p. 172).

The most curious thing about this transformation is that it was based essentially on the same facts and experimental evidence. If one read Haller's description of the embryological development of the hen's egg, one would see a solid proof in favor of epigenesis. His experiments on the hen's egg were basically a reproduction of Malpighi's experience. In fact, Haller constantly compared his results with those of Malpighi during his descriptions. In those comparisons, Haller found that their results were very similar, except for the rate of change, which he found to be slower in his case. He described the appearance of organs "one after the other", which was the characteristic definition of epigenesis. Then, why did Haller convert himself to evolution? This was his explanation: "the animal passes evidently through considerable changes, solely by the evolution [*évolution*] of its already existent parts, and without the occurrence of any new creation, as soon as it is examined with care the nuances [*nuances*] of these changes. I believed I had found, in the heart of the chick, a proof in favor of epigenesis, and I convinced myself that a curved tube could become a four-lodged muscle only by the addition of some new parts: but the same experience has forced me to see that the changes of this principal organ are only superficial, and that they originate from its primordial structure by successive degrees [*degrés successifs*], what implies a proof in favor of evolution [*évolution*], rather its refutation" (Haller, 1758, vol. 2, p. 172). Then, Haller explained in more detail how this evolution would occur: "I have found that the simple elongation of the parts, exerted naturally by the force of the heart, can originate all the new appearances, such as the umbilical membrane […] If you go back in the consideration of the successive changes of this umbilical membrane, you will be easily convinced that it has always existed with its vessels, that it has been folded upon itself, that the impulsion of the blood has prolonged the arteries or unrolled [*dévidé*] those folds [*plis*]" (Haller, 1758, vol. 2, p. 173). A few pages later, he discussed in greater extent this mechanism: "Now I move to the mechanism that produces new figures [*figures*] in the animal parts. The simplest way and, at the same time, the most effective, is the uneven expansion [*accroissement inégal*]. Animals look alike when a part of their organs decreases and falls into nothingness, while the rest grows and develops [*dévelope*]; or when a part grows in a great proportion, while the rest makes little progress [*petits progrès*]" (Haller, 1758, vol. 2, p. 182). Therefore, for Haller, embryological development was a process of evolution, in its literal meaning (i.e. unfolding), through successive degrees, in which all its constitutive parts existed from the beginning, although they were folded and invisible, and they became visible and fully formed thanks to this process of unfolding or unrolling.

Bonnet: the germ as the principle of biological organization

Charles Bonnet (1720-1793) published *Considérations sur les corps organisés* in 1762. In this book, Bonnet affirmed that "philosophy has understood the impossibility of explaining the formation of organized beings mechanistically" and "fortunately they imagined that they already exist in miniature, in the form of *Germs* or *Organic corpuscles*" (Bonnet, 1762, vol. 1, p. 1). Bonnet set out two hypotheses regarding the origin of these germs: 1) nesting [*emboîtement*]: germs were contained one inside another as a Matryoshka doll; 2) dissemination [*dissémination*]: germs were spread throughout nature (air, soil, water). These germs contained "the whole series of future generations" of the same species: "Carried within the feminine ovaries or inside the masculine seminal vesicles, they are the principle of the generation of the fetus" (Bonnet, 1762, vol. 1, p. 3).

Bonnet argued that embryological development was a process of expansion [*accroissement*]. Organized bodies were already present in seminal particles. They were constituted by particular elements [*élémens*]. These elements were disposed in the form of a network [*réseau*], constituting simple fibers [*fibres simples*]. Growth consisted in the introduction and deposition of nutritive particles within the meshes [*mailles*] of the network, which allowed them to expand. Therefore, "the act of generation [*génération*] cannot be anything else than the principle of the unfolding [*développement*] of the germs" (Bonnet, 1762, vol. 1, p. 15). Development was an unfolding process, in the strictest sense of the term.

When Bonnet affirmed that the germ contained the organized body as a miniature, he was not saying that one would find its final organization in small size. Bonnet considered the germ as a draft [*ébauche*] or sketch [*esquisse*] of the organized body. This sketch contained "actually in short all the essential parts of the plant or animal it represents" (Bonnet, 1762, vol. 1, p. 20). Then, the main difference between the germ and the developed animal is that "the first is composed only of the elementary particles, and the meshes they form are as tight as possible; while in the second, the elementary particles are joined to an infinity of other particles that nutrition has associated with them, and the meshes of the simple fibers are here as stretched as possible" (Bonnet, 1762, vol. 1, p. 21).

As we can see, Bonnet took many ideas advanced by Haller. The most important of these ideas was undoubtedly the concept of evolution, as the proper concept to explain embryological development, that is, as a process of gradual unfolding of a preexistent biological organization[6]. However, Bonnet went further in these conceptual developments, and introduced the concepts of nesting [*emboîtement*] and palingenesis [*palingénesie*], into the conceptual framework of evolution.

Bonnet took the concept of nesting from Leibniz, although it was first developed by Malebranche (Bowler, 1971). In this manner, Leibniz affirmed: "there is a machine in the parts of the natural machine *ad infinitum*, and so many envelopes and organic bodies enfolded one within another that an organic body never could be produced altogether new and without any preformation; nor could an animal already existing be entirely destroyed" (Leibniz, 1890, p. 168). One could see the influence that Malebranche had on Leibniz's conceptual developments, reading the following passage from the former: "Nor does it appear unreasonable to think that there are infinite trees concealed in a single cicatricle; since it not only contains the future tree whereof it is the seed, but also abundance of other seeds, which may all include in them new trees still, and new seeds of trees: which new seeds possibly may be big with other trees, and other seeds of trees as fruitful as the former, in an incomprehensible littleness, and thus *in infinitum*" (Malebranche, 1700, p. 14). As well as there was an illation among the conceptual developments of Malebranche, Leibniz and Bonnet, there was also a logical necessity between the concept of nesting and a strict theory of preformation. Therefore, it was not surprising that the proponents of preformation were led to the development of the concept of nesting: if descendants were already formed in the progenitor, the same should be true for all the successive generations. This led to the other inevitable consequence of this reasoning: all the future generations were already formed from the beginning. Malebranche pushed this conceptual trajectory to the limit by affirming, leaning on the works of Malpighi and Swammerdam: "We see in the cicatricle of a tulip-root an entire tulip. We see in the cicatricle of a new-laid egg, and which had

6 In fact, Haller made common use of the term "ébauche" (draft, sketch) as the form of first appearance of an organ. However, Haller did not make a general concept from this term. He did not develop it conceptually as Bonnet did.

never been brooded, a chicken, which is possibly completely formed. We see frogs in the eggs of frogs, and we shall see other animals still in their cicatricles when we have art and experience enough to discover them [...] all the bodies of men and of beasts, which should be born or produced till the end of the world, were possibly created from the beginning of it" (Malebranche, 1700, p. 14). We saw that Mapighi's and Swammerdam's findings did not support these assertions.

The concept of palingenesis, in turn, was a complexification of the concept of nesting. By the concept of palingenesis, not only all the future generations of an organism were contained in its germ, but also all the forms that the organism would have in the future. In other words, organisms were predesigned to develop new forms. Therefore, through this concept, Bonnet was not only manifesting against fixism, but also he was postulating a progress in nature. For Bonnet, this progression was in the direction of an increasing perfection, which consisted in the acquisition and improvement of the senses, mediated by changes in the organization: "The more or less accelerated development [*développement*] of this organic system will provide the animal with a new being. Not only will its present senses be perfected, but it is possible that it also acquires new senses, and with them, new principles of life and action. Its perceptions and operations will multiply and diversify in an indefinite degree" (Bonnet, 1769, vol. 1, p. 199).

Another contemporary researcher who proposed a similar theory was Jean-Baptiste Robinet (1735-1820). He published *Considérations philosophiques* de la *gradation naturelle des formes de l'être* in 1768, where he proposed that organisms were formed from a primitive design, a prototype, and that all the different forms of being were generated by successive metamorphoses of this original prototype: "All beings were conceived and formed from a unique design which are their variations to infinity. From this prototype [*prototype*], and its metamorphoses considered as a great progress towards the most excellent form of being, which is the human form" (Robinet, 1768, p. 1). For Robinet, a plant, an insect, a reptile, a quadruped, "can be considered as more or less distant types [*types*], as if referring to a common primitive design [*dessein primitif*], and they were all products of the same idea more or less developed [*développée*]" (Robinet, 1768, p. 6). All forms of being consisted of the same essential pieces, and the differences between them were in their number, proportion, disposition, "things that can all be derived from the original plan, so to speak, by means of an evolution [*évolution*]" (Robinet, 1768, p. 7). In consequence, Robinet considered nature as a process of progressive metamorphoses from a prototype, which resulted in a scale of forms of beings, in which each one was an envelope [*enveloppe*] in a series of developings.

Kant: development from natural predispositions

Immanuel Kant (1724-1804), the philosopher from Königsberg, was one of the first proponents of anthropology as an autonomous area of study and gave lectures on this subject for many years.

In his anthropological writings, Kant defended and proposed a rather preformationist theory of organic development and heredity. For Kant, organisms were composed of germs [*Keime*] and natural predispositions [*natürliche Anlagen*]. The unfolding of these germs gave rise to the different body parts, while the natural predispositions determined the size and relation between the parts: "The grounds of a determinate unfolding which are lying in the nature of an organic body (plant or animal) are called *germs* [*Keime*], if this unfolding concerns particular parts; if, however, it concerns only the size or the relation of the parts to one another, then I call them *natural predispositions* [*natürliche Anlagen*]. In birds of the same kind which yet are supposed to live in different climates there lie germs for the unfolding of a new layer of feathers if they live in a cold climate, which, however, are held back if they should reside in a temperate one. Since in a cold country the wheat kernel must be more protected against the humid cold than in a dry or warm climate, there lies in it a previously determined capacity or a natural predisposition to gradually produce a thicker skin. This care of Nature to equip her creature through hidden inner provisions for all kinds of future circumstances, so that it may preserve itself and be suited to the difference of the climate or the soil, is admirable. In the migration and transplanting of animals and plants it creates the semblance of new kinds; yet they are nothing other than variations and races of the same species the germs and natural predispositions of which have merely developed on occasion in various ways over long periods of time" (Kant, 2007, p. 89). In these words of Kant, there were sketches of an adaptationist conceptual framework: characters appeared as a consequence of being in different environmental conditions. However, these "adaptations" were preformed. Therefore, in a strict sense, they were not adaptations: they were only expressions, "hidden inner provisions" that were stimulated to be developed by a process of unfolding. In that context, Kant made an assertion which seemed a warning to the future science of biology: "For outer things can well be occasioning causes but not producing ones" (Kant, 2007, p. 90)[7].

7 The oblivion of this principle was the origin of the adaptationist programme. Kant's conceptual framework was, therefore, an antecedent of later developments of the concept of adaptation. However, as it was pointed out, his proposal was not *adaptationist*, but rather *expressionist*. Kant was not only one of the first proponents of the modification of organisms by exposure to different biogeographical conditions, but also, he was one of the first proponents of an arboreal structure of variation through his concepts of stem [*Stamm*] (difference of kind) and race [*Racen*] (difference of species).

Blumenbach: from evolution to epigenesis and the Bildungstrieb

Ananke, while spinning the threads of time, wanted that Johann Blumenbach (1752-1840) made an exact but opposite turn as the one previously made by Haller. Initially an advocator of the theory of evolution, as understood by Haller and Bonnet, Blumenbach then converted to epigenesis.

As Blumenbach himself reported, the crucial experience that led to his conversion were his own experiments with polyps. While walking in the country during some holidays, he discovered in a stream a green armed polyp, with a long spiral body. When Blumenbach divided the animal, he found that after a few days, the animal had not only recovered its lost parts, but also the divided parts had become complete animals.

Blumenbach's favorite biological phenomenon to stand for epigenesis and reject evolution was regeneration. He saw in regeneration an unquestionable proof to turn down the theory of evolution: how could an animal regain a lost part, an arm, a tail, if it was supposed to be developed from a germ with no capacity of generation? How could a germ regenerate a part of an organism if its only function was to develop what it was already present from the beginning? Did it contain spare arms and tails?

Blumenbach envisioned that a force should be present in every organism that governed not only the process of regeneration, but also the process of generation itself, a force or drive that he called *formative drive* [*Bildungstrieb*]: "That there is no such thing in nature, as pre-existing organized germs: but that the unorganized matter of generation, after being duly prepared, and having arrived at its place of destination takes on a particular action, or nisus, which nisus continues to all through the whole life of the animal, and that by it the first form of the animal, or plant is not only determined, but afterwards preserved, and when deranged, is again restored. A nisus, which seems therefore to depend on the powers of life, but which is as distinct from the other qualities of living bodies, (sensibility, irritability, and contractility) as from the common properties of dead matter: that it is the chief principle of generation, growth, nutrition, and reproduction, and that to distinguish it from all others, it may be denominated the *Formative Nisus* (*Bildungstrieb*, or *Nisus formativus*)" (Blumenbach, 1792, p. 20).

Blumenbach established a clear difference between his concept of *formative drive* and Wolff's concept of *vis essentialis*. According to Blumenbach, the *vis essentialis* seemed to fulfill the task of distributing the nourishment to the different parts of an organism, but it was not responsible for its correct formation. In any case, it was clear that the concept of *Bildungstrieb* introduced an innovation. By this power, an organism was regenerated, that is, its order, its form, was restored. Therefore, this form could not be lost during the process, but was maintained and preserved in integrity.

A philosopher that benefited and made use of Blumenbach's concept was Kant, who, like the former, modified his views on the matter and adopted an epigenetic conceptual framework. Being interested in how to explain teleology in nature, Kant transformed an intrinsically vital and organizational principle in nature into a regulative and heuristic principle. This allowed him not only to justify teleology in nature but, at the same time, to continue considering mechanism as the only constitutive principle: "As regards this theory of Epigenesis, no one has contributed more either to its proof or to the establishment of the legitimate principles of its application, partly by the limitation of a too presumptuous employment of it, than Herr Hofr. Blumenbach. In all physical explanations of these formations he starts from organized matter. That crude matter should have originally formed itself according to mechanical laws, that life should have sprung from the nature of what is lifeless, that matter should have been able to dispose itself into the form of a self-maintaining purposiveness - this he rightly declares to be contradictory to Reason. But at the same time he leaves to natural mechanism under this to us indispensable *principle* of an original *organisation*, an undeterminable but yet unmistakeable element, in reference to which the faculty of matter in an organised body is called by him a *formative impulse* (in contrast to, and yet standing under the higher guidance and direction of, that merely mechanical *formative power* universally resident in matter)" (Kant, 1914, p. 345). Kant's interpretation of Blumenbach's concept of *Bildungstrieb* was quite inaccurate and misleading. Blumenbach did not start his reasoning from organized matter, as Kant asserted, but, on the contrary, he started from a homogeneous substance. Moreover, this homogeneous substance was endowed, imbued, with the formative drive, so it was rather confusing to affirm that this principle was an ability or faculty of matter. Despite considering it contrary to reason, Kant constantly seemed to imply that life sprung from what is lifeless, i.e. matter[8].

Weismann: the germ-plasm theory

August Weismann (1834-1914) is generally recognized as the proponent of the germ-plasm theory. A retrospective reading of this theory, made by the modern evolutionary synthesis and neo-Darwinism, posited this theory as the *coup de grâce* for the final collapse of the theory of inheritance of acquired characteristics and, in general, of any

8 The relation between Kant and Blumenbach regarding the concept of *Bildungstrieb* was explained in detail by Richards (2000).

kind of organic evolution[9]. However, this was a decontextualized and biased interpretation of Weismann's theory. His theory was much more complex and interesting.

Weismann's germ-plasm theory was an attempt to improve the evolution theory advanced by Haller and Bonnet, and reformulated subsequently by Kant. Weismann understood that the old conceptions of epigenesis and evolution were inappropriate to explain development, but while the former was founded on an erroneous assumption that made it incapable of correction, the latter could be improved in order to establish a modern theory of evolution: "Wolff's Epigenesis routed Bonnet's theory so completely from the field that, until quite recently, epigenesis was regarded as the only scientifically justifiable theory, and a return to the "evolutionist" position would have been looked upon as a retrograde step, as a reversion to a period of fancy which had been happily passed. I myself have been repeatedly told, with regard to my own "evolutionistic" theory, that the correctness of epigenesis was indisputably established, that is, was a fact, verifiable at any time by actual observation!" (Weismann, 1904, vol. 1, p. 352). Weismann's rejection of epigenesis was based on two fundamental reasons: "on the one hand taking the *appearance* of a homogeneous germ-substance for reality, and, on the other, assuming a special power, which caused a heterogeneous organism to arise from a homogeneous germ" (Weismann, 1904, vol. 1, p. 353).

What did Weismann understand by the concept of germ-plasm? As a first approximation, the *germ-plasm* was the hereditary substance contained in the nucleus of germ cells, i.e. chromatin. Weismann considered the germ-plasm as the *idioplasm*, a concept that took from Nägeli, although he used it with a different theoretical conception of its mode of action. He adopted from Nägeli the idea that the idioplasm was the "bearer of the primary constituents [*Anlagen*]" and the responsible for "determining the whole structure of the organism" (Weismann, 1904, vol. 1, p. 349). The idioplasm was never formed anew, it was always derived from another cell. Therefore, it not only determined the characteristics of a particular cell, but also those of all its descendants.

What was the constitution of this idioplasm? In the first place, the *idioplasm* was composed of *ids*. *Ids* were "the complexes of primary constituents [*Anlagen*] necessary to the production of a complete individual" (Weismann, 1904, vol. 1, p. 349). In other words, an *id* represented *virtually* the whole organism and, therefore, it contained as primary constituents [*Anlagen*] all the parts of a perfect animal. An *id* corresponded, in

9 This would include what we now know as "epigenetic mechanisms", and what we subsume under the concept of *epigenetics*.

general, to a chromosome[10]. In the second place, *ids* were composed of *determinants*. Weismann called *determinants* [*Bestimmungsstücke*] to the particles or units of an *id* that corresponded and determined the production of a particular part of the organism, i.e. primary constituents [*Anlagen*]. Weismann made it clear that these determinants should not be considered as miniature models of the parts they determined, a clarification that could also be applied to Bonnet's theory. In the third place, *determinants* were composed of *biophors*. The *biophors* were the bearers of cell qualities. They were the fundamental *vital units*, the smallest units that exhibited the primary vital forces (assimilation, metabolism, growth and multiplication). Weismann did not provide a complete explanation of these proposed vital units. He assumed they were composed of different kinds of molecules, such as albumin, and these molecules were arranged and organized in many different ways, giving rise to an almost unlimited number of biophors. However, he did not venture to question how this vitality was produced: "in what form these substances are contained in the biophors, and how they affect each other in order to produce the phenomena of life by going through a ceaseless cycle of disruptions and reconstructions, is still entirely hidden from us. We have, however, nothing to do with that here; we content ourselves with recognizing in the biophors the characteristics of life" (Weismann, 1904, vol. 1, p. 369).

With this conceptual framework in mind, Weismann then attempted to explain ontogeny. For him, ontogeny was "a series of gradual qualitative changes in the nuclear substance of the egg-cell" (Weismann, 1893, p. 32). In this regard, the germ-plasm was the first ontogenetic stage of the idioplasm of an animal or plant, that is, the first onto-idic stage. Therefore, development was a process mediated and driven by the stepwise and gradual modification of the idioplasm of the newly generated cells, but ultimately, by the architectural organization of the idioplasm of the germ-cell, i.e. germ-plasm. Weismann proposed a segregation model of development[11]. According to this model, the idioplasm of the dividing cells were not segregated equally, but depended on the positional information of the generated cells: "the germ-plasm contains the primary constituents of all the cells in the body in its determinants, and it only remains to inquire how each kind of determinant reaches the right part in the right number" (Weismann, 1893, p. 61). In principle, one *id* was sufficient for the complete ontogeny of an organism, and one *determinant* was sufficient to determine and control a cell. In this manner, the correct development of an organism depended on three main factors: the historically inherited architecture of the germ-plasm, the definite position of each

10 Sometimes, Weismann defined a chromosome as an *idant*, which was considered as a group of *ids*.
11 This model was very similar to the "mosaic theory" of Roux (see below).

determinant, and the unequal segregation of these determinants based on that positional information.

This theory of development devised by Weismann, which represented a complexification and atomization of the theory of evolution advanced by Bonnet, had its limitations and deficiencies. It presented problems on how each corresponding determinant would reach "the right part in the right number", especially, if in each cell division the determinants would halve and lose, thus, the architectural figure of the *id* that provided the positional information for each individual determinant. Weismann stated that "each id, in every stage, ha[d] its definitely inherited architecture" (Weismann, 1893, p. 73) or, in other words, that "each ontogenetic stage [was] characterised by a definite "determinant figure", i.e., a sort of geometrical structure composed of the determinants" (Weismann, 1893, p. 80). However, he never stated clearly how the original architecture of the germ-plasm, a single idic architectural figure, could accommodate all the subsequent architectures of the numerous idic (ontogenetic) stages.

Driesch: entelechy as intensive manifoldness

Hans Driesch (1867-1941), a former student of Weismann and Haeckel, carried out in 1891 a series of experiments with sea urchin eggs that seemed to contradict the results and conclusions reached by Roux in 1888. Roux destroyed one of the first two blastomeres of a frog egg. As a result, he obtained exactly half of the complete organism. He interpreted his results as a confirmation of the segregation model of development proposed by Weismann, and his own mosaic theory. On the other hand, Driesch divided the first two blastomeres of a sea urchin egg. Unlike Roux, Driesch obtained a complete organism from both blastomeres. In this manner, Driesch refuted a mosaic theory of development. Instead, he proposed that development was a process governed by the activity of an organizational principle that he called *entelechy* (Ostachuk, 2016). Driesch took the term from Aristotle. It could be translated from Greek as "with the end in itself".

Driesch defined entelechy as an *intensive manifoldness*. An organism, on the other hand, could be considered as an extensive manifoldness. If a certain number of elements were arranged one beside another in space, or one after another in time, then it was an extensive manifoldness. As an intensive manifoldness, entelechy was not placed in extensive space or time. It was the principle of individualization of an organism, a principle that established it as a unity from its origin. An extensive manifoldness could not be divided without a loss of its parts. Conversely, an intensive manifoldness could be divided and still retain its integrity, for the simple reason that it had no spatial dimensions: "Therefore we had better not speak of entelechy as an agent which "remains whole in spite of its division into parts", but simply say that entelechy may manifest itself wholly even after the division of a certain organic body, on which, had it remained one whole, entelechy would have manifested itself as one whole also. Entelechy always manifests itself individually" (Driesch, 1908, vol. 2, p. 258). Therefore, entelechy possessed the quality of *individuality*. This quality was actually the responsible for conceiving things such as a totality, integrity or an organism. In fact, Driesch considered that there should be a faculty in order to conceive entelechy conceptually: "I propose to give the name of *individuality* or *constructivity* to the new category we are studying here […] In fact, by saying that "individuality" leads to individual construction and is elemental in itself the role of this category seems better expressed than in any other way. Some special category we must have in order to acquire any systematized experience about specific and typical constructions at all; there would not be any such experience without it. The construction itself may be spatial or temporal or both; that is to say, the whole of the construction may be a typical order of elements in space or in time or in both; no matter, its logical aspect remains *construction of individual wholeness* in spite of its being composed of parts" (Driesch, 1908, vol. 2, p. 312). Furthermore, in posterior works, Driesch not only considered individuality as a category or faculty of knowledge, but also as a true kind of causality: the *unifying* or *individualizing causality*. The unifying causality was the causality responsible for the production of unities and wholes, by which "an equal sum-like distribution of possibilities [was] transformed, without preformation in space, into an unequal and whole distribution of actualities" (Driesch, 1914, p. 52).

CONCLUSIONS

Post-formation and preformation

The origin and development of the concept of evolution was the problem of organismal generation. The development of the concept of evolution has advanced, therefore, through a tension and dialectical movement between two apparent opposed and incompatible concepts: post-formation (i.e. epigenesis) and preformation (i.e. evolution). However, every possible concept of post-formation must rely on some kind of preformation. The most usual solution was to resort to a vital force that carried within itself the future form and characteristics of the organism. This solution was not only convenient or opportune, it was a logical necessity. In other words, although an *actual preformation* is denied, it must always be accepted as a *virtual preformation*. Otherwise, the following questions arise: (1) how does the organism obtain its form?; (2) how does this form is "formed"? The first question is an evasion, whereas the second is a self-contradiction.

This virtual preformation is not restricted to the process of animal generation. The problem of regeneration, discussed by Blumenbach, constitutes an interesting case for consideration. This process provides one of the best examples in nature on how an actual form can be restored thanks to the "persistence" of a virtual form. When an organism loses a part of its body, its actual form is lost. Therefore, the form should be present virtually in order to be properly restored.

Transmutation and evolution

Transmutation and *evolution* are different concepts. The difference between them is in how the transformation occurs. In the first case, the transformation is caused by an external event: it is an external moulding cause. The information necessary for the transformation is provided from outside. In the second case, the transformation is caused by an internal content: it is an internal expressionist cause. An external event could only act as a trigger, but it cannot provide any content for the future development of the organism. One could think of Malebranche's occasional cause at this point, although he used it in a different conceptual framework and for a different purpose.

The point of departure of both conceptual trajectories could theoretically be located in the oblivion of the aforementioned warning of Kant, occurred at the beginning of the 19^{th} century: "For outer things can well be occasioning causes but not producing ones" (Kant, 2007, p. 90).

Explicated order and implicated order

Transmutation is a geometrical change within an *explicated order*. On the other hand, metamorphosis is an event occurring in an *implicated order*. An explicated order is the typical three-dimensional space, where everything is outside everything, each thing is next and beside the other. An implicated order is an order where everything is inside everything, each thing contains everything. In the first case, the movement that enables to go from one thing to the other is a *translation* [*translatio*]. In the second case, the movement that enables to go from one thing to the other is an *unfolding* [*evolutio*]. This determines that transformations in an explicated order are gradual and expected, whereas transformations in an implicated order are drastic and unpredictable.

One could wonder if Anaxagoras was not thinking of such an implicated order when he asserted that there is a portion of everything in everything: "And since the portions of the great and of the small are equal in number, so too all things would be in everything. Nor is it possible that they should exist apart, but all things have a portion of everything. Since it is not possible that there should be a smallest part, nothing can be put apart nor come to be all by itself, but as things were originally, so they must be now too, all together. In all things there are many ingredients, equal in number in the greater and in the smaller of the things that are being separated off" (Kirk & Raven, 1957, p. 375).

Intensive evolution

Henri Bergson (1859-1941) conceived life as an evolutionary process driven by an inner impulsive movement called *élan vital*. Bergson was deeply influenced by Herbert Spencer, who proposed a theory of development from a simple, undifferentiated homogeneity to a complex, differentiated heterogeneity, accompanied by a process of increasing integration (Spencer, 1857). Despite this influence, Bergson was very critical of Spencerian evolutionism: "the usual device of the Spencerian method consists in reconstructing evolution with fragments of the evolved" (Bergson, 1944, p. 396). Is not the fundamental distinction between evolution and transmutation contained in this critique? The *evolved* is the extensive world, a world populated by mutually-exclusive entities, whose only mode of action is by external influence. On the other hand, the *evolving* is the intensive world, a world populated by serially-inclusive entities, whose mode of action is by internal unfolding.

Bildung and evolution

In the end, do not epigenesis and evolution share the same principle? Do not the main systems of epigenesis ascribe development to a formative power? Do not these different formative powers consist of a virtual preformation? The key to this conceptual breakthrough could be found in the passage from the Blumenbachian *Bildunstrieb* to the Drieschian unifying causality: what was tacit and implicit in Blumenbach's theory, that what was supposed to be regenerated should be present from the beginning, was made explicit by Driesch when he transformed it into a cause. This cause was not elementary or mechanical, it was a structural and organizational principle. However, we consider the terminology of Blumenbach more appropriate: the concept of *Bild* (image) fully expresses the wholeness [*holos*] required for the case.

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