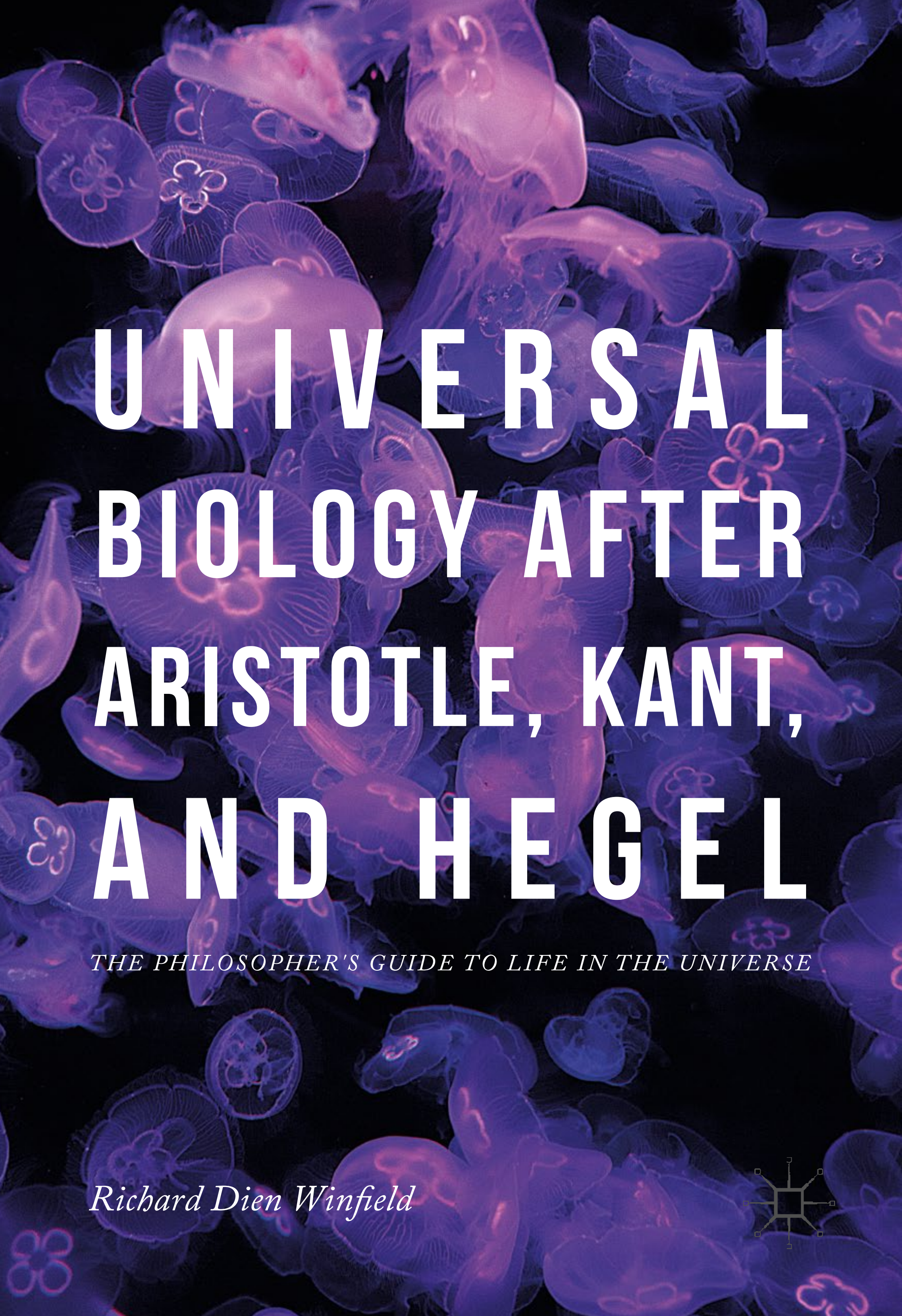

UNIVERSAL BIOLOGY AFTER ARISTOTLE, KANT, AND HEGEL

THE PHILOSOPHER'S GUIDE TO LIFE IN THE UNIVERSE

Richard Dien Winfield

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The Philosopher's Guide to Life in the Universe

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In memory of my paternal grandparents, Sadie Margolis and Samuel Weinfeld

Contents

1

Introduction

Life is an unfathomable mystery for anyone who attempts to comprehend it by using the categories suited for conceiving the mechanics of matter in motion, the physical processes of electromagnetism, and the chemical interactions of different atoms and molecules. Although life incorporates all of these natural phenomena, the essential life functions exhibit uniquely biological processes that are irreducible to the inorganic factors of which living things are composed and with which they interact.

The complementary functionality of the organs of the living individual involve an internal teleology where each part of the organism is both means and ends to its counterparts, sustaining them and thereby sustaining itself, while allowing the whole life form to function for the sake of continuing its own operations. Whereas inorganic entities are subject to lawful relations that determine them from without with indifference to what they are, the organic unity of the living thing upholds itself by its own differentiation into mutually supporting organs whose functions are intrinsic to the specific nature of the organism.

Similarly, the metabolism of living things relates them to their environment so as to sustain the metabolic activity of the organism, whereby

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it exchanges material with what lies outside, assimilating factors that become integrated into the ongoing metabolic process. By contrast, the mechanical, physical, and chemical interactions of inorganic factors neither perpetuate themselves, nor enliven their constituents, but instead succumb to the march of entropy, in which order gives way to disorder. Metabolism makes resistance to entropy an enduring occupation of life, which always strives to maintain its active self-organizing unity.

Finally, the reproduction of organisms enables life to give itself a species being, consisting in the propagation of unique living individuals who generate others of the same kind. Inorganic entities can do nothing of this nature. Admittedly, the evolution of species may reflect external contingencies, involving astrophysical, geological, chemical, and physical factors that influence the production of mutations and the survival of certain genetic varieties. Nonetheless, evolutionary development can solely proceed upon the basis of self-sustaining entities that maintain themselves as not just individuals, but members of natural kinds that aim at perpetuating themselves.

In all these life processes, organic nature exhibits a self-organizing and self-sustaining character that transcends the external necessitation of efficient causality, where factors are determined from without with indifference to their essential nature. The natural reality of living things does involve manifold contingencies that only empirical observation can apprehend. Life, however, does have an essential, universal nature that philosophy can investigate. Reason can explore what is constitutive of life in general as well as what are the fundamental particular forms that life can take wherever in the universe living things may arise. In pursuit of this exploration, philosophy can develop a universal biology transcending the contingencies of life on earth, where living things happen to be carbon-based and infused with RNA and DNA.

Aristotle, Kant, and Hegel, three of our greatest earthly philosophers, have already provided important contributions to universal biology. We do well to stand upon their broad shoulders and use their conceptions to think through how nature becomes a biosphere in which life can arise and flourish, what are the basic life processes common to any organism, how evolution can give rise to the different possible forms of life, and what distinguishes the essential life forms from one another. In pursuing this task, we can come to understand our own biological origins and make intelligible how nature can engender rational animals capable of conceiving its true character.

The following work attempts to provide a philosopher's guide to life in the universe, building upon the seminal achievements of Aristotle, Kant, and Hegel, with the aid of some more recent theorists. Our goal is to develop an outline of universal biology, providing the crowning consummation of the philosophy of nature.

This work is the sequel to my recent book, *Conceiving Nature after Aristotle, Kant, and Hegel: The Philosopher's Guide to Nature*, which attempts to think through the universal constitution of nature to the point where nature becomes a biosphere in which life emerges and makes possible our undertaking the philosophy of nature.[1] Although that preceding work provides important foundations on which the investigation of life depends, rational animals anywhere in the universe need only look at themselves and their own environment to make sense of the following exploration of universal biology.

Notes

1. Richard Dien Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel: The Philosopher's Guide to Nature* (Palgrave Macmillan, 2017).

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2

Nature as Biosphere

Life and Its Biosphere

Life is the consummation of the development of nature, including and presupposing all inorganic processes from the mechanics of matter in motion to the physics of electromagnetism and chemical interaction. The conception of organic nature thus comprises the concluding section of the philosophy of nature. On the one hand, life cannot emerge in nature without inorganic nature at hand, which can exist without the presence of living things. On the other hand, life encompasses and relates to all developments of inorganic nature. Without their existence, life cannot be, and without comprehending them, we cannot conceive life. Life is therefore the most concrete realization of nature, just as the conception of life is the most comprehensive and challenging part of the philosophy of nature. Moreover, life can evolve into rational animals who can know what nature is in truth and produce culture and history, whose conventions nature makes possible but leaves undetermined. Consequently, the full development of life brings closure to nature in both reality and philosophical conception, while providing the basis for the non-natural reality of rational agency and the historical world we make for ourselves.

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In order for life to arise and develop, inorganic nature must somewhere and at some time come to constitute a biosphere, an environment allowing living things to emerge, sustain themselves, and reproduce. This biosphere presents the natural precondition and setting within which life both comes to be and continues its development. Consequently, before the philosophy of nature can consider the emergence and evolution of life, the constitution of nature as a biosphere must be determined. Admittedly, only the conceptually and naturally subsequent development of life can certify that nature as biosphere fulfills its life-enabling character. Nonetheless, nature that is pregnant with life does not yet include any specification or trace of the life process.

This reflects the developmental character of the totality of nature. That totality has its full-fledged reality only when nature contains life and life has made its way through its evolutionary process to give rise to the rational animals that generate a non-natural culture and history for themselves. At no time need nature contain life nor will life necessarily continue to exist once it emerges. Not only do stars and their solar systems undergo astrophysical developments that end up destroying the conditions for life, but life may drive itself to planetary extinction. The failure of any extra-terrestrial rational beings to have made unequivocal contact with humanity suggests that rational life may have an especially fragile endurance, given its ability to destroy itself once it reaches a certain technological development.

When and wherever life does emerge and evolve, it will face two challenges that each pose conceptual hurdles for the philosophy of nature. One consists in the challenge of remaining alive in a biosphere confronting the living organism with inorganic processes that act externally upon it. The other consists in the coordinate challenge of containing inorganic processes without their mechanisms obstructing from within the self-preservation and reproduction of the organism. In both respects, the relationship between what is alive and what is not alive is constitutive of life and its defining processes. To the degree that this is so, there can be no point in wondering whether everything in the universe could be alive.

What upholds the impossibility of a universe that is completely alive is the principle of entropy enshrined in the second law of thermodynamics. According to this principle, the degree of order of any independent material system will progressively diminish. Living things seem always to be resisting entropy by sustaining their living process instead of succumbing to the decomposition awaiting any physical entity from which life has been extinguished. Organisms make a career of defying the loss of order and if the universe consisted solely of living things, it would defy the second law of thermodynamics without exception. If, however, life exists in a world that contains inorganic as well as organic entities, the second law of thermodynamics can hold sway so long as the advancing entropy of the biosphere compensates for the self-sustaining order of living things.

Hegel contributes to our understanding of how nature comprises a biosphere in which life can arise and continue to evolve in ways that neither Aristotle nor Kant can follow. Unlike these predecessors, Hegel extends the philosophy of nature to address the development of life, without losing sight of its fundamental difference and relation to what is inorganic. Although Kant will think about certain fundamental features of life, he does so in order to indicate how life falls outside the philosophical knowledge of nature proper, which he limits to the mechanics of matter in motion.[1] Aristotle, for his part, certainly includes life within his philosophy of nature and investigates the forms of life at great length. What Aristotle fails to do is properly distinguish life from the inorganic processes of nature. He tends to conceive nature in general in terms that are specifically appropriate to life. This is evident from the very outset of his *Physics*, where Aristotle characterizes what is by nature as that which moves itself according to what form it has.[2] Accordingly, in nature, form and end coincide, such that natural entities have an active form, comparable to a soul.[3] On this basis, Aristotle treats natural entities that are not alive as if they contained an *animus*, moving themselves according to what kind of thing they are. Aristotle can thus associate a special place to each of the different elements, to which they gravitate if nothing stands in their way. The distinction between what is living and what is inorganic in nature loses its proper divide. This is most offensive to early modern philosophers through Kant, who incorrectly conceive all of nature as a mechanism, such that a Descartes can regard animals as if they were machines.[4] Aristotle's view is also problematic, however, for any attempt to acknowledge the mechanism of undifferentiated matter, the dynamics of electromagnetic physics, the specificity of chemical process, and the way in which life can emerge by incorporating and relating to these inorganic constituents of the universe. Hegel provides us with an account that allows us to understand how nature has room for life, without failing to comprehend the fundamental difference between organisms and the inorganic biosphere they inhabit. On this basis, it will be possible to escape the mind-body dualism of early modern philosophy and its latter day epigones, who reduce all natural process to the external governance of material law, excluding any place for the self-activity of life and mind. Their reductionism of nature to mechanism not only leaves mind banished from nature and with no explicable connection to a body, but leaves an abyss between ourselves and all other life forms. The nature that instead has room for self-sustaining organisms will also have place for organisms with minds, as the evolution of animal life will provide. Then, we can regard our position as an object of zoology as a basis for comprehending other forms of animal minds with differing endowments.

Hegel invites us to follow him in exploring a nature that contains mechanism, physical process, and life.[5] This exploration will turn out to be a voyage of self-discovery to the extent that the examination of life will encompass the development of plants, brute animals, and the rational animals that can acquire true knowledge of nature.

Hegel's Account of the Biosphere as a Geological Organism

Since life emerges from an inorganic environment with which it remains in an inescapable relationship, the reality and conception of life must begin with the constitution of nature as a biosphere with the potential to foster the origination and evolution of life. Hegel accordingly begins his account of "organics" by determining the biosphere from which life emerges. He does so, however, by characterizing it as a geological totality whose inorganic processes integrate themselves into a relatively self-sustaining unity. Insofar as this environment is relatively self-sustaining, Hegel sees fit to describe it as a geological organism, which exhibits certain forms of organization that are comparable to aspects of living things.[6]

Hegel's description of geological nature as "implicitly" an organism[7] invites us to think of him as foreshadowing the theory put forward in the 1970s by James Lovelock and Lynn Margulis under the rubric of the Gaia Thesis. This thesis maintains that the earth is a living totality insofar as it replicates on a global scale the kind of functions that an organism individually realizes. The earth contains parts that are mutually dependent upon one another, serving as means and ends of one another as well as allowing the totality of the earth to maintain its environment. The earth may have a geological history, relative in certain respects to the evolution of the solar system, but in the era when life arises and subsists, the global environment maintains sufficient stability to allow its different geological and atmospheric processes to carry on and allow the earth as a whole to remain a biosphere. Like an organism, the earth thereby functions as a self-sustaining totality consisting in components whose interdependent changes allow them and the whole to which they belong to subsist for some time.

The Gaia thesis does not claim that the earth engages in reproduction, asexual or sexual. Nor does it claim that the earth grows. The Gaia thesis does, however, allow for the earth to repair itself by overcoming disruptions of its environmental balance in various ways. Like a barren organism, the earth still acts upon itself to preserve the proper integration of its components and thereby sustain itself, at least for long enough to host the evolutionary development leading to the proponents of the Gaia thesis.

What differentiates Hegel's account of geological nature from the Gaia Thesis is that Hegel's geological "organism" does not yet incorporate life, whereas the Gaia Thesis specifically involves a world that has life. Such a world has an ecosystem and not just a geologically self-regulating nature. The Gaia Thesis very much focuses on the way in which living organisms on the planet earth play a very significant role in maintaining the ecosystem in a way that allows life to persist. The Gaia Thesis does not apply to the inhospitable environments of Venus and Mars, nor to the planet earth before life arose. Ecological balance first pertains to our planet when life enters the geological system.

One can grant plausibility in two respects to Hegel's description of geological nature as "implicitly" an organism. On the one hand, it can signify simply that geological nature constitutes a biosphere in which life can emerge. When that happens, the earth becomes explicitly a world of life, which necessarily contains both organic and inorganic processes. On the other hand, the implicit organic character of geological nature can signify that its world has sufficient self-regulating stability to keep its regions within the bounds that permit living inhabitants to confirm its character as a biosphere. Hegel certainly acknowledges that geological nature constitutes the setting specific to life, insofar as it provides all the inorganic resources to be potentially a world hosting living things. An inhabitable world is a natural entity that has all of the processes of inorganic nature that life both incorporates and depends upon. A biosphere cannot be a star, whose nuclear fusion precludes the chemical processes on which life depends. Nor can it be a barren meteor equally devoid of meteorological or chemical process, or a larger body lacking a molten core to provide a magnetic field protecting nascent life from deadly radiation. It must be a very special physical totality, not only with enough geological, meteorological, and chemical processes to allow for life, but also sufficiently moderate environmental change to secure the survival and evolution of living things. Moreover, it must include the astrophysical entities, such as stars and moons, which may not themselves host life, but provide the radiant energy and tidal variations that make it possible for other bodies of solar systems to give rise to living things.

Nature as biosphere is thus not only the totality of inorganic nature, but specific environments that have the potential to generate and host life. Nature as biosphere is thereby the enabling condition of enduring life and warrants determination before the development of organic nature can be and be conceived.

Nature as biosphere entails a crucial factor concerning the character of life. Although life may be self-sustaining, life originally emerges not from itself, but from a preexisting inorganic biosphere. Once life emerges, however, it engages in maintaining itself over and against the inorganic processes that provide its enabling conditions. Moreover, at some point living organisms take on the ability to reproduce and engender the evolutionary process by which rational animals can eventually emerge somewhere in the universe. Never can the development of life eliminate the inorganic nature in relation to which its metabolism depends. Hence, the biosphere can never be completely absorbed into the life process and become a genuinely living totality, as the Gaia Thesis may suggest.

At the opening of Hegel's account of "Organics", he presents a threefold division, which might seem to conflict with taking nature as biosphere as the starting point.[8] Hegel characterizes the first section of this division as the *geological* organism, which is "the universal image of life."[9] A second division follows, characterized as the *vegetable* organism, which constitutes the shape of life "as particular, formal subjectivity."[10] Finally, the concluding third section is the *animal* organism, which constitutes the shape of life "as individual, concrete subjectivity."[11] Since Hegel here divides life into the geological organism, plants, and animals, one might suppose that the geological organism is not the biosphere, but rather the primitive shape of life that precedes the emergence of plants. When, however, Hegel elaborates on this division, he characterizes the first section as only the *immediate* Idea of life, which "is therefore external to itself."[12] This geological organism is accordingly "non-life, only the corpse of the life-process, the organism as totality of the inanimately existing, mechanical and physical Nature."[13] Hegel confirms that this latter characterization does not make the geological organism a primitive form of life, which is not yet plant or animal. Rather, the geological organism, as "only *implicitly* organism, does not exist as a *living creature*." Instead, as Hegel proceeds to elaborate in the rest of his account of geological nature, the geological organism is nature as biosphere, containing the history, structure, and "life" of the earth that constitute it as the generic environment in which life proper can explicitly emerge and evolve.[14]

On this account, the biosphere becomes a habitable environment only after undergoing a certain geological development. This history of the earth establishes the geological structure on which life can arise and develop thanks to the "life-process" of the biosphere, which provides a sufficiently stable environment for living organisms to endure and evolve on the basis of its geological and meteorological processes. These processes will make possible the self-sustaining activity of living organisms to which Hegel will ascribe certain types of subjectivity, which geological activity lacks.

The immediate totality of the geological organism will pave the way for the subjective totality of the living thing, and in doing so, warrant description “as only implicitly organism.”[15] The biosphere does not exist as a living creature, but it has a history of its own development, which leads to the inorganic totality whose processes have the potential for bringing life into enduring being. In these respects, geological nature is not just a restatement of nature’s mechanics and physics. It adds to these the specific configuration whereby these aspects of inorganic nature comprise a biosphere. The history of the genesis of the biosphere is not a history of stars, comets, asteroids, or uninhabitable moons and planets, but rather the history of the earth, where earth figures properly as the generic biosphere that certain planets and moons may comprise. Similarly, the structure of the earth is that of such inhabitable bodies, just as the “life of the earth” is properly the geological and meteorological process of a stable environment on such life-friendly bodies. Only such a history, such a structure, and such stable processes can bring nature to become something fundamentally different from what it already comprises. Nature as biosphere is this new frontier that is ready to unfold.

Although Hegel describes geological nature as having something akin to organic unity, he equally points out that it lacks the features that are distinctive of a living organism. The parts of the biosphere are not organs in the same way as those of a living thing. The biosphere has something like the shape of an organism insofar as the inhabitable earth is a universal system of individual bodies of different sorts,[16] where the dynamics of land masses, oceans, and atmosphere impact upon one another so that they maintain a relatively stable environment.

This analogy to organic unity cannot hide significant differences that become evident as the history and structure of earth are examined. Hegel makes clear at the outset of his treatment of the history of the earth that its process of formation is very different from that of an organism. The organs of a living thing contain the life process within their own functioning, producing one another and the whole to which they belong in its ongoing metabolism. By contrast, the biosphere is an “external *system*” whose parts do not generate one another nor their unity, and whose “*process of formation* lies in the *past*” rather than in their current existence.[17]

The order of treatment of history in nature reflects this difference when one compares it with where the history of rational agents comes up in the philosophy of spirit or rational agency. Hegel addresses the latter history as something susceptible to philosophical treatment at the end of his ethics, his *Philosophy of Right*.[18] This history is a prescriptive, rather than descriptive *a priori* theory of freedom. It consists in an examination of what has to happen in order for the institutions of freedom, which realize right, to come into being. Accordingly, we can address this normative history only after determining the normative institutions of freedom, whose existence comprises the end of the history of freedom. Philosophy also provides the starting point of such a normative history insofar as philosophical investigation can determine the natural and psychological constituents of rational agents, without which no non-natural history can develop. Hegel recognizes that there can be no philosophical descriptive history because conventions are arbitrary, being the product of what individuals will in relation to one another. Nonetheless, the normative history of the institutions of freedom may gain some descriptive power if and when conventions emerge that embody the structures of right. Nonetheless, given the willful contingency of convention, there is no *a priori* way of determining what automatically must happen in non-natural history. Indeed, the very origination and continuation of such history is contingent upon external natural occurrences. The next time an asteroid comes into our vicinity it may well interrupt the march of freedom in the world and put an end to our history.

The biosphere, however, does have a determinable descriptive history. On the one hand, the biosphere is itself normatively neutral, being the precondition of any form of rational life, good or bad. On the other hand, the astrophysical dynamics that generate planets and large moons provide the starting point from which the history of "earths" can proceed, owing to the inorganic processes each earth contains.

Although the history of the earth may set the stage for the emergence of life and any eventual march of non-natural history, Hegel duly considers it before he addresses the structure of the earth as a full-fledged biosphere. Since the biosphere must itself be included in the existence and conception of life, and the biosphere comes into being through certain astrophysical and geological developments, the history of their procession must come before the processes of the constituted biosphere can be or be conceived. This is why Hegel insists that the formation of the earth lies in the past,[19] before the geological "organism" can exhibit its structure. The living organism is continually forming and sustaining itself in its entirety through the complementary functioning of its organs, by which it survives and grows. By contrast, the earth's formation as a biosphere produces its geological structure, which has a given place in the solar system, wherein its own parts lie outside one another, subject to mechanical and physical forces, rather than being the product and producer of one another.[20] The formative powers of the organs of the living thing do not exist apart from its life process. The forces at work in geological and meteorological process are not intrinsically bound up with the individuality of the earth as biosphere. Because the earth is "not a living subject", Hegel recognizes, "it endures, it does not produce itself."[21] So long as it endures with a sufficient degree of continuity, the life of the earth can provide a relatively stable environment for the emergence and development of living things.

If, instead, each biosphere were the product of another biosphere, then its process of formation would not be something antecedent to the existence of biospheres in general. The earth, however, is not produced by another earth in the manner of the reproduction that becomes characteristic of living organisms, once they develop the ability to provide for their own species being. The formation of the earth lies entirely outside the earth in the genesis and possible interaction of solar systems, with their comets and asteroids in tow.

One might ask why the history of the earth did not already come up in Hegel's determination of solar systems, first as gravitational systems, and then as emitters of light, fostering the physical processes that lead eventually to the chemical reactions that can become constitutive of an organism.[22] The plausible answer is that neither of these preceding determinations involved everything that must be at hand for a biosphere to come into being. They are certainly included in the history of earth, but that history must also contain every physical process up through chemistry that develops on their basis.

Similar questions arise with respect to the structure and life of the earth. Hegel already situated the meteorology of the phase changes of the states of matter in a planetary or comparable lunar setting. Why did this meteorology not already incorporate the geological structure and processes of the biosphere? Once more, the answer is the same. The geological organism does indeed incorporate the elementary meteorology of the states of matter, but it further involves all the relevant mechanical, physical, and chemical processes that determine the encompassing life of the earth as a biosphere.

The generic history of the earth will accordingly consist in the processes whereby a potential biosphere comes to acquire all the states of matter in the form of an atmosphere, liquid bodies, and solid territories, together with a liquid core to produce a protective magnetic field, and a source of radiant energy not too near nor far to be tolerable. Whether or not these geological endowments contain a carbon chemistry and the chemicals out of which RNA and DNA can form is not a prerequisite for the universal biology to which a biosphere in general should be compliant. What matters is that these endowments allow for the chance integration of chemical reactions into a self-sustaining, autopoeitic whole, which then can survive the conditions on its lonely outpost somewhere in the vast reaches of space.

The history of the "earth" of which the first part of geological organics consists is thus properly a universal history whereby a biosphere comes into being as life implicit, as the world that possesses the potential to generate and foster the development of living things. What this history brings into being is a world possessing the structure specifically enabling life to arise and persist. Hegel describes the emergent structure of the earth in terms of the distinct geological formations of our lonely planet, involving different types of minerals.[23] What is properly at stake is the universal physical structure a world must have to foster life. This might allow for condensed and frozen gases to provide the liquid and solid regions in which organisms might live with a completely different extraterrestrial chemistry. We may soon encounter biospheres of this character on such frozen moons of Jupiter and Saturn as Europa and Enceladus.

Whatever the particular constitution of a biosphere's structure, it must be such as to involve global processes, the life of the earth, as Hegel describes it,[24] in relation to which living things can form, metabolize, and reproduce. Since life depends upon chemical reactions, which themselves require catalysts, for which liquids are most suited, the world as biosphere must give rise to meteorological processes providing the materials and environment in which autopoeisis, the "self-making", self-preserving process of life can occur.[25] Consequently, the structure of the biosphere must involve regions embodying the different states of matter, together with the geological and meteorological processes specifically enabling life to arise and persist. These processes proceed both within and between the geographic regions distinguished by their general state of matter: the solid regions of land masses, the liquid regions of oceans and inland rivers and lakes, and the gaseous region of the atmosphere. The life of the earth will involve the very concrete interaction whereby the geological upheavals of the land impact upon the bodies of liquids and the atmosphere, just as these wash away and weather the land's solid material.

In developing the geological history, structure, and life of the earth, Hegel acknowledges that they are not just internally determined, but also bear the impacts of the biosphere's relation to the other bodies of the solar system to which it belongs. These impacts include the tidal effects of the moon's orbit, collisions with asteroids and comets, and variations in solar radiation associated in part with fluctuations in the earth's orbit and of its magnetic field. Regarding the processes internal to the life of the earth, Hegel points to two formative processes: "vulcanism" and "neptunism."[26] Vulcanism refers to all the prior and continuing volcanic processes transforming the earth's surface. Neptunism, by contrast, refers to all the geological transformations produced by the movements of water over and against land, wearing down the landscape, carving new paths for waterways, and depositing silt and sand. Vulcanism produces igneous rocks once lava solidifies, then the pressure of rocks upon one another produces metamorphosed minerals, all of which wind and water then weather, producing alluvial deposits. Hegel details these mineralogical formations in familiar terrestrial terms,[27] but we should reconceive them in terms of a universal geology that can take into account biospheres of different physical compositions.

This need for generalization applies to the meteorological processes that fall within the domain of any biosphere. To begin with, the states of matter might apply to very different chemical elements, such that, for example, land and seas might be frozen and liquid gases that do not exist in such states on earth. Moreover, a biosphere could be a water world with no land masses breaking through to an atmosphere. Alternately, frozen material could entirely cover the surface of a biosphere, below which liquid could exist, warmed by radioactivity and gravitational pressures.

In every case, the geological and meteorological processes must retain sufficient stability to allow life to arise and survive. By being such a relatively stable, self-maintaining environment, the biosphere can have a "life" of its own, by which it is life implicit, possessing the potentiality for fostering organisms.

The enduring character of the biosphere has two successive dimensions. On the one hand, the biosphere has a stability prior to the emergence of life that enables life to arise and survive. On the other hand, the biosphere must retain a sufficient enduring character after life emerges and transforms the biosphere into an ecosphere, in which living things transform their environment. Life forms may, of course, perniciously alter their ecosystems and thereby undermine their own survival. Moreover, intelligent animals may develop the ability and negligence to destroy the biosphere by transforming it into a Venus-like furnace too hot for any life form to persist. For the biosphere to maintain its character after life arises and produces an ecology, the newly inhabited planet or moon must retain its conditions within the boundaries of livability.

Although Hegel has characterized the earth as a geological organism, with a history, structure, and life-process, he describes the earth as a "crystal of life".[28] Like a crystal, the earth has a shape. Like the shape of a crystal, that of the earth is the outcome of antecedent processes. Moreover, like the shape of the crystal, the shape of the earth does not contain the process of its formation. Instead, the earth is the outcome of processes that are part of its history. Unlike the crystal, the earth has inherent in it a meteorological process, thereby becoming "fructified into vitality".[29] As an emergent biosphere, the earth becomes a source of life.

Not surprising, Hegel suggests that the sea and where sea meets land comprise those environments that give life its real possibility.[30] There the availability of materials and catalysts provide the most likely setting for the self-renewing concatenations of chemical reactions giving life its most elementary beginnings. All this depends upon a beneficent weather, whose meteorological transformations must not disrupt the conditions nurturing the first fragile organisms.

The Emergence of the Rudimentary Forms of Life

Hegel suggests that the land and the sea give rise to different types of life forms. He maintains that the land is preeminently the source of plant life and that the seas are preeminently the source of animal life.[31] Of course, to make sense of that dubitable claim, plants and animals must be distinguished and we have yet to treat their determination systematically. Instead, what the biosphere immediately makes possible is the original generation of life from inorganic material, which is fundamentally distinct from reproduction. Reproduction presupposes not only the emergence of an organism from non-living substances, but the development of an organism that has the potential to generate another organism from itself. Hegel identifies the original generation of life as a *generatio aequivico*, where the most elementary organisms arise from inorganic sources.[32] These elementary life forms lack the specific differentiations that distinguish multicellular plants from animals. Hegel finds examples of such rudimentary organisms in the slime in the sea (presumably algae) and the lichens, molds, and fungi found on land.[33] These he erroneously supposes to be examples of the original life forms that emerge not from life itself but from something other than organic nature. Hegel describes these primitive organisms as transitory insofar as they lack the ability to reproduce.[34] They have a metabolism, but cannot generate another living organism.

What Hegel has no cognizance of are those even more rudimentary entities that reproduce without having a metabolism of their own. Viruses are such beings, but they do not precede the most elementary life forms. As simple as viruses may be, they exist only thanks to the metabolism of the living cells they invade and with whose genetic material they multiply. Consequently, viruses follow upon the development of organisms that have the capability of generating other organisms like themselves.

If life must originally arise from inorganic material in a biosphere, what form can such a living thing be? By way of anticipation, let us grant that the minimal form of life consists in an enclosed array of chemical reactions that reproduces those reactions together with the semipermeable membrane that encloses them and permits the exchange of materials on which its self-renewing activity depends.[35] This autopoeitic entity involves both an organic unity of complementary organs and a metabolic interaction with its environment.[36] On the one hand, the enclosing membrane keeps the autocatalytic chemical stew in place, while selectively absorbing materials from the environment to sustain the ongoing chemical reactions. On the other hand, those chemical reactions maintain that membrane itself.

Such a minimal entity constitutes the cell, the elementary unit of life. Like the atom that provides inorganic nature with its fundamental unit, the cell is the basic constituent of organic nature, providing the most rudimentary specifically biological reality. Viruses may be more elementary, replicating themselves without possessing any metabolic functioning. Nonetheless, viruses can only partake in organic nature by entering a cell and using the genetic material the cell provides to replicate themselves.

The same dependency upon the cell holds for the massive macromolecules that provide the enzymes, proteins, and genetic material with which cells operate. Like any chemical factor, these macromolecules require catalysts to enter into further chemical reactions and in no individual reaction is the outcome the same as the starting point. Macromolecules become a party to life only by being integrated within the self-renewing, autopoeitic totality of the cell.

The life process of the cell operates through chemical, molecular transformations, involving the exchange of electrons of different energy levels, rather than through nuclear transformations, that alter the nuclei of atoms. In order for the required chemical interactions to occur, the chemicals within the cell must be brought close enough so that the electromagnetic interaction between electrons and the positive charge of atomic nuclei can forge or break molecular bonds. Although chemicals are primed to react in specific ways owing to their atomic structure and the distribution of their electrons at different energy levels, a catalyst is needed to bring them into sufficient contact to undergo chemical reaction. The semipermeable membrane of the cell maintains the supply of the needed chemicals as well as provides the boundary keeping them from dispersing. It is not enough, however, for the cell membrane to keep these chemicals in relative proximity. The cell must also contain the proper catalysts to precipitate the needed chemical reactions. Enzymes, which are composed of proteins, play the role of holding smaller molecules in just the right position to enter into the appropriate chemical reactions.[37] Although each of these reactions ends with molecular results different from their starting point, the different reactions occurring within the cell boundary must be so integrated as to provide in aggregate the chemical components that can rekindle the same complex of reactions.

Crucial to renewing the supply of chemicals and the enzymes that act as their catalysts is something that can insure the proper pattern of enzymes to maintain the various life processes of the cell. This requires some chemical resources within the cell to insure the supply and due arrangement of the enzymes and the proteins in which they consist. On our lonely planet, DNA serves as a key cell constituent that is determinative of what enzymes are produced and in what order they are generated. Pieces of the DNA break off to form RNA molecules that migrate to other cell components, microsomes, which then produce the proteins from which enzymes are constituted.[38] Richard Feynman describes this process as one in which DNA functions as a blueprint, carrying the information for manufacturing enzymes within the cell.[39] This suggests that DNA is an immaterial design that some agency imposes upon a given material not yet embodying that design. DNA, however, is not immaterial, but an actual chemical substance within the cell, whose own activation depends entirely upon the presence of other chemicals and catalysts alongside it. Since the cell is a self-renewing totality, the enzymes that DNA will help generate must already be at hand. Only by being one element integrated within the ongoing functioning of this biological unity, can DNA serve to determine which enzymes are replicated and where that will occur within the cell.

The inadequacy of identifying DNA with a blueprint becomes most evident in multicellular organisms, where each differentiated cell contains the same DNA at every stage of the development of the living thing. Whereas a design imposes the same single form upon whatever material embodies it, the DNA of a multicellular organism underlies the production of a whole host of different cell types within an organism whose own total form may undergo the most striking metamorphoses. What allows

DNA to be involved in such a dynamic differentiation is that DNA is itself a physiological element of the organism, subject to the functioning of other constituents that activate different parts of its elaborate structure. The same would be true of the DNA analogues belonging to extraterrestrial organisms with wholly different chemical compositions.

Whatever be its chemical configuration, the original life form will not be a multicellular organism. A multicellular living thing is not only much more developed than any unicellular organism, but presupposes the prior existence of unicellular organisms from which it could be composed and evolve.

Moreover, the first living thing would be a prokaryote rather than a eukaryote unicellular organism. Prokaryotes have simply two "organs": the enclosing semipermeable cell membrane and the autocatalytic chemical stew it contains. Eukaryote cells follow upon prokaryote organization, for they supplement the prokaryote cell's two primary "organs" with other internal membrane-enclosed "organs", such as a nucleus and organelles.

Further, the original prokaryote cell would not have the ability to reproduce itself, since that capability is something requiring significant biological additions to a prokaryote that has a metabolism but cannot reproduce. As Feynman notes, the inorganic physical constituents of organisms have little about themselves that exhibits reproduction. Atoms too do not enlarge and then divide into replicas any more than do molecules.[40] When, however, a cell contains a macromolecule with the double chain structure of DNA, a new possibility beckons. Each of the chains of the DNA double helix is so composed that if the chains separate, the only chemicals that can bond with the parts of each chain are the constituents of the corollary chain. In the case of DNA, each chain consists of just four kinds of molecules, adenine, thymine, cytosine, and guanine, each of which is and can only be connected to the type of complementary counterpart it faces on the opposite chain.[41] Consequently, if the double helix can be separated in a cellular chemical soup that contains the molecules that specifically bond with each section of each chain, then the cell can give itself two double helixes of the same composition. If these then interact with their chemical surroundings to produce all the elements of the cell, the cell will contain two parallel totalities, each containing the same type of life process. Since this includes the formation of an integral cell membrane, once the double helix becomes separated and then replicated, the cell material will end up dividing into two comparable autopoeitic totalities, each constituting an individual cell of the same kind.

It is important to recognize that the double chain macromolecule does not itself accomplish reproduction. Like any chemical, it does not break itself apart. Something else in the cell must split apart the rungs of its two twisted chains. Secondly, the separated chains do not themselves provide the chemicals with which they bind. These must not only be present in the surrounding cell environment, but catalysts must be at hand to put them in the right position to forge the new chemical bonds of the two newly constituted parallel double-chained macromolecules. Then, of course, these two new double-chained macromolecules will only begin to help renew and order an integral cell totality thanks to the presence of further chemicals and enzyme catalysts. All this must be provided by the metabolism of the cell, which now extends to supply the resources for reproduction.

Here we have a rudimentary constitution of the two minimal biological developments on the basis of which life can become an abiding element of a biosphere. The basic autopoeitic cell first gives life an ephemeral, all too vulnerable debut. Then, whenever a cell comes to contain the double complementary chained macromolecule resources for reproduction, life can take its place as an enduring element of a biosphere. This development transforms the biosphere into an ecosphere, where reproducing life forms interact with one another and their inorganic environment.

These basics are worth sketching at this juncture, in anticipation of how the emergence of living things confronts us with the more imposing task of conceiving what development life can take in exhausting its fundamental possibilities.

Notes

1. For further discussion of why Kant limits the philosophy of nature to the mechanics of matter in motions, see Richard Dien Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel: The Philosopher's Guide to the Universe* (Houndmills, UK: Palgrave Macmillan, 2017), pp. 62–76, 97–120, 146–161, 172–181.

2. Aristotle, *Physics*, Book II, Chapter 1, 192b12-23, in *The Complete Works of Aristotle*, Volume One, p. 329.
3. For further discussion of how the active form Aristotle ascribes to nature contrasts with the passive form of artifacts, see Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel*, pp. 22–26.
4. See Descartes, *Discourse on Method*, Part Five, p. 139, in *The Philosophical Writings of Descartes – Volume I*, trans. John Cottingham, Robert Stoothoff, Dugald Murdoch (New York: Cambridge University Press, 1985).
5. For a detailed critical rethinking of Hegel's account of the mechanism and physical process of inorganic nature, see Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel*, pp. 81–396.
6. Hegel, *Philosophy of Nature*, §338, p. 277.
7. Hegel, *Philosophy of Nature*, §338, p. 277.
8. Hegel, *Philosophy of Nature*, §337, p. 273.
9. Hegel, *Philosophy of Nature*, §337, p. 273.
10. Hegel, *Philosophy of Nature*, §337, p. 273.
11. Hegel, *Philosophy of Nature*, §337, p. 273.
12. Hegel, *Philosophy of Nature*, §337, p. 273.
13. Hegel, *Philosophy of Nature*, §337, p. 273.
14. Hegel, *Philosophy of Nature*, §339–342, pp. 278–303.
15. Hegel, *Philosophy of Nature*, §338, p. 277.
16. Hegel, *Philosophy of Nature*, §338, p. 277.
17. Hegel, *Philosophy of Nature*, §339, p. 278.
18. Hegel, *Elements of the Philosophy of Right*, §341–360, pp. 372–380.
19. Hegel, *Philosophy of Nature*, §339, p. 278.
20. Hegel, *Philosophy of Nature*, Zusatz 1 to §339, p. 278.
21. Hegel, *Philosophy of Nature*, Zusatz 2 to §339, p. 279.
22. For a critical rethinking of these accounts, see Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel: The Philosopher's Guide to the Universe*, pp. 188–195, 204–207, 218–225.
23. Hegel, *Philosophy of Nature*, §340, pp. 285–286.
24. Hegel, *Philosophy of Nature*, §341, pp. 293–294.
25. See Evan Thompson, *Mind in Life: Biology, Phenomenology, and the Sciences of Mind* (Cambridge, MA: Harvard, 2007), pp. 91–127, for a discussion of the contemporary bio-chemical understanding of autopoeisis.
26. Hegel, *Philosophy of Nature*, Zusatz to §288, pp. 121.
27. Hegel, *Philosophy of Nature*, Zusatz to §340, pp. 286–293.

28. Hegel, *Philosophy of Nature*, §341, pp. 293–294.
29. Hegel, *Philosophy of Nature*, §341, p. 294.
30. Hegel, *Philosophy of Nature*, §341, p. 293.
31. Hegel, *Philosophy of Nature*, §341, p. 298.
32. Hegel, *Philosophy of Nature*, Zusatz to §341, p. 296.
33. Hegel, *Philosophy of Nature*, Zusatz to §341, pp. 298–299.
34. Hegel, *Philosophy of Nature*, Zusatz to §341, p. 296.
35. For a discussion of how chemical interaction provides the prerequisites for life, see Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel*, pp. 389–396.
36. See Thompson, *Mind in Life*, pp. 91–127, for more detailed discussion of the biochemical process of autopoeisis, as understood by modern biologists.
37. Richard P. Feynman describes this process in *Six Easy Pieces: Essentials of Physics Explained by its most Brilliant Teacher* (New York: Basic Books, 1995), p. 53.
38. Feynman, *Six Easy Pieces*, pp. 57–59.
39. Feynman, *Six Easy Pieces*, p. 56.
40. Feynman, *Six Easy Pieces*, p. 56.
41. Feynman, *Six Easy Pieces*, p. 57.

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3

The Basic Life Processes

Hegel begins his account of organic nature proper by directly considering plant life and then proceeding to determine animal life as the consummating development of all nature. He will not address life in general in his *Philosophy of Nature*. This is partly because the *Science of Logic* gives a systematic account of the determination of life in general,[1] one of whose possible embodiments is the reality of organisms in nature. Although nature may include rudimentary forms that are neither plants nor animals proper, no life exists in nature that does not have an individual existence and a particular form. Consequently, anyone expecting the systematic argument of Hegel's *Philosophy of Nature* to contain a specification of life in general will be sadly disappointed.

Nonetheless, before we turn to mine Hegel's account of the fundamental forms of life in nature, it is worth our while to explore what is generic to life and how organisms are different than inorganic natural entities or machines. Although Kant does not allow reason's knowledge of nature to extend beyond the pure mechanics of matter in motion, he does consider how life can be thought in light of our experience of living things. This examination, which Kant undertakes in his *Critique of Judgment*, can serve to focus our understanding of life, before we tackle philosophical botany and zoology.

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Kant's Account of Life

Kant compactly presents his account of life in the three sections in his *Critique of Judgment* where he describes what is distinctive about living organisms, while insisting that the life he conceives is not objectively knowable.[2] Kant cannot admit life within the domain of objects of knowledge because his foundational epistemology renders objectivity knowable to the extent that it is determined by the structure of knowing. This leaves all possible objects of knowledge externally determined by the same epistemological foundation, submitting them all to a necessity indifferent to what specific nature or import they have. Knowable nature is thereby restricted to a domain governed by efficient causality, mandating laws of matter. Life, however, is a self-sustaining end in itself and therefore Kant must consider it as part of his investigation of teleology, which may be thinkable, but not knowable within the world of pure mechanics to which Kant must reduce nature. An inquiry into ends is not identical to a consideration of life, but Kant's consideration of life revolves around an exploration of teleological judgment, which investigates how we can think of ends and give them any applicability to nature.

To begin with, Kant distinguishes formal purposiveness, such as one finds in geometric proofs where certain geometric constructions serve the purpose of allowing us to arrive at knowledge about certain types of geometric figures.[3] With life, however, we are dealing with what Kant calls a material purposiveness, which has some relation to objective nature.

Kant recognizes that conceiving life requires drawing a further distinction between different kinds of purposiveness that may apply to material, as opposed to merely mathematical objects. In paragraph 63 of the *Critique of Judgment*,[4] he differentiates between relative purposiveness in nature and the internal purposiveness that is essential to thinking life. Kant introduces this differentiation by explaining that experience leads our power of judgment to the concept of an objective and material purposiveness, the concept of an end of nature. We find ourselves confronted by phenomena that we cannot sufficiently explain by the material lawfulness of efficient causality. In the *Critique of Pure Reason*, Kant had argued that the relation of cause and effect specific to efficient causality is the very precondition of experiencing any objective temporality.[5] Unless we comprehend each antecedent state of affairs to be the necessary condition for the state of affairs that follows it, we will be unable to distinguish between subjective, imaginary successions of representations and objective events. Since this requirement applies to happenings involving any possible objects of experience, it applies to objects irrespective of what they are, including, presumably, whether they are alive or inorganic. Efficient causality, as a principle of knowable nature, mandates that a material situation is the condition for the existence of some other material situation, irrespective of what form or import the objects involved may have.

Accepting the reduction of objective necessity to efficient causality, Hume consistently maintained that the concept of something, that is, the thought of an object's specific nature, cannot indicate whether it has any efficacy or not. On the other hand, Hume acknowledged, just experiencing associations presenting similar connections is never sufficient to establish necessity.[6] Experiences can only establish the fact that a certain kind of pattern has been observed at certain times and in certain places for certain observers. No amount of observations can ever certify that any experienced pattern is necessary and universally the case. If, however, as Kant presumes to have shown, efficient causality is constitutive of any awareness of objective succession in time, then no experience can fail to exhibit its governance of events.

Since the resulting fabric of observable events concerns alterations that are indifferent to what things are and pertain to matter in general, change in knowable nature amounts to locomotion and laws of nature are restricted to governing the spatial-temporal determination of matter. This restriction is exhibited in Kant's reduction of the genuine science of nature to pure mechanics.

Nonetheless, Kant acknowledges that our observation of nature confronts us with entities, namely living things, whose specific process involves alterations that cannot be reduced to locomotion. Instead, we find before us entities that have a form of organization whose intelligibility seems to depend upon teleology, that is, determination in respect to ends. Whereas natural necessity otherwise dictates laws of matter, Kant here finds in nature something whose comprehension requires paying attention to both its form and its end.

Why would form and end go together in addressing the living thing? Aristotle connects form and end in conceiving natural entities of any kind. Natural entities, unlike an artifact, have a form that determines their motion (in the broadest sense of alteration in general) and in this respect what change they undergo is for the sake of being what they are. Whereas the form of an artifact is something imposed upon material by an external agent, the form of a natural entity functions like a soul, actively changing that entity in accord with its specific nature. Admittedly, in an artifact, the form is connected to its function, for the sake of which it is produced. The artificer of the artifact antecedently conceives both its form and end. Then the artificer imposes that form upon some given material, enabling the resulting product to serve the end in question. The process of imposing the form does not reside within the artifact itself. By contrast, for Aristotle, all natural things move themselves in a manner tied to what they are. Their form involves a specific way of moving themselves. Without relying upon any external agent, natural things undergo a change inherent to their specific nature. Since the change is not a departure from their being, but a realization of what they are, their form is self-realizing. The form is thereby an end that the natural entity reaffirms in the changes it undergoes due to its own nature.

Kant identifies an end as a concept of an object that is the condition for that object's actualization.[7] This characterization suggests that the end involves a self-realization, since the concept as end makes possible the realization of what it specifies. Kant tells us that we are drawn to the concept of an end of nature in two circumstances. The first consists of encounters with an object serving as an end. This occurs whenever we come upon an object that is a product of art, that is, an artifact. Any artifact constitutes an end since the process of art aims at producing the product that issues from its making. The end of artisanship, which makes its engagement of value, is the product in which its activity terminates. An agent undertakes that instrumental activity by antecedently representing the concept or design that the agent then imposes upon the material on which the agent works, producing the artifact at which the artisan activity aims.

It is also possible to think of an object as being an end if that object is a natural entity having an internal purposiveness. Whereas the artifact is the end of an instrumental activity that proceeds prior to and separately from the product in which it results, an internal purposiveness involves a process of realization that is somehow contained within the entity at which it aims. Kant attributes internal purposiveness to life and he attempts to explain how living things distinguish themselves form both inorganic natural things and artifacts by possessing this special type of teleology.

To do so, Kant attempts to identify the key aspects of living things by differentiating their internal purposiveness from the external purposiveness of artifacts. In so doing, Kant draws upon a further distinction of ends that applies to the difference of an organism from an artifact, but has a further extension. This is the distinction between a purposiveness that is relative and a purposiveness that is intrinsic or for its own sake.

Something has a relative purposiveness when it serves as a means to something else. Artifacts have relative purposiveness to the extent that they are of use insofar as their design allows them to fulfill a function whose result is desirable. Similarly, objects given by nature can also have a relative purposiveness insofar as they are advantageous to other beings. This applies to inorganic materials and organic entities. The water in a stream has relative purposiveness to an animal that drinks it to quench its thirst, just as a plant has a relative purposiveness insofar as it serves as a means to the nutrition of an animal that eats it. In all these cases, the relative purposiveness of something is contingent upon the presence of other things for which it can be of use.

By contrast, something will have purposiveness independently of other things if it somehow serves nothing but itself. To do so, of course, something will have to be for its own sake, that is, be an end in itself. It will then have an intrinsic purposiveness that is not relative. Although both artifacts and natural objects, whether inorganic or alive, can be of advantage to other things, living things are distinguished, Kant will now show, by possessing an internal purposiveness that has nothing relative about it.

As Kant points out, nothing of relative purposiveness can be useful necessarily unless what it is useful for is itself necessary.[8] In a nature governed by the material necessity of efficient causality, no specific natures can exist necessarily. Since what governs such nature are laws of matter rather than any *a priori* hierarchies of form, there can be no necessity that there be objects of any particular kind. What exists is empirically contingent and any kinds of things are just family resemblances that are themselves always corrigible. Consequently, the relative purposiveness of anything is contingent and never necessary, for whatever it serves exists contingently.

Hence, if there is to be any purposiveness that is necessary, any lawful purposiveness in nature, it will have to reside in something whose purposiveness is not external, not relative to anything else. This requires something that is an end in nature, something that is intrinsically purposive.

How can something in nature be possible as an end in itself? As Kant notes in paragraph 64 of the *Critique of Judgment*,[9] nothing can be an end in itself if it is determined solely by the natural laws that govern appearances under the sway of efficient causality. The law regulating nature as a mechanism of matter in motion leaves all natural process contingent upon external factors that are themselves subject to equally contingent external causality. In order for something to be intrinsically purposive, Kant acknowledges, it must have a form that does not appear to be possible in accord with such natural laws, which mandate how things are allegedly determined in experience.[10]

Consequently, to address the intrinsic purposiveness of something that is an end in nature, Kant must appeal to reason and think the character of something that our understanding of objects of experience cannot know. In some respect, such an entity can be considered to be possible through a process that reason, rather than understanding, can conceive.

In the domain of conduct, Kant allows for reason to determine lawful ends that are of intrinsic value and can be realized by the exercise of free will.[11] Here, in nature, however, what lies at issue are internally purposive natural entities that are not objects of practical reason. Instead of being brought into being through our conduct, they have an independent reality that contains a purposiveness of its own. What can they be and how does their special character unveil the mystery of life?

As Kant notes, we might come across a geometrical figure that is drawn in the sand in some uninhabited land and find ourselves unable to find any ground for its possibility based on the blind necessity of natural law.[12] We could, however, consider the figure to be a product of art, dependent upon the purposive activity of an artisan. Here we are led to invoke purposive activity, but not the internal purposiveness of something that is a product of nature.

Something that exists by nature and is at the same time an end is in no way explicable in terms of the intelligent design of some divinity. Intelligent design, whether divine or not, is an exercise of artisanship, whose product is an artifact, of purely relative, external purposiveness. What is a product of nature and an intrinsic end cannot be an artifact in principle. It has a fundamentally different character, whose determination is about to be explicated in terms of its internal purposiveness.

What is internally purposive cannot be the product of any imposition of design, be it by a god or a mortal. Instead, Kant tells us, whatever exists as a natural end is both cause and effect of itself.[13] To be cause and effect of itself turns out to be a key to thinking a living thing. Kant introduces this formula without immediately connecting it to life. Instead, he presents this idea to characterize what is not an artifact but a natural object that is an end. That which is cause and effect of itself is intrinsically an end and not an end relative to other things that are themselves completely contingent. Precisely because this natural entity is cause of itself, it is an end in itself, causing itself to be in virtue of its very own nature. It is thus for its own sake, since it is self-realizing, rather than serving as a means to or being caused by something else.

Kant finds no contradiction in thinking what is cause and effect of itself and how such an entity is an end by nature. Nonetheless, Kant maintains that we cannot know such an entity because our knowledge is restricted to what conforms to the material law governing objects of experience, according to which everything in nature is caused by something else and causes something other than itself. Although Kant thus admits that the end in nature contradicts the mechanistic law of nature, the natural entity that is cause and effect of itself is not internally contradictory, allowing life to be conceived but not objectively known.

Hegel, by contrast, neither restricts knowledge of nature to the mechanism of undifferentiated matter in motion, nor has any problem acknowledging that life presents us with something that involves contradiction. Life does so by uniting terms that oppose one another, such as cause and effect, as well as inner and outer, and subjectivity and objectivity. Hegel points out that life is indeed an inscrutable mystery for Kant's understanding, which constitutes the thinking that is governed by the principle of contradiction and empty without intuition. Only reason proper can think life, as Kant himself acknowledges.[14]

Still, Kant's account of the natural end does provide a basic knowledge of life, even though it cannot fit within the mechanistic framework in which he straitjackets experience. At the start Kant identifies the natural end as being both cause and effect of itself, without further indicating what such an entity may be. Although Kant does not expressly argue why a living thing is the type of natural entity that is both cause and effect, he immediately turns to the example of a tree to illustrate this unity of cause and effect. Significantly, everything that he cites in reference to the tree is readily observed, challenging Kant's own assumption that nature as we can experience it is a mechanism devoid of purpose.

It is important to examine what Kant attributes to a tree, not just to understand how experience does not exclude knowledge of ends, but more importantly to grasp what is fundamental to life. We have to keep in mind that there are different forms of life and we must consider whether what Kant finds exemplified in his example of a tree pertains to life in general or only to the branch of plant life, to which a tree belongs. In this connection, we must ask whether reason can distinguish what is alive from what is not alive and then further differentiate the forms of life. Even if reason can conceive the divide between organisms and inorganic nature, might the difference between plant and animal life be just an empirical matter, involving family resemblances that are always subject to revision in light of new observations?

Kant does not have much to say about the distinction between plant and animal life, but he does choose to illustrate the natural end by referring to a tree, with which he will presumably locate relationships that should apply to all organisms. Aristotle as well as Hegel do discriminate between plants and animals at length, attempting to distinguish them in some necessary way. Kant, of course, need not here engage in any such philosophical labor, for any example of life cannot help but be a particular form of life, whose differentiating features are not what is at issue. Our task is to see what his example contributes to understanding life in general and to be alert to any characterizations that only apply to the particular form of life that a tree also exemplifies. In this regard, Kant may alert us to features that distinguish not only life from inorganic nature, but plants from animals.

A philosophical account of life constitutes a universal biology that will address what pertains to life no matter what its form and no matter what particular kind of chemistry it may involve. A universal biology must thus identify the essential processes of living things, whether or not they have a carbon based chemistry and contain RNA and DNA. A universal biology must then explore to what extent one can conceive the possible forms that life can take. Although Hegel focuses primarily upon plant and animal life forms, he does acknowledge other life forms, such as fungi and simple forms to which he points without much characterization. Empirical science distinguishes not just between fungi, plants, and animals but also between organisms whose cells have nuclei and other organelles with their own membrane (so-called eukaryotes, which include fungi, plants, and animals) and those which lack such structures (so-called prokaryotes), such as bacteria and archaea in general. Although prokaryote life forms are much more minute than eukaryote life forms, the mass of prokaryote life on earth exceeds that of eukaryote organisms. If prokaryotes be accepted as living things, then Kant's example of a tree should provide basic aspects of life that apply to prokaryotes as well.

Kant's focus is illustrating how a natural entity can be both cause and effect of itself. His tree example allows Kant to show three different ways in which an organism can be both cause and effect at the same time. Do all three of these ways apply to life in general or do all or some apply only to the specific life form that the tree possesses?

To begin with, Kant maintains that a tree is both cause and effect of itself by generating another tree according to a known natural law.[15] This natural law cannot be a law of matter in motion, but rather a specifically biological law of reproduction, whereby an organism gives rise to a new organism of the same type. Since, as Kant recognizes, empirical observation can never establish the necessity and genuine universality of a law, if there is a biological law of reproduction, it must be grounded in the very nature of a living thing. With regard to experience, this would signify that we cannot recognize something to be a living thing without acknowledging that it is the product and/or agent of reproduction, unless, perhaps, we are encountering an organism that has arisen from the chance concatenation of chemical reactions and may not yet have the power to reproduce itself.

Strictly speaking, reproduction does not literally exemplify how the tree is cause and effect of *itself*. As Kant acknowledges, in reproduction the tree does not cause itself as an individual, but rather causes itself as a species, whose individuals are distinct from one another, but are of the same kind. Sexually reproducing organisms exhibit this distinction most explicitly, since their offspring are genetically different from all their parents. Even, however, in asexual reproduction, where cell mitosis endows offspring and parent with the same genetic material, the resulting organisms are still different. Not only are asexual offspring numerically distinct from their "parent", but they cannot help but acquire differences owing to their individual relations to their environment. In any event, Kant is here presenting life as having a species being that is cause and effect of itself by means of reproduction, where the species renews itself by having a member of the species affirm its species being in generating another organism of the same type.

Admittedly, not all organisms are capable of reproducing, nor have the opportunity to do so. Some living things are infertile by birth, or become so by disease or accident, or simply die before having any chance to reproduce. Moreover, if life initially comes to be from the accidental concatenation of chemical reactions, there are living things that are not effects of reproduction and which may not have the ability to reproduce until further chance developments endow life with the capability of overcoming its transient, individual existence through reproduction. Nonetheless, life as an abiding natural end will generally have the ability to reproduce and be cause and effect of itself as a species being. This will not be limited to the plant realm of Kant's tree example, but can extend across all phyla of life.

The connection between reproduction and the species being of life is something that Kant by no means restricts to organisms that sexually reproduce, even if trees may fall under that category. Modern biologists define the species of a sexually reproducing organism through the geographic and biological boundaries that restrict with what other organisms a life form can reproduce. Asexual reproduction defines species being in a more limited sense, since here species membership resides in a continuous line of cell division. In both cases, species being is biologically determined through the reproductive process of organisms.

It is important to recognize that reproduction cannot be explained in terms of efficient causality, to which Kant reduces the natural law governing objects of experience. Efficient causality is a material necessity that governs matter in motion, with complete indifferent to the specific nature of natural entities. By contrast, reproduction involves transformations that are determined by what the object in question is. Its own specific nature, as a species being, is the end mandating how the process of reproduction unfolds. Mechanical forces and chemical reactions may be involved, but they are subordinated to a life process in which the species identity of the individual organism affirms itself by being an active form, wielding a formative power to fashion living material into a new living organism of a certain type.

Kant formulates this active form in terms of the unity of cause and effect, and this unity is precisely what efficient causality cannot alone provide. The cause and effect in mechanistic process are different from one another, which is symptomatic of how their causal relation has nothing to do with what they are. Their specific being has no efficacy in the world of mechanism, in which every cause impacts upon something different from itself, just as every modification an object undergoes is determined by some other material entity in a manner indifferent to both their specific natures. Reproduction, by contrast, involves the specific nature of the natural entity that is both cause and effect, for the end of the process is nothing other than the generation of the species being of that entity.

Whereas Kant first identifies the natural end as such a species being that is cause and effect of itself through the reproduction of individual organisms, he next locates the unity of cause and effect in a life process belonging to any individual living thing. The tree once more illustrates the unity ingredient in life by being cause and effect of itself as an individual. Kant could be addressing the general metabolism of the living organism, whereby it relates to its biosphere, exchanging material to sustain its ongoing life process. This might not involve the growth of the organism, especially when the organism is an animal reaching the latter part of its lifespan. Nonetheless, Kant identifies the growth of the tree with its being cause and effect of its individual being.[16] According to Kant, the tree generates itself as an individual by growing, claiming that growth is no merely mechanical increase in size, but something equivalent to generation. The tree's growth is not merely the addition of new appendages replicating the structure of those it adjoins, as in crystal "growth". Even though the growth of a tree, unlike that of an animal, may involve new branches, leaves, and roots similar to those already in place, these new additions are organs of the tree, involved in metabolic processes whose complementary functioning allows the tree to survive and continue to grow. The additions to a crystal are not organs, lacking not only any complementary functioning, but any internal process other than the atomic and molecular motions common to all parts of the homogeneous crystalline material.

Unlike animals, whose growth process may reach a mature plateau, the metabolic process of a tree coincides with growth, such that the self-sustaining nutrition of the organism is inseparable from its proliferation of new appendages, be they roots, branches, or leaves. This coincidence of growth and nutrition is common to plants and it allows Kant to identify growth with generation since the self-preservation of the plant organism coincides with its growth. The growth process can be said to regenerate the entire tree and to always do so from a preexisting organism that is always present as the living precondition for the continuation of its own further metabolism and growth. Kant can thus suggest that growth is reproduction by another name. What, of course, is decidedly different about growth is that what is "reproduced" as cause and effect of itself is the individual tree, rather than its species being. The growth process is internal to the individual tree, a part of its very own life process, which may depend upon the exchange of material from its biosphere, although what is excreted is not another living thing, but what it cannot assimilate into itself.

The increase in size of growth is fundamentally different from any mechanical increase in size in several fundamental respects.

First, the increase in size of an organism in growth results from the metabolic activity of the living thing, which is inherent in the type of entity it comprises. By contrast, a mechanical increase in size occurs due to causes that are external to the object that enlarges. A material may expand due to pressure and temperature changes in its environment or due to accretions of material that add or combine with it independently of any activity on its part. Gravitational or electromagnetic forces may allow a body to attract other material to it, which may increase its force field as well as its mass. This depends, however, upon the presence of other suitable material, which the body in question does nothing on its part to find, nor does its nature impel it to do so. The living thing grows through its own active interaction with its biosphere, which is not externally determined, but subordinate to its existence as a natural end, which is both cause and effect of itself by subordinating its external interactions to its own survival. The tree takes in sun light, draws in water and nutrients, absorbs and expels different gases all as functions that enable the tree to carry on those very processes in sustaining itself in and through its increase in size.

Furthermore, in growing, the organism engages in an assimilation of external material that is fundamentally different from any mechanical process whereby an object becomes larger through any mechanistic aggregation or expansion of matter. The mechanical enlargement of an object does not impart any activity to whatever material is added to it. By contrast, the living thing takes in external nutrients on which its metabolism operates, transforming them into components of itself that now engage in the constitutive life functions that sustain the organism and, in the case of some animals and plants, generate further growth. The assimilation of external material in metabolism and growth may certainly involve movements of matter and chemical reactions. Nonetheless, they proceed within the self-sustenance of an entity that therein exhibits one of its modes of being cause and effect of itself. No mere inertial movement, gravitational attraction, electromagnetic discharge, or chemical process can be both cause and effect of itself, nor be determined by an indwelling end. Metabolic assimilation and the associated growth process exhibit two correlative biological features that no inorganic increase in size can possess. The assimilated material takes on the active form pervading the entire "self" of the organism, whose self-preservation governs the operations of all its distinguishable organs. This form is not the passive form of an artifact, whose design is given antecedently apart from the matter on which an external agent imposes it. The active form that integrates the assimilated matter for growth is a form that realizes itself continually, being both cause and effect of itself throughout its living existence.

Consequently, the material that the plant assimilates does not have a form imposed upon it like an artifact. Rather, it becomes alive, and alive in the specific way in which this individual organism integrates all its organs in order to maintain itself. In growing, the tree is not producing artifacts, but developing itself through its metabolism with its biosphere. The tree does not give the material it absorbs a new design, but rather subsumes it to the same active form that pervades its entire organism.

The growth of the organism does involve a relationship to what is other than itself. To grow and survive, the tree must appropriate what it needs and make it a constituent partaking of the life of the organism to which it belongs. The tree thus produces its growing self by incorporating what is alien, overcoming its alien character, and subsuming it to the encompassing life activity that continues to be the product of its own metabolic process. The growth of the tree is the effect of its life activity, and that effect is none other than the survival of the living self that causes growth in the first place.

Kant adds a third type of life process uniting cause and effect in a distinctive manner. In this case, the tree is both cause and effect insofar as one part of the tree preserves itself such that it is reciprocally dependent on the preservation of the other parts of the tree. Reproduction concerned the relation of the organism to a new organism it generates, whereas growth concerned the process whereby the organism sustains itself by assimilating what is other to it. This third example of the biological unification of cause and effect consists in how the organs of the living thing relate to one another and the whole to which they belong. The tree will produce leaves, which enable the branches and roots to survive, just as they allow the leaves and one another to grow and survive. Each part of the tree operates as a complementary organ, which serves as a means to the survival of its counterparts, while functioning to sustain itself and the whole tree. Through their reciprocal interdependence, the tree organs do not only generate one another, but also repair any part that suffers an injury. In doing so, they uphold the health of the whole tree and of all its individual organs.

The unity of cause and effect takes on an added complication in this realization of organic unity. Each organ causes its counterparts to grow and maintain their complementary functions. It thereby equally facilitates its own growth and maintenance, since the functioning of the other organs serves to sustain it. Thus, as Kant points out, each organ operates as both a means and an end to the others.[17] At the same time, through the mutual interdependent functioning of the organs, the organism sustains itself as a self-sustaining entity, whose active form produces the differentiation of organs that maintain its life process. Together each organ causes both its counterparts and the whole organism to live, enabling the organism to be cause and effect of itself.

These signal features of organic unity apply to all living things, whether or not their differentiated parts are composed of cellular structures or specialized cells. Kant, however, describes a relation of the parts of a tree that involve a relative independence that is not generic to life, but specific to the comparatively limited unity that characterizes plants. Kant notes that if one takes the bud from the leaf of one tree and grafts it into the branch of another tree, it grows into an "alien stock" of the same species that lives upon the tree to which it has been attached.[18] The graft grows as if it were an independent tree that nourishes itself parasitically upon the tree to which it is externally joined. Kant suggests that this reflects something about the character of the organic unity of a tree.[19] Namely, although the parts of the tree have a mutual dependency, they also have a certain independence. Given the proper conditions, any part can be separated from the whole and become a whole tree on its own. Unlike almost all animals, a tree and most other plants are made up of parts that can be grafted and grow into a new organism that uses its host as a proximate biosphere for its metabolism. Kant applies this relationship to the organs of the tree itself and maintains that they are each like parasites, using the rest of the tree as a source of nourishment, while retaining the potential to have a separate existence as an independent living thing. This relative independence is reflected in how the tree can continue to live and grow even when it loses some leaves, branches, and roots. Although some animals can regenerate lost limbs and continue to survive the destruction of certain appendages, all animals have organs which cannot regenerate and whose loss extinguishes the life of the whole. Consequently, the relative independence of parts that Kant describes is not generic to life, but a fixture of a certain life form that a philosophical botany may address.

The Dynamic Identity of the Living Thing

Complementing Kant's insights into the nature of life is the consideration of the distinctive dynamic unity of living things that Hans Jonas presents in *The Phenomenon of Life*.[20] Jonas points out that understanding the living organism depends upon recognizing how a living thing has a very different type of identity from what is not alive. Unlike an inorganic substance, an organism persists as the same living thing precisely by never consisting of the same material. The moment an organism continues to contain the same matter, it ceases to be alive, or at best, enters a temporary suspended animation, like a spore. The life process instead depends upon the organism continually exchanging its material with its environment. Without engaging in such metabolic activity, the organism cannot subsist. To be, it must constantly be in material flux. Otherwise, it reverts to the same unchanging material identity by which inorganic materials typically exist, apart from the physical and chemical transformations impinging from without and the particle emissions of radioactive decay.

This material flux is not a peripheral feature of living things, nor something that occurs only at particular moments. Rather, as Jonas maintains, it continually infuses the entire self of an organism so long as its life is not suspended or terminated. The basic reason why this is so is the fundamental role of metabolism as a life process interpenetrating the entire being of the organism. This applies not just to unicellular organisms, but to multicellular living things as well. The continuous exchange of matter and energy with the environment is a prerequisite for every cell and every organ of a living thing to maintain its constitutive functioning.

Admittedly, as Jonas points out, the chromosomes and DNA of cells may not undergo the continuous material flux that pervades all other constituents of living things.[21] The relative constancy of the genetic material does not alter the fact that its own sheltered existence is sustained by the metabolic activity that replenishes all other cellular material throughout the organism. This replenishment may replace the organisms' material, but the types of materials that compose the organism can remain relatively constant, so that its differentiated components can carry on their complementary functions. The types of materials may thus be stable ingredients in the abiding organism, while the individual materials themselves come and go. The life of the organism will depend upon retaining the type of chemicals whose renewed reactions enable the living thing to sustain itself, whereas the individual chemical substances will be continually replaced by others through the combined activities of organic unity and metabolism.[22]

Metabolism and the Self-Centered Individuality of the Organism

The living organism is thus a dynamic whole, whose identity consists in an ongoing process that maintains its unity through the continual replacement of its material. That material flux involves the metabolic exchange whereby the organism assimilates needed matter and energy from its environment and expels material that it cannot reintegrate into its active unity. Jonas characterizes this unity as having a self-centered individuality.[23] Is it appropriate to bring in a type of selfhood, let alone a self-centered one, in conjunction with the metabolism generic to all forms of life? Is Jonas falsely anthropomorphizing the basic character of organisms?

To begin with, the metabolic process on which the material flux of the organism rests does involve setting a boundary between what is within and without the living thing. Although the metabolic exchange assimilates material from the environment, it does not unite the organism with the biosphere. Metabolism rather takes what lies outside and integrates it into the internal workings of the living thing, which remains poised to renew that interaction with what opposes it. The organism must relate to what it is not to be what it is, and in doing so, it assimilates what it finds useful for the sake of maintaining its own constitutive life process. The living thing thereby treats what is outside as a means to the perpetuation of itself. Unlike a chemical that gives up its character in reacting with others, the organism cannot help but turn its external entanglements into relations that serve its own continued wellbeing. Within its boundary, the organism is a self-organizing totality, whose persisting identity depends upon being self-centered in its commerce with its environment. The internal process of organic unity distinguishes itself from what surrounds it and selectively interacts with those surroundings in order to make them serve its continued survival, first as an individual and perhaps also as a species.

By both distinguishing itself from what is other to it and by functioning as an end in itself in its relations to externality, the organism has the exclusiveness of individuality and the unified active centrality of a self. Unlike an inorganic substance, defined by its persisting matter, the living thing has its identity in an ongoing process that not only renews it*self*, but does so by affirming its *self* against its environment.

This self-centered individuality is exhibited in the autopoeisis through which the most rudimentary life can exist. In order for a concatenation of chemical processes to renew themselves as a whole, they must be enclosed in a permeable membrane that keeps them together and supplies them with the needed energy and new material they and the membrane together need to subsist. Already here the living thing involves a divide between inner and outer through which the organism can affirm its self by using what lies beyond it for the purposes of continued survival.

The self-centered character of the organism is very difference from any concurrence of forces that bind materials together, such as attraction of matter towards a center of gravity or the electromagnetic attraction of oppositely charged particles. The organism is self-centered not in virtue of external moving forces acting upon materials, keeping them in a state of contiguous stability, but instead by being an end in itself whose internal purposiveness transforms external materials into its own active self. Instead of attracting bodies to adhere to its own material, the organism selectively assimilates parts of its environment, giving them a new purposive vitality. The gravitational unity of bodies and the electromagnetic unity of charged particles do not share the active unity of the organism, whose continual material transformations provide its self with its abiding identity. That identity consists in an exclusive individual that distinguishes itself from its environment in realizing its self-sustaining metabolism.

Jonas connects the self-centered individuality of the organism with a freedom lacking in anything inorganic. This freedom is not identifiable with the free will of a rational animal. It instead consists in a "needful freedom" that applies to all organisms.[24] The metabolism of the organism exhibits the negative side of this freedom insofar as it allows the living thing to sustain its own active form by being independent of any of the individual materials it contains at one moment. The metabolizing organism shows itself to have a form free of bondage to any of these substances by exchanging them with other materials in its environment. Whereas inorganic entities are directly identical with their matter, the metabolism of the living thing emancipates its form from any immediate identity with its material.[25] This is not a freedom from particular types of materials, for the organism's metabolic emancipation of form from matter remains *needful* since it depends upon exchanging the right *types* of materials. Although the organism is continually overcoming its connection to its matter of the moment, its self-sustaining system of complementary functions is both its starting point and result. The organism's metabolic freedom of form from matter is not a positive freedom to give itself its form. Rather, the organism has its active form by nature, not by any genuine self-determination. On the one hand, the first organisms obtain their rudimentary autopoeitic identity from the chance concatenations of chemicals. On the other hand, the organisms that come into being through reproduction owe their species being identity to that of their parents. In both cases, the organism functions as an end in itself, acting to sustain the specific active functions in which its identity consists.

Nonetheless, the metabolism basic to life places every organism in a relationship to space and time fundamentally different from that of inorganic entities, which are immediately identical with their material constituents. What is inanimate is determined externally with respect to space and time. Matter, being inertial, does not determine its location in space-time in virtue of its specific nature. Conversely, by occupying a different time and place, inanimate material does not change its nature.[26]

The individual identity of inorganic material is only specifiable by its spatial-temporal location. Whether it is a particular mass of matter, or a particular charged particle, or a particular chemical, an inorganic entity is indistinguishable from others of the same type except for its unique position in the space-time continuum. The living thing may have a determinate location and trajectory, as well as a typical chemical composition. Nonetheless, it individuates itself through its self-centered purposive life process, where it relates to its environment as an individual self, rather than as a type of chemical or physical configuration. Only when the organism is overcome by external forces, such as powerful earth tremors, tornados, or irresistible waves, does it lose its metabolic control over its material entanglements and get moved like any other physical entity.

Jonas aptly characterizes this special relation of organisms to the rest of the universe in terms of a polarity of self and world.[27] The characteristic identity of the living thing consists in this fundamental opposition of a being with selfhood and the biosphere in respect to which it preserves itself. This applies to not just animals with perceiving and desiring minds, but the simplest unicellular organisms. Even an amoeba navigates the opposition of self and world, confronting its environment as an otherness that it must subordinate to the needful freedom of its metabolizing subject. Selfhood depends upon polarity with the world, for this opposition is constitutive of an entity that has an internal purposiveness to which everything external must be made compatible. What defines the selfhood of the amoeba is not its continuity in space and time, but rather its dynamic opposition to its environment. That dynamic opposition is the self-assertion of a metabolizing living individual, a being for its own sake facing the world in which its specifically biological want is to be satisfied. The lowest life form can possess such selfhood, for every organism acts as an end in itself through its dynamic relation to its environment, where it distinguishes itself from what is not itself. All these features go together, as basic aspects of the metabolic process shared by unicellular organisms, plants, and animals.

It follows that the life process has a specific relation to space and time. Once life enters the universe, a biological space and time arises, qualified by how the metabolic process orients the organism spatially and temporally. On the one hand, the living organism, as Jonas puts it, operates with a spatial self-transcendence, necessarily relating metabolically to what lies beyond its own boundaries.[28] The organism must engage with what is outside itself in order to sustain its life process. The needful freedom of metabolism drives every living thing to nourish itself with what is spatially beyond, be it contiguous with its own borders or at a distance. This is not the indifferent outwardness of mechanical impacts or electromagnetic force fields, but rather a spatial self-transcendence rooted in the specific nature of the organism and its selective biological requirements. Only the specific inwardness of the living thing directs it to transcend its own space and relate not blindly, but purposively to its surrounding environment. This relation involves both some sensitivity to what it needs and some corresponding responsiveness, enabling the organism to take in selectively what will sustain itself.

Such talk of sensitivity and responsiveness is not a false importation of features specific to animal life. Sensitivity is not sentience, any more than responsiveness is motility. An amoeba has sensitivity in selectively approaching what it needs, just as a plant has responsiveness by growing its roots towards moisture. Every cell has a membrane that is selectively permeable and in that way exhibits a minimal sensitivity and responsiveness to its environment, both of which are self-centered to the degree that they allow the cell to continue to carry on its life functions.

These features involve not only a biological space relation, but an accompanying biological temporal orientation. Just as the organism must transcend its own spatial boundary to survive, so the organism must transcend its present state in order for its self-organizing, self-sustaining identity to exist. To be what it is, the living thing must realize its selfhood in future activity, both inward and outward. What it does in the present can affirm its own being only by enabling it to carry on its life functions tomorrow. Otherwise, metabolism ceases, and with it, the life of the organism.

Jonas, who studied with Heidegger, but unlike his classmate Hannah Arendt, never forgave Heidegger for his embrace of Nazism, applies a key element of Heidegger's account of *Dasein* to the selfhood of the living thing. Just as Heidegger in *Being and Time* made care (*Sorge*) a fundamental aspect of the being in the world of human subjectivity,[29] so Jonas regards the self-centered individuality of the metabolizing organism as exhibiting the practical orientation to the world of care.[30] Instead of confronting its environment with the disengaged detachment of a theoretical spectator, the organism is always acting upon its biosphere for the sake of sustaining itself and/or its species. Whatever selective sensitivity the organism has is an instrument of self-concern, tied to the responsiveness by which the living thing secures its survival. Although Heidegger employs care as a constitutive aspect of the embodied mind of a rational animal, Jonas' use is coherent, provided it not imply any psychological attitude. Care can apply to unicellular organisms as well as plants so long as it pertains to the internal teleology governing the quest for survival generic to life. Because the self-maintenance of life depends upon the metabolic exchange of material with the external environment, the organism always functions under the imperative of caring for itself and, ultimately, its species. This care addresses the biological want or need of the organism, a want satisfied as well as renewed by the ongoing process of metabolism. Although the mediated metabolism of animals may have a desire for what they need, biological want applies to all organisms, whether they metabolize immediately or through the mediation of an effort traversing an interval of space and time. Plants do not have desires, but they have wants that their immediate metabolism aims to satisfy. Accordingly, the attribution of want, care, self-concern, and self-centered individuality to the organism need not be an anthropomorphic or zoological imposition of psychological determinations. They are simply basic biological determinations that separate the living from the lifeless.

The Contrast Between Machines and Organisms

The nature of life is further clarified by comparing a machine with an organism. Both a machine and an organism have parts and the relationship of their components involves purpose. The machine is designed to carry out a function, which requires that its parts operate in proper conjunction with one another. The parts of the machine are purposive with regard to one another because a machine cannot fulfill its end unless its parts act upon one another with a connected functionality. Each cog in the machine moves another cog and is moved in turn by another, all in accord with the purposive design of the whole to which they belong. What design each part has is dictated by the design of the whole, whose operation depends upon how its parts fit together in the functioning of the entire machine. Insofar as the machine is an artifact, produced for a purpose tied to how it functions, the existence of each part depends upon its relation to the whole. The parts will only be produced insofar as they can subsequently be assembled into the machine and allow it to serve its overall purpose.

Does the machine really differ from an organism by how the possibility of the form and existence of its parts resides in their relations to the whole to which they belong? A key difference noted by Kant is that the parts of an organism produce one another and the whole,[31] rather than being produced by some external agency that designs them and that then makes and assembles them into the whole. The interdependence of the parts of the organism is consequently not equivalent to the interconnection of the parts of a machine, although their complementary functioning also enables them all to contribute to the operation of the whole. As Kant notes, the organs do not just fulfill complementary functions that allow the organism to live.[32] Unlike the parts of a machine, the organs further enable one another to grow and be repaired, as well as enable the whole organism to grow and develop, both forming itself and supplying its own material. The parts of an organism produce one another. By contrast, an external agent makes the parts of a machine. Their manufacture takes place prior to and outside of the machine itself, which comes to be only after an external agency has assembled those parts according to the antecedently given design of the whole machine. That design specifies how the configuration of the machine's parts and how they fit together into a purposive whole, and the design thereby provides the rationale for the manufacture of its components.

Because the design of the machine is not an active form, but a passive form that neither produces its components or assembles them, these parts can and must exist prior to their integration into the whole. This departs radically from how the organs of an organism relate to the whole to which they belong. The organs of an organism properly exist in their defining functionality only insofar as they are integrated within the organism. As Aristotle pointedly noted, a hand detached from a body is no longer a genuine hand.[33] The severed hand loses the animated functionality it possesses as part of the body and begins decomposing into physical and chemical residues bereft of the hand's constitutive character. For this reason, the body cannot be assembled out of organs that do not originate in some living organism, nor can its organs exist apart from a living body or some artificial substitute. A machine must be built out of parts that have their form and matter before the machine is assembled. Accordingly, a machine's externally combined parts can later be detached without forfeiting their design and material being. What makes the parts of an organism be *organs* is that their form and matter, as well as their integral existence, are internal to the functioning of the living thing to which they belong. They have no antecedent or posterior separate being. This is why they come to be within the development of the organism, where both the "form" and "material" arise in and through the growth process, which may involve successive metamorphoses of the most contrasting character. Further, the parts of a machine can lie idle, when either apart or assembled together. Organs, however, cannot exist without performing the functions by which they serve one other and the organism to which they belong. In so doing, they enable it to live and to have its life process penetrate and sustain all parts of its self-renewing process.

Accordingly, the unity of the organism involves a very specific kind of differentiation that contains the actual activation of its components. The active form of life cannot exist apart from the workings constitutive of the living thing. Passive rather than active as well as potential rather than actual, the design of a machine does not provide for its own realization. This is why the design of a machine, as well as that of any other artifact, has a universal character that leaves unspecified its individual embodiment. By contrast, the "form" of the organism has no embodiment apart from the individual itself. This is because the living thing's "form" contains the activity of its own realization, as well as the formation of the "material" out of which it constitutes itself. The complementary functionality of organs is therefore not a potentiality that can be detached from its actualization. The organ's ability to perform its function exists only in its actual activation as part of the life process of the individual organism. As soon as that life process is extinguished, the organs lose their complementary abilities and begin decomposing, falling prey to external mechanical and chemical causalities.

Whereas the concrete unity of the organism involves its own self-maintenance, the machine is constructed by a manufacturing process prior to and outside of its working and the machine produces something other than itself. Hence, it is not an end in itself, but exhibits a relative purposiveness. Even if the machine were to produce the parts from which it is assembled, its production would not generate the parts that currently belong to it, nor would their production assemble them into the machine that produces them. The machine cannot be an "organized and self-organizing being",[34] like the living thing.

The type of power the machine wields reflects this inability. As Kant puts it, the machine has motive power, whereas an organism has formative power.[35] The machine might appear to have formative power if one were to understand such power as consisting in the power to impose a predetermined form upon a given material. Such is the power wielded in the manufacture of artifacts, where the product embodies a design that can inform any number of materials whose matter is altered to take on that design. The machine that imposes a design on material does not however produce the form it imposes any more than it produces the material. Nor does the machine generate the energy it expends in altering the object upon which it works. A machine that produces shoes out of leather does so by the motion of its parts. Its parts act externally upon the leather, cutting it, fastening it to a last, stitching it, and otherwise exerting moving force. The production of the leather can itself involve chemical processes that tan the leather. Kant, of course, does not grant chemical process a properly discrete objective standing within the mechanism of nature. Nonetheless, the employment of chemical process by machinery involves movement that imparts an alteration to something other than the machinery itself. Whatever machinery engages in the tanning process must move in order to mix and apply the proper tanning agents to the animal skins and allow the chemical reactions to proceed. None of these activities produces the energy that activates the machinery. Instead, some agency outside the machine must supply it with the energy that permits it to operate. The machine is not self-activated, nor does it produce the form it imposes on its raw material or produce the raw material itself.

By contrast, the organism is self-activating and it generates both the form and material it embodies in its own self-maintenance and growth process. Moreover, it does not produce offspring by imposing an externally supplied form upon an external material, but rather provides from itself both the "form" and "material" of the new organism it generates in reproduction.

The machine shapes its material, impacting upon it in various external ways. The organism acts upon itself, which is why the living thing does not involve the inactive form and given material that apply to artifacts. The "material" of the living thing contains the process by which it forms itself, just as its "form" is an active self-organizing power that enables its "material" to be what it is and subsist. When the organism ingests external material in its metabolism with the environment, the "formative power" of the organism imparts its own active process to the "material" it assimilates. By contrast, when a machine imposes form upon the material it works upon, the product does not become part of the machine and begin exerting its motive power.

These contrasts should put to rest any temptation to consider the material exchanges of metabolism as a mechanical process, equivalent to the inflows and outflows of a machine or to the input and output of information in the information processing of computers. Admittedly, a machine, be it manufacturing widgets or computing results, takes in fuel and other inputs and generates some output, including waste products. How is this different from metabolism? As Jonas points out, the parts of the machine are not affected by the inflow and outflow other than with respect to whatever wear and tear those parts suffer.[36] By contrast, the exchange of materials in metabolism replenishes and repairs the organs of the living thing. Whereas the reconstitution of the machine is not the aim of its operation, metabolism continually transforms the material constitution of the organism itself, while maintaining the organism's active form and fundamental processes. This is why the inputs of the machine are not constitutive of the material composition of its parts. The information fed into a computer has no special relation to the hardware, any more than the materials used in manufacturing must be those that enter into the production of the machinery itself. Accordingly, the machine can be turned off without appreciably affecting its composition, whereas the organism cannot cease to metabolize without quickly destroying the organs in which it consists, unless it enters into some type of suspended animation.

Descartes, who considers animals to be machines, pursues his mechanistic reductionism by inviting us to think of metabolism as a form of mechanical combustion, where food is burnt to provide the heat giving the organism the energy to move. As the example of immobile plants makes manifest, metabolism is hardly a method of power generation, supplying kinetic energy. Rather, as Jonas points out, the sources of nutrition become the organism itself, which is "wholly and continuously a result of its metabolizing activity".[37] Unlike fuel, what gets assimilated by the organism is both object and agent of the metabolic process.[38] Admittedly, there may be oxidation processes in digestion that produce heat in an animal. Nonetheless, the metabolic system integrates such chemical reactions so that the organism continues with its metabolism. No feedback loop machine process can emulate this self-renewal of the organism, for the feedback loop does not reconstitute the machinery with which it makes its circuit.

How the metabolizing organism comprises a non-mechanistic, dynamic whole is further clarified by considering the contrast between what can be called an event structure and a crystal structure.[39] An event structure can be exemplified most simply by a wave, which retains its form by passing through continually different material. By contrast, a crystal structure is inseparable from material that rigidly embodies it. Through metabolism, the organism dynamically maintains its identity, altering its material all the while. Unlike a wave, however, the organism does not owe its form to some external impetus, but generates its form and matter through its own growth process, once autopoeisis has emerged in a biosphere. Machines will come later, but never duplicate what the simplest life form must to do to become what it is.

Why No Organism Can Be the Product of Intelligent Design

An organism cannot be the product of any intelligent design precisely because the organism does not need an external designer to give it its form, nor an external agency to manufacture it and then set it in action upon an externally supplied material. The self-organizing process of the living thing is completely distinct from the form-matter composite constitutive of an artifact. Kant recognizes this and acknowledges that the living thing is something we cannot make because its very self-organizing character lies beyond any of our possible powers of craft.[40] One can imagine having in one's laboratory a "monster" who can somehow be reanimated, leading one to exclaim, "it's alive!" This achievement, however, is not a making of a living being, but rather a working upon a preexisting organism. The same applies to any process of genetic engineering. What is "produced" is not an artifact, but an altered living thing, generated from given living substances. In both cases, what comes to be does not arise from a fashioning of inanimate material.

Why DNA Is Not a Blueprint of the Organism

DNA may seem to be the genetic code of most organisms on our lonely planet, but it would be a mistake to consider DNA the blueprint of a living thing. To begin with, DNA is not an intelligible design that exists apart from and antecedently to the existence of the organism it allegedly determines. DNA is itself a physiological component of the cell or cells of the organism to which it contributes. It is therefore not a blueprint that is imposed upon a preexisting material. As a part of the organism, DNA subsists, gets activated, and divides thanks to the life process involving the other components of the living thing.

Not only is DNA a "material" component of the living thing, but every cell in a multi-cellular organism has the same DNA, despite possessing different structures and different functions in the life of the organism. A blueprint, by contrast, informs artifacts with one and the same form and function. Moreover, an organism, whose differentiated cells all share the same DNA, undergoes a process of growth and metamorphosis, involving morphological and material changes. These may all be conditioned by the DNA they contain, but that DNA cannot be functioning as a design or blueprint. Rather, it must be differentially activated both in the process whereby the organism's cells become specialized and in the process whereby the organism develops as a whole. This differential activation depends upon alterations of other components within the organism. These determine what parts of the DNA can interact with other chemicals within the cells and form new chemical components fostering developments of the organism that further change the conditions within its cells. Far from acting as a blueprint, DNA has its components "turned on and off" by transformations in the other cellular components that together constitute each cell's internal environment. Once more the internal purposiveness of organic unity resists reduction to the form/matter composite of artifacts.

Rather than constituting a blueprint, DNA figures more as chemical constituent of the cell that, given the proper activation by other chemical constituents in the proper sequence, helps produce and renew the proteins and enzymes that underpin the life processes of the cell, as well as the differentiations it may undergo in embryonic development. Dennett describes the role of DNA as more of a "recipe" than a "blueprint",[41] given how DNA conditions the chemical productions that are integrated within the autocatalytic self-preservation of the organism. A recipe, however, is just as much an ideal procedure as a blueprint is an ideal form. DNA, by contrast, is a real biochemical constituent of the cell and it enters into chemical interactions as no blueprint or recipe can.

Dennett characterizes the cell components that activate different parts of DNA as a "reader", emphasizing how DNA does nothing without the addition of that external agency, which may take the form of the cellular environment or an ovary or egg.[42] DNA, however, is not just information, nor a text, nor a signifier of any sort. Like any chemical, DNA is primed for certain reactions with specific other atoms and molecules under specific physical conditions. The "reader" of DNA is not a unified agent but rather the multiplicity of chemical reagants that populate the cell and that, in the case of multicellular organisms, populate certain organs of the growing, developing organism.

DNA and its possible extraterrestrial counterparts do play a central role in the self-regulating life of the cell and in reproduction. For this reason, a true understanding of evolution will require recognizing how such macromolecules are neither blueprints, recipes, nor information awaiting reading. Only then will we be able to understand how evolution is not a process of design.

Notes

1. Hegel, *Science of Logic*, pp. 761–774.
2. Kant, *Critique of Judgment*, §64–66, p. 242–249.

3. Kant, *Critique of Judgment*, §62, pp. 235–238.
4. Kant, *Critique of Judgment*, §63, pp. 239–241.
5. Kant, *Critique of Pure Reason*, A211–235/B256–287, pp. 316–333.
6. Hume, *An Inquiry Concerning Human Understanding*, pp. 40–53.
7. Kant, *Critique of Judgment*, §61, p. 234.
8. Kant, *Critique of Judgment*, § 63, p. 241.
9. Kant, *Critique of Judgment*, §64, p. 242.
10. Kant, *Critique of Judgment*, §64, p. 242.
11. It turns out, however, that all such ethical ends amount to realizations of a willing that is lawful not because of the content of its ends, but due to its lawful form.
12. Kant, *Critique of Judgment*, §64, p. 242.
13. Kant, *Critique of Judgment*, §64, p. 243.
14. Hegel, *Philosophy of Nature*, Zusatz to §337, p. 274.
15. Kant, *Critique of Judgment*, §64, p. 243.
16. Kant, *Critique of Judgment*, §64, p. 243.
17. Kant, *Critique of Judgment*, §65, p. 245.
18. Kant, *Critique of Judgment*, §64, p. 243.
19. Kant, *Critique of Judgment*, §64, pp. 243–244.
20. Jonas, *The Phenomenon of Life*, p. 75ff.
21. Jonas, *The Phenomenon of Life*, pp. 97–98.
22. Jonas, *The Phenomenon of Life*, p. 98.
23. Jonas, *The Phenomenon of Life*, p. 79.
24. Jonas, *The Phenomenon of Life*, pp. 81–82.
25. Jonas, *The Phenomenon of Life*, p. 81.
26. Jonas, *The Phenomenon of Life*, p. 81.
27. Jonas, *The Phenomenon of Life*, p. 83.
28. Jonas, *The Phenomenon of Life*, pp. 85–86.
29. Martin Heidegger, *Being and Time*, trans. John Macquarrie and Edward Robinson (New York: Harper & Row, 1962), p. 225 ff.
30. Jonas, *The Phenomenon of Life*, p. 86.
31. Kant, *Critique of Judgment*, §65, p. 245.
32. Kant, *Critique of Judgment*, §65, pp. 245–246.
33. Aristotle, *Metaphysics*, 1036b30-33, in *The Complete Works of Aristotle*, Volume Two, p. 1637.
34. Kant, *Critique of Judgment*, §65, p. 245.
35. Kant, *Critique of Judgment*, §65, p. 246.
36. Jonas, *The Phenomenon of Life*, note 13, p. 76.

37. Jonas, *The Phenomenon of Life*, note 13, p. 76.
38. Jonas, *The Phenomenon of Life*, note 13, p. 76.
39. Jonas, *The Phenomenon of Life*, p. 77.
40. Kant, *Critique of Judgment*, §65, p. 246.
41. Daniel Dennett, *Darwin's Dangerous Idea: Evolution and the Meanings of Life* (New York: Simon & Schuster Paperbacks, 1995), p. 112.
42. Dennett, *Darwin's Dangerous Idea*, p. 113.

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4

Evolution and the Development of the Different Forms of Life

The Two Conditions of the Emergence and Development of Life

The emergence and development of life is predicated on two coordinate factors. One is the constitution of nature as a biosphere. The other is the minimal specification of the processes fundamental to life. Nature as biosphere does not contain any teleological mandate to give rise to living things. Rather, the contingent operations of inorganic processes are what alone enable life to emerge. The life that emerges qualifies as such insofar as it exhibits the fundamental life processes. These processes are threefold. One consists in the organic unity of the living thing, whereby its differentiated components engage in complementary functions that sustain one another as well the whole organism to which they belong. Another consists in the metabolic process whereby the organism relates to its environment, which initially is entirely inorganic, and exchanges material so as to continue its active self-sustaining organic unity. This process involves the assimilation of inorganic materials that become incorporated in the organism and infused with life processes that uphold the functional components, which, for their part, maintain the whole

R. D. Winfield, *Universal Biology after Aristotle, Kant, and Hegel*,
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organism. Metabolism may or may not involve growth, which may or may not involve metamorphoses as well as size increase. Thirdly, organisms may have the power to reproduce, that is, to generate another living thing of the same kind from the living material of just itself or a combination of living material from two or more organisms.

The emergence of life minimally requires an organism that contains chemical materials including sufficient catalysts to precipitate reactions that produce in their aggregate the chemicals from which those same reactions can reoccur. To be such an autocatalytic entity, the minimal organism must have a semi-permeable boundary that allows it to exchange the material providing for its ongoing life process as well as to maintain the membrane that keeps its constituents in proximity and selectively admits and expels what substances are requisite for its continuation. Insofar as entropy insures that all complex macromolecular structures break down over time, the organism must be an "open" system that can take in fresh materials and energy with which it can replenish itself.[1] The minimal life form must thus have both a rudimentary organic unity, with complementary components and a rudimentary metabolism with its inorganic environment.

Combining minimal organic unity with minimal metabolism, the cell constitutes the basic atom of life. It provides the units that could combine into a multicellular entity constituting a multicellular organism if those unit cells have complementary functionalities that allow them to be integrated into a self-sustaining whole. Alternately, one cell could penetrate the semipermeable membrane of another to form a new type of cell that contains within it a "nucleus", namely, an internal structure that has its own semipermeable membrane enclosing interacting chemicals of its own. In that way one might imagine how elementary prokaryote cells (cells with only an outer membrane enclosing an autocatalytic stew of chemicals) combine into a eukaryote cell (a cell with a nucleus or other membrane-enclosed organelles).

The first such organisms need not have the ability to reproduce. If they do not, the continuation and development of life will hang on the thread of the limited ability of each organism to resist decomposition by the mechanical, physical, and chemical impacts of the environment and on the repeated unlikely chance concatenation of chemical reactions that could produce a minimal organism. The continuation and development of life only acquires a relatively secure basis when organisms acquire the ability to reproduce. As we have seen, this capability can be provided by double chained macromolecules, like DNA, whose components are in a complementary linkage such that when the chains are separated, they will combine only with the chemicals composing their opposing chain. Then, each separated chain can become a double-chained duplicate, so long as the cell contains the requisite chemicals as well as the catalysts breaking the chains apart and then bringing to the separated strands the complementary chemicals that make them whole once more. This will produce a pair of organisms provided each double-chained molecule is in a cell environment supplying the proper chemicals. These must allow it to produce and order the proteins and enzymes to constitute the autopoeitic functioning of an integral cell, bounded by its own semipermeable membrane and containing the component chemicals for its self-renewing process.

The question then arises how rudimentary reproducing organisms can come to generate not just other living things of the same type, but other species beings. Furthermore, once there is some mechanism by which different species can originate, the question arises as to what fundamental types they can have and whether these types are such that they must arise in a definite order.

Aristotle's Ladder of Life Forms

Before addressing the process that could generate an evolution of species, it is helpful to hark back to Aristotle, whose *Ethics* presents a stepladder of life forms in considering what could characterize the distinctly human function of life.[2] Here Aristotle develops a series of life functions in a phylogenetic order of constitution.

First comes the nutritive function, without which no other life functions can operate. Like all life functions, nutrition has an active form or soul subsuming its activity, which sustains the organism through metabolism and perpetuates the species through reproduction. As primary, the nutritive function could be independently realized in a type of organism with nothing but a nutritive soul. Aristotle identifies plants as having this rudimentary life form.

Next comes a further function that can be added to the nutritive function, without need of any other life functions. This second function involves perceiving and desiring. These go together, Aristotle implies, since an organism only desires what it perceives. The sentient soul, which combines perception and desire, distinguishes the animal organism.

All that is needed to arrive at the knowers of nature is the addition of a third function, the function of thinking with reason and acting in accord with reason. Just as animals possess the nutritive function that plants possess by itself, so we rational animals have the nutritive and sentient functions that brute animals enjoy.

One can explore this ladder in reverse and ask, what is it about a plant that precludes it from possessing the further functions that distinguish the life of an animal? Is there something about the way the plant is organized that excludes perception and desire, as well as the feelings of pain and pleasure that attend the frustration and fulfillment of want? The answer lies in the nature of plant metabolism. Plants generally survive by taking in continuously immediately available sunlight, moisture, and air. During these periods, plant metabolism operates without any gap between biological need and its nutritive fulfillment. Plants may be locally sensitive to sunlight, water, insect pests, and one another, and respond in the correlatively local manner of tropisms. Nonetheless, they do not perceive nor have desires and this can be seen to follow from the nature of plant metabolism the moment one considers the contrasting character of animal metabolism. Unlike plants, animals cannot metabolize what is immediately at hand. They instead depend upon sources of nutrition that must be found at a distance. Consequently, animals face a recurrent gap between need and satisfaction. Because the object of animal need is not immediately given, it is an object of desire, which has yet to be satisfied. Moreover, because the object of desire is given at a distance, the animal must be able to perceive remotely and then have the motility to traverse time and space with sufficient motivation to obtain what it needs for survival and reproduction.[3]

Although Kant provides us with a basic groundwork for developing how life can develop in nature, he does not consider these differences, nor consistently distinguish between the processes of life per se and plant life. Hegel and Hans Jonas offer more of a guide, which soon will warrant following.

The Problem of Differentiating the Fundamental Forms of Life

Hegel recognizes that when it comes to distinguishing what it is to be a plant and what it is to be an animal, various aspects of cell structure and multicellular organization come into play. Can these physiological differentiations be determined a priori? Are there specific features that universally and necessarily determine fundamental possibilities in the development of the particular forms of life? Hegel will proceed to conceive the basic differences between plants and animals. Nonetheless, he acknowledges that one cannot strictly define particular natural entities because nature is such that it has a necessary contingency within it, engendering intermediary forms that transgress any rigid boundaries. This contingency will become evident in the process of natural evolution through which the different forms of life arise. Particular natural species will end up having fluid boundaries that may be nothing more than "family resemblances", corrigible groups in need of continual retrospective revision in face of future observations of new and unnoticed living things. Might the contingency of natural species render moot the attempt to conceive such fundamental divides as that between plants and animals? Or will that contingency still operate by realizing distinguishable basic possibilities that govern any development of life anywhere in the universe?

Already, the emergence of life in a biosphere provides one basic differentiation that cannot be denied. Namely, the most elementary life forms will exhibit the autopoeisis of a self-sustaining metabolism, but do so without having the ability to engage in reproduction. These life forms will continually disappear as soon as they succumb to external mechanical, physical, and chemical impacts that disrupt their metabolic activity. Life will only acquire a qualitatively greater endurance when life forms acquire a species being by producing from themselves other living things of the same kind. This provides the most elementary divide that necessarily applies to the development of life forms. A further differentiation can be drawn conceptually between those elementary reproducing living things that have specific structures with membranes of their own within the permeable boundary of the organism and those that do not. On this basis one can distinguish conceptually between eukaryote and prokaryote organisms. Next one can distinguish between unicellular organisms in general and multicellular living things.

This differentiation may carry with it the distinction between organisms that reproduce asexually and those that reproduce sexually. Unicellular organisms can easily reproduce asexually through mitosis, where the individual cell divides itself, producing two cells with the same genetic character. Multicellular organisms cannot feasibly reproduce through the mitosis of each cell, since their reproduction requires the duplication of not only the individual cells, but their specific integration into a single organism. This is evident in how the individual cells of multicellular organisms do undergo mitosis in order to repair and sustain the individual organism, whereas their reproduction requires something more that only sexual reproduction can accomplish, namely a fertilized gamete cell in a proper biological environment allowing the further embryonic differentiations from which the full multicellular organism can develop. It would thus seem that the conceptually determinate divide between asexual and sexual reproduction falls within the divide between unicellular and multicellular organisms.

Can any further conceptual divides be established *between* types of multicellular organisms? This question puts us at the threshold of the differentiation between plants and animals.

The Individuality of Organisms and Their Species Being

It must be kept in mind that any distinction of types of living things is fundamentally different from the differentiation of inorganic entities, such as given by a periodic table of chemical elements. Organisms always have an essential individuality, even if they equally possess a species being. Chemicals of the same type can only be individuated with respect to their position in space and time. Otherwise their structure and their components are indistinguishable. Artifacts, on the other hand, may share a blueprint, that can inform an indefinite number of instances whose material embodies the same predetermined design. They may be individuated by the different materials in which the same form is embodied, but their material differences are inessential, since the value of the artifact resides in how perfectly it embodies its design. Only when the material differences prevent an artifact from fulfilling the function for which it is designed do they figure in a negative manner. By contrast, the self-sustaining character of an organism gives its individual being an essential character. This is true even when the organism sexually reproduces and sacrifices itself in the act of reproduction or in caring for its offspring. The species being that the organism then promotes still perpetuates itself only through the individuality of its members, whose self-preservation is necessary to bring it to the point of engaging in reproduction and furthering the continuation of its species. The living thing retains a unique individuality that is fundamental to its life process.

This individuality is exhibited in how the unity of the organism is connected to the constitutive life processes of metabolism, growth, and reproduction. The complementary functions of the organs of the organism do not only sustain the individual whole to which they belong by figuring reciprocally as means and ends. Their complementary functioning equally operates the metabolism of the organism, whereby it exchanges material from its environment and transforms what it appropriates into an integral part of its living self, which may grow in so doing. Moreover, the organic unity of the living thing also maintains whatever reproductive capability it possesses and thereby underlies the performance of reproduction, whereby the organism affirms its species being. Admittedly, certain organisms can temporarily suspend their metabolism without destroying their internal organization, as do hibernating animals and elementary organisms that take the form of inactive spores. Also, particular individuals of a species may be unable to reproduce and entire hybrids may be infertile. Nonetheless, these exceptions are themselves tied by species membership or by descent to individuals whose organic unity is tied to all life functions. Generally, the internal workings of the organism will reflect how it interacts with its environment and, in the case of reproducing organisms, with other members of its own species. These dual interconnections will be at hand in every form of reproducing life, and one of the challenges in differentiating plants from animals will lie in identifying the distinctive way in which these life processes integrate themselves.

The Emergence of the Evolution of Species

Any determination of the order of emergence of life forms and what types they can have presupposes some process of natural biological evolution. Such evolution itself depends upon both the genesis of life from inorganic nature and the genesis of life that reproduces itself. The move from life that does not reproduce itself to that which does is not itself the product of natural evolution. It is rather the product of chance concatenations of physical and chemical processes that are not generated by life itself. Evolution depends upon reproducing life forms, for only they provide for the existence of species, from which any evolution of species can begin. Each successfully reproducing organism affirms its species being through generating other organisms of the same kind. That there be a plurality of species depends first of all upon the contingent inorganic circumstances that give rise to organisms, each of which may well have a different composition, so long as some autopoeitic cell emerges that has the capability of reproducing itself. This suggests that these first species consist of asexually reproducing organisms whose life processes proceed with distinct structures and chemical reactions.

Any further evolution depends upon some transformation of the species being of an organism that is itself reproducible, potentially giving rise to a new species. Given that a cell contains genetic material that accounts for its mitosis and for the duplication of organisms of a specific kind, something must alter that genetic material, while still allowing for a reproduction generating organisms whose altered inheritance makes them members of a new species. Whatever internal and/or external contingencies produce alterations in inherited genetic material, new species can only emerge if they survive and propagate. If the environment necessitates that organisms must compete to survive, then those endowed with altered inheritances making them more fit to metabolize and reproduce will form a new species, whereas those whose unaltered or altered inheritances make them less competitive may go extinct. These are the basic conditions seemingly allowing the evolution of the species to proceed. With them in place, nature can apparently set in motion the developments leading to those who now think through its course.

Is it, however, all so simple? Long before Darwin's investigations, there was little problem recognizing the prolific diversity of living things and how the diverse species being of organisms exhibited different types of adaptation to their equally diverse environments. Moreover, it was evident that the specific features providing for adaptation were to a significant degree inherited and that different species had to compete with one another in order to survive. There was also long experience with animal husbandry that showed how selective breeding produces different varieties. Selective breeding, however, never produces new species. How then can a genetic account explain the diversity of species by developing new species out of others through a struggle for existence in which the more adapted species survive?

The existence of mutations was acknowledged, as natural "monstrosities" were observed and even put on show. Yet how could a monstrosity breed with other organisms to produce a new species? Would the mutation not dilute itself in the course of successive generations, eliminating any chance of originating a new species? If an organism with a mutation has to reproduce with another organism that lacks it, how can this establish the nodal boundary of a new species, instead of the continuity of intra-species variation? Admittedly, this problem pertains specifically to sexually reproducing multicellular organisms, but it is inescapable if we are to account for the genesis of more than unicellular organisms.

Underlying the difficulty is the whole problem of identifying a species from the given reality of its putative members. They all have multiple features and multiple variations and the question arises as to how one can distinguish the essential species differentia from those that are inessential. Any empirical selection would appear to be arbitrary, producing a purely nominal species identity.

The theory of evolution will attempt to circumvent this problem by relying on a genetic account of species differentiation, where what they are is determined by how they come to be. To do so, the problem of new species origination will have to be solved.

How Evolution Is Feasible

Commonly it is thought that the theory of evolution introduced by the Darwinian revolution subjects life to the blind necessity of mechanism and thereby provides a genetic understanding of living things without reference to ends. External causalities supposedly now overtake the internal teleology that appears so constitutive of the basic life processes of organic unity, metabolism, and reproduction, opening the door to mechanistic explanations of life and all the specific features of different organisms.

Long before Darwin, Aristotle rejected natural evolution for ignoring the internal teleology of living things. Early in the *Physics*,[4] Aristotle considers the idea that species originate from a contingent process where organisms of different types find themselves in a struggle for survival, where only those who are most fit to compete manage to persist, leading to an evolution of species generated by blind natural selection. On this account, what determines the character of organisms is the external necessity of being fit to succeed in the struggle for survival. Aristotle objects that this mechanistic explanation ignores how living things for the most part generate offspring like themselves. He acknowledges that nature sometimes produces monsters that deviate from the normal species being of their parents.[5] These are exceptions to the rule and the rule is governed by the teleology inherent in reproduction, where the active form of the parent dictates what kind of offspring it generates. What species there are thus depends on not any blind external necessity, but the indwelling telos that is constitutive of reproduction and the species being of every living thing.

What Aristotle and neo-Darwinians both ignore is that evolution involves *both* the internal teleology of reproduction and the blind external necessity of natural selection. Evolution operates only on the basis of organisms that generate offspring of the same species as themselves. On the other hand, evolution adds to this teleological process the contingent production of mutations that allows the mechanism of natural selection to generate a development of new species. Unless the mutations can be inherited through the teleological process of reproduction, there can be no evolution, even if the course of evolution depends equally upon external necessitations.

A constant refrain of the naysayers of evolution is that blind necessity could never account for the miraculous internal purposiveness of any complex living thing, let alone of even the simplest multicellular organism. How could mechanistic contingencies ever generate living things with all of the incredibly calibrated interconnected fitness with which their organic unity, metabolism, and reproduction operate? This disbelief in the fecundity of evolution leads many such naysayers to appeal to intelligent design to produce what blind necessity could never generate. What these advocates of intelligent design ignore is that the internal purposiveness of organisms that leads them to question evolution is incompatible with the character of artifacts. Intelligent design cannot possibly produce what is fundamentally incompatible with any embodiment of an antecedent design. Because life is self-organizing and self-forming, it cannot be manufactured by some external agency imposing inactive form, i.e. design, upon given material.

Hans Jonas points out how the combination of the teleology of the organism with contingently caused mutations and competition for survival makes explicable how evolution can give rise to increasingly complex organisms.[6] The life process permits evolution to work its wonders for, as Jonas, explains, the teleology of reproduction dramatically lowers the bar for what each implementation of blind necessity must achieve. Evolution does not render the production of new species equivalent to the random typing of a monkey who starts from a blank page and somehow, after innumerable tries, comes up with *Paradise Lost*. If that were the predicament of each evolutionary advance, the development of a new species would likely take longer than the lifespan of any biosphere. Instead, each mutation adds to the cumulative endowment of prior evolutionary developments, which are present in the genetic material that is replicated in every normal reproduction. Blind necessity never works upon a blank page, but instead operates upon a living organism, with all of its inheritance of accumulated internal purposiveness. Consequently, each evolutionary change can involve a slight simple alteration that builds upon the entire living heritage that reproduction carries along. In this way, evolution involves a gradual cumulative development that can lead to the most intricately purposive organisms before solar burnout makes planetary conditions unlivable.[7]

The two natural developments upon which evolution itself depends are similarly achievable owing to their respective rudimentary character.

The first is the spontaneous production of a minimal life form from the chemical brew that nature as biosphere makes available. Admittedly, on our lonely planet, it appears to have taken many more billions of years for life to spontaneously arise and endure than for natural evolution to generate the rational animal typing these letters from the most elementary reproducing life forms. That accidental concatenation of chemicals into the original life form may take eons to occur. After all, it requires a completely random combination of physical and chemical processes to congregate in proximity and engage successively in reactions that all together produce a self-sustaining process that sufficiently encloses itself against its environment to contain its own processes and supply them with the exchange of material and energy needed to continue. What makes this stupendously fortuitous occurrence possible within the limited lifespan of the biosphere is the minimal character of the autopoeitic entity comprising the most rudimentary living thing. As Jonas points out, the more minimal the transformation from inorganic to organic process, the more likely can it take place. The probabilities of the requisite chance combinations become manageable when all that need be produced is the simplest possible life form.[8] All that lies at stake is giving rise to a permeable membrane within which chemical reactions integrate into a process whose products supply the inputs for its continual renewal, as well as the maintenance of the enclosing membrane. Our own existence testifies to how the possible can become actual before it is too late.

The second condition for evolution is the emergence of a life form that not only metabolizes, but reproduces. Since this requires nothing more than the simplest mitosis of a single celled organism, the leap from the most minimal life form to reproducing organisms need not be an insurmountable challenge within the billions of years left in which a biosphere can maintain its relatively stable life-permitting environment. Once these two landmark developments occur, evolution can begin its blind but cumulative process, whose protean energy may populate innumerable habitable planets with a diversity of life forms that imagination can never fully anticipate.

Because evolution builds upon its own achievements at every step along the way, the path from simple unicellular organisms without nuclei to eukaryote unicellular organisms with nuclei to multicellular life forms to plants and then to animals and ourselves can all occur with ever accelerating speed in a relatively brief geological period. On one estimate, our earth took an estimated billion years to give rise to the simplest prokaryote cell and then another two billion years for one prokaryote to invade the membrane of another and produce a viable eukaryote cell.[9] As Dennett explains, with the rise of eukaryotes, endowed with such membrane enclosed internal "organs" as a nucleus, organelles, plastids, chloroplasts, and mitochondria, cells could become specialized. This development provided the resources for the emergence of multicellular organisms, which took another 700 million years to occur. Once multicellular life arose, the pace of evolutionary development could accelerate so that in only another 700 million years rational animals could emerge and know how evolution gave rise to themselves.[10] Then the natural history of evolution reaches the threshold at which the pace of genetic change becomes overtaken by the much more rapid transformations of cultural development. These spawn a history of the new world of convention that rational agents forge for themselves, involving changes in mores and institutions that have no genetic correlate.

Our emergence as a further evolutionary development of animal life dispels the two barriers that Descartes and most other early modern philosophers erected separating animals from ourselves and mind from the living body. Insofar as such thinkers reduced nature to a mechanism, a Descartes could think of animals as machines, leave life itself with no foothold in nature, and banish mind from the material universe. Moreover, by reducing animals to mechanisms, these thinkers deprived themselves of the opportunity to consider the evolution of different forms of mind, leading from brute to rational animals. Once, however, we recognize how life emerges in a biosphere and potentially evolves into rational animals like ourselves, we are in a position to leave behind all mind/body dualisms and acknowledge different phylogenetic stages in the development of mind. There is no reason in principle for animals that are unable to speak and think not to be conscious and self-conscious.[11] The divide between plants and animals will reveal that the emergence of animal life equally signifies the emergence of mind in the natural universe.

Heredity and the Diversification of Species

Of key importance in evolutionary development is the way in which heredity and species diversification are intertwined.

In the most elementary case of a unicellular organism reproducing asexually, mitosis generates another organism that shares the same cellular material. Each is therefore quite literally one of a kind constituted in the identity of their respective biological composition. Moreover, the survival of the species is not entirely distinct from the survival of its particular members since each cell effectively lives on in the offspring that contain its actual living substance.

Once multicellular organisms arise and sexual reproduction occurs, species being takes on a more complex character. Admittedly, sexual reproduction can produce siblings that have identical genetic compositions, comparable to that of asexually produced offspring.[12] Nonetheless, even when sexual reproduction produces identical twins, they are genetically distinct from their parents and any other siblings. This is because each offspring combines genetic material from each of its sexually differentiated parents, doing so in potentially different ways, especially when environmental factors influence the inheritance and expression of genes. The species being of sexually producing organisms therefore cannot be constituted by any exactly duplicated genetic character. Rather, it would seem to reside in two factors. One is biological, comprising the range of different types of organisms that physiologically can reproduce with one another. This range sets a limit to how encompassing the particular species could be. The other factor consists in the geographical frontiers within which such potential mates have the opportunity to reproduce with one another. These contingent circumstances circumscribe the boundaries that different species can have, irrespective of the mutations that may divide and transform those populations according to the same conditions. Whether these boundaries enclose enduring species depends upon their viability, both as individual organisms and as organisms that can succeed in reproducing themselves. If they have sufficient viability, then they establish a distinct species being that does not dissolve into the continuity of commensurate varieties.

In order for any new species to evolve, organisms must undergo mutations that meet two basic requirements. First, the mutations must be inheritable and be retained within a population they differentiate from others thanks to biological and geographical restrictions upon reproduction. Secondly, the mutations must be expressed in biological features that enable the mutated organism to compete successively in its struggle to survive and reproduce. Of course, the competitive struggle for survival entails natural selection only if not all organisms are equally able to reproduce.

Proceeding from these common conditions, the emergence of new species is further determined by the two paths of speciation that distinguish asexually from sexually reproducing organisms.

On the one hand, an asexually reproducing organism that has a competitively viable mutation can establish a new "species" simply by mitosis. Each of its offspring will share the same genetic composition until any one of them undergoes a different mutation giving it equal or better chance to survive and reproduce. On the other hand, when a sexually reproducing organism undergoes a mutation that is inheritable and viable, some if not all of its offspring may carry on that mutation. If that mutation gives them competitive advantages in the struggle for survival and the struggle to reproduce with potential mates, then those offspring who have and express that mutation will more likely reproduce than their siblings which lack it. The boundaries of any species composed of organisms with that enhancing mutation will be determined by both the range of other organisms with whom they can reproduce and their geographical distribution.

It follows that the process of speciation is in continual flux. Not only does each species gradually transform itself through the accumulation of viable mutations, but their offspring may gradually divide into new species themselves. These new species are based upon not only new inheritable mutations, but the range of organisms with which these offspring reproduce as well as the geographical frontiers that may separate them.

Of course, to speak of species requires some enduring presence of common inheritance, rather than a continual maelstrom of genetic transformations, leaving each new offspring one of a kind. Complete anarchy is partly limited by the biological limits on which organisms can breed with one another and the geographical limitations on what breeding opportunities are available. If organisms could instead randomly reproduce with any other organisms, each organism could be a unique hybrid and no species differences would have a chance to be established. The selective pressure of evolution would itself work against such random dissemination of hereditary materials. If any mutation is to produce advantageous adaptations in an organism that could be passed on to further descendants, this will much more likely happen if the range of sexual partners is limited. Otherwise, each mutant will remain a unique transient exemplar, with little chance of producing an organism like itself. The mutation will be much more likely to disappear if random couplings can proceed.

What prevents a riot of new mutations from undermining all species divides is the very complexity of the internal purposiveness of every life form. As the naysayers of evolution duly recognize, no contingent mutation can plausibly generate all by itself a whole new organism. Instead, each mutation more likely supplies a minor alteration that must fit together with the rest of the internal anatomy of the living thing to have any chance of viability. This requirement applies to both asexual and sexual reproduction. If a mutation cannot meet this condition, the resulting mutant is literally a dead end, an unworkable monstrosity.

A further challenge that must be surmounted for evolution to be an evolution of species is a problem that applies specifically to sexually reproducing organisms. Any viable competitive mutation of an asexually reproducing organism will automatically be transmitting to all its offspring, without any dilution. This is not case with sexually reproducing organisms. Since their offspring share different combinations of their respective genetic materials, these offspring will not all have the mutation, nor transmit it to all their descendants. It would seem that any mutation of sexually reproducing organisms will have a progressively diminished distribution among the offspring of a species. What counters this tendency are two factors. First, the genetic diversity of sexual reproducing organisms gives them more variations with which to successfully adapt to changing environmental conditions. This allows sexually reproducing species to maintain themselves more easily. Secondly, a new mutation that enhances survival and reproduction chances will give those offspring who inherit it a better opportunity to reproduce than those who do not. This inherited advantage will tend to increase the proportion of offspring carrying it, which will further increase its inheritance among the next generation, leading to a continually accelerating proliferation. New species will thereby have a growing chance to emerge and sustain themselves until changes in their ecosphere put them at a disadvantage.

Richard Dawkins has suggested that what really reproduces itself and evolves in evolution is the genetic material itself, rather than the organisms comprising the various species.[13] The genetic material, however, has no real independence, but is itself an organ of an organism, whose own activation depends upon the complementary function of other elements in the cell, as well as in the complementary functions of organs composed of differentiated cells in multicellular organisms. The "selfish gene" is not a self at all, for unlike the entire organism, it has no independent agency. Genes are neither self-activating nor able to act upon any other part of an organism without their subordination to the self-sustaining process of the living thing. Although evolution will blindly select which species endure and which new ones evolve, the only self-active subjects are the living things, which affirm their species being through their survival and reproduction.

The possibilities of evolution may be unpredictable and incredibly protean, as life on earth can testify. Nonetheless, there are important constraints that govern the process wherever it may occur in the universe. Although the possible permutations of genetic factors may be virtually endless, the actual conditions of natural selection sharply narrow the range of viable options. Instead of yielding a purely random, aimless genetic drift, the concrete circumstances of evolution foster a different, more focused itinerary.

The basic complementary functionality of organic unity imposes the most primary limitation. To be viable and inheritable, a mutation must not introduce biological features that impede the mutually supportive operations that allow the organs of the living thing to sustain one another and the whole to which they belong. Instead, any new genetic alterations must be in harmony with the rest of the organism and its possible reproduction. Given how complex any organism is, this requirement vastly reduces the numbers of feasible alternatives.

Secondly, new variations will only persist if they meet the general astrophysical and geological constraints of the biosphere. These planetary parameters may dictate very different chemistries and metabolic processes from those that characterize the carbon based, DNA and RNA sharing life forms on earth. Moreover, the general conditions of gravitational attraction and fluid dynamics will favor certain forms of anatomical symmetry. In addition, the concrete qualitative features of habitats will dictate which types of sensitivity and sentience are needed to navigate the environment, as well as what heat and radiation tolerances are required to survive. Any new mutation will be an evolutionary dead end if it fails to fit these all-encompassing physical bounds.

Thirdly, no mutation will be viable if it prevents the organism it alters to survive the competition from the life forms that dominate its particular ecosphere.

All three of these factors impact upon the viability of any genetic alterations, but they have different degrees of constancy and range. Whereas astrophysical relations ordinarily provide the most abiding background condition, geological conditions usually supply the second most enduring and extensive environmental challenge. The dominant life forms, by contrast, likely have a comparatively briefer and more regional reign, as they may succumb to new local biological challenges that arise before astrophysical or geological conditions have significantly changed. Taken together, these three dimensions of viability present a continually changing challenge[14] that life forms must surmount by enlisting the ever creative resilience of natural selection until the point is reached when a world ceases to be a life-friendly biosphere.

Given how evolutionary change must contend with all the above restraints, are there still identifiable stages that life must progress through anywhere and everywhere in the universe? The answer lies in considering first how the cell, the basic atom of life, can be structured and how the cell can give rise to multicellular life. Then, the basic possibilities of metabolism will provide a further clue to help uncover the fundamental stages in evolutionary development.

Fundamental Stages in Evolutionary Development

Whenever and wherever biospheres give rise to reproducing organisms, any ensuing evolution will follow a basic order. At the very start, the most minimal life form will be a single celled prokaryote organism that reproduces asexually. Next, in order of biological complexity, are single celled eukaryote organisms that contain nuclei and other organelles within their encompassing cell membrane. Looming beyond the world of single celled organisms is the emergence of multicellular life forms.

Multicellular organization affords living things the capabilities that the complementary specialization of cells can provide. These include a new form of reproduction, sexual reproduction, that may accelerate the diversification of life. Generally, organisms that develop the ability to reproduce sexually will have an added advantage since each offspring will have at its disposal different genetic material from each parent. This diversity, combined with that obtained through genetic mutations, will give sexually reproducing organisms a greater range of variations. This may make them more fit to survive, especially in changing conditions, which include the emergence of new competing organisms. To the extent that unicellular organisms reproduce exclusively asexually, the emergence of multicellular organisms sets the stage for some to evolve into sexually reproducing species, whose future survival and evolution is thereby enhanced.

It bears repeating that multicellular organisms cannot reproduce exclusively through asexual mitosis for the simple reason that their reproduction involves not only duplicating the cells that make up the multicellular organism, but also their integration into a single living thing. Only sexual reproduction and embryonic development can together generate multicellular offspring.

Of decisive importance for the differentiation of multicellular species and the order of their development is what type of metabolism they have. There are two fundamental options. On the one hand, an organism can metabolize immediately, selectively exchanging material with its immediate environment, and assimilating what it takes in. On the other hand, an organism may be unable to metabolize with what its immediate environment provides. It will instead have to achieve its metabolism through the mediation of factors that are not immediately available, but must be obtained by exertions traversing space and time.

The original minimal organism must be able to secure its metabolism by immediate contact with its environment through the selective semipermeable membrane enclosing its self-renewing chemical processes. This type of immediate metabolism is not limited to unicellular organisms, but can characterize, as we shall see, plant life. On the other hand, unicellular and multicellular organisms can arise that lack the ability of metabolizing through immediate contact with their environment. Such organisms must consequently have the ability to perceive at a distance the nutrients they need, as well as the ability to move themselves to those nutrients, by both desiring those objects and possessing sufficient emotive urge to reach their prey. How these metabolic imperatives distinguish animals from plants is the next topic of philosophical biology.

Metabolism and the Differentiation of Fundamental Life Forms: Lessons from Hans Jonas

Metabolism is a basic life function, which, together with organic unity, precedes reproduction in the development of life. Although viruses may lack metabolism and duplicate themselves, their "reproduction" depends upon invading a cell that has a metabolism of its own and provides the viruses with the genetic material they use in duplicating themselves. On the other hand, many metabolizing organisms are unable or never have a chance to reproduce. Certain hybrids, like mules, are infertile. Of course, many reproducing animals continue living beyond the period when they can reproduce and nurture offspring.

Although metabolism precedes reproduction as a fundamental life process, one might wonder whether an organism can have an autopoeitic organic unity, in which all its constituents are both means and ends, without engaging in a metabolic relation to its environment. Why can a rudimentary cell not carry on its self-renewing chemical reactions and sustain the enclosure that keeps them intact without exchanging material with its biosphere? Why can an organism not exhibit its formative power as a self-organizing being, with organs sustaining one another together with their unity, without relating metabolically to what is other than itself? To do so, an organism would have to create as much energy as it uses and be a living perpetual motion machine, single handedly refuting the laws of thermodynamics. In order to carry on its self-sustaining activity, the living thing must therefore draw from its environment energy as well as materials that it uses but cannot immediately replenish. At the same time, the organism must expel the detritus that accumulates within its complementary functions, impeding rather than contributing to their further operations. In these respects, the organic unity of the living thing is intrinsically connected to its metabolism with its environment. Without metabolizing, an organism must cease its operations, either temporarily, as in the case of spores, or permanently, as in the case of the death that eliminates the active form of life.

Hans Jonas, following in the footsteps of Hegel, shows how plants and animals are fundamentally distinguished by the different ways in which they metabolize.[15]

As Jonas and Hegel both point out, plants are able to metabolize continuously, directly availing of what they need so long as light, air, water, and the minerals dissolved in it, are immediately at hand.[16] This continuous intake of what is materially contiguous is not entirely passive. Plants, like any metabolizing organisms, selectively absorb what they need to survive, thanks to a local sensitivity to those external factors on which nutrition depends. Moreover, plants may respond to the general elements to which the plant is sensitive, growing roots towards moisture, while turning stems and leaves to the sun. These tropisms are localized reactions to the localized sensitivity by which plants selectively interact with their immediate environment.

Animals, by contrast, cannot metabolize with what is immediately present to them. They have no roots to absorb water and mineral nutrients, nor any leaves with which to photosynthesize sunlight. Instead, they must do more than selectively absorb what contacts their body and alter the growth and orientation of particular body parts to exchange energy and material directly and continuously with their biosphere. Because animals cannot satisfy their natural needs with what is materially contiguous, they must sense the remote objects of their need. Moreover, animals must be able to make the effort to move themselves through space and time to obtain those objects they perceive at a distance. Since animals cannot metabolize what they need through immediate contact, they must further act upon what they obtain to make it susceptible of being assimilated. This involves mechanical, physical, and chemical transformations allowing the object of need to be ingested and then digested.[17] Insofar as animals cannot immediately and continuously assimilate what they need from the environment, but must make an intervening effort to obtain nutrition, animals face a recurring gap between unfulfilled need and satisfaction. This gap, which elicits an effort to satisfy natural need, allows for animals to have desires. Plants can have no desires since they confront no spatial or temporal interval between need and its fulfillment, but continuously absorb nutrients contiguous with them.[18] What desire must precipitate is the movement by which the animal transports itself as a whole to where its object of nutrition lies. This is a particular thing, rather than a general element, such as the moisture, air, and sunlight that plants continuously enjoy. The animal's metabolism through that distant object of need is mediated by desire, perception at a distance, and emotive urge to traverse an interval of time and space. More than any plant, an animal cannot always get what it needs and must live in fear of failure.[19]

The Differences in Metabolism and the Order of Evolutionary Development

Does the difference between immediate and mediated metabolism dictate the order in which plants and animals arise? Plants and all other organisms that metabolize immediately can exist without animals.

Admittedly, once animals emerge, plants may evolve that do depend upon animals to fulfill certain life functions. Such is the case of plants that depend upon insects for pollination and for birds for the distribution of seeds. Nonetheless, plants can emerge in a biosphere that has yet to contain animal life.

Animals, like plants, cannot avoid arising from minimal unicellular life forms that metabolize immediately with their environment. The nutrients needed for animals' mediated metabolism may involve inorganic substances, such as air and water, but also other organisms. These can be both organisms, such as plants, that do metabolize immediately, and organisms whose metabolism is mediated by perception, desire, emotion, and motility, that is, other animals. Could, however, animals emerge in a world without plants, where an animal's only source of nutrition, besides inorganic substances, would be other animals? Such a predicament seems to put animals on a road to quick self-extinction, since they would be compelled to consume one another. Differing rates of reproduction would not suffice to guarantee any escape from mutual annihilation, since those animals that propagate most rapidly would only produce more predators to satisfy. Consequently, animals could only arise and have any chance to endure and evolve either after or together with the emergence of plant life. Only with plants on hand can animals achieve their mediated metabolism without undercutting their own survival. This means that at least some, but not all animals must be herbivorous or omnivorous, since only then could some animals survive without consuming other animals. These plant eaters could then be a source of nutrition for omnivorous or carnivorous animals, provided two conditions are met. First, the population of herbivores and omnivores must never be such as to make extinct the plant life on which they depend in whole or part for their nutrition. Secondly, the balance between carnivores and their prey must be such as to allow surviving herbivores and omnivores to reproduce enough to maintain future nutrition for the carnivores, instead of progressively diminishing to the point where carnivore populations collapse. In any event, whether animals come to be after plants evolve or coincidently with their emergence, carnivores cannot arise until herbivores have evolved to provide them with prey.

Since plants need not depend upon animals, whereas animals cannot endure and evolve without plants, plants precede animals in the reality and conception of nature. Philosophical botany must come before philosophical zoology.

The Order of Evolution and the Inevitability of Increasing Biological Complexity

Does evolution inevitably generate increasing biological complexity, progressively producing organisms that have a greater perfection? The very fact that every new species variant builds upon a pre-existing life form suggests that evolution has a cumulative development that necessarily advances to more and more complex organisms. These could be said to be more and more perfect in the manner of Aristotle's ladder of life forms, in which each ascending organism incorporates the life functions of those below it in the order of constitution. On these terms, rational animals bring the development of life to its consummating complexity, adding rational intelligence to the sentience, desire, and motility that brute animals add to the nutrition, growth, and reproductive function of plants.

On a more elementary level, the same impetus to complexity seems entailed in the structural dependence of multicellular life upon single celled organisms. Multicellular organisms can hardly arise until prokaryote cells have merged to produce eukaryotes that have sufficient internal membrane-enclosed organelles to produce differentiated cells capable of uniting into a single integrated organism. The opposite direction of downward genetic drift towards ever simpler organisms seems, by contrast, to be devoid of any inherent ground, especially since life is always resisting the disorganizing pull of entropy.

Similarly, increasing complexity appears mandated by the metabolic dependence of animals upon plants. Since animals can only emerge once plants are at hand, evolution seems to lead inexorably to the greater complexity of animal life, whose existence requires the company of the other fundamental life forms.

Moreover, the accumulation of more and more life functions in the more complex organisms suggests that these provide a greater flexibility and corresponding capability to adapt to the most diverse and challenging environments. This enhanced fitness seems to reach its acme in rational animals, whose universal reason provides unrivalled insight into how to deal with any particular situation. Descartes celebrated this universal instrumentality of human reason in his *Discourse on Method*, where he contrasts it to the fixed particular functionality of machines, to which he reduces animals.[20] It would appear that thanks to the universality of our thought, we have the greatest chance of triumphing in the struggle of existence, giving the most complex of all organisms the final word in natural history. Kant tempered this enthusiasm for the survival prowess of our reason, noting in his *Groundwork of the Metaphysics of Morals* how rational animals may use their reason to undercut their own existence.[21]

If Kant's warning has gained greater weight with the advent of nuclear weapons and the accelerating human impact upon our climate, it does not dispel how all of the alleged tendencies towards complexity reflect how more complex organisms arise from or depend upon less complex organisms. The emergence of "higher", more "developed" life forms does not, of course, eliminate the accompanying persistence of "lower", more "undeveloped" life forms, which continue to flourish. Nor does the succession of ever more complex organisms establish the necessity of this progress. At any juncture, mass extinctions of "higher" life forms are possible. To the extent that the blind contingencies of natural selection determine which new species emerge, whether increasing complexity results is never secure. Nonetheless, to the extent that "higher" forms do emerge, they will be preceded by a cumulative "ascent" that has them as its outcome. This progress will exhibit the structural imperatives of the formation of multicellular life from unicellular organisms, and of animals following upon plants. Still, we may yet turn the world over to "lower" organisms thanks to our own self-destructive prowess.

The Order of Evolution and the Weak and Strong Anthropic Principles

In investigating the order of evolution, we who conduct the inquiry can hardly fail to acknowledge that our evolutionary theory must make intelligible the emergence of rational animals who can know in truth how evolution gives rise to organisms like ourselves. Otherwise, our theory of evolution leaves no possible opportunity for our very engagement in theorizing about evolution.

This consideration is not equivalent to the mandate of the "strong" anthropic principle, which maintains that evolution *must* give rise to rational practitioners of evolutionary science.[22] According to this view, evolution has as its necessary telos the emergence of rational animals such as ourselves. Our emergence in the course of evolution hardly warrants this conclusion. Like every other species, homo sapiens are the product of innumerable contingencies, whose "blind", unintended concatenations have led to our existence with all its physiological idiosyncracies, many of which have little adaptive significance. Indeed, at any moment along the path to our emergence, natural occurrences might have interrupted what followed. Super-volcanic eruptions, meteor collisions, extreme solar eruptions, or deadly disease might all have wiped out the lines of descent from which we happen to have arisen.

From the contingent fact of our own existence, we can, however, look back at evolutionary history and reinterpret it as a process that has led to our emergence. Moreover, we can recognize the general insight that if a science of evolution is to be actually pursued, the universe must house the process by which living beings come to be who can develop that science. These considerations allow for a "weak" anthropic principle that does not maintain that evolution *must* give rise to rational practitioners of evolutionary science, but only that evolution must be able to lead to such a result if the universe is to contain rational animals who theorize about evolution. Although we can testify to the fact of our existence and to the fact of our theorizing about natural evolution, that evolution has produced us still remains a contingent matter. Even if we have come to be, the course of evolutionary development does not have as its necessarily governing telos the arrival at our emergence. Evolution on earth might not have led to homo sapiens and if we obliterate ourselves there is no necessity that what life forms survive will end up giving rise to some other rational animal.

If, however, evolution does give rise to rational animals here on earth or anywhere else in the universe, does natural evolution face an entirely new dynamic? We may be accidents of natural evolution, with only a fragile hold on our own species' endurance. Do we, nonetheless, now have the power to suspend evolution's very operation?

Do Rational Animals Suspend Natural Evolution?

Whatever be the fundamental stages in the evolution of species, is there a turning point, where an organism arises that can withdraw its species from the blind dynamic of natural selection and artificially preserve or shape its own and other species? The likely suspect is a rational animal like ourselves. Our science fiction authors may imagine humans of the future with greatly enlarged heads atop spindly hairless bodies. There is, however, reason to consider our current human natural endowment to be condemned to a relative stasis until we ourselves choose to modify it through selective breeding and genetic engineering.

To remove our species from future selective pressure, we have to insure that hereditary differences not be allowed to dictate whether individuals survive or reproduce. At times, eugenic policies have been implemented to sterilize or exterminate the "less endowed". On the other hand, human institutions have protected those who might not survive on their own due to genetic impairments, allowing them to live and reproduce. To the extent that human communities care for individuals irrespective of their genetic variations, natural selection will be hindered from altering the hereditary endowment of future generations. Rational animals can resist succumbing to a pitiless social Darwinism, where survival and reproduction hinges upon an unrestricted competition in which the less genetically adapted fall by the wayside. Moreover, even if human communities embrace a laissez faire economy, where those in need must fend for themselves in the market place, the outcome will not be a genetically determined selection. This is because the results of unregulated market competition depend more upon social luck and the marketable wealth with which individuals enter the economy than biological inheritance.

Admittedly, incurable diseases that sterilize or kill individuals of a certain genetic makeup may cull a rational animal species. Nonetheless, the selective pressure of most other inheritable factors will depend upon how rational animals decide to care for one another. The result may be a relatively stable species being, awaiting external or self-inflicted extinction.

There is, of course, the other option, which rational animals are uniquely empowered to do. They can shape their future biological development by imposing selective breeding and genetic engineering upon their population. So long as the resulting modifications do not undermine the survival and reproduction of their species, these rational animals may give themselves an artificial evolution.

Several aspects of evolution make such modification possible while limiting its options. As we have seen, any genetic alteration will only be viable if it meets several requirements. First, the results of genetic modification must conform to the systemic complementarity of organic unity. Whatever physiological changes genetic engineering entails must fit together with the complex mutual functioning of the other parts of the organism. Otherwise, the genetic alteration will operate like a cancer that disrupts the self-maintenance of the living thing. Second, the genetic modification must not undermine the ability of the organism to perform successfully its metabolic and reproductive activity in relation to its environment, including the presence of other living things that compete for survival. Admittedly, the efforts of rational animals to use their care and technology to shield themselves from the pressures of natural selection can limit the scope of this second proviso. Nonetheless, genetic modification can only succeed if it maintains the specific range of basic functions that survival and reproduction require.

What facilitates much current technology in genetic modification is the common inheritance that our "tree of life" provides.[23] The enabling genetic commonality is built into evolutionary development insofar as any line of evolutionary descent always operates through cumulative modifications of the inheritance that each new species incorporates from its predecessors. Because we inevitably share much hereditary material with the organisms from which we have descended it is possible to use other related organisms, such as bacteria, to produce altered genes. Thanks to our linked inheritance, we can insert these modified genes into our own cells and have them be "read" by the enclosing cellular environment to produce the proteins and enzymes needed for their viable efficacy. A certain trans-species uniformity of "reading" is secured by the cumulative heritage underlying our descent and presumably that of any other rational animal elsewhere in the universe.

Thanks to the uniformity of basic genetic material and the process of its activation across species linked by descent, genetic engineering can have a broad application.[24] Consequently, rational animals can apply the same tools of selective breeding and genetic engineering to other organisms and artificially direct their evolution. We cannot bring back extinct organisms simply by extracting their DNA from such sources as the amber enclosed insects that sucked the blood of dinosaurs.[25] By itself, DNA cannot produce the proteins and enzymes by which an individual cell can operate, let alone function as a stem cell from which embryonic development can generate an entire multicellular organism. To succeed in our interventions, we must enclose the retrieved and reconstituted DNA within the proper cell environment, as well as within the surrounding living context provided by an egg or ovary, that can activate different parts of the DNA in the complex series of stages by which a new multicellular living thing comes to be. The same holds true of genetically engineered DNA, which can only help generate an entire new organism if we integrate it within the appropriate cellular and multicellular totality.

For this reason, genetic engineering does not generate organisms through a wholly artificial, mechanistic process of manufacture. Rather our genetic modification of ourselves and other life forms must always rely upon the organisms that natural evolution provides.

Whereas our genetic modification of ourselves can take advantage of the conventional suspensions of selective pressures, this does not apply to our genetic engineering of pre-rational organisms. To the extent that we insert them in the wild, their future evolution will depend upon the selective pressures of the natural struggle for survival and reproduction.

Notes

1. Dennett, Daniel C., *Darwin's Dangerous Idea* (New York: Simon & Schuster: 1995), p. 127.
2. Aristotle, *Ethics*, Book I, Chapter 7, 1097b30–1098a17, in *The Complete Works of Aristotle, Volume Two*, p. 1735.

3. Hans Jonas develops all these salient points in the essay, "To Move and to Feel: On the Animal Soul", in Hans Jonas, *The Phenomenon of Life* (Evanston, IL: Northwestern University Press, 2001), pp. 99–107.
4. Aristotle, *Physics*, Book II, Chapter 8, 198b24–199a8, in *The Complete Works of Aristotle – Volume One*, p. 339.
5. Aristotle, *Physics*, Book II, Chapter 8, 199a35–199b4, in *The Complete Works of Aristotle – Volume One*, p. 340.
6. Jonas, *The Phenomenon of Life*, pp. 43–44.
7. Jonas, *The Phenomenon of Life*, pp. 43–44.
8. Jonas, *The Phenomenon of Life*, p. 43.
9. Daniel C. Dennett, *Darwin's Dangerous Idea: Evolution and the Meaning of Life* (New York: Simon & Schuster Paperbacks, 1995), p. 86.
10. Dennett, *Darwin's Dangerous Idea*, p. 86.
11. For a detailed account of pre-linguistic consciousness and self-consciousness, see Richard Dien Winfield, *The Living Mind: From Psyche to Consciousness* (Lantham, MD: Rowman & Littlefield, 2011).
12. Identical twins, as well as offspring of asexual mitosis, may be further individuated due to epigenesis, where environmental factors impact upon both how and when sections of the genetic material are activated, and even alter the genetic material itself.
13. Richard Dawkins, *The Selfish Gene* (Oxford: Oxford University Press, 1976).
14. Dennett, *Darwin's Dangerous Idea*, p. 116.
15. Jonas, *The Phenomenon of Life*, pp. 99–107.
16. Jonas, *The Phenomenon of Life*, p. 102; Hegel, *Philosophy of Nature*, Zusatz to §344, p. 308.
17. Jonas, *The Phenomenon of Life*, p. 103.
18. Jonas, *The Phenomenon of Life*, pp. 101–102.
19. Jonas, *The Phenomenon of Life*, p. 107.
20. Descartes, *Discourse on Method, and Meditations*, trans. Laurence J. LaFleur (Indianapolis: Library of Liberal Arts, 1960), p. 36.
21. Kant, Immanuel, *The Groundwork of the Metaphysic of Morals*, trans., H. J. Paton (New York: Harper & Row, 1964), pp. 62–63.
22. Dennett discusses the "weak" and "strong" anthropic views in *Darwin's Dangerous Idea*, pp. 165–166.
23. See Dennett, *Darwin's Dangerous Idea*, pp. 85–103, for a discussion of this "Tree of Life", and its retrospective character.
24. Dennett makes this point in *Darwin's Dangerous Idea*, p. 114.
25. See Dennett, *Darwin's Dangerous Idea*, p. 114, for an elaboration of this point.

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5

Plant Life

Hegel's Introduction of Plant Life as the First Developed Form of Life

Hegel introduces plant life as the primary developed form of life. He acknowledges the existence of more elementary types of organisms, such as lichens and the slime of algae. These may be alive, but they exhibit only partially and imperfectly what life proper constitutes. Plant life may overcome their limitations, but on Hegel's account, only the emergence of animals will bring life to its full development.

What is the significance of this ranking? Is it akin to Aristotle's ladder of life forms, where every successive step incorporates the life functions to which the prior forms were limited, while adding further dimensions of its own? Under the Aristotelian view, plants are restricted to the function of nutrition, whereas brute animals incorporate that function but add perception, desire, and motility, until finally the highest life form emerges, the rational animal, which incorporates nutrition, perception, desire, and motility, but adds reason. Does the consummation of life in the rational animal confer supreme rank upon us because we exhaustively encompass the possible reach of the life process, which the "lower" forms only partially contain?

R. D. Winfield, *Universal Biology after Aristotle, Kant, and Hegel*,
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Or is the ascent from elementary life forms to plants and then to animals only the contingent ordering of evolutionary development? Does the ranking of types of life simply reflect the blind direction of evolution, which has given rise to plants from elementary life forms and then has generated animals from accidental mutations transforming plants? Or does the temporal sequence of evolutionary development only confirm the structural ranking, since the higher life-forms can only incorporate every function of the lower life-forms if these have already come to be before further mutations can be added?

These questions can only be answered by investigating the fundamental types of life and considering how they stand in relation to one another. Hegel provides us with philosophy's most concerted attempt to comprehend how plant and animal life exhibit what is generic to life, but do so in fundamentally different ways that push the development of nature to closure.

Before we think through Hegel's account of plant life, it is helpful first to consider Aristotle's less developed, but salient examination in his short treatise, *On Plants*. There Aristotle uncovers some fundamental guideposts for conceiving plants in distinction from animals. These will provide a point of departure for Hegel's more encompassing conception.

The Lessons of Aristotle's Account of Plant Life

Aristotle's inquiry into the nature of plants revolves around the connection between life and soul. In *De Anima*, Aristotle maintains that the soul is the principle of life in general,[1] and accordingly plants must possess soul to qualify as living organisms. This presents a puzzle, for whereas soul is clearly manifest in animals, in plants soul is hardly evident and hidden at best.[2] Whereas animals plainly exhibit such psychological features as sensation, desire, and pleasure and pain, plants seem to lack all of these. To confirm the presence of life in plants, Aristotle must establish that plants nonetheless possess a soul in some respect.

Earlier thinkers, such as Anaxagoras and Empedocles, were ready to attribute sensation, desire, and joy and sadness to plants, and to attest the presence of soul in plants by maintaining that they breathe, sleep, and have sex. In the *Timaeus* 77 AC, Plato, Aristotle notes, declared plants to feel desire simply because of their need of nutriments.[3] If we grant desire to plants, we must also grant that they have sensation as well as pleasure and pain. These all go together since desire aims at what an organism senses it lacks, and pleasure and pain follow according to whether desire is satisfied or frustrated.

Aristotle does connect nutrition with the presence of the nutritive soul and is willing to attribute this aspect of the soul to plants. Nutrition is basic to life, constituting the fundamental process of metabolism. Aristotle also acknowledges that plants grow and reproduce, sharing these further life processes. What Aristotle will not attribute to plants and the soul specific to plant life are sensation, desire, and pain and pleasure, nor the foresight and intelligence that higher animals possess. Plants, as alive, have soul, but their soul is restricted to the process of nutrition, leaving the plant soul an imperfect psyche in comparison to the more perfected psyche of animal life, which adds sensation, desire, emotion, and eventually theoretical and practical reason to the repertoire of its mind.

If we think back on Jonas' account of metabolism[4] we can locate aspects that give Aristotle some support for ascribing "soul" to the nutritive process that plants share with any living organism. The organism has a "needful freedom". Its metabolism liberates it from identification with any material, since the organism must exchange material with its environment in order to maintain itself and the ongoing metabolic process on which its life depends. The organism must, however, continually excrete and ingest certain types of material in order to survive. In so doing, the metabolic process operates in terms of a division between interior and exterior. The interior is not simply a spatially defined domain, like the interior of a crystal. The inside of the organism is rather an active process that sustains itself by relating to its environment and assimilating what lies beyond. Through this process a self sustains itself, differentiating itself from its externality and using factors in its environment for its own sake. This is a needful process and it requires a sensitivity to the environment in order to discriminate between what factors the organism must appropriate and those that it need not. To carry on its metabolism, the organism must have both a discriminating sensitivity and a discriminating responsiveness so that it can engage in the assimilation that nutrition involves.

Plants do have sensitivity and irritability like any other organism. Aristotle recognizes, however, that this minimal selfhood does not involve sensation proper, nor desire, nor pain and pleasure. Need is one thing. Desire is another. Desire directs itself at an object of need that an organism both lacks and perceives itself to lack. Only with a receptivity to unfulfilled need can an organism register the satisfaction or lack of satisfaction of desire and feel pain or pleasure. Further, only if the organism has the means to perceive the object of desire it lacks and then make an effort to fulfill its desire can it have the urge to take whatever action its desire satisfaction requires.

As Aristotle recognizes, sensation, desire, and pain and pleasure address not just nutriments, but also objects of sexual desire. Where sexual reproduction operates by means of some reproductive act on the part of sexual partners, it depends upon a receptivity to the presence of the other gender and a sexual responsiveness to this sexual stimulation. All this involves a recognition of the sexual object, a sexual desire, and the pain or pleasure following from the frustration or satisfaction of that desire. If we acknowledge that plants assimilate nutrients and that at least some reproduce sexually, but have neither sensation, desire, nor pain and pleasure, we must somehow conceive how these life processes can operate in plants with only what Aristotle calls a "nutritive soul", restricted to the rudimentary selfhood of the metabolic process.

A similar challenge applies to two other life processes that some might attribute to plants, but whose attribution Aristotle questions: respiration and sleep. Terrestrial plants may absorb carbon dioxide and expel oxygen, but does this involve the effort that respiration involves as an activity of the organism? Respiration is an activity of multicellular organs and not just the passage of gases through an individual cell membrane. Analogously, plants do enter a different state at nighttime, closing flowers and refraining from orienting leaves and stems as towards daylight. Do this mean that plants sleep and awaken? The distinction between sleep and wakefulness, which Aristotle addresses in his short treatise *On Sleep*,[5] is associated with different levels of sentient awareness. Sleep is not just a vegetative state, where sentience is completely absent. Far from being deprived of all sensation and imagination, the sleeping individual may dream and have dream content influenced by what the sleeper is dimly sensing while asleep, as well as be woken by strong sense stimuli. Although Aristotle does not refer to the distinction between conscious and unconscious states of mind, if one characterizes sleep as an unconscious phase, it is still not a vegetative state since it contains a certain, albeit limited degree of sentience and a very active dream work imagination. As Aristotle notes, "Sleeping is an enfeebled condition of sensation, and nothing of this kind is found in that which vegetates at all times in the same condition, and is itself naturally without sensation."[6]

Aristotle thus refuses to attribute sleep to plants for the same reason he refuses to attribute feeling and emotion to plant life. Plants have no sensation and thus have no desire, which depends upon sensation of the object of desire.[7] Moreover, plants have no power of locomotion, which desire satisfaction requires to the extent that the desired object is at a distance. All this is evident since "in plants we do not find sensation nor any organ of sensation, nor any semblance of it, nor any definite form or capacity to pursue objects, nor movement or means of approach to any object perceived, nor any sign whereby we may judge that they possess sense-perception corresponding to the signs by which we know that they receive nutriment and grow."[8]

Nonetheless, plants are sensitive to light and orient their stems and leaves to face the sun, just as plants are sensitive to moisture and grow their roots towards sources of water. They have both sensitivity and irritability, like any organism. They undergo change to metabolize, but, as Aristotle maintains, they do not have the power to move themselves as a whole and achieve locomotion. When a Venus Fly Trap closes its lidded leaves in response to the stimuli of contact with its prey, it immediately reacts but does not move to a different location to reach a perceived object of desire. The Venus Fly Trap instead exercises a local tropic response tied to the local sensitivity to the contiguity of its unfortunate fly. The Venus Fly Trap does not do anything to seek out its prey as a distinct object. Instead, the fly comes to it, makes contact, and the Venus Fly Trap responds. For Aristotle, this involves no sensation, desire, effort, or locomotion, but only the metabolic activity of the nutritive soul.

The "imperfection" of the plant soul applies not just to be absence of sensation, desire, and the corresponding endowments of sense organs and capacities for locomotion, but also to the indefinite character of the form of plants. Aristotle does not deny that plants have distinct parts. In Chapter 3 of Book I of *On Plants* he notes how "the bark of a plant resembles the skin of an animal, while the root of the plant is like the mouth of an animal, and its fibres are like an animal's sinews."[9] Aristotle points out, however, that plants shed their parts without detriment and grow an indeterminate number of leaves, stems, and roots.[10] Plant growth involves an indefinite proliferation whereas animal growth does not just duplicate already existing appendages. The animal grows as a whole, which may involve the total form transformations of metamorphosis. The plant parts do possess the complementary functionality basic to the organs of a living thing, but their number is indeterminate. In other words, the plant soul exhibits an imperfection in not determining in an exhaustive way how the plant is internally differentiated. The plant has "only part of a soul"[11] and this is reflected in the indefiniteness of the plant's organic unity.

This indefiniteness is further manifest in how plant metabolism occurs through an immediate process of composition, without the stages characterizing animal digestion. The plant engages in a continuous, uninterrupted feeding that absorbs light, water, and nutrients directly.[12] Whereas animal digestion requires an interconnected system of organs carrying out specific functions that successively break down and absorb food, the immediate absorptions of plant metabolism can operate without any definite number of plant parts. In animals the acquisition of food, its preparation for ingestion, and its subsequent passage through the digestive system are accompanied by sensation, which guides the effort involved in hunting and eating. In plants, by contrast, nutrition can and does proceed without any sensation. Sensitivity to light and moisture may be present, but the plant does not sense its surroundings, unifying its local sensitivities into a single field of sentience, with which a unified bodily control can operate.

Given the absence of sensation and desire in plants, Aristotle cannot acknowledge any proper sexual reproduction in plant life. He does recognize a kind of mingling of male and female in plant reproduction, but this does not involve any sexual acts performed by male or female plants.[13] Instead, the seed arises after a pollination depending upon wind or insects or birds.

Due to its imperfect soul, the plant cannot develop modes of behavior. Plants do have tropic responses and local sensitivities. Nonetheless, as Aristotle notes, "plants have no fixed habits, nor the power of action possessed by animals".[14] Here, where sensation, desire, and locomotion provide a basis for habit and action, we reach the boundary at which life leaves its plant form behind.

Aristotle's account of plants sets in relief essential features of this fundamental shape of life and Hegel will build upon them to provide a unified philosophical botany.

The Incomplete Subjectivity of Plant Life

Hegel opens his examination of plant life by focusing on the type of subjectivity distinguishing plants from other life forms.[15] Plant life, like all life forms, involves the basic subjectivity by which an organism exists as something singular, pursuing its self-centered metabolism. Moreover, plants have an articulated shape, with distinct parts that exhibit the complementary functionality of organs. These aspects are generic to life, but Hegel maintains that plant life presents the first, immediate stage of subjective vitality.[16] This immediacy shows itself in how the objective organism of the plant is immediately identical with its subjectivity.[17] To help clarify this identity, Hegel points out, by way of anticipation, that the animal organism does not have an immediate identity between its objective being and its subjectivity. The subjectivity of the animal is not submerged in its physiological functioning, but instead has a distinguished being of its own to which Hegel applies the term, "soul".[18] Insofar as the animal organism has soul, it brings into nature the first realization of mind. Accordingly, Hegel has put upon himself the task of demonstrating how the immediate identity of objective organism and subjectivity precludes plants from having any mental life, which is so manifest in the perception, desire, emotion, and motility that will distinguish animals.

This looming differentiation of plants and animals represents a fundamental break with Aristotle. As we have seen, in *De Anima*, Aristotle identifies the soul as the active form of life as such.[19] Anything alive must therefore have an animating subjectivity to which Aristotle seems to confer a minimal form of mind. He thus attributes a nutritive *soul* to plants, as if mind were at hand in the metabolic process basic to every organism.

Hegel, by contrast, attributes soul and mind in general to animal life, but not to plants or any more elementary life forms. We will see how the distinct subjective unity and mediated metabolism of animal life calls for perception at a distance, desire, emotion, and centrally directed motility, making animals ineluctably possessed of mind. Our task here, however, is to understand how plant life gives the fundamental organic processes a form that is incompatible with the life of the mind.

To understand the mindless vitality of plant life it serves us well to explore what Hegel means by the immediate identity between the subjectivity and objective organism of plants. Hegel explains that this characteristic immediate identity is exhibited first and foremost in how the plant differentiates itself into distinct parts. Although a plant exhibits the complementary functionality of parts generic to organic unity, it does so in a particular manner that is fundamentally different from that of animals. The organic unity of the plant is such that, as Hegel puts it, the plant "comes forth from itself and falls apart into a number of individuals".[20] These individuals are not literally detached from the plant organism, but constitute parts that can each develop into whole organisms of their own if they are separated and allowed to root themselves. Roots, stems, and leaves, the characteristic plant parts, do each perform complementary functions on which the life of the whole plant depends. Nonetheless, each one can be separated and planted so as to turn into a new plant with its own roots, stems, and leaves. Thereby, the whole plant is more like a provident ground for such separable individuals than a subjective unity of organs, which can subsist only by remaining part of the whole within which they grow and function. Similarly, since each one of the different plant parts can become an entire plant, their differentiation is more like a stage of metamorphosis, awaiting transformation into a whole new seedling.

Moreover, as the plant grows, it proliferates new roots, new stems, and new leaves. Unlike an animal, that ordinarily grows by increasing in size while retaining the same number of organs and appendages, the plant "comes forth from itself" into an indeterminate number of parts. This indeterminacy reflects how the unity of the plant has a certain incompleteness, leaving undetermined how many parts it can have. Any number can be lost without destroying the vitality of the plant. By contrast, the unity of the animal dictates which and how many organs and appendages it has. Each part has a unique indispensability, which would not be the case, if an animal, like a plant, could indefinitely produce new organs and appendages of the same type. Not only can a plant shed many of its different parts and still survive, but these separated parts can develop into new plants of their own under the proper circumstances.

This relative independency of the parts to the whole is further reflected in how the plant functions with respect to the sensitivity and responsiveness generic to living organisms. On the one hand, each part of the plant has its own specific sensitivity to the particular environmental factors on which plant sustenance relies. Roots are sensitive to moisture, whereas stems and leaves are sensitive to the orientation of light on which photosynthesis depends. On the other hand, each plant part responds separately and locally to those factors to which it is sensitive. Roots grow towards moisture, whereas stems and leaves grow and orient themselves to receive as much sunlight as possible. Plants thereby exhibit tropisms, local movements of separate parts allowing them to best position themselves while the plant as a whole remains rooted in place. Thus, as Hegel notes, all the flowers in a field will be pointed towards the sun and slowly change their orientation to follow it as it rises and sets, whereas at night, flowers and leaves will close, only to reopen after day break.[21] Moreover, these tropic movements are automatic local responses to local stimuli, rather than optional improvisations, like those of many animal predators. As we have noted, the Venus Fly Trap, for example, cannot choose when to close its entrapping leaves upon an insect, but does so the moment its prey lands on their gaping interior.

These local forms of sensitivity and responsiveness or irritability perfectly fit both the incomplete subjectivity of the plant organism and the immediate metabolism characterizing plants. Insofar as the plant grows by producing an indefinite number of parts, each of which is dispensable and potentially independent, it must be able to carry on its life functions in a decentralized, isolated manner. This is achieved through local sensitivity and irritability, which can operate no matter how many parts are present and whether they are connected or separated into new plantings.

If instead the sensitivity and irritability of the plant required a fixed number of organs to function, the incomplete subjectivity of the plant would doom it to extinction by failing to guarantee provision of what such concrete unity needs. Similarly, to the extent that plants can metabolize with what is immediately contiguous with their own surfaces, a dispersed local sensitivity and responsiveness can suffice to carry on the material exchange of the plant with its environment. If instead metabolism depended upon the unified coordination of the sensitivity and irritability of the whole organism, tropic reaction could never enable the organism to survive.

As we shall see, animals have a very different organic unity, reflected in very different types of sensitivity and irritability, as well as in a very different form of metabolism. All of these factors will be intimately connected in comprising the specific type of subjectivity pervading the animal organism. Unlike plants, animals will have a centralized sensitivity and bodily control, requiring such physiological modifications as a rigid skeleton or exoskeleton, a musculature, and a central nervous system. Instead of local sensitivity, the animal will have feelings and sentience, just as, instead of reacting with local tropisms, the animal will move itself as a whole from one place to another and engage in centrally coordinated activities of feeding and reproduction. Feelings, unlike local sensitivities, are felt by the same self, just as perceptions integrate themselves into a unified horizon of awareness by which the animal self apprehends its opposing environment as a whole.

By contrast, the different parts of the plant will immediately be sensitive to and respond to the various nutritionally relevant factors that stimulate localities on its surface. These local sensitivities and reactions are not integrated by any central bastion of the plant self, but remain decentralized. What is lacking in the incomplete subjectivity of the plant is, on the one hand, a feeling and perceiving self, for which all sensitivities are united into a single awareness of the world at large, and secondly, a central unified agency with which the organism can respond as a whole to what it feels and perceives. These "theoretical" and "practical" attitudes of mind are absent in the plant organism owing to the specific way in which parts and whole fit together in its immediate life processes.

The subjectivity of the plant, consisting in its ongoing self-maintenance, is immediately immersed in its objectivity precisely because sensitivity and irritability are dispersed in its relatively independent parts, without any centralized detachment by which the self could act upon its embodiment as a whole. This absence of a centralized subjectivity is not equivalent to the absence of a particular organ, such as a brain. Although the animal subjectivity will require specific types of internal systems, the mind pervades the organism as a whole and depends upon its entire functioning in order to operate. The plant lacks this pervasive, yet centralized subjectivity, which is why it can neither sense its environment as a unified objectivity nor move itself as a whole. As Hegel observes, the parts of the plant are only in relation to one another and not to the whole, whereas in an animal, the centralized subjectivity relates to itself in every one of its organs that it can feel, sense, or move.[22] Unable to perceive its whole environment or pursue what it apprehends at a distance, the plant rather depends upon what is directly at hand, for which its immediate form of metabolism is suited.

Nonetheless, the plant still has subjectivity, at work in the self-centered self-preservation of the organism. The form of its immediate dispersal in the plant provides the key to the distinguishing configuration of plant life. Hegel, like Kant before him, points out how each part of the plant is like the plant as a whole.[23] This is exhibited in how each part shows itself to be the whole plant in being detachable and able to develop into an independent plant of the same kind. In this respect, as Hegel further notes, the differentiation of plant parts is only formal, for each part incipiently contains all the parts in itself and is not intrinsically needed for the survival of the plant to which it belongs.[24] A plant can live on with or without any one of its roots, stems, and leaves, just as these can forge a separate life of their own under suitable conditions. One can thus think of the plant as being a collection of individuals, where the incomplete subjectivity of the plant fails to fully subordinate its parts. The plant, unlike the animal, is virtually a conglomeration of individuals. To reiterate these ramifications, Hegel cites Goethe, who writes in *Zur Morphologie*, "The more imperfect a creature is, the more do the parts resemble each other, and the more are they like the whole. The more the parts resemble each other, the less they are subordinate to each other."[25]

The growth of the plant manifests these aspects explicitly. As Hegel notes, the plant grows not by assimilating external factors into its abiding active form, increasing in size like a growing animal. Rather, the plant grows by multiplying itself in a "going-forth-from-itself", where additional parts proliferate with quantitative indifference.[26]

Plant growth can also directly exhibit how each part is the whole. Not only can plant parts be separated and grow into whole independent plants, but a plant can be uprooted and replanted upside down, with the result that the plant sends out new roots from its former top and new stems and leaves from its former bottom.[27] Through these metamorphoses the differentiation of plant parts shows its superficiality. Each part may be distinct from its counterparts, but this is just as much a transient phase that can be supplanted insofar as each part can assume the function of the others if it needs to, as well as become a new plant with all its defining parts. The aspect of metamorphosis should not, however, be overemphasized. Hegel criticizes Goethe for so doing.[28] Admittedly, Hegel acknowledges, the parts of the plant are almost like stages in a process where each part becomes the whole. Nonetheless, the plant always has these different parts simultaneously. They are not just diachronic phases, but synchronic organs as well. Even when any part becomes the whole, the whole it becomes contains all the different parts in complementary functional connection to one another. The plant is not just a leaf, or just a root, or just a stem, even though the leaf can become a stem and root, and so forth. The differentiation of parts is a constant, despite how relatively independent the parts may be.

This combination of part and virtual individual distinguishes the internal structure of the plant from that of animals. Hegel points out the decisive difference in contrasting the parts of a plant with the viscera of an animal.[29] The viscera consist of different organs, each functioning in complement to its counterparts under a fixed numerical relation. This fixity is reflected in how the growth of the organism does not multiply indefinitely its organs, but instead involves a progressive enlargement of the animal, along with metamorphoses that may occur beyond the embryonic stage. As Hegel notes, any such metamorphoses involve transformations of the animal as a whole, rather than the addition of more of the same parts.[30] As an animal grows it does not acquire additional hearts, brains, limbs, ears, or eyes. Instead, its total form expands or undergoes a total form change. Moreover, each organ can only survive in unity with the others within the animal organism, just as that organism cannot survive losing any organs, except those that are vestigial or can have their functions compensated by others. No organ of the viscera can turn into a whole animal, although special stem cells may reincarnate embryonic development under artificial conditions engineered externally by rational animals. By contrast, the parts of a plant have no fixed number since they can each be detached and develop into a separate whole plant without killing the organism to which they originally belonged. By the same token, the growth of the plant is not an enlargement maintaining the same concrete form, but rather a self-multiplication, where parts proliferate indefinitely. Admittedly, as Hegel acknowledges, plant structure tends to involve numerical patterns, where each stem may have a specific number of leaves and a flower may have a fixed number of petals.[31] Nonetheless, the plant grows by falling asunder into more roots, more stems, and more flowers, together with a multiplication of the patterns they may incorporate. This indefinite proliferation still operates under the limitations imposed by the mutual functions of the different parts. A plant cannot grow more and more stems and leaves unless it simultaneously grows sufficiently more roots to meet the increased nutritional needs of the self-multiplied organism.

Hegel encapsulates these contrasts in terms of different relations of parts to one another and to the whole organism. In the plant, the parts are particular only in relation to each other, but not in relation to the whole. By contrast, in the animal the parts are particular not just in relation to each other, but also in relation to the whole.[32] The plant parts cannot be particular in respect to the whole insofar as each part is at least implicitly the whole. This is why Hegel can state that in the plant the particularity of its structure is immediately identical with the plant's vitality in general.[33] Or, as he put it at the very opening of his account of plant life, the objective organism is identical to its subjectivity.[34] The subjectivity of the animal has no such identity with its particularity, for none of its organs can be or become the whole animal. They are subordinated to the concrete animal subjectivity, whose unity specifies them both qualitatively and quantitatively.

The relation of particularity and whole in plant life has a further ramification for the relation of growth and reproduction, which Kant recognized, but seemed to attribute to life in general. Because the growth of the plant is self-multiplication, a coming forth from itself and falling apart into a number of individuals,[35] the process of formation of a singular individual coincides with the process of the genus.[36] Growth and reproduction go together in plant life insofar as the addition of plant parts is incipiently a generation of new individual plants. Plant growth is in this way the perennial production of individual plants.

Nonetheless, it is an exaggeration to suggest that plant reproduction *entirely* coincides with plant growth. As we shall see, Hegel acknowledges this and examines how there is a plant reproduction that is distinctly different from the growth of the individual plant. Some plants, like the Kolkata Botanical Garden banyan tree, proliferate until they cover an entire park, with branches sending shafts down into the soil as roots from which new trunks arise. Other plants, however, do reproduce and some will do so in a sexual manner.

Still, plant reproduction does not achieve the decisive break that separates animal growth from animal reproduction. Hegel will maintain that even sexual reproduction in plant life has a superficiality distinguishing it from its counterpart in the animal world. We will have to explore to what extent that claim holds up.

The unity of the plant has further implications for its distinction from an animal. With the subjectivity of the plant immediately immersed in its organism, plants are incapable of doing two things that depend upon a subjectivity standing apart from and in relation to its entire objectivity. First, the plant cannot freely determine its place and move itself as a whole from one location to another. Second, the plant cannot be for itself, cannot stand in self-relation in its totality over and against its environment. Lacking a pure self-like unity distinguishable from its parts, the plant cannot be objective to itself. A plant may be locally sensitive and respond tropically, but it cannot relate to itself as a whole, either theoretically, as self-feeling and sentient, or practically, as self-controlling.[37] The particular plant parts relate to one another in functional terms, root to stem and leaf, stem to root and leaf, leaf to stem and root. Nowhere in the life process of the plant, however, does the whole plant relate to itself. If it did, the plant would feel like an animal feels, feeling all of itself as its feeling pervades its entire organism. The plant, although both sensitive and irritable, cannot be self-feeling and sentient because its selfhood is directly immersed and dispersed in its parts. With their relative independence, these parts are incompatible with any centralized sensitivity and any centralized responsiveness. Each is locally organized and complementary, but nowhere in the plant is there a single agency that can unite all its sensitivities into one standpoint and enable its "body" to act as a whole.

The Basic Life Process of Plants

The incomplete subjectivity of the plant has its complement in a type of metabolism that can operate with no greater unity than the plant organism provides. Hegel delineates the basic features that distinguish the metabolic activity of plant life, enabling us to comprehend how plants can survive without minds and how plants relate to their environment in a way that renders them mindless.

First, Hegel points out that the nutrition of a plant proceeds not as an interrupted process but in a continuous flow.[38] The plant metabolizes continuously so long as its nutritive factors are in contact with its surface. In so metabolizing what is immediately present to it, the plant does not relate to individual things scattered across the biosphere. Instead, as Hegel notes, the plant relates to universal elements.[39] Plant life on earth, Hegel recognizes, depends upon air, water, and light. Although these are not identical to the states of matter (e.g. liquid, solid, gas, and plasma), Hegel's reference to elements properly signifies that plants take in certain physical factors as generally available, rather than seeking after individual nutrients at some particular location in space time. Unlike animals that quench their thirst by taking a sip after arriving at a water source, plants soak up water through their roots continuously so long as water is in the soil and the plant has not completely saturated itself to preclude further absorption. Similarly, plants take in sunlight for photosynthesis for as long as the sun is shining. By contrast, animals must find food where and whenever they can perceive it and then move to obtain it. Only then can the animal prepare the food for ingestion and subsequently engage in a digestive process. Plants have no separate intermittent digestive process, for plants' continuous absorption of light, air, and water is uninterruptedly accompanied by the transformative assimilation provided by ongoing photosynthesis or its extraterrestrial analogue.

On Hegel's account, the metabolic relation of plants to light is of key importance to the limited subjectivity of plant life. Hegel describes plants' relation to light as being akin to a relation to an external self.[40] The plant contains no self residing within it in any distinction from its immediate objectivity, as animal life will show itself to have in being pervaded by the centralized sentience, desire, emotion, and motility control of mind. Nonetheless, light operates as a veritable controlling self that lies outside the entire plant. Sunlight draws the plant to it as a force that cannot be resisted, not as some inertial external impact or magnetic attraction, but by instigating the localized tropic irritability by which the plant responds to its biosphere in function of the plant's own self-sustaining nature. Earlier in the physical account of light, Hegel had attributed a self-like character to light insofar as light enabled physical bodies to reveal themselves in the ideal form of illumination.[41] Here, in philosophical botany, light acts as a kind of self for the plant by doing much more than simply illuminate it. To an important degree, light directs the plant to grow and to orient itself to the light it needs to metabolize. Unlike an animal, the plant does not have its own unified control over its response to its environment. Nor do plants feel or see light, for they lack the centrally unified sensitivity constitutive of the sentient mind that feels and perceives. On both accounts, the plant has its metabolism controlled by something outside itself to which it tropically responds in function of its own botanical character.

Can there be plants without light or plants that do not respond to light? Is there something fundamentally different in how a plant reacts to light compared to how it reacts to other sources of nutrition, such as air and water? Can there be plants that do not engage in photosynthesis, but instead achieve an immediate metabolism drawing upon other sources of energy, such as thermal or chemical energy? A universal biology must not confine itself to the predominant conditions of plant life on our lonely planet. Admittedly, our terrestrial configurations of life forms must exhibit the generic options that distinguish plants and animals, but we must distinguish between what is contingent and what is inherent in the development of plant life. Our atmosphere and bodies of water may provide factors essential to plant life, but this does not preclude atmospheres and oceans of other chemical compositions from providing biospheres for different types of plants and animals. Admittedly, in any solar system with a biosphere, sunlight may be the most available source of energy with which life, and plant life in particular, can emerge and survive. Nonetheless, it is not impossible for remote planets to contain volcanically and magnetically heated seas below their frozen crusts, enabling life forms to develop with both immediate and mediated metabolisms despite the absence of light.

Hegel, however, sticks to our earthly conditions in developing the fundamental features of plant life and our task is to see to what extent he uncovers what is generic to plants. In the *Republic*, Socrates spoke of the sun as what provides for the being of what is and allows life to exist.[42] Without its light, plants could not survive. Light is one of several inorganic factors upon which plant life subsists. Animals may also require inorganic factors like air and water to survive, but they must complete their metabolism by consuming organic things, like plants and other animals. Plants, however, can do what animals cannot, namely, assimilate nothing other than inorganic materials and transform them into constituents of a living being. Photosynthesis is one way by which organisms can harness inanimate energy and matter and enliven them. If we consider it as an example of a generic requirement for the immediate metabolism of plants, then we can also acknowledge that other forms of energy could play an analogous role to light. Whether the needed energy is thermal or chemical, the plant would still have to grow and orient itself towards its external source, which would play the role of what Hegel has described as an outer self, an external controller of the plant's irritability.

One further feature that Hegel suggests is characteristic of the mindless limitations of plant life is the absence of an internal generation of regulated heat and sound.[43] Warm-blooded animals have the capability of producing and sustaining a level of body heat, and many, if not all animals seem to be capable of producing sounds from within. Plants lack these internal generations of vibration and of alterations of cohesion through molecular kinetic energy. Although plants may maintain internal temperatures different from external readings, this is due to the insulation of their cellular material, rather than to heat generation. Why is it that plants lack these capabilities? The answer is to be found in examining how plants and animals are structured and how their life processes proceed.

The Process of Formation in Plants

The specific character of plants is exhibited in all three dimensions of the life process: organic unity, metabolism, and reproduction. Hegel provides a detailed investigation of how each of these life processes takes on a distinctively botanical character and in so doing he shows how the relation between these three processes in plants has a character very different from that found in animals.

Hegel begins addressing the life processes of plants by turning first to what he calls the "process of formation", from which he next considers the metabolic process of assimilation, and concludes with the genus process of reproduction. The order of treatment follows what applies to the consideration of life in general. The process of formation, which involves organic unity or the internal composition of the living thing, comes first since the metabolic relation of the organism to its biosphere presupposes and incorporates the living thing as it is internally organized. The genus process comes after the process of assimilation, since reproduction presupposes and incorporates the self-sustaining living thing from which others of the same kind are to be generated. As we shall see, these three life processes end up being intertwined in plant life to a degree that separates plants from animals.

Hegel develops the plant process of formation as the process of the plant in relation to itself.[44] The organic unity of plants is not an external arrangement of given parts, but rather the internal self-formative process of the plant as, to paraphrase Kant, a self-organized entity. The plant, considered in itself, is not a fixed entity, like a crystal, but rather a self-active living thing, whose form and matter cannot be extricated from one another.

By contrast, Hegel develops the plant process of assimilation as the active relation the plant has to its biosphere, sustaining itself by taking in and transforming inorganic material. Plant life here relates specifically to inorganic nature, with the few exceptions of carnivorous plants that accompany their immediate, elemental metabolism with the digestion of small animals. Plants will become the fodder of herbivorous and omnivorous animals, who, like carnivores, must find organic material to survive. This relation of plant and animal metabolisms will depend upon plant life's own distinctive interaction with its biosphere. Life, to begin with, must have a metabolism that consists in a relation between the living organism and what is not alive. The first life form must be able to survive solely upon inorganic material. Only once such a life form establishes itself, can other organisms arise whose metabolism need not depend exclusively upon inorganic elements, but can and need also assimilate other living things. The phylogenetic priority of plants over animals lies in this situation.

Finally, Hegel considers plant reproduction as a specific type of genus process, where, once more, what lies at stake is an internally determined generative activity transcending mere physical or chemical process. Plant reproduction will show itself to be fundamentally different from animal reproduction and also in a very different relationship to the other fundamental life processes.

Early in Hegel's development of plant life, he points out that the specific character of plant organic unity, metabolism, and reproduction undercuts the possibility of keeping these life processes discretely apart.[45] Each one shows itself to contain aspects of the others. Seeing how this is true will be crucial for grasping what is distinctive about plant life's realization of the processes generic to life.

Hegel begins addressing the plant process of formation by characterizing the inner organization of the plant as involving a relation to itself that immediately relates the plant to the outer world. The internal constitution of the plant organism is equally an externalization.[46] How is this the case? How can the internal operations of the plant be immediately a relation to the outer world through an externalization? This seems to suggest that the organic unity of the plant is just as much a metabolic process between the plant and its biosphere.

To some extent this entanglement of organic unity with metabolism might seem to be a feature of life in general. The internal process by which the parts of the organism exhibit a mutual functionality upholding the organism and one another seems to have to involve a metabolic process since the organism cannot subsist without assimilating external material and energy from its biosphere. Is the distinction of organic unity and metabolism only a nominal one, existing in our thought but not in nature? Admittedly, the organism may not survive without metabolizing, but this does not preclude a real difference between the internal process of the organism and the specific interaction constituting its metabolic relation to its environment. What is distinctive about the inner formative process of the plant is that its organic unity has an immediate connection with metabolism that is not to be found in animal life. Recognizing this difference will illuminate how the internal relation of the living thing is something different from its relation to its environment, even if these functions are interrelated.

One might think that the special connection between inner self-relation and externalization in plants has to do with how plants continuously take in the "elements" their nutrition requires. By contrast, animals will only intermittently perceive and move themselves to obtain the water and food they need. Indeed, sleep will be a common feature of animal life, involving a complete cessation of the mediated metabolic activity distinguishing animals. Admittedly, animals will continuously breathe the air they need and the circulation of oxygen and nutrients throughout the body will continue. Still, plants will immediately and continuously metabolize so long as the elements they need are in direct contact with the surface of some plant part.

Hegel, however, has in mind another feature of the organic unity of the plant that concerns how plant parts sustain one another by proliferating new roots, stems, and leaves. Thereby, as Hegel intones, the plant is at one with itself by externalizing, by coming forth from itself, falling apart into new extensions of itself that are virtual individuals.[47]

Plant structure directly exhibits this aspect. As Hegel repeatedly points out, the plant has no viscera properly speaking.[48] Unlike animals, whose organs are within the body and retain their number as the animal grows, plants have parts that are external to one another, where roots proliferate underneath the stem, just as leaves sprout from out of the stem. None of these parts subsist together within the plant. Unlike viscera that are contained inside the animal body, each plant part is in immediate contact with the environment. This is what allows each part to potentially grow into a whole plant. Whereas viscera cannot extract themselves from the animal interior and achieve any independence, plant parts can be broken off and, in the proper conditions, achieve a separate existence as an integral plant. Plants do not have an internal stomach, on whose digestive process all parts subsist.[49] Instead, plant metabolism has as Hegel observes, a simple, almost chemical character, where external elements make contact with different parts of the plant and undergo a reactive transformation devoid of any process, such as digestion entails.[50] Each plant part carries out its aspect of metabolism separately. Roots absorb water and soluble nutrients, leaves absorb light and photosynthesize products, and the stem supports the leaves so that light can reach them, while transmitting what the roots absorb and what the leaves produce to all parts of the plant. The different plant parts carry out their functions by being outside one another in direct contact with what is external. As Hegel remarks, unlike an animal, the plant lacks the inwardness which can be free from relationship to the external biosphere.[51]

This is evident in the two sides of the plant's internal differentiation that Hegel delineates.

On the one hand, there is the differentiation of parts. Essentially, this involves the distinction between leaf and root, which in immediate connection can carry on the metabolism on which the plant depends. There can also be a mediating part, a stem that intercedes between roots and leaves. Stems, however, are not necessary, and among the plants on our lonely planet there are many in which leaves sprout directly atop the roots, such as grasses, lettuce, and certain palm trees.

On the other hand, there is the externalization accompanying this structural differentiation. The leaf is in direct contact with the air and sun, photosynthesizing and taking in carbon dioxide and giving off oxygen. The roots are taking in water and other soluble nutrients, while microbes on their surface fix nitrogen. The distinction of these two essential plant parts is immediately a distinction of metabolic interactions with the environment which together sustain the whole organism. In connecting with one another, roots and leaves are just as much making contact with what lies outside the plant.

There is something more, however, that enters into the internal structure of the plant, which consummates plant metabolism. This is what Hegel identifies as the sap, into which the metabolic process transforms what it assimilates.[52] The sap circulates in the plant, sometimes by means of a vascular system of tubes that connect roots and leaves through the stem. The sap is a plant analog of blood, circulating so as to allow the multicellular plant organism to nourish all its parts. Somehow what is drawn up by the roots and what is produced in the leaves, thanks to chlorophyll and photosynthesis, must get back to every cell in the plant organism, which is to say that some internal circulation must occur.

This inner process may not proceed in direct contact with the environment, but it still fundamentally differs from how circulation occurs in the animal organism. The animal has viscera functioning inside the body without immediate contact with the external biosphere. Their process is not directly connected to the outer environment, but proceeds internally and requires a circulation between all the viscera, as well as with the surrounding physiological structures that give the animal its sentient and mobile exterior.

What further renders the internal process of the plant an externalization is the connection of growth to the mutual functioning constitutive of organic unity. The internal workings of the plant are directly related to its growth. Not only are the principal plant parts all "on the outside", but they proliferate indefinitely together with any ongoing metabolism. Lacking the internal integration of viscera, which limits organs in number, plant parts have a formation that allows their multiplication, so long as all parts do so in a viable proportion to one another.

Nonetheless, together with growth, the internal formation of the plant involves a self-mediation, a circulation of the vital nutrients provided by the absorptions of roots and the photosynthesis of leaves. This requires two structural features, which Hegel identifies as the woody fiber, and the vital spiral vessels.[53] One might wonder whether these features apply to all plant life or only to those plants that have stems connecting roots and leaves. Even in plants without stems, however, the circulation in question requires some vehicle for distributing throughout the plant what roots supply and leaves produce. Moreover, in order to prevent these vehicles from becoming physically deformed in ways that block the needed circulation, they must have some supporting structure. Accordingly, what Hegel refers to as the woody fiber and the vital spiral vessels can be considered generic features of plants, whether or not they have stems. Hegel considers this circulation system to be transmitting the sap, which contains the nutrients every plant cell depends upon. The circulation does not occur by means of some pumping organ, like a heart. Rather, the sap simply seeps through the spiral vessel and then enters the plant cells through the permeable membranes that enclose them.

The woody fiber, for its part, gives the plant the minimal abstract structure or shape on which its metabolism depends. This botanical skeleton allows the plant to reach the elements it continuously assimilates and to circulate them and their products throughout the organism. Like root, stem, and leaf, the woody fiber is both an internal part of the plant and a factor in giving it direct contact with the environment.

These internal features of plant circulation are continually added on in virtue of how the preservation of the whole plant falls together with its growth process. Since the growth process is the plant's coming out of itself through further proliferation of its parts, the same self-multiplication applies to the woody fiber and spiral vessels. This is evident in how a tree grows by adding rings of new woody fiber and spiral vessels, rather than simply increasing the size of those that are already at hand.

Hegel points to one additional element in the plant's internal formation. This is the production of the bud.[54] The bud exhibits an individuality similar to that which the other plant parts, roots, leaves, and stem, can exhibit when separated and successfully planted. The bud can be grafted onto another plant and continue its development. That development consists in the sprouting of further leaves and stems of the same type as those of the plant from which the bud originates. The bud, however, does not generate roots. Nevertheless, Hegel points to the bud as another evidence of how the internal formation of the plant is directly connected to the other life functions. In this case, we have the plant formation producing something from which another plant arises to the extent that the outgrowths from the bud represent a new plant that grows parasitically upon the plant from which it sprouts. Already, the connection of plant organic unity with growth of new roots, stems, and leaves that may become independent plants, suggests the same connection of plant formation with reproduction. On both accounts, the self-relation of the plant falls together with the implicit generation of new independent individuals.

The Process of Assimilation in Plant Metabolism

What distinguishes plant metabolism is that, as Hegel duly notes, the assimilation of external inorganic nutrients by the plant takes place without mediation.[55] Each of its essential parts, root and leaf, are in direct contact with the particular elements on which survival depends. They do not seek out individual objects but rather take in the types of factors required by plant nutrition: principally water, air, and light. These are not liquids and gases in general, but rather the particular type of liquids, gases, and electromagnetic radiation enabling plants to metabolize. The selection process takes place immediately. The root absorbs water and soluble nutrients from the soil in immediate contact with it, rather than other liquids and chemicals, whereas the leaf exchanges just oxygen and carbon dioxide with the air immediately reaching its surface, while engaging in photosynthesis thanks to the light that hits the leaf. Light here operates, as Hegel suggests, like an external self, drawing the plant out of itself towards the light source and thereby allowing the plant to "return to itself" but using the light to secure its self-preservation.[56] These immediate contacts with water, air, and light lead directly to transformations of these physical elements into usable nutrients, which the circulation process within the plant distributes throughout the organism. In animals, by contrast, metabolism is achieved through a complicated process that must traverse separate stages. First nutrients must be perceived at a distance, then grasped after a concerted effort to reach them, and next, in the case of solid food, broken apart to enter the chemical process of digestion, which transforms the nutrients into material that can be circulated throughout the organism.

Further distinguishing plant metabolism is its connection with the process of formation and reproduction. Through its immediate relation to inorganic nature, plant metabolism is directly tied to plant growth and aspects of plant reproduction. The consumption of nutrients by the plant does not just preserve the existing parts of the plant. It also directly fosters plant growth. This is because the process of formation itself is directly connected with metabolism and growth, since the internal self-activity of the plant is a development outwards into its environment.[57] What immediately results from metabolism is a proliferation of additional roots, stems, and leaves that can achieve a separate existence as complete plants of their own. This does not mean that each essential plant part contains an integral metabolic process of its own. The roots may absorb water and liquid nutrients, but their own life depends upon receiving in return the fruits of photosynthesis that plant circulation delivers back to root cells. The stem may facilitate plant circulation as well as leaf photosynthesis, but it too depends upon what roots absorb and what leaves produce photosynthetically. Finally, of course, the leaves equally depend upon what roots absorb and stems transmit to them. Nonetheless, each of these parts has the potential to separate and develop into a whole plant, precisely because none are viscera but all are directly in contact with the environment.

In this connection, Hegel notes, the mediating role of the vessels of plant circulation does not involve any transformation of the assimilated nutrients.[58] The vessels simply convey what has been immediately assimilated at either end of the plant. They do not digest anything, but simply let capillary action lead the sap to its destinations. Although capillary action may play a role, it does so only insofar as the biological need of the plant requires more water and soluble nutrients.[59] The roots and stem are not merely tubes subject to mechanical air pressure and liquid surface tension, but parts of an organism regulated by the requirements of its self-preservation. Although the plant does not take sips, but continually absorbs water, this can continue only so long as the plant has not yet reached the point of saturation.

Throughout plant metabolism, the plant exhibits its sensitivity to the external factors it needs to assimilate. The plant grows its roots in the direction of moisture, it grows its stems and orients its leaves towards the light, and breathes in and out just those gases on which its assimilation process depends. The plant, however, does not sense these factors in the way in which animals have a centralized sensitivity, uniting all sensitivities into a unitary field of sentience, allowing the animal to perceive objectivity as a whole and to centrally control its responses so as to navigate through its environment.

In following out Hegel's account of plant metabolism to its end, it is important to reconsider whether he abides by the generality of universal biology or rather characterizes the plant assimilation process with respect to how plants have developed on earth. All plants must secure energy from their environment to maintain their life processes, but visible light need not be the exclusive source. Other electromagnetic wave lengths and thermal energy could provide what plants need. Similarly, all plants must take in inorganic material and transform it into living plant protoplasm. This does not, however, mean that plants are limited to water and water soluble nutrients or to exchange oxygen and carbon dioxide. Plant life can conceivably operate with other chemicals, liquid, solid, and gaseous as the case may be, and still have the immediate metabolic interaction distinguishing plants from animals. Whatever the case may be, plants must have the parts to take directly in the factors with which they metabolize, as well as to circulate the assimilated "sap" throughout their organism. In light of these general imperatives, we can take Hegel's characterization in a more generic way and make use of it to represent the universal features that differentiate plants from animals.

The Genus Process of Plants

Plants do have a distinguishable genus process, involving the generation of seeds which depend upon a fertilization process involving a sexual division between parts of the same plant or of different plants. As Hegel observes, plant fertilization may unite sexually distinguished cells from the same organism, as in hermaphroditic Monoecia plants, or from sexually distinct organisms, as in Dioecia plants.[60] Either way, these reproductive processes remain formal and superfluous.[61] This is because the internal formation of the plant and the growth connected to it already provide a proliferation of parts that are each able to be separated from the plant and, if proper environmental conditions avail, to grow into a whole new plant. Moreover, in both the germination of seeds and the establishment of new seedlings, plant reproduction depends upon external elicitation, unlike the eggs of animals. Moisture is needed to get seeds to germinate and seedlings to sprout roots, stems, and/or leaves as the case may be. Further, plant reproduction may appear to be sexual in character, but the differentiated genetic factors that combine to form a fertilized seed reside in isolated parts of the plant, whose sexual differences do not extend throughout the rest of the plant organism.[62] These parts may resemble animal sex organs, as the delirious flower paintings of Georgia O'Keefe can testify. Nonetheless, these plant parts cannot achieve any sexual consummation on their own. Instead, plant fertilization only occurs when the opposing genetic materials are brought together by external factors, such as gravity, wind, or other organisms, like birds and bees. Since plants lack any centralized sensitivity, emotion, or irritability, they cannot engage in any effort of copulation, nor possess any sexual urges that could precipitate such sexual behavior. Accordingly, as Hegel notes, plant reproduction never attains to a relationship between individuals as such.[63] Whereas animals have sexual *partners*, plants have reproductive *parts* that locally produce genetic material whose unification depends not on plants themselves, but on something else.

Nonetheless, although plants can reproduce without seeds, the seed has a character that goes beyond what plant parts and buds represent. The seed is explicitly directed at reproduction, unlike the plant parts that serve both as complementary functioning organs and as potential independent individuals. Furthermore, although the bud has little to do with sustaining existing roots, stems, and leaves, its reproduction function is limited insofar as it only develops into stems and leaves proliferating out of existing stems, instead of giving rise to an entire independent plant that has roots of its own.

The distinctive character of the seed is manifest in how seeds are produced, as Hegel points out, by negating the further proliferation of other plant parts.[64] The flower arises in place of roots, stems, and leaves, in devotion to the sole task of producing the seed from which a new plant can be independently generated. The seed may require a prior fertilization uniting male and female cells, as well as moisture to precipitate germination. Nevertheless, the seed holds within itself the springboard for a self-development by which its living material undergoes successive metamorphoses bringing a new plant into being. There is no miniature plant "homunculus" within the seed, which progressively increases in size. Rather, the seed undergoes an embryonic development, successively engendering new forms and new living material as it develops into a full-fledged plant. The seed entails these developmental transformations in and of itself and it mobilizes various mechanical, physical, and chemical processes to become the plant it is genetically destined to be. This process is very different from the original emergence of life, which consists in the spontaneous eruption of the minimal organism from inorganic material. Here, the seed is a product of an existing plant and begins with organic material pregnant with the developmental maturation of a new plant.

Nonetheless, in the final analysis, plant reproduction retains a formality as something distinct from plant formation and plant metabolism. Plant metabolism is already a reproductive process, with its proliferation of new parts, each of which can become a new plant. For this reason, Hegel characterizes the genus process of plants as a "digestive process". Whereas in animals, mediated digestion sustains the individual animal itself, in plants the "immediate digestion of growth" is equally a generation of individuals.[65] Even in seed production, sexual relations proper are only anticipated. The sexual difference applies more to plant parts than to whole plants and, in the absence of any actual impregnation, fertilization remains beyond the power of plants themselves.[66] The universe will have to wait for animals for real sex to emerge.

Notes

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4. Hans Jonas, *The Phenomenon of Life: Towards a Philosophical Biology* (Evanston, IL: Northwestern University Press, 1966), pp. 64–98.

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15. Hegel, *Philosophy of Nature*, §343, p. 303.
16. Hegel, *Philosophy of Nature*, §343, p. 303.
17. Hegel, *Philosophy of Nature*, §343, p. 303.
18. Hegel, *Philosophy of Nature*, Zusatz to §344, p. 305.
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20. Hegel, *Philosophy of Nature*, §343, p. 303.
21. Hegel, *Philosophy of Nature*, Zusatz to §344, p. 307.
22. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
23. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
24. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
25. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
26. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
27. Hegel, *Philosophy of Nature*, Zusatz to §345, p. 313.
28. Hegel, *Philosophy of Nature*, Remark to §345, p. 311.
29. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 305.
30. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
31. Hegel, *Philosophy of Nature*, §345, p. 311, Zusatz to §345, pp. 320–321.

32. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
33. Hegel, *Philosophy of Nature*, Zusatz to §343, p. 304.
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39. Hegel, *Philosophy of Nature*, §344, p. 305.
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49. Hegel, *Philosophy of Nature*, Zusatz to §346a, p. 330.
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52. Hegel, *Philosophy of Nature*, Zusatz to §346a, p. 332.
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56. Hegel, *Philosophy of Nature*, §347, p. 336.
57. Hegel, *Philosophy of Nature*, §347, p. 336.
58. Hegel, *Philosophy of Nature*, Zusatz to §346a, p. 330.
59. Hegel, *Philosophy of Nature*, Zusatz to §346a, p. 331.
60. Hegel, *Philosophy of Nature*, Zusatz to §348, p. 344.
61. Hegel, *Philosophy of Nature*, §348, p. 342, and Zusatz to §348, pp. 345–346.
62. Hegel, *Philosophy of Nature*, Zusatz to §348, p. 344.
63. Hegel, *Philosophy of Nature*, §348, p. 343.
64. Hegel, *Philosophy of Nature*, §348, p. 343.
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6

Animal Life

From Plants to Animals

Something fundamentally new enters the universe when blind evolution leads mutating plants to give rise to animals. This development consists in nothing less than the natural emergence of mind. What above all distinguishes animals from plants is that animals have a soul, a centralized sensitivity and irritability that together give animal life a degree of subjectivity that plants lack.

For understanding how this is so, two philosophical contributions stand out. One is Hans Jonas's essay, "To Move and Feel: On the Animal Soul",[1] which focuses on how the immediate metabolism of plants leaves them mindless, whereas the mediated metabolism of animals requires sentience, emotion, and self-controlled mobility. The other contribution, which is far more encompassing, is Hegel's development of animal life in his *Philosophy of Nature*.[2]

In examining Jonas' account we must consider whether he has imported into animal life in general features that are specific to the soul of a rational animal. When Aristotle distinguished three types of soul, he identified the plant soul with nutrition, the animal soul with perception and desire,

R. D. Winfield, *Universal Biology after Aristotle, Kant, and Hegel*,
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and the rational animal soul with perception, desire, and reason. Although neither Jonas nor Hegel ascribe any soul to plants, Aristotle's plant soul is actually nothing more than the life process of metabolism, which Aristotle acknowledges to belong to plants, brute animals, and rational animals alike. All three recognize that plant life is not reducible to metabolism, but also involves an internal organic unity and reproductive processes. For Jonas and Hegel, possession of all three of these life processes does not necessarily involve a mind, properly speaking. They recognize that the dividing line between mindless life and ensouled life is what separates plants from animals.

This dividing line is not the divide between what has subjectivity and what does not. Life of any sort has the subjectivity of a self-centered, self-sustaining active entity, which distinguishes itself from its environment and maintains itself in interacting with its environment. What lacks subjectivity in nature is everything that is merely inorganic. The difference between mindless life and life with mind is therefore a distinction between life forms with different types, or, perhaps, degrees of subjectivity. It would be a mistake to identify real subjectivity with mind or, more specifically, with consciousness or sentience in general.

Jonas' Account of Animal Life

Jonas begins his account of animal life by presenting three characteristics that distinguish animals from plants. These are perception, emotion, and motility.[3]

Motility refers to the distinctive way in which animals are able to move themselves. Whereas plants can orient their leaves and stems towards light and grow their roots towards moisture, they remain stuck in place, be it in soil, water, or air.[4] Plants are unable to pick themselves up as a whole and move themselves to a new location. Animals, however, have motility in the sense of being able to change the location and orientation of their body as a whole, exercising a centrally unified, rather than localized control.

Perception is more than sensitivity. Aristotle, Hegel, and Jonas all agree that plants, like all living things, are sensitive and accordingly responsive to their environment. Plants follow light in orienting themselves. They grow their roots down in specific directions, from wherever moisture reaches their surface. Plants even defend themselves against insect predators, releasing chemicals when certain insects make contact with them. All such sensitivity is nonetheless very different from perception, just as plant responsiveness is very different from what animals do in virtue of their emotion and motility.

Emotion, however, seems difficult to attribute to animals in general. Do ants have emotions? Do fish have emotions? Do even cold unfeeling cats have emotions? Is there any emotion felt by the relentless killer grizzly bear that Werner Herzog observes devouring the Grizzly Man in his film of the same name? Or is emotion something that genuinely applies only to rational animals?

Such questions do not deter Jonas and he instead insists that emotion is a fundamental constituent of animal life as such. As we shall see, all three features, perception, emotion, and motility, manifest the same common principle and this common principle will radically demarcate animal life from plant life.

What is this underlying principle on which, according to Jonas, perception, emotion, and motility are based? It is none other than the mediated metabolism that defines animal life.

Hegel, much like Aristotle, refers instead to the sentient subjectivity of animals as the decisive differentiating factor that pervades every aspect of animal life. We will have to see whether Jonas' common principle and Hegel's sentient subjectivity ultimately go hand in hand and whether they end up differently depicting the essential nature of all animals. Most importantly, we must see to what degree Jonas and Hegel give us the means to properly draw the boundary between the botanical and zoological realms.

Interestingly enough, Jonas presents the three features defining animal life as having been subject to a progressive evolutionary elaboration.[5] Moreover, he indicates that this elaboration has had a particular direction. The direction consists in a progressive increase in two correlative factors. One consists in an increasing disclosure of the world, whereas the other consists in an increasing individuation of the self.[6]

One may wonder whether this progressive elaboration of world disclosure and self-individuation are completely contingent occurrences or rather inherent in evolutionary development. The ultimate disclosure of the world better be provided by Jonas or Hegel or Aristotle or you and I if any of we rational animals are to know the universe as it is. After all, what provides the ultimate disclosure of the world are those rational animals who can conceive in truth what the world is, namely, the successful philosophers of nature. Hence, if we want to talk about that ultimate disclosure of the world as a product of animal evolutionary development, we are talking about the emergence of beings like ourselves. These are not necessarily homo sapiens, but any kind of rational agent who possesses the inherited endowment to partake in the cultural development by which language and thought become empowered to engage in philosophical investigation.[7] Any undertaking of the philosophy of nature presupposes that there has been such an evolutionary and cultural development.

What about the increased individuation of the self? What is its consummation and how is the ultimate disclosure of the world connected to it? Presumably, if these two developments of self-individuation and world disclosure are connected, then the maximal individuation of the self will accompany the emergence of the philosophy of nature. How do rational animals achieve not only the ultimate disclosure of the world, but the greatest possible individuation of the self?

Jonas does not directly answer these questions, but instead focuses on the antecedent determination of self-individuation and world disclosure.

To the extent that self-individuation involves the individual giving itself the character by which it is uniquely distinguished, it consists in self-determination, which, with regard to action, involves free will. Jonas' primary concern is with determining how animal life in general surpasses plant life in world disclosure and self-individuation. Can the will be part of this development, which precedes the divide between brute and rational animals? Jonas will invoke will at certain conjunctures of his account of animal life and he speaks of freedom in connection with life as such. We must consider whether will applies per se to animal life, as well as whether the freedom Jonas ascribed to life is really reserved solely for animal life, and in particular, for rational animal life. The early modern philosophers, from Hobbes through Kant, all agreed that freedom is not to be found among animals, since they are allegedly deterministically governed as inhabitants of a nature subject solely to efficient causality. Does the development of plant and animal life give living proof to the contrary?

One way to think of increasing individuation of the self is to consider something that comes more and more to owe its character to itself. Such a being is increasingly *self*-individuated, rather than defined and individuated by external factors. The entire development by which nature constitutes itself appears to present a progress in which external determination becomes more and more limited.[8] To begin with, there is the mechanics of space, time, matter, and motion, in which material masses interact in terms of the external, efficient causal determination of inertial mechanics and gravitational systems. Within mechanics, entities figure as bodies of matter, individuated solely with respect to their mass and spatial position over time. These may provide a unique identification, but it lacks any connection to *what* the entity is in its own right. In physics, entities gain additional differentiation through factors that involve qualitative distinctions made possible by the electromagnetic determinations that supervene upon matter in motion. This distinguishes celestial bodies with respect to light, rather than just their position and gravitational role in solar systems and galaxies. It also allows for different states of matter ranging from solid to liquid to gas to plasma, as well as for bodies to have different densities and cohesions and different relations to light, heat, and sound. Magnetism further individuates materials while setting the stage for the formation of individuating shapes of bodies to which gravity is indifferent. Next, chemical interaction brings materials to exhibit their chemical elements and enter into new molecular relationships in which the chemical composition of bodies individuates them.

At this point, nature takes a giant step in increased self-individuation with the emergence of life. For the first time, natural entities operate as ends in themselves, relating to their environment in order to preserve their own self-centered active functioning. As Hegel has emphasized in his account of the incomplete subjectivity of plants, plant life remains burdened by external determination, despite its self-sustaining nutritive activity and its species-sustaining reproduction. It *follows* the direction of light and water, while failing to have a unity that fully specifies its parts. They not only can become independent plants of their own, but relate to the external world directly through local sensitivity and tropisms. Moreover, their proliferation in growth and separation exhibits how the unity of the plant leaves undetermined how many parts it has and the degree to which it depends upon each and each depends upon the whole. Further, the plant lacks all capability of uniting its local sensitivities and local responses into a central self-aware horizon of sentience and a centrally controlled irritability. The individuality of the plant self is both subject to external determination and powerless to pervade its parts in all respects.

Jonas presents at this stage in the development of nature a new increased individuation of the self to which the disclosure of the world correlates. Namely, a world comes to be for the organism only when the organism acquires the selfhood that is capable of unitarily confronting the world in its entirety. Conversely, the organism only acquires selfhood to the extent that there is a unified world for it from which it can distinguish itself. These dual developments are achieved, as Jonas proceeds to make clear, only with animal life.

One is tempted to regard the interconnection between selfhood and the disclosure of a world as equivalent to the interconnection between awareness of objectivity and consciousness of self. If this is so, animals will automatically be self-conscious. We will have to consider whether the animal mind per se is both conscious and self-conscious.

Jonas begins by noting that life as such involves an openness to the world.[9] This generic openness exhibits itself in two correlative features basic to life: sensitivity and irritability. Sensitivity to external stimuli underlies the selective interaction with the biosphere on which every metabolism depends. Minimally speaking, the organism lets in only those factors that it needs for its survival. To do so, it must recognize them and once it does this, the organism must appropriately respond to obtain the factors it needs. This responsiveness is the irritability all life forms possess as an intrinsic feature of their metabolic subsistence. Jonas can therefore rightly attribute both sensitivity and irritability to the most elementary life form, a single celled organism.[10] Even it is sensitive to its environment and responds in the simple manner its meager physiology permits. Otherwise, it would revert to a lifeless chemical agglomeration, subject solely to the influence of external mechanical, physical, and chemical processes.

Sensitivity and irritability are more than just mechanical action and reaction. Nor do they simply involve chemical interaction, where chemical elements and molecules are primed to combine or become dismembered if the proper catalysts and conditions happen to be at hand. Instead, sensitivity and irritability both operate as aspects of the internal teleology of the organism. The specific biological nature of the organism determines what it is sensitive to and how it responds. Sensitivity and irritability function over and above mechanical action and reaction as well as chemical process. These biological functions may make use of mechanics and chemistry, but that use is governed by the requirements of the continued existence of the life processes of the organism. These requirements determine the selectivity of sensitivity and the appropriate response.

The openness to the world to which Jonas refers is itself uniquely biological. It is not the mere susceptibility of the organism to inertial impacts, gravity, electromagnetism, and chemical reactions. It is instead the relationship to the external world on which the ongoing metabolism of the organism depends. The openness to the world is not something specific to animal life. It is rather the basic interaction with the biosphere that all life forms must undertake in order to achieve the metabolic exchange of material and energy on which survival rests. Without that openness to the world, the organism forfeits its active form and becomes something static and dead.

This openness to the world may be common to all life forms, but it takes on a different character as living things become more and more self-individuated. As Jonas explains, the biological basis for a full world disclosure relation is the advent of organisms with senses, motor structures, and the central nervous system that enables these to function as elements of a new type of sensitivity and irritability.[11] These endowments are biological features that pertain exclusively to animals. Indeed, they pertain only to animals of a certain level of development that surpasses the intermediary forms of primitive animal life that still exhibit plant-like characteristics, such as shell fish and corals.

With senses and a central nervous system, an animal can have a centralized integration of all the stimuli its organs of sensitivity provide. This biological realization furnishes the sentience with which begins any awareness of a true world of objects. On this basis, the animal can do something that no more limited life form can do: relate to its world in a theoretical manner, as subject of an opposing objectivity that its sentience leaves relatively unaltered. The local sensitivity of plants cannot provide that theoretical opposition, for the dispersion of sensitivity throughout different parts of the plant relates those parts directly to their immediate environment without ever unifying the plant's localized sensitivity into the encompassing view of an entire world. Plants do not have sense organs properly speaking, although they are sensitive to light and water. When they sense light they do not see as an eye sees. Sight requires a unification of the visual field and the further unification of that field with those of all the other senses of the organism. Only through these dual unifications does an objective world emerge of which the living thing can be sentient.

The eye can see because it is connected to a central nervous system or its biological equivalent. This renders visual sensation an integral part of an animal's centralized sensitivity. Only with these biological endowments can a living thing relate itself to a *world* of objects, rather than to local stimulations. The world is a totality. It is the biosphere as a whole. The plant may relate to its immediate environment, but it does not relate to the environment taken in its entirety. The animal does just this thanks to the biological endowments that give it sentience rather than mere localized sensitivity. When the animal sees, it sees objects that are part of a world of which it is aware.

The other side of animal life concerns the new formation of irritability, which constitutes the animal's practical relation to its world. The biological constituents of distinctively animal irritability are motor structures integrated with a central nervous system or its biological equivalent. This integration gives the animal a unified control over those parts of its body that are susceptible to centralized activation. The animal may retain various life functions that involve localized sensitivity and response, such as endocrine hormonal systems that can operate with slower chemical reactions. Nonetheless, these plant-like functions are subsumed within a new type of life form that can exercise a unified self-control. With the new endowments of motor structures and a central nervous system operating with electric speed, the animal can engage in active congress with the disclosed world through the exercise of motility. This exercise allows the animal to act upon its world as a unified agent. Graced with motility, the animal can move itself as a whole, rather than be limited to the tropisms of the plant, where parts of the plant respond to local stimuli while the plant as a whole remains fixed in place. Animal sensitivity and irritability together enable the animal to act as a unified self in a relationship to the world that it can sense as a whole.

These developments carry with them further aspects specific to animal life. In this connection, Jonas invokes two dimensions to which life as such is constitutively related. These comprise two horizons into which life is continually, as Jonas puts it, transcending itself.[12] One such dimension is time, for the living organism is always, in some respect, relating to what lies beyond its present condition. To be what it is, the organism must obtain in the future the materials and energy on which its life process depends. It is what it becomes and it ceases to be what it is if it lives statically, caught in the present or past. The other dimension is space, since the organism must always relate to what lies outside itself spatially, as well as temporally. This spatial externality is basic to metabolism, which involves the organism's material exchange with its external environment. Jonas can therefore rightfully maintain that "life by its nature faces forward and outward at once."[13] This holds true of plants as well as animals. Every plant must continue its immediate metabolism into the future or face death, just as it must make use of light, water, minerals, and air that lie outside its surface or cease to be alive.

What is important for the current topic is how animal life distinctively tackles these generic vital relations to time and space. Animals relate to time and space differently than plants because of how animal sensitivity and irritability function. Through the endowments of sense organs, motor structures, and a centralized nervous system, animals can mobilize their centralized sensitivity and centralized bodily control to tackle the challenges of sustaining themselves and their species through what lies in the future and at a distance.

In two respects, possession of centralized motor control and centralized sensitivity is not identical to the ability to move about and to perceive at a distance.

On the one hand, there are primitive animals that are relatively rooted in their location, such as sea cucumbers and shellfish. They may change their position from time to time, but otherwise they remain stuck on the seafloor, resembling sea plants or Beckett's inhabitants of trashcans, if only they could stop chattering. Moreover, the perception of such primitive animals involves a limited array of senses, which depend upon direct contact with what is sensed, such as touch, smell and taste. These may be united into a single horizon of sentience, but one largely confined to what is contiguous with the surface of the organism. The experience of such animals is thus limited to the differential of what is inside and what is outside the organism. The resulting world disclosure lacks the more determinate perception at a distance provided by sight and hearing, as well as other electromagnetic sensitivities.

On the other hand, the engagement of motility involves more than just centralized self-control. It requires the evolutionary development of a power of emotion to sustain the effort of moving across space and over time. Emotion is not just feeling or sensation. It is neither merely a proprioception of the animal's own body nor a perception of what confronts the animal in its environment. Emotion does involve feeling, but it is a *practical* feeling, urging an agent on to achieve an end. The power of emotion only applies to an organism that aims at ends that are not yet fulfilled. As Jonas notes, this presupposes a gap between having the end and its fulfillment.[14] Only on the basis of such a gap, can an organism have a desire and an urge to satisfy it. If satisfaction is immediate, there is no opportunity for any feelings of lack to arise and take the form of a desire for an end that is unsatisfied and an urge to make an effort to fulfill it. This gap between end and fulfillment can be both spatial and temporal. It is clear that only organisms with the mediated metabolism of animal life face this spatial and temporal gap as a recurring feature of their condition. Conversely, as Jonas argues, animals can only achieve their mediated metabolism if emotion accompanies their perception at a distance and motility, impelling them to make the effort to bridge the spatial and temporal gap between the object of their desire and its attainment.[15] Otherwise, they lack the motivation to use their powers of perception and motility to secure their survival and reproduction. Because plant life depends upon an immediate metabolism, where needs are continuously satisfied, plants can have no desires or any practical urges. They can be locally sensitive and respond with local tropisms, but these involve the same continuous satisfactions, which occur without any unified agency that can desire, have urges, and make an effort to attain an unsatisfied aim. By contrast, emotion becomes mandatory for any organism with a repeatedly interrupted metabolism that requires an extended effort guided by a centralized sentience and employing a bodily self-control to obtain the awaited satisfaction. Such is the defining predicament of animal life. Endowed with perception at a distance, motility, and emotion, the mediated metabolism of animals can obtain success. An internal feeling of unsatisfied want and the perception at a distance of objects of desire precipitate the practical feeling of emotion, with its urge to undertake the effort needed to achieve satisfaction.

This third factor of emotion is largely neglected by Aristotle, who distinguishes the animal soul by its possession of nutrition, perception and desire, without mention of practical feeling.[16] Hegel, by contrast, does acknowledge the role of desire and urge in animal life. Admittedly, Hegel addresses emotion, or practical feeling, in his treatment of practical intelligence in his *Philosophy of Mind*.[17] Although this suggests that emotion is specific to rational animals, one might distinguish between the practical feeling of brute animals and the practical feeling of animals with language and thought. Brute animals may be limited to practical feelings pertaining to ends that are perceived or imagined, rather than conceived. They may not be able to aim at universal principles of conduct, but they can motivate themselves to aim at obtaining objects of satisfaction presently perceived or, if the animal is sufficiently endowed, remembered. This might seem to reduce itself to appetite, where, on Hegel's account, an agent acts to annihilate the independent existence of some object, rather than give objective embodiment to a subjectively imagined end.[18] The latter is the aim for which practical emotion provides motivation. Although some animals may be restricted to the negative obliterations of a consuming appetite, others engage in behavior that has a more positive outcome.

Notably, although animals possess sense organs and appendages for moving, there is no physical organ of emotion. As Jonas observes, emotion is something inward, within the animal soul.[19] Although the posture and movements an animal makes express emotion, emotion has a psychological character, indicative of an agent with a mind. Emotion requires us to speak about the animal soul or mind. Admittedly, sentience and self-control already bring mind into play, insofar they are activities of a centralized subjectivity with a view of its world and an ability to navigate within it. Nevertheless, only emotion brings these activities together in the efforts of a unified agent. Desire and emotion are ingredient in how the animal operates with respect to time and space, moving itself in pursuit or in flight of perceived or imagined objects. To engage in any protracted pursuit or flight, the animal must be able to perceive what is at a distance and have the motility to pursue or flee. To these endowments must be added emotion, for without it, the animal cannot make an enduring effort to achieve its aims in the future and afar. Every animal must be able to drive itself to extended activity. It is not enough just to be able to move and to be able to perceive at a distance. The animal must also have the emotive force to achieve the ends that are built into its life process.

Jonas rightly presents pursuit, rather than flight, as the primary animal motion.[20] To survive, the animal organism must aim at something at a distance that it is attempting to obtain. The animal is not just reacting to a stimulus. Rather, it is driving itself to obtain an end that is specifically connected to its very existence. The goal may involve something external, but it is intrinsic to the self-sustaining vitality of the animal. The animal only pursues that of which its nature has need. Flight is secondary since it involves fleeing from predators rather than fulfilling the animal's mediated metabolism. An animal may not be in circumstances where flight arises often or ever. No animal, however, can escape the urge to pursue what it needs to survive and reproduce.

Perception at a distance, motility, and emotion also underlie the reproduction of animals. The species being of animal life involves an urge to reproduce and a corresponding controlled effort to consummate the generation of offspring. Plants have no such reproductive urge and activity. They rely upon external factors to achieve reproduction. Gravity brings seeds to fall to the ground, just as wind may blow them afar. Moisture must be added to germinate seeds that make it to the soil, just as wind or animals must be depended upon to pollinate sexually reproducing plants. By contrast, animals desire the acts required for reproduction and, having perceived at a distance the partner or eggs with which fertilization can be consummated, are motivated by emotion to employ their motility until the reproductive act can be realized.

Like animal mediated metabolism, animal reproduction occurs across a gap in space and time. Once more, this gap allows animal reproduction to involve perception at a distance, a desire and urge, and the emotion to sustain the action that must be performed before reproduction is actualized. Whereas plant reproduction involves no such psychological elements, animal reproduction does not occur without mind at work.

In defining the basic life processes of animal life, it is important not to import any psychological processes that only belong to animals of a certain level of evolutionary development. Perception at a distance, self-controlled motility, and emotion must be considered in their minimal determination if they are to apply to animal life in general.

This minimal determination should reflect something that Jonas points to as underlying each of these animal endowments. This is the basic separation between subject and object, between self and disclosed world. Perception at a distance, the motility to move from one place to another, the desire for what is not continuously consumed, and the emotion to sustain urges all are predicated upon the separation of subject and object, with which the animal organism confronts its world as a sentient, desiring, emotive, and self-controlled agent. This subject-object opposition is more than the metabolic relation of an organism to its environment. It involves the advancing individuation by which the animal organism centralizes its sensitivity and irritability into a unified self that is both aware of and ready to act in the world it confronts. As Jonas puts it, what distinguishes animal life from plant life, is that "a more pronounced self is set over against a more pronounced world".[21] Plants can neither sense the world as a whole nor act as a unified agent. They lack both the "theoretical" and "practical" stance constitutive of an organism with a mind straddling the subject-object rift that animal life first opens.

Does this subject-object opposition signify that knowledge enters into the animal psyche from the very beginning? Desire depends upon some awareness of its object, as does the urge and emotion that sustains the effort to move towards it and prepare it for digestion. If knowledge involves a certain type of representation and an act of judgment relating it to an object, imputing knowledge to an animal involves more than imputing perception at a distance, motility, and emotion. For this reason, the world-disclosure basic to animal life is not equivalent to a discursive knowledge of objectivity. Only with talking and thinking animals does knowledge proper enter into nature.

It is important to clarify how the subject-object separation is not already ingredient in life as such. This is incumbent with regard to Jonas' account of the plant-animal divide, since he ascribes to organisms in general a self-centered individuality that relates to the world in order to sustain itself. On Jonas' own admission, the metabolism basic to all forms of life involves a split between inside and outside, between organism and environment. This inside/outside divide cannot be what constitutes the subject/object opposition, if the latter is the defining core of *animal* life.

When life first arises, the metabolic relationship between organism and environment is contiguous with the organism. This is because as far as the organism is concerned its environment is nothing but its immediate surroundings. The organism makes contact with its environment and engages in the chemical interchanges by which it assimilates what it needs to survive and reproduce. This happens continuously so long as contact is maintained. Then the satisfaction of the organic needs of the living thing takes place immediately and continuously. The needs in question are recurring and lifelong. The metabolic process is thus part and parcel of the life process of the organism. In this rudimentary form of life, there is never any gap between needs and satisfaction since the needs are continually being addressed in the ongoing metabolic process.

So long as an organism has such continuous nourishment going on through its contiguous relationship with the environment, there is no room for desire. Need passes directly into satisfaction by the steady operation of metabolism. The renewal of the organic form is continuously taking place. The material that it needs is continuously available, so there is no occasion for any kind of concern about the continuance of this process. Desire and worry can only occur when the contiguous relation to the biosphere is severed. Only when there is a separation between the organism and the environment can the self be engaged in a subject–object opposition. There is a gap and confrontation.

Where does this separation come from? What produces it? Jonas is willing to grant that natural evolution produces a life form that no longer can metabolize with what is contiguous with it and thereby needs to sense at a distance and have the motivated mobility to traverse the gap separating it from the nourishment its metabolism requires.

This development, however, is sufficiently radical as to require a series of less ambitious alterations to complete the transition from plants to animals. Evidence of these transitionary developments can be seen in the intermediate forms of animal life that have plant-like characteristics. Such primitive animals lack the full array of sense organs that allow for any accurate perception at a distance as well as for the motor endowments and emotive power permitting much in the way of locomotion. Nonetheless, even these primitive animals must possess some means of taking in the particular nutrients they need, break them down mechanically to prepare them for ingestion, and then subject them to the chemistry of a basic digestive system, whose products can somehow be circulated throughout the animal. Carnivorous plants do digest insects and some, like the Venus Fly Trap, even catch them by tropically responding to the stimuli of their pressure when they land upon its enclosing leaves. These carnivorous plants, however, go directly to the chemical stage, without any antecedent preparation of their animal prey. The ensuing chemical transformation of the unlucky insect does not take place inside the plant, as in the digestive viscera of animals. Instead, the digestive juices are pooled directly on the outside of the containing plant leaves, as in the open vessels of the appropriately named pitcher plant.

One must not forget that the relationship of plant and animal metabolisms is not just a matter of one following the other. Rather, animal life must be accompanied by plant life in order to subsist.

Even inorganic factors that animals need are available thanks to plant life. The water and air on earth depends in no small part upon the contribution of plants to our planetary ecosystem. Although animals can take in water and air without the direct presence of plants, plant life has some role in mediating animals' consumption of these inorganic necessities. More directly, animals find nutrition by consuming plants and/or by preying on other animals, which themselves may be herbivores, omnivores, or carnivores. Ultimately, the food chain begins with plants and their immediate metabolism, on which depends animal life of each and every diet.

Jonas points out that animal metabolism must provide sufficient energy to enable the animal the engage in the mediating activity whereby it secures nourishment.[22] Plant life need only supply the energy to carry on its immediate metabolism in contiguity with nature. Lacking any analog to photosynthesis, animals have to live off other live forms, the organic substance of which already contains the fruits of their own metabolism and can provide the additional energy animal life requires.[23] Animal life is parasitic upon plants or other animals, irrespective of whether it operates with our familiar carbon based organic chemistry or through other extraterrestrial chemical options. Internally animals may have internal organs with plant-like features, immediately absorbing gas or liquids that circulate in the bloodstream. Some of those organs may have the branching proliferation common to plants, with the restriction that the number of such branches is inherently limited by the complementary organic functioning of the viscera. As a whole, however, animal metabolism confronts the challenge of a mediated metabolism that must rely upon the evolutionary progress that provides other organisms on which to feed.

Is Jonas' Account of Animal Emotion an Anthropomorphic Distortion?

Jonas has explained how the mediated character of animal metabolism pits the animal against the world in a subject-object opposition informing the defining animal features of perception at a distance, motility, and emotion. The world holds what the individual animal self needs. Each animal has to go out and obtain what its subsistence and reproduction requires. Jonas maintains that the world confronting the animal constitutively contains not just objects of desire, but also objects of fear.[24] Why is this so and how can fear, as well as perception, motility, and desire, belong to every animal?

Since animal metabolism depends upon perceiving at a distance the proper object of satisfaction, urging itself on to satisfy its desire for that object, and using its motility to reach and ingest that object, the possibility of failure is inescapable. The animal may have incorrectly perceived what it is aiming at, as well as where it is located, and what lies in the territory it must traverse to reach it. The animal's movement towards its goal may be obstructed and, even if not, by the time the proper location is attained, circumstances may have changed preventing the final capture. These changed circumstances can include the arrival of other animals seeking the same object of satisfaction, the flight of the animals on which the animal might prey, or attack by other animals who prey upon it. Given the animal's own powers of perception and of flight, the animal is capable of recognizing at least some of the dangers threatening its own efforts to survive as well as of motivating itself to evade the looming perils. Fear can well be understood as that basic emotion motivating the animal to contend with the possibility of failure to reach needed nutrition, to fulfill reproductive acts, or to care for offspring. Fear, as the animal urge to evade hazards to survival and reproduction, does haunt the lives of animals, given the defining mediated character of animal metabolism. All it signifies is the presence of an emotion or practical feeling to deal with danger to successful achievement of the ends basic to animal existence. As such, animal fear need not involve any of the capabilities specific to rational animals that would make it an anthropomorphized emotion. Brute animal behavior can exhibit fear, just as it can exhibit the satisfaction of achieving its natural goals.

Do all animals, however, feel fear? When a caterpillar under attack by wasps perceives the wasps and manifests an urge to evade them, does it exhibit the emotion of fear? Are we not engaged in an overreaching anthropomorphism, imputing a psychological life well beyond the capabilities of an insect? If, however, we allow that emotions consist in practical feelings or urges to act in regard to the achievement of ends, why cannot any urge to escape signify fear of some minimal sort? Brute animals certainly cannot be haunted by fear of moral failure or of failing to meet any universal standards that require thought and language for their apprehension and expression. They are able, however, to fear what can be perceived and imagined, and they as well as we cannot escape the possibility of failure.

Emotions are not just elements of reflex reactions, governed by mechanistic causality. They represent instead urges that rest upon an animal nature that is capable of perceiving what it needs to survive and reproduce, of moving itself so as to achieve these natural goals, and of sustaining the motivation necessary to make the needed effort. Although external factors may act mechanistically upon the animal, the response of the animal is not a mechanical reaction, but an exercise of irritability governed by the internal teleology of animal life. When one touches a bug and it rolls into a ball, this is not a mechanical effect, but a response governed by the survival strategy of the bug. Similarly, when a turtle retracts its head into its shell in face of danger, its action is mediated by both perception, motility, and the emotion of fear, understood minimally as the urge to evade peril.

Such behaviors can be instinctual to the extent that they comprise responses that are not learned but inborn. Instinct, however, is still not a mechanical reflex for it consists in behavior guided by perception, utilizing motility, and urged on by emotion with respect to the achievement of goals dictated by the self-preservation of the animal and its species. When instinct drives birds to migrate at a certain time of year, they become consumed by the urge to fly off in the requisite direction and if predators threaten their passage, fear drives them to flee. So too, when instinct drives a bear to hibernate, some emotion is at work in urging the bear to complete its preparations.

Jonas speaks of a wide range of animal emotions: pangs of hunger and thirst, pangs of unsatisfied reproductive urges, agonies of fear in face of danger.[25] The animal predicament of mediated metabolism requires it to mobilize its sentience, motility, and emotion and be alert to its circumstances. The animal must be wakeful. It cannot afford to rest in a vegetative state, at least for long. Always, the animal confronts two possibilities: the enjoyment awaiting successful satisfaction of its natural wants or the suffering of failing to do so. Both, as Jonas points out, are intrinsic to the effort that must be made to survive and reproduce.[26] "Animal being", unlike plant being, is "essentially passionate being".[27] As such, the animal has a psyche endowed with sentience, feeling, central bodily control, and emotion.

Should one add love to the emotions basic to animal life? Love is more than the urge to reproduce. It involves the urge to care for another and make its welfare one's own. Some animals seem to exhibit such an urge. These are the animals that live with their mate or mates in an enduring relationship and/or care for their offspring until they can fend for themselves. Such care can extend to the wider compass of a herd or pod. On the other hand, many animals have no urge to remain in any relation with their partners in reproduction or to concern themselves with offspring who are able to survive on their own soon after birth. Consequently, love might be attributed to some animals, but certainly not to animal life as such. *Ethical* love, for its part, can only be possessed by rational animals, since it involves conduct in observance of rights and duties, whose universal prescriptions require reason and language to be considered and purposively followed.[28]

A distinction needs to be drawn between those emotions that are generic to animal life and those that are specific to rational animals. Since emotion is a practical feeling concerning the fulfillment of ends, rational animals alone can have those emotions that pertain to the achievement or obstruction of rational ends, involving conduct in accord with rational principle. Ethical emotions can only be felt by animals capable of apprehending universal norms, which may be illustrated by imagery, but can never be properly grasped and pursued without reason and language. Even passions concerned with the achievement of happiness require the rationality to generalize desire satisfaction and represent the goal of achieving satisfactions in their totality. This general goal cannot just be imagined, but must be thought, despite the contingency affecting desires and their fulfillments.

These phylogenetic differences in the types of emotions that can be possessed by different animal species have their counterpart in ontogenetic differences appearing in the stages of maturation of rational animals. Children who have yet to develop propositional speech are limited to the generic emotions of animal life, but cannot feel urges regarding explicitly rational goals until they have achieved sufficient linguistic competence to begin to reason.

Hegel's Account of Animal Life

Reason has more to say about animal life than what Jonas' basic sketch provides. Much of what remains to be conceived lies in Hegel's development of animal life, which occupies the final section of his *Philosophy of Nature*.[29] Hegel's account of the animal organism is filled with empirical illustrations and our task consists in determining what he offers that holds necessarily of animal life.

Hegel begins addressing animal life by focusing on how the subjectivity that pervades the animal organism does so to a fundamentally greater degree than that of the incomplete subjectivity characterizing plant life.[30]

The parts of the plant may perform complementary functions, but they retain an independence indicating how the subjective unity of the plant fails to penetrate them completely. Plant parts are indefinite in number and each is in immediate contact with the environment. Every part can be separated off and form a new plant. Moreover, each part can metamorphose into a different plant part if conditions make this necessary, such as with an inversion of the plant, causing leaves to become roots and roots to become leaves. Plant growth further exhibits the incomplete selfhood of the plant by being tantamount to reproduction. As a plant grows, it produces new plant parts and new buds in an indefinite profusion, each of which can become independent plants. Finally, plant sensitivity and irritability operate only in a local manner, leaving the plant self with no centralized unification of their processes.

The defining subjectivity of animals is exhibited both in the structure of the animal organism and in the activities in which it engages. First, the parts of the animal are genuine organs whose complementary unity completely determines them. Unlike the quasi organs of the plant, animal organs cannot survive independently. The unity of the animal specifies their number, so that growth does not consist in a proliferation of new parts, but rather in either metamorphoses or increases in size of the entire animal organism. Moreover, the organs of the animal do not each have immediate contact with the environment. The external biosphere may be in immediate contact with sense organs and an enclosing surface of skin, scales, carapace, fur, or feathers, but all the other organs are viscera, contained within the animal. All these features fit together with the fundamental evolutionary development enabling both the sensitivity and irritability of the animal to be centralized within a unitary subjective self, which thereby possesses sentience and centralized motor control as well as the emotive urge that allows its effort to be directed and sustained in fulfilling a mediated, rather than immediate metabolism.

Hegel proceeds to delineate the principal biological features that distinguish the animal organism. Unlike plants, Hegel notes, full-fledged animals possess freedom of *self-movement*, with which the animal organism can spontaneously determine its place, removing itself from its given entanglement in its environment.[31] Secondly, the animal has a voice.[32] The capacity for voice is related to the power of self-movement since voice is an internal self-movement, a free self-sounding vibration within the organism. Other things in nature, including inorganic objects and plants, are made to sound by the external causalities of mechanical and physical forces. The animal organism can sound itself and the voice of the animal is an expression of its selfhood. In particular, it can express something lacking in plants and inorganic material – emotion. Sound can also, at least in some animals, designate factors relevant to survival and reproduction. In the case of brute animals, the self-sounding of the animal is connected to the governing ends to whose fulfillment animal behavior contributes. In the case of rational animals, self-sounding takes the form of discourse, with which interlocutors can consider normative issues that transcend the hold of natural necessitations.

Hegel next brings in animal heat as a process in the self-regulation of the animal organism.[33] It, like voice, is connected to animal self-movement since heating here involves a dissolving of cohesion and shape that the animal itself generates. Hegel might seem to be ascribing self-heating to animals in general, without regard for how some animals are cold blooded and lack the ability to regulate their warmth apart from moving into locations with sufficient insulation or heat sources to maintain the life process. Nevertheless, only animals can have an internal heat regulation since it consists in a type of internal self-movement that is centrally controlled and implemented, even if it is done without explicit awareness and effort. Moreover, cold-blooded animals can take the initiative of seeking places with the proper warmth and thereby purposefully regulate their own heat. Unless this is done by continuous automatic regulation or by explicit effort, the animal cannot generate sufficient energy to fulfill its mediated metabolism and reproduction.

Another salient feature of animal life, to which Hegel here draws our notice once again, is that animals nourish themselves not continuously with respect to general elements of nature, but rather through a specific effort aiming at individual objects of nutrition.[34] Hegel does not here address the dependence of animal nutrition upon other living things, such as plants or animals of prey. He is instead noting a more general encompassing feature of the mediated metabolism of animals, namely, how it requires moving to specific factors of nutrition that are not immediately contiguous with the animal.

Finally, Hegel points out what he considers to be the most fundamental feature of animal life: the feeling of the animal organism. Hegel characterizes this feeling as the "*existent* ideality of being determinate" and as the "individuality which in determinateness is for itself" as "immediately *universal*, simply abiding with itself and preserving itself".[35] How are we to decipher these characterizations? Generally, when Hegel refers to "ideality", he is describing something becoming the component of something else, losing its initial immediacy and becoming mediated by its inclusion in that encompassing factor. What does feeling have to do with this? Feeling is a modification of the animal organism involving some stimulation from without or within. What makes the resulting modification a feeling is that it becomes integrated into the field of sentience of the animal. This integration is indicated when Hegel describes feeling as "individuality which in determinacy is for itself." In feeling, the animal relates to its own modification as a determination of its own self even while the feeling is indicative of something outer or inner. If the feeling figures as a sensation of an object impinging upon the sentience of the animal, it is felt by the animal as a specification of something falling within its field of perception. If the feeling figures as a sensation of the body's own movement and position, it is felt as a proprioceptive sensation. If the feeling figures as an internal sensation of the animal's own embodied mind, it indicates a particular state of the soul that is at one with itself in every one of its sensations and feelings.

In feeling, the animal organism is communing with itself at the same time that it senses what is outer or inner. Feeling is felt by a self that therein recognizes its own modifications. By being the universal field of them all, the animal subject is sentient. In this way, sentience comprises a centralized sensitivity, whose unifying self both encompasses all its sensations and feelings and thereby confronts a unified world, within which it senses its own body and from which it senses what lies outside its embodied being. In every manifestation of sentience, the animal relates to itself as a universal insofar as its sentient self pervades all its feelings and sensations as their unifying subject.

These preliminary characterizations give way to the systematic development of the animal organism, whose course is sketched in paragraph 352 of the *Philosophy of Nature*.[36] Hegel there indicates that he will be following the same basic pattern that applied to the development of plant life. The organism as such involves those same principal life functions that Kant pointed to when he was examining the different ways in which the organism is both cause and effect of itself. To begin with, there is organic unity itself, which consists in the internal process by which the living thing relates to itself. What first lies at stake in developing animal life is determining the defining organic unity specific to the animal organism. This comes first since it is presupposed by and contained within all further life functions of the animal. Next comes the animal organism's relation to its environment, which concerns the specific type of metabolism distinguishing animal life. The assimilation process of the animal is radically different from that of plants and understanding animal metabolism requires taking into account how the organic unity specific to animals underlies how they relate to their environment in order to survive. Finally, the development of animal life must address the life process that presupposes and incorporates organic unity and metabolism, namely the genus process whereby animals reproduce. Since this operates with the specific internal organization and assimilation process distinguishing animals, animal reproduction will have a character of its own.

What complicates the successive development of the animal life processes is something that complicates the examination and being of any life form. To some degree, the different processes of a living thing contain the other processes as well. The internal structure of the animal, like that of any organism, cannot help but contain within itself the organs with which its metabolism operates. Although the assimilation process of metabolism transpires in the interaction between the animal and its environment, its facilitating biological conditions are structurally embedded in the internal anatomy of the animal. The same entanglement applies to reproduction. Whether reproduction occurs asexually or sexually, it depends upon anatomical features contained within the complementary functionality of organic unity, as well as upon the fruits of metabolism. As Hegel suggests, each process of the animal organism implicates all the others and in that respect is a transition into them as well as the same totality.[37] Since the animal organism is endowed with sentience, motility, and urge, all of these distinctive features will figure in the internal animal anatomy, in the assimilation process of animal metabolism, and in the specific behavior through which animals reproduce.

These involvements become further concretized in light of how, on Hegel's account, animal anatomy is differentiated into different systems biologically realizing the sentience, motility, and emotion distinguishing animal life. There must be an anatomical system of centralized sensitivity and centralized irritability. This will involve sense organs, a nervous system, and motor responders. There will also be an anatomical system for animal assimilation, involving the organs for obtaining and preparing nutrients for ingestion as well as the organs for digestion. Finally, there will be an anatomical system for reproduction. Both metabolism and reproduction will mobilize sense organs, nervous systems, and motor capabilities in their behalf. In these respects, each bodily system will implicate and contain the others.

Thus the nervous system will penetrate all the other systems necessarily. Similarly, the circulation system will pervade its counterparts, all of which depend upon the oxygen and nutrients it delivers. Glandular systems will likewise intertwine with the other anatomical structures. Every section of the animal organism will contain the whole in its own differentiated system, yet each system will have one aspect of the whole dominating its operation.

These entanglements of the three life process in animal life are very different from how organic unity, metabolism, and reproduction fall together in plant life. As Hegel has duly shown, the complementary functioning of plant parts is ordinarily directly combined with the continuous operation of plant metabolism. Plant parts are in direct contact with the environment and the immediate metabolism of plants allows them to obtain nutrients continuously. By contrast, the functioning of organic unity in animals is not automatically connected to the full engagement of animal metabolism. Animals only intermittently make the effort to obtain the individual nutrients they need and their organs are primarily viscera that operate inside the body. Further, as Hegel noted, in plants, growth combines with reproduction since plant parts can become independent plants and plant growth involves the proliferation of such parts. By contrast, the growth of the animal either involves metamorphosis of the entire animal or an increase in its size, whereas animal organs have a fixed number and cannot survive apart. Moreover, animal reproduction depends upon the effort of animals to perform a wide range of behavior that permits mating and care for offspring. These activities may make use of the anatomical systems on which the other life processes depend, but animal reproduction proceeds independently. In these respects, the life processes of animals have a relatively separate being, despite the entanglements of animal anatomical systems.

The Basic Anatomy of Animal Life

The internal organization of animals must provide the anatomical resources to fulfill the fundamental features of animal life. The animal must have the organs to achieve its mediated metabolism. This entails that animal anatomy must contain the internal structures enabling the animal to have sentience and perceive at a distance, to have centrally controlled motility, and to have emotions that can drive the animal to make the necessary effort to obtain and ingest nutrition and to carry out reproduction, including whatever care offspring may require.

These requirements are met through two distinctive sides of animal anatomy. On the one hand, there is the inner configuration of the internal workings allowing the organism to maintain itself without immediately engaging in all its interactions with the biosphere. The internal functioning of complementary organs must itself be shielded from the environment so as prevent external influences from disrupting its operation. So shielded by some protective enclosure, this internal functioning involves a physiological configuration of its own that does not directly reflect the activities to obtain nutrition and reproduce. The internal viscera will thus have a shape very different from that of the parts of the animal that directly interact with the biosphere. Whereas the viscera will be shaped to fit together to perform their complementary functions, the external parts will have to possess sufficient symmetry and balance to enable the perception at a distance and self-controlled motility on which animal mediated metabolism and reproduction depend.

The degree to which these structural imperatives are realized may vary. As Hegel notes, invertebrates can be regarded as less fully anatomically developed than vertebrates.[38] Some invertebrates have relatively well-developed anatomical features directed towards the outer world, but their internal structure is very simple. Insects, for example, have finely configured sense organs, wings, and legs, but their insides have relatively simple viscera. By contrast, other invertebrates like mollusks, have well-developed viscera, but little in the way of outer appendages.

Whatever the case, the demands of external activity must be heeded anatomically. It is thus no accident that animals that move through their environment tend to have a symmetrical external configuration. Appendages necessary for motility, such as tentacles, fins, flippers, wings, and legs will be able to cope with the demands of gravity and fluid dynamics by being evenly distributed on the sides of the animal so as to promote balanced motility. Similarly, sense organs, such as eyes, ears, and odor receptors in nostrils will commonly be symmetrically placed to take advantage of the depth perception of stereoscopic vision, hearing, and smell.

Inside the organism, symmetry need not prevail as the configuring principal of the viscera. We may have two lungs and two kidneys, but our other organs do not come in pairs or reside on opposite sides of our torso. The symmetry of our dual lungs and kidneys may reflect the needs of redundancy or direct connection to some external functioning, such as breathing through nostrils, where outer symmetry must be accommodated. Basically, however, internal anatomy is a very different structural world than outer anatomy. Whereas some aspects of the interior may have geometric regularities, most will exhibit an irregular configuration. Bilateral symmetry will tend to govern external animal shape in function of its advantages for motility and perception. Although natural mutations may produce the most irregular external shapes, these will tend to be weeded out in the struggle for survival due to their inherent liabilities in contending with gravity and navigating through liquids and gases.

These basic distinctions between inner and outer shapes present the framework within which animal life functions take on further anatomical differentiation. Hegel proceeds to develop this concrete configuration of animal anatomy in reference to the organic unity distinctive of animals. This cannot be entirely detached from the other life functions of metabolism and reproduction, but its anatomical structure has a being of its own that these further functions necessarily incorporate.

The key to the concrete development of animal anatomy is the physiological realization of the different functional systems that animal life requires. Hegel accordingly proceeds to determine animal anatomy in regard to three physiological systems, each of which has specific resources for contributing to the three life functions of the animal. These three functional systems are the nervous system, the circulatory system, and the digestive system.[39] A nervous system is required to facilitate perception at a distance, emotion, and centrally controlled motility. A circulatory system is needed to allow the mediated metabolism of the animal organism to supply energy and cell replenishing materials throughout the body. Finally, the digestive system is needed to enable animal metabolism to assimilate the individual nutrients that have been perceived at a distance, obtained through motivated effort, broken down through mechanical activity, and ingested. Without some anatomical embodiment of these three systems, animal life cannot function.

One might wonder whether these three systems should be developed in the order of Hegel's presentation, where the nervous system comes first, the circulatory system next, and the digestive system last. The nervous system might seem to deserve first place, since it enables animal metabolism to obtain the nutrients it needs, whereas the digestive system might seem to deserve second place, since it provides the nutrients in a form whereby they can be circulated throughout the body. On the other hand, the order may be regarded as an unimportant convenience of exposition, since these three subsystems are mutually dependent and thus coeval anatomical structures. With this in mind, let us think through Hegel's presentation, starting, as he does, with the nervous system.

Hegel identifies the nervous system as the system of sensibility that underlies all the aspects of animal life that depend upon the centralized sentience and control distinguishing animals from plants. Accordingly, he further differentiates the nervous system into three subsystems that provide for the organic unity, metabolism, and reproduction of the animal.[40]

First, the system of sensibility involves what Hegel calls the *osseous* system, which generally provides a protective enclosure for the internal organs as well as sufficiently firm support to enable the animal to move itself as a whole to orient its sense organs and approach what it perceives at a distance. This osseous system might not seem to be part of the nervous system proper, but without its protection and relative rigidity, the other functions of sensibility could hardly operate.

Second, the system of sensibility contains the neurological resources to enable the irritability of the animal to operate with its characteristic centralized sentience and motility. This involves on the one hand, some sort of cerebral system to centrally coordinate the sensitivity and irritability of the animal. On the other hand, the nervous system must contain the sensory and motor nerves that disclose the world to the animal and enable it to respond as a unified subject. These latter functions presuppose, of course, the presence of sense organs feeding the sensory nerves and muscles or their equivalent reacting to motor nerve stimulations.

Thirdly, the nervous system must contain the neural structures on which reproduction rests. These include, on Hegel's account, the sympathetic nerves and the ganglia on which sexual and parental urge depend.[41] Of course, the cerebral system and the sensory and motor nerves play their parts in guiding the behavior by which animals mate and care for young.

These three sub-systems of the system of sensibility have a discrete physiology, with organs of their own, but they all are subject to the complementary functionality by which the entire animal is sustained. Not only must they accommodate the shape provisos governing the inner and outer configuration of the animal, but they must integrate themselves with the two other anatomical systems.

The second primary anatomical system is the system of irritability, which involves the animal's interaction with its environment. Hegel identifies this system as a circulatory system, but this must be understood broadly with respect to all that animal irritability anatomically encompasses. Since this "circulatory" system must cohere with all the animal life functions, Hegel appropriately differentiates it into three subsystems of its own.

The first is the subsystem of "*muscle* in general", which converts the receptivity mediated by sensory nerves into the reactivity mediated by motor nerves.[42] This conversion depends upon the attachment of extensor and flexor muscles to some relatively rigid framework. Hegel here identifies such a framework as "skeletal",[43] which would improperly limit this subsystem to vertebrates. Instead, it should be understood as any type of anatomical support that would allow the contraction and expansion of muscle equivalents to help move the body as a whole, as well as protect the nervous system itself.

The second subsystem draws upon a proper circulatory system, whose pulsating action allows fluid material to bring to all parts of the body the necessary exchange of materials by which metabolism is internally fulfilled. This involves both inward and outward aspects, since the body must assimilate nutrients, including liquids and gases, and expel materials that cannot be retained. Hegel here invokes the duality of pulmonary and portal systems whereby the blood takes in and distributes air from the lungs while removing wastes and transporting them towards their exit.[44]

Finally, Hegel identifies a third subsystem of irritability consisting in the "self-coalescing totality", wherein the circulatory process renews itself and the body as a whole through the dual systems of arteries and veins and the corresponding organization of chambers of the heart.[45]

One can see how each of these subsystems allows animal irritability to function so as to uphold organic unity, metabolism, and ultimately the reproduction of the genus. Hegel offers fewer distinguishing details in delineating the third primary system, which he identifies as the digestive system. Here again he offers subsystems that exhibit the entanglement of anatomy with all three life processes.

First, Hegel refers to the subsystem of glands whose local chemical sensitivities and responses comprise an immediate vegetative reproduction.[46]

This endocrine system effects an *immediate* metabolism to the extent that it depends upon sensitivity to contiguous substances and chemical releases that follow directly upon that contact.

Second, Hegel points to the subsystem of the stomach and intestines, whose digestive process is a *mediating*, rather than immediate reproduction of the animal.[47] Their digestion of ingested nutrients is a mediating reproduction since the objects of satisfaction are obtained through effort, broken down into a digestible form by further action, and then subjected to chemical processes whose results must then be distributed through the body.

Hegel does not explicitly add a third subsystem, but one might expect some physiological organs producing the specific materials on which reproduction of the genus depends. This includes not only organs producing the reproductive cells for sexual reproduction, but also organs producing the nutrients on which some animal young depend.

What Hegel does append to his whole edifice of animal anatomy is acknowledgement of the total structure that arises from the union of distinct internal anatomical systems.[48] This total structure contains the linkage of the three primary systems as well as their distribution within the interior of the animal. That distribution must accommodate the demands of external shape and the activities that depend upon the latter. An example, Hegel notes, is the division of the insect body into head, thorax, and abdomen,[49] a division that is only one of the many options that animal life can follow.

In considering Hegel's development of animal anatomy, it is important to determine to what degree the differentiations are inherent in animal life in general, rather than illustrative of life forms that have emerged on our lonely planet. Central to this question is the necessity of the specific physical processes that are mobilized by the different anatomical systems.

Primary among these is the utilization of neuro-chemical electricity in the nervous system. Is this required in animal life? Could mere chemical reactions suffice to support the functions of centralized sentience and motility that the nervous system physiologically realizes? The obvious problem with relying on chemistry, rather than electricity, is the speed of reactions. Chemical reactions may suffice for hormonal adjustments that occur on a local scale. Sentience and motility, however, require continuous simultaneous integrations of sensitivity and irritability that traverse the whole organism. In order for animals to perceive at a distance environmental circumstances to which they must react by moving themselves as fast as possible, the centralized integration of local sensations and the centralized control of motor reactions must occur rapidly. Electrical impulses that travel from sense organs to cerebral centers can quickly register sensations from throughout the body and integrate them into a unitary horizon of a changing world. Electrical impulses that travel from the cerebral centers through motor nerves to muscles can then stimulate a motivated unified response in time to take advantage of the situation. If chemical reactions had to be relied upon, an animal would hardly have a chance to take in its environment and react before circumstances had irredeemably changed. Of course, the utilization of electricity requires that the simple binary differentiation of positive and negative and of on and off can provide sufficient resources to convey perception and behavior. It is not implausible to imagine that the binary difference of electrical charge can activate the muscular oppositions of contraction and relaxation to move the body and orient its sense organs in the most complicated and precise manner. How electricity can determine the disclosure of the world and emotive reaction to it is a more challenging matter, although the achievements of cybernetics indicate how binary means can represent the most complex information.

An analogous question is whether animals must have respiratory systems. Animals on our lonely planet may chiefly depend upon taking in air, and oxygen in particular, and expiring certain other gases, such as carbon dioxide. This reflects how our planetary animal metabolism relies upon oxidation to supply energy. There are, however, anaerobic microbes that survive without oxygen and one might wonder whether on other planets in other solar systems, animals might emerge who satisfy their energy needs without respiration. Could animals, as well as plants, survive without exchanges of gases and solely with exchanges of liquids or solids? If so, the generic anatomy of animals would have to deviate somewhat from Hegel's scheme, although sentience, emotion, and motility would still have to have sufficient physiological embodiment. Circulation might avoid transmissions of gases, but animal metabolism would still require a circulatory system to nourish all cells of its multicellular body.

The same can be said of digestion, which would have to supply the mediated chemical transformation that animal metabolism entails. Immediate osmosis is not an animal option. Animal nutrition must always be intermittently acquired at a distance, broken down into an ingestible form, and then subjected to the digestive process that makes nutrients available to all parts of the body. Animals must be anatomically equipped to carry out each of these successive stages of metabolism. Every animal must have some anatomical means to perceive its source of nutrition, to move itself to that source's location, to seize and ingest it, and finally to digest it. One must remember that digestion is not merely a chemical process. Instead, it is a complementary element in the self-renewing self-sustaining life process of an animal. The organs of the digestive system are themselves parts of the body in need of the nutrition they help supply.

Animal Metabolism

The anatomy of the animal already provides the physiological means for engaging in the metabolic process specific to animal life. Animal metabolism may incorporate the ongoing functioning of the animal body, but it further engages in a distinct succession of activities to carry out its nutrition. These activities largely proceed in the playing field of centralized sentience and irritability and take up part of their operations. Only part of sentience, motility, and emotion are concerned with metabolism, because animal reproduction equally requires their mobilization.

Hegel begins his account of animal metabolism under the rubric of "assimilation" and characterizes it initially as if it consisted in a relationship between the animal and inorganic nature. Hegel describes a state of tension wherein the animal confronts an inorganic nature opposing it as the external condition and material of its sustenance.[50] Admittedly, animals do need air of some sort, water or liquids more generally, and solid minerals. Yet, animals cannot survive unless they have organic material or its artificial substitute to feed upon. This organic material, which may come from plants or animals, may well be dead before it is seized and ingested, but it still contains the fruits of the immediate metabolism of plants, which animals cannot duplicate.

If instead, inorganic nutrients could suffice for animal survival, animals' distinguishing mediated metabolism would be obviated. The inorganic nutrients on which animals do partially depend are generally available. Air is omnipresent on the surface of the planet and mixed with waters near their surface, whereas water surrounds all sea life. Immediate osmosis would replace the effort of mediated metabolism and evolution would have no excuse for giving rise to anything so superfluous as an animal organism.

Living things are not everywhere and, whether they be plant or animal, whatever feeds upon them must be sufficiently endowed to perceive their location at a distance, motivate itself to move towards them, and begin the process of ingestion, from which digestion follows. In every case, the animal food chain rests upon metabolizing what has been immediately metabolized.

The process of assimilation, however, depends first upon the animal making use of its sentience. This requires sense organs, whose modalities reflect the different types of physical properties that identify what an entity may be. Those enthusiasts of early modern philosophy who deny the reality of secondary qualities might wonder how animals could navigate a world in which the only objective properties are the spatiotemporal determinations of tasteless, odorless, silent, colorless matter. Physics, however, can overcome the limits of mechanics and constitute objective processes in which taste, odor, sound, and color consist, not to mention density, elasticity, heat, magnetism, and electric charge.[51] Animal life can hardly ignore these physical features so long as any of its nutrients or any of its prospective mates and offspring can be distinguished by these features. Animal life must therefore develop sensory organs that can sense the physical properties that serve to identify what must be perceived and sought after in order to survive and reproduce. The modes of sensory organs are not unlimited, despite the different ranges of sensitivity and physiological configuration each may take. What define the types of possible sense organs are the types of differentiating physical features that make manifest the objects of metabolism.

Whatever be the sensory apparatus of an animal, it must employ it to sense and locate the nutrients it requires. Hegel describes this endeavor as a theoretical process insofar as it can proceed at a distance without significantly altering the object of perception.[52] This theoretical perception must also include awareness of the basic environmental conditions with which mediated metabolism must cope. These include sensing gravity, cohesion, and heat, all of which may condition how the animal must move through its biosphere.[53] In addition, the theoretical process of the senses must kindle desire and the practical feeling to seek out and ingest the needed nutrients.

With desire and emotion arising in the animal, its practical relationship to the objects of its metabolism gets underway. Hegel still invokes the confrontation with inorganic nature to characterize this practical relation.[54] Admittedly, many animals must seek out water and mineral nutrients, just as some, such as marine mammals, must make a concerted effort to reach and breathe the air they need. Since, however, animal metabolism cannot escape dependence upon organic nutrients, the practical relationship of assimilation must meet the challenge of perceiving, seizing, and ingesting live plants and/or animals and/or their remains. Here animal irritability enters in in response to the centralized sensitivity of perception and as enlivened by desire and emotion.

Hegel construes the ensuing practical relationship as the working of instinct.[55] As Hegel notes, the practical relationship of assimilation operates on the basis of a feeling of lack that only animals can have. This feeling of lack precipitates the emotion to undertake an effort since an urge is the activity of overcoming the defect that is felt.[56] Plants cannot have such feeling, not only because they have no centralized sentience, emotion, and motility, but because their needs are continually being satisfied through their immediate metabolism. Due to animals' mediated metabolism, they are driven by the urge to survive, and this urge, as initially merely *subjective* in form, that is, as only in the living being, is *instinct*.[57]

Why call this urge, this emotion that is felt by the animal, instinct? First of all, the urge in question is given by the species being of the animal, whose specific nature endows it with certain nutritional needs, as well as with a specific sensory, emotive, and motor physiology. The urge is not acquired through any process of learning, nor is it something conventional, depending upon the choices of rational animals and the mores of their community. It is instead a purely natural practical feeling common to all animals insofar as they have desires for and urges to obtain what meets their biological requirements. What particular content instinct has depends upon the specific anatomy and metabolic requirements of the animal. These are inheritable, with the exception of those requirements arising from new mutations that cannot be passed down to offspring.

The instinctual urge to overcome the lack rooted in the metabolic requirements of the animal is directed at specific objects of satisfaction and motivates specific behaviors that reflect the sensory and motor endowments of the animal and the environment to which it must respond. Formally speaking, the realization of instinct proceeds from the subjective feeling of the urge to the motivated effort that aims at fulfilling it. This process is formal insofar as it applies to all urges or instincts, without entailing any particular ones.

Instinct, however, always entails particular behaviors of various sorts since it is directed at real objects of satisfaction and mobilizes the real physiology of a particular animal. Breathing, drinking, and eating entail specific behaviors in each animal. The perception of the object of satisfaction itself involves particular actions to orient the sense organs. So too does the movement towards the source of nutrition, as well as the seizure and mechanical preparation of food for ingestion and digestion. All of these species specific behaviors follow upon species specific urges. More elaborate instinctual behaviors include the great migratory journeys of animals to seasonal food sources that cannot be found locally. They also involve what Hegel describes as the "constructive instincts" of animals that modify their environment to facilitate their survival, such as beavers that build damns and birds that build nests.[58] Even relationships between animals of different species can fall under the sway of instinct, as in the case of symbiotic relations and the less mutual affair of ants who cultivate other insects as prey.

As Hegel warns us, instinct cannot be properly understood if it is equated with an external teleological relationship, where an agent imposes form upon some material to produce a functional product. Nor can instinct be understood in the mechanistic terms of behaviorism, where dispositions are acquired through the efficient cause of reflex repetitions with indifference to the nature of the animal. Instinct instead partakes of the *inner* teleology by which the living organism acts as an end in itself, operating so as to sustain its own life activity.[59]

For this reason, instinct does not operate as a conscious purposive activity, in which an agent chooses among ends and then plans how to realize them. Conscious agency has no determinate connection of itself to what purpose the conscious agent aims. The conscious agent is free to opt for any purpose the agent may choose, whether or not it can be successfully achieved. Moreover, the purpose need not be bound up with the survival of the agent. By contrast, instinct is an urge whose content is mandated by the survival needs of the animal. The animal does not choose what instincts it has. It rather immediately feels the urge to take the action instinct demands the moment it feels a lack that its own zoological nature impels it to overcome. The instinct is not imposed upon the animal by some conscious agent any more than it is acquired through learning or training. The urge of instinct is built into the animal.

This does not mean, however, that in fulfilling an instinct, the animal always acts unconsciously or without choosing between different behaviors or improvising. A rat in a maze may be driven by an urge to obtain food, but the movements it makes can vary as the rat tries out different paths to reach the end motivating its activity. It is not responding mechanistically to given stimuli, but is rather motivated to find some route to an object that it lacks. Any behaviorist account stumbles in trying to identify what exactly is the stimulus to which an animal responds. In Quine's behaviorist account of language this dilemma gives rise to an indeterminacy of translation, exhibited by how repeated association of a word with the appearance of a rabbit cannot itself tell us whether that word refers to a rabbit, the white of the rabbit, the rabbit at a particular place, and so forth.[60] So too, with a rat navigating a maze one is stumped to decide whether the animal turns in response to a red spot on a wall, the background of the spot, the location of the spot, or something else. Once one acknowledges the inner teleology of instinct, these problems can be left behind.

Animals find themselves driven by their instincts to perform activities of the most challenging and complicated sort, such as the migratory exploits of butterflies and birds and the communal empire building of social insects. Indeed, as Konrad Lorenz observes, the survival of animals is most ensured when such stupendous behaviors are rooted in instinct, rather than having to be learned and remembered. Then, the animal can rely upon "a vast amount of phylogenetically acquired information stored in the genome".[61]

Lorenz here acknowledges an important point that Hegel's account neglects. Animal behavior may be driven by instinct, but that does not mean that certain animals cannot learn and improvise and use these capabilities to fulfill their metabolic needs. Rational animals may invent all sorts of artificial means to satisfy their biological requirements, but rational animals can equally rise above their instincts and ignore them entirely. We, who can individually or collectively commit suicide, possess a reason that can hardly be trusted as the most reliable guide to survival. Kant acknowledges this unreliability in his *Groundwork of the Metaphysic of Morals*, where he observes that if we supposed that "for a being possessed of reason and a will the real purpose of nature were his *preservation*, his *welfare*, or in a word his *happiness*", then "the end in question could have been maintained far more surely by instinct than it ever can be by reason."[62]

The unconscious purposiveness of instinct leads animal metabolism to its concluding stage – the digestion of nutrients. The various sub-systems of animal anatomy now allow the products of digestion to circulate throughout the body or be expelled as needed. With this, as in all forms of metabolism, the organism returns to itself in exchanging material with its biosphere. After all its efforts, the animal now comes back to itself in that its interaction with externality ends up sustaining the animal individual as the goal of its own activity. Digestion finalizes how the animal's relation to other has become its own self-production to the extent that self-preservation is the maintenance of an ongoing life activity that never remains with a fixed material.[63]

Animal Reproduction

Hegel's account of the animal genus process is not just about sexual reproduction. He does address the sexual reproductive relation of animals, but he also examines the diversification of animal species and disease and death.[64]

The connection of these topics is significant and plausible. The sexual reproduction of animals can be considered primary to the diversification of animal species on two accounts. First, every animal species will contain members who engage in reproduction or else face impending extinction.

Second, animal reproduction is the basis for the evolution of animal species, provided that the genetic materials of animals mutate and that the most adaptive mutations survive as new species, from which further mutations may arise and engender more speciation. Hegel does address how animal species diversification reflects adaptations to different external conditions, including geological habitat, climate, and the presence of and interaction with other organisms.[65] He does not, however, explicitly discuss the evolution of animal species. Nor does he insert a discussion of species diversification in his treatment of plant reproduction. There is, however, nothing about the processes of animal diversification that do not apply to plant speciation. In both cases, reproduction can give rise to mutations, whose adaptation to external conditions leads to the emergence of new species and the extinctions of others. The same could be said about Hegel's third section, which addresses disease and death. These biological processes also apply to plants and there is no reason for philosophical botany to omit addressing them. Moreover, disease and death confront any animal and do not depend upon speciation, although both may impact upon the emergence of new species and the persistence of any.

Hegel's account presumes that the animal genus process depends upon sexual reproduction. When Hegel developed plant reproduction, he also acknowledged a role for sexual reproduction, but he considered it both superfluous and underdeveloped.[66] Plant sexual reproduction is superfluous insofar as the incomplete subjectivity of plant life renders each part of the plant a potential independent individual, such that growth coincides with reproduction. Plant sexual reproduction is undeveloped insofar as it occurs without any sexual feeling and urge, but simply by the production of male and female genetic materials, whose unification depends upon external conditions, such as wind or fertilizing insects and birds. Since plant reproduction cannot and need not involve any consummating effort by plants, there is no place for sexual feeling and sexual urges in plant life.

The genus being of animals, like that of any other organism, depends upon the reproductive generation of a plurality of individuals composing a group of the same kind. The most basic life forms achieve this through the asexual reproduction where an organism divides itself in two, generating two organisms of identical genetic inheritance. Asexual reproduction is preeminently the domain of single-celled organisms, which undergo cell mitosis to affirm their species being. There can be some life forms that are composed of many single-celled organisms, which come together and act like an organism with differentiated functions. These can reproduce the whole through asexual mitoses followed by a re-aggregation of the single cells into two comparable colonies.

If, alternately, reproduction could not occur asexually, the initial prospects of life in any biosphere would be dim. Once life forms initially emerge, it is much easier for a single organism to replicate itself through division than for it to encounter another organism that is endowed with the precise biology to mate and produce offspring. It is enough of a challenge for the biosphere to happen upon the right concoction of chemicals to produce the first minimal life form, but life faces a tremendous obstacle if it can only reproduce sexually. Thanks to asexual reproduction, unicellular organisms can arise and reproduce for eons, gradually acquiring the cumulative fruit of endless mutations until finally life forms evolve that can sexually reproduce.

Whether or not unicellular organisms can ever sexually reproduce, multi-cellular life forms present a virtually insurmountable challenge for asexual reproduction. This is because not only must each of the differentiated cells reproduce, but their integrated unity must be replicated. Sexual reproduction can produce an embryonic cell that can divide into connected cells that further divide and differentiate themselves until a new multicellular adult arises. To the extent that plants and animals are multicellular, both can avail of sexual reproduction. The necessity for sexual reproduction is greatest for animals, since, unlike plants, they have no other means of reproducing. Consequently, animal reproduction is the preeminent arena of sexual reproduction, in which the full development of sexual desire, urge, and effort can occur.

Admittedly, sexual reproduction can take multiple forms, each of which can take adaptive advantage of the continual generation of offspring with largely unique new mixtures of genetic materials. Sexual reproduction can involve separate male and female animals of the same species, but it can also involve hermaphrodites, animals which have both male and female reproductive cells and the means of fertilizing them. If the hermaphroditic animal reproduced simply be relying upon its own male and female reproductive cells it would not be able to avail of the wider genetic diversity that insemination with another animal provides. Hermaphrodites could, however, reproduce with other hermaphrodites of the same species and enjoy that advantage. In that case, however, the hermaphroditic duality would lose any adaptive purpose and would likely fall prey to evolutionary elimination.

On the other hand, animal species with separate male and female organisms could evolve to become transgendered when this transformative ability favors reproductive success. Certain fish are known to change their sex when they face a paucity of potential partners of the opposite sex. This ability to transgender themselves has obvious adaptive advantages.

Although Hegel may not acknowledge all the possibilities of animal sexual reproduction, he is not without reason in presuming that animal reproduction is sexual rather than asexual, and that the animal genus process is the arena in which sexual urge and mating behavior can develop.

Hegel speaks about the sexual process of urge and mating behavior in terms of the same feeling of lack that underlies the instinct to fulfill the needs of mediated metabolism.[67] The sexual urge is an instinct just like the urge to eat and drink and sexual animals have that urge by nature. Hegel does not address the full spectrum that such an urge can take, from heterosexual to homosexual to bisexual. Although homosexual and bisexual urges do not in and of themselves contribute to reproduction, they can just as well be an instinctual urge addressing a lack of their own. So long as these urges do not preclude their bearers from passing their genetic material down to further generations, animal species can continue to contain a variety of instinctual sexual orientations.

Like the instinct to drink and feed, the sexual instinct can be fulfilled with a wide range of behavior, some of it learned and improvisational in character. Sexual behavior need not be accompanied by any knowledge on the part of the animals that their mating is responsible for producing offspring. All that is required is that the sexual act strives to overcome a felt lack. Nor need mating be accompanied by any enduring relationship between the sex partners. Some animal species may have an urge to enter into enduring relationships, but many may be happy to move on.

Moreover, sex partners need not feel the urge to care for any offspring they produce, so long as this does not compromise the survival chances of the species. If nurturing behavior is instinctual, it will reflect the needs of offspring for continuing care by at least one, if not both, of its parents or of some other adult.

Evolutionary selection will mandate that the sexual urge to reproduce with another animal will have to be directed at other members of at least the same species or of other species with which the participating animals are able to generate viable offspring. Generally, there can be no evolution of species unless there are some limits on with what other animals an animal can mate and produce offspring. Otherwise, species divisions can never emerge. This proviso for limited range of mating possibilities has implications for what specific sexual urges each type of animal will have. Mutations may alter such urges, but whether those alterations become prevalent depends on how they impact upon successful reproduction.

Hegel describes the offspring that results from the sexual relation as an "asexual life", as the "realized genus".[68] The offspring is asexual to the extent that it is the product of the resolved sexual tension from which mating proceeds. The offspring is the realized genus insofar as the parents have realized their species being by producing another organism of their kind. Of course, the offspring has a sexual identity of its own that will give rise to urges to engage in sexual activity with others of a determinate sexuality.

Hegel adds a further determination that follows from the sexual relation: the death of the mating animals.[69] This becomes thematic in the third section, addressing the relation of the genus to the individual animal.[70] Hegel acknowledges that only in certain lower animals does death directly result from the act of copulation. Higher animals survive mating, but, like all animals, and, indeed, all organisms, they fall prey to disease and death. The genus survives the demise of its particular members, but their individual species being is inherently subject to a more transient existence, save when the death of the last animal of a species brings its genus to an end.[71]

To the extent that animals, not to mention plants, are mortal, they will eventually die after reproducing. Generally, the genus does have an existence that is independent of any particular individuals that belong to it, save when extinction looms. The genus has a universal being that its individual members never possess. They are just immediate individuals, none of which can count for the genus itself. This individuality applies to the "asexual" product of their reproduction, which is just another individual potentially subject to all the same sexual urges.

Hegel suggests that the genus process which is realized in reproduction logically combines what goes on in formation and in assimilation.[72] In the internal complementary process of formation the organism reproduces itself in the self-sustaining complementary functioning of its organs. In the metabolic process of assimilation, the organism relates to what is not itself so as to reproduce or sustain itself as an individual. In sexual reproduction, the organism relates to another like itself in order to reproduce another of its kind. Hegel characterizes the offspring as "the negative identity of the differentiated individuals and is as realized genus, an asexual life."[73] Why call it a "negative identity"? The genus is that in which the individuals are united, but also left behind. Their unity is, after all, manifest in a separate offspring. They are left behind because their unity lies outside them, in something different from themselves, even though they and their offspring are of the same kind. Moreover the reproducing animals eventually die. The life of the genus goes beyond their own lives to persist in the transient lives of other organisms of the same kind. The genus is like, Hegel observes, a spurious infinity, which keeps on going from one individual to the next without ever arriving at anything more durable.[74] Because the offspring is equally just another individual organism, the genus is not identical to it. The genus is that which consists in the ongoing process whereby individuals generate other individuals and pass aside through their deaths. Death is thereby just as much the culmination of the genus process.

Hegel roots death in the discrepancy between the universality of the genus and the immediate individuality of each organism. No organism is ever fully identical to its genus and this, Hegel maintains, is the root of its mortality.[75] In the sexual relation this discrepancy is felt in the urge of each individual animal to unite with its sexual partner.[76] In the genus process, this discrepancy is made manifest in the affirmation of the genus through the transient passage of its immediate individual members.

There is, however, an evolutionary explanation of mortality that helps buttress Hegel's suggestion that death is bound up with the genus process. First of all, if individual organisms did not die, their reproduction would intensify the competition over resources and push their genus more likely towards extinction. Secondly, whenever members of a genus undergo adaptive mutations that enhance survival, these will only be able to supplant the less adaptive forms if those give way their place by dying. Evolution provides a biological basis for organisms to be mortal and not live forever. It is not just that individual living things are subject to external contingencies that put their lives in jeopardy. Rather, there is something inherent in their evolutionary emergent character which makes death an internal eventuality. It is no accident that cells have a structure that limits how many times they can undergo mitosis. This genetically determined feature naturally effects the mortality of the whole organism to which such cells belong. It serves the purpose of maintaining the genus, in all its protean plasticity, by insuring that the less adapted forms pass from the scene.

Life is a sickness unto death and Hegel has reason to conclude his account of life in its most developed animal form with a discussion of disease and the long good bye.

Disease, he observes, cannot afflict what is inanimate, for sickness strikes at the health of an organism, whose self-sustaining complementary functioning becomes impeded when disease strikes.[77] Hegel initially characterizes the state of disease as involving an internal imbalance, where particular organs or organ systems begin acting against the unity of the organism due to some stimulation arising from opposition to the inorganic forces of its biosphere.[78] This arises from a "disproportion between irritation and the capacity of the organism to respond".[79] The ills of exposure to too much heat or cold, or radiation, or injurious chemicals can all obstruct the complementary functioning of organ systems. On the other hand, sickness can arise from particular external factors that affect particular organs.[80]

Hegel never directly identifies such external factors as other livings things. Nor does Hegel mention infections due to the intrusion of microorganisms, but one can incorporate infectious disease within the framework of his account, at least insofar as infectious disease disrupts the internal workings of the organism. The same can be said of cancer, be it caused by inorganic carcinogens, infectious microbes, or the accumulation of genetic mistakes in reproducing cells. It too causes illness by obstructing the complementary functioning of organs.

All these forms of disease apply to plants as well as animals. Hegel, does however, add a further form of disease that is exclusive to animals. This, he says, originates in the universal subject, the soul that permeates the entire animal organism.[81] Terror, grief, and other mental extremes can traumatize the animal so that it not only falls ill, but may even die. Hegel notes that such mental disease occurs especially in man,[82] but insofar as all animals have some degree of mind, the ills of trauma need not be confined to rational animals.

Many of these diseases can be cured, but one affliction is beyond alleviation. This is the inevitable mortality of the animal organism. Perhaps unicellular life forms achieve a relative immortality through their successive asexual reproductions. Animal life, like multicellular plant life, has no such opportunity. Animals cannot escape the big sleep. This is not due to the astrophysical developments that will lead stars to burn out and galaxies to collapse into black holes until the next big bang produces new biospheres. Rational animals may someday engineer their escape from their doomed solar systems and migrate to other planetary systems. These escapes will not, however, allow individuals to transcend their mortality physiologically.

Hegel ends his account of the genus process under the rubric of the "self-induced destruction of the individual".[83] If the organism can escape destruction at the hands of external forces, it will bring about its own demise from old age.[84] Hegel once more attributes this inevitable self-annihilation to the disparity between the universality of the genus and the immediate individuality of the animal or plant.[85] This disparity is the "*original disease*", the "inborn *germ of death*",[86] for which there can be no cure.

Nature can offer nothing new in the annals of natural history once all the possible forms of animal life confront their mortality. At this juncture, the philosophy of nature hands the baton of reason to the philosophy of rational agency, which Hegel called the "philosophy of spirit". The time has come to consider how rational animals can develop language and thought,[87] enact the conventions of culture, and produce a history that natural evolution leaves undetermined. This is not the unique preserve of homo sapiens, but the arena of humanity in the broadest sense of rational animals of any species being. Within a universe in which history has at last erupted, we can become not just pregnant in body, but "pregnant in soul"[88] and seek immortality in deeds and creations worth remembering forever.

Notes

1. Hans Jonas, *The Phenomenon of Life*, pp. 99–107.
2. Hegel, *Philosophy of Nature*, §350–376, pp. 351–445.
3. Hans Jonas, *The Phenomenon of Life*, p. 99.
4. Examples of plants rooted in water are hydroponically grown plants, and examples of plants rooted in air are those like Spanish moss, that attach themselves to trees but draw in nutrients and moisture from the air.
5. Hans Jonas, *The Phenomenon of Life*, p. 99.
6. Hans Jonas, *The Phenomenon of Life*, p. 99.
7. For an account of how thought and language arise, see Richard Dien Winfield, *The Intelligent Mind: On the Genesis and Constitution of Discursive Thought* (Houndmills, UK: Palgrave Macmillan, 2015), pp. 108–203.
8. See Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel: The Philosopher's Guide to the Universe*, for a detailed thinking through of this progress.
9. Hans Jonas, *The Phenomenon of Life*, p. 99.
10. Hans Jonas, *The Phenomenon of Life*, p. 99.
11. Hans Jonas, *The Phenomenon of Life*, p. 100.
12. Hans Jonas, *The Phenomenon of Life*, p. 100.
13. Hans Jonas, *The Phenomenon of Life*, p. 100.
14. Hans Jonas, *The Phenomenon of Life*, pp. 101–102.
15. Hans Jonas, *The Phenomenon of Life*, pp. 101–102.
16. Aristotle, *De Anima*, Book II, Chapter 3, 414a29–414b19, in *The Basic Works of Aristotle* – Volume One, pp. 659–660.
17. Hegel, *Philosophy of Mind*, §471–472, pp. 230–231.
18. Hegel, *Philosophy of Mind*, §426–429, pp. 167–170.
19. Hans Jonas, *The Phenomenon of Life*, p. 100.

20. Hans Jonas, *The Phenomenon of Life*, p. 101.
21. Hans Jonas, *The Phenomenon of Life*, p. 107.
22. Hans Jonas, *The Phenomenon of Life*, p. 104.
23. Hans Jonas, *The Phenomenon of Life*, p. 104.
24. Hans Jonas, *The Phenomenon of Life*, p. 105.
25. Hans Jonas, *The Phenomenon of Life*, pp. 105–106.
26. Hans Jonas, *The Phenomenon of Life*, p. 105.
27. Hans Jonas, *The Phenomenon of Life*, p. 106.
28. For a systematic account of ethical love, see Richard Dien Winfield, *The Just Family* (Albany, NY: State University of New York Press, 1998).
29. Hegel, *Philosophy of Nature*, §350–376, pp. 350–445.
30. Hegel, *Philosophy of Nature*, §350, p. 350.
31. Hegel, *Philosophy of Nature*, §351, p. 352.
32. Hegel, *Philosophy of Nature*, §351, p. 353.
33. Hegel, *Philosophy of Nature*, §351, p. 352.
34. Hegel, *Philosophy of Nature*, §351, p. 353.
35. Hegel, *Philosophy of Nature*, §351, p. 353.
36. Hegel, *Philosophy of Nature*, §352, p. 356.
37. Hegel, *Philosophy of Nature*, §352, p. 356.
38. Hegel, *Philosophy of Nature*, Zusatz to §370, p. 423.
39. Hegel, *Philosophy of Nature*, §354, p. 359.
40. Hegel, *Philosophy of Nature*, §354, p. 359.
41. Hegel, *Philosophy of Nature*, §354, p. 359.
42. Hegel, *Philosophy of Nature*, §354, p. 359.
43. Hegel, *Philosophy of Nature*, §354, p. 360.
44. Hegel, *Philosophy of Nature*, §354, p. 360.
45. Hegel, *Philosophy of Nature*, §354, p. 360.
46. Hegel, *Philosophy of Nature*, §354, p. 360.
47. Hegel, *Philosophy of Nature*, §354, p. 360.
48. Hegel, *Philosophy of Nature*, §355, p. 372.
49. Hegel, *Philosophy of Nature*, §355, p. 372.
50. Hegel, *Philosophy of Nature*, §357, p. 380.
51. For a detailed consideration of these physical qualitative features and associated processes, see Winfield, *Conceiving Nature after Aristotle, Kant, and Hegel: The Philosopher's Guide to the Universe*, pp. 273–352.
52. Hegel, *Philosophy of Nature*, §357a, p. 381.
53. Hegel, *Philosophy of Nature*, §358, p. 382.
54. Hegel, *Philosophy of Nature*, §359, p. 385.

55. Hegel, *Philosophy of Nature*, §360, p. 388.
56. Hegel, *Philosophy of Nature*, §360, p. 388.
57. Hegel, *Philosophy of Nature*, §360, p. 388.
58. Hegel, *Philosophy of Nature*, Zusatz to §365, p. 407.
59. Hegel, *Philosophy of Nature*, Remark to §360, p. 389.
60. Willard Van Orman Quine, *Word and Object* (Cambridge, MA: the MIT Press, 1960), pp. 29–46.
61. Konrad Lorenz, *Behind the Mirror: A Search for a Natural History of Human Knowledge*, trans. by Ronald Taylor (New York: Harcourt Brace Jovanovich: 1977), p. 99.
62. Immanuel Kant, *The Groundwork of the Metaphysic of Morals*, trans., H. J. Paton (New York: Harper & Row, 1964), 395, pp. 62–63.
63. Hegel, *Philosophy of Nature*, Remark to §366, p. 409.
64. Hegel, *Philosophy of Nature*, §367–376, pp. 410–419. Here Hegel addresses the sexual relationship first, then species diversification, and finally disease and death. In the German Suhrkamp *Werkeausgabe* Edition of Hegel's collected works, the order of treatment is different. There the speciation of animals comes first, followed by the reproductive sexual relationship, and then animal sickness followed by animal death. See G. W. F. Hegel, *Werke 9 – Enzyklopädie der philosophischen Wissenshcaften II* (Frankfurt am Main: Suhrkamp, 1970), §367–376, pp. 498–539.
65. Hegel, *Philosophy of Nature*, §370 (§368 in 3rd edition of the *Encyclopedia*), pp. 415–426.
66. Hegel, *Philosophy of Nature*, §348, Zusatz to §348, pp. 342–349.
67. Hegel, *Philosophy of Nature*, §368(§369 in 3rd edition of the *Encyclopedia*), p. 411.
68. Hegel, *Philosophy of Nature*, §369 (§370 in 3rd edition of the *Encyclopedia*), p. 414.
69. Hegel, *Philosophy of Nature*, Zusatz to §369 (§370 in 3rd edition of the *Encyclopedia*), p. 414.
70. Hegel, *Philosophy of Nature*, §371–376, pp. 418–445.
71. Throughout I am using "genus" and "species" interchangeably since Hegel's account of the genus process is equivalent to the species process whereby organisms reproduce and produce offspring of the same type.
72. Hegel, *Philosophy of Nature*, Zusatz to §368, p. 412.
73. Hegel, *Philosophy of Nature*, §369 (§370 in 3rd edition of the *Encyclopedia*), p. 414.

74. Hegel, *Philosophy of Nature*, §369 (§370 in 3rd edition of the *Encyclopedia*), p. 414.
75. Hegel, *Philosophy of Nature*, §369 (§370 in 3rd edition of the *Encyclopedia*), p. 414.
76. Hegel, *Philosophy of Nature*, §368 (§369 in 3rd edition of the *Encyclopedia*), p. 411.
77. Hegel, *Philosophy of Nature*, Zusatz to §371, p. 429.
78. Hegel, *Philosophy of Nature*, §371, p. 428.
79. Hegel, *Philosophy of Nature*, Zusatz to §371, p. 429.
80. Hegel, *Philosophy of Nature*, Zusatz to §371, p. 431.
81. Hegel, *Philosophy of Nature*, Zusatz to §371, p. 431.
82. Hegel, *Philosophy of Nature*, Zusatz to §371, p. 431.
83. Hegel, *Philosophy of Nature*, §375, p. 441.
84. Hegel, *Philosophy of Nature*, Zusatz to §374, p. 441.
85. Hegel, *Philosophy of Nature*, §374–375, pp. 440–441.
86. Hegel, *Philosophy of Nature*, §375 p. 441.
87. For an account of how mind becomes rational, see Richard Dien Winfield, *The Living Mind: From Psyche to Consciousness* (Lanham, MD: Rowman & Littlefield, 2011), and Richard Dien Winfield, *The Intelligent Mind: On the Genesis of Discursive Thought* (Houndmills, UK: Palgrave Macmillan, 2015).
88. Plato, *Symposium*, 209a1, in Plato, *Complete Works*, p. 491.

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Index

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