Substance and Organism-as-a-Whole: A Correlation Between Aristotelian-Thomistic Metaphysics and Contemporary Holistic Biophilosophy

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The last few decades have witnessed a proliferation of literature about various topics in bioethics, especially those concerning the margins of life: issues both at the beginning-of-life and the end-of-life. Some of these topics, such as abortion and brain death (BD) and its connection to organ donation-transplantation, have been subjects of intractable contention, involving both academia and the public sphere. Within academic circles, such contentious issues have drawn in scholars not only from diverse disciplines (including medical sciences, philosophy, ethics, and law, among others) but also from divergent traditions and worldviews, of which two prominent categories are the secular materialist and the Judeo-Christian theistic worldview.

Ethical discussions on issues at the margins of life inevitably touch on the crucial metaphysical questions about human nature and personhood. In this regard, the investigation of any bioethical issue, if it is to be thorough, entails a triangular approach that is inherently interdisciplinary.[1] This approach begins with a critical examination of the empirical evidence. It then moves "upward" to a coherent philosophical discourse on the nature of human beings, and finally arrives at an ethical conclusion that is objectively and logically valid. This diversity in

[1] Doyen Nguyen, *The New Definitions of Death for Organ Donation: A Multidisciplinary Analysis from the Perspective of Christian Ethics* (Bern: Peter Lang, 2018), 496.

disciplines and traditions is a positive contributory factor to bioethical investigations. However, part and parcel with such diversity are several impediments with respect to scholarly discourse. A typical example of such impediments is medical scientists' lack of familiarity with philosophical anthropology, and conversely, philosophers' and theologians' limited ability to assess the validity of certain medical or scientific claims. In some instances, it is assumed without sufficient reflection that certain medical or scientific claims are established factual truths.[2]

The problem is further accentuated by the lack of a common philosophical language in the discourse on human nature. There exists a "gap" between the Scholastic language of the Aristotelian-Thomistic tradition and that of modern and contemporary philosophies. On the one hand, the Aristotelian-Thomistic doctrine of hylomorphism and substantial form remains the most coherent account of the nature of corporeal living things (including human beings) and the nature of their changes (substantial and accidental changes).[3] On the other hand, the concept of substantial form has been under attack ever since the time of Descartes, such that today

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[2] For instance, in the brain death (BD) controversy, medical scientists who argue that BD is death *simpliciter* have insistently claimed that brain-dead individuals are dead but only appear alive because the ventilator masks death. Not a few Catholic philosophers, theologians, and ethicists have embraced this "masking death" argument seemingly out of deference to medical expert opinion. See President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, *Defining Death: A Report on the Medical, Legal and Ethical Issues in the Determination of Death* (Washington, DC: USGPO, 1981), 22, 33, 35–36; Antonio Battro et al., *Why the Concept of Brain Death is Valid as a Definition of Death: Statement by The Pontifical Academy of Sciences*, (Vatican City: 2008), 13. However, the "masking death" argument is metaphysically and scientifically flawed for the simple reason that a thing cannot provide what it does not have, otherwise known as the principle of proportionate causality. The ventilator, even when supplemented with pharmacological agents, only supplies air to the lungs; it is not involved in the process of oxygenating the blood. It also plays no role in a myriad of physiological functions such as homeostasis, circulation, assimilation of nutrients, and excretion of waste, among others. If the ventilator could mask death, then connecting it to the corpse of a person whose death was established by traditional criteria, should cause what it is alleged to be capable of, to make the corpse appear alive. This does not happen, however. See Nguyen, *New Definitions of Death*, 92–97.

[3] Even some theologians of the Protestant tradition, which for centuries has rejected Scholastic philosophy, have come to recognize that the Thomistic substance view of human nature is superior to the Cartesian or Lockean approach. See J. P. Moreland and Stan Wallace, "Aquinas Versus Locke and Descartes on the Human Person and End-of-Life Ethics," *International Philosophical Quarterly* 35, no. 3 (1995); John Moreland and John Mitchell, "Is the Human Person a Substance or a Property-Thing?" *Ethics & Medicine: A Christian Perspective on Issues in Bioethics* 11, no. 3 (October 1995).

Aristotelian-Thomistic anthropology is notably underutilized in bioethical debates, except by some Catholic scholars.[4]

Inherent in the Cartesian mind-body dualism is the mechanistic view of life whereby "the body is nothing else but a statue or machine made of earth,"[5] which implies that the body can be treated as an object (a property-thing) to undergo manipulations as we see fit. Descartes's ideas, subsequently further developed by scientists and philosophers, have led to a rise in a materialistic and mechanistic approach to living organisms and, concomitantly, accelerated progress in the biological and medical sciences.[6] The fundamental tenet of mechanistic thinking, still prevalent today especially in the medical field, is that the whole is equal to the sum of its parts. Consequently, the approach for studying the biological sciences has been: (i) to reduce a complex whole to its components (the reduction process can be repeated as far as possible to the microscopic and molecular levels), (ii) investigate their properties; and (iii) on this basis, explain the complexity of the whole by postulating that such and such a mechanism accounts for an observed phenomenon (e.g., a life process) of the complex whole.[7] The mechanistic approach thus entails both reductionism and a linear-causal paradigm of bottom-up causality whereby

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[4] Examples of Catholic scholars who refer to Aristotelian and/or Thomistic anthropology in their writings (most of which revolve around the brain death controversy) include Michel Accad, Nicanor Austriaco, Jason Eberl, Patrick Lee, Melissa Moschella, and Doyen Nguyen. The degree of engagement with Aristotle and/or Aquinas varies from cursory (e.g., Lee, Moschella) to extensive (e.g., Eberl, Nguyen). Two of the authors also have experience in systems biology (Austriaco, Nguyen).

[5] René Descartes, *L'Homme et la Formation du Foetus*, ed. Claude Clairsellier (Paris: Theodore Girard, 1677), paragraph II, page 1. The original text in French reads: "*le corps n'est autre chose qu'une statue ou machine de terre*."

[6] Examples of notable figures of the mechanistic approach during the 18th-20th centuries include: (i) Julien de La Mettrie (1709-1751) who wrote *L'Homme Machine*; (ii) Claude Bernard (1813-1878) who, in his *Introduction à l'étude de la médecine expérimentale,* insisted that all biological processes are governed by deterministic physicochemical laws; (iii) Jacques Loeb (1859-1924) who wrote *The Mechanistic Conception of Life*, and (iv) Francis Crick (1916-2004) who in his work, *The Astonishing Hypothesis: The Scientific Search for the Soul*, asserted that the human person is nothing more than a pack of neurons and their molecules.

[7] James A. Marcum, *The Conceptual Foundations of Systems Biology: An Introduction* (New York: Nova Science Publishers, 2009), 17; Andrew C. Ahn et al., "The Limits of Reductionism in Medicine: Could Systems Biology Offer an Alternative?" *PLOS Medicine* 3, no. 6 (2006): 709, https://doi.org/10.1371/journal.pmed.0030208.

some fundamental parts (or one critical part) determine or control the organism's complex biological processes and functions. Such an approach necessarily presupposes that the parts are ontologically anterior to the whole, which is true only of non-living things and artefacts.

Within this climate of accelerated progress in mechanistic biology, a number of scholars in natural sciences came to recognize that life and organisms cannot be reduced to the idea of a machine, especially as they rediscovered the teaching of Aristotle. Among these scholars were two notable pioneers: (i) Edward Russell (a philosopher in biology) who applied Aristotle's *De Generatione Animalium* as the starting point for his work on developmental biology and heredity,[8] and (ii) Ludwig von Bertalanffy (a biologist turned philosopher) who attributed the notion of "the sum is greater than the parts" to Aristotle, and credited it as instrumental to his general systems theory.[9] The result has been a gradual shift from reductionism and mechanism to an approach of systems biology based on organismic holism and synergism,[10] which, in essence, is a return to the basic traditional principles for the study of natural sciences prior to the scientific revolution in the 16th-17th centuries. As Konopka has stated, "the term 'system' signifies here an entity that represents wholeness, which can be superficially divided (fractioned) into components (parts) but whose pivotal properties cannot be fully explained solely from the knowledge or the parts."[11] Systems biology is not about a collection of facts, but rather a way of thinking "that can be traced back to … the writings of Aristotle."[12] Fundamental concepts, namely, those concerning "whole and parts" relationships, have remained essentially the same despite changes

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[8] Edward S. Russell, *The Interpretation of Development and Heredity: A Study in Biological Method* (Oxford: Clarendon Press, 1930). The first chapter in Russell's book, after the Introductory chapter, is on Aristotle's '*De Generatione Animalium*.'
[9] Marcum, *The Conceptual Foundations of Systems Biology*, 4.
[10] Marcum, *The Conceptual Foundations of Systems Biology*, 2.
[11] Andrzej K. Konopka, "Basic Concepts of Systems Biology," in *Systems Biology: Principles, Methods, and Concepts*, ed. Andrzej K. Konopka (Boca Raton, FL: CRC Press, 2007), 1.
[12] Konopka, "Basic Concepts of Systems Biology," 1.

in methodologies which have generated new scientifico-philosophical concepts, such as the notion of organism-as-a-whole (OW)—which will be discussed in detail below. The terminology OW, which has occasionally appeared in the current bioethical literature, is part of the language of contemporary holistic biophilosophy (CHB).[13]

As a multidisciplinary field, CHB seeks to reappropriate the principles of Aristotle's philosophy of nature in light of scientific advances in biology.[14] The question arises whether the Aristotelian-Thomistic doctrine of hylomorphism and the new knowledge of CHB can be "merged" together to circumvent the aforementioned problems with scholarly discourse. As to be shown in this paper, the traditional and the contemporary system share several important points of contact and complement one another to make such "merging" possible. If put into practice, this will result in a robust scientifico-philosophical account of the human being grounded in realism to shed light on current bioethical controversies about the margins of life.

Overview of the Aristotelian-Thomistic Substance View of Organisms

In contrast to the prevailing philosophical trends (heirs to the Cartesian-Lockean school of thought) which define human personhood on the basis of certain mind- or brain-dependent

[13] In this paper, the terms systems biology, systems thinking, and contemporary holistic biophilosophy (CHB) are used interchangeably.

[14] Some CHB scholars consider their field to be a "revolution" from reductionism. But other scholars (many of whom are biologists) who refer to Aristotle in their writings, such as Bothwell, Grene, and Mayr, recognize that the principles used in CHB for explaining biological systems have their origins in Aristotle's biological works (e.g., *History of Animals* and *Generation of Animals*). In CHB, the study of a biological system (an organism) aims to elucidate four key properties: (i) the physical parts of the organism, (ii) how the parts relate or connect to each other, (iii) the various conditions which produce changes in the organism and through which it develops, and (iv) its teleological property, understood in the sense of the organism becoming what it is designed to be (an acorn to become an oak tree), as well as its adaptation to other organisms and its physical environment. These four key properties correspond to Aristotle's four causes (four different accounts to explain a biological system), material, formal, efficient, and final. Note, however, that CHB understands the formal property only in the sense of physical form. See John H. F. Bothwell, "The Long Past of Systems Biology," *New Phytologist* 170, no. 1 (2006); Ernst Mayr, "Cause and Effect in Biology: Kinds of Causes, Predictability, and Teleology Are Viewed by a Practicing Biologist," *Science* 134, no. 3489 (1961); Marjorie Grene, "Aristotle and Modern Biology," *Journal of the History of Ideas* 33, no. 3 (1972).

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qualities such as consciousness and the capacity to feel pain,[15] the Aristotelian-Thomistic view of personhood is grounded in human nature itself. This means that a human person and a human being are coextensive and, therefore, the idea of a human non-person is inconceivable. In this traditional view, the definition of man combines two concepts: (i) man is a rational animal,[16] and (ii) a person is an individual substance of a rational nature.[17] On the most basic level, man is a human substance whose nature includes both the animal and rational dimensions; on account of the latter, man is a person.

The notion of man as a substance rests on the Aristotelian-Thomistic doctrine of hylomorphism, according to which every corporeal living thing is a substance with two aspects, matter and form. Here, form refers not to sensible form (e.g., shape and size) but to the substantial form of a living organism (plant, animal, man), which Aristotle also refers to as the soul. Defined as that which unites with matter, and "shares its being and perfection with matter, actualizes the potencies of matter and, together with matter composes a definite [living] material

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[15] Secular philosophers and ethicists who defend and promote abortion and/or brain death hold views that can be traced back to Cartesian or Lockean thinking. For example, Mary Ann Warren (who defends abortion) argues that human embryos and fetuses are human in the genetic sense, but they are not persons (and, therefore, have no moral rights) because they lack the required characteristics of personhood (consciousness, reasoning, self-motivated activity, the capacity to communicate an indefinite variety of topics, and the presence of self-concept). See Mary Anne Warren, "On the Moral and Legal Status of Abortion," *The Monist* 57, no. 1 (1973). Similarly, pro-brain death scholars who advocate "higher brain death" (e.g., John Lizza, Ronald Cranford) also insist on consciousness and cognitive function as the defining characteristics of personhood. They argue that the permanent loss of consciousness has the same significance as the loss of cardiopulmonary function and, therefore signifies death. See Ronald E. Cranford and David Randolph Smith, "Consciousness: The Most Critical Moral (Constitutional) Standard for Human Personhood.," *American Journal of Law & Medicine* 13, no. 2-3 (1987). The brain death paradigm practiced in the United States is "whole brain death." Undergirding this paradigm is James Bernat's rationale of the brain as the master integrator of the body. See James L. Bernat, Charles M. Culver, and Bernard Gert, "On the Definition and Criterion of Death," *Annals of Internal Medicine* 94, no. 3 (March 1981). Bernat's rationale exalts the status of the brain over the rest of the body, as if the brain were an entity in its own right and not part of the body. In brief, the materialist brain-body dualism of the "whole brain death" paradigm is nothing but a variation of Cartesian dualism, in which the status of the brain is inappropriately exaggerated as if it were the organ of ensoulment.

[16] Thomas Aquinas, *Commentary on the Metaphysics of Aristotle*, trans. John Patrick Rowan (Chicago: H. Regnery Company, 1961), Book VII, Lectio 3, no. 1326.

[17] Thomas Aquinas, *Summa Theologiae* [*ST*], trans. Fathers of the English Dominican Province (New York: Benziger Bros., 1947), I, q. 29, a. 1. According to Aquinas, there are three different types of persons: divine persons, angelic persons, and human persons. The common characteristic joining these different levels of persons is rationality.

substance or natural body,"[18] the substantial form/soul of a living organism is the immanent active principle that "makes a thing [an organism] to exist absolutely;"[19] and makes it what it is. The soul is thus the formal cause of the organism, making it a corporeal living whole of a particular species: "a human soul animates a man, a lion soul animates a lion, and a lima bean soul animates a lima bean plant."[20] In other words, the soul of a corporeal living thing is both its principle of life and that which determines its nature, its unity, and its identity. This necessarily implies that the soul is the principle which determines the developmental trajectory of the organism from the beginning of its existence until death and,[21] as such, the principle which accounts for the somatic integration and continuing existence of the organism, maintaining it in a state of dynamic stability, both structurally and functionally.

In the context of hylomorphism, i.e., the union of matter and a substantial form, the notion of matter refers not to sensible matter (secondary matter), such as a lump of bronze matter or a block of marble, but *prime* matter. Unlike the various kinds of secondary matter which are already informed by their respective substantial forms, prime matter is pure potency which cannot come into existence without being actualized by a substantial form.

> [Prime matter is] without any form whatsoever, nor subject to any privation, … but it is wholly receptive of any form whatsoever. It is the completely undifferentiated basic material of the physical universe. It is not something, in the sense of something or other, but it is not nothing either. It is the closest there is in the universe to nothingness without being nothingness, since it has no features of its own but for the potential to receive substantial forms. … It is changeless, but is the support of all substantial change, and as such is subject to numerical identity, so that prime matter is conserved throughout substantial change.[22]

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[18] Bernard Wuellner, *A Dictionary of Scholastic Philosophy*, 2nd ed. (Milwaukee, WI: The Bruce Publishing Company, 1966), 106.
[19] *ST* I, q. 77, a. 6.
[20] Nicanor Austriaco, "Immediate Hominization from the Systems Perspective," *National Catholic Bioethics Quarterly* 4, no. 4 (2004): 730.
[21] Most organisms reproduce sexually, especially higher and more complex organisms such as mammals. Organisms with sexual reproduction come into existence at the moment of fertilization.
[22] David S. Oderberg, *Real Essentialism*, Routledge Studies in Contemporary Philosophy; 11, (New York: Routledge, 2007), 72.

Just as prime matter can never exist by itself without a substantial form, form is never existent unless instantiated in matter, except in the case of man in which the human soul can subsist disembodied (an unnatural condition) in the intermediate state between death and the universal resurrection. Regarding man, it has been entrenched in our language to say 'the union of body and soul,' but this metaphysical concept needs to be understood more precisely as the 'union of primary matter and soul.' As pointed out by Aquinas, "the soul … places man in a determinate species of substance, no other substantial form intervenes between the soul and prime matter."[23] This last notion is known as the unicity of form: an organism of a particular kind comes into being by virtue of one and only one substantial form; that organism ceases to exist when it loses that form (i.e., when death occurs).

The Aristotelian-Thomistic substance view of nature also includes a general hierarchical distinction between living things according to their substantial forms, whereby the form of the higher and more complex being also possesses the functions of the lower forms: (i) a plant is animated by its particular type of vegetative soul and, therefore, possesses vegetative functions; (ii) an animal is animated by its particular kind of sensitive (sensorimotor) soul, endowing it with both vegetative and sensorimotor functions; (iii) a human being is animated by a human rational soul which possesses both vegetative and sensorimotor functions, in addition to intellect and will. Aquinas speaks of the human soul as follows:

> The first principle by which the body lives is the soul. And as life is manifested through various operations among the different degrees of living things, that by which we primarily perform each of all these vital actions is the soul. For the soul is the primary principle of our nourishment, sensation, and local movement; and likewise of our understanding.[24]

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[23] Thomas Aquinas, *Quaestiones Disputatae de Anima*, trans. John Patrick Rowan (St. Louis: N. Herder Book Company, 1949), a. 9.
[24] *ST* I, q. 76, a. 1.

These diverse activities of life manifest the three fundamental capacities/powers of the human soul – vegetative, sensitive (sensorimotor), and intellective – related to one another in a strict ontological hierarchy, in which the lower power is the precondition for the existence of the higher powers. Both the intellective and sensorimotor powers need the vegetative power as a necessary prerequisite, but not vice versa, because the vegetative is the foundational power of the soul in virtue of which all living things have life.[25] Under normal conditions, the presence of the vegetative power is manifest through a whole host of vegetative functions (from the molecular to the macroscopic level) working together to maintain the organism integrated and alive.

To sum up, the soul accounts for the intelligibility of the organism and every aspect of its existence from its integrative unity and identity, to its structural and functional properties. The Aristotelian-Thomistic system thus provides a *holistic* vision of human persons expressed in terms of substance. As formulated by Norris Clarke in contemporary language, a substance possesses the following four fundamental characteristics:

> (1) [A substance] has the aptitude to exist in itself and not as a part of any other being; (2) it is the unifying center of all the various attributes and properties that belong to it at any one moment; (3) if the being persists as the same individual throughout a process of change, it is the substance which is the abiding, unifying center of the being across time; [and] (4) it has an intrinsic dynamic orientation toward self-expressive action, toward self-communication with others, as the crown of its perfection, as its very *raison d'être*.[26]

The characteristic most relevant to bioethical debates on the margins of life is that substance grounds the identity of the human person throughout his/her existence all the while undergoing various organic physical changes ('accidental changes' in Scholastic language) of growth,

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[25] Aristotle, *De Anima: Books II and III (with Passages from Book I)*, trans. David W. Hamlyn (Oxford: Clarendon Press, 2002), II.414b28-32.15a24-5; Doyen Nguyen, "Why the Thomistic Defense of 'Brain Death' Is Not Thomistic: An Analysis from the Perspectives of Classical Philosophy and Contemporary Biophilosophy," *The Thomist* 82.3 (July 2018): 417.

[26] W. Norris Clarke, *Explorations in Metaphysics: Being–God–Person* (Notre Dame, IN: University of Notre Dame Press, 1994), 105.

development, and senescence. With the rejection of substantial form ever since Descartes, Locke, and Hume, the term substance is rarely used in bioethical debates, however. What is used instead, is the biophilosophical notion of 'organism-as-a-whole' (OW).

The Contemporary Holistic Biophilosophy View of Life and Organisms

The Biophilosophical Notion of the Organism-as-a-Whole

Contemporary biophilosophy includes two broad strands: (i) the reductionist-mechanistic school (heir to Cartesian thinking) according to which the parts account for the whole, i.e., the "higher-level properties and laws of a system [are] determined by (hence reducible to) the properties and laws of its components," and (ii) the holistic school (systems thinking) according to which the whole accounts for the parts.[27]

The terminology and concept of OW is shared by both schools. An OW is defined by the following four characteristics: (1) it is an independent living unit completed in itself and not a part of a greater living whole; (2) the *biological finality* of the OW is its own self-preservation, the *telos* to which all life processes and functions of its subsystems and organs are directed; (3) it is indivisible, i.e., it cannot be divided to produce two or more living organisms; and (4) growth and senescence does not change its identity over the course of its existence; it remains one and the same even after having suffered the (non-fatal) loss of some of its parts, whether physically or functionally.[28] As Bernat points out, "individual subsystems may be replaced (such as, by pacemakers, ventilators, pressor) without changing the status of the organism as a whole."[29] Thus, the OW is not the same thing as the whole organism. The whole organism *only* refers to

[27] Martin Mahner and Mario Bunge, *Foundations of Biophilosophy* (Berlin: Springer, 1997), 40.
[28] Nguyen, *New Definitions of Death*, 62.
[29] Bernat, Culver, and Gert, "On the Definition and Criterion of Death," 390.

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the sum of its parts; it is a static and quantitative concept. The notion of OW is a dynamic concept; it includes the network of numerous complex and ordered mutual interactions between the parts, all of which produce gradual biological changes in the organism.[30]

The above definition of OW echoes Norris Clarke's formulation of substance. Both refer to a living system which (i) exists in itself and not as part of any other being and (ii) which maintains its integrative unity and, therefore, its identity, throughout its existence while it continuously undergoes a particular trajectory of physiological changes according to its species and under the influence of its environment. An example of this kind of change in human beings is the acquisition of brain functions during fetal development, or conversely the loss of brain functions and consciousness due to dementia or severe brain injury. That the end of the OW consists in operations aimed at its own self-preservation also echoes the traditional view that "operation is the end of the creature."[31]

Unlike the Aristotelian-Thomistic substance view, the contemporary notion of OW says nothing about the formal causality which accounts for the intelligibility of the OW. This lacuna – the lack of a modern concept equivalent to the substantial form – has been the result of the combined Cartesian mechanistic thinking and scientific revolution which only retain material and efficient causality as explanatory principles in scientific disciplines, while discarding both formal and final causality. With the gradual shift from mechanistic to systems thinking during the 20th century, CHB has recovered final causality – understood in the sense of biological teleology (as used in Aristotle's study of nature) according to which every living thing has a

[30] The following example illustrates the difference between a whole organism and an organism-as-a-whole (OW). At age 22, Mr. A was a healthy soldier with all of his body parts in good condition. At age 25, he was sent to the frontline where he suffered severe injuries: he lost one leg, one arm, an eye, and the left lung. The whole organism that Mr. A was at age 25 is not the same as the whole organism that he was at age 22; the sum of the parts has changed. However, Mr. A remained the same person (his identity has not changed) despite having lost several body parts. In other words, the OW that Mr. A was at age 22 is the same as the OW that he was at age 25.
[31] *ST* I, q. 105, a. 5.

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telos, a mature form toward which it grows and develops if the process is not impeded by some lethal external interference.[32] However, CHB has not recovered formal causality because the scientific community, despite recognizing that life and organismic integration go hand in hand, has not accepted the idea that an immaterial something (some mysterious vital force) is the causal principle of life and of organismic integration.

The conceptual understanding of the OW according to systems thinking, to be discussed further below, diverges vastly from that of the reductionist-mechanistic school. The mechanistic view rests on material causality and postulates that the OW is determined by one of its parts, a dominant or critical part. A first example in this regard is genetic determinism (which fueled the Human Genome Project), the view that the organism's genes (the genotype) determines its phenotype, its capacities, as well as its physiological and behavioral tendencies.[33] A second example is BD, i.e., death by neurologic criteria (DNC), according to which the brain, because it is irreplaceable, is both (i) the critical organ controlling all other bodily systems and, as such, the organ responsible for the integration of the human OW and, (ii) the seat of rational potencies, such that the permanent loss of whole brain functioning signifies that death has occurred.[34] Here, the status of the brain is exalted over the body as if it were an independent entity, a material stand-in for the human soul and not part of the body. However, as Accad pointed out, a material part, whether the brain or any other organ, cannot be the 'central integrator' to account for the integration of the human OW, because

> the material part causing the integration would have to be directly controlling all other parts of the body to prevent them from being subject to forces of nature pulling them away from the body. A

[32] Grene, "Aristotle and Modern Biology," 397.
[33] Marcum, *The Conceptual Foundations of Systems Biology*, 23.
[34] Stephen Napier, "Brain Death: A Morally Legitimate Criteria for Determining Death?," *The Linacre Quarterly* 76, no. 1 (02/01/ 2009): 73; Julius Korein, "The Problem of Brain Death: Development and History," *Annals of the New York Academy of Sciences* 315, no. 1 (November 1978): 24; James L. Bernat, "The Definition, Criterion, and Statute of Death," *Seminars in Neurology* 4, no. 1 (1984): 48.

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> question would then arise: how does the integrator itself remain integrated? It cannot be its own cause of integration, since an external agent is necessary for efficient causality. Another part would have to integrate the integrator, in which case this other part takes precedence as 'central integrator,' setting up an infinite regress.[35]

Corporeal life and integration go hand in hand. The passage quoted above echoes Aquinas's teaching, that "nothing corporeal can be the principle of life."[36] The common thread in both aforementioned examples is reductionism: in the first view, man *is* his genes; in the second, man *is* his brain.

Organism as-a-Whole: An Anti-Entropic, Autopoietic Living System with Dynamic Hierarchical Organization

The shift from mechanistic thinking to holism and systems thinking began with pioneer thinkers in the 19th and 20th centuries who rediscovered the sharp distinction between living and non-living things which Descartes had blurred. Two of the thinkers in the 20th century played a significant role in laying the groundwork to CHB, even though their works encountered disparagement from the mechanistic school.

The first was Edward Russell, who advanced the two cardinal rules for the study of biological sciences, namely, that "*the activity of the whole cannot be fully explained in terms of the activities of the parts isolated by analysis* […and] *no part of any living unity and no single process of any complex organic activity can be fully understood in isolation from the structure*

[35] Michel Accad, "Of Wholes and Parts: A Thomistic Refutation of 'Brain Death'," *The Linacre Quarterly* 82, no. 3 (August 2015): 222. Integration applies only to corporeal living things because they are constituted of different parts which, as already recognized by the ancient Greeks and Aristotle, are composed of opposite elements (fire, water, earth, air) that, on their own, will not remain together, let alone function together harmoniously. Aristotle's notion of substantial form provides a coherent account of how a living thing is what it is, i.e., how its different parts are held together structurally and work together harmoniusly. They can only be integrated structurally and functionally by something that does not belong to the physical/material order, i.e., the soul. Integration does not apply to the soul because it is not composed of material parts.

[36] *ST* I, q. 75, a. 1.

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and activities of the organism as a whole" (italics original).[37] These two cardinal rules echo the classical notion of substance as that which "bears accidental properties and exists as a deeply unified whole that is ontologically prior to its parts."[38] Both rules allude to the axiomatic principle that the organic whole is ontologically prior to its parts and greater than the sum of its parts. The corollary to this is that no part can account for the organic whole, and a part is intelligible only with reference to the living whole.

The second thinker was Joseph Woodger, a biologist, whose chief contribution included the notion of *Bauplan* (blueprint) and the concept of organismic dynamic hierarchical organization.[39]

Organismic Dynamic Hierarchical Organization

According to Woodger, every OW is a "four-dimensional entity with temporal as well as spatial extension."[40] The temporal dimension refers to the dynamicity of the OW which, at the macroscopic level, corresponds to the changes in growth, development, and senescence. At the sub-macroscopic level, this dynamicity refers to a web of interrelated life processes – occurring continuously throughout the body and involving an unceasing flux of molecules – necessary for keeping the organism integrated and functioning.[41] As pointed out by Woodger,

> the living organism is the seat of ceaseless activity, it is always *functioning*; secondly, its functions are always manifested through some material form; and finally, these functions, sooner

[37] Russell, *The Interpretation of Development and Heredity*, 147.
[38] The term 'properties' refers to the parts and their activities. John Moreland and John Mitchell, "Is the Human Person a Substance or a Property-Thing?" *Ethics & Medicine: A Christian Perspective on Issues in Bioethics* 11.3 (October 1995): 50.
[39] Joseph H. Woodger, *Biological Principles: A Critical Study* (London: K. Paul Trench Trubner, 1929); Joseph H. Woodger, "The 'Concept of Organism' and the Relation Between Embryology and Genetics. Part I," *The Quarterly Review of Biology* 5, no. 1 (1930); Joseph H. Woodger, "The 'Concept of Organism' and the Relation Between Embryology and Genetics Part. II," *The Quarterly Review of Biology* 5, no. 4 (1930); Joseph H. Woodger, "The 'Concept of Organism' and the Relation Between Embryology and Genetics. Part III," *The Quarterly Review of Biology* 6, no. 2 (1931).
[40] Woodger, "The 'Concept of Organism'," 10.
[41] Nguyen, *New Definitions of Death*, 371.

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> or later, directly or indirectly, have reference to the surrounding of the organism, that is to say, to its *environment* [italics original].[42]

The following two examples illustrate this 'ceaseless activity' in man and other mammalian species: (i) the uninterrupted blood circulation (pumped by the heart) to and from all the parts of the body, and, (ii) the continuous synthesis of adenosine triphosphate (ATP) by aerobic respiration in mitochondria throughout the body. The ceaseless activity thus consists of vital life processes and, as such, it is the foundation of biological life. That it is ceaseless also "most closely reflects the uninterrupted presence of the soul [in the OW] as the first act of the body."[43]

In terms of the spatial dimension, an OW is a hierarchically organized living system according to the specific *Bauplan* of its species.[44] As pointed out by Woodger, "an organism is an organism from the start … whereas the house is not a house until it is finished."[45] All complex organisms such as human persons begin life at as a single cell zygote. Successive levels of organization forming a hierarchy *emerge* as the zygote undergoes a developmental process according to its inherent *Bauplan* – a process in which non-genetic factors also play a role and which involves a complex series of cellular division, differentiation, and spatial organization following a certain temporal order. Organismic hierarchical organization thus arises from the organism itself. Such self-organization is a universal characteristic common to all living things.

While the notion of hierarchy in the usual usage of the term connotes control and dominion exercised by a particular member at the top of the hierarchy, the same term used in systems biology refers instead to the multilevel "nesting of systems within systems much like Russian

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[42] Joseph H. Woodger, *Elementary Morphology and Physiology for Medical Students: A Guide for the First Year and a Stepping-Stone to the Second* (London: Oxford University Press, 1924), 457.
[43] Nguyen, *New Definitions of Death*, 371.
[44] The *Bauplan* ('building plan' or 'blueprint') refers to the structural and morphological features that characterize a specific group of organisms. Though the notion of *Bauplan* evokes the Scholastic notion of form; it is not equivalent to the latter because it only refers to the physical form.
[45] Woodger, *Biological Principles*, 294.

dolls."[46] In oversimplified terms, a paradigmatic example of organismic hierarchical organization in a complex organism is as follows (in ascending order): the organization of cells into tissues, of tissues into organs, of organs into organ systems, and of organ systems into an OW. The summit of the hierarchy is thus the OW itself, and not the brain or any other organ. Hierarchical organization also exists within every cell, in the following descending order: from cell to organelles, i.e., the nucleus (containing chromosomes), the mitochondria, and other cytoplasmic organelles; from organelles to macromolecular systems (such as ordered protein arrays); and from the latter to macromolecules, such as nucleic acids and enzymes. Thus, as stated by Paul Weiss, any living organism can be represented as "a hierarchy of inscribed shells of subsystems of progressively lower orders of magnitude."[47]

> Each shell differ[s] from its outer and inner neighbor by some distinctive properties (e.g., composition and distribution of content, physical consistency, reactivity, etc.) ... For each shell, the adjacent ones are evidently "environment" in which they lie entrapped. None of the shells can ever be truly isolated. … Each can be described and understood solely in reference and in relation to its particular immediate environment with which it is in dynamic interaction. Since each part, in turn, constitutes environments for its neighbors, the true dynamics of an organism must be envisaged as [an] intricate web of interactions.[48]

In other words, hand in hand with a hierarchy of organizing structures is a hierarchy of organizing relations. At a given level (e.g., the level of tissues), a part is involved in different relations: (i) relations with other homologous and heterologous parts belonging to the same hierarchical level, (ii) relations with the upper level(s) of the organismic hierarchy, in particular, the relations with the "local" whole of which it is a part, (iii) relations with components of the lower level which constitute it, and (iv) relations with the non-cellular elements (including

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[46] John Mingers, "The Contribution of Systemic Thought to Critical Realism," *Journal of Critical Realism* 10, no. 3 (2011): 307.
[47] Paul A. Weiss, *Hierarchically Organized Systems in Theory and Practice* (New York: Hafner, 1971), 39.
[48] Paul A. Weiss, *The Science of Life: The Living System—A System for Living* (Mount Kisko, New York: Futura Publishing Company, 1973), 12.

nutrients and a supportive matrix) which are part of its natural organic environment.[49] From the perspective of any body part, the overall encompassing environment is the OW itself.

While its hierarchical organization of structures and mutual interrelations remain essentially unaltered, the OW undergoes constant changes (accidental changes) that are not visible to the naked eye, as the result of a continuous exchange of energy and matter with the environment (namely, absorption of nutrients and oxygen, and excretion of waste) which leads to a continuous replacement of molecules at the cellular level. Similarly, in some organs such as the skin, the lungs, and the digestive tract, proliferation and degeneration of cells continue throughout life; the standard pattern of structure and function of these organs remains unaltered despite the constant turnover of their respective cellular constituents. At a certain point, however, cell loss in tissues and organs exceeds cell proliferation. This phenomenon is a contributing factor to the physical symptoms of aging; it also occurs earliest in the nervous system since the multiplication of neurons ceases shortly after birth. The above-described dynamic hierarchical organization necessarily entails

> the differentiation of functional roles (i.e. division of labor) among the parts of a system and, at the same time, […] their integration and coordination as a whole. Furthermore, organization involves a generative dimension in the form of a mutual dependence, such that the very activity and existence of each organized part depends on its mutual relationship with the others.[50]

The following oversimplified sketch is a case in point to illustrate the mutual interdependencies among the parts:

> (i) every part in the human body depends on blood circulation to receive its required nutrients and eliminate its waste [in order to function properly]; (ii) but the blood itself must be pumped, hence its dependence on the heart; (iii) the blood must also be properly oxygenated and cleared of excess carbon dioxide; hence its dependence on the lungs; (iv) the inflation of the lungs, in turn, needs the activity of the diaphragm (and intercostal muscles); (v) the activity of the diaphragm

[49] Nguyen, *New Definitions of Death*, 373 (footnote 1165), 376.
[50] Matteo Mossio, Maël Montévil, and Giuseppe Longo, "Theoretical Principles for Biology: Organization," *Progress in Biophysics and Molecular Biology* 122, no. 1 (October 2016): 26.

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> requires the neural input from the midbrain respiratory center; and (vi) the latter, in turn, needs to be triggered by some increase of carbon dioxide in the blood.[51]

The above example demonstrates that the parts are linked in a closed dynamic network of interdependence in which each operation (a life process) triggers a subsequent one. This is referred to as the "*reticular or circular character of organization*" (italics original).[52] This pattern of organizational circularity (or operational closure) has been recognized to be a key characteristic of all living systems, from a simple unicellular organism such as an ameba to a highly complex mammal such as the human being. In a complex multicellular organism, operational closure is present at all levels, from the macroscopic level manifest in the dynamic interdependent relations between organs or organ systems down to the microscopic intracellular level manifest in the dynamic molecular network of biochemical processes. An example of operational closure at the intracellular level is the constant production of enzymes (especially those involved in the continuous processes of gene transcription and translation) which requires an existing template of the same specificity and entails several processes in an ordered sequence: the transcription of specific segments of deoxyribonucleic acid (DNA) into the corresponding segments of messenger ribonucleic acid (mRNA), the translation of these into the corresponding chains of amino acids, and the assembly of these into complex protein macromolecules. However, for these processes to occur at all, "they require, the specific cooperation of their own terminal products – the enzyme systems which, being indispensable prerequisites for all the links in the metabolic chains, including those for their own formation, thus close the circle of

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[51] Nguyen, *New Definitions of Death*, 373–74 (footnote 1166).
[52] Leonardo Bich and Luisa Damiano, "Life, Autonomy and Cognition: An Organizational Approach to the Definition of the Universal Properties of Life," *Origins of Life and Evolution of Biospheres* 42, no. 5 (October 2012): 392.

interdependent processes to a coherent integrated system."[53] Put simply, the synthesis of a protein X requires the involvement of ready-made protein X.

The connection of the parts in a network of interdependencies means that the interactions among the parts are guided by certain constraints such that they are ordered and harmonious at all levels. At the intracellular level, molecular processes follow an ordered sequence. The pattern of interactions within a cell differs from that between those same molecules in a test tube. This is because

> the heterogeneous population of molecules that constitutes a living cell does not have the unlimited degrees of freedom of interaction that it would have in the dispersed state of thermal agitation in a test tube solution. Evidently, the physical parameters of the intact cell constitute a dynamic framework which enables different species of the molecular population to aggregate or segregate, as the case may be, in separate chemical domains [in a way analogous to how] living beings on earth occupy niches in characteristic patterns of mutual relations determined by each ecosystem as a collective unit.[54]

The spatio-temporal hierarchical organization of the OW thus corresponds to a closed, complex, giant, and multidimensional reticular network of co-dependencies and nonlinear dynamics between its parts at all levels. Nonlinear interdependencies are characteristic of living things, in contrast to the linear causal chains typical of non-living things. It follows, therefore, that "no process or component can be considered as the starting point or control center to account for the autonomous dynamics of the organism."[55] This point, namely, that no constituent of the OW – be it the brain, the heart, the mitochondria, or the genes – can be the critical element that determines or accounts for the whole, has been repeatedly emphasized in CHB literature:

> Based on this nonlinearity [(the nonlinear dynamics)], causal control within a [living] system is not limited to one specific level within a hierarchy but rather distributed throughout a system or

[53] Weiss, *The Science of Life*, 37–38.
[54] Weiss, *Hierarchically Organized Systems*, 41.
[55] Nguyen, *New Definitions of Death*, 414.

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> network. Thus, identifying any one specific level as the center of causal control distorts any possible understanding of the overall system.[56]

That the 'causal control' is distributed throughout the OW necessarily signifies that (i) "the life of an organism is a global property, and cannot be ascribed to any single component,"[57] and, (ii) somatic integration is a non-localized phenomenon. This holistic understanding matches the Aristotelian-Thomistic hylomorphic notion that, because "the soul is united to the body as its form, it must necessarily be in the whole body, and in each part thereof."[58] This signifies the non-localization of the soul, i.e., the soul is everywhere in the body.

Included in the theory of organismic hierarchical organization is the notion of emergence, which provides a meta-scientific explanation for the synchronic relations between the parts or properties at the lower level and those at the higher level. Emergence refers to "the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems."[59] The following example illustrates the concept of emergence:

> An organ like the heart—composed of various cells and tissues—functions to pump blood throughout the body. Both the structure of the heart *qua* pump and its function *qua* pumping represent emergents, which are not reducible *in toto* to … cells and tissues or to the properties of those components. In other words, the heart and its ability to pump blood are a novel entity and a unique property *vis-à-vis* its … parts and their properties.[60]

On the one hand, emergents (the properties at higher levels) are constituted by and generated from the components and processes at the lower levels; on the other hand, "higher levels are not predictable from our knowledge of their constituent parts, and their operations are often …

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[56] Marcum, *The Conceptual Foundations of Systems Biology*, 6.
[57] Pier L. Luisi, "Autopoiesis: A Review and a Reappraisal," *Naturwissenschaften* 90, no. 2 (2003): 53.
[58] *ST* I, q. 76, a. 8.
[59] Jeffrey Goldstein, "Emergence as a Construct: History and Issues," *Emergence* 1, no. 1 (March 1999).
[60] Marcum, *The Conceptual Foundations of Systems Biology*, 46.

irreducible to the lower levels."[61] The notion of emergence thus reflects the axiomatic dictum that a living whole is greater than the sum of its parts and no part can account for the organic whole of which it is a part.

The significance of the dynamic hierarchical organization of structural parts and vital processes in living organisms is summed up in the following passage by Bertalanffy:

> The chief contrast between living and dead only comes to light when we no longer consider the single processes but the totality of all processes within an organism. … We then find that these processes do not proceed arbitrarily and independently, but are organized and harmonized in a definite way. This organization of the processes is the clearest, and indeed the only decisive distinguishing feature between the vital happenings and the ordinary physico-chemical processes. It is in this way that the events in the living organism are essentially distinguished from the reactions which occur in a weather-beaten stone or in a corpse.[62]

In a nutshell, the dynamic hierarchical organization is a distinctive feature separating the living from the dead. Another distinguishing characteristic is metabolism, to which the discussion no turns.

Metabolism: The Fundamental Phenomenon of Anti-Entropic Autopoiesis, Somatic Integration and Biological Life

Another important contribution to the holistic understanding of the OW comes from scientists who recognized that the most striking characteristic of life is that it runs counter to the second law of thermodynamics. According to this second law, every process in nature, including life processes occurring in living organisms, leads to an increase in entropy tending toward the permanent state of thermodynamic equilibrium, i.e., of maximum entropy. Entropy production is synonymous with the process of decay or degradation. As Schrödinger noted, every "living

[61] Niels Henrik Gregersen, "Emergence and Complexity," in *The Oxford Handbook of Religion and Science*, ed. Philip Clayton and Zachary Simpson (New York: Oxford University Press, 2006), 769.
[62] Ludwig von Bertalanffy, *Modern Theories of Development: An Introduction to Theoretical Biology*, trans. Joseph Henry Woodger (London: Oxford University Press, 1933), 48.

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organism continuously increases its entropy … and thus tends to approach the dangerous state of maximum entropy, which is death. … [Nevertheless, it succeeds] in delay[ing] the decay into thermodynamical equilibrium,"[63] thereby maintaining itself in a dynamic homeostatic condition. Life, expressed in thermodynamics terms, is biological anti-entropy.

The way any organism staves off entropy is self-evident: it does so "by freeing itself from the degraded energy it produces, and by utilizing free energy coming from [the] environment,"[64] i.e., by excreting waste and carbon dioxide into its surrounding, and by assimilating nutrients and oxygen coming therefrom. This continuous two-way communication with the environment is the fundamental phenomenon of life which involves a whole host of bodily functions (occurring at various organismic levels) and complex intracellular biochemical processes, and which Bertalanffy referred to as *metabolism* in the following passage:

> Every living organism is essentially an open system. It maintains itself in a continuous inflow and outflow, a building up and breaking down of components, never being, so long as it is alive, in a state of chemical and thermodynamic equilibrium but maintained in a so-called steady state which is distinct from the latter. This is the very essence of that *fundamental phenomenon of life* which *is called metabolism*, the chemical processes within living cells [italics added].[65]

Two important points can be drawn from the above passage: (i) metabolism is indispensable to life, and (ii) because it involves processes occurring in all cells of a multicellular organism, metabolism is a constitutive and immanent property of every OW.[66] The above text should not be construed as a reduction of the phenomenon of life to intracellular metabolic activity, however. As shown in an earlier quote, Bertalanffy (in reference to the dynamic hierarchical organization

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[63] Erwin Schrödinger, *What Is Life? and Other Scientific Essays* (Garden City, NY: Doubleday, 1956), 71, 73. An example illustrating the second law of thermodynamics is the following: a cup of hot tea placed in a cold room quickly loses its heat until its temperature equals that of the room.
[64] Pietro Ramellini, *Life and Organisms* (Vatican City: Libreria Editrice Vaticana, 2006), 81.
[65] Ludwig von Bertalanffy, *General System Theory: Foundations, Development, Applications* (New York: George Braziller, 1969), 39.
[66] Nguyen, *New Definitions of Death*, 381.

of the organism) indicated that the organization of the vital processes is the distinguishing feature between a living organism and a corpse.

Metabolism, understood in its fullest sense, entails exchange of energy and matter with the outside world, and the internal "use and budgeting of energy for bodily construction and maintenance, as well as behaviours."[67] Here, the term 'behavior' includes all the physical activities (internal and external) of the OW, irrespective of whether it is a simple unicellular or complex multicellular organism. As shown below, the significance of metabolism is multifold.

At the core of metabolism is the continuous production of the high-energy macromolecule adenosine triphosphate (ATP), the source of energy needed by all life forms. "Energy use allows organisms to resist entropic forces that would otherwise irreversibly damage the body's cells and disperse vital cell components (e.g., DNA) throughout the inanimate environment."[68] The synthesis of ATP is oxygen-dependent and takes place in mitochondria present in all cells throughout the body. Known as 'the power houses of the cell,' mitochondria are where fuel (pyruvate derived from glucose, and fatty acids) is converted into ATP via the complex process of oxidative phosphorylation in mitochondrial respiration. This activity of the mitochondria is continuous as cells do not store ATP. A byproduct of energy production is heat which, in a complex multicellular organism such as man, means bodily heat. Thus, a sign indicative that a person is alive is 'warm, pink flesh.' At death, as ATP production ceases and all vital functions completely stop beyond the possibility of resuscitation, the *earliest* sign occurring within

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[67] Margaret A. Boden, "Is Metabolism Necessary?" *The British Journal for the Philosophy of Science* 50, no. 2 (1999): 236.
[68] Jacquelyn Shaw, "Of Mitochondria and Men: Why Brain Death is Not the Death of the Human 'Organism as a Whole'," *McGill Journal of Law and Health* 7, no. 2 (2014): 266.

minutes of the death event is the rapid drop in temperature of the corpse to the level of the ambient temperature.[69]

The role of mitochondria is critical because

> [their] vast supply of energy fuels both cellular and whole organism activities. Most basically, vital homeostatic processes of cell growth, repair, and reproduction require constant energy to counteract the damaging, chaotic effects of entropy. Mitochondrial energy also makes possible other whole-organism 'emergent properties' such as whole-body movement, observed in the whole body but not at the cellular level, enabling threat evasion, food-seeking, or other self-sustaining activities. Another emergent process using large amounts of mitochondrial energy is neural activity, which permits sensory processing, reflexes, learning, communication, and consciousness. These whole-body, emergent properties require considerable energy and would be impossible without mitochondria.[70]

Hans Jonas recognized that metabolism plays a central role in maintaining the identity of a living organism throughout its life. As shown below in the next two sections, metabolism is involved in processes by which the OW "is never the same materially and yet persists as its same self, by not remaining the same matter."[71]

A. Metabolism and Autopoiesis

One of the principal anti-entropic works of the OW is the building (especially during the stage of growth and development) and maintenance of its biological hierarchical organization, which also includes repair and adaptation to perturbations (e.g., injuries and illnesses). To this end,

> [the OW] constantly produces within itself its own components including those which make up the boundary between itself and the external world. … The components which it produces internally are in turn integrated into the same dynamic network of ordered processes (or relations) which produces the components, and which constitutes the organism as a unity. In other words, the organism works by itself and for itself.[72]

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[69] Nguyen, *New Definitions of Death*, 415, 419.
[70] Shaw, "Of Mitochondria and Men," 272.
[71] Hans Jonas, *The Phenomenon of Life: Toward a Philosophical Biology* (New York: Harper & Row, 1966), 76.
[72] Nguyen, *New Definitions of Death*, 412.

This work, whereby the organism makes itself from within by metabolizing nutrients (obtained from its environment) to become its own constituents, is called "autopoiesis," a term coined by Maturana and Varela to emphasize the fact that the universal phenomenology common to all living systems is self-organization.[73] As an autopoietic system, "a living body … is wholly and continuously a result of its metabolizing activity … while it is also an agent of it."[74] Autopoiesis necessarily requires energy and thus depends on metabolism. It is an immanent property of the OW. An example of autopoiesis is the constant turnover of the cellular elements that comprise the semi-permeable boundary (such as the skin and mucosal lining of the gastrointestinal tract in humans) between the OW and the external world. At the cellular level, there is a continuous turnover of the lipid component of all cell membranes throughout the body.[75]

Three important points about autopoiesis deserve to be mentioned. First, the phenomenon of autopoiesis, though not referred to as such, was already known by Aquinas. Aquinas wrote:

> In a man's body while he lives, there are not always the same parts in respect of matter, but only in respect of species. In respect of matter there is a flux and reflux of parts: still that fact does not bar the man's numerical unity from the beginning to the end of his life. We have an example in a fire, which, while it goes on burning, is called numerically one, because its species remains, though the wood is burnt out and fresh wood supplied. So it is in the human body: for the form and species (kind) of the several parts continues unbroken throughout life, but the matter of the parts is dissolved by the natural heat, and new matter accrues by nourishment.[76]

Second, "autopoietic systems may have allopoietic components."[77] This statement of Maturana and Varela reiterates the understanding that being an OW does not exclude dependence on artificial devices. In other words, a human OW remains who he/she is even when

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[73] Humberto R. Maturana, "The Organization of the Living: A Theory of the Living Organization," *International Journal of Man-Machine Studies* 7, no. 3 (1975): 317.
[74] Jonas, *The Phenomenon of Life*, 76, footnote 13.
[75] Steven R. Goodman, *Goodman's Medical Cell Biology*, Fourth ed. (London, United Kingdom: Academic Press, 2021), 29.
[76] Thomas Aquinas, *Summa Contra Gentiles: Book IV, Chapter 81*, trans. Joseph Rickaby (London: Burns & Oates, 1905).
[77] Humberto R. Maturana and Francisco J. Varela, *Autopoiesis and Cognition: The Realization of the Living* (Dordrecht, Holland: D. Reidel Publishing Company, 1980), 68.

the individual becomes dependent on external devices such as the ventilator or feeding tube to provide him/her with oxygen and nutrients. Third, as pointed out by the same authors, "the establishment of an autopoietic system cannot be a gradual process; either a system is an autopoietic system or it is not. … There are not and cannot be intermediate systems."[78] Put differently, autopoiesis is an all-or-none phenomenon just as the phenomenon of life is.

B. Metabolism and Life Constitutive Integration

As repeatedly pointed out by scholars in CHB, life depends on metabolism because, as shown above, the latter is an essential requirement for "living bodies [to] organize and maintain themselves as integrated physical systems."[79] However, in the ongoing BD/DNC controversy, it has been repeatedly argued that the brain is the critical organ keeping the human organism integrated, such that the irreversible loss of all brain functions signifies somatic disintegration and, therefore, human death. In addition to the fact that a part cannot integrate the living whole of which it is a part because it is ontologically posterior to the whole, a second approach to show that this claim is untenable is to unpack the notion of integration. In this regard, Shewmon made an important contribution by recognizing that integration in the human OW consists of two broad categories: (i) life-maintaining integration, which comprises health-maintaining integration (HMI) and survival-promoting integration (SPI), and (ii) life-constitutive integration (LCI).[80]

As the more encompassing and foundational dimension of integration, LCI is that which "makes a body *to be* alive and *to be* a whole" [italics original].[81] LCI is the result of complex

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[78] Maturana and Varela, *Autopoiesis and Cognition*, 94. Francisco Varela, *Principles of Biological Autonomy* (New York: North Holland, 1979), 27.
[79] Margaret A. Boden, "Autopoiesis and Life," *Cognitive Science Quarterly* 1 (2000): 119.
[80] D. Alan Shewmon, "You Only Die Once: Why Brain Death is not the Death of a Human Being; A Reply to Nicholas Tonti-Filippini," *Communio* 39, no. 3 (Fall 2012): 435–41.
[81] Shewmon, "You Only Die Once," 435.

networks of fundamental metabolic activities throughout the body. The following is Shewmon's synoptic description of such metabolic activities:

> Biological anti-entropy involves crucial biochemical processes powered with energy generated, for the most part, by the oxidation of basic molecular substrates in mitochondria. It is an orderly process … consisting in innumerable highly complex and mutually influencing biochemical exchanges within and between all the cells throughout the body. … Long distance exchanges are accomplished by blood circulation (intravascular compartment), while short-distance exchanges occur in the extravascular compartment through diffusion, active and passive transport across cell membranes, etc. … The circulation also accomplishes critical energy-maintaining exchanges between the internal milieu and external environment, at specialized interfaces … (e.g., at the alveoli of the lungs, bringing in oxygen and eliminating carbon dioxide; at the intestinal lining, absorbing molecular substrates for eventual oxidation; at the glomeruli of the kidneys, eliminating soluble wastes, etc.).[82]

The above passage echoes Bertalanffy's understanding about metabolism and further underscores the fact that the fundamental dimension of life is the vegetative life present in all living things. Though operating in the background, so to speak, and being taken for granted until some serious illness/injury supervenes, LCI is the distinctive characteristic separating the living from the dead. Just like autopoiesis, LCI is an all-or-none phenomenon. As long as there remains sufficient numbers of cells throughout the body participating in energy production, LCI continues to be present.

The above paragraph also shows that, by virtue of its constituents and processes, LCI is immanent and dispersed throughout the body. As such, LCI reflects the non-localization of the soul which, as the substantial form of the body, is not "tied down" to any particular part or disposition of the body, but is present throughout the body to vivify the human OW. From the perspective of the doctrine of hylomorphism, the formal principle of LCI is the soul.[83] The

[82] Shewmon, "You Only Die Once," 436–37.
[83] *ST* I, q. 76, aa. 6–7.

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biophilosophical concept of LCI thus coheres with the Aristotelian-Thomistic understanding that the nutritive soul is the first power by virtue of which a natural thing is alive.[84]

In simplified terms, LCI is constituted by a network of interconnected complex processes involved in four crucial tasks indispensable to life:

> (i) energy production (including the generation of body heat), (ii) complex communication between all parts of the body, (iii) assimilation of oxygen and nutrients, and (iv) elimination of carbon dioxide and waste. The role of blood circulation, and by extension, that of its pump (the heart) are necessarily critical since blood is involved in at least three of the four tasks.[85]

Just as the vegetative power of the soul is the foundational precondition for sensitive and rational powers, LCI is the necessary prerequisite for HMI and SPI. HMI "keeps the organism's/organ's/cell's internal milieu optimal with a wide safety margin from death, [while SPI] has to do with goal-directed interactions with the environment."[86] HMI, just like LCI, also belongs to the vegetative level of integration; it involves a wide range of integrative functions, such as those of the pancreas or the immune system. The neuroendocrine function of the hypothalamic-pituitary axis in the brain is the sole instance of HMI involving the brain directly. The brain is otherwise only involved in SPI. This entails cognitive functions, sensorimotor functions (which require spinal cord-mediated integration), and modulating certain already existing integrative functions via the vagus nerve or the spinal cord. Maintenance of body temperature is an example of SPI. Here, the brain only functions as a 'thermostat-modulator' and not as a source of immanent body heat, which results from metabolic activity and mitochondrial production of ATP throughout the body. In addition to ample medical evidence showing that the

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[84] Aristotle, *De Anima: Books II and III (with passages from book I)*, trans. David W. Hamlyn (Oxford: Clarendon Press, 2002), Book II, 415a24-25; Thomas Aquinas, *Sentencia Libri De Anima*, trans. Kenelm Foster and Sylvester Humphries (New Haven, CT: Yale University Press, 1951), Book II, Lectio 7, no. 312.
[85] Nguyen, *New Definitions of Death*, 400.
[86] Shewmon, "You Only Die Once," 438–39.

brain does not mediate LCI,[87] the most overt evidence comes from human embryology. Every human being begins his or life as an integrated single-cell zygote that develops and grows into a multicellular embryo and subsequently a fetus with increasing structural and functional complexity according to its inherent species-specific *Bauplan* and environmental factors. Put differently, the constituents and processes necessary for LCI, the most fundamental aspect of integration that makes the organism simply to be alive and to be a whole, thereby resisting entropy, are already contained within the zygote. The neural tube (the earliest precursor of the brain and spinal cord) which is formed from the neural groove that appears around the third week after fertilization, does not close until around day 30. In the meantime, the cardiovascular system has already been formed and "cardiac contraction begins after 3 weeks."[88] In other words, the earliest precursor of the brain and spinal cord only comes into existence weeks after the human being has already come into existence and constituted as a fully integrated OW (initially as a zygote then as an embryo). In what way, then, can the brain be involved in LCI?

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[87] Some may claim that the brain plays a role in complex communication and regulation of carbon dioxide (CO_2) levels, and that these are the two crucial tasks of life constitutive integration (LCI). First, regarding neural communication, it is known that the whole of the nervous system (i.e., not just the brain but also the spinal cord) does not have influence on every part and constituent of the body (such the bone marrow, blood, and immune system, among others), whereas circulation does reach essentially everywhere. The few parts of the body without capillaries communicate with the nearest capillaries by diffusion. Second, the brain does not regulate CO_2 levels *per se*, rather the brain regulates the rhythm of breathing in response to the changes in blood levels of oxygen (O_2) and CO_2. The process is as follows: peripheral chemoreceptors located in the carotid bodies respond to the fluctuations in O_2 and CO_2 levels by sending signals to the neurons of the respiratory centers in the pons and the medulla (in particular, the pre-Bötzinger complex, a respiratory pacemaker). These neurons, in turn, send signals to the spinal cord, and the spinal cord sends signals to the diaphragm and intercostal muscles via the phrenic nerve and the nerves that innervate the intercostal muscles. These muscles contract, making the lungs expand and draw in air. The exhaling phase is passive as the muscles relax and the lungs return to their resting state. The role of the brain in breathing (which also involves other body parts besides the brain) is thus one of a modulator, which does not pertain to LCI but to the category of survival-promoting integration. Note that this role of the brain in regulating breathing does not even come into play in fetuses in utero. More importantly, breathing is not the same thing as respiration. Respiration, in the proper sense of the word, entails (i) exchange of O_2 and CO_2 across cellular membranes of the alveolar lining in the lungs and of tissues throughout the body, and (ii) complex processes of mitochondrial "respiration" in all cells of the body. The brain plays no role in these processes of respiration because respiration begins as the human being comes into existence as a unicellular zygote.

[88] Julius Korein, "Ontogenesis of the Brain in the Human Organism: Definitions of Life and Death of the Human Being and Person," in *Advances in Bioethics: New Essays on Abortion and Bioethics*, ed. Rem B. Edwards (Greenwich, CT: JAI, 1997), 14.

It can be intuited that the loss of SPI or HMI "does not make a [human OW] instantly, *ipso facto*, dead, [but] it will lead to premature death if not compensated for."[89] Medical progress has made it possible to provide substitutes or compensate (even if partially) for such loss, thereby allowing the individual to continue to live with variable degrees of disability. In contrast, because LCI is immanent and dispersed throughout the body,

> [it] is intrinsically and absolutely not substitutable. … Nor is it partially substitutable. … [Consequently,] no futuristic intensive care technology can prevent the increase in entropy (i.e., biological decay) if it is not endogenously opposed from the very life processes themselves of the living organism.[90]

The corollary to the above passage is that, based on the evidence drawn from science and biophilosophy, death results from the loss of LCI,[91] and not from the irreversible loss of all brain functions (however widespread its legal acceptance is throughout the world). To intuit what the loss of LCI signifies, suffice it to see the dramatic changes in a brain-dead donor before and after organ removal.

Complementarity between the Aristotelian-Thomistic Substance View and the Contemporary Holistic Biophilosophy View of Life and Organisms

The understanding about life and organism is enriched when one combines the new knowledge obtained from CHB with the sound tenets of Aristotelian-Thomistic metaphysics, especially since CHB follows the realist approach characteristic of both Aristotle and Aquinas. Not a few CHB scholars consider Aristotle as the first systems biologist whose main contribution consists in his biological works and his four-causal explanatory scheme: material, formal, efficient, and

[89] Shewmon, "You Only Die Once," 439.
[90] Shewmon, "You Only Die Once," 440.
[91] Doyen Nguyen, "Death: The Loss of Life-Constitutive Integration," *Diametros* 16, no. 60 (2018). https://www.diametros.iphils.uj.edu.pl/diametros/article/view/1244.

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final causes.[92] In a way, the pioneers of CHB (namely, Woodger, Russell, and Bertalanffy) emulated Aristotle: they were also biologists with practical experience who became philosophers, devoting themselves to theoretical biology.

Current literature in bioethics contains very few publications in which the traditional Scholastic metaphysics and systems biology are brought together. To this author's knowledge, there are two notable instances in this regard. The first is Austriaco's work on the beginning of life, which includes a synthesis of the systems perspective and Aristotelian-Thomistic hylomorphism into 'systems hylomorphism.' However, Austriaco's view of the human organism focuses primarily on the molecular level, as shown in the following passage:

> The more radical perspective offered by systems biology is to see the human organism as a dynamic, complex, and seamlessly integrated network not of organs nor of cells but of *molecules,* including DNA, RNA, lipids, and proteins, connected by reaction pathways which generate shape, mass, energy, and information transfer over the course of a human lifetime...The organism is seen here as a single, unified whole, a complex and dynamic network of interacting molecules that appear and then disappear in time. It is an embodied process that has both spatial and temporal manifestations [italics original].[93]

The second is this author's previous investigation of BD/DNC, examining it from both the Aristotelian-Thomistic substance view and the CHB view of life and organisms. What follows below is a synopsis of the correlation (previously made by this author) between the Aristotelian-Thomistic and CHB approaches.[94]

There are several important points of contact between the Scholastic and the CHB approach. First, according to the doctrine of hylomorphism, the soul is the first principle by which living

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[92] Ernst Mayr, "Cause and Effect in Biology"; Grene, "Aristotle and Modern Biology"; Marcum, *The Conceptual Foundations of Systems Biology*, 8. Note that the modern usage of the term "cause" is limited to the sense of "cause and effect." In Aristotelian-Thomisitic thinking, however, the four causes refer to four different ways of explaining something from four different aspects, perspectives, or levels.
[93] Nicanor Austriaco, "On Static Eggs and Dynamic Embryos: A Systems Perspective," *National Catholic Bioethics Quarterly* 2, no. 4 (2002): 661-62; Austriaco, "Immediate Hominization from the Systems Perspective," 722-23.
[94] Nguyen, *New Definitions of Death*, 420-25.

things have life,[95] and as such, it is always in act. In a parallel manner, both LCI and autopoiesis are uninterrupted phenomena which allow the OW to resist entropy and remain in a homeostatic condition, thereby staying alive. It would not be an exaggeration to think of a living organism as 'the seat of ceaseless activity.' In the human OW, a whole host of activities operate in an uninterrupted manner – activities which we take for granted and are not aware of, but which are foundational to life, including blood circulation, exchange of nutrients and waste, (as well as oxygen and carbon dioxide) across all cell membranes, and mitochondrial production of ATP, among others. Such biological functions manifest the presence of the soul in the body; their uninterrupted operations also closely mirror how the soul is always in act.

Second, according to Aristotle, every living thing

> must have the *nutritive* soul, from birth until death, for anything that has been born must have growth, maturity, and decline, and these are impossible without nourishment. The potentiality for *nutrition* must therefore be present in all things which grow and decline [italics added].[96]

Despite the rudimentary scientific knowledge of his day, Aristotle had the deep insight that the cornerstone of organismic life is nutrition. Likewise, Aquinas also intuited the phenomenon which CHB refers to as autopoiesis. Aquinas recognized that there is a continuous replacement of the material constituents of the parts of the body, but the "the form and species (kind) of the several parts continue unbroken throughout life" and the living organism retains its identity from the beginning to the end of its life.[97] The major contribution of CHB to the Aristotelian-Thomistic philosophy of nature is that it provides a more complete scientific picture of the complex phenomenon which Aristotle referred to as 'nutrition.' At the very least, this aspect of vegetative life corresponds to the CHB notion of biological anti-entropy. Organismic anti-

[95] Aristotle, *De Anima: Books II and III*, 413b1.
[96] Aristotle, *De Anima: Books II and III*, Book III, 434a22-26.
[97] Thomas Aquinas, *Summa Contra Gentiles: Book IV, Chapter 81*.

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entropy entails a web of complex processes that comprise metabolism, LCI, and autopoiesis, all of which are immanent and fundamental to life.

The additional knowledge from CHB should help us to develop a greater awareness of the indispensability of the vegetative dimension of human life – one that is too often disregarded in modern society, as evidenced by the legalized practice of euthanasia of individuals whose lives are deemed not worth living because they have lost cognitive functions and/or sensorimotor power. The relationship of vegetative life to the sensorimotor and cognitive dimensions of human life is analogous to *agere sequitur esse* because, without vegetative life, the organism simply does not exist. Conversely, as long as vegetative life is manifest in the human body, the human soul is present, and therefore, the individual in question is still a living human person.

Third, in more than one way, CHB has demonstrated that there is no master control center to account for the integration of the multitude of biological processes in the OW. Rather, integrative unity is a property of the organic whole, and not of any particular part. As previously mentioned, LCI is dispersed throughout the OW; it is present from the very start of the OW's existence. Somatic integration is thus a non-localized phenomenon, which in turn mirrors the non-localized presence of the soul in the body. With reference to the BD/DNC controversy, this is the most important point of concordance between CHB and the Aristotelian-Thomistic doctrine on hylomorphism: both refute the theory of the brain as the critical organ for somatic integration.

Fourth, the Scholastic system and CHB share the same understanding that the organic whole accounts for the parts because the OW is greater than the sum of its parts and ontologically prior to them. Based on this principle alone, it is self-evident that no organ can claim itself to be the one responsible for the integrative unity of the OW. Put simply, just as the body-soul union is not

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mediated by any organ or disposition,[98] neither is somatic integration mediated by any organ, as zygotes and embryos clearly demonstrate.

What CHB lacks is a metaphysical foundation. Since its inception, CHB has avoided addressing this fundamental question: what is the ultimate principle (the formal cause) which accounts for the innumerable complex biological phenomena observed in living organisms? However, the aforementioned points of contact show that CHB coheres with and fits squarely into the framework of Aristotelian-Thomistic metaphysics. Both complement each other: the latter provides the metaphysical foundation while the former provides a fuller picture about life and organisms based on recent scientific advances.

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[98] *ST* I, q. 76, aa. 6-7.