# *Articles*

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# *Immediate Hominization from the Systems Perspective*

Rev. Nicanor Pier Giorgio Austriaco, O.P.

## Introduction

Jean Porter has claimed that the apparent change this past century in the Catholic Church's position regarding the origins of the human person has left Catholics without a systematic metaphysical account that supports the fully personal status of very early-stage human embryos.[1] Her argument is relatively straightforward. Before the twentieth century, the Church officially taught that early abortion was not considered the killing of a human being—though it remained gravely evil—because the magisterium believed that the unformed fetus was not a human person in the full sense of the word.[2] According to Porter, this perspective was based, not

I would like to thank John Berkman, William E. May, Austin G. Murphy, O.S.B., and my Dominican brothers, Thomas Joseph White, Michael Dodds, O.P., and Basil Cole, O.P., for their helpful comments on earlier drafts of the manuscript. My research has been supported in part by a Calihan Academic Fellowship from the Acton Institute for the Study of Religion and Liberty. Their support is gratefully acknowledged. Address correspondence to: Rev. Nicanor Austriaco, O.P., Dominican House of Studies, 487 Michigan Ave., NE, Washington, D.C. 20017-1584. Email: austriaco@op.org.

[1]Jean Porter, "Is the Embryo a Person? Arguing with the Catholic Traditions," *Commonweal* 129.3 (February 8, 2002): 8-10.

[2]For an extensive history of the Catholic Church's teaching on abortion, see John R. Connery, S.J., *Abortion: The Development of the Roman Catholic Perspective* (Chicago: Loyola Press, 1977).

primarily upon flawed medieval embryology, but upon a metaphysical account of the human person grounded in the hylomorphic theory associated with Aristotle and St. Thomas Aquinas. More specifically, she maintains that this perspective logically flowed from the important metaphysical principle found in hylomorphism that matter has to be disposed to receive a particular kind of soul.[3] Hence, for both the Peripatetic Philosopher and the Angelic Doctor (and the Catholic Church which followed them), a human, rational soul cannot inform a body unless that body possesses a level of complexity and organization appropriate to that form of life. This is the theory of delayed hominization.[4]

In contrast, today, the Catholic Church, pointing to advances in the biological sciences for justification, teaches that procured abortion extending from conception to birth is murder.[5] Though the magisterium has not expressly committed itself to an affirmation of a philosophical nature regarding the ensoulment of the human person,[6] Porter argues—correctly, in my opinion—that this current perspective favors a theory of immediate hominization that attributes personhood to the earliest stages of human embryonic life. If this is true, however, has the Church, in implicitly rejecting the theory of delayed hominization, not also rejected the hylomorphism on which this theory stands? More specifically, Porter asks, has the Church, in favoring immediate hominization, not also rejected the metaphysical principle that matter has to be disposed to form? At first glance, the one-celled human embryo does not appear to be sufficiently organized to be disposed to the human form and so to have a

[3]Thomas Aquinas, *Summa Theologiae* (New York: Benziger Brothers, 1947), I. Q. 76.5, replies 1, 3.

[4]For a now classic exposition of the theory of delayed hominization, see Joseph F. Donceel, S.J., "Immediate Animation and Delayed Hominization," *Theological Studies* 31.1 (1970): 76–105. For a response, see Benedict Ashley, O.P., "A Critique of the Theory of Delayed Hominization," in *An Ethical Evaluation of Fetal Experimentation*, ed. Donald G. McCarthy and Albert S. Moraczewski, O.P. (St. Louis, MO: Pope John XXIII Center, 1976), 113–133. Also see the essay of Jean de Siebenthal, "L'animation selon Thomas d'Aquin: Peut-on affirmer que l'embryon est d'abord autre chose qu'un homme en s'appuyant sur Thomas d'Aquin?" in *L'Embryon: Un homme. Actes du Congres de Lausanne 1986* (Lausanne: Societe suisse de bioethique, 1986), 91–98, summarized in W. May, *Catholic Bioethics and the Gift of Human Life* (Huntington, IN: Our Sunday Visitor, 2000), 164–165.

[5]"[P]rocured abortion is the deliberate and direct killing, by whatever means it is carried out, of a human being in the initial phase of his or her existence, extending from conception to birth. The moral gravity of procured abortion is apparent in all its truth if we recognize that we are dealing with murder." John Paul II, *Evangelium vitae*, n. 58, http://www.vatican.va/holy_father/john_paul_ii/encyclicals/documents/hf_jp_ii_enc_ 25031995_evangelium-vitae_en.html.

[6]Sacred Congregation for the Doctrine of the Faith, *Donum vitae*, I.1, http://www.vatican.va/roman_curia/congregations/cfaith/documents/rc_con_cfaith_doc_19870222_respect-for-human-life_en.html. Also see Sacred Congregation for the Doctrine of the Faith, *Declaration on Procured Abortion*, note 19, http://www.vatican.va/roman_curia/congregations/cfaith/documents/rc_con_cfaith_doc_19741118_declaration-abortion_en.html.

rational soul. Whether it is, is certainly debatable. Thus, Porter concludes that differences between defenders of delayed and immediate hominization involve "fundamental philosophical and theological issues that do not depend on scientific facts in any obvious and non-question-begging way."[7] In other words, in her eyes, the theory of immediate hominization does not appear to cohere with the classical hylomorphic account of the human person that is presupposed by much of the Catholic tradition. Hence, her challenge to Catholics is that they reconcile what Porter considers the sound and compelling philosophical principles of Aristotelian-Thomistic hylomorphism with the modern scientific account of embryogenesis that undergirds the Church's current teaching on the origin of the human person at conception.

Though there is much that can be disputed in Porter's essay, her central thesis that Catholics would benefit from a scientifically sophisticated and robust metaphysical account of the human person seems to be correct. How are we to talk about a human "soul," human "nature," or the "disposition of matter" in this new century, which some have already predicted will be the century of biology? Even within Catholic circles, a lack of a metaphysical account of the person that properly acknowledges the advances of molecular biology and genomics has led to much controversy on bioethical issues both at the beginning-of-life and at the end-of-life.[8]

To contribute to this ongoing debate, this paper will develop a metaphysical account of the human person using insights taken from the emerging discipline of systems biology.[9] It opens with an overview of this new, and for most people, still unfamiliar scientific perspective. However, as we shall note below, hylomorphism remains a potent description of living things. Good science cannot replace good philosophy. Thus, the systems perspective that will be described here will presuppose the basic conceptual framework outlined by Aristotle and St. Thomas. It does not even attempt to demonstrate the existence of souls or substances or natures. Rather, the systems perspective represents one attempt to translate the terms and concepts used by the Catholic tradition into a modern idiom that brings together the commonplace intuitions of everyman with the experimental insights of the twenty-first century biologist. It seeks to account for the integrity, dynamism, and identity of the human organism in a way that is comprehensible to today's scientifically sophis-

[7]Porter, "Is the Embryo a Person?" 9.

[8]As discussed in this paper, Catholic thinkers disagree on how one is to understand the ensoulment of a human being. At the end of life, on the other hand, there is also disagreement on how one is to understand and define death. For a taste of this second debate, compare Edward J. Furton, "Brain Death, the Soul, and Organic Life," *National Catholic Bioethics Quarterly* 2.3 (Autumn 2002): 455–470, with D. Alan Shewmon, "The Brain and Somatic Integration: Insights into the Standard Biological Rationale for Equating 'Brain Death' with Death," *Journal of Medicine and Philosophy* 26.5 (October 2001): 457–478.

[9]This paper continues to develop and explore the systems perspective first proposed in my essay, "On Static Eggs and Dynamic Embryos: A Systems Perspective," *National Catholic Bioethics Quarterly* 2.4 (Winter 2002): 659–683. The text for the section that follows("The Systems Perspective") is taken, in modified form, from this published work.

ticated audience. Porter has challenged Catholics to reconcile a theory of immediate hominization with the philosophical principles that are rooted in their own tradition. The systems perspective is one possible response to her challenge. It reformulates hylomorphic theory in light of recent scientific discoveries and in doing so, justifies a theory of immediate hominization that embraces the fully personal status of the very early-stage human embryo.

## The Systems Perspective

A product of the post-genomic explosion in biological information, systems biology is an emerging field of research that seeks to understand the living whole as a dynamic network of integrated parts.[10] Its goal is to uncover the fundamental design principles of living systems by looking at what system theorists call a system's structure and its dynamics. An analysis of a system's structure identifies all the parts of the system and describes their interactions. In biology, this would involve cataloging all the molecules that go into assembling a living organism and then determining which ones interact with each other. An analysis of a system's dynamics focuses on the behavior of these interacting molecules over time. In biology, this would involve questions regarding growth, development, and maintenance of the living organism. As will be discussed below, the structure and the dynamics of a living system are inseparably interdependent. A living system is always molecules in motion. Thus, the most important question for the systems biologist is how both the structure and dynamics of a living system together give rise to the physical properties and visible behavior of the organism.

The two insights of systems biology that are of particular interest to us here as we update classical hylomorphism are its emphases on the holism of the living organism and the determinism of animal development. First, the emphasis on holism. Consider the human body. The most common view is to see the human being as a collection of organs working together under the sway of the central nervous system. Another approach is to see the body as an organized collection of 73 trillion cells of different kinds—nerve cells, heart cells, or skin cells, just to name a few of the approximately 260 cell types in the human body—all working together in the organic whole. However, 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 or cells but of *molecules,* including DNA, RNA, lipids, metabolites, and proteins, connected by reaction pathways which generate shape, mass, energy, and information transfer over the course of a human lifetime. In contrast to the first two prevailing reductionistic and mechanistic views mentioned above, the organism is seen here as a single, unified whole, a complex and dynamic network of interacting

[10]For concise overviews of systems biology, see L. Hartwell et al., "From Molecular to Modular Cell Biology," *Nature* 402.6761 Suppl. (December 2, 1999): C47–52, and Hiroaki Kitano, "Systems Biology: A Brief Overview," *Science* 295.5560 (March 1, 2002): 1662–1664. Good introductions to different aspects of the systems perspective written for the non-specialist can be found in Stuart Kauffman, *At Home in the Universe* (New York: Oxford University Press, 1995) and Albert-Laszlo Barabasi, *Linked: The New Science of Networks* (Cambridge, MA: Perseus Publishing, 2002).

molecules that appear and then disappear in time. It is an embodied process that has both spatial and temporal manifestations.

To illustrate the holistic perspective, we turn to a symphonic orchestra. One way to view a classical orchestra would be to say that it is made up of four groups of musicians playing a type of instrument: woodwind, brass, percussion, or string. Another is to say that it is made up of approximately ninety musicians. The systems view would be to see it as a single dynamic network of interacting parts where the whole is greater than the sum of the parts. Since each musician has an instrument and a score (and these could also each be counted as discrete 'parts'), the orchestra at a minimum has 270 parts, all organized and seamlessly integrated into a single unity that produces music. In fact, from the systems perspective, an orchestra is not truly an orchestra until its parts begin to interact with one another; i.e., when it is performing a symphony. Therefore, to see the living organism as a dynamic system is to see it as a symphonic whole, where DNA, RNA, lipids, and protein molecules, like musicians and their instruments, appear and then disappear on stage in the choreographed performance called life.

As noted above, systems biology, in addition to emphasizing the holism of the organism, also underscores the deterministic nature of animal development. In this, there is a crucial difference between an orchestra and an organism. One orchestra can play many symphonies, because the musical score determines how and when the different parts will interact. In other words, the same structure can give rise to different dynamics—the same parts of one orchestra can interact in different ways to produce either Beethoven's Ninth Symphony or Mozart's Symphony No. 40. Thus, one cannot predict the future performance of an orchestra from simply studying its parts. It is an indeterminate system. An organism, on the other hand, is a deterministic system that follows a particular developmental trajectory. In other words, there is a causal relationship between the past, present, and future states of a living system because the molecular composition of the organism constrains the possible sequence of ordered transformations through which the system can advance. A puppy cannot grow into an ostrich.

In this deterministic view, an organism changes and progresses through a sequence of ordered molecular changes precisely because each subsequent step in a reaction pathway is driven by the products of the previous step. Consequently, from the systems perspective, every developmental change, including the teething of an infant or the sexual maturation of a teenager, can be traced to necessary transformations in the molecular composition of that particular human individual. In the end, the trajectory of animal development is like a falling chain of molecular dominoes that manifests itself as outward physical changes in the organism. Once the process begins, it is a self-driven, self-perpetuating chain reaction of molecular transformations that continues throughout the life span of the animal.

Finally, let me emphasize here that the determinism of the biological process that drives development does not rule out the very real effects of the environment on the living organism. From the systems perspective, at any given point in time, the development of an organism is determined because at that point in time its molecular network can only change in one way. However, not all the molecules in the network

are derived from the genome. In fact, most of them are derived from the environment. Approximately 66 percent of the human body, for instance, is made up of water molecules. Thus, it should be no surprise to anyone that an individual raised in the calorically restricted environment of Somalia would look different from the individual's identical twin raised in the calorically affluent United States. Nurture influences nature.[11] Nevertheless, the genetic constitution of the organism still does constrain its developmental possibilities in a fixed and species-specific manner. Regardless of their childhood homes, the physical resemblance between the African and his American twin would still be striking.

## Systems Hylomorphism: The Human Organism from the Systems Perspective

With an overview of the systems perspective in mind, we can now begin constructing a systems-based description of the human organism. The primary challenge for this task will be to explain the stable dynamism of a being that is able to maintain its integrity and its identity over a period that can last up to a century. This is a real stability despite the numerous kinetic and metabolic studies using a variety of experimental techniques that have shown that 98 percent of the atoms of the adult human body, including those found in the brain and nervous system, are replaced in about two years.[12] How are we to reconcile both these observations? To put it another way, the human organism is a being that has an origin, undergoes biological development, and then dies. It is always changing but still remains the same. How is this so? An adequate philosophical anthropology would have to explain this stable dynamism.

As Porter has correctly noted, however, a coherent and compelling philosophical solution to the challenge of describing the human being already exists in the hylomorphic theory of Aristotle and St. Thomas Aquinas. She is not alone in this assessment. In their book, *Body & Soul*, Protestant philosophers J.P. Moreland and Scott B. Rae also defend hylomorphism (which they call Thomistic dualism) as the most coherent explanation for the human being.[13] As we shall see in brief below, I believe these authors are correct—hylomorphism is already able to adequately explain the stability and the change found in living things. There is no need to re-invent the wheel. The theory simply needs to be updated in light of recent scientific advances. Thus, as mentioned in the introduction, in constructing a scientifically informed description of the human being, the approach we use here will be to weave

[11]For an insightful discussion of the interrelationship between nature and nurture, see Matt Ridley, *Nature Via Nurture: Genes, Experience, and What Makes Us Human* (New York: HarperCollins, 2003).

[12]For details, see my essay, "The Pre-implantation Embryo Revisited: A Two-celled Individual or Two Individual Cells?" *Linacre Quarterly* 70.2 (May 2003): 121–126.

[13]James Porter Moreland and Scott B. Rae, *Body & Soul: Human Nature & the Crisis in Ethics* (Downers Grove, IL: InterVarsity Press, 2000).

together the basic principles of Aristotelian-Thomistic hylomorphism and the insights of the systems perspective.[14]

Before turning to a systems-based analysis of the human being, we begin with a basic review of hylomorphism.[15] First proposed by Aristotle, and developed by his disciples, especially St. Thomas Aquinas, hylomorphic theory sought to explain the nature of things and the nature of their changes. In brief, for the Aristotelian tradition, all things—especially all living things—are substances composed of both a formal and a material principle. The formal principle, also called the substantial form or, in living things, the soul, constitutes every being as a specific kind of thing with specific causal powers, those powers that allow it to be a particular kind of thing and to do what that kind of thing does. In the biological realm, it gives the creature its stability, its unity, and its identity. It structures the organism, determines its nature, and specifies its end. The matter, on the other hand, is the corresponding principle of potency that the form determines or actualizes. According to the hylomorphic theory, both matter and form are inseparable.[16] Together both constitute a stable substance.

Stable substances, however, often change. For the Aristotelians, change involved the replacement of form. This process happens in two ways, corresponding to the two types of change evident in the world. First, there is substantial change, which radically alters the identity of the thing. Substantial changes involve the replacement of one substantial form with another in matter that is properly disposed to receive the new form. The classic example of this type of change involves the death of an organism, where, say, the form of a living dog is replaced by the individual forms of the elements in the dog's carcass. Next, there is accidental change, which only modifies a thing without changing its nature. This kind of change involves the replacement of one accidental form with another, again, in matter that is properly disposed to receive the new form. An example of this type of change involves the growth in size of an organism. Thus, according to hylomorphism, all change observable in nature can be accounted for by invoking the replacement of forms in properly disposed matter. Note that during accidental changes, the substantial form or soul remains, ensuring the integrity and identity of the organism. This explains well

[14]This approach is particularly attractive to the Catholic tradition, which committed itself to Aristotelian-Thomistic language in 1312 when the Council of Vienne defined *de fide* that the human soul is the form of the body. Henricus Denziger and Adolfus Schonmetzer, eds., *Enchiridion Symbolorum: Definitionem et Declarationum de Rebus Fidei et Morum* (New York: Herder and Herder, 1965), n. 902; see also *Catechism of the Catholic Church*, 2nd ed., trans. United States Conference of Catholic Bishops (Vatican City: Libreria Editrice Vaticana, 1997), n. 365.

[15]For a good summary of classical hylomorphic theory, also see William A. Wallace, O.P., *The Elements of Philosophy: a Compendium for Philosophers and Theologians* (New York: Alba House, 1977), 41–84.

[16]The human form or soul is an exception to this rule, since it can exist apart from the material principle. However, as so existing, it is not a complete person. For discussion, see Anton C. Pegis, *St. Thomas and the Problem of the Soul in the Thirteenth Century* (Toronto, Canada: Pontifical Institute of Medieval Studies, 1934).

the stable dynamism of the human being. A man is stable because of his substantial form, yet he is dynamic because he is capable of changing his accidental forms.

We now turn to the systems perspective. How are we to talk about a human "soul," human "nature," or the "disposition of matter" in a scientifically informed manner? In other words, how are we to translate classical hylomorphism into a modern idiom? To begin, we should note that the systems perspective, like the hylomorphic perspective, is a substantial perspective; i.e., it affirms the existence of bona fide substances in the world.[17] The organism is seen here as a single, unified network of interacting molecules that is organized in a species-specific manner. Here, the whole is greater than the sum of the parts. A typical 70-kilogram man is made up primarily of oxygen (43 kg), carbon (16 kg), hydrogen (7 kg), nitrogen (1.8 kg), and calcium (1 kg).[18] However, what makes this reference man radically different from a 68.8-kg pile of these five elements is that in his case, the elements are organized and interact in a particular way, a species-specific way. Indeed, a snapshot of the human body at any point in time would reveal an intricate net of molecular interactions distributed in three-dimensional space. From the systems perspective, this particular pattern, this organization of the molecules of the human being, would be a manifestation of his immaterial soul.[19]

To see how the network of molecular interactions can be said to reflect and manifest the soul, note the parallels between three functions associated with this network and the three functions traditionally associated with the formal principle of an organism. First, the soul makes an organism what it is and determines its end. From a physiological perspective, the net of molecular interactions makes the man what he is and distinguishes him from a lion or a lima bean plant or some other living thing. Furthermore, since life is a deterministic process of molecular transformations, these molecular interactions also define his developmental trajectory and determine his biological end. Second, the soul unifies and integrates an organism, maintaining its identity through changes. As noted above, the human body is in a constant state of molecular flux. Every two years, nearly all of its atoms are replaced. How-

[17]As noted earlier, the systems perspective presented here presupposes the metaphysical framework put forward by classical hylomorphic theory. Given the dynamic nature of the human body, which is continually undergoing molecular change, anyone who rejects the distinction between living substances and nonliving aggregates would have to conclude that he or she can only exist and be identified as a distinct and unique human individual for a maximum of two years. This, I believe, is obviously ludicrous. For a modern defense of the substantiality of the human person, see J.P. Moreland and John Mitchell, "Is the Human Person a Substance or a Property-thing?" *Ethics & Medicine* 11.3 (Fall 1995): 50–55.

[18]Body composition data was obtained from *Report of the Task Group on Reference Man (International Commission on Radiological Protection No. 23: A Report*) (Burlington, MA: Elsevier Science and Technology Books, 1975).

[19]Again, systems hylomorphism presupposes the classical conviction that the human soul is immaterial and subsistent. For a clear summary of the arguments for this view, see Brian J. Shanley, O.P., *The Thomist Tradition* (Dordrecht: Kluwer Academic Publishers, 2002), 153–166.

ever, the pattern of the molecular interactions remains the same, providing a ground for the substantial unity and identity of an individual with a life span of eighty or more years. Finally, to the ancients, the soul is the source for the powers and capacities of the organism. It is the principle of the being's nature. Analogously, the net of molecular interactions can also be said to ground the human being's physiological capacities. To illustrate this, everyone knows that a man is able to see because he has eyes. However, from the systems perspective a man only has eyes because there are molecules in his body that interact to form these eyes. Thus, in the lingo of systems theory, vision is a capacity that emerges from the network of molecular interactions that define the man as a human being.[20] It is also rooted in the soul. With all this in mind, it should be easy to see how the systems perspective can envision a human being as a substance consisting of informed matter, here seen as a single dynamic system of molecules organized in a species-specific configuration.

However, how then do we account for change? If all change simply involves the rearrangement of atoms, does this mean that change can only be of the accidental variety? Not quite. To see how the systems perspective understands hylomorphic substantial and accidental change, we have to first discuss several aspects of the structure of living systems. As a dynamic system, the living organism is a robust system. In other words, it is able to maintain its function in spite of the loss or breakdown of one or even many of its individual components. For example, it is not uncommon to find persons who live normal lives with several mutated genes. Systems theorists have discovered that this robustness, this high tolerance for error, arises from the particular topology or structure of natural systems.[21] They are organized in such a way that the molecules are related to each other in a hub-spoke network analogous to the route network of any airline. A few molecules are highly connected to other molecules—they are the hubs of the living network, just as major airports in Chicago or Atlanta are the hubs for several U.S. airline route systems—while the rest of the molecules are only peripherally connected to a few other molecules—these are equivalent to the smaller airports often found in less populated states.

In this type of hub-spoke system,[22] two types of change are possible. First, there are changes that involve the addition or the removal of molecules that lead to

[20]For a nontechnical discussion of emergence and the emergent properties of different systems, see Steven Johnson, *Emergence: The Connected Lives of Ants, Brains, Cities, and Software* (New York: Scribner, 2001). For a philosophical analysis, see Timothy O'Conner, "Emergent Properties," *American Philosophical Quarterly* 31.2 (1994): 91–104.

[21]For two recent studies on the robustness of biological systems, see Andreas Wagner, "Robustness against Mutations in Genetic Networks of Yeast," *Nature Genetics* 24.4 (April 2000): 355–361; and Z. Gu et al., "Role of Duplicate Genes in Genetic Robustness against Null Mutations," *Nature* 421.6918 (January 2, 2003): 63–66.

[22]In the jargon of systems theory, the hub-spoke system is called a scale-free network. For a review, see Z. N. Oltvai and A. L. Barabasi, "Systems Biology: Life's Complexity Pyramid," *Science* 298.5594 (October 25, 2002): 763–764. For recent studies involving scale-free networks in living systems, see H. Jeong et al., "Lethality and Centrality in Protein Net-

alterations in the behavior of the network without changing its overall shape or trajectory. These involve the loss or addition of peripheral molecules in the network, and would be equivalent to shutting down a small and relatively isolated airport in Fargo, ND, or opening a new one in Statesboro, Georgia. These changes do not affect the overall network of air traffic in the country. Indeed, even the loss or addition of several small nodes would not change the overall pattern of the system. Similarly, in a living system, one could lose or add different kinds of peripheral molecules to the network without changing its fundamental structure. A human being, for example, could lose or gain weight. Despite these molecular changes, however, the basic framework of the organism and its developmental trajectory remain intact. This type of molecular change would be the systems analog to Aristotelian-Thomistic accidental change.

In contrast, there are changes that involve the addition or removal of molecules that lead to system collapse. This would involve the loss or addition of well connected molecules and would be equivalent either to shutting down an airport like Chicago's O'Hare or the sudden opening of a new hub in Boston's Logan Airport. Both would produce chaotic conditions that could even lead to the collapse of the entire national air traffic system. Similarly, in a living system, the loss of a hub molecule either by genetic mutation or inactivation by a poison like cyanide would lead to a loss of the integrity of the network. Losing these molecules would be equivalent to generating gaps in a row of toppling dominoes. The chain reaction stops, the network collapses, and the organism dies. This type of molecular change that alters the very nature of the being would be the systems analog to Aristotelian-Thomistic substantial change.

To summarize, the systems perspective described here represents one attempt to reformulate the received philosophical framework of classical hylomorphism so that it incorporates the insights of modern biology. Here, the human organism is a substantial being, a dynamic network of molecules now existing not as independent molecules *per se* but as different parts of one human organism. This species-specific network, which is distributed in three-dimensional space and is able to interact over time in the deterministic process that we call human development, is a manifestation of the human being's formal principle, his immaterial soul. It is the soul that makes a man a human being by organizing the matter, determining his identity and stability, and specifying his biological end. Further, all change observable during development, both substantial and accidental, can be accounted for by invoking the replacement of forms manifested as changes in the molecular interactions within dynamic systems.

One more point needs to be made. In the Aristotelian worldview adopted by St. Thomas, there were three generic kinds of souls, each characterized by its ca-

works," *Nature* 411.6833 (May 3, 2001): 41–42; E. Ravasz et al., "Hierarchical Organization of Modularity in Metabolic Networks," *Science* 297.5586 (August 30, 2002): 1551–1555; and J. J. Han et al., "Evidence for Dynamically Organized Modularity in the Yeast Protein-Protein Interaction Network," *Nature* 430.6995 (July 1, 2004): 88–93.

pacities and powers. Associated with plants, Aristotle taught that the lowest type of soul is the nutritive or vegetative soul, which enables an organism to grow and reproduce.[23] Next, associated with animals, there is the sensitive or animal soul, which, in addition to the powers of the nutritive soul, also enables an organism to sense and to desire.[24] Finally, associated with human beings, there is the human or rational soul, which, in addition to the powers of the vegetative and animal souls, enables an organism to think and to will.

Recent advances in biology, however, have shown that this perspective may have to be modified. Today, it is becoming clear that it is likely that all organisms, plants and animals included, communicate with each other and with other living beings in order to achieve particular ends. The work of three laboratories is particularly illuminating. First, Ian Baldwin and his colleagues in Germany were able to show that the common desert plant *Nicotiana attenuata* is able to *specifically* recognize the larvae of a particular predator insect that is tolerant to some of its chemical defenses, and to modify its physiology accordingly.[25] Further, this recognition is *immediate,* as evidenced by a physiological change that is propagated throughout the damaged leaf ahead of the rapidly foraging herbivore.[26] Next, Meiners and Hilker, also in Germany, have demonstrated that egg laying by a herbivore beetle induces the elm tree to release organic compounds in the air which attract other insects that prey on these eggs.[27] Finally, and most spectacularly, Arimura et al., in Japan, have demonstrated that lima bean plants communicate with each other and

[23]"For this reason all plants too are thought to live; for they evidently have in them such a potentiality and first principle, through which they come to grow and decay in opposite directions. For they do not grow upwards without growing downwards, but they grow in both directions alike and in every direction—this being so of all that are constantly nourished and continue to live, as long as they are able to receive nourishment … This is obvious in the case of plants; for they have no other potentiality of soul." Aristotle, *De Anima*, 413 a25–33. All citations are taken from Aristotle, *De Anima: Books II and III*, trans. D.W. Hamlyn (Oxford: Oxford University Press, 1993).

[24]"But it is because of sense-perception first of all that [living things] will be animal, for even those things which do not move or change their place, but which do have sense-perception, we speak of as animals and not merely as living." Aristotle, *De Anima: Books II and III*, 413 b2–3; "Plants have the nutritive faculty only; other creatures have both this and the faculty of sense-perception. And if that of sense-perception, then that of desire also; for desire comprises wanting, passion, and wishing." Aristotle, *De Anima: Books II and III*, 414 a32–35.

[25]J. Kahl et al., "Herbivore-induced Ethylene Suppresses a Direct Defense but Not a Putative Indirect Defense against an Adapted Herbivore," *Planta* 210.2 (January 2000): 336–342.

[26]U. Schittko, C. A. Preston, and I. T. Baldwin, "Eating the Evidence? *Manduca sexta* Larvae Cannot Disrupt Specific Jasmonate Induction in *Nicotiana attenuata* by Rapid Consumption," *Planta* 210.2 (January 2000): 343–346.

[27]Torsten Meiners and Monika Hilker, "Induction of Plant Synomones by Oviposition of a Phytophagous Insect," *Journal of Chemical Ecology* 26.1 (January 2000): 221–232.

with insects.[28] These authors showed that a lima bean plant that is under attack by spider mites emits volatile substances that prompt neighboring and distant lima bean plants to undergo physiological changes, that will protect them from a future attack of these mites. Furthermore, they also demonstrated that this same plant when it is being attacked emits signals that attract predatory mites that will feed upon the original infestation of spider mites. These studies are only a sample of many that demonstrate that it is becoming increasingly difficult to distinguish plants and animals as the ancients did.[29] Both plants and animals grow, reproduce, and interact with other organisms in the biosphere. All organisms affect and are affected by each other. Plants can respond to touch, and in a primitive manner, they can also smell. Thus, to different degrees, both plants and animals are able to sense as the ancients understood these actions. Apparently, both plants and animals have souls with *both* nutritive and sensitive powers.

But how then are we to distinguish different types of souls? Are there only two generic kinds of souls in the world, i.e., rational, and thus, human, and nonrational but sensitive, and thus nonhuman? As noted above, from the systems perspective, the soul of any organism manifests itself as a species-specific network of molecular interactions. From this, it follows that one reasonable way of classifying souls is to emphasize, as the ancients perhaps did not, that there are as many different kinds of souls as there are natural species of living things—a human soul animates a man, a lion soul animates a lion, and a lima bean soul animates a lima bean plant.[30] The importance of this point will become evident below.

## Hominization from the Systems Perspective

Jean Porter has asked for a scientifically sophisticated philosophical account of the human being that respects classical hylomorphic theory. The systems perspective described here is one possible response to this challenge. It is a holistic account of living substances that recognizes the molecular basis for life. However, Porter has also asked for a philosophical account that can justify a theory of immediate hominization. To successfully accomplish this charge, the systems perspective has to explain three things. First, it needs to show how fertilization is an animation event that involves the appearance of a new soul unlike the soul of either the egg or

[28]G. Arimura et al., "Herbivory-Induced Volatiles Elicit Defence Genes in Lima Bean Leaves," *Nature* 406.6795 (August 3, 2000): 511–515.

[29]For a review of plant-plant and plant-insect communication, see Edward E. Farmer, "Surface-to-Air Signals," *Nature* 411.6839 (June 14, 2001): 854–856.

[30]As both Aristotle and St. Thomas acknowledged, there is no generic animal or generic plant soul. Rather, each animal or plant soul is a particular kind of animal or plant soul depending upon the particular animal or plant species it informed. For example, St. Thomas speaks of the form of a horse, *forma equi*, (*Sentences*, Ia, 36, 2, ar. 2., ad. 2) and the form of wood, *forma substantialis ligni*, (*Sentences* IV, 10, 1, 3, co, line 34) in the mind of God. Significantly, he does *not* talk about an animal form incidentally specified as horse, or a plant form incidentally specified as wood. I thank Fr. Michael Dodds, O.P., for pointing this out to me. Thomas Aquinas, *Sentences,* Opera Omnia, vol. 6 (Parma: Typis Petri Fiaccadori, 1856).

the sperm. Second, it needs to show that this soul in the human zygote is, in fact, the same soul found in the mature human adult. Third, it has to show how both these previous facts support an argument for the personhood of the very earliest human embryo.

First, there is the animation event that is fertilization. As I have argued in detail elsewhere, the systems perspective highlights the seamless unity of the developmental process that begins with conception and ends with the death of the organism.[31] In brief, when the sperm and the egg fuse at fertilization, new molecules are introduced into the egg, radically changing it. Indeed, since the egg now has a new structure, it is in fact a new system. It is now an embryo. As explained above, the composition and the behavior of a deterministic system are necessarily linked. Thus, in addition to changing the structure of the egg, fertilization also triggers a change in its dynamics, by reorganizing and activating the interconnected network of inert maternal molecules that make up most of its contents. This initiates the chain of reactions and molecular interactions that drive cell division and differentiation. In the absence of anything to disrupt it, this self-driven, self-perpetuating process of molecular interactions will continue for nine months and beyond, transforming the living system called the embryo into the living system called a healthy eight-pound baby. Whereas the egg before fertilization had a life span of only twenty-four hours, the embryo after fertilization now has a span of seventy or more years. Thus, from the systems perspective, fertilization involves the transformation of one static network into a dynamic one. However, since networks are manifestations of souls, a new network must reflect a new soul. At fertilization, the zygote is animated by a new soul. It is animated in such a way that its subsequent development is species-predictable.

At this point, we should note that Porter and others, pointing to the totipotency of the cells that constitute the early mammalian embryo, have argued that the early embryo is animated not by one soul but by several souls.[32] They conclude this because, in their view, the pre-implantation embryo lacks individuality. To them, it is a ball of individual cells rather than a multi-celled individual. As I have argued elsewhere, however, the most recent scientific evidence demonstrates that the totipotent mammalian embryo is a single, integrated dynamic system defined by a single set of embryonic axes.[33] A single system reflects a single soul.

But what *kind* of soul animates the zygote? In response, the systems perspective allows one to see that calling the human organism an embryo, fetus, infant, teenager, or adult is to arbitrarily label and distinguish certain segments of a continu-

[31]Austriaco, "On Static Eggs," 671–674.

[32]For example, see Jean Porter, "Individuality, Personal Identity, and the Moral Status of the Preembryo: A Response to Mark Johnson," *Theological Studies* 56 (1995): 763–770; Thomas A. Shannon and Allan B. Wolter, "Reflections on the Moral Status of the Pre-Embryo," *Theological Studies* 51.4 (December 1990): 603–626; and Lisa Cahill, "The Embryo and the Fetus: New Moral Contexts," *Theological Studies* 54.1 (March 1993): 124–142.

[33]For details, see my essay, "The Pre-implantation Embryo Revisited."

ous chain of developmental events that do not differ in kind. Each is a different manifestation of the same organism, the same living system, at a later stage of change. Each is a different manifestation of the same molecular network. Each is a different manifestation of the same soul, a human soul. From the systems perspective, once development begins at fertilization, there simply is no place in a deterministic process of molecular reactions for the series of substantial changes envisioned by delayed hominization. Substantial change can occur only at the onset of development because the organization of the molecules that drives development and specifies the identity of the thing is established then. All change after this point has to be accidental. Thus, at fertilization, the zygote is animated by a human soul.

Finally, if hominization occurs at fertilization, then the very earliest human embryos must also be persons. To see this, recall that in the Catholic tradition, the commonly accepted definition for personhood is that a person is an individual substance of a rational nature.[34] Note that according to this definition, personhood is attributed to substances and says something about the nature of a thing. Thus, every adult human being is a person, not simply because he has functions of thinking and feeling but because he has a human nature that empowers him to perform these functions.[35] It is a nature grounded in his soul. However, as we noted above, from the systems perspective, the human embryo has the same human soul as the adult

[34]This is the Boethian definition of personhood that was embraced by the Western philosophical tradition until the dawn of modernity (Boethius, *De persona et duabus naturis*, vol. 64, ed. J.P. Migne [Paris: Patrologia Latina, 1847]; also see St. Thomas Aquinas, *Summa Theologiae*, Ia, 29, 1). Today, there is much disagreement among philosophers and bioethicists on the proper definition of personhood. As Ruth Macklin has noted, authors writing on the notion of personhood fall into two camps: "low standard" and "high standard." Low standard personhood corresponds to those who believe that the embryo is a person quite aside from brain function. High standard personhood corresponds to those who believe that some form of self-consciousness is necessary to achieve personhood. See her "Personhood in the Bioethics Literature," *Milbank Memorial Fund Quarterly: Health and Society* 61 (1983): 35–57. Metaphysically speaking, these two categories correspond to those who equate personhood to the presence of a human nature and those who equate personhood to the presence of certain functions or capabilities. As many others have shown, the classical Boethian definition of personhood presumed by the systems perspective can explain the integrity and unity of the *embodied* human being experienced by the ordinary individual. In contrast, those definitions that reject the personhood-as-nature distinction inevitably lead either to substance dualism or the rejection of the embodied experience of human persons. For details, see, for example, both Germain Grisez, "When Do People Begin?" *Proceedings of the American Catholic Philosophical Association* 63 (1989): 27–47; and Helen Watt, "The Origin of Persons," in *The Identity and Status of the Human Embryo: Proceedings of the Third Assembly of the Pontifical Academy for Life*, eds. Juan de Dios Vial Correa and Elio Sgreccia (Vatican City: Libreria Editrice Vaticana, 1999), 343–364.

[35]In the same way, the adult human male is a mammal, not because he can lactate and bear live young, which he will never be able to do, but because he has a human nature that empowers females of his species to perform these functions. For leading me to this insight, I am indebted to Jenny Teichman in her article "The Definition of 'Person'," *Philosophy* 60 (1985): 175–185.

he will eventually develop into. Thus, the human embryo must be as much a person as the human adult he will develop into, since both are the same substance with the same nature. Accordingly, at fertilization, the zygote is animated with a human soul, thus making him a substance with a human nature. He is a person.

## Responding to Possible Objections from Delayed Hominists

The most significant change in classical hylomorphic theory advanced by the systems perspective—and it is a change in emphasis rather than in substantial content—is the proposal that we classify souls with species-based rather than genera-based categories. The human soul and every other kind of soul would be conceptualized here not according to their generic powers, but by their specific power to organize the molecular network that drives species-specific development. In other words, from within the systems perspective, what makes a human soul human is neither its power to think nor to will (though it would still have these of course) but its power to organize a human body and to drive human development. In the same way, a lion would have a lion soul that would have the power to organize a lion body and to effect lion development. Therefore, there are as many kinds of souls as there are natural species. With this move, the central concern of Porter and other delayed hominists, that of identifying a biological substratum that can properly support rationality and thus predispose the developing embryo to a human, rational soul, becomes moot. Rather, within the context of systems hylomorphism, matter is disposed to receive a soul when it contains all the molecules required to give rise to the species-specific network that corresponds to a particular type of soul. Thus, a human body is disposed to receive a human soul at fertilization.

But Porter and colleagues could object. They could contend that the move to reclassify souls is an illegitimate one, because the three-category classification of souls is an essential philosophical element of classical hylomorphic theory. As noted above, however, classifying souls using species-specific rather than genera-specific categories is not alien to the thought of either Aristotle or Aquinas. Even delayed hominist Joseph Donceel, S.J., seems to assume that there are forms of individual kinds of beasts.[36] Furthermore, I could also respond to the objection by pointing out that an even more basic philosophical principle in the Aristotelian-Thomistic tradition is the conviction that philosophical analysis is dependent upon our perception and experience of the real world. In other words, natural philosophy relies upon and is governed by our observations of nature. For a case in point, the three-category

[36]"In order that the idea of prime matter may be grasped, it may be useful to consider an example. A cat kills and eats a mouse. The mouse is assimilated by the cat, becomes part of the cat. During this process of assimilation something has disappeared and something has persisted. When digested by the cat, the mouse is no longer a mouse; its 'mouseness,' its substantial form, has disappeared. But its prime matter persists. The prime matter is neither the cat nor the mouse; it is not the dead mouse or the proteins or other chemicals which analysis may discover in it. It is a principle of being which, when united to the substantial form of a cat, constitutes a cat, and when combined with the substantial form of a mouse, constitutes a mouse. It can never exist by itself, it co-exists with the substantial form. What happened to the substantial form of the mouse when the mouse was assimilated by the cat?

system of classifying souls was based upon Aristotle's observations of the living organisms around him. His observations convinced him that plants do not interact with their environment as animals do. They simply grew and reproduced. As noted above, however, current observations of this same natural order strongly suggest that plants do indeed have capacities of interacting with their environment that involve primitive sensitive and appetitive powers. Thus, in light of this data, it is not unreasonable, and in fact would be in accord with the tradition, to reclassify Aristotle's generic categories of souls to better reflect the reality of the world.

In response, Porter and colleagues could suggest that all that is needed is a reformulation of a genera-based classification of souls. For instance, William Wallace, O.P., who has advocated a theory of delayed hominization,[37] has proposed a genera-based classification of souls that defines an animal as an organism that not only senses but also moves.[38] However, this would be a modification of Aristotle's and St. Thomas's view.[39] Though this approach of reformulating a genera-based classification is certainly feasible, it could still lead to some counter-intuitive classifications whereby the apparently animal-like plants, the Venus flytrap (*Dionaea muscipula*) and the touch-me-not (*Mimosa pudica*), could be considered animals.

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Exactly what happens to the roundness of the clay when you flatten the ball? The roundness disappears exactly when and insofar as it is replaced by some other shape. In the same way, the substantial form of the mouse disappears exactly when and insofar as it is replaced by the substantial form of the cat. As it is impossible to imagine a piece of clay existing without any shape, so it is impossible to conceive prime matter existing without any substantial form." See his *Philosophical Psychology* (New York: Sheed and Ward, 1955), 6.

[37]William A. Wallace, O.P., "Nature and Human Nature as the Norm in Medical Ethics," in *Catholic Perspectives on Medical Morals*, eds. Edmund D. Pellegrino, John P. Langan, and John Collins Harvey (Dordrecht: Kluwer Academic Publishers, 1989), 23–52.

[38]William A. Wallace, O.P., *The Modeling of Nature: Philosophy of Science and Philosophy of Nature in Synthesis* (Washington, DC: The Catholic University of America Press, 1996), 100–106.

[39]"But an animal is such primarily by sensation. For we also call animals things that do not move or change their place, provided they have sensation, and do not merely live. There seem to be many of this sort: by nature they stay in one place, but they have one of the senses." Aristotle, *De Anima: Books II and III*, 413 b2–4. St. Thomas in commenting on this passage of the Philosopher notes, "there are many such animals whose nature restricts them to one place, but which have the power of sense, e.g., shell-fish, which cannot move from place to place." *Commentary on Aristotle's* "De Anima*,"* Lecture III, n. 259. Later on in this commentary, St. Thomas makes the distinction that local motion is a characteristic only of the *higher* animals: "For the present it suffices to say that soul is the one principle underlying the four distinct modes in which life is manifested, namely the vegetative mode which belongs to plants and to all living things; the sensitive mode in all animals; the intellectual mode in all men; and fourthly, the mode that is a power to move from place to place, which exists in all the higher animals, both those with sense only and those with intellect as well." *Commentary on Aristotle's* "De Anima*,"* Lecture III, n. 261. All citations from St. Thomas's commentary are taken from Thomas Aquinas, *Commentary on Aristotle's* "De Anima," trans. Kenelm Foster, O.P., and Silvester Humphries, O.P. (Notre Dame, IN: Dumb Ox Books, 1994).

In contrast, a species-based classification of souls would avoid these problems. Further, it would also be the superior strategy, because it has more explanatory power than its classical counterpart. Three advantages immediately come to mind.

First, systems hylomorphism solves the problem of explaining efficient causality during embryogenesis. As Benedict Ashley, O.P., and Stephen J. Heaney have pointed out, a modern theory of delayed hominization leaves this question unanswered: what is the efficient cause that prepares the embryonic body to receive a rational soul?[40] According to the classical Thomistic account, the embryonic body was brought to that stage of organization just prior to its hominization by the vital spirit (*virtus*) of the father working through his semen as an instrumental power. The semen, for St. Thomas, remained as an active substance throughout the whole period of preformation of the embryo.[41] This was a crucial element of a classical theory of delayed hominization. Today, as Ashley correctly notes, we know that the semen does not even survive the first five days of embryonic development. However, without the semen, what organizes the embryonic body? What prepares the embryo to receive the rational soul? Porter and her fellow delayed hominists have not responded to this critique.

Ashley has suggested an alternative Thomistic theory that involves invoking a paternally derived instrumental power that forms an embryo's primary organ. This organ then receives the instrumental power so that it acts as the body's prime mover and the efficient cause for embryogenesis.[42] According to Ashley, in the zygote, the primary organ is the nucleus with its genome. When this zygote divides and forms first the blastula, and then the gastrula, the single primary organ would either be a cell or patch of cells in the embryo that drives embryonic development. Eventually, these cells which constitute the primary organ would develop into the nervous system and then the brain. The problem with this proposal, however, is that experimental work has shown that no single cell or group of cells in the early mammalian embryo before the blastocyst stage has primacy over the other cells. No cell or group of cells is indispensable for the continued development of the embryo. Rather, the development of each cell is specified by the interactions among all the cells.[43]

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[40]See Ashley, "A Critique," 115–121, and Stephen J. Heaney, "Aquinas and the Presence of the Human Rational Soul in the Early Embryo," *The Thomist* 56 (1992): 19–48.

[41]For a detailed discussion of St. Thomas' understanding of human generation, see Michael Allyn Taylor, "Human Generation in the Thought of Thomas Aquinas: A Case Study on the Role of Biological Fact in Theological Science," (S.T.D. diss., The Catholic University of America, 1982). Also of interest is the essay by Jacques Maritain, "Toward a Thomist Idea of Evolution," in *Untrammeled Approaches (The Collected Works of Jacques Maritain, Vol. 20)*, Jacques Maritain and Bernard Doering (Notre Dame, IN: University of Notre Dame Press, 1997), 85–131.

[42]Ashley, "A Critique," 121.

[43]Mammalian embryos are characterized by conditional specification of the cells, in which cell identity is determined primarily by the interactions among the cells rather than by one cell or by a single group of cells. For details, see Scott F. Gilbert, *Developmental Biology,* 6th ed. (Sunderland, MA: Sinauer Associates, 2000), 56–66.

Thus, if there is a primary organ responsible for driving early embryonic development before the blastocyst stage, biologists cannot find it. Moreover, I ask the question, What would drive the embryonic development of the primary organ itself? Ashley proposes that the embryonic primary organ is a patch of cells that is eventually transformed into the brain and the nervous system. But what drives this process? Note that this transformation is not simply a change in the size of the primary organ. Rather, it involves the differentiation of a few relatively simple cells into a complex structure made up of trillions of cells of diverse cell types. In fact, it is a process of transformation not unlike the development of the embryo itself. From his paper, it appears that Ashley presupposes that the primary organ can act as the efficient cause for its own development. However, if this is the case, could the embryo as a whole not do the same for itself?

Next, in another reinterpretation of Thomistic embryology, Robert Pasnau has suggested that from the scientific view, the *virtus formativa* begins to look very much like the DNA present in every cell.[44] I would argue, however, that this proposal undermines the unity of the embryo: What coordinates the ten genomes, the ten separated *virtus formativa*, in the embryo at the ten-cell morula stage?

In contrast, a species-based classification of souls would properly respond to the problem of efficient causality without raising other problematic questions: The parents prepare the zygote for ensoulment through the action of their gametes. At fertilization, the human soul that animates the zygote acts as a formal cause, making the zygote a human embryo. Once it is formed, the human embryo, as an individual substance with its own species-specific nature, would then drive its own development. Here, embryonic development would be attributed to the organism as a whole and not to any single part of the developing embryo, in the same way that running is attributed to the runner and not to his soul, his brain, or his legs. Putting it another way, the embryo is the efficient cause of its own development in the same way that the runner is the efficient cause of his running.

Second, the move to reclassify souls would reconcile an apparent contradiction between the philosophical perspective offered by hylomorphic theory and the scientific perspective offered by developmental biology. Consider this: According to classical hylomorphism, human development is a discontinuous process involving the sequential appearance of three separate and distinct substances. First there is the living being animated by a soul with vegetative powers, then there is the living being animated by a soul with sensitive powers, and then there is the living being animated by the rational soul. In contrast, according to modern developmental biology, human development is a continuous process involving one living being that is undergoing change. Porter asks for a philosophical argument that "will convince our fellow citizens, most of whom know the facts as well as we do."[45] But one of these

[44]See Robert Pasnau, *Thomas Aquinas on Human Nature: A Philosophical Study of "Summa Theologiae," 1a, 75–89* (Cambridge: Cambridge University Press, 2002), 103–104.

[45]Porter, "Is the Embryo a Person?" 10.

hard facts is the organismal continuity of the developing human being![46] It is a fact that leaves classical hylomorphism with its genera-based understanding of souls out in the cold. In contrast, systems hylomorphism with its species-based understanding of souls is able to acknowledge the temporal unity of the developing organism—the developing human being is one throughout development because it has one human soul—while retaining the basic framework of hylomorphism. It is an explanation that out-explains its rival.

Finally, when seen within a larger picture, a species-based classification of souls would allow the philosopher of nature to ask questions not accessible to Aristotle or to St. Thomas. For instance, when is the mouse embryo disposed to receive its soul? Or when does a genetically engineered rice plant cease being rice? Or to put it another way, when does genetic engineering change the disposition of matter such that it cannot be informed by a rice soul? These and similar questions are becoming more common-place and more complex in light of the rapidly growing field of genomics and transgenic technology. A genera-based description of souls is simply not capable of addressing these issues.

There is one final objection that can be leveled against systems hylomorphism. One could ask, Are the species differences upon which the framework is based any more real than the apparent differences between animals and plants posited by Aristotle? To respond, though some philosophers-of-science have doubted the reality of biological species, the consensus among professional biologists is that the species concept, the idea that there are distinct populations of organisms belonging to a particular kind, is still a valid one. As Larry Arnhart has persuasively argued, denying the historical permanence of species does not deny the reality of species of natural kinds.[47] Though evolutionary theory has demonstrated that species are not eternally fixed, this does not make them any less real during their time of existence. In the twentieth century, biologists have employed different ways of classifying organisms, and when these various criteria coincide in identifying individual organisms as belonging to one species, it is reasonable to regard this species as a natural kind.[48] Further, the natural reality of these species is confirmed by the remarkable uniformity across cultures in the "folk classifications" of species studied by biological anthropologists. Several studies have shown that human beings around the world

[46]Significantly, even the most ardent proponents of legalized abortion acknowledge that the earliest human embryo is the same human organism as the adult. What they dispute is the moral status; i.e., the personhood, of this human organism at the earliest stages of its development. For example, see Mary Ann Warren, "On the Moral and Legal Status of Abortion," *The Monist* 57.1 (January 1973), reprinted in Joel Feinberg, ed. *The Problem of Abortion*, 2nd ed. (Belmont, CA: Wadsworth Publishing, 1984), 102–119.

[47]I am indebted to Larry Arnhart's analysis for the ideas and references mentioned in this paragraph. See his *Darwinian Natural Right: The Biological Ethics of Human Nature* (Albany, NY: SUNY Press, 1998), 232–238.

[48]Michael Ruse, "Biological Species: Natural Kinds, Individuals, or What?" *British Journal for the Philosophy of Science* 38 (1987): 225–242.

categorize plants and animals according to universal regularities that reflect the natural order of living things.[49] Natural species and kinds do exist in the world.

## A Challenge Met

This paper has responded to Porter's challenge to Catholics to reconcile a theory of immediate hominization with the philosophical principles that are rooted in their own tradition, by advancing a philosophical framework that reformulates hylomorphic theory in light of recent scientific discoveries. Especially significant, and probably most controversial, is the proposal to combine the plant/animal categories associated with classical hylomorphism. The human soul and every other kind of soul would be understood here not according to their generic powers but by their capacities to organize the molecular network that drives species-specific development. It is a proposal that enhances the explanatory power of hylomorphic theory without sacrificing its basic principles, which affirm the substantiality of living organisms that are able to change and yet remain the same. Not insignificantly, systems hylomorphism also justifies a theory of immediate hominization that embraces the fully personal status of the very early-stage human embryo.

Let me be the first to acknowledge that much work remains to be done with the systems perspective. The most important task ahead would be to develop the conceptual framework so that it can explain how and if particular genetic mutations of either natural or artificial origin can so affect the disposition of matter that the organism that results has been changed enough so that it can be considered a different species, a question that will shape the response of Catholic bioethics to genetic engineering.[50] This would involve computer modeling of dynamic networks.[51] However, as the Angelic Doctor himself acknowledged by appropriating the methods of his pagan predecessors and contemporaries, the Catholic intellectual tradition can and should be advanced and made more intelligible to our contemporaries by borrowing ideas and concepts from the secular sciences. Finally, the physical and metaphysical framework of systems hylomorphism needs to be integrated with a more personal and existential account of the human being. Only a holistic view of this type would do justice to the embodied spiritual creature who is the human person.

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[49]For details, see Scott Atran, *Cognitive Foundations of Natural History: Towards an Anthropology of Science* (Cambridge: Cambridge University Press, 1990), and Brent Berlin, *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies* (Princeton: Princeton University Press, 1992).

[50]Recent popes have suggested that nature should not be modified but "helped to develop." However, the line between modifying nature and favoring its development is not clear. By distinguishing genetic modifications that give rise either to accidental or to substantial changes, the systems perspective may be able to clarify this distinction. For an ethical overview of issues raised by genetic engineering, see my "Genetic Engineering, Post-Genomic Ethics, and the Catholic Tradition," *National Catholic Bioethics Quarterly* 1.4 (Winter 2001): 497–506.

[51]Computer modelling would allow one to compare different dynamic systems to each other and to a species-specific standard. Thus, one would be able to determine if a particular living system belongs to the species; i.e., does not differ from the species-specific standard.