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ARISTOTLE AND THE METAPHYICS OF EVOLUTION

FRAN O'ROURKE

Aristotle was nature's scribe, his pen dipped in mind.[1]
Ancient Greek saying

Linnaeus and Cuvier have been my two gods, though in very different ways, but they were mere schoolboys to old Aristotle.[2]
Charles Darwin

I recall that in 1951 Harold Cherniss told me that Aristotle's biology was the key to his metaphysics; unfortunately I did not have the wit to interpret this Delphic utterance.[3]
J. L. Ackrill

DOES ARISTOTLE'S PHILOSOPHY rule out evolution? The short answer is "Yes, but . . .!"; the long answer: "No, . . . however!" Summarizing his excellent account of the reasoning which led Aristotle in book 7 of the *Metaphysics* to identify substance in the first place with specific form, W. K. C. Guthrie, in the final volume of his monumental history of Greek philosophy, concluded: "Doubtless this is not a satisfactory explanation of reality. For one thing it makes Darwinian evolution impossible."[4] The matter, needless to say, is not quite so simple. Two questions are immediately raised: Does the doctrine of substantial form necessarily exclude evolution? If so, is this of itself sufficient reason for us to reject form? With these questions in mind, I propose

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Correspondence to: Department of Philosophy, University College Dublin, Dublin 4, Ireland.

[1] Ὅτι Ἀριστοτέλης τῆς φύσεως γραμματεὺς ἦν, τὸν κάλαμον ἀποβρέχων εἰς νοῦν. See Ingemar Düring, *Aristotle in the Ancient Biographical Tradition* (Göteborg: Elanders Boktryckeri Aktiebolag, 1957), 327.

[2] Letter to William Ogle on the publication of his translation of *Parts of Animals* (hereafter, "*PA*"). See *The Life and Letters of Charles Darwin*, ed. Francis Darwin (London: John Murray, 1888), 3:251. For a reproduction of the Ogle–Darwin letters and a full discussion, see Allan Gotthelf, "Darwin on Aristotle," *Journal of the History of Biology* 32 (1999): 3–31.

[3] J. L. Ackrill, *Essays on Plato and Aristotle* (Oxford: Clarendon Press, 1997), 7.

[4] W. K. C. Guthrie, *A History of Philosophy VI, Aristotle: An Encounter* (Cambridge: Cambridge University Press, 1981), 222.

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to consider some broader aspects of the relation between Aristotle's metaphysics and his biology, in order to speculate how he might respond to the modern theory of evolution.

Aristotle's metaphysics was continually nourished by his experience as a biologist; the data of Aristotle the biologist were in turn frequently illuminated by his insights as metaphysician. In our own time, biology and metaphysics are obliged to enter into dialogue regarding the theory of evolution through questions which are central to both disciplines. Evolution is viewed by some, proponents and opponents alike, as a claim for total explanation, not only of how the living cosmos came to be, but also as an exhaustive account of its ultimate origins and final purpose—or absence thereof. Such a claim is tantamount to a metaphysics of total reality. It is provoking to speculate how Aristotle would judge such a theory. While Aristotle indeed explicitly rejects evolution, I will argue that his philosophy is in many ways eminently receptive to the theory. His metaphysics, furthermore, will elucidate many of the philosophical questions encountered by any evolutionary theory. Aspects of his metaphysics which I maintain are fundamental for a theoretical consideration of evolution are his concepts of act and potency, form and finality, the nature of causation, and the explanation of chance.

It is appropriate to relate themes of biology and ontology in the work of Aristotle. It is impossible to read the famous passage from *Parts of Animals* and remain unmoved by the philosophic eros which it expresses: these are not just the words of a biologist but of one inspired by a loving fascination with the concrete, living individual, filled with the desire to understand it radically.[5] The passage is close to the hermeneutic of philosophy given in *Metaphysics* 1, which begins with the simple declaration: "All men by nature seek to know."

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[5] *PA* 1.5.644b22–645a26. It is appropriate to cite these lines from the translation which Charles Darwin received as a gift from William Ogle: "Of things constituted by nature some are ungenerated, imperishable, and eternal, while others are subject to generation and decay. . . . Both departments, however, have their special charm. . . . Having already treated of the celestial world, as far as our conjectures could reach, we proceed to treat of animals, without omitting, to the best of our ability, any member of the kingdom, however ignoble. For if some have no graces to charm the sense, yet even these, by disclosing to intellectual perception the artistic spirit that designed them, give immense pleasure to all who can trace links of causation, and inclined to philosophy. Indeed, it would be strange if mimic representations of them were attractive, because they disclose the mimetic skill of the painter or sculptor, and the original realities themselves were not more interesting,

Aristotle engaged first in exhaustive and widespread empirical observation and proceeded through reflective analysis toward a synthetic grasp of causes, in which the desire for knowledge is ultimately fulfilled. This impulse for unified comprehension is exemplified in his biology as much as his metaphysics.[6] It will be of interest to recall briefly Aristotle's significance as a biologist.

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to all at any rate who have eyes to discern the reasons that determined their formation. We therefore must not recoil with childish aversion from the examination of the humbler animals. Every realm of nature is marvellous: and as Heraclitus, when the strangers who came to visit him found him warming himself at the furnace in the kitchen and hesitated to go in, is reported to have bidden them not to be afraid to enter, as even in that kitchen divinities were present, so we should venture on the study of every kind of animal without distaste; for each and all will reveal to us something natural and something beautiful. Absence of haphazard and conduciveness of everything to an end are to be found in Nature's works in the highest degree, and the resultant end of her generations and combinations is a form of the beautiful"; Aristotle, *Complete Works*, ed. Jonathan Barnes (Princeton: Princeton University Press), 1:1003–4.

[6] It is agreed that Aristotle carried out his natural researches during his middle years; A. L. Peck therefore suggested that "we might legitimately proceed to interpret Aristotle's more strictly philosophical work in the light of his work in natural history"; A. L. Peck, Preface, *Generation of Animals* (hereafter, "*GA*") (Cambridge: Harvard University Press, 1942), viii. Sophia M. Connell, however, has noted more recently that "since such works as the *Generation of Animals* and the *Movement of Animals* exhibit an intellectual sophistication on a par with much of the *Metaphysics* and the *Ethics*, it is generally thought that the biology was not systematized and recorded until later on. This implies that Aristotle was thinking about biology for much of his life; and as Balme has suggested, there was likely to have been a 'reciprocal influence' between the biology and those texts which are traditionally considered to be more central to his thought. . . . Because Aristotle himself does not attempt to distinguish the biological from the philosophical, it makes sense to read all Aristotelian texts as potentially representative of the same philosophical outlook"; "Toward an Integrated Approach to Aristotle as a Biological Philosopher," *Review of Metaphysics* 55, no. 2 (December 2001): 301–2. Aristotle himself emphasizes the need for careful observation of the physical world as a preparation for any general interpretation of the cosmos: "Lack of experience diminishes our power of taking a comprehensive view of the admitted facts. Hence those who dwell in intimate association with nature and its phenomena are more able to lay down principles such as to admit of a wide and coherent development; while those who through much abstract discussion have lost sight of the facts are more likely to dogmatize on the basis of a few observations"; *On Generation and Corruption* 1.2.316a5–10 (trans. H. H. Joachim, *Complete Works* 1:515).

I

Aristotle as Biologist. Opinions vary regarding the value of the biological works of Aristotle. A longstanding problem, now thankfully a thing of the past, was that of ignorance.[7] Another was ridicule; Aristotle's biological treatises abound in risible *curiosa*, which suggest that they are not to be taken quite seriously; for example, men have more teeth than women[8] (perhaps neither of his wives, Pythias or Herpyllis, acquired their wisdom teeth, since he himself states that women sometimes acquire them into their eighties!); the bison defends itself by projecting its excrement—in extraordinary quantities—to a distance of eight yards, and it is so pungent that it sears the hair of pursuant hounds[9] (reported in conversation with a drunken Latin-speaking hunter,[10] losing perhaps some of its accuracy in translation); the Celtic lands are too cold for donkeys to survive;[11] only humans have a heartbeat, since unique among animals man alone lives in hope and expectation of the future.[12] These and others, however, Ingemar Düring suggests, should not cause us to dismiss Aristotle's serious contribution as a scientist, unparalleled for centuries.[13] As Jonathan Barnes remarks, the *History of Animals* "is not flawless, but it is a masterpiece . . . a work of genius and a monument of inde-

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[7] See J. L. Ackrill: "There were parts even of Aristotle that were hardly known to exist by most mid-century philosophers. Aristotle's biological works form a large part of his preserved work, and were clearly for him an important, integral part of philosophy"; *Essays on Plato and Aristotle*, 7.

[8] *History of Animals* 2.3.501b19–20.

[9] *History of Animals* 9.45.630b8–14.

[10] See Georg Wöhrle, "Aristoteles' biologische Schriften heute lesen?" (hereafter, "Aristoteles' biologische Schriften"), in *Beiträge zur antiken Philosophie*, ed. H.-Ch. Günther and A. Rengatos (Stuttgart: Franz Steiner, 1997), 233.

[11] *History of Animals* 8.28.606b4–5; *GA* 2.8.748a25–6.

[12] *PA* 3.6.669a19–21.

[13] Ingemar Düring, *Aristoteles. Darstellung und Interpretation seines Denkens* (Heidelberg: Carl Winter, 1966), 521–2: "Die Verdienste des Aristoteles als Beobachter von Tatsachen, besonders meeresbiologischer, sind unstreitbar. . . . Jene Gelehrten, von G. H. Lewes bis zu Bertrand Russell, die sich daraus ein Vergnügen machen, alle Irrtümer des Aristoteles zu registrieren, übertreiben deren Bedeutung; die überwältigende Mehrzahl der in seinen Schriften verzeichneten Beobachtungen ist richtig, und viele sind genial. In das entgegengesetze Extrem verfallen jene, die wie W. Ogle alle Irrtümer als Textfehler oder spätere Interpretationen wegerklären. Konstatieren wir ruhig, daß Aristoteles sich zuweilen von seinen Gewährsmännern irreführen ließ."

fatigable industry."[14] Aristotle is regarded by many today as the founder of biology as a science.[15] Some of his empirical work, moreover, has stood the test of time; recent fieldwork carried out by Jason Tipton on the island of Mytilene confirms that Aristotle's detailed observations of the natural history characteristics—including diet, sexual dimorphism, spawning details, and habitat—of the kobios (*Gobius cobitis*) and phycis (*Parblennius sanguinolentus*) were largely accurate.[16]

The German scholar Wolfgang Kullmann, in a masterly and comprehensive work on Aristotle and modern science,[17] notes a widely held cliché that the theory of gravity finally rendered Aristotelian science redundant. According to this view, progress in the natural sciences is linear; earlier discoveries continuously become obsolete. The

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[14] Jonathan Barnes, *Aristotle: A Very Short Introduction* (Oxford: Oxford University Press, 2000), 20, 23. The scope of Aristotle's investigations is breathtaking, including in its wide range detailed and minute descriptions of countless varieties of insects, birds, fish, and other animals. It incurred the criticism of Proclus, who laments that Aristotle "neglected theological principles and spent too much time on physical matters"; Proclus, *In Platonis Timaeum Commentarii*, ed. E. Diehl (Leipzig: Teubner, 1903), 1.295.26: τῶν μὲν θεολογικῶν ἀρχῶν ἀφιστάμενος, τοῖς δὲ φυσικοῖς λόγοις πέρα τοῦ δέοντος ἐνδιατρίβων. Aristotle's riposte is to be found at *On Generation and Corruption* 1.2.316a5–10, quoted in footnote 6 above.

[15] See George Wöhrle, "Aristoteles' biologische Schriften," 233: "Auch im 20. Jahrhundert hat man Aristoteles, soweit zu sehen ist, weitgehend als Begründer der Biologie gewürdigt." George Henry Lewes (1817–78), one of Aristotle's severest critics, wrote concerning *Generation of Animals*: "It is an extraordinary production. No ancient work, and few modern works, equal it in comprehensiveness of detail and profound speculative insight. We find there some of the obscurest problems of biology treated with a mastery which, when we consider the condition of science at that day, is truly astounding"; *Aristotle: A Chapter from the History of Science* (London: Smith, Elder and Co, 1864), 325. Joseph Needham wrote: "The depth of Aristotle's insight into the generation of animals has not been surpassed by any subsequent embryologist, and, considering the width of his other interests, cannot have been equalled"; *A History of Embryology* (Cambridge: Cambridge University Press, 1959), 42.

[16] I am grateful to Professor Tipton for communicating to me a synopsis of his conclusions. Publication of his valuable research is eagerly awaited.

[17] Wolfgang Kullmann, *Aristoteles und die moderne Wissenschaft* (hereafter, "*Aristoteles*") (Stuttgart: Franz Steiner, 1998), 23. All translations from Kullmann are mine.

truth however, Kullmann suggests, is that despite an increase in detailed scientific knowledge, "the total perspective and foundation is not in every case always better." Scientific progress is viewed more adequately as a spiral curve which advances with the accumulation of more detailed knowledge, but which oscillates like the radius of a circle with respect to basic positions. Kullmann argues that Aristotle's works have repeatedly given new impulses to modern science and that many of Aristotle's positions have in recent times acquired an actuality which they lacked for centuries.[18] As an example of spirallike progress in scientific knowledge, Kullmann cites biology, especially embryology and genetics; in these areas of research, theories have alternated from ancient to modern times quite independently of scientific detail.[19] According to this model, many of Aristotle's fundamental insights retain their validity. No less an authority than Max Delbrück, preeminent among the pioneers of molecular genetics, has

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[18] Kullmann, *Aristoteles*, 29. In similar vein John Herman Randall Jr. writes: "The temporary eclipse of Aristotle's physics [from the age of Newton through the end of the nineteenth century] is emerging as a kind of adolescent stage in the development of our own physical theory, a mere passing blindness. Today it is Aristotle who often seems strikingly modern, and Newton who appears 'of mere historical interest.' Newton, despite his epoch-making contributions to 'natural philosophy,' that is, to the science of dynamics, seems in his notions and concepts of his more general 'philosophy of nature' to have been confused, in many of his ideas barren, and even wrong in his aim. It is Aristotle who strikes the present-day student as suggestive, enlightening, and sound"; *Aristotle* (New York: Columbia University Press, 1960), 167–8. A. L. Peck suggests that the works of Aristotle suffered by association from an antischolastic prejudice: "[D]uring the seventeenth century, the authority of Aristotle and the scholastic doctrine with which he was identified were being combated in the name of freedom, and thus it came about that the zoological works also, which had been brought to light by the dark ages, were allowed to pass back into oblivion by the age of enlightenment. They were not discovered until the end of the eighteenth century by Cuvier (1769–1832) and Saint-Hilaire (1805–1895) in the nineteenth"; "Introduction," in Aristotle, *Parts of Animals* (Cambridge: Harvard University Press, 1945), 44.

[19] See Kullmann, *Aristoteles*, 284: "Wohl die bedeutendste naturwissentschaftliche Leistung des Aristoteles ist seine Embryologie. Das beruht darauf, daß ihm auf diesem Gebiet einzigartige empirische zoologische Beobachtungen gelungen sind und daß es ihm möglich war, diese Beobachtungen theoretisch und begrifflich in einer Weise zu formulieren, die bis in die Gegenwart hinein diese Disziplin terminologisch bestimmt hat."

declared: "Anyone who is familiar with today's physics and biology, and who reads Aristotle's writings in these two fields, must be struck by the aptness of many of his biological concepts. . . . [H]is biology abounds in aggressive speculative analysis of vast observations on morphology, anatomy, systematics, and, most importantly, on embryology and development."[20]

Of particular relevance to the discussion on evolution is Aristotle's approach to the genetic development of living individuals. Democritus first formulated the theory of "pangenesis," according to which semen is drawn from all the organs of the body, and the embryo contains all its parts already fully preformed in miniature. Aristotle rejected this, maintaining that there is a true formation of new structures as the embryo grows: organs emerge gradually and successively.[21] The individual develops progressively from a simple form to a more complex one. Aristotle's distinction of act and potency here provides the profound metaphysical insight, guiding and enabling the biological explanation: the parts of the animal are formed

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[20] Max Delbrück, "Aristotle—totle—totle," in *Of Microbes and Life*, ed. Jacques Monod and Ernst Borek (New York: Columbia University Press, 1971), 55.

[21] *GA* 1.19.726b15–24: "Thus, the semen of the hand or of the face or of the whole animal really is hand or face or a whole animal though in an undifferentiated way; in other words, what each of those is in actuality, such the semen is potentially, whether in respect of its own bulk, or because it has some dynamis within itself . . . since neither a hand nor any other part of the body whatsoever is a hand or any other part of the body if it lacks soul or some other dynamis; it has the same name, but that is all." (trans. Peck, 91–3). In chapters 17 and 18 of *GA* 1, Aristotle outlines in detail the various arguments in favor of pangenesis, and he rejects each in turn. According to Kullmann, by a strange irony of history, Aristotle's objections against Democritus are still valid against Darwin's (hypothesis of) preformationism; see *Aristoteles*, 31 and 311. See G. E. R. Lloyd, "Empirical Research in Aristotle's Biology," in *Philosophical Issues in Aristotle's Biology*, ed. Allan Gotthelf and James Lennox (Cambridge: Cambridge University Press, 1987), 59–61. See David Depew's brief but incisive remarks in "Etiological Approaches to Biological Aptness in Aristotle and Darwin," in *Aristotelische Biologie. Intentionen, Methoden, Ergebnisse*, ed. Wolfgang Kullmann and Sabine Föllinger (Stuttgart: Franz Steiner, 1997), 219–20; also Montgomery Furth, *Substance, Form and Psyche: An Aristotelian Metaphysics* (Cambridge: Cambridge University Press, 1988), 113–17.

successively, with the gradual actualization of what is initially present in potency, under the agency of what is actual.[22]

While the term "epigenesis"[23] is coined much later, the concept was first elaborated by Aristotle: embryonic development is a chain of new constructions, each perfecting the preceding, with the final differentiation of the living individual emerging at the end. Epigenesis was championed, among others, by William Harvey (1578–1657), founder of modern biological and medical science, who famously discovered the circulation of blood. The pendulum subsequently oscillated once more toward pangenesis, gaining tentative adherence among others from Charles Darwin, according to whose "Provisional Hypothesis of Pangenesis" the complete body contributes to heredity: atoms from the entire body of both mother and father are united in their offspring.[24] The spiral turned again in the twentieth century toward an Aristotelian view of embryonic development with the definitive, experimental proof of epigenesis—the successive emergence of organs.[25] Wolfgang Kullmann remarks: "Despite the infinite distance in detailed knowledge between Aristotle and modern biology, common to both is the conviction that hereditary disposition is present in the entire body (in blood or the genes of every cell), but is transmitted

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[22] See *GA* 2.1.733b23–735a26. See Kullmann, *Aristoteles*, 285: "Die sukzessive Entstehung der Organe steht für ihn also fest, eine Präformation aller Teile ist ausgeschlossen."

[23] The term was made popular by William Harvey in *Exercitationes de generatione animalium* (1651) and Caspar Friedrich Wolff in *Theoria generationis* (1759). A. L. Peck notes: "The discussion which follows shows that Aristotle fully appreciated the greatest problem of embryological theory, a problem which gave rise to centuries of controversy. Does the embryo contain all its parts in little from the beginning, unfolding like a Japanese paper flower in water ('preformation'), or is there a true formation of new structures as it develops ('epigenesis')? Aristotle was an epigenesist, but he was not vindicated till the time of C. F Wolff and K. E. von Baer, at the end of the 18th and the beginning of the 19th century"; Peck, *GA*, 144. See G. E. R. Lloyd, *Aristotle: The Growth and Structure of his Thought* (Cambridge: Cambridge University Press, 1968), 84: "While the controversy remained a live issue well into the nineteenth century, the epigenesis view eventually prevailed, thanks largely to the work first of Caspar Friedrich Wolff and then of K. E. von Baer."

in coded form and with delayed action to the developing embryo."[26] Kullmann thus concludes: "Aristotle's genetics, considered as an abstract model,[27] has an extraordinary similarity with the modern theories in molecular biology of DNA and the genetic code. While Aristotle's position is not superior to modern science, compared to which it is greatly deficient in detail, it is *more balanced* than the

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[24] See Charles Darwin, *The Variation of Animals and Plants under Domestication* (London: John Murray, 1868), 2:357–404. According to Darwin's hypothesis, small particles or atoms (*gemmules*) are transmitted from all cells of the entire body; these are contained in the smallest egg or semen and control reproduction and heredity. See Kullmann, *Aristoteles*, 31, 310–11. Having published his views as a "provisional hypothesis," Darwin wrote to J. D. Hooker: "I feel *sure* that if Pangenesis is now still-born it will, thank God, at some future time re-appear, begotten by some other father, and christened by some other name"; *The Life and Letters of Charles Darwin* 3:78. In March 1870, he wrote to E. Ray Lankester: "I was pleased to see you refer to my much despised child 'Pangenesis,' who I think will some day, under some better nurse, turn out a fine stripling"; ibid., 120. David Depew argues that, according to recent scholarship, Darwin "held an epigenetic (rather than a preformationist or proto-Mendelian) conception of development. He believed that variation, albeit undirected, arose when normal epigenetic systems were stressed by the same competitive ecological pressures that would differentially determine the fate of this variation, and indeed that variation would not exist unless normal development had been interrupted by such stresses. Darwin's hypothesis of pangenesis was intended to show how this information could be gathered together and passed on. Pangenesis was not, therefore, an alternative to epigenesis so much as a modification of it designed to show how the process described by Aristotle and his modern successors could slowly and gradually give rise to changing descriptions of lineages. When Darwin is read in his own terms, accordingly, the similarities between him and Aristotle . . . become even more salient"; "Etiological Approaches to Biological Aptness in Aristotle and Darwin," 227 n. 39. For an extensive treatment, see M. J. S. Hodge, "Darwin as a Lifelong Generation Theorist," in *The Darwinian Heritage*, ed. David Kohn (Princeton: Princeton University Press, 1985), 207–44.

[25] See Kullmann, *Aristoteles*, 32, 284, and 308–9. Kullmann notes (309) Driesch's later espousal of vitalism, the belief in the existence of an immaterial element, also called *Entelechie* but understood quite differently to Aristotle.

[26] Kullmann, *Aristoteles*, 312.

[27] What Kullmann calls "abstract model" may well be taken as the basic metaphysical insight guiding Aristotle's interpretive inquiry into biological reality.

picture of embryology and genetics in the first half of the 20th century."[28] Max Delbrück declares: "If that committee in Stockholm, which has the unenviable task each year of pointing out the most creative scientists, had the liberty of giving awards posthumously, I think they should consider Aristotle for the discovery of the principle implied in DNA."[29]

II

Aristotle's Metaphysics of Nature. W. K. C. Guthrie remarks: "Aristotle's philosophy was rooted in nature, especially living nature, and the characteristic of natural beings which called above all for explanation, and offered the greatest challenge to the philosopher, was that they moved about, changed, were born and died."[30] In his analysis of beings, Aristotle sought to discern the metaphysical principles involved in the world of the many changing, active beings encountered in sense experience. A being which is open to change reveals an inherent diversity; a diversity not of beings but of principles or ἀρχαί. It was by observing the difference and distance between what beings are and what they can be that Aristotle was led to distinguish between actual being and potential being. This distinction is disclosed induc-

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[28] Kullmann, *Aristoteles*, 32 (emphasis in original). See ibid., 287: "Erst die Methoden der modernen Molekularbiologie konnten auf diesem Gebiet eine größere empirische Basis erarbeiten. Gleichwohl ist die Ausgewogenheit und Aktualität der aristotelischen Position erstaunlich." Also see ibid., 309. It is worth noting that, having been regarded for centuries as a "finalist"—whether positively or negatively—in the conflict between "vitalists" and "mechanists," it is now recognized that with his concept of finality, according to which a living thing reproduces its own *eidos*, Aristotle had basically the same thing in mind as today's biologist who speaks of chemically coded programs, such as those contained by a chicken egg for it to become a hen, guaranteeing all her necessary functions and operations. See Wöhrle, "Aristoteles' biologische Schriften," 237.

[29] Delbrück, "Aristotle—totle—totle," 55. Delbrück justifies his surprising suggestion as follows: "What strikes the modern reader most forcibly is his insistence that in the generation of animals the male contributes, in the semen, a *form principle*, not a mini-man. . . . Put into modern language: The form principle is the information which is stored in the semen. After fertilization it is read out in a preprogrammed way; the readout alters the matter upon which it acts, but it does not alter the stored information, which is not, properly speaking, part of the finished product"; ibid., 53–4.

[30] Guthrie, *A History of Philosophy VI*, 243.

tively and grasped analogically by way of example. It is the difference between that which builds and that which is capable of building, that which sees and that which has its eyes shut but has the power to see; the finished product compared with the raw material. These contrasting pairs make clear to Aristotle the distinction between act and potency. First discovered by distinguishing between dormant states and active motions, it is verified—again analogically—at more primordial levels: (1) the duality of principles required to make sense of substantial change, namely prime matter and substantial form; (2) the distinction of substance and accident, which accounts for accidental change, for example when the individual is perfected by its actions. At these levels the distinction has profound metaphysical import.

Our grasp of this distinction and of the deep presence of potency as a principle of reality is for Aristotle, it would appear, intuitive rather than discursive. On the nature of such intuitive knowledge Coleridge quotes Plotinus, that "we ought not to pursue it with a view of detecting its secret source, but to watch in quiet till it suddenly shines upon us."[31] (Coleridge gives as good an account of potency as I have encountered: "They and they only can acquire the philosophic imagination, the sacred power of self-intuition, who within themselves can interpret and understand the symbol that the wings of the air-sylph are forming within the skin of the caterpillar; these only who feel in their own spirits the same instinct which impels the chrysalis of the horned fly to leave room in its involucrum for antennae yet to come. They know and feel that the *potential* works *in* them, even as the *actual* works on them!"[32])

Aristotle explains that the notion of actuality properly belongs first to motion or movement (κίνησις), and is then extended.[33] The deeper meaning of actuality is expressed in the words ἐνέργεια, to be at work, that is, to be active, and ἐντελέχεια, to have completed one's action and so in some respect be perfect. Ἐντελέχεια is thus the completed reality of οὐσία. (John Hermann Randall Jr. has put it in lapidary form: "Things with powers exercise those powers—they proceed from 'can work' to 'working' to 'work done,' from δύναμις to ἐνέργεια

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[31] *Enneads* 5.5.8.

[32] Samuel Taylor Coleridge, *Biographia Literaria* 1, Collected Works, Vol. 7 (London: Routledge and Kegan Paul, 1983), 241–2 (emphasis in original).

[33] *Metaphysics* 9.3.1047a30–2 (hereafter, "*Meta*").

to ἐντελέχεια.")[34] Aristotle makes an important distinction between two kinds of activity, which throws light on the nature of actuality and, as we shall later see, on the role of form. Some actions are a means to an end. They do not contain within themselves their own goal and are thus incomplete activities (ἀτελές)—for example, slimming, learning, walking, and building. One does not go on a diet for its own sake but in order to feel better; one does not learn simply for the sake of learning but in order to know. On the other hand, to see, to think, or to contemplate can be ends in themselves; they are also their own fulfilment. More obvious examples are to live well or to be happy. The first, Aristotle calls motions (κινήσεις); the second, actualizations (ἐνέργειαι). Κίνησις is the imperfect exercise of becoming actual; ἐνέργεια, the pure exercise of actuality without change.[35]

Movement is incomplete activity.[36] In activities proper, as distinct from motions, the goal is the exercise of the faculty itself; it does not lie in an outside product as, for example, in a house. "The actualization resides in the subject; for example, seeing in the seer, contemplation (θεωρία) in the one who contemplates, life in the soul." Aristotle forcefully declares: "It is therefore evident that substance and form are actuality."[37] This is because substance, through form, is the ground of all its operations and activities as origin, agent, and end. Substance has a certain completeness in itself; it is the center and foundation of its activities, which proceed from it and perfect it in return.[38]

As a *flatus vocis*, "form" is an exceptionally flat sounding term with which to denote what is for Aristotle the defining element of a

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[34] John Hermann Randall Jr., "Introduction," in Frederick J. E. Woodbridge, *Aristotle's Vision of Nature*, ed. John Hermann Randall Jr., Charles H. Kahn, and Harold A. Larrabee (New York: Columbia University Press, 1965), xx. Charles H. Kahn states: "The standard etymology of ἐντελέχεια, referred to by Woodbridge [coined from ἐν, τέλος and ἔχειν, which dates from the Renaissance, is linguistically impossible: ἐχεια has nothing to do with ἔχειν, to have. The term seems to be an abstract noun derived from the adjective, ἐντελής, 'perfected' or 'completed'"; ibid., 36.

[35] *Meta* 9.6.1048b18–34. See John Wild, *Plato's Theory of Man* (New York: Octagon Books, 1964), 292. On the meaning of κίνησις and ἐνέργεια, see John Dudley, *Dio e contemplazione in Aristotele. Il fondamento metafisico dell' Etica Nicomachea* (Milan: Vita e Pensiero, 1999), 155–64.

[36] *Physics* (hereafter, "*Phys*") 3.2.201b31–2: ἥ τε κίνησις ἐνέργεια μὲν τις εἶναι δοκεῖ, ἀτελὴς δέ. See *De Anima* 2.5.417a16.

[37] *Meta* 9.8.1050b2–3 (my translation).

real life substance. It carries for the ordinary ear the meaning of external or superficial, suggesting "outline," "condition," "contour," "shape," or "appearance." The popular perception is of an outer shell rather than the inner core; it is shallow in contrast with the philosophical significance of Aristotelian form. *Eidos* is not a profile or lineament which simply may be perceived as *Gestalt*, but the intrinsic, determining principle which actualizes a corresponding potential prime matter and thus radically constitutes the composite as a single individual. For Aristotle, the thing's εἶδος is the origin of its identity in what it is, distinct from all others in its mode of being. It is what makes each thing at its very foundation that which it is, determining what he calls its τὸ τί ἦν εἶναι, that is, the basic characterization of what in principle and *ab initio* was its role and destiny in the scheme of things, its intrinsic essence. For Aristotle, εἶδος was the οὐσία of the individual, its "beingness," in virtue of which it is an existent individual endowed with concrete determination.

The most significant instance of form for Aristotle is the soul, which he defines as "the first actuality of a natural body endowed with organs."[39] The body will act and actualize itself through its various organs, but in order to do so, these must first be determined and coordinated as the organs of this particular body. Before it can do anything whatsoever, the body must itself be actualized as such. The soul fashions the body with all its components into an individual and is therefore its basic, most rudimentary, determination. It is the soul which

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[38] The following lines from the poem "Flowers do not ask questions" by Greek poet George Thémelis contain a suggestion of such self-contained fullness: "Perhaps they drive on toward the point of the origin of origins to close the circumference, / To end the adventure of the long escape and to exclude / From the province of the completed all eventualities and all vain flights, / Casting themselves out, canceling themselves out, / Having no beginning and no end within the immobility of fulfillment, / Sealing the perfect movement in the fullest immobility, / Like a statue, like a ship in bas-relief that sails on and on . . . / Flowers will reach perfection by returning to their fullest reality / And their glory shall be to give themselves without hesitation to our fullest gaze"; *Modern Greek Poetry*, trans. Kimon Friar (New York: Simon Schuster, 1973), 319.

[39] *De Anima* 2.1.412b5–6: ἐντελέχεια ἡ πρώτη σώματος φυσικοῦ ὀργανικοῦ.

first molds the body into a unitary, self-subsistent, living being. The body's activities are a second actualization, but without the first actualization by soul there is no thinking or perception, movement or rest, reproduction or nutrition, growth or decay. "It is the soul by which we primarily live, perceive, and think; so that soul is the λόγος or form, and not the matter."[40] Living is distinguished from nonliving by ψυχή: a cadaver is not a body but only the remains, an aggregate of disparate chemicals. "A corpse has the same shape and fashion as a living body; and yet it is not a man."[41] (Mark Anthony will not address Caesar as a man, but as a "bleeding piece of earth . . . the ruins of the noblest man that ever lived in the tide of times."[42])

"Nature" (φύσις) is another name for the form of growing bodies. As defined by Aristotle at *Physics* 2, φύσις is the "principle of that which has within itself its own source of motion and change."[43] However, it is not only the principle of change, but also of rest (τοῦ κινεῖσθαι καὶ ἠρεμεῖν). It is the intrinsic principle of each living thing in its self-possession as well as its self-perfecting activity:[44] an artifact has no intrinsic identity; it does not have within itself the principle of its own making.[45] Nature is, he concludes, the distinctive "shape and form" (μορφὴ καὶ τὸ εἶδος) of things which have within themselves their own source (ἀρχή) of movement and change.[46] It determines each living thing as the kind of thing which it is by definition (ἡ μορφὴ καὶ τὸ εἶδος τὸ κατὰ τὸν λόγον).[47] As Joseph Owens observes, Aristotle exploits two basic significations of nature in the Greek tradition, "the stable constitution of a thing and the thing's growth and development. Against this historical background of both change and permanence, Aristotle seems to take the best of both worlds. He finds

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[40] *De Anima* 2.1.414a12–14 (my translation). For a comprehensive account, see *De Anima* 2.4.415a14–b28.

[41] *PA* 1.1.640b33–5. See 1.1.641a17–21: "Now it may be that the form of any living creature is soul, or some part of soul, or something that involves soul. At any rate, when its soul is gone, it is no longer a living creature, and none of its parts remains the same, except only in shape, just like the animals in the story that were turned into stone" (trans. Peck, 69).

[42] William Shakespeare, *Julius Caesar* 3.1.254–7.

[43] *Phys* 2.1.193a29–30 (my translation); compare 2.1.192b13–14.

[44] *Phys* 2.1.192b21–3: "For nature is the principle and cause of motion and rest to those things, and those things only, in which she inheres primarily, as distinct from incidentally" (trans. Philip H. Wicksteed and Francis M. Cornford [Cambridge: Harvard University Press, 1980], 109).

[45] *Phys* 2.1.192b28–9.

[46] *Phys* 2.1.193b4.

[47] *Phys* 2.1.193a30–1.

the basic philosophical meaning of 'nature' to be the *unchangeable* components of *changeable* things."[48]

Since φύσις derives from φύειν ("to grow"), the cognate concept of γένεσις opens up another dimension of εἶδος and φύσις. "Nature as γένεσις is the path to nature. . . . That which is born starts as something and advances or grows toward something. Toward what, then, does it grow? Not toward that from which it came, but toward that to which it advances. It is form (μορφή), therefore, which is nature (φύσις)."[49] It is form as ἐντελέχεια which is the τέλος of γένεσις, that is, of the coming-to-be of φύσις. In its state of completion, φύσις is synonymous with ἐντελέχεια, the fulfillment of εἶδος. These various terms reveal distinct nuances of the same reality, substantial form in its various stages of potency and actualization, development and completion. "Whatever each thing is when its coming-to-be (γένεσις) is completed, is what we call its φύσις, whether we are speaking of a man, a horse, or a family. Besides, the final cause and end of a thing is the best, and to be self-sufficient is the end and the best."[50] A reflection on the generation and growth of living substances brings to light the intimate and dynamic relation between formal cause—the substantial form enduring through the process of γένεσις—and the final cause, substantial form as ἐντελέχεια, complete and fully achieved.

The primacy of the final cause is also confirmed through a comparison with the moving or efficient cause.

> Furthermore, we see that there are more causes than one concerned in the formation of natural things (γένεσις φυσική): there is the cause *for the sake of which* the thing is formed, and the cause to which *the beginning of the motion* is due. Therefore another point for us to decide is which of these two causes stands first and which comes second. Clearly the first is that which we call the final cause—that for the sake of which the thing is formed—since that is the *logos* of the thing—its rational ground, and the *logos* is always the beginning for products of nature as well as for those of art."[51]

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[48] Joseph Owens, "Aristotelian Ethics, Medicine, and the Changing Nature of Man," in *Aristotle: The Collected Papers of Joseph Owens*, ed. John R. Catan (Albany: State University of New York Press, 1981), 173.

[49] *Phys* 2.1.193b12–18 (trans. Wicksteed and Cornford [modified], 115–17).

[50] *Politics* 1.2.1252b32–1253a1: ἡ δὲ φύσις τέλος ἐστίν· οἷον γὰρ ἕκαστόν ἐστι τῆς γενέσεως τελεσθείσης, ταύτην φαμὲν τὴν φύσιν εἶναι ἑκάστου, ὥσπερ ἀνθρώπου ἵππου οἰκίας. ἔτι τὸ οὗ ἕνεκα καὶ τὸ τέλος βέλτιστον· (trans. B. Jowett [modified], *Complete Works* 2:1987).

[51] *PA* 1.1.639b11–17, Peck's translation, 57. For a detailed study, see Alan Code, "The Priority of Final Causes over Efficient Causes in Aristotle's PA," in *Aristotelische Biologie*, 127–43.

The final cause ultimately provides us with the clearest explanation, since it indicates the goal of substance and, for that very reason, its most adequate definition.

In seeking the *fundamentum inconcussum* of metaphysics, Aristotle remarks that it is neither possible nor necessary to prove everything.[52] It is equally futile and superfluous in the life sciences to demonstrate the existence of nature: "It is ridiculous to try to prove that φύσις exists."[53] It is a manifest fact, unnecessary and impossible to prove. It would be to prove the apparent from the obscure, showing ignorance of what is self-evident and what is not, as if one were to use words without a grasp of what they mean; it would be as ludicrous, he suggests, as a man born blind arguing about colors. Aristotle declares, "It is evident that many things with nature exist" (φανερὸν γὰρ ὅτι τοιαῦτα τῶν ὄντων ἐστὶ πολλά). Nature, moreover, is ever-present and all-powerful. Intimately active in all her works, she resembles the artist who models in clay rather than the carpenter, since she shapes her product not at arm's length through an intermediate tool but by palpably touching it herself in direct action.[54] This analogy, as Aristotle recognizes, itself fails to express the full power of nature, since "the final cause and the beautiful are more fully present in the works of nature than in the works of art."[55]

Nature is at once both origin and end; the essence of natural things is that they develop and construct themselves from within. This self-construction is not arbitrary or random but self-guiding and self-limiting; it is directed toward a concrete goal or τέλος. "Now, the nature of a thing is its end and its purpose, since in any case of continuous change which comes to an end, this concluding point is also the purpose of the change."[56] Nature, in its original sense of φύσις, denotes the growth and development of a living being from its beginnings to the fullness of maturity. A living body acts according to its natural form; of itself form "actualizes" (ἐνεργεῖ).[57] It exists to exercise its powers, first within itself as it tends toward self-completion, but it overflows also into outward action, culminating in the activity

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[52] *Meta* 4.4.1006a8–9.

[53] *Phys* 2.1.193a3: ὡς δ' ἔστιν ἡ φύσις, πειρᾶσθαι δεικνύναι γενοῖον (my translation).

[54] *GA* 1.22.730b29–32.

[55] *PA* 1.1.639b19–21: μᾶλλον δ' ἐστὶ τὸ οὗ ἕνεκα καὶ τὸ καλὸν ἐν τοῖς τῆς φύσεως ἔργοις ἢ ἐν τοῖς τῆς τέχνης (trans. Peck [modified], 57).

[56] *Phys* 2.2.194a28–30 (my translation).

[57] Compare *Phys* 8.4.255a1–b24.

of propagation. Within the larger perspective, animals reproduce because they seek the eternity of the unmoved mover; unable to achieve it as individuals, they seek to attain it in the species. Since the being of things (οὐσία τῶν ὄντων) resides in the particular, nature cannot be eternal in the numerical identity of the individual but only through the specific form.[58]

Aristotle declares: "There is purpose (τὸ ἕνεκά του) in things that come about and exist by nature. . . . It is absurd to presume that there is no purpose because one does not observe the agent deliberating. Art does not deliberate either. If the art of shipbuilding were in the timber, it too would act like nature. If purpose is inherent in art, it is also in nature. . . . It is clear then that nature is a cause, that is, a final cause."[59] Teleology is equally obvious for Aristotle both within the internal behavior and the outward activity of the living organism: here too there is manifest order. From his observations of animals, Aristotle concluded that the structure of the body is so constructed by nature as best to fulfill a definite function; so too, more minutely, are its parts. The bird's wings are shaped so that it can fly; the fins of the fish are so designed since its nature is to swim in water. "Nature," Aristotle declares, "makes nothing without a purpose but always with a view to the best possible for each individual, preserving the particular substance and essence of each" (διασώζουσαν ἑκάστου τὴν ἰδίαν οὐσίαν καὶ τὸ τί ἦν αὐτῷ εἶναι).[60]

To appreciate Aristotle's fundamental attitude toward nature, one should keep this principle to the fore. "We must begin our inquiry by assuming the principles which we are frequently accustomed to employ in natural investigation, namely, by accepting as true what occurs in accordance with these principles in all works of nature. One of these principles is that nature does nothing in vain, but always does the best possible for the substance of each kind of animal (τῇ οὐσίᾳ περὶ ἕκαστον γένος ζῴου τὸ ἄριστον); therefore, if one way is better than another, this is also the way of nature."[61] He does not explicitly call this guiding motif a "principle" in the way, for example, the principle of noncontradiction is πασῶν βεβαιοτάτη ἀρχή;[62] it is, however,

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[58] *GA* 2.1.731b24–732a1.

[59] *Phys* 2.8.199a7–8, 199b26–33.

[60] *Progression of Animals* 8.708a9–12 (my translation).

[61] Ibid. 2.704b11–18 (trans. E. S. Forster [Cambridge: Harvard University Press, 1993], 487).

[62] *Meta* 4.3.1005b18.

an assumption adopted at the beginning which guides his investigation. It cannot command the apodictic power of analysis, but it is revealed through the natural patterns of the world; translators of Aristotle invariably render it as "principle." It is the starting point of natural inquiry and has the effective status of a first principle.[63]

Aristotle compares nature to a good housekeeper (οἰκονόμος ἀγαθός)[64] which provides everything that is necessary but nothing wasteful or superfluous. The finality of nature is, however, immanent to the cosmos itself; there is no economist, lawgiver, or demiurge. Τέλος is confined to the individual itself and ultimately the species; the eternity of the species indeed precludes any such global finality or teleology. It has been suggested that Aristotle's concept of orderedness and finality—a basic tenet and evidence—is best expressed by the recent term "teleonomy"; here he is close to modern biology, which circumscribes the import of orderedness. The term "teleonomy" was introduced in 1958 by the American biologist C. S. Pittendrigh, to refer to the finality of nature without any suggestion of outside conscious design. Pittendrigh was haunted by J. B. S. Haldane's quip that "[t]eleology is like a mistress to the biologist: he cannot live without her, but he's unwilling to be seen with her in public."[65]

William A. Wallace helpfully distinguishes between three senses of "end." There is, first, end as *terminus* or goal, that is, the point at which a process, when completed, stops; second, the good or perfec-

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[63] James G. Lennox has provided a most helpful study of the use and status of this assertion in his article "Nature does nothing in vain . . ." in *Beiträge zur antiken Philosophie,* 199–214; reprinted in James G. Lennox, *Aristotle's Philosophy of Biology: Studies in the Origins of Life Science* (Cambridge: Cambridge University Press, 2001), 205–23. The following passages will suffice to illustrate the variety of articulations: "Nature never makes anything without a purpose, nor omits anything that is necessary" (*De Anima* 3.9.432b21–2: ἡ φύσις μήτε ποιεῖ μάτην μηθὲν μήτε ἀπολείπει τι τῶν ἀναγκαίων); "Nature is neither neglectful, nor does it work anything in vain" (*GA* 5.8.788b21–2: οὔτ' ἐλλείπουσαν οὔτε μάταιον οὐθὲν ποιοῦσαν); "Everything which Nature does is done either because it is necessary or else because it is better" (*GA* 1.4.717a15–16: πᾶν ἡ φύσις ἢ διὰ τὸ ἀναγκαῖον ποιεῖ ἢ διὰ τὸ βέλτιον); "It is what occurs generally that is most in accord with the course of Nature" (*GA* 1.19.727b29–30: τὰ δ' ὡς ἐπὶ τὸ πολὺ γινόμενα μάλιστα κατὰ φύσιν ἐστίν); "Nature and God do nothing in vain" (*De Caelo* 1.4.271a33: ὁ δε θεὸς καὶ ἡ φύσις οὐδὲν μάτην ποιοῦσιν). He also uses the formula: ταῦτα πάντα εὐλόγως ἡ φύσις δημιουργεῖ (*GA* 1.23.731a24). See also *GA* 5.2.781b22–3.

[64] *GA* 2.6.744b16.

tion attained through the process; finally, end as the intention or aim purposively pursued by a cognitive agent. It is clear that finality in the first two meanings is central to Aristotle's biology. Confusion arises when the notion of τέλος is laden with intention and conscious purposiveness, thus raising problems which lie outside the scope of biological observation.[66] The more limited term "teleonomy," therefore, more adequately describes Aristotle's grasp of finality and is helpful since it allows biology to proceed to the limits of its inquiry with a clearly circumscribed model of investigation, free from metaphysical

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[65] See the text of Pittendrigh's letter to Ernst Mayr, *Toward a New Philosophy of Biology* (Cambridge: The Belknap Press of Harvard University Press, 1988), 63–4. Pittendrigh remarks: "The more I thought about that, it ocurred to me that the whole thing was nonsense—that what it was the biologist couldn't live with was not the illegitimacy of the relationship, but the relationship itself. . . . What it was the biologist could not escape was the plain fact—or rather the fundamental fact—which he must (as scientist) explain: that the objects of biological analysis are organizations (he calls them organisms) and, as such, are end-directed. Organization is more than mere order; order lacks end-directedness; organization *is* end-directed." For the first use of the word "teleonomy," see C. S. Pittendrigh, "Adaptation, Natural Selection, and Behavior," in *Behavior and Evolution*, ed. A. Roe and G. G. Simpson (New Haven: Yale University Press, 1958), 394. Decades earlier J. H. Woodger, had in fact remarked: "It would doubtless be desirable in biology to avoid the term 'teleology' if a suitable substitute could be found"; *Biological Principles* (London: Kegan Paul, Trench, Trubner & Co., 1929), 453 n. 1. See Kullmann, *Aristoteles*, 301–2: "[Die moderne Biologie] unterscheidet zwischen wirklichen teleologischen Prozessen, die von einem Bewußtsein intendiert sind, und scheinbar teleologisch ablaufenden Prozessen, wie sie in der lebenden Natur ständig vorkommen." For a detailed account of Aristotle's teleology, see ibid., 255–312. The term *teleologia* was coined in 1728 by Christian Wolff (1679–1754), who in his *Logica*, chap. 3 (*Discursus Praeliminaris*, n. 85), wrote of "still another part of natural philosophy, which sets forth the purposes of things (*quae fines rerum explicat*). So far it is without name, though it is most noble and most useful. It could be called 'Teleology'" (trans. Joseph Owens, *Aristotle: The Collected Papers of Joseph Owens*, 216 n. 1). The O.E.D. dates its first use in English to 1807, referring to the "doctrine of final causes." See James G. Lennox, "Teleology," in *Keywords in Evolutionary Biology*, ed. Evelyn Fox Keller and Elisabeth A. Lloyd (Cambridge: Harvard University Press: 1992), 324.

[66] William A. Wallace, "Finality in Aristotle's Definition of Nature," *Proceedings of the American Catholic Philosophical Association* 72 (1998): 60–1. Wallace remarks: "Much of the difficulty with teleology in nature arises from conceiving all final causality as intentional or cognitive and not sufficiently distinguishing the cognitive from the terminative and the perfective. St. Albert the Great gave expression to this mentality with the aphorism: *opus naturae est opus intelligentiae*, the work of nature is the work of intelligence"; ibid., 61–2.

or theological concern. The question of the origin and ultimate purpose of finality within nature is thus bracketed from the examination of living things. Kullmann suggests that Aristotelian "teleology" is not in reality teleological but eminently teleonomic, since the finality which is observed is not intended.[67] Τέλος in Aristotle's biology does not mean "plan" or "purpose."[68] Purposive action requires deliberation and choice—Aristotle's concern in the *Ethics*. Natural processes, however, are not the result of deliberation. The ends of nature are the forms intrinsic to natural bodies. Form is a principle of actuality, determining a corresponding matter organically disposed in a body. It determines also the sphere of action and interaction proper to an individual substance.

Aristotle's concept of form occupied a central place in the worldview of the medieval period and beyond. That it attained widespread currency is evident from the lines of Edmund Spenser: "For of the soule the bodie forme doth take / For soule is forme and doth the bodie make."[69] However, to quote from the opening lines of Newton's preface to the *Principia*, "the moderns, *rejecting substantial forms and occult qualities*, have endeavored to subject the phenomena of nature to the laws of mathematics."[70] Substantial form could not be measured by mathematics or verified through experiment and was thus rejected by the new physics. Francis Bacon struck a heavy blow: "Matter rather than forms should be the object of our attention, its configurations and changes of configuration, and simple action, and law of action or motion; for forms are figments of human mind, unless you will call those laws of action forms."[71] He inaugurates the modern attitude to final causality: "Causarum finalium inquisitio sterilis est et,

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[67] "So kann man nur zu der Aussage kommen, daß die aristotelische Teleologie in Wirklichkeit nicht teleologisch, sondern in hohem Maße teleonomisch ist. Die Zweckmäßigkeit, die konstatiert wird, ist nicht intendiert"; Kullmann, *Aristoteles*, 302.

[68] Kullmann indicates that it is clearly erroneous to interpret Aristotle in any sense anthropomorphically. See ibid., 288–9.

[69] Edmund Spenser, "An Hymne in Honour of Beautie."

[70] Isaac Newton, *Mathematical Principles of Natural Philosophy* (Berkeley: University of California Press, 1960), xvii. I owe this reference to Terence Nichols, "Aquinas' Concept of Substantial Form and Modern Science," *International Philosophical Quarterly* 36, no. 3 (September 1996): 304 (emphasis added).

tamquam virgo Deo consecrata, nihil parit."[72] Likewise potency is jettisoned since it cannot be grasped in a clear and distinct idea. Descartes reduced the natural world to outer extension; only geometric form remained. Causality is viewed as an external, efficient relation; Aristotle's comprehensive understanding of αἰτία is abandoned.

Reduced in this manner to the dimensions of external extension, the natural world is, I suggest, deprived of its inner dynamism and natural tendency. Some of Aristotle's richest insights are lost, namely, intrinsic form and the potency of being. Unless we affirm, however, the presence in natural beings of some element akin to immanent form, it is difficult to understand why they act in the determinate and intelligible ways continually disclosed by science at ever more microcosmic depths. Bereft of form and potency, bodies are deprived of the

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[71] *The New Organon*, bk. 1, aph. 51 (*The Works of Francis Bacon*, ed. James Spedding, Robert Leslie Ellis, and Douglas Denon Heath [New York: Garrett Press, 1968], 4:58). For Latin original, see *The Works of Francis Bacon* 1:168–9.

[72] *De augmentis scientiarum*, bk. 3, chap. 5 (*The Works of Francis Bacon* 1:571). For translation, see *The Works of Francis Bacon* 4:365. A contrary view concerning the perennial role of finality is given by D'Arcy Wentworth Thompson (translator of Aristotle's *History of Animals*), in his classic *On Growth and Form*, a work which has received exceptional praise from many Darwinian adherents: "Time out of mind it has been by way of the 'final cause', by the teleological concept of end, of purpose or of 'design', in one of its many forms . . . that men have been chiefly wont to explain the phenomena of the living world; and it will be so while men have eyes to see and ears to hear withal. With Galen, as with Aristotle, it was the physician's way; with John Ray as with Aristotle it was the naturalist's way; with Kant as with Aristotle it was the philosopher's way. . . . It is a common way, and a great way; for it brings with it a glimpse of a great vision, and it lies deep as the love of nature in the hearts of men"; *On Growth and Form* (Cambridge: Cambridge University Press, 1942), 3. On Bacon's attitude to Aristotle, Jonathan Barnes remarks: "It is worth adding that our modern notion of scientific method is thoroughly Aristotelian. Scientific empiricism—the idea that abstract argument must be subordinate to factual evidence, that theory is to be judged before the strict tribunal of observation—now seems a commonplace; but it was not always so, and it is largely due to Aristotle that we understand science to be an empirical pursuit. The point needs emphasizing, if only because Aristotle's most celebrated English critics, Francis Bacon and John Locke, were both staunch empiricists who thought that they were thereby breaking with the Aristotelian tradition. Aristotle was charged with preferring flimsy theories and sterile syllogisms to the solid, fertile facts. But the charge is outrageous; and it was brought by men who did not read Aristotle's own works with sufficient attention and who criticized him for the faults of his successors"; *Aristotle: A Very Short Introduction*, 137.

dynamic structure which orients them by natural tendency.[73] As the life sciences reveal more and more marvellous instances of determination and directional behavior throughout the world of nature, these provide fresh illustrations of Aristotle's deepest metaphysical intuitions.

III

Evolution: Form and Finality? One of the dominant narratives of our time is the theory of evolution. It is one of the most far-reaching interpretations of the world, and uniquely of man, and equally invites urgent dialogue with every tradition which claims to have relevance today; it imposes the challenge of self-reflection and renewal. Evolution thrives in a chiaroscuro between the brilliance of creative theory and the darkness of evidence shrouded in the past; perhaps the subtlety of Aristotle's thought will illuminate some aspects of the question in its philosophical relevance. My leitmotif in the following pages is the status of form, as raised by the remarks of W. K. C. Guthrie reported at the outset.

If we are to believe Marjorie Grene, Charles Darwin followed Descartes in exorcising the specter of form; his view is diametrically opposed to that of Aristotle. She writes: "Here I believe we really meet the ruling passion of Darwinism: in the determination not to

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[73] See Desmond Connell, "Substance and the Interiority of Being," *Essays in Metaphysics* (Dublin: Four Courts, 1996), 47. Wolfgang Wieland writes: "Scientists today consider Aristotle's teleological interpretation of nature to be at best an interesting mistake, perhaps explicable in historical terms. They hold it responsible for delaying the progress of science some two thousand years, and for obscuring the first steps Democritus took on what they hold to be a more fruitful path. It cannot be denied that modern science was right to criticize what it rejected when it abandoned traditional teleology. For because its guiding principle had been used far too narrowly and mechanically, the teleology associated with traditional Aristotelianism had already reduced itself to near-absurdity. It was a less important question whether this traditional teleology could justifiably claim Aristotle's authority, and one in which there was little interest at the beginning of the modern era—even if Galileo, for example, had some inkling of the discrepancies between Aristotle and Aristotelianism"; "The Problem of Teleology," in *Articles on Aristotle*, ed. Jonathan Barnes, Malcolm Schofield, and Richard Sorabji (Duckworth: London, 1975), 1:142.

look at structure. Structure must be explained *away*; it must be reduced to the conditions out of which it arose rather than acknowledged *as* structure in itself."[74] This would explain Guthrie's rejection of Aristotle in opting for Darwin. However, against Guthrie's summary dismissal I wish to suggest some reasons why, on the contrary, one should consider substantial form necessary to make sense of the world in all its multifarious variety, as experienced both prescientifically and as interpreted by the life sciences. My principal aim is one of methodic procedure: the question of form is prior to the debate regarding evolution. Aristotle's denial of evolution in his biological writings does not, a priori, render unsatisfactory his fundamental insight into form as a metaphysical principle of beings. I will argue, to the contrary, that evolutionary theory must not only affirm the reality of a principle akin to form but must embrace, moreover, other elements of Aristotle's metaphysics.

It is axiomatic for Aristotle's biology that the world is eternal and composed of kinds which are more or less constant in themselves.[75] However, no less a specialist than David Balme writes: "Reproduction is part of self-preservation, and its continuance is part of the continuance of the universe. The *fixity* of species is a different matter, not entailed by the continuance of species. . . . There is nothing in Aristotle's theory to prevent an 'evolution of species', i.e. a continuous modification of the kinds being transmitted."[76] In favor of evolution, Balme cites the possibility of new species arising from fertile hybrids, and the fact that on the *scala naturae* it is not always possible to distinguish between certain types of plants and animals. As against this, James G. Lennox objects: "If to continue a species is to continue

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[74] Marjorie Grene, *The Understanding of Nature* (Dordrecht: Reidel, 1974), 141.

[75] Aristotle would doubtless agree with the definition of species generally accepted by neo-Darwinians, that is, a group of interbreeding individuals. Ernst Mayr states: "Species are groups of interbreeding natural populations that are reproductively isolated from other such groups"; *Toward a New Philosophy*, 318. Aristotle maintained that an essential characteristic of a proper species is the ability to produce fertile offspring; hybrids, on the other hand, are normally sterile and are unable to perpetuate a constant and identifiable line of propagation.

[76] *Aristotle's De Partibus Animalium* I *and De Generatione Animalium* I, trans. D. M. Balme (Oxford: Clarendon Press, 1972), 97.

replicating its form, it does entail fixity."[77] This is the interpretation most consistent with Aristotle's view that the goal of living things is to preserve the good of the kind.

The apparent conflict between Balme and Lennox may be resolved by distinguishing between a consideration of the biological data as such and the presuppositions involved in their metaphysical interpretation. Balme records what might be regarded as adumbrations of evolution; Lennox sets out the ultimate demands of species. Precisely because occasional deviations from the formal control of generation are chance events, Aristotle could not accept them as fixed within the population—that is, as part of its nature. If faced with the evidence for chance variation as part of nature, however, Aristotle would no doubt be lead to change his metaphysical interpretation. It may be argued *a fortiori*, in reply to Balme, that it is metaphysical presuppositions which must change, not merely low level biological conclusions. Since, as Lennox notes, "metaphysical principles interacted in subtle ways with [Aristotle's] biological explanation of reproduction,"[78] the recognition of evolution demands, more importantly, a change of metaphysical perspective. That is precisely the pivotal problem of the present article.

Commenting on Lennox's view that the continuity of species demands fixity, Alasdair MacIntyre has remarked: "What Lennox does not take into account perhaps is the ὡς ἐπὶ τὸ πολύ character of the relevant generalization. To continue a species it is necessary that characteristically and for the most part the individuals who are members of that species continue replicating its form. But there may come to be individuals in which *per accidens* modifications take place, so that their descendants in time come *not* to replicate that form. From an Aristotelian point of view then the history of Darwinian evolution viewed prospectively is a series of accidental changes."[79] This fully

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[77] James G. Lennox, "Are Aristotelian Species Eternal?" in *Aristotle on Nature and Living Things*, ed. Allan Gotthelf (Pittsburgh: Mathesis Publications, 1985), 90; reprint, *Aristotle's Philosophy of Biology*, 155. I express my gratitude to Professor Lennox for graciously offering a comment on an earlier version of my text; my interpretation of his position goes beyond our exchange, and I do not wish to ascribe to him any particular view in the matter.

[78] Ibid.

[79] Letter, 26 May 1999; I am most grateful to Professor MacIntyre for an extremely helpful exchange of views, both in conversation and correspondence. I do not wish to attribute to him any opinions expressed elsewhere in this article.

accords with the interpretation of Lennox which I have proposed: evolution cannot be accommodated without a change of metaphysical perspective. What is ultimately at stake is the metaphysical status of the deviations from the pattern of the ὡς ἐπὶ τὸ πολύ. MacIntyre offers a very plausible suggestion how evolution could be viewed in Aristotelian terms. When members of a species migrate to a new environment, succeeding generations may be modified gradually to such an extent that they cannot mate with the descendants of their ancestors remaining in the original habitat; the original form has been replaced. This is the classic Darwinian case of nature selecting those random genetic mutations which are best suited for survival in the new environment. It could be asked, however, whether a series of "accidental changes" can amount to a change in the specific nature of the offspring. Are we obliged to speak in evolution of an alteration analogous to substantial change? Or must we locate ultimate metaphysical identity—axiomatic for Aristotle—at some other level which bears the potency for novel determinations?

Given constant circumstances, for Aristotle, each member of a species, having grown to maturity, propagates its like. Other factors, through chance or luck, sometimes thwart the normal progression of events. Nature, however, as a good housekeeper, is not accustomed to discard anything if it can serve some purpose. She always does the best in every circumstance;[80] what is more appropriate than to modify such deviations and determine new life forms? The point to be stressed, however, is that the question of fixity within species is secondary to the reality itself of εἶδος as a principle of fundamental explanation. If Aristotle's metaphysical analysis of growth and change is correct, the principles of form and the affirmation of potency will hold *a fortiori* for the evolutionary process. The validity of the theory of evolution is best decided in the light of empirical evidence—of fossil data and molecular analysis. Aristotle's metaphysics, however, will

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[80] *PA* 4.10.687a15–16: ἡ δὲ φύσις ἐκ τῶν ἐνδεχομένων ποιεῖ τὸ βέλτιστον. Note the following comment by Francis Bacon: "So does the wisdom of God shine forth more admirably when nature intends one thing and Providence draws forth another"; *De Augmentis Scientiarum*, bk. 3, chap. 4 (*The Works of Francis Bacon* 1:570).

both accommodate the empirical data and oblige us to ask fundamental questions about the nature of the reality which evolves.

At the most obvious level, form fulfils the basic function of taxonomy—that is, the need to order the variety of beings and account for their differences. There must be some entitative presence—an element or principle—intrinsic to the parrot which is the source of its distinction from the oak tree.[81] It somehow shares this "something" with other parrots and transmits it to its offspring. Form accounts for the basic similarity that exists within classes of like individuals. At a more radical level, there must be an element within it which distinguishes it as living from dead. The well-known Monty Python sketch on the demise of a pet parrot—a parrot "bereft of life," a parrot which "is no more," an "ex-parrot"—reveals with delightful humor the profound contrast, such that, from a linguistic point of view: "All statements to the effect that this parrot is still a going concern are from now on inoperative." In simple ontological terms: "He has ceased to be."

The determinative importance of form in living things is summed up by James G. Lennox: "Aristotle held that any case of a biological generation presupposed the presence of the form of what came to be. . . . [I]t is clear that this was a metaphysically fundamental principle for him. Matter could never organize itself into a functional organism of high complexity—that kind of organization could only be provided by a pre-existent instance of the kind reproduced."[82] Lennox expresses the prevailing interpretation: living beings, according to Aristotle, cannot irreducibly be explained by matter or by a necessity deriving from their originating conditions. The question becomes sharper with respect to the inner teleology of living things. Allan Gotthelf[83] is perhaps the leading exponent of the "strong irreducibil-

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[81] From the perspective of his discipline, Ernst Mayr sharply states the question: "The so-called species problem in biology can be reduced to a simple choice between two alternatives: Are species realities of nature or are they simply theoretical constructs of the human mind?"; *The Growth of Biological Thought: Diversity, Evolution, and Inheritance* (Cambridge: The Belknap Press of Harvard University Press, 1982), 285. He notes that attacks on the concept of biological species come either from mathematicians who have only a limited acquaintance with species in nature, or from botanists, whose "myopic preoccupation" with "messy" situations has prevented them from seeing that "the concept species describes natural diversity in plants quite adequately in most cases."

[82] Lennox, *Aristotle's Philosophy of Biology*, 155.

ity" thesis at the core of Aristotle's biological thought, summed up as follows: "Living organisms and their parts do not come to be by material necessity alone." He states: "In my view, the absence of a full material-level account requires the presence of an irreducible potential for form, and this irreducible potential provides a primitive directiveness upon an end which is the ontological basis for Aristotle's natural teleology."[84] While other interpretations argue for more limited or "weak irreducibility," there is a general consensus that, according to Aristotle, form cannot be reduced to matter.[85] It lies beyond our present scope to discuss whether and in what sense Darwin embraced teleology;[86] it is certain, however, that he did not share Aristotle's belief in final causality as the dynamic potency of the formative cause, proceeding by natural propensity toward its own completion.

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[83] See his first and highly influential article, "Aristotle's Conception of Final Causality," *Review of Metaphysics* 30, no. 2 (1976): 226–54, reprinted with a postscript in *Philosophical Issues in Aristotle's Biology*, 204–42; hereafter with page reference to both versions.

[84] Allan Gotthelf, "Understanding Aristotle's Teleology," in *Final Causality in Nature and Human Affairs*, ed. Richard F. Hassing (Washington, D.C.: The Catholic University of America Press, 1997), 75–6. Gotthelf's article presents an excellent account of the divergent positions, together with an exhaustive relevant bibliography. For another comprehensive discussion of the respective positions, see Fred D. Miller, Jr., "Aristotelian Natural Form and Theology—Reconsidered," *Proceedings of the American Catholic Philosophical Association* 49 (1995): 69–79. Robert Bolton remarks: "Recent commentators have nearly all followed the earlier tradition in supposing that for goal-oriented entities, on Aristotle's view, the securing of goals, or the tendency to do so, is theoretically *primitive* in the sense that this feature is not itself capable of explanation by reference to anything scientifically more basic while it itself serves as the starting point for the scientific explanation of the other features of the entities in question, such as, for instance, their material constitutions"; Robert Bolton, "The Material Cause: Matter and Explanation in Aristotle's Natural Science," in *Aristotelische Biologie*, 97.

[85] Gotthelf ascribes what he calls the "pragmatic view" to Wolfgang Wieland, Martha Nussbaum, and Richard Sorabji: "Living organisms and their parts *do* come to be by simple material necessity alone; material-efficient causes are the only actual *causes* involved"; "Understanding Aristotle's Teleology," 76 (emphasis in original). On such accounts, teleological explanantions fulfill an epistemological function.

[86] This has been the subject of an engaging debate between James Lennox and Michael Ghiselin, indicated by the titles of their respective articles: "Darwin *was* a Teleologist," *Biology and Philosophy* 8 (1993): 409–21, and "Darwin's Language may Seem Teleological, but his Thinking is Another Matter," *Biology and Philosophy* 9 (1994): 489–92. See also T. L. Short, "Darwin's Concept of Final Cause: Neither New nor Trivial," *Biology and Philosophy* 17 (2002): 323–40.

Aristotle's irreducibility thesis has more than historic interest. It is widely held that in spite of the successes of reductionistic molecular biology there remain biological problems which are inexplicable by mechanistic causation; another principle is required—a formal cause. Terence L. Nichols enumerates some examples:

> One of these is morphogenesis—the development of form in organisms. Another is the regeneration of organs which have been damaged or removed. If for example the lens is removed from the eye of a newt, the eye grows a new lens. A third is the ability of many organisms to regenerate themselves from parts: if a flatworm is cut into pieces, each piece will develop into a complete flatworm. Morphogenesis and regeneration are completely beyond the capacity of any machine. Machines cannot be grown from simple units like eggs or single cells, nor can they regenerate parts of themselves, or regenerate the whole machine if they are broken into pieces. Thus morphogenesis and regeneration point to a difference between natural organisms and artifacts.[87]

These facts suggest that the status of natural forms is still of immediate concern for our understanding of living beings. The debate suggests, moreover, that the question of the existence of an intrinsic principle of the organism is prior to the problem of how recent or remote its ancestry. The question of evolution, that is, how form came about historically, is secondary to its role as intrinsic, determining cause of the concrete living beings which we experience here and now.

On the other hand, to emphasize the importance of form as an inner constituent of the individual does not necessarily commit one to the fixity of species. What is stated is that as long as a natural substance of a determinate kind persists, its distinguishing and determining element is form. It may cease to exist; if, however, it mutates to such a degree as to be transformed, it is equally the presence of a new form which accounts for the change—the very word "transform" conveys as much. But there must remain at least some element which makes the transformation possible; the old must be potential to the new. In all of this, some principle akin to form—however one choses to describe it—exerts both a formative and transformative role.

Many questions regarding the nature and status of finality are raised by Darwinian evolution. The philosophical problem concerns not evolution as such but rather how it happened, and how it was possible for it to happen. Did the profusion of life forms come about by

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[87] Nichols, "Aquinas' Concept of Substantial Form," 309.

chance, or does evolution harbor an inner teleology? Living beings clearly manifest an inherent organization: the reciprocal interdependence of heterogeneous parts and their mutual cooperation in the service of a whole which is greater. The intrinsic organicity, the confluence of instruments, cannot be explained in the same way as the mechanical interaction of the homogeneous parts of an artifact. It cannot be communicated by the impact of an extrinsic motor cause. Is it conceivable that accidental forces can explain the origin, emergence, and nature of an individual, all of whose activities are directed by an innate tendency toward a final intrinsic goal, namely, the preservation of itself and its self-fruition in generation? Is it possible to conceive that man, marked by intelligence—a capacity defined precisely in terms opposed to blind chance—has emerged through a series of haphazard mutations? In his discussion of the successive emergence of the distinctive souls, together with their graded powers, in *Generation of Animals* Aristotle raises what he calls "the question of greatest difficulty" (ἀπορία πλείστη) which is equally urgent for the evolutionary biologist of today: "When and how and whence is a share in reason (νοῦς) acquired by those animals that participate in this principle?"[88]

Much has been made of the role of chance in evolution. This term, perhaps more than any other, needs to be clarified; Aristotle's analysis is illuminating. He distinguishes between two kinds of incidental or "chance" events: first, that which happens spontaneously, "of itself" (τὸ αὐτόματον),[89] when an agent acting without deliberation produces an unintended effect; second, when an unforeseen effect derives from a deliberate action, it is due to "fortune" or "luck" (τύχη).[90] Aristotle realistically recognizes the occurrence of results which are unintended and unforeseen, both by nature and deliberation; but these always result from the activity of an agent. So-called chance events

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[88] *GA* 2.3.736b5–7 (trans. A. Platt, *Complete Works* 1:1143).

[89] According to Aristotle, in what Randall terms "a dubious etymology" (*Aristotle*, 183), τὸ αὐτόματον is derived from μάτην, that is, the thing itself happens in vain: αὐτὸ μάτην γένηται (*Phys* 2.6.197b22–3). Aristotle himself uses αὐτόματον at *GA* 2.1.734b10 in the sense of something which moves of itself. The terms διὰ τύχην ("by chance") and διὰ τὸ αὐτόματον ("of itself"), are somewhat fluid; both have variously, together and separately, been translated as "chance."

[90] *Phys* 2.6.197b18–22. See *Phys* 2.4.196b5–7: "Some, moreover, hold that fortune is a genuine cause of things, but one that has a something divine and mysterious about it, that makes it inscrutable to the human intelligence" (trans. Wicksteed and Cornford, 147).

may be unintended, unforeseen, or unpredicted; they are, however, caused and may be explained. The results of spontaneity and chance might have been the goal of mind or of nature, but in the circumstances have emerged coincidentally. Nothing, however, occurs simply through incidental causation: "Since there can be nothing incidental unless there is something primary for it to be incidental to, it follows that there can be no incidental causation except as incident to direct causation. Chance and fortune (τὸ αὐτόματον καὶ ἡ τύχη), therefore, imply the antecedent activity of mind and nature as causes."[91] Chance presupposes an order of natural teleology and is posterior to that order.[92] Chance is thus coincidence: the accidental concurrence of a sequence normally due to natural teleology. Aristotle may thus declare: "Both luck and chance, then, are causes that come into play incidentally and produce effects that possibly, but not necessarily or generally, follow from the purposeful action to which in this case they are incident, though the action might have been taken directly and primarily for their sake."[93] As Wolfgang Wieland states, "Chance is possible because different independent teleological connections can coincide."[94]

A number of Aristotle's principles are thus at work in a metaphysical network which accounts for chance effects in living beings: the existence of active, autonomous substances; the profound presence of potency and its dependence upon actuality for realization; the providence of nature, which does the best in every circumstance. Natural substances are adaptable; they harbor deep possibilities and are affected by their environment. Since ours is an uncertain world of adventure, freedom, and chance, the environment may cultivate or

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[91] *Phys* 2.6.198a7–10 (trans. Wicksteed and Cornford, 163).

[92] See Randall, *Aristotle*, 183.

[93] *Phys* 2.5.197a32–5 (trans. Wicksteed and Cornford, 155); see *Phys* 2.6.197b18–20.

[94] Wieland, "The Problem of Teleology," 146; see 144–5: "For Aristotle chance is not an independent force which could frustrate or disturb a universal cosmic teleology. Aristotle seeks rather to show that quite generally, where we speak of chance, teleological structures are already presupposed. With chance, an apparent, 'as if' teleology is involved; this is present *if a goal is reached, although* there was *no intention* to reach it as such. So this goal proves to be accidental, as it were: i.e., reached *via* the intention to reach another goal. Consequently we never leave the realm of teleology in our talk of chance." For a detailed study, compare John Dudley, *The Evolution of Chance in the Physics and Ethics of Aristotle* (Amersfoort: Acco, 1997).

thwart, but nature will adapt. Nature continually asserts herself and is continually inventive. As animals and plants reproduce, there is indeed a natural process toward the selection and survival of the fittest: breeders and gardeners alike are familiar with mutations. Those which are best suited to their environment are most likely to survive.

Thus, rather than speak of chance as though to relinquish the need for explanation—surely the antithesis of science, as if to say things could happen without reason—one should speak, with Aristotle, of accidental causes. The appeal to chance does not absolve one from explanation but obliges rather that one seek to identify the surrounding circumstances—coincidental causes—which somehow favorably influence the unfolding of molecular processes and alter their normal invariance. What are these causes and how do they work? The appearance of new organs or new species would seem to be entirely inexplicable unless one admits the quiescent presence, within the genetic code, of "virtualities" or potencies which "e-volve," that is, unfold when favorable circumstances permit. Even if one excludes the finality of goal, there is an immanent, emergent directionality which points each agent in the direction proper to its resources. The goal may be unpredicted, but given its determinant resources, it may perhaps be extrapolated. The form which is to undergo the transformation must harbor within itself a determinate openness to develop the new mode and acquire the new determination: it must have potency, and this potency must be real; it is not a vacuum to be filled. *Natura non facit saltum.* Nature is a continuity; not, as Aristotle puts it, a "series of episodes, like a bad tragedy."[95]

Stephen Jay Gould recognizes that randomness "is an unfortunate term because we do not mean random in the mathematical sense of equally likely in all directions. We simply mean that variation occurs with no preferred orientation in adaptive directions."[96] Ernst Mayr further explains: "It does not in the least mean that any variation can occur anywhere, any time. On the contrary, mutations, in a given species, are highly 'constrained.' . . . When it is said that mutation or variation is random, the statement simply means that there is no correlation between the production of new genotypes and the adaptational needs of an organism in the given environment. Owing to

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[95] *Meta* 14.3.1090b19–20.

[96] Stephen Jay Gould, *The Panda's Thumb: More Reflections in Natural History* (New York: Norton, 1982), 79.

numerous constraints, the statement does not mean that every conceivable variation is possible."[97]

From the Aristotelian perspective it must be stressed, however, that even if the development of an organ comes about through random mutation, with the nonsurvival of countless unsuccessful stages, whichever one becomes established must be in some sense preordered in the nature of things. Darwin declared: "If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down."[98] In *The Blind Watchmaker*, Richard Dawkins states: "Not a single case is known to me of a complex organ that could not have been formed by numerous successive slight modifications. . . . If it is . . . I shall cease to believe in Darwinism."[99] There is nothing illogical about the gradual evolution of a complex system or organ; from the Aristotelian point of view, however, what is unacceptable is that such development occur through exclusively material and efficient or mechanistic forces; the gradual evolution, for example, of the eye entirely makes sense in the perspective of formal and final causality—it has been constructed uniquely in order to see. It is fully consistent with the prior, virtual presence of a real and determinate potency, which comes to actuality under external factors. The case for final causality—the unfolding toward a goal not yet attained, latent but targeted—is strengthened by the hypothesis of gradual evolution.

Here it is crucial to point out a fundamental difference between the so-called teleonomies of Aristotle and neo-Darwinism. Rejecting all suggestion of a teleology proper to evolution, Ernst Mayr declares: "If *teleological* means anything, it means *goal-directed.* Yet, natural selection is strictly an *a posteriori process* which rewards current success but *never sets up future goals.* Natural selection rewards past events, that is the production of successful recombinations of

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[97] Mayr, *Toward a New Philosophy*, 98–9. A similar point is made rhetorically by Aristotle at *Phys* 2.8.199b13–14.

[98] Charles Darwin, *The Origin of Species* (London: Penguin, 1985), 219.

[99] Richard Dawkins, *The Blind Watchmaker* (London: Penguin, 1991), 91.

genes, but it does not plan for the future."[100] Among neo-Darwinians, Francisco Ayala makes a stronger case than usual for teleology within natural selection; he agrees however on the essential point: "The end-state is causally—and in general temporally also—posterior."[101] There seems to be a confusion here of the different senses of *telos*: "terminal," "perfective," and "intentional." For Aristotle, final causality, both terminal and perfective, is not exerted by a future goal or preexisting end-state; rather, the potency proper to form, latent within the individual, simply takes its natural course and comes to fruition under the influence of efficient agents in its environment. Aristotle stresses the dynamic unity of formal and final cause. In order to grasp this, it is first necessary to affirm the unquestionable reality of potency; otherwise it makes no sense. To suggest that "end-states" of themselves initiate the action whereby they are brought to completion involves the contradiction that something preexists itself and causes its own existence.

In the absence of purpose and finality, chance and necessity are the factors which shape the course of evolution: as well as random variation, Darwinians also appeal to the inescapable demands of natural selection imposed by environment. Aristotle likewise appeals to necessity to explain the generation of new individuals—the operative factors are for him necessity and final causality.[102] Necessity, for Aristotle, however, is a conditional necessity, governed by the integral construction of the individual: "The whole body, as each of its parts, has a purpose for the sake of which it is; the body must therefore, of necessity, be such and such, and made of such and such materials, if

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[100] Mayr, *Toward a New Philosophy*, 43. Gould remarks: "If temperatures are dropping and a hairier coat would aid survival, genetic variation for greater hairiness does not begin to arise with increased frequency. Selection works upon unoriented variation and changes a population by conferring greater reproductive success upon advantageous variants"; *The Panda's Thumb*, 79.

[101] Francisco J. Ayala, "Teleological Explanations in Evolutionary Biology," in *Nature's Purposes: Analyses of Function and Design in Biology*, ed. Colin Allen, Marc Bekoff, and George Lauder (Cambridge: MIT Press, 1998), 42.

[102] *PA* 1.1.642a1–2: εἰσὶν ἄρα δύ' αἰτίαι αὗται, τό θ' οὗ ἕνεκα καὶ τὸ ἐξ ἀνάγκης.

that purpose is to be realized."[103] Therefore, for Aristotle, necessity is that of the necessary self-construction, survival, and evolution of the individual toward the goal immanent within its form. It is a necessity emanating from φύσις, that is, its formal cause rather than its matter, since "nature is much more a first principle than is matter" (ἀρχὴ γὰρ ἡ φύσις μᾶλλον τῆς ὕλης).[104] It is a natural necessity governing the development of a living substance from potency to completion. It is not a physical coercion since, as he points out, every growth has a τέλος and, unless hindered, proceeds naturally toward its achievement.[105]

IV

Aristotle and Evolution. Guthrie suggests that "Aristotle remained too much of a Platonist" to countenance anything like a theory of evolution.[106] The matter, I venture, is not quite so simple. Aristotle's Platonism is his belief in form, but his concept of form is literally worlds apart from that of his master. In the words of W. B. Yeats, "Plato thought nature but a spume that plays upon a ghostly paradigm of things";[107] it was, to borrow from F. H. Bradley, "some spectral woof of impalpable abstractions, or unearthly ballet of bloodless categories."[108] For Aristotle, on the contrary, nature is a form immersed in blood and bones, flesh and marrow; not transcendent but

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[103] *PA* 1.1.642a11–13 (trans. Peck, 77). At 1.1.663b22–4, he states that ἡ κατὰ τὸν λόγον φύσις makes use of the products of ἀναγκαία φύσις in order to serve a purpose. See *PA* 1.1.640a33–b4: "*Because* the essence of man is what it is, *therefore* a man has such and such parts, since there cannot be a man without them. . . . There cannot be a man at all otherwise than with them. . . . *Because* man is such and such, *therefore* the process of his formation must of necessity be such and such and take place in such a manner; which is why first this part is formed, then that. And thus similarly with all the things that are constructed by Nature" (Peck's translation and emphasis, 63). See also *Phys* 2.9.200a5–10: "No doubt it is a fact that the building cannot dispense with these materials [stones and bricks], and in that sense they 'must be there'; but they do not of themselves 'make' the building in the sense of constructing it, but only in that of constituting its material. What causes the building to be made is the purpose of protecting and preserving certain goods. And so in all other cases where a purpose can be traced. It cannot be accomplished without materials that have the required nature; but it is not they that 'make' the purpose-filling instrument, except materially" (trans. Wicksteed and Cornford, 181).

[104] *PA* 1.1.642a17.

[105] *PA* 1.1.641b23–6.

[106] Guthrie, *A History of Philosophy VI*, 291.

incarnate. It is a "this something," a τόδε τι, which replicates its incarnate likeness through the sexual union catalogued in such variety by Aristotle. By repeatedly emphasizing that "man generates man," he draws attention to the existential mode of substantial form and its concrete reality. This simple fact refutes, better than any elaborate theory, Plato's theory of otherworld Ideas: "Evidently there is no necessity for the existence of the Ideas. For man is begotten by man, each individual by an individual."[109] Form is generated by one living substance and bestowed upon a new individual within the species. Guthrie writes: "The specific form, the essence of the individual, is a changeless, *non-material* entity which exists, but exists only in the manifestations of nature, i.e., in conjunction with matter, not in a transcendental world."[110] This is, I suggest, somewhat too Platonic a view to attribute to Aristotle; if one views form as an immanent, incarnate principle rather than a nonmaterial entity, the problem is removed. For Aristotle, at least as regards nonintellectual animals, the soul is nothing separate from the organism; the species subsists in its members.

Guthrie, as many others, attributes to Aristotle a false "essentialism"; this understanding has been the most stubborn obstacle to a rapprochment with Darwin. As one of the leading neo-Darwinians, Ernst Mayr, notes, essentialism has "dominated Western thinking for more than two thousand years after Plato." According to this view, Mayr explains, "the changing variety of things in nature is a reflection of a limited number of constant and sharply delimited underlying *eide*, or essences. Variation is merely the manifestation of imperfect reflections of the constant essences. . . . For an essentialist there can be no evolution, there can only be a sudden origin of a new essence by a major

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[107] "Among School Children." Another Irish poet, Louis MacNeice, expresses in his poem "Autumn Journal" the contrast between Aristotle and Plato: "Aristotle was better who watched the insect breed, / The natural world develop, / Stressing the function, scrapping the Form in Itself, / Taking the horse from the shelf and letting it gallop." From the same poem: "And look for the formal as well as the efficient cause. / Aristotle's pedantic phraseology / Serves better than common sense or hand-to-mouth psychology. / ἔσχε τὴν φύσιν – 'found its nature'; the crude / Embryo rummages every latitude / Looking for itself, its nature, its final pattern."

[108] F. H. Bradley, *The Principles of Logic*, Vol. 2 (Oxford: Oxford University Press, 1967), 591.

[109] *Meta* 12.3.1070a27–9 (trans. W. D. Ross, *Complete Works* 2:1690).

[110] Guthrie, *A History of Philosophy VI*, 222 (emphasis added).

mutation or saltation."[111] Indeed Mayr himself for many years attributed such a view to Aristotle, but he changed his opinion under the influence of a number of scholars, notably David Balme, who in 1980 published an article entitled "Aristotle's Biology was not Essentialist."[112] According to Balme, Aristotle's teleology deals with the question, "What benefits an [individual] animal of this kind?", and not with the question "What benefits *all* animals of this kind?" "Species" is treated by Aristotle as "merely a universal obtained by generalisation."[113] Balme sums up the distorted position: "The extraordinary later misinterpretations of Aristotle, the magical entelechies and real specific forms, must be largely due to these imported concepts—Species, Essentia, Substantia—which presided like three witches over his rebirth in the Middle Ages, but should be banished to haunt the neoplatonism from which they came."[114] Essentialism is the reification of essence into changeless categories of mental concepts; it is a confusion of the logical with the natural. Clearly it is not Aristotle's understanding of nature.[115]

I propose that in the light of his basic metaphysical principles, with minimal modification to his philosophy of nature, Aristotle might readily accommodate an evolution of species. He already anticipates some features of evolutionary thought. One of the most exciting doctrines of evolution is its thesis of common ancestry, that all living beings are genetically related. From the metaphysical point of view, evolution offers a beautiful, panoramic synopsis of life, a narrative for the unity of the variegated living world—this is confirmed by molecular biology where the fossil evidence is lacking. Aristotle, for other reasons, also believes that the cosmos is essentially and integrally united: "All things are ordered together somehow, but not all alike—both fishes and fowl and plants; and the world is not such that one thing has nothing to do with another, but they are all connected. For all are ordered together to one end."[116]

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[111] Mayr, *Toward a New Philosophy*, 172.

[112] David Balme, "Aristotle's Biology was not Essentialist," *Archiv für Geschichte der Philosophie* 62 (1980): 1–12.

[113] Ibid., 1.

[114] David Balme, "Aristotle's Biology was not Essentialist," in *Philosophical Issues in Aristotle's Biology*, 306; this is a reprint of the 1980 article augmented by two appendices.

[115] Anthony Preus aptly labels this "Noah's Ark Essentialism." See his excellent article, "*Eidos* as Norm in Aristotle's Biology," in *Essays in Ancient Greek Philosophy*, ed. John P. Anton and Anthony Preus, vol. 2 (Albany: State University of New York Press, 1983), 340–63.

Aristotle recognized, moreover, the ascending grades of living things, the *scala naturae*, reality as a graded crescendo from the lifeless through the animate and animal, ascending to the human. According to Joseph Needham, "the Aristotelian doctrine of the 'ladder of souls'—vegetative, sensitive, rational—is a foreshadowing, in fact, of the evolution-concept which ensues as soon as the ladder is realised to exist within time."[117] Given the graded relation among various species, Aristotle's form-concepts are to some extent elastic: "Nature proceeds from the inanimate to the animals by such small steps that, because of the continuity, we fail to see to which side the boundary and the middle between them belongs."[118] Again: "Nature passes in a continuous gradation from lifeless things to animals, and on the way there are living things which are not actually animals, with the result that one class is so close to the next that the difference seems infinitesimal."[119] In *Generation of Animals* he comments: "There is a good deal of overlapping between the various classes" (συμβαίνει δὲ πολλὴ ἐπάλλαξις τοῖς γένεσιν).[120] The point at which a form in its evolutionary unfolding requires a new taxonomy is hence a matter of discretion—though not entirely arbitrary since there are grounds for whichever order is selected. Thus, whether Aristotle chooses to class the sponge as a plant or as an animal, he has valid reasons for both.[121] Without exaggerating its importance, Aristotle recognizes man's link

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[116] *Meta* 12.10.1075a16–19 (trans. W. D. Ross, *Complete Works* 2:1699).

[117] N. J. T. M. Needham, *Science and Civilisation in China*, Vol. 1 (Cambridge: Cambridge University Press, 1954), 155. Once more, Guthrie's comment is less favorable: "It was, one must admit, Aristotle who burdened science for centuries with the dogma of the fixity of species. It is strange to have to say this of the man who emphasized so strongly the difficulty of drawing a line between living and non-living. He wrote that nature exhibits a continuous progression between the two, and that the border is imperceptible. Yet he saw no need to convert this static continuity, in which one form of existence differs only minutely from the next, into a dynamic progression or evolution in time. This conviction of the immutability of species, like that of the eternity of the cosmos, was bound up for him with wider philosophical questions, doctrines of form and substance in which he developed and crystallized the Platonic elements in his intellectual heritage"; *In the Beginning. Some Greek Views on the Origin of Life and the Early State of Man* (London: Methuen, 1957), 62.

[118] *History of Animals* 8.1.588b4–6 (trans. D. M. Balme [Cambridge: Harvard University Press, 1991], 61–3).

[119] *PA* 4.5.681a12–15 (trans. Peck, 333).

[120] *GA* 2.1.732b15 (trans. Peck, 137).

[121] For his interpretation of the sponge as plant, see *PA* 4.5.681a15–17; as animal, due to its apparent sensation, *History of Animals* 1.1.487b9–10 and 5.16.548b10–14.

to the primates: the ape, the monkey, and the baboon, he states, "dualize in their nature with man and the quadrupeds" (ἐπαμφοτερίζει τὴν φύσιν).[122] "The ape is, in form, (διὰ τὴν μορφὴν) intermediate between man and quadruped, and belongs to neither, or to both."[123]

With his declaration, "Man is begotten by man *and by the sun as well*,"[124] Aristotle affirms the influence of the cosmos in the generation of new living beings; along with heredity, external factors also play a role in determining the progeny. The offspring is a new individualized incarnate form, not a cloned replica. Unlike Aristotle, we now appreciate that throughout geological time the environment is itself subject to change. The environment conceivably enters into the determination of the living individual to an intimate degree. In parallel with geological change or upheaval, major adaptations may occur over time; living forms undergo transformation, unfold latent virtualities, and acquire new determinations. Such long term changes under external influences can be more than transient; they may intimately alter the genetic identity of the molecular blueprint such that the new determination is in turn transmitted to succeeding generations. Should the environment influence the process of heredity to such a degree that it immeasurably alters the form which is transmitted or, to use a phrase of Aristotle, "should the abnormal increase be one of quality as well as of quantity, it may even take the form of another animal."[125]

Most significantly, Aristotle interprets Empedocles' theory of the survival of the fittest in light of his own theory of cause and chance:

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[122] *History of Animals* 2.8.502a16–18 (trans. A. L. Peck, *Historia Animalium* [Cambridge: Harvard University Press, 1991], 103).

[123] *PA* 4.10.689b31–3 (trans. Peck, 387).

[124] *Phys* 2.2.194b13 (trans. R. P. Hardie and R. K. Gaye, *Complete Works* 1:332 [my emphasis]). In the context of our discussion, it is interesting that in the Loeb translation Cornford renders this passage as follows: "In Nature man generates man; but the process presupposes and takes place in natural material already organized by the solar heat and so forth." He explains in a footnote: "There appears to be a hiatus in the original after ἥλιος, but the meaning, as I have tried to restore it, is obvious" (126).

[125] *Politics* 5.3.1302b38–40 (trans. B. Jowett, *Complete Works* 2:2068–9). On the role of quantity as determining substance, Pierre Pellegrin, in his outstanding study of Aristotle's biology, comments: "[T]here is here a kind of return to a form of Pythagoreanism, a doctrine that Aristotle nevertheless fought"; *Aristotle's Classification of Animals: Biology and the Conceptual Unity of the Aristotelian Corpus* (Berkeley: University of California Press, 1986), 193.

"In cases where all of the organs were combined as if they had been arranged on purpose, such things survived, having been suitably formed by the operation of chance" (ἀπὸ τοῦ αὐτομάτου).[126] Crucially, however, because of his insistence upon form, he rejects Empedocles' explanation of the generation of animals in terms of the circumstances of their development.[127] Guthrie[128] regards the following remark of Aristotle as antievolutionary: "The ordered and definite works of nature do not possess their character because they developed in a certain way. Rather they develop in a certain way because they *are* that kind of thing, for development depends on the essence and occurs for its sake. Essence does not depend on development."[129] This text is indeed anti-Darwinian, since Aristotle here affirms the priority of the formal cause over the process of becoming. For Aristotle, as outlined, γένεσις is governed by the dynamic bond between the individual in its initial potency and the goal toward which it tends. Growth and development are consequent upon essence. Guthrie is correct: evolution exclusively in terms of material and external factors would be unacceptable to Aristotle. Form must play a central role in the unfolding development of living beings. Rather than explain essence by appeal to prior material and efficient causes, Aristotle explains development of the individual through the kind of individual it is, its nature or form. His reply is clear: "Empedocles was wrong when he said that many of the characteristics which animals have are due to some accident in the process of their formation . . . was unaware that the seed which gives rise to the animal must to begin with have the appropriate specific character; and that the producing agent was preexistent: it was chronologically earlier as well as logically earlier: in other words, men are begotten by men, and therefore the process of the child's formation is what it is because its parent was a man."[130] Empedocles did not know that the εἶδος of an animal is predetermined through its λόγος.[131]

Guthrie rejects Aristotle's metaphysics of form and substance, because he believes it to be incompatible with evolution, which he

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[126] *Phys* 2.8.198b29–31 (my translation).
[127] Compare *PA* 1.1.640a19–27.
[128] Guthrie, *A History of Philosophy VI*, 110 n. 1.
[129] *GA* 5.5.778b2–6 (trans. Guthrie, ibid.).
[130] *PA* 1.1.640a19–27 (trans. Peck, 61–3).
[131] See Michael Boylan, *Method and Practice in Aristotle's Biology* (Washington, D.C.: University Press of America, 1983), 224.

understands exclusively in terms of prior conditions and influences, without regard to formal or final causes.[132] Aristotle does allow a certain role to the efficient and material causes in determining some incidental aspects of an organism: the "conditions" (παθήματα) in respect of which the parts of animals differ. Thus while the existence and the formation of the eye is for the sake of a definite purpose, because it is in accordance with the λόγος of the individual, the fact that it has a certain color, however, does not serve a particular purpose; it is incidental to its essence and must of necessity (ἐξ ἀνάγκης) be traced back to its matter and moving cause.[133] In a detailed discussion in *De Anima*, Aristotle distinguishes the difference between explanations in terms of material and final causes.[134] In a distinction, which recalls Socrates' contrasting accounts of his presence in prison, he considers two possible explanations of anger. The διαλεκτικός will respond that it is a craving for retaliation, giving thus an account of its form and essence (εἶδος καὶ τὸν λόγον . . . τοῦ πράγματος). The φύσικός will reply that it is a surging of the blood and heat around the heart, an explanation in terms of ὕλη. The real philosopher of nature will include both in his definition. There is no doubt, however, which is the more significant for Aristotle.

V

Aristotle, Evolution, and Modern Biology. Given the fact of evolution, it is incumbent to ask: Can it be explained by the principles of Aristotle? Is there place for form, or does "evolution of form" equate to its denial?[135] The notion of "evolving essence" seems intuitively to contradict the very definition of essence itself. It is necessary to recall the primacy of the natural before the logical; Aristotle was a keen

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[132] Guthrie's assessment of Aristotle is no doubt influenced by his own view on the matter ("Knowing as we do"), that "man has evolved from lower types of life"; *The Greek Philosophers from Thales to Aristotle* (London: Methuen, 1978), 127.

[133] Compare *GA* 5.5.778a16–778b1. This text immediately precedes the passage considered by Guthrie to be antievolutionary.

[134] See *De Anima* 1.1.403a24–b16.

[135] According to Mayr, consistent with essentialism is the theory that "an existing species could give rise to a new species, by a sudden leap. This, however, is not evolution. The diagnostic criterion of evolutionary transformation is gradualness"; *Toward a New Philosophy*, 173.

student of nature, and was guided by the actions and operations exhibited by living things. How would he interpret the data of modern biology? I propose the following interpretation in Aristotelian terms, retaining the central but extended role of form. A living individual is a unitary, single substance; it is not, however, simple but is itself composed of multiple ingredient components, determined by their own formal structure: atoms, molecules, cells, minerals, and so forth, each of which retains its own identity even though subordinate, perhaps suspended, in the overall service of the organism. Aristotle himself notes that while the elements do not actually persist in a compound, "neither are they destroyed or altered . . . for their power is preserved" (σώζεται γὰρ ἡ δύναμις αὐτῶν).[136] Commenting on this text Aquinas notes that "[t]he *forms* of the elements are present in compounds not actually but virtually."[137] The individual is thus determined not only by its own substantial form but embraces within itself a multiplicity of subsidiary forms which retain the power of their specific nature. William A. Wallace's use of the term "natural form," as distinct from "substantial form," is appropriate to denote these subordinate forms.[138] The individual organism may be viewed as a single substance governed by a unifying substantial form but comprising a diversity of parts and elementary constituents which are determined in turn by their own natural forms; the organism is itself composed of a plurality of unities. Substantial form is the coalescent principle of a vast diversity within the individual; it is a unity of unities. Darwin himself aptly remarks: "An organic being is a microcosm—a little universe, formed of a host of self-propagating organisms, inconceivably minute and numerous as the stars in heaven."[139]

From the point of view of heredity, and therefore of evolution, most important among the constituent elements within the makeup of the parent are the gene cells. While in one sense dependent upon the

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[136] *On Generation and Corruption* 1.1.10.327b29–31.

[137] *De mixtione elementorum*, in *Opuscula Philosophica*, ed. Raymund M. Spiazzi (Turin: Marietti, 1954), p. 156, par. 439: "Sunt igitur formae elementorum in mixtis non actu, sed virtute." The translation is from V. Larkin, "On the Combining of the Elements," *Isis* 51 (1960): 72 (my emphasis). See also *Summa Theologiae* I, q. 76, a. 4, ad 4. Compare Nichols, "Aquinas' Concept of Substantial Form," 315.

[138] William A. Wallace, *The Modeling of Nature: Philosophy of Science and Philosophy of Nature in Synthesis* (Washington, D.C.: The Catholic University of America Press, 1996), 10.

[139] Darwin, *The Variation of Animals and Plants*, 404.

entire body for their existence and sustenance, they have an autonomous identity of their own. They carry *in nuce* the elements which, combined from both parents, form the new and unique offspring; Aristotle, needless to say, was ignorant of gene cells. In the *Generation of Animals*, he outlines in detail the roles of semen and menses, which he believed to be the active and passive factors in generation. According to Aristotle, the active element within semen is the living heat of *pneuma*, endowed with the actuality to enact the movements required for the generation of new offspring. The bodily aspect of semen as such (το σῶμα) plays no part; the active cause (ἡ ποιοῦσα) is the power and movement it contains (ἐν αὐτῷ δύναμις καὶ κίνησις).[140] As Montgomery Furth explains:

> Aristotle's hypothesis is that there is in the semen, not the form itself, nor any portion destined to become the form, but the power of constructing new individuals *of* that form. The nature of this power is informational (thus it is frequently referred to as a logos, a formula) . . . the semen is several times referred to as having in it the 'logos *of* these movements', for which various analogies can be found elsewhere in the natural world, but whose operation here is nevertheless *sui generis*.[141]

The semen therefore is, as it were, in Gotthelf's phrase, an "internal transmitter."[142] As an intermediary or instrumental cause in the process of reproduction, semen is possessed of its own power and nature, separate and distinct from those of the father, the external agent.

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[140] *GA* 1.21.729b5–6.

[141] Montgomery Furth, *Substance, Form and Psyche: An Aristotelian Metaphysics* (Cambridge: Cambridge University Press, 1988), 117; see *GA* 2.1.734b33, 2.1.735a2, 2.4.740b32, 4.3.767b20. Furth remarks that although Aristotle's account "is by present-day lights quite crude and childlike compared to the actual mechanisms involved, which are more complicated and more indirect as between the nature of the genetic material itself and the form manifested in the eventual offspring . . . the correctness of these ideas on some significant matters of principles is notable also. . . . The genetic material carries specific form, not by containing little whole animals or parts of animals, but as *information* that under the proper circumstances can proceed to direct the stepwise construction of co-specific offspring. . . . The affinities with some more recent findings in this area are quite striking" (119). See also the excellent, forthcoming article by Steven Snyder, "Evolution and the Origin of Species: Aristotelian Reflections," in *Science, Philosophy, and Theology*, ed. John O'Callaghan (South Bend: St. Augustine's Press, 2004). I am grateful to Steven Snyder for providing me with a copy of his article, from which I have drawn much benefit.

[142] Gotthelf, "Aristotle's Conception of Final Causality," 239/216; see note 83 above.

Like all instrumental agents, semen acts in virtue of its own powers and natures, distinct from those of the principal cause. From genetics we know that the gene cells of the parent, that is, those which determine and transmit the DNA of the offspring, can possess major differences compared with those of the parent. Hereditary information is carried by the sequence of nucleotides whose groupings as genes form the DNA molecule.[143] Gene cells are subject to mutation: for example, by radiation from the external environment, or endosomatically through the action of chemicals within the body itself. All that is required for mutation to take place in the gene cell is the change of a single nucleotide; this suffices to provide the code for a new protein. If the new genetic structure in time becomes predominant within the gene pool, the way is open for evolution of the species itself. In light of Guthrie's dismissal of Aristotelian form as incompatible with Darwinian evolution, it is ironically indicative both of the pace of scientific discovery as well as a more refined historical appreciation that many biologists today regard the discovery of DNA—the strongest vindication of evolution—as a more accurate elaboration of Aristotelian form.

Although Aristotle never espoused it, I suggest that with certain modifications his metaphysics is compatible with evolution, understood as the development of virtualities latent within specific form. This would entail extending the meaning of potency beyond individual members of the species, viewed in isolation, to the prospective potency of the entire species, that is, beyond the phenotype to the genotype and genepool itself. Such evolution would be governed for Aristotle by a teleonomy rooted in the bond between formal and final causes, and influenced by the external circumstances of generation. Admittedly, this would involve a refocus of explanation. It would require, analogously, a shift away from a "pangenetic" view of form, in which species as a whole are already globally preformed, to an "epigenetic" unfolding of new forms, present within the deep potency of the genotype. Despite Guthrie's suggestion of a Platonic prejudice, there is nothing fundamentally uncongenial in Aristotle's metaphysical thought to prevent us from incorporating an evolution of species in

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[143] Compare Robert Russell, "Special Providence and Genetic Mutation," in *Evolutionary and Molecular Biology: Scientific Perspectives on Divine Action*, ed. R. J. Russell, W. R. Stoeger, and F. Ayala (Vatican City: Vatican Observatory Publications, 1998), 205.

the light of modern discoveries. This would not be a violation of his thought but rather a response to his deepest metaphysical intuitions and attitude to nature, as well as his scientific spirit, that is, the desire to submit to the empirical evidence and shape one's vision accordingly.

The single greatest stumbling block in attempting to incorporate evolution into Aristotle's world is the fixity of species—for the Philosopher a preordained goal of cosmic, even transcendent, significance. The primary aim of all living things is to replicate their type faithfully through reproduction, thus guaranteeing the perpetuity of the species. This results from the primitive impulse in all things to persist in being. Aristotle declares: "Being is better than not-being, and living than non-living."[144] This, he affirms, is the radical reason for male and female: unable to live eternally as individuals, living beings strive to maintain their class (γένος) and species (εἶδος) through the process of generation. To deviate from specific form would be entirely contrary to this purpose and confer no advantage. In the context of modern biology, however, one might recognize that the drive for perpetuity operates not only within the species, composed of discrete and autonomous individuals (men, horses, parrots, and so forth), but throughout all subsidiary life-forms. (Dawkins merely substitutes the selfish gene for Aristotle's singleminded species—the opposite extreme.) Aristotle's observations focused on living things as whole and complete substances; εἶδος determines the individual and orders it within its class, which in turn it aims to perpetuate. I have suggested that in modern biology natural form is seen to operate not only at the over-arching and all-commanding level of complete substance, but also throughout the diverse range of lesser structures and determinations which cohere in substance. Heredity is not dependent upon the agency of the individual but is rather determined by the genetic cells. Genes have their *eidos* but are open to mutation. By recognizing *eidos* as operative at this level we can integrate Aristotle's metaphysics and the theory of evolution; interpreted in this manner, Aristotelian form thus contributes to the mutational mechanism of evolution. Here we can

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[144] *GA* 2.1.731b28–30: Βέλτιον . . . τὸ εἶναι τοῦ μὴ εἶναι καὶ τὸ ζῆν τοῦ μὴ ζῆν (trans. Peck, 131). See *De Anima* 2.4.415a26–b1: "For any living thing that has reached its normal development . . . the most natural act is the production of another like itself, an animal producing an animal, a plant a plant, in order that, as far as its nature allows it, it may partake in the eternal and divine" (trans. J. A. Smith, *Complete Works* 1:661).

meet the objection against the concept of "evolving essence": it is in the nature of genes to adapt and mutate while still performing their stable function of transmitting the code of life. In the universal context of whole and complete substances, it is a discovery of modern genetics that all living beings are fundamentally related. Aristotle's fixity of species is no longer tenable; in the light of the evidence, however, the principles of his metaphysics acquire new verification and relevance.

The notion of Aristotelian form thus continues to perform an indispensable role within contemporary biology, a timeless revenant defying all attempts to have it banished.[145] The abiding and actual relevance of Aristotelian εἶδος is clearly expressed by Ernst Mayr, who suggests that we substitute modern terms such as "genetic program":

> One of the reasons why Aristotle has been so consistently misunderstood is that he uses the term *eidos* for his form-giving principle, and everybody took it for granted that he had something in mind similar to Plato's concept of *eidos*. Yet the context of Aristotle's discussions makes it abundantly clear that *his eidos* is something totally different

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[145] See William Wordsworth's Valedictory Sonnet to the River Duddon: "Still glides the Stream and shall for ever glide; / The Form remains, the Function never dies." The experience of Leibniz provides an interesting historical parallel: "In the beginning when I had freed myself from the yoke of Arisotle, I had taken to the void and the atoms, for they best fill the imagination; but on recovering from that, after many reflections, I realized that it is impossible to find the principles of *a true unity* in matter alone or in that which is only passive, since everything in it is only a collection or mass of parts to infinity. Now multitude can only get its reality from *true unities* which come from elsewhere and are quite different from points (it is known that the continuum cannot be composed of points). Therefore to find these *real unities* I was compelled to have recourse to a formal atom, since a material being cannot be both material and perfectly indivisible or endowed with a true unity. It was necessary, hence, to recall and, so to speak, rehabilitate the *substantial forms* so descried today, but in a way which would make them intelligible and which would separate the use we should make of them from the abuse that has been made of them. I thence found that their nature consists in force, and that from that there ensues something analogous to feeling and appetite; and that accordingly they must be conceived in imitation of the idea we have of Souls. But as the soul should never be used to explain any detail of the economy of the animal's body, I judged likewise that these forms must not be used to explain the particular problems of nature though they are necessary to establish true general principles. Aristotle calls them *first Entelechies*. I call them perhaps more intelligibly, *primitive Forces* which do not contain only the *act* or the complement of possibility, but further an *original activity*"; "New System of Nature and of the Communication of Substances, as well as of the Union of Soul and Body," in *Selections*, ed. Philip P. Wiener (New York: Scribner, 1951), 107–8 (emphasis in original).

> from Plato's *eidos* (I myself did not understand this until recently). Aristotle saw with extraordinary clarity that it made no more sense to describe living organisms in terms of mere matter than to describe a house as a pile of bricks and mortar. Just as the blueprint used by the builder determines the form of a house, so does the *eidos* (in its Aristotelian definition) give the form to the developing organism, and this *eidos* reflects the terminal *telos* of the full-grown individual.[146]

It is not possible, however, simply to equate *eidos* with DNA, as perhaps implied by Mayr. DNA is present in every cell of the body, yet each organ develops differently; this would be impossible if they were following the same program. There is a higher level of organization which governs the genetic program and translates the blueprint into the construction process of the organism. The gene, furthermore, is a dependent part within the overall makeup of the parent, yet it has a certain autonomy and individual identity. No single part controls the whole, and while the individual unites all its parts and constituent elements within itself, it does not entirely dominate them—heredity is independent of the parent.

Multiple forms of organization, with overlapping but distinct roles, must therefore be affirmed; there is a diversity of εἴδη within the individual. Aristotle's attention was on the single, all-enveloping form which determines complete substance. This is admirably conveyed in *Parts of Animals*, in the continuation of the famous passage, referred to earlier, which expresses his basic scientific motivation and attitude:

> When any one of the parts or structures, be it which it may, is under discussion, it must not be supposed that it is its material composition to which attention is being directed or which is the object of the discussion, but rather the total form. Similarily, the true object of architecture

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[146] Mayr, *Toward a New Philosophy*, 56–7 (emphasis in original). Mayr remarks: "No other ancient philosopher has been as badly misunderstood and mishandled by posterity as Aristotle. . . . Although the philosophers of the last forty years acknowledge quite generally the inspiration which Aristotle derived from the study of living nature, they still express his philosophy in words taken from the vocabulary of Greek dictionaries that are hundreds of years old. The time would seem to have come for the translators and interpreters of Aristotle to use a language appropriate to his thinking, that is, the language of biology, and not that of the sixteenth-century humanists. . . . Much of Aristotle's discussion becomes remarkably modern if one inserts modern terms to replace obsolete sixteenth and seventeenth century vocabulary"; ibid., 55–6.

> is not bricks, mortar or timber, but the house; and so the principal object of natural philosophy is not the material elements, but their composition, and the totality of the substance, independently of which they have no existence.[147]

Substantial form is not the only one, but it is the most important.

Aristotle's εἶδος retains its explanatory role. Many evolutionary authors have a comparable principle in mind when they reject extreme reductionism, arguing instead for a holistic, integrative biology.[148] They place the organism rather than the gene at the center of life, and they aim at "Making Biology Whole Again."[149] Stephen Jay Gould (a self-professed "dyed-in-the-wool Darwinist") rejects Dawkins's "ultimate (and logically false) reductionism to the selfish gene," emphasizing that natural selection is "a hierarchical process working simultaneously at several levels of Darwinian individuality (from genes to organisms to demes to species to clades)."[150] There are distinct degrees of irreducible organization and complexity, none of which can be reduced to its lower elements. Using a very simple illustration, Steven Rose (from a proclaimed materialist perspective), explains how the physiology of a frog's leap "requires a set of irreducible organizing relations" which are absent from either the biochemistry or

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[147] *PA* 1.5.645a30–6 (trans. W. Ogle, *Complete Works* 1:1004).

[148] I am grateful to Terence Nichols for drawing my attention to the relevant literature. See Terence L. Nichols, *The Sacred Cosmos* (Grand Rapids: Brazos Press, 2003) for an expanded treatment of holism in recent biology. Besides those authors referred to here, one may also mention Richard Lewontin and Brian Goodwin, *How the Leopard Changed its Spots* (New York: Charles Scribner's Sons, 1994); *Beyond Neo-Darwinism: An Introduction to the New Evolutionary Paradigm*, ed. Mae Won Ho and Peter Saunders (London: The Academic Press, 1984); David J. Depew and Bruce H. Weber, *Darwinism Evolving* (Cambridge: MIT Press, 1995); Robert G. Wesson, *Beyond Natural Selection* (Cambridge: MIT Press, 1991).

[149] See Steven Rose, *Lifelines: Biology, Freedom, Determinism* (London: Penguin, 1998), x, 302. See p. 7: "[My main task] is to offer an alternative vision of living systems, a vision which recognizes the power and role of genes without subscribing to genetic determinism, and which recaptures an understanding of living organisms and their trajectories through time and space as lying at the centre of biology."

[150] Stephen Jay Gould, "Self-Help for a Hedgehog Stuck on a Molehill," *Evolution* 51, no. 3 (1997): 1023. Natural selection is, he suggests, "a necessary but by no means sufficient, principle for explaining the full history of life"; ibid., 1022.

chemistry involved; it is a case, he states, of the whole being more than its parts.[151] He declares: "Each level of organization of the universe has its own meanings, which disappear at lower levels."[152] Noting, moreover, that "[e]very molecule, every organelle, every cell, is in a constant state of flux, of formation, transformation and renewal," he concludes, in words echoing the metaphysics of Aristotle: "Dynamic stability of form persists, although every constituent of that form has been replaced."[153]

Taking his cue from Karl Popper,[154] who argued for what he called "active Darwinism"—the living organism "helping to determine its own fate by itself challenging and modifying its environment to meet its own needs"—Rose emphasizes that living things are not merely products of their environment but first wholes which themselves influence in turn their own environment. Stuart Kaufmann likewise claims that besides random mutation and natural selection, self-organization plays an important part in the evolutionary process.[155] That there are different levels of biological identity and function accords with our earlier suggestion, in Aristotelian terms, that as well as the all-enveloping, singular, and unitary form of the individual, there are lower or subsidiary levels of formal determination and organization. The term "holon," coined by Arthur Koestler,[156] is particularly suited to convey the role of such lesser, relatively independent subwholes, complete in themselves yet open to further determination as elements within a higher totality; it is an apt substitution for subsidiary "form."[157] The ontological unity of the universe is thus, as Rose puts it, "a nested hierarchy of holons."[158]

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[151] Rose, *Lifelines*, 93.

[152] Ibid., 296.

[153] Rose, *Lifelines*, 306–7.

[154] Karl Popper, 1st Medawar Lecture to The Royal Society, 1986, cited in ibid., 75, 96. For Rose's view, see ibid., 309.

[155] Stuart Kaufmann, *At Home in the Universe* (New York: Oxford, 1995), 25. See Rose, *Lifelines*, 270: "Life is inevitably autopoietic, self-generating, self-developing, self-evolving."

[156] Arthur Koestler, *The Ghost in the Machine* (London: Picador, 1967), 48–54; see the diagram in ibid., 60; Arthur Koestler, "Beyond Atomism and Holism—the Concept of the Holon," in *Beyond Reductionism: New Perspectives in the Life Sciences*, ed. Arthur Koestler (London: Hutchinson, 1969), 192–232.

In light of the intrinsic connection for Aristotle between formal and final causality, it will be of further interest to refer to a recent suggestion that evolution is not entirely bereft of inherent directionality. This has arisen from laboratory experiments by the microbiologist Barry G. Hall of the University of Connecticut, published in 1982 in an article entitled "Evolution on a Petri Dish."[159] Hall deleted from the bacteria *E. coli* the structural gene which enables it to metabolize lactose (milk sugar), and then challenged these bacteria to grow on a culture of lactose.[160] Initially they were unable to grow, since they could not produce the enzyme needed to digest the sugar. After nine days, however, strains of bacteria emerged which, contrary to expectation, metabolized the lactose. It appears that the bacteria reconstructed the code from the missing gene by manipulating another dormant or "cryptic" gene, thereby bringing about a mutation in an existing enzyme so that it could perform the function of the one deleted. Crucially, another prior mutation was also needed, namely in the gene which regulated the dormant gene. According to Hall, the random

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[157] See Steven Rose: "The divisions between [different levels of organization of matter] are confused. In part they are ontological, and relate to scale and complexity, in which successive levels are nested one within another. Thus atoms are less complex than molecules, molecules than cells, cells than organisms, and organisms than populations and ecosystems. So at each level different organizing relations appear, and different types of description and explanation are required. Hence each level appears as a holon—integrating levels below it, but merely a subset of the levels above. In this sense, levels are fundamentally irreducible; ecology cannot be reduced to genetics, nor biochemistry to chemistry"; *Lifelines*, 304–5.

[158] Ibid., 94.

[159] Barry G. Hall, "Evolution on a Petri Dish," *Evolutionary Biology* 15 (1982): 85–150; "Evolution of New Metabolic Functions in Laboratory Organisms," in *Evolution of Genes and Proteins*, ed. Masatoshi Nei and R. K. Koehn (Sunderland, Mass.: Sinauer Associates, 1983), 234–57. For references to this literature I am again gratefully indebted to Terence Nichols, upon whose presentation of this topic I rely here. See also Kenneth R. Miller, *Finding Darwin's God: A Scientist's Search for Common Ground Between God and Evolution* (New York: Harper Collins, 1999), 145–7; D. J. Futuyama, *Evolution* (Sunderland, Mass.: Sinauer Associates, 1986), 477–8.

[160] Like the fast-breeding fruit fly (*drosophila*), the *Escherichia coli*, or common gut bug, has the advantage that it replicates and mutates rapidly, thus allowing scientists to accelerate the accumulation of data from which to extrapolate the patterns of evolution. Ironically, as Steven Rose remarks, despite the diversity of life forms—estimated between 14 and 30 million—"most biochemical and genetic generalizations are still derived from just three organisms: the rat, the fruit fly and the common gut bug"; *Lifelines*, 2, 4.

chance that both mutations would occur together in the same bacterium was 1 in 10^{18}, which in normal conditions, he calculated, would require 100,000 years; it had occurred in nine days. Hull declared: "We can only conclude that under some conditions spontaneous mutations are not independent events—heresy, I am aware."

The results of this accelerated and artificial sequence of enforced "evolution" offer the strongest evidence that, contrary to neo-Darwinian orthodoxy, these mutations were far from random, that is, unrelated to the individual, but were indeed clearly directed to the organism's benefit. Although Hall's conclusion has been challenged, his critics were obliged to accept the much higher frequency of favorable mutations under controlled conditions.[161] If vindicated, the recognition of such "directed mutations" would lend empirical weight to Aristotle's conviction of internal finality within the organism itself in the ineradicable bond between formal and final causes.

Having attempted to defend the indispensable role of form, there remains the pertinent question: What *is* form? How is it to be defined? Need we affirm, for example, in every human a *homunculus*, as some early users of the microscope imagined they saw in spermatozoa? Are we committed to some mysterious principle such as Bergson's *élan vital*, or the immaterial entelechy of Hans Driesch's vitalism? Εἶδος, for Aristotle, is indeed ἐντελέχεια, that is, completeness or perfection; form is determined actuality. What does this tell us? What is the reality of form which actualizes and determines one individual substance as a human being, another as a parrot? Where does it reside? I suggest that while this is a pressing and legitimate question, it is not one which needs to be fully resolved in order to justify the validity of what is asserted. In other words, we may affirm the reality of form although we do not fully grasp its nature. It is sufficient to point to its effects and operations, that is, the actions of the individual substance which proceed from it. Substances are known through their actions, since these reveal how something actualizes itself according to a determinate mode of being.

Form is the real and actualizing principle which determines the essences of things. A helpful scientific parallel is the synonymous

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[161] See Richard E. Lenski and John E. Mittler, "The Directed Mutation Controversy and Neo-Darwinism," *Science* 259, no. 5092 (8 January 1993): 188–94.

term "structure." Quantum mechanics affirms the existence of elementary particles and assigns to them very definite characteristics which can be identified and measured; they are distinguished from one another by their different roles and behavior.[162] Each particle has its particular specificity: electric charge, mass, spin, location within a range of time and place, and so forth. As we proceed to higher modes of being or essence, it becomes increasingly more difficult to delimit structure. Uniqueness is more easily recognized but less easily measured. Individuality is clearer the more perfect the substance, but it yields less readily to investigation. Substances become more inscrutable with the increase of selfhood or inner complexity.

The example of the comparatively stable knowledge which the physical sciences have of elementary particles, allied with the continuity and differences which obtain among distinct modes of being, allows us analogously to conclude that higher modes of life equally have an intrinsic structure and specificity, proper to their kind, which is the ground of the actions and operations which they exercise. Substances of different kinds act in different ways; thus diverse actions reveal diverse modes of substance, although they do not disclose them entirely or exhaustively. Aristotle distinguishes between living organisms on the basis of their proper powers: plants exhibit the fundamental powers of nutrition, growth, and reproduction; in addition, animals enjoy motion and sensation; humans have intellection and will. Nevertheless, with respect to the immediate object of knowledge, the principle inevitably holds true: *individuum est ineffabile.* Our knowledge is indeed limited and deficient, yet it is adequate for us in the concrete to distinguish among different kinds of essence by virtue of their

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[162] For the theoretical problems associated with such knowledge, see the excellent article by William A. Wallace, "Are Elementary Particles Real?" in *From a Realist Point of View: Essays on the Philosophy of Science* (Washington, D.C.: University Press of America, 1979), 187–99. Highly pertinent to our entire discussion of the role of form is the following remark by Wallace: "One can only be struck by the outstanding contribution made by genetics to the understanding of evolutionary processes, particularly in terms of DNA–RNA molecular groups, genes, chromosomes, and so on. And what is most remarkable about this development is that the causal explanations it supplies are made, not in terms of efficient or final causality, but rather in terms of material and formal causality"; *Causality and Scientific Explanation*, vol. 2, *Classical and Contemporary Science* (Ann Arbor: University of Michigan Press, 1974), 317–18.

characteristic operations.[163] Does this commit us to the "essentialism" condemned by W. V. Quine?[164] In his own words, "This is the doctrine that some of the attributes of a thing (quite independently of the language in which the thing is referred to, if at all) may be essential to the thing, and others accidental." Most likely, but it is a charge one may carry lightly. Are not some attributes indeed more important to an individual's essence than others? Is it not more important to humans that they are rational than to have feet? It is moreover a necessary stratagem in mapping the world through human knowledge. Εἶδος is the object of Aristotelian νοῦς,[165] but it can only work through abstractive insight and distinction: by isolating some features of the object as referentially more significant than innumerable others. This is but another of Aristotle's insights which may not be easily discarded.[166]

In an exhaustive and well-grounded study, the German scholar Johannes Hübner compellingly argues that soul is to be understood as activity.[167] He takes this suggestion from Aristotle's illustration in *De*

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[163] William A. Wallace notes: "Natures are a shorthand way of indicating the intelligible aspects of things in terms of which they can be understood and defined. Thus the concept of nature is not exclusively an empirical concept, if by empirical one means whatever can be measured or photographed or otherwise presented directly to the senses. It is transempirical, for although it takes its origin from sense experience it still requires going beyond the world of sense for its proper comprehension. To refer to the nature of a thing is therefore to designate an inner dimension that makes the thing be what it is, serves to differentiate it from other things, and at the same time accounts for its distinctive activities and responses. This inner dimension is not transparent to the intellect, for we usually do not achieve distinct and comprehensive knowledge of a nature the first time we encounter it in experience. Rather we grasp it in a general and indeterminate way that is open to progressive development and refinement on the basis of additional information"; *The Modeling of Nature*, 4–5.

[164] W. V. Quine, "Three Grades of Modal Involvement," in *The Ways of Paradox* (New York: Random House, 1966), 173–4. See David Charles's remarks on Quine's position in *Aristotle on Meaning and Essence* (Oxford: Oxford University Press, 2001), 354–7. The validity of "natural kinds," as defended by Quine, is of course a prerequisite in our present discussion, both for Aristotle's notion of φύσις and evolutionary species. See "Natural Kinds," in *Ontological Relativity and Other Essays* (New York: Columbia University Press, 1969), 114–38. Compare William A. Wallace, "A Place for Form in Science: The Modeling of Nature," *Proceedings of the American Catholic Philosophical Association* 49 (1995): 39.

[165] *De Anima* 3.8.431b2: Τὰ μὲν οὖν εἴδη τὸ νοητικὸν νοεῖ. See 3.8.431b29–432a1.

Anima 2.1, of the two senses of ἐντελέχεια by the analogous distinction between ἐπιστήμη and θεωρεῖν, knowledge as possession or disposition, and knowledge as the very act of knowing itself. Going beyond the standard interpretation of soul as prerequisite of action, he suggests that the very essence of soul is activity. Representative of the "traditional interpretation" is D. W. Hamlyn: "The soul is actuality only as *hexis*, i.e. in a dispositional way, since something may still be alive when asleep and not *doing* something."[168] Of the authors discussed in the present study, we can cite James Lennox, who understands Aristotelian soul to be "a unified set of goal-oriented capacities—nutritive, reproductive, locomotive, and cognitive."[169] A disposition, however, is by definition itself a potency and therefore dependent on a more primitive actuality. In the example employed by Hamlyn, it is not enough to say that while something is asleep, it is not "*doing* anything"; quite the contrary, it is very active indeed: it is alive. To be alive is its manner of being. In a significant phrase (not invoked by Hübner), Aristotle declares that "to be alive" is itself the very being of living things: τὸ δὲ ζῆν τοῖς ζῶσι τὸ εἶναί ἐστιν, αἰτία δὲ καὶ ἀρχὴ τούτων ἡ ψυχή.[170] This is underpinned moreover by Aristotle's statement in *Metaphysics* 12, that God's act of thinking is his very life and actuality, that is, his being: ἡ γὰρ νοῦ ἐνέργεια ζωή, ἐκεῖνος δὲ ἡ ἐνέργεια.[171] Risking what may seem an apparent tautlogy, actuality is the primary reality of anything. This happens for each being in the

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[166] Jonathan Barnes writes: "Some modern philosophers have rejected—and ridiculed—Aristotle's talk of essences. But Aristotle shows himself the better scientist; for an important part of the scientific endeavour consists in explaining the various quirks and properties of substances and stuffs in terms of their fundamental natures—that is to say, in terms of their essences. Aristotle's axiomatic sciences will start from essences and successively explain derivative properties. The theorems of animal biology, say, will express the derived properties of animals, and the deduction of the theorems from the axioms will show how those properties are dependent upon the relevant essences"; *Aristotle: A Very Short Introduction*, 56.

[167] Johannes Hübner, "Die Aristotelische Konzeption der Seele als Aktivität in de Anima II 1," *Archiv für Geschichte der Philosophie* 81 (1999): 1–32.

[168] D. W. Hamlyn, *Aristotle, De Anima* (Oxford: Clarendon Press, 1993), 82.

[169] Lennox, *Aristotle's Philosophy of Biology*, 128; see xx: "Animals are unities of matter and form—souls are simply forms (read 'functional capacities') of animate bodies."

[170] *De Anima* 2.4.415b13–14.

[171] *Meta* 12.10.1072b.26–7.

measure of its form—in the case of living things, according to their soul.

It is easier in this context to understand why Aristotle, having distinguished in the *Metaphysics* between motions (κινήσεις) which are incomplete (ἀτελές) and activities (ἐνέργειαι) which contain within themselves their own completion and fulfilment (ἐντελέχειαι), declares: "It is therefore evident that substance and form are actuality" (ἐνέργεια).[172] The sheer activity of an act of contemplation (θεωρεῖν) does not seek fulfilment beyond itself in the further discovery of truth, thereby actualizing residual potential, but rather it rests in the enjoyment of an insight already attained; likewise the actuality of substantial form is already complete in itself, as the fundamental and completed actualization of matter which it constitutes as an individual. (This is not to deny the potency which characterizes all beings other than the First Mover; each being is open to new actualizations, but not at the basic level of form. While I continually realize latent potencies, I cannot become a human being to a higher degree; as Aristotle notes in the *Categories*, there are no grades of substantiality.) We may also grasp the definition of form as activity, in light of the discoveries of particle physics. The structures of subatomic particles are not inert but consist of energy; the basic building blocks of the material world undergo endless recombinations but retain clear levels of identity, recognized by their dynamic inner activity.

Careful not to confuse act with movement in suggesting that form is activity, it is equally important to grasp the analogical nature of actuality. The act of the soul in actualizing the body is not the same kind as the act of contemplation exercised by the soul but rather of a prior order. The concept of actuality is itself fundamental and cannot be further analyzed into any notion more elementary. It coincides with our basic grasp of being; for Aristotle, actuality is the primary sense of reality.[173] Form is primary actuality—activity—not in the existential order but in the order of essence or modality; it signifies the *modus agendi* according to which each thing exists. For reasons which lie beyond our present scope, modes of being, that is, essences, are themselves potential with respect to the primary, actualizing power or

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[172] *Meta* 9.8.1050b2–3: ὥστε φανερὸν ὅτι ἡ οὐσία καὶ τὸ εἶδος ἐνέργειά ἐστιν.

[173] *De Anima* 2.1.412b9.

presence of existence; form is thus consequent upon existence, the secondary activity of beings, causing each thing, not radically *to be* (that is, in the primary sense of *exist*), but to be *what* it is: determining its essence or τὸ τί ἦν εἶναι.[174]

We must recognize here the inevitable limits of our knowledge; since we have no direct, illuminative knowledge of forms or souls, the best we can do is describe them in terms of the most revealing and perfect attributes which they exhibit, elucidated through the fundamental concepts at our disposal. Such knowledge is of its nature deficient. It is not possible (in Leibniz's phrase—misattributed to Bacon, whose motive he thereby sought to praise)[175] to put nature "on the rack" and with screws to wrest her secrets. As Goethe saw, "Nature falls silent under torture."[176] It is not within our power, in words of the Bard, to "pluck out the heart of mystery"; yet, as Aristotle recognized, the occasional and scanty insights we attain of profound realities is more worthy than the detailed knowledge afforded by the senses.

Aristotle's biology provided a richness of experience and insight which greatly nourished his metaphysics; his metaphysics provides, in turn, a deeper dimension and perspective within which to understand and evaluate the undercurrents which inwardly sustain living things in their operations. Aristotle's metaphysics offers timeless insights which are of fundamental value to human experience and which are necessary if the life sciences are themselves to be adequately articulated—even if such insights themselves lie beyond the scope of science. As a scientist of abiding relevance and perennial philosopher par excellence, his wisdom is a valuable guide in assessing whatever theories may emerge regarding man and the cosmos. Leibniz declared that Aristotle's utterances regarding the basic concepts of natural philosophy were "for the most part entirely true."[177] Henri Bergson states

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[174] I am introducing here a distinction not found in Aristotle.

[175] Leibniz's letter to Gabriel Wagner (1696); *Philosophical Papers and Letters* 2, ed. Leroy E. Loemker (Chicago: University of Chicago Press, 1956), 758. Bacon's aim is to "dissect nature": "Melius autem est naturam secare, quam abstrahere"; *Novum Organon*, bk. 1, aph. 51 (*The Works of Francis Bacon* 1:168).

[176] Johann Wolfgang von Goethe, *Maximen und Reflexionen*, Werke 12, (Hamburg: Wegner, 1967), 498. See p. 434: "Die Natur verstummt auf der Folter."

[177] Letter to Jakob Thomasius, April 1669: "Quae Aristoteles enim de materia, forma, privatione, natura, loco, infinito, tempore, motu, ratiocinatur, pleraque certa et demonstrata sunt"; *Sämtliche Schriften und Briefe* II, 1 (Berlin: Akademie Verlag, 1987), 15.

that if we remove from Aristotle's philosophy everything derived from poetry, religion, and social life, as well as from a somewhat rudimentary physics and biology, we are left with the grand framework of a metaphysics which, he believes, is the natural metaphysics of the human intellect.[178] These views echo the opinion of Aquinas, according to whom the characteristic of Aristotle is never to depart from the obvious.[179]

The preceding reflections have been concerned in the first place with εἶδος as an undeniable principle of being, verified analogously at diverse levels of reality; and secondarily with the theory of evolution, insofar as it explains the emergence of multitudinous life forms. My belief in the validity of Aristotle's insight was strengthened by an experience far removed from philosophic speculation regarding the metaphysical origins of biodiversity. I visited Lebanon shortly after the civil war. After years of relentless destruction, Beirut was an overpowering shock to the senses and an assault on one's comprehension: bombed-out buildings, their façades shrapnel-scarred, stood desolate among charred surroundings, pitiably ironic monuments to the failure of human purpose. It was at the time the biggest building site in the world and also—given the many-layered civilizations (Phoenician, Greek, Roman, Byzantine, Medieval) being unearthed—the greatest archeological site. The most striking story I heard, told to me by journalist Robert Fisk, concerned the excavation of a Roman site. The archeologist was distressed when the contents of a jar were accidentally spilled. When it rained, corn began to sprout—after 2000 years! This suitably Aristotelian chance event provided, to my mind, a striking illustration of what Aristotle meant by φύσις or nature, the "something extra" (ἕτερόν τι)[180]—however one chooses to name it: εἶδος, vital principle, *élan vital*—which abides deeply within all living things and which distinguishes them from the inanimate. Another picture stays in my mind—a mature tree growing from the balcony of a wrecked and tangled building, having germinated from a windblown seed years earlier. Life defiantly asserts itself after a gap of two millennia in the fire and flare of man's folly and destruction. Despite the

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[178] Henri Bergson, *Creative Evolution* (London: Macmillan, 1928), 344.

[179] *De Spiritualibus Creaturis*, a. 5: "Proprium philosophiae eius fuit a manifestis non discedere." (*Quaestiones Disputate*, vol. 2, ed. M. Calcaterra and T. S. Centi [Turin: Marietti, 1965], 389.)

[180] *Meta* 7.17.1041b17.

tragic consequences of human deliberation, perhaps we can after all share in Aristotle's optimism that Nature is not in herself a malign tragedy and does nothing in vain.[181]

University College Dublin

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