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0521544955 - Genes and the Agents of Life: The Individual in the Fragile Sciences Biology

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PART ONE

INDIVIDUALS, AGENCY, AND BIOLOGY

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Individuals and Biology

1. INDIVIDUALS AND THE LIVING WORLD

What are the agents of life? This book is a partial answer to this simple-sounding, yet puzzling, question. In this first chapter, I shall unpack what is built into this question and introduce some of the issues that answering it will lead us to explore.

The living world not only surrounds us physically, but its denizens also occupy much of the content of human thought and action. These agents of life range from the plants and animals that fill our homes and domestic lives, to those we consume as part of our ecological regime, to organisms of all types: blue whales, dolphins, chimpanzees, dogs, fungi, flowering plants, rainforests, bacteria, viruses, sponges, tapeworms, and so on.

The living world and the agents of life that constitute it excite the full range of our passions – love, wonder, joy, fear, and disgust. Our interactions with them have inspired human artistic expression from the earliest cave drawings to late-twentieth century experiments in bio-art.

Part of what impresses us, what leaves a mental mark, is the fact that we are not simply immersed in the living world but part of it. We are each subject to its vicissitudes, such as disease and death, and each of us owes our own existence to the activities of members of the living world most like us: other human beings. Human beings are the agents of life that preoccupy most of us, most of the time, and it is more than naive anthropomorphism that places us and our own peculiar qualities at the heart of many of our representations of the living world.

But there is more to what catches our eye about the living world. It is rich, complex, and diverse. Both its particularity and its lawfulness are

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the basis for at least a minor kind of awe, one that can stem from our everyday interactions with the rest of the living world. If you have ever carefully observed large mammals in their natural environments, played with a young kitten or puppy, watched a flower bloom or a bee work its way across the stamens in the flower, or learned how rapidly viruses and bacteria can multiply and change their structure, then you might have experienced the little “Wow” that I am trying to evoke.

There is a simplicity to our common-sense thinking about the richness, diversity, and complexity to the living world that is taken for granted in both common sense and the biological sciences. The living world is made up of living things, and living things are agents. We think about the dimensions of the living world, and the vague and contentious boundaries to it, in terms of the individual agents that the living world contains. These individuals range in size from single-celled organisms that can only be viewed through moderately powerful microscopes to giant sequoias that reach hundreds of meters into the sky and whose full physical scale, both above and below the ground, cannot be observed in any single, direct way. The living world includes individuals that vary massively in their longevity, with lifespans of minutes to those of hundreds of years; in their general strategies for living (for example, plants versus animals); in their internal complexity; and in their relationship to one another and their environments.

In short, when we think of the living world we think of the individual agents in it, the properties those individuals have, and the relationships they enter into, both with other living things and with the nonliving world. We think of life as we think of the mind – as tied to and delimited by agents. Neither life nor mind float free of agents, but are, in some sense, features that individuals either have or lack.

There is a flip side to this tie between life and agency. Life, like mind, does not simply belong to agents, but is more intimately woven into their fabric. Life and mind determine what it is to be an agent. Life and mind are, in some sense, *inside* individuals. They are deep features that make an important difference to the kind of individuals that have them, and they cannot be removed from any individual without changing their status as agents.

2. LIFE AND MIND

This raises the question of just how closely life and mind are related. Ancient and modern theories of both life and mind imply an intimate

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relationship between the two, an intimacy reflected in the etymology of classical and modern languages. For example, Aristotle distinguished between three kinds of soul that living things can possess – vegetative, animal, and rational. Herbert Spencer, the great integrator of nineteenth-century philosophy and science, viewed life and mind as being of a piece, and took a treatment of one to be incomplete without a treatment of the other. The words usually translated as “soul” from Sanskrit, Greek, and Latin – *atman*, *psyche*, and *anima* – all have the connotation of breath, something that fills a living thing and is necessary for its survival. The contemporary physicist and popular science writer Fritjof Capra says “[d]escribing cognition as the breath of life seems to be a perfect metaphor,” and identifies life and mind.¹

Today these views of life and mind are likely to be seen as antiquated or quaint, and met with corresponding bemusement or the impatience that leads to contempt. We treat life and mind as independent features that an individual either has or lacks. The study of life and mind has been compartmentalized into, respectively, the biological and the cognitive sciences. This sort of disciplining of the domains of life and mind, however, was contingent rather than inevitable. While it has created the opportunity for deep insights into both life and mind, it has also produced its own blind spots. One of these concerns the role and conception of agents in thinking about life and mind. Let us begin comparatively and consider two ways in which these roles differ.

First, in the case of the mind, we have a clear paradigm for the sort of agent that minds belong to. They belong to rational beings, and, for better or worse, we view human agents as rational beings. This is not to deny that we often think of other kinds of agents as having minds. For example, intelligent robots or computers, such as HAL in *2001: A Space Odyssey*, God (on at least most conceptions), and nonhuman animals all have minds of some kind. But human beings are the gold standard in that the minds of these other agents are typically conceptualized as being somewhat like those of human agents but diminished or enhanced in some or all of their characteristics. The focal role that human rational agency plays in our common-sense thinking about minds survives in the sciences of the mind – from artificial and computational intelligence to comparative psychology – where minds are conceptualized in terms of categories, such as perception, learning, decision, and memory. Although these straddle the divide between human and nonhuman cognition, again they have their paradigm existence in human agents.

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In the case of life, we also have a paradigm conception of what sort of agent has it, one that encompasses human agency but is somewhat broader. Our paradigm examples of living things are organisms. We are organisms, true enough, but it is also true that we are simply one kind, perhaps one very special kind, of organism. Our place in the living world is not as central as it is in the domain of cognition, a point reflected in the diminished role that human agency has within the biological sciences relative to that in the cognitive sciences.

A second difference between the role and conception of agents in thinking about life and mind concerns the physicality of individuals. By this I mean their boundedness in space and time, their material composition, and the role of dimensions of physical continuity in the survival of individual entities. Living agents have a high level of physicality. They are born (come into existence) and die (pass out of existence), they have a particular material structure important to what they can and cannot do, and their identity over time as the very same living thing – and not just the same kind of living thing – depends heavily on their physical continuity during that time. Cognitive agents, by contrast, have a low level of physicality. They are often thought of as having an essence that can be separated from their physical embodiment. This is so, not only in religious thought that embraces the survival of the soul after the death of the body, but also in the familiar fantasies of science fiction in which minds can be stored as information and beamed from one physical medium to another. The minimal physicality of cognitive agents is also manifest in the traditional view within artificial intelligence, which takes physical embodiment to be an add-on to a cognitive agent, something into which the artificial intelligence is injected after an agent has been created or established. It is part of what philosophers often think of as a Cartesian tradition that sees minds and bodies as operating in two different worlds, the mental and the physical.²

3. AGENTS: BIOLOGICAL, LIVING, AND OTHER

So far I have moved freely between talking of organisms as paradigms of living things, as individuals in the biological sciences, and as agents. It is time now to sharpen our focus and introduce some terminology. The central notions here will be those of a *living agent* and a *biological agent*.

I intend to characterize an agent in quite a general way: an agent is an individual entity that is a locus of causation or action. It is a source of

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differential action, a thing from which and through which causes operate. Consider some concrete examples of agents that are physical, biological, and social in nature.

Agents in the physical world, or physical agents, include very small things, such as elementary particles and atomic elements; ordinary physical objects of the sort that you can see with the naked eye or manipulate with your body, such as balls, tables, and rocks; and larger and more distant objects, such as tectonic plates and stars. Agents in the biological world, or biological agents, include proteins, genes, cells, organisms, demes, species, and clades. Social agents include individual people, but also groups of people, institutions, networks, and larger systems that consist of these other agents organized in particular ways.

The notion of an agent is linked, but not identical, to that of a cause. Agents are individuals, and causes often are not. I would be content to contrast individuals with other kinds of things that we might invoke as “the cause” in a given instance, such as forces and fields, processes and events, and properties and states. But I do not want to be legislative about this, and there are certainly ways in which we can and do think about, for example, certain winds or a particular magnetic field as an individual. Giving them a proper name, such as the North Wind or Hurricane Eliza, or personifying them more generally, are two ways of treating forces and fields, for example, as individual agents.

Crucial to being an agent, in the broad sense I intend, is having a boundary, such that there are things that fall on either side of that boundary. This notion of an agent should both make it clear why organisms are paradigmatic agents and why bodily *systems*, such as the digestive system, and biochemical *pathways*, such as the integrin signaling pathway that mediates cell adhesion, might be considered biological agents. As these examples suggest, agents sometimes operate as biological mechanisms: they have functions to perform in the context of some larger agent, and in turn contain further agents (such as the stomach and cadherins, in the two above examples) that perform contributory functions.

I find it compelling to think of these agent-marking boundaries as spatial and temporal, and so view agents as having both spatial and temporal beginnings and endings, as well as spatio-temporal continuity throughout their existence. Yet some of the agents most commonly invoked across cultures in explanations and accounts of our personal experiences are thought to be nonmaterial: from God, to angels, to ghosts, to ancestral spirits. Any view of agency needs to say something about such putatively nonmaterial agents, but we need not do so in this introductory chapter.

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Consider then (and for now) just physical agents, agents that have spatial and temporal boundaries, a material composition, and continued existence in space and time. Biological agents are one kind of physical agent. What of *living* agents? Put simply, these are biological agents that are living. Living things are often characterized in terms of one or more of the following properties: they have a metabolism, grow, contain adaptations, evolve, or have heterogeneous, specialized parts. The relationship between the concepts of organism, agency, and life is the topic for several chapters in Part Two. For now, I simply appeal to these properties as a way to provide a fix on what a living agent is, and note that, with the exception of organisms, we might reasonably question whether *any* of the examples of biological agents that I provided previously – proteins, genes, cells, demes, species, and clades – are living agents in and of themselves.

There are two important features of the way in which we think about biological agents, including living agents, particularly in the contemporary biological sciences.

First, biological agents are often conceived as forming a hierarchy of increasingly inclusive entities, starting with very small biological agents and ending with larger entities comprised of the agents with which we began. As the philosopher Todd Grantham says,

Life on earth is hierarchically organized. The biotic world consists of many ‘levels’ with the entities at each higher level composed of lower-level entities. Groups of cells form the tissues and organs out of which organisms are constructed, and organisms form various kinds of groups such as kin groups, populations, and species.³

This hierarchical thinking is ubiquitous in the biological sciences, and it extends to include not just agents (in my sense) but processes, events, properties, and states. In all of these cases, our default view is a sort of realism about these hierarchies. They and the individuals they contain are a part of the fabric of the world, rather than simply a product of our ways of thinking about the world, something we discover rather than invent.

Second, it is common to distinguish kinds of biological agents from one another. For example, some are physiological (cells), others are genetic (segments of DNA), some are ecological (predators), others evolutionary (species). These specific kinds of biological agents are also thought to be organized hierarchically. Together with the fact that the resulting more specific lists of biological agents are almost always distinct, this suggests that there is no single listing of “the” biological agents there are in the world.

TABLE 1.1. *The genealogical hierarchy and two versions of the ecological hierarchy*

Genealogical	Ecological (1)	Ecological (2)
Monophyletic taxa	Regional biotas	Biosphere
Species	Communities	Ecosystems
Demes	Populations	Populations
Organisms	Organisms	Organisms
Chromosomes	Cells	Cells
Genes	Molecules	Molecules

Source: Redrawn from Table 6.3 of Niles Eldredge, *Unfinished Synthesis* (New York: Oxford University Press, 1985).

Consider a version of the distinction between genealogical and ecological hierarchies initially introduced by the paleontologists Niles Eldredge and Stanley Salthe (Table 1.1).⁴

The genealogical hierarchy contains entities that form historical lineages and give rise to patterns of ancestry and descent. The ecological hierarchy, by contrast, orders entities that play some sort of economic or functional role in the activities of life. As the distinction between two possible ecological hierarchies suggests, there are different ways to individuate the entities in these hierarchies, here turning on whether, as in the middle column, we restrict our ecological hierarchy to living things, or whether we take it to also include the abiotic environment, as in the right-most column.

Both the role and nature of hierarchical thinking within the biological sciences, and the idea of pluralism about biological agents, are topics that will occupy us further throughout *Genes and the Agents of Life*. As a way of illustrating how both topics are engaged by alternative conceptions of the individual in the biological sciences, I turn next to consider the long shadow cast by the Aristotelian view of the natural world and challenges to it in relatively recent biological thinking.

4. SPECIES AND NATURAL KINDS: THE
ARISTOTELIAN SHADOW

I have already noted the obviousness of individual organisms when one looks at or reflects on the organization of the biological world. Only slightly less perspicuous a feature of that organization is that organisms are not randomly assorted throughout nature but cluster in groups whose

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members are similar to one another, or are of a kind. Plus or minus a bit, biological species – whether they are human beings, domestic dogs or cats, or robins, to take four of the species most often invoked in common-sense thought and talk – strike us as a form of organization in nature, a natural kind. As recent work in folk biological taxonomy suggests, “[h]umans everywhere classify animals and plants into specieslike groupings that are as obvious to a modern scientist as to a Maya Indian.”⁵

Given the naturalness, at least to us, of this level of organization in the biological world, it should be no surprise to learn that the idea that individual organisms belong to natural kinds, species, has a long history. It is often associated with Aristotle, and some conception of biological species has remained central to the history of Western thought about the structure of the biological world since his time. The general metaphysical categories of individual, species, and genus, and the relationships between them, and between them and the rest of reality, play a central role within Aristotle’s metaphysics. Many of the examples that Aristotle uses to illustrate these general categories are biological in nature. Since the general outlines of Aristotle’s views have remained influential throughout a range of other, sometimes quite radical, changes in metaphysical views, it will pay to have at least that outline before us in thinking about individuals and species in the biological world.

Individual organisms are paradigmatic instances of what Aristotle calls *substances*, the true subjects in the world, the things of which everything else is predicated but which are not themselves predicated of other things. Substances are the focus of the study of metaphysics, which strives to understand their nature or essence. Throughout his writings, Aristotle recognizes some of the similarities between individuals and what he calls species of individuals. In his *Categories* he goes so far as to distinguish explicitly between *primary* substances, individuals, and *secondary* substances, of which species, including biological species, are paradigmatic instances. In so doing he underscores the importance of these similarities. An individual human is an example of primary substance, and to predicate “human” of that person is, in part, to define what sort of thing that individual is, in a way that predicating color or height of him or her does not. To say that humans are animals, that is, to predicate the genus of the species, is to do just the same thing. Thus, for Aristotle, both species and genus are secondary substances, with species being “more truly substance than the genus.”⁶

Aristotle’s metaphysical picture implies that the biological world is hierarchically structured, and that this structure constitutes a way in which

the biological world is unified. There is a single way in which it hangs together, represented by the taxonomic schemata of evolutionary biology. On the Aristotelian view, species are a fixed part of the order of things. Although the fixity of species was one of the central ideas challenged by Darwin's *On the Origin of Species*, a modified essentialism about species, one that viewed them as natural kinds, albeit with essences that could change over time, has largely been taken for granted throughout the history of biology and philosophy.

Biologists and philosophers of biology have, over the past thirty years, challenged this Aristotelian framework, particularly its essentialism about species and its unificationism about the order in the biological world. These challenges and the resulting alternatives to essentialism and unificationism – namely, the idea that species are individuals and species pluralism – have been so successful that they have usurped the traditional view of species in contemporary philosophy of biology. Species are not simply comprised of individuals but are themselves individuals, not natural kinds. And there is not any one order of things in the biological world, represented by “the” species concept and its place in the Linnaean hierarchy, but many such orders, represented by various species concepts.⁷

Both the thesis that species are themselves biological individuals, and the claim that we should be pluralists about species concepts, deserve more articulation than that provided by my bare summary. But it should be clear already that these views are integral to a variety of issues about the nature of the biological world and our thinking about it, and that they have been viewed as such by their proponents. For example, if species are themselves individuals, rather than natural kinds, then individual organisms are parts of, rather than members of, species, and essentialism about species membership looks something like what philosophers call a *category mistake*. And if pluralism is true, then attempts to articulate “the” species concept can never succeed, for there is no single biological reality for such a concept to map to.

5. PLURALISM, REALISM, AND SCIENCE

Pluralism has considerable vogue within contemporary philosophy of biology and biology itself. I have already mentioned pluralism about species concepts, a pluralism that can be readily extended to the various more general approaches within systematics (for example, cladistics, phenetics). But one can find pluralistic views in many other areas of biology: in