# Section I
# Classical discussions of life

Humans have long been puzzled about the nature of life—how living things are similar to and different from nonliving things, both natural and artificial, and whether the characteristics that are universal in familiar Earth life are genuinely essential to all possible forms of life. The chapters in this section provide classical historical perspectives on present day philosophical and scientific debates about life. These perspectives have an often underappreciated and sometimes even unrecognized influence on current philosophical and scientific thought. Cutting-edge contemporary ideas are sometimes not so novel after all! More importantly, however, sometimes the older debates, which typically focus on more general, and hence more fundamental, conceptual issues, can provide unexpected insights into present-day controversies.

This section begins with the writings of three intellectual giants: Aristotle, René Descartes, and Immanuel Kant. Best known today for their philosophical work, each also made important contributions to the development of modern science. Each holds a different view about the nature of life. As the remaining chapters in this book illustrate, the differences between them are still relevant today.

One central theme running from the writings of the ancient Greek philosopher Aristotle right up to the present is the idea that living things have distinctive *functional* characteristics. Aristotle also thought that living things are distinguished from inanimate objects by the ability to self-organize (develop from fertilized eggs) and maintain this self-organization against both internal and external perturbations. Unlike scientists and contemporary philosophers of science, Aristotle distinguished four different kinds of "cause:" material, efficient, formal, and final (discussed below). Aristotle thought that life forms had material causes (material composition) and formal causes (organization or structure), but he also thought that all life forms had final causes (teleological and functional explanations). Aristotle's concept of life is fundamentally different from the contemporary scientific concept of chemical substances such as water, because water is distinguished from other chemical substances, e.g., nitric acid, by a unique molecular composition and structure ($H_2O$); water is not viewed as having a teleological or functional explanation.

As the chapters in this section underscore, one of the great controversies about the nature of life is whether its *prima facie* teleological characteristics are primitive or analyzable in terms of (i.e., "reducible to") nonteleological (e.g., compositional or structural) characteristics. Aristotle thought not. Some like-minded people today agree with Aristotle that the striking goal-directed characteristics of life (nutrition, development, growth, maintenance, repair, sensation, and reproduction) cannot be explained without an appeal to natural ends or intrinsic purposiveness. The question of how to provide a naturalistic account of the *prima facie* teleological characteristics of organisms has been at the heart of philosophical and scientific debates about life since the time of Aristotle.

Writing at the dawn of modern physics, just before the birth of Isaac Newton, Descartes (1596–1650) attacked the long-standing Aristotelian tenet that life is intrinsically teleological. Comparing organisms to the intricate artificial mechanisms (clocks, church organs, and elaborate fountains) popular during his day, Descartes argued that organisms are just exceedingly complex machines. He believed that the teleological aspects of life were fully analyzable using only the principles and concepts of the newly emerging physics. Descartes's view of living systems is reflected today in versions of "hard" artificial life that take seriously the possibility of robotic life forms composed of mechanical and electronic parts (see, e.g., Ch. 19). At the same time, it is worth noting that some have argued that hard ALife provides a strong argument *against* the dominant Cartesian orientation in classical and connectionist cognitive science. Michael Wheeler (2007), for example, gives a Heideggerian interpretation of the emphasis on embodiment and dynamical systems in contemporary hard artificial life.

Less than 200 years later, Kant (1723–1804) concluded that Descartes was wrong about the capacity of classical physics to explain the teleological characteristics of life. According to Kant, the purposiveness exhibited by organisms is fundamentally different from that exhibited by the most elaborate artificial mechanisms. Unlike a mechanical device, an organism is both "cause and effect of itself." When Kant famously declared that there would never be a Newton of biology, he was calling attention to his belief that the teleological characteristics of life could never be explained mechanistically. At the time he was writing, in the heyday of classical physics, this amounted to the claim that these characteristics would never have a physical explanation.

Kant thought that teleology is the central characteristic of life forms that distinguishes them from the nonliving. Even those who disagree with Kant's explanation of teleology might still agree that teleology is one of life's deepest hallmarks. Kant's writings on life brought to the forefront the previously under-appreciated difficulty of reconciling the *prima facie* teleological aspects of life (the appearance of design) with the nonteleological concepts of classical physics. Many different approaches to resolving this conflict were explored in the ensuing years. Some tried to circumvent it by developing distinctively biological concepts or principles, whereas others appealed to non-classical (twentieth century) physics or chemistry.

As Ernst Mayr discusses in this section (Ch. 6), vitalism is a historically important view that proposed a distinctively biological concept, or, depending upon the version, principle of life. Vitalism holds that life is conferred upon nonliving matter by a special kind of animate substance ("protoplasm") or organizing energy or force ("vital spark" or "élan vital"). Vitalists thus agree with Aristotle and Kant that the teleological properties of life cannot be explained in terms of classical physics. They depart from Kant, however, in contending that they can be explained scientifically in terms of distinctively biological (namely, vitalist) concepts or principles. With the advent of biochemistry and molecular biology in the twentieth century, vitalism lost its appeal to biologists (Oparin, Ch. 5), and is now scorned as unscientific. But as philosopher Marc Lange discusses in Section III, an unanalyzed concept of vitality could still end up playing a fundamental theoretical role (analogous to that of mass in Newtonian physics or proton in contemporary physics) in explaining the hallmarks of life. (Lange does not, however, endorse this view.)

With the advent of Charles Darwin's theory of evolution by natural selection in the mid-nineteenth century, some philosophers and scientists concluded that the teleological aspects of life could be fully explained within the framework of classical physics after all, without importing suspect concepts such as vitality. As Richard Dawkins's contemporary defense of universal Darwinism in Section IV illustrates, the Darwinian view that evolution by natural selection centrally explains life remains popular. More general evolutionary views, inspired by Darwin but not limited to natural selection, have also been developed; see, for example, Ruiz-Mirazo and colleagues and Bedau in Section IV. Not everyone, however, finds evolutionary approaches to the nature of life convincing. Contemporary Darwinian biology takes populations of organisms, classified by common ancestry (species, genus, families, etc., or, in recent years, lineages), as the basic unit of analysis. Hence, some Darwinian definitions of "life" do not classify sterile hybrids such as mules as cases of life, and some even reject the idea that a fertile individual organism counts as a living thing. The same is true of some of the more general evolutionary accounts. For example, Mark Bedau (Ch. 31) asserts that individual organisms, including both horses and mules, are all "secondary" forms of life, and the "primary" form of life is the whole biosphere undergoing "open-ended evolution," because the evolving biosphere can explain what he identifies as the familiar hallmarks and puzzles about life. The point is that there is a tendency for most contemporary evolutionary accounts of life to focus on the evolutionary histories of evolving populations of well-adapted organisms, and consider of secondary importance each individual organism and its individual teleological properties (self-organization, self-maintenance, self-repair, etc.). For some philosophers and scientists, this makes evolutionary accounts unsatisfactory.

The chapters by Erwin Schrödinger, Alexander Oparin, Ernst Mayr, and Tibor Gánti represent a different approach to making good scientific sense of the teleological characteristics of life. None of these authors believe that the purposive properties of individual organisms can be fully understood in terms of classical physics and Darwin's theory of evolution by natural selection. While concurring that Darwin's theory is crucial to understanding important aspects of life on Earth, they differ on how central it is to explaining the *nature* of life. Gánti takes the most extreme position, contending that Darwinian evolution is not essential to life, considered generally, even though it is important for understanding the history of life on Earth. Schrödinger, Mayr, and Oparin, in contrast, take Darwinian evolution to be necessary but not sufficient for life. They believe that something more is required.

In Chapter 4 Schrödinger, a theoretical physicist, appeals to concepts and principles from the "new" physics of his day (specifically, statistical thermodynamics and quantum mechanics), developed during the early part of the twentieth century. He attributes the teleological features of life to its ability to maintain itself in a state of disequilibrium by extracting energy from its environment. In fact, he views this open chemical metabolism as perhaps the most essential hallmark of individual life forms. This aspect of Schrödinger's work anticipates more contemporary accounts of life in terms of dissipative structures and far from equilibrium systems; as an example, see Stuart Kauffman's chapter in Section IV.

Oparin, Mayr, and Gánti, in contrast, appeal to twentieth century chemistry. Departing the furthest from the machine metaphor, Oparin (Ch. 5) and Mayr (Ch. 6) contend that life is a product of the gradual chemical evolution of a "primordial soup" into a highly complex, tightly integrated chemical system able to exert a degree of control over its parts not found in any mechanical or electrical device. Gánti (Ch. 7) also analyzes life as a chemical system but, unlike Oparin and Mayr, portrays it as machine-like in a novel way. He describes life forms as "fluid" chemical automata; on his view, living systems are chemical automata ("chemotons"). Gánti's chemoton model is a forerunner of the more abstract autopoietic model of life proposed by Maturana and Varela (1980), which is not restricted to chemical compounds. The chemoton and autopoietic models of life focus on explicating minimal life as an autocatalytic network separated from its surroundings by a boundary, and both admit the possibility of life forms that cannot evolve. Autopoesis is discussed by Luisi and colleagues (Ch. 21) in Section III and Ruiz-Mirazo and colleagues (Ch. 25) in Section IV.

Oparin, Mayr, and Gánti disagree about the chemical possibilities for life. Mayr and Gánti are open to inorganic (e.g., silicon-based) forms of chemical life, whereas Oparin specifically restricts life to organic (carbon-containing) compounds. In addition, Oparin and Gánti tie the nature of life to the origin of life, contending that the former cannot be understood independently of the latter. This approach is not uncommon today. It is reflected in discussions of the nature of life that appeal to theories of the origin of life such as the RNA world; see, for example, Pace (Ch. 11) and the NRC report (Ch. 15) in Section II. Nevertheless, it is not obvious that a theory of the nature of life presupposes an understanding of the origin of life (see the introduction to Section II). The origin and extent of life are covered in detail in Section II of this book.

Each of the classical discussions of life in this section attempts to place the phenomena of life within the framework of the empirical and theoretical understanding of nature during its day. Taken together, the chapters exhibit a wide range of explanatory principles and frameworks. Aristotle's explanatory principles are his four "causes" (see below). Descartes proposed to explain all the phenomena of life within a purely physical and mechanistic framework, often by postulating invisible micro-mechanical entities and processes. Kant concluded that Descartes's purely mechanistic framework could never explain life's autonomous purposiveness. As Mayr recounts in Chapter 6, vitalists posited non-physical vital substances or forces, to explain the hallmarks of life. Schrödinger focused on how life's metabolism sustains a complex and robust organization in the face of the second law of thermodynamics. He also presaged how DNA and RNA govern metabolic processes, and how this control is inherited when life reproduces. Oparin and Gánti both attempted to understand how the simplest and earliest forms of life emerged from nonliving materials.

Unlike some contemporary literature, the classical discussions in this section typically ignore methodological questions about the proper way to evaluate explanations of the nature of life. Of course, even though they do not *discuss* methodologies, the discussions still *display* them. The methodologies displayed include cultural preconceptions and armchair conceptual analysis, as well as empirical investigations of fundamental biological, chemical, and physical mechanisms. The examples set by these authors raise concrete questions about the proper methodology for investigating the nature of life. This issue is revisited in later sections, especially Section IV.

This overview of Section I ends with brief biographies and background information about the authors of each chapter in this section.

## ARISTOTLE

Best known as a philosopher, Aristotle (384–322 BC) was also one of the first scientists. Unlike his teacher Plato, Aristotle emphasized the importance of observation in theorizing about the world. He was especially fascinated by life, and dedicated considerable time to studying it. His devoted student Alexander the Great reputedly sent him exotic animals that he encountered on his conquests. Aristotle's writings on ethics and metaphysics draw extensively from his work in biology, and vice versa. The selection from Aristotle included in this section is taken from his work *De Anima*, sometimes translated as *"On the Soul."*

Aristotle sets the stage for subsequent debates about the nature of life in Chapter 1 by distinguishing the "mineral [inanimate] kingdom" from the "animal and vegetable kingdom" and "defining" life *functionally* in terms of its capacities or powers, and what he called "souls" (a capacity for a set of activities). One cannot understand Aristotle's notion of a soul independently of his theory of explanation. Aristotle distinguishes four different kinds of factors that could be cited in an explanation: material, efficient, formal, and final. These explanatory factors are traditionally called "causes," but this can be very misleading because they differ from how we think of causes today. Efficient causation has survived to the present day; this is the causal trigger (e.g., flipping a switch) that brings about an effect (the lighting of a room). We also still recognize material causes, e.g., the disposition of a wine glass to shatter if struck. For Aristotle, however, the capacities that distinguish life from inanimate matter critically involve formal causation (which constitutes the *essence* of something) and final causation (which constitutes its natural *purpose*), neither of which has an exact analog in modern science. For more on Aristotle's view of causation and explanation, see his *Physics,* Book II, Section 3. (For the philosophically unsophisticated, Falcon (2008) provides an accessible discussion of Aristotle's highly complex ideas about causation and explanation.)

For Aristotle, something is alive if and only if it has a certain kind of "soul." It is important to realize that what Aristotle means by "soul" is very different from the Christian theological notion of the soul. Aristotle's soul is not a disembodied spirit but a set of animating capacities produced by certain natural internal faculties (Matthews, 1996). On Aristotle's account, plants as well as animals have souls. Aristotle called special attention to the capacities of nutrition, perception, locomotion, and thought. Two of life's fundamental capacities involve the mind: sensation and rational thought. So, for Aristotle, anything with a mind is necessarily alive. There is a minor renaissance today in more ambitious connections between life and mind (e.g., Thompson, 2007).

The capacities that Aristotle associated with life are multifaceted. For example, nutrition involves the capacity to grow and reproduce; perception involves the capacity for pleasure, pain, desire, and appetites; thought involves understanding, reason, and imagination. There are various kinds of dependencies among these capacities. Aristotle thought that the most fundamental life-conferring capacities are (self-)nutrition and reproduction; all life forms (plants as well as animals) possess them, and some (e.g., human beings) possess additional capacities (the set that make up the "rational" soul). Aristotle further argued that reproduction is more basic than nutrition. His writings anticipate contemporary debates over whether metabolism or replication is more fundamental to life; see, for example, Orgel (Ch. 8), Shapiro (Ch. 9), Pace (Ch. 11), Boden (Ch. 18), Dawkins (Ch. 29), Kauffman (Ch. 30), and Bedau (Ch. 31).

## RENÉ DESCARTES

The great seventeenth-century French philosopher René Descartes (1596–1650) is foundational not only to modern philosophy but also to mathematics. He developed the Cartesian coordinate system of analytic geometry, which allows geometrical shapes to be represented algebraically and was crucial to the invention of calculus. Descartes's writings played a pivotal role in the downfall of Aristotelian-oriented scholastic philosophy and science. Indeed, he is commonly called the "father of modern philosophy." In addition to his work in philosophy and mathematics, Descartes made important contributions to a number of fields of science. His views about the nature of life were strongly influenced by his detailed studies of animal physiology. Chapter 2 includes his most extensive discussion of the nature of life in *Treatise on Man*.

Breaking with Aristotle, Descartes sharply distinguished mind ("rational soul") from life ("body"). His arguments for the distinction are powerful and do not rest upon the limited science of his day. They gave rise to the infamous "mind-body problem" that still exercises many philosophers.

Descartes is easier to read than Aristotle in large part because Descartes laid the philosophical foundations for modern science. Modeling science on what would become classical (Newtonian) physics, he rejected any appeal to purposes—natural or divine—in explaining natural phenomena. For Descartes, living systems ("bodies") do not differ in nature from mechanical devices such as clocks and fountains; like the latter, the former can be fully understood in terms of efficient causation, namely, the pushing and pulling of different physical parts (organs, muscles, tendons) on each other. In short, living systems are just machines. Variants of this view of life are still popular today. Contemporary molecular biologists have a tendency to characterize organisms as complicated molecular "machines" (see the chapters in Section II). In addition, some ("hard") versions of artificial life view certain machines made with mechanical and electronic parts as alive.

## IMMANUEL KANT

Broadly educated in science and philosophy, the great German scholar Immanuel Kant (1724–1804) made important contributions to both. His work in astronomy, which included formulating the nebular hypothesis and deducing that the Milky Way and possibly other nebula are huge disks of stars, is foundational to modern astronomy. He is best remembered, however, for his philosophical writings. Kant's writings on life are found in the *Critique of the Power of Teleological Judgment*, from which the excerpts in Chapter 3 of this section are taken.

By the eighteenth century, Newtonian physics was considered the foundation for all of science. Kant became convinced, however, that it could not explain life. Breaking with Descartes, he argued that an organism ("organized being") is not a mere machine ("artifact"). While organisms share with artifacts the appearance of design, organisms nonetheless differ from artifacts in a fundamental way: They are "natural ends" (self-causing rather than externally caused). Kant's work represents a return to the Aristotelian idea that life involves a special kind of causation—intrinsic natural purposiveness.

Kant's writings are notoriously difficult to understand, and there is disagreement among Kant scholars over how to interpret them. He sometimes says that organisms *are* natural ends and sometimes says only that they must be "regarded" as such by us. Moreover, his claims about natural purposes sometimes seem to conflict with each other, e.g., his assertion that we must endeavor to explain *everything* in nature in mechanical terms. According to the most widely accepted interpretation, Kant is claiming only that organisms cannot be *comprehended* by the human mind (and hence scientifically *explained*) as mechanical devices. But this does not mean that they are not *in fact* such devices. On this interpretation the teleological aspects of life are a product of the limitations of the human intellect, as opposed to an objective feature of a mind-independent world of nature.

It seems clear that Kant was trying to reconcile the teleological properties of life with the science of his day. His successors took up the challenge. They concurred that the teleological aspects of life cannot be explained within the framework of classical physics, but they were reluctant to ascribe them to what amounts to a defect of the human intellect. So, they sought a solution in new scientific theories and developments, such as Darwin's theory of evolution by natural selection, twentieth-century physics and chemistry, and even mathematics (complexity theory and chaos theory). For a survey of contemporary perspectives on natural teleology, see Allen *et al.* (1997).

## ERWIN SCHRÖDINGER

An Austrian physicist, Erwin Schrödinger (1887–1961) received the Nobel Prize in 1933 for the Schrödinger equation, one of the central principles of quantum mechanics. Schrödinger was also fascinated by life. In 1944 he wrote *What is Life?*, a now classic book that arose from a series of public lectures on life given in Ireland during World War II. Key excerpts from this book are included here as Chapter 4. Schrödinger believed that the teleological aspects of life could be explained through the concepts and principles of non-classical physics, especially those of thermodynamics and quantum mechanics. In addition to famously anticipating the structure of the "hereditary substance" (the DNA molecule) as a "large aperiodic crystal," he provocatively suggests that new principles of thermodynamics might be required for understanding the purposive aspects of life, which he identifies with the ability of individual organisms to maintain order by extracting energy from their environments (i.e., metabolism). Schrödinger's speculations about the importance of metabolism in life have been revisited in recent years (e.g., Boden, Ch. 18), and are the inspiration behind attempts to explicate life in terms of far from equilibrium systems and dissipative structures; a good example is Kauffman (Ch. 30), who proposes a fourth law of thermodynamics as central to understanding life.

## ALEXANDR OPARIN

Oparin (1894–1980), a Russian biochemist, is the father of "protein-first" metabolic accounts of the origin of life. Oparin believed that a genetic system capable of evolution by natural selection could not arise unless a primitive metabolic system was already in place. He thus opposed "genes-first" accounts of the origin of life; see Shapiro (Ch. 9) for a contemporary discussion of this position in the context of the currently popular (genes-first) RNA world theory. Oparin's ideas evolved over the years. Chapter 5 in this section is taken from a book, entitled *Life*, written in his later years.

Like Kant, Oparin rejects the machine analogy for life. He is also adamantly opposed to vitalism. Oparin identifies organizational complexity and purposiveness as the most essential properties of life, and he stresses that they can be fully explained in terms of twentieth-century chemistry. Oparin believes that the molecular possibilities of life are limited to carbon compounds. (The chapters in Section II contain the latest scientific developments along these lines.) According to Oparin, life developed on Earth through the gradual chemical evolution of organic (carbon-based) compounds from a "primordial soup" consisting of simpler organic molecules. Because the British geneticist and evolutionary biologist J. B. S. Haldane (1937) proposed a similar hypothesis at around the same time as Oparin first developed these ideas, this theory has become known as the "Oparin–Haldane hypothesis." Oparin was one of the first to claim that a theory of the nature of life cannot be separated from a theory of the origin of life. On his view, understanding the nature of life presupposes understanding the transition from a nonliving ensemble of organic molecules to a living chemical system, which amounts to understanding how life originates from nonliving chemicals.

## ERNST MAYR

Born in Germany, the evolutionary biologist Ernst Mayr (1904–2005) immigrated to the United States in his twenties. Mayr played a key role in the development of the modern evolutionary synthesis of Darwinian natural selection with Mendelian genetics. One of his important contributions was redefining the concept of a species, which was previously based upon morphological similarities, as a group of individuals that can breed among themselves and are reproductively isolated.

Mayr was also interested in the more general question of what distinguishes life from nonlife. Like Kant and Oparin, he rejected the machine analogy, and like Oparin, he was opposed to vitalism. Chapter 6 in this section is taken from a book, *This is Biology*, written for the general public in his later years. It includes an extended discussion of the history of vitalism and mechanism as well as a discussion of the works of Kant, Haldane (whose views are very similar to Oparin's), and Schrödinger, indicating where they went wrong and what they got right. As a consequence, Mayr's chapter provides an interesting survey from a biologist's point of view of nineteenth-century and early-to-mid-twentieth-century thought about life.

According to Mayr, the "characteristics of living organisms that distinguish them categorically from inanimate systems" are the capacities for (1) evolution, (2) self-reproduction, (3) growth and differentiation through a genetic program, (4) metabolism, (5) self-regulation, (6) response to stimuli from the environment, and (7) change at both phenotypic and genotypic levels. Unlike Oparin, Mayr believes that certain distinguishing characteristics of life (such as hierarchical organization and purposiveness) cannot be fully explained in terms of physico-chemical mechanisms at the molecular level. He contends that these unique characteristics of life literally "emerge" *de novo* at higher levels of organization and integration; they cannot be fully "reduced to" or "predicted from" a knowledge of their lower level parts. Thus Mayr believes that he can make good scientific sense of the intuitive idea that an organism, as a whole, is more than the sum of its parts.

Known as organicism, Mayr's account distinguishes life from "inert matter" in terms of organizational characteristics. Unlike Oparin, he does not restrict life to organic compounds; the key to life is chemical organization, as opposed to chemical composition. Organicism faces the problem of making good scientific sense of the mysterious concept of "emergence" without falling into something closely resembling vitalism. Some scholars have sought a solution to this problem in complexity theory, a fairly new, interdisciplinary field of research growing out of work in theoretical computer science and mathematics. For a collection of recent philosophical and scientific perspectives on emergence, including those based on the contemporary study of complex systems, see Bedau and Humphreys (2008).

## TIBOR GÁNTI

The Hungarian chemical engineer Tibor Gánti (b. 1933) has made many underappreciated contributions to our understanding of the nature of life. A recently published collection (Gánti, 2003) of English translations of his most important papers is the source of the seventh and final chapter in this section. Gánti proposes criteria of life and a model of minimal chemical life. While his hallmarks of life are similar to those proposed by others, there are some significant differences. It is instructive to compare them with, for example, the hallmarks listed by Mayr. One novelty is that Gánti divides the hallmarks of life into two categories: *absolute* life criteria, which are necessary and sufficient for individual organisms to be alive, and *potential* life criteria, which are necessary only for life to populate and be sustained indefinitely on a planet. As the reader will discover, this distinction gives Gánti the conceptual resources to claim that something could be alive and yet not part of an evolving system, while still agreeing with Oparin and Mayr that the capacity to evolve is essential for life to adapt to the environment and diversify.

Gánti's views about the nature of life are informed by his experience as a chemist, and he emphasizes life's chemical requirements. But since he wants to formulate a conception of life that applies as broadly as possible, his chemical analysis is abstract and functional. The result is Gánti's celebrated chemoton model. The chemoton model depicts minimal chemical cellular life necessarily as an autocatalytic (self-sustaining) chemical network that integrates three kinds of chemical subsystems: a metabolism, a container, and a heritable chemical program. Because Gánti does not restrict life to organic compounds, the chemoton model represents a metabolism-first but not a protein-first perspective (see the introduction to Section II). The three subsystems cannot function separately, and they cooperate to create a unified whole that can exhibit the hallmarks of life. More or less similar chemical triads are presupposed in many contemporary experimental and theoretical investigations into creating new forms of life in the laboratory (Rasmussen *et al.*, 2008), although Gánti's emphasis on stoichiometric coupling of the functional triad is usually dropped and the internal program usually does more work.

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# 1 • De Anima (selections)

ARISTOTLE

*DA* II 1 T

**[412a1]** Let this much be said about what has been handed down concerning the soul by our predecessors. Let us start anew, as if from the beginning, endeavoring to determine what the soul is and what its most common account would be.

Among the things which are, we call one kind substance. Belonging to this is, first, matter, which in itself is not some this; another is shape and form, in terms of which something is already called some this; and the third is what comes from these. Matter is potentiality, while form is actuality; and actuality is spoken of in two ways, first as knowledge, and second as contemplating.

Substances seem most of all to be bodies, and among these, natural bodies, since these are the sources of the others. Among natural bodies, some have life and some do not. We mean by 'life' that which has through itself nourishment, growth, and decay.

It would follow that every natural body having life is a substance, and a substance as a composite. But since every such body would also be a body of this sort, that is, one having life, the soul could not be a body; for the body is not among those things said of a subject, but rather is spoken of as a subject and as matter. It is necessary, then, that the soul is a substance as the form of a natural body which has life in potentiality. But substance is actuality; hence, the soul will be an actuality of a certain sort of body.

Actuality is spoken of in two ways, first as knowledge, and second as contemplating. Evidently, then, the soul is actuality as knowledge is. For both sleeping and waking depend upon the soul's being present; and as waking is analogous to contemplating, sleeping is analogous to the having of knowledge without exercising it. And in the same individual, having knowledge occurs prior to contemplating. Hence, the soul is the first actuality of a natural body which has life in potentiality.

This sort of body would be one which is organic. **[412b]** And even the parts of plants are organs, although altogether simple ones. For example, the leaf is a shelter of the outer covering, and the outer covering of the fruit; even the roots are analogous to the mouth, since both draw in nutrition. Hence, if it is necessary to say something which is common to every soul, it would be that the soul is the first actuality of an organic natural body.

Consequently, it is not necessary to ask whether the soul and body are one, just as it is not necessary to ask this concerning the wax and the seal, nor generally concerning the matter of each thing and that of which it is the matter. For while one and being are spoken of in several ways, what is properly so spoken of is the actuality.

It has now been said in general what the soul is: the soul is a substance corresponding to the account; and this is the essence of such and such a body. It is as if some tool were a natural body, e.g., an axe; in that case being an axe would be its substance, and this would also be its soul. If this were separated, it would no longer be an axe, aside from homonymously. But as things are, it is an axe. For the soul is not the essence and structure of this sort of body, but rather of a certain sort of natural body, one having a source of motion and rest in itself.

What has been said must also be considered when applied to parts. For if an eye were an animal, its soul would be sight, since this would be the substance of the eye corresponding to the account. The eye is the matter of sight; if sight is lost, it is no longer an eye, except homonymously, in the way that a stone eye or painted eye is.

What has been said in the case of parts must of course be understood as applying to the whole living body. For there is an analogy: as one part is to one part, so the whole perceptive faculty is to the whole of the body which is capable of perception, insofar as it is capable of perception. The body which has lost its soul is not the one which is potentially alive; this is rather the one which has a soul. The seed, however, and the fruit, is such a body in potentiality.

Hence, as cutting and seeing are actualities, so too is waking an actuality; **[413a]** and as sight and the potentiality of a tool are, so too is the soul. The body is a being in potentiality. But just as an eye is a pupil plus sight, so an animal is the soul plus the body.

Therefore, that the soul is not separable from the body, or some parts of it if it naturally has parts, is not unclear. For the actuality of some parts belong to the parts of the body themselves. Even so, nothing hinders some parts from being separable, because of their not being the actualities of any body.

It is still unclear, however, whether the soul is the actuality of the body in the way that a sailor is of a ship.

So let the soul be defined in outline and sketched out.

### *DA* II 2 T

**[413a11]** Because what is sure and better known as conforming to reason comes to be from what is unsure but more obvious, one must proceed anew in this way concerning the soul. For it is not only necessary that a defining account make clear *that something is*, which is what most definitions state, but it must also contain and make manifest the cause. As things are, statements of definitions are like conclusions. For example: "what is squaring? It is an equilateral rectangle being equal to an oblong figure." But this sort of definition is a statement of the conclusion. The one who states that squaring is the discovery of a mean states the cause of the matter.

We say, then, taking up the beginning of the inquiry, that what is ensouled is distinguished from what is not ensouled by living. But living is spoken of in several ways. And should even one of these belong to something, we say that it is alive: reason, perception, motion and rest with respect to place, and further the motion attendant upon nourishment, decay and growth.

For this reason, even plants, all of them, seem to be alive, since they seem to have in themselves a potentiality and the sort of principle through which they grow and decay, in opposite directions. For it is not the case that they grow upward but not downward; rather they grow in both directions and in all ways, those, that is, which are always nourished and continue to live as long as they are able to receive nourishment.

This capacity can be separated from the others, but among mortals the others cannot be separated from this. This is clear in the case of plants. For no other capacity of soul belongs to them.

**[413b]** Living, then, belongs to what lives because of this principle, but something is an animal primarily because of perception. For even those things which do not move or change place, but which have perception, we call animals and not merely living things. The primary form of perception which belongs to all animals is touch. But just as the nutritive capacity can be separated from touch and from the whole of perception, so touch can be separated from these other senses. By nutritive we mean the sort of part belonging to the soul of which even plants partake. But all animals are seen to have the sense of touch. The reason why each of these two things turns out to be the case we shall state later.

For now let just this much be said: the soul is the principle of the capacities mentioned and is delimited by them, namely, nutrition, perception, thought, and motion. It is not difficult to see whether each of these is a soul or a part of a soul, and if a part, whether in such a way as to be separate in account alone or also in place. But in some cases there is a difficulty. For just as in the case of plants, some, when divided, evidently go on living even when separated from one another, there being one soul in actuality in each plant, but many in potentiality, so we see this occurring in other characteristics of the soul in the case of insects cut into two. For each of the parts has perception and motion with respect to place, but if perception, then also imagination and desire. For wherever there is perception, there is also both pain and pleasure; and wherever these are, of necessity is appetite.

But concerning reason and the capacity for contemplation nothing is yet clear. Still, reason seems to be a different kind of soul, and it alone admits of being separated, in the way the everlasting is from the perishable.