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# Aristotle: Tradition and Influence

An account of the Aristotelian tradition would cover, without any interruption, the whole of the intellectual history of the Western world and, in recent times, of other areas as well. On the other hand, the influence of Aristotle's works and doctrines on the cultural developments of civilization is, in most fields, elusive and undefinable. Especially in the province of science-if we use "science" in the stricter, modern sense-it may be found that Aristotle's influence is very limited, or effective only in the sense that mistakes, eliciting opposition, criticism, and new solutions to old and new problems, are the starting point of scientific progress. Positive influence and starting points for positive developments are found, for the different sciences, much more frequently in the works of Euclid and Ptolemy; of Hippocrates and Galen; of Archimedes; of al-Farabi, Ibn Sina (Avicenna), and Ibn Rushd (Averroës); possibly of Boethius; and, back through Boethius, of Nicomachus of Gerasa.

Still, there are two aspects in this progress that bear the Aristotelian imprint and justify an extensive account of the spread of Aristotle's works and of their study; the methodical aspect and the conceptuallinguistic aspect. These two cannot always be separated, but they must not be confused if Aristotle's influence is to be clearly seen and properly assessed. This section will, therefore, be devoted first and foremost to such an account. We shall then consider a set of concepts and words that became essential for the elaboration of scientific problems and, indeed, for making scientific discoveries clearly expressible and understandable in the technical and, at the same time, the common language. some exemplification will be given of the methodical aspect, insofar as it can be traced back to Aristotle's influence, and of the actual contributions derived from his works, mainly by discussion, rejection, and positive substitution of antiAristotelian views. In this connection it must be recorded that a very limited amount of the literature that developed around the works of Aristotle in later antiquity, in the Middle Ages, and even into the eighteenth century has been properly edited, much less has been critically read, and only a minimal proportion of it has been examined from the point of view that interests us here.

The transmission and spread of Aristotle's works can best be followed by considering the different languages or groups of languages in which it took place: basic, of course, was the Greek tradition, from which all others sprang, directly or indirectly (fourth century B.C. to our times); most important and permanent in value was the Latin (fourth century A.D. to sixteenth and seventeenth centuries); very influential, especially through elaborations and translations into Latin, was the Semitic (first Syriac, then [and mainly] Arabic, finally Hebrew [fifth century A.D. to sixteenth century]; only occasionally effective in its own right and more valuable as a help in the rebirth of the study of Greek civilization was the tradition in German, Neo-Latin, English, and, more recently, many other modern languages (tenth century to our times); limited to very narrow cultural units was the Armenian and possibly the Georgian (*ca*. fifth century A.D. to tenth century and later).

*The Transmission of Aristotle's works in Greek*. Compared with the impact of what constitutes the traditional Aristotelian corpus, typically represented by the Berlin Academy edition of 1835, the influence of the other works of Aristotle-preserved, if at all, in a number of more or less extensive fragments--can be considered negligible; we cannot pursue their tradition here. The corpus, based mainly, it seems, on lectures, preparations for lectures, accounts of lectures, and elaboration of collected material *(De animalibus)*, must have begun to be organized in Aristotle's own time, by Aristotle himself and his pupils (Theophrastus, Eudemus, and others). The process continued in his school, with vicissitudes, for 250 years after his death. The quasi-final organization of Aristotle's available material seems to have been accomplished by Andronicus of Rhodes (*ca*. 70 B.C.). It may be assumed that from Andronicus' edition there derived, with minor changes and developments, the transmitted texts as we know them in Greek. From Andronicus to the middle of the sixth century. the spread of the corpus or parts of it is continuously testified by the activities in the several philosophical schools, whether mainly Peripatetic in character, or eclectic, or more purely Neoplatonic. Andronicus' pupil Boethus of Sidon 'commented on Aristotle's works making the Physics the basis of Aristotelian philosophy; as century after, Nicholas of Damascus expounded Aristotle's philosophy and wrote (in the mood of Aristotle's *De animalibus*) a *De plantis*, which came to be ascribed to Aristotle; and *ca*. A.D. 100, Ptolemy Chennos of Alexandria wrote a work on the life and works of Aristotle. In the second half of the second century A.D., Galen, famous for his medical work, was a critical popularizer of Aristotle's logic, physics, and metaphysics, and many other authors comented on this or that work.

The texts of Aristotle were, obviously, already popular over a wide area. When *ca*. A.D. 200, Alexander of Aphrodisias became professor of philosophy in Athens, as a "Second Aristotle," he commented upon a large proportion of the corpus and left in his works abundant evidence of the variety of readings that had been infiltrating the nearly 300-year-old transmission of the basic edition. Although only minor fragments of papyri containing Aristotle's texts from the corpus and no manuscript older than the ninth century exist, the expanding study of the works in Athens, Constantinople, Alexandria, and Pergamum justifies the statement that many manuscripts were available in many centers. The sixth century adds new evidence, since, at

least in the case of some logical works, we possess not only the quotations of many Greek commentators but also theliteral translations into Latin, Syriac, and Armenian: these testify to the variety of the Greek tradition, a variety that continued and became more complicated in later centuries.

The ban on pagan schools in 529 led to a reduction, if not to a halt, in the production of Greek copies of the works of Aristotle until the revival of the late eighth and ninth centuries. Then really "critical" editions of some works, and transcriptions of many, if not all, started again. The University of Constantinople became a center of studies of some of these works; the old libraries still possessed among them at least one copy of each of the writings of Aristotle. And it is possible to surmise that in form (some of them were rich in scholia extracted from the old commentaries) they were like the manuscripts of the sixth or earlier centuries. The number of extant manuscripts of the ninth and tenth centuries is very small, and does not cover the whole corpus; but the stronger revival of the eleventh century was the beginning of the uninterrupted transcription and transmission of the more popular works. This gathered momentum, not only in Constantinople but also in the numerous centers where lay and theological schools were flourishing.

By the thirteenth and fourteenth centuries publication had expanded to such an extent that about 150 manuscripts from that period still survive. There are only a few exceptions to show that not all of Aristotle was dominating the higher philosophical studies, side by side with Plato: the *Politics*, unearthed perhaps in the eleventh century and turned into a fruitful career by the Latin translator William of Moerbeke, does not appear in our collections in any manuscript older than the thirteenth century. The Poetics appears in late manuscripts, except for one of the eleventh century and one of the thirteenth. But the bigger collections, especially of the logical works, are relatively numerous. A new impetus to the dissemination was given in the fifteenth century by the migration of scholars from the Greek world to Italy and by the interest in Greek studies in Florence, Venice, and other cities. In the fifteenth century the number of copies of the several parts of the corpus, including the rarest works, multiplied, and the way was prepared for the printed editions, from the Aldine of 1495-1498 to those of the seventeenth century. There was then about a century of interruption: Aristotle was "out" from most points of view. By the end of the eighteenth century the new interests of learning brought about the new wave of Greek editions of Aristotle-a process that is still in full swing.

*The Transmission of Aristotle's Works in Latin*. No evidence has come to light to show that any work by Aristotle or any extensive paraphrase was available in Latin before *ca*. A.D. 350. Cicero's claim that his *Topica* was based directly on Aristotle's work of the same title is false. His model was the work of a rhetorician, not of a logician, and bears only vague, occasional, accidental resemblances to what Aristotle wrote. The latinization of Aristotle took place through different channels: by far the most important was the direct translation from the Greek originals; second in importance was the translation of Greek paraphrases and commentaries; third, the translation of some of Aristotle's works from direct or indirect Arabic versions, whether alone or accompanied by Arabic commentaries; fourth, the versions of Arabic works based, in various measure, on Aristotelian texts; finally, some translations from the Hebrew renderings of Arabic versions, commentaries, and paraphrases. All this happened in the course of four identifiable stages, very different in length, between the middle of the fourth century and the end of the sixteenth: (a) the first stage probably lasted only a few years and involved a few individuals belonging to two groups working in Rome; *(b)* the second corresponds to a few years in the first quarter or first half of the sixth century, with Boethius as the only person concerned with this activity in Italy, and possibly some minor contributors in Constantinople; *(c)* the third stage covers about 150 years, from *ca*. 1130 to *ca*. 1280, when the work was carried out probably in Constantinople and certainly in Sicily, Italy, Spain, Greece, England, and France by at least a score of people of many nationalities and callings--by the end of this period the whole of the Aristotelian corpus as it has reached us in Greek, with very minor exceptions, could be read and studied in Latin; *(d)* the fourth stage extended from shortly after 1400 to *ca*. 1590. Only in the third stage did the Arabic tradition contribute directly to the Latin one; and only in the fourth did it do so through the Hebrew.

*(a)* The intellectual intercourse between Greek and Latin in the third and fourth centuries, of which the most striking example outside religion was the spread of the knowledge of Plotinus' doctrines, led to the need for Latin texts of some of the works considered basic by the Greeks. It was in this Neoplatonic atmosphere (tempered by Porphyry with more Aristotelianism than Plotinus had accepted, rather than discussed and criticized) that the African Marius Victorinus, a pagan converted to Christianity, popularized the contents of Porphyry's introduction to logic, the *Isagoge;* if we accept Cassiodorus' testimony, he also translated Aristotle's *Categories* and *De interpretatione*. He certainly included Aristotelian views in his *De definitionibus*, the only work by Victorinus that contains some Aristotle and that has reached us in full (only sections of his version of the Isagoge survive in one of Boethius' commentaries). The attraction exercised by Themistius' school in Constantinople led to another, possibly purer, wave of Aristotelianism among the pagan revivalists, so vividly depicted in Macrobius' Saturnalia. Vettius Agorius Praetextatus, one of their leaders, rendered into Latin Themistius' teaching on the Analytics. Agorius' work was probably lost very soon, and there was no Latin text of Themistius' work on the Analytics until the second half of the twelfth century. This was based on an Arabic translation of part of that work (which was not translated from the Greek before the end of the fifteenth century). But Themistius' teaching of the Categories-a detailed exposition with additions and modernizations-found its Latin popularizer in a member of the same circle (perhaps Albinus). It is from this work, later ascribed to St. Augustine, under the title of Categoriae decem, that the Latin Aristotelianism of the Middle Ages started its career, never since interrupted.

*(b)* The middle and late fourth-century Aristotelianism, and much else of the cultural life of that time, was a faded, but not a lost, memory when, in the first decade of the sixth century, Boethius married a descendant of one of the prominent intellectual families, Symmachus' daughter Rusticiana. He took up what remained of that tradition, and was encouraged by his father-in-

law to renew it. Cultural relations with the Greeks were not as active around 505 as around 370, but Boethius managed to obtain some Greek books, among them a copy of the collection of Aristotle's logical texts with an ample selection of notes from the greater masters of the past (Alexander, Themistius, and, mainly, Porphyry). So he probably managed to achieve what he had planned, to translate as much of Aristotle as he could get hold of: at least, we still preserve, in more or less original form, his translations of the Categories, *De interpretatione, Prior Analytics, Topics*, and *Sophistici elenchi;* he also claims to have produced a now lost translation of the *Posterior Analytics*. Since, by the fifth century, Aristotle's logical works were prefaced by Porphyry's *Isagoge*, Boethius also translated this text. He wrote that he intended to comment upon the works of Aristotle accessible to him; as it turned out, he commented on only the two shortest texts, the *Categories* and *De interpretatione* -or, better, he translated, adapted, and coordinated passages from Greek commentaries that he must have found on the margins of his Greek volume. The existence of a double recension for many section s of the *Categories, Prior Analytics*, and one short section of the *Topics;* the existence of a Latin version of a considerable collection of scholia to the Prior Analytics translated from the Greek and connected with one of the two recensions of this work; and a variety of evidence pointing to some editorial activity in Constantinople centering on Boethius'work in the first half of the sixth century suggest that Boethius'work as a translator in Italy had some continuation in the circle of Latin culture in Constantinople.

(c)The third stage is by far the most impressive, representing as it does a variety of interests, of cultural backgrounds, of centers of progressive attitude toward the renewal, on the basis of older traditions, of the intellectual life in Europe and, to a certain extent, also representing one further step in a continuity of Aristotelian studies, hardly interrupted from the first century B.C. to the thirteenth century a.D. It is here necessary to consider separately the translators from the Greek and those from the Arabic, as well as some of the centers and people connected with this transmission of Aristotle, First of all, it cannot be emphasized too strongly that Aristotle was latinized from the Greek much more than from the Arabic and, with very few exceptions, earlier from the Greek than from the Arabic. Although competent scholars have tried to make this fact known, the commonly held view of historians of ideas and of people in general is the wrong view: that the Latin Middle Ages owed their knowledge of Aristotle first and foremost to the translations from the Arabic.

(c-1)The Aristotelian revival of the ninth and the eleventh centuries in the higher schools of Constantinople-particularly the second revival, due to such people as Michael Psellus, Ioannes Italus, Eustratius of Nicaea, and Michael of Ephesus-brought its fruits to the Latin revival (or, better, discovery) in the twelfth and thirteenth centuries. In the second quarter of the twelfth century James(Iacobus), a cleric with philosophical, theological, and juridical interests who seems to describe himself as Venetian-Greek, was in Constantinople and in touch with the Aristotelian corpus. He translated, either in Constantinople itself, or possibly in Italy, at least the *Posterior Analytics*, the *Sophistici elenchi, the Physics, the De anima*, parts of the *Parva naturalia*, and the *Metaphysics*. Of the translation of the last work only Books I-III and the beginning of Book IV remain; of the translation of the *Elenchi* only fragments have been recovered, mainly in contaminated texts of Boethius'version. He also translated some Greek notes to the *Metaphysics*, a short introduction to the *Physics* (known, in much of the Latin tradition, as *De intelligentia Aristotelis)*, and probably Commentaries to the *Posterior Analytics* and *Elenchi* ascribed to Alexander of Aphrodisias. Finally, he himself commented at least on the *Elenchi*. James's translations, in spite of their extreme literalness, reveal a considerable knowledge of the learned Greek language of his time and interests in a variety of fields. Conscious of his limitations, which seem to be more marked when the technical language of mathematics and some philosophical terminology in Latin are concerned, he transcribes some key words in Greek letters, occasionally attempting an approximate translation. Some if his versions remained the basis, directly and through revisions, of the knowledge and study of much of Aristotle until the fifteenth and sixteenth centuries.

In 1 158 Henry, nicknamed Aristippus, a Norman dignitary of the church and court in Sicily, was on an embassy at Constantinople, from which he brought back several books. With its combination of a recent Arabic past, enlightened Norman rule, and refined cultural life, Sicily was, in its own right, one of the best training grounds for a man like Henry, interested in problems of human life and death (he translated Plato's Phaedo and Meno) and curious about the workings of nature (like Empedocles, he climbed Mt. Etna to observe the volcano firsthand). He, and others around him, were conscious of the scientific tradition of Sicily; books of mechanics, astronomy. optics, and geometry were available, and attracted people from as far as England. Henry contributed to this tradition with a translation of at least Book IV of the Meteorologics. With less pedantry than James, he varied his vocabulary more than a work of science could admit; still, his translation remained indispensable for about a century, and what may be called Aristotle's physical chemistry was known primarily through his text.

(c-2)At approximately the same time, and presumably drawing on the same Greek sources of Aristotelian studies, a number of scholars with quite a good knowledge of Greek produced either new versions of texts already translated-whether the older translations were known to them cannot always be established -and versions of works previously unknown in Latin. These scholars remain anonymous. with the possible exception of a certain John, who produced, after the Venetian James, another translation of the Posterior Analytics; a second scholar translated anew the Topics and the Prior Analytics; a third, the De sensu; a fourth, the short treatises *De somno* and *De insomniis; a fifth, the De generatione et corruptione and the Nicomachean Ethics* (of which only Book I ["Ethica nova"], Books II and III ["Ethica vetus"], and fragments of Books VII and VIII ["Ethica Borghesiana"] remain); a sixth, again after James, the *Physics* (only Book I ["Physica Vaticana"] remains) and the *Metaphysics* without Book XI (the first chapter is lost); and a seventh, probably the *Rhetoric*. Some of these translations had little or no success *(Prior and Posterior Analytics, Topics, Rhetoric, Physics);* the others, within the limits of their survival *(De generatione et corruptione, De sensu, De somno, De insomniis, Nicomachean Ethics, Metaphysics)*, remained in use, in the original form or in revisions, for three or four centuries. They all testify to the vast interest in the recovery of Aristotle in the twelfth century.

(c-3) While Constantinople, possibly together with minor Greek centers, was giving the Aristotelian material to the Latin scholars, the intense cultural activity of the Arab world had spread to northwestern Africa and Spain, providing Latin scholarship, especially in the part of Spain freed from Arab domination, with a vast amount of scientific and philosophical material and the linguistic competence for this to be rendered into Latin. Leaving aside for the moment the spreading of Aristotelian ideas through works of Arabic writers, mention must be made of the one translator of Aristotelian ideas through works of Arabic writer, mention must be made of the one translator of Aristotelian work from the Arabic, the Italian Gerard of Cremona, active in Toledo from ca. 1150 to his death in 1187. Being a scientist, he translated from the Arabic what was accessible to him of the more scientific works of Aristotle: the Posterior Analytics (theory of science by induction and deduction), *Physics, De generatione et corruptione, De caelo, and Meteorologics* (most of Book IV of this was either not translated or was soon lost). He also translated Themistius' paraphrase of the *Posterior Analytics*. The two of these works that did not exist in translation from the Greek *(Meteorologics I-I11 and De caelo)* were often transcribed and not infrequently studied for about sixty years in these versions from the Arabic. The others were occasionally used as terms of comparison or as additional evidence where the texts from the Greek were considered basic. It should also be mentioned that Gerard translated, under the name of Aristotle, thirty-one propositions from Proclus' *Elements of Theology* accompanied by an Arabic commentary, which formed the text (occasionally ascribed to Aristotle, more frequently left anonymous by the Latins) known under the title *Liber de causis*. Toward the end of the twelfth century, Alfred of Sareshel translated, again under the name of Aristotle (which attribution remained unchallenged for several centuries), Nicholas of Damascus' *De plantis*.

By the end of the twelfth century most of Aristotle had, therefore, found its way into Latin, but that does not mean that his works were soon widely accessible. To make them so, activity was still necessary in both transcription and translation. Some works had not yet been translated, and versions of others had been partly or completely lost; it was also relaized that new versions made directly from the Greek would be necessary where only translations from the Arabic or inadequate versions from the Greek were available, and that revisions were necessary for almost every text; finally, it was felt that in order to achieve a more complete understanding of the words of Aristotle, translated by people whose knowledge of Greek was based mainly on the modernized, Byzantine usage, it was useful or necessary to give the reader of Latin access to many of the commentaries, Greek or Arabic, that linked the present with the past.

(c-4) The work done with these aims in view, on the basis of Greek texts, was carried out almost completely in the thirteenth century by two outstanding northerners: Robert Grosseteste, bishop of Lincoln and chancellor of Oxford University, and the Flemish Dominican William of Moerbeke, later archbishop of Corinth. A minor contribution came from a Sicilian, Bartholomew of Messina. Grosseteste, philosopher and theologian, linguist and scientist, politician and ecclesiastic, grew up at a time when it was already known how much Aristotle could help in the promotion of that Western European culture of which the foundations had been laid in the twelfth century. He was well aware of the contributions that the fading Greek renaissance could now offer, at least in books and teachers of the language. Grosseteste encouraged other Englishmen to go to Greece, southern Italy, and Sicily to collect books and men of learning. With their help, in the second quarter of the thirteenth century, he learned the language and, what concerns us here, thoroughly revised what remained of the older version of the *Nicomachean Ethics*; translated anew the major part of it, of which the older translation had been lost; and translated a large collection of commentaries on the several books of this work, some of them dating as far back as the third century, some as recent as the eleventh and twelfth. He also replaced with a translation from the Greek the *De caelo*, available until then only in a version from the Arabic, and added the translation of at least part of the vast commentary by Simplicius on the same work. Finally, he translated as Aristotelian the short treatise *De lineis insecabilibus* ("On Lines Not Made of Points").

William of Moerbeke, also a philosopher, theologian, scientist, and ecclesiastic, but in these fields a lesser man than Grosseteste, traveled from the Low Countries to Italy, Greece, and Asia Minor, widening the scope of his discoveries and of his translations to include Neoplatonic philosophy, geometry, mechanics, and medicine. His activity as an Aristotelian translator was enormous and covered approximately the third quarter of the century. He was the first to translate from Greek into Latin the Aristotelian zoological encyclopedia, the *De animalibus*, and Books I-III of the *Meteorologics;* he can almost be considered the discoverer, for our civilization, of the Politics; he was the first to translate into Latin the Poetics and Book XI of the *Metaphysics;* he translated anew the De caelo, the Rhetoric (he probably did not know of the existence of the Greco-Latin translations of these two works), and Book IV of the Meteorologics; he accompanied his versions of Greek commentaries with new translations of the *Categories* and *De interpretatione;* and he revised, with different degrees of thoroughness but always having recourse to Greek texts, James's versions of *Posterior Analytics, Physics, De anima, De memoria* and other minor texts of the *Parva naturalia*, Boethius'version of the *Sophistici elenchi*, and the anonymous versions of the De *generatione et corruptione*, of Books I-X and XII-XIV of the *Metaphysics*, and of the *De sensu, De somno*, and De insomniis. He also translated the extensive commentaries by Simplicius on the *Categories* and (again, after Grosseteste) the De caelo, by Alexander of Aphrodisias on the *De sensu and Meteorologics*, by Themistius on the *De anima*, by Ammonius on the De *interpretatione*, and by Philoponus on one part of Book III of the *De anima*. With the possible exception of the *De coloribus* (one fragment seems to be translated by him), he avoided all the works wrongly ascribed to Aristotle.

In contrast, Bartholomew of Messina, working for King Manfred around 1260, specialized in the pseudepigrapha; *De mundo, Problemata, Magna moralia, Physionomia, De mirabilibus auscultationibus, De coloribus, and De principiis* (Theophrastus' Metaphysics). The only translation of a possibly genuine Aristotelian text made by Bartholomew is that of the De Nilo. To complete the picture of the translations from the Greek of "Aristotelian" works before the end of the thirteenth century (or possibly a little after), we should add a second translation of the *De mundo*, by one of Grosseteste's collaborators, Nicholas of Sicily, two anonymous translations of the *Rhetorica ad Alexandrum*, and two partial translations of the Economics. Finally, an anonymous revision of Books I-II and part of Book III of James's translation of the *Metaphysics* was made around 1230, and

an equally anonymous revision of the whole of Grosseteste's version of the *Nicomachean Ethics* was carried out probably between 1260 and 1270.

(c-5) The work of translating Aristotle or Aristotelian commentaries from the Arabic in the thirteenth century centered, again, mainly in Toledo and to a smaller extent in southern Italy. Most of this work was carried out by Michael Scot; other contributors were William of Luna and Hermann the German. Michael Scot was the first to make known to the Latins the *Books on Animals*, and it was his translation of most of the *Metaphysics* (parts of Books I and XII and the whole of Books XI, XIII, and XIV were not included), together with Averroës' *Great Commentary*, that provided many students of Aristotle with the bulk of this complex of Aristotelian texts: most of James's translation had probably been lost before anybody took any real interest in this work, and the anonymous Greco-Latin version (Media) made in the twelfth century emerged from some isolated repository ca. 1250. Under the title Metaphysica nova, Michael's version, isolated from Averroës' commentary, held its ground for about twenty years and was quite widely used for another twenty. The following translations must be ascribed to Michael Scot, some with certainty, some with great probability: the *De anima, Physics, and De caelo with Averroës' Great Commentary, the Middle Commentary of the De generatione et corruptione* and of Book IV of the Meteorologics, and Averroës' *Summaries* of the *Parva natturralia*.

William of Luna translated, in or near Naples, the *Middle Commentaries* to Porphyry's *Isagoge* and Aristotle's *Categories*. *De interpretatione*, and Prior and *Posterior Analytics*. Hermann the German translated Averroës' *Middle Commentaries* on the *Nicomachean Ethics, Rhetoric, and Poetics*. The last-mentioned was, in fact, the only source from which Latin readers acquired what knowledge they had-and that was mainly distorted-of Aristotle's Poetics: under the title *Poetria (Averrois or Aristotelis)* it was read quite widely; William of Moerbeke's translation from the Greek remained unknown until 1930, and the next translation from the Greek was not made until shortly before 1500.

By the end of the thirteenth century, the whole of the Aristotelian corpus as we know it, and as it has been known-if we except the relatively few fragments of early works-since that first century B.C., was available in Latin to practically everybody who cared to have access to it. The only exception consisted of the four books of the *Ethics* that are not common to the *Nicomachean Ethics* (which appears with the full complement of ten books) and to the *Eudemian Ethics* (which normally contains only the four that differ from those of the *Nicomachean*); only a small portion of this seems to have been translated, and is connected with passages of the *Magna moralia* in the so-called *De bona fortuna*. The general picture of the diffusion of Aristotle in these translations until the beginning to the sixteenth century is provided by the survival to our times of no fewer than 2,000 manuscripts containing from one to about twenty works, and by the fact that the most complete catalog of early printings (down to 1500) lists over 200 editions, without counting a large number of volumes that contain some of these translations with commentaries.

The detailed picture, when properly drawn, will show the difference in the popularity of the several works; but the difficulty in drawing such a picture derives from the fact that many works, especially minor ones, were transcribed as parts of general, mainly Aristotelian, collections without being actually taken into detailed account. Still, it may be significant that one of these collections, *Corpus Vetustius*- containing the *Physics, Meteorologics, De generatione et corruptione, De anima, Parva naturalia, De caelo*, and *Metapysics* in the translations made before 1235-remains in slightly fewer than 100 manuscripts, all of the thirteenth (or very early fourteenth) century; a similar collection, including the same works in the new or revised translations in a more complete form (*Corpus recentius*) is preserved in about 200 manuscripts of the thirteenth, fourteenth, and fifteenth centuries. This shows that the more scientific of the works of Aristotle became indispensable in all centers of study and in private libraries. A statistical study of their provenance has not been made: it is, however, clear that France and England are most prominent in this respect for the *Corpus Vetustius;* and France, Italy, Germany, England, and Spain for the *Corpus recentius*.

If we consider the translations that most influenced Western culture and ascribe the authorship to those who produced them in the basic form, a quite accurate assessment of the individual abilities in transmitting Aristotle's works, and thus in shaping some of the philosophical, scientific, and common language of modern civilization, can be made. Their success in presenting formulations that, although not always carefully and strictly Aristotelian, have contributed a basis for discussion and polemics, and have thus led, in the dialectic of history, to much progress, can be suggested by the following list:

(1) Boethius: *Categories, De interpretatione, Prior Analytics, Topics, Sophistici elenchi;*

(2) James the Venetian-Greek: *Posterior Abalytics, De anima, Physics, De memoria (perhaps Metaphysics* I-III);

(3) Twelfth-century anonymous translators from the Greek: *Metaphysics* IV-X, XII-XIV (perhaps I-III), *De generatione et corruptione, Nicomachean Ethics* I-III, *De sensu, De somno, De insomnits;*

(4) Michael Scot: Metaphysics I-X, XII, *De animalibus;*

(5) Robert Grosseteste: *Nicomachean Ethics* IV-X;

(6) William of Moerbeke: *Meteorologics, Politics, Rhetoric, De animalibus, Metaphysics* XI, *De caelo*.

An important, if sometimes misleading, role in the Latin transmission of Aristotle must be ascribed to the translators of commentaries. All of them contributed to the transmission and improvement of the technique of interpretation, as developed in the Greek schools of the second through sixth centuries. From this point of view, the greatest influence was probably exercised by the commentaries adapted from the Greek by Boethius and those of Averroës, which are linked, through an almost continuous line of scholastic discipline, with the tradition of the Greek schools. From the point of view of the contributions to the actual critical understanding of Aristotle, probably the most important of Averroës' commentaries were those on the *Metaphysics, Physics*, and *De anima*.

(*d*) The last stage in the Latin transmission of Aristotle-if we disregard the occasional translations of the seventeenth to twentieth centuries-covers what is normally called the humanistic and Renaissance period. This is the period beginning with and following the reestablishment of a more intimate collaboration between Greeks and western European scholars, which extended and deepened the understanding of the "old" Greek through a wider knowledge of the history, literature, science, etc., of the ancient world and a much more accurate understanding of the language as it was understood in ancient times. Another aspect that was soon presented as typical of the new movement in translations was the purity and perspicuity of the Latin language (purity ought to have carried with it the elimination of technical words that were not yet technical in classical Latin); but a closer study of many translations shows that the standards of knowledge of the ancient Greek background and of the Greek language were not consistently higher than in the Middle Ages, and that the need for very literal translations and technical usages of a medieval or of a new kind could not be avoided. In fact, very many new versions of Aristotle are hardly distinguishable, in their essential features, from those of the twelfth and thirteenth centuries. And what there was of a new philosophy of language applied to translations-the philosophy of meanings of contexts as against the meanings of individual words—was not always conducive to a better understanding of the original.

A complete survey of new translations down to the last quarter of the sixteenth century is impossible here. Although some of the later versions may still have exercised some influence in their own right, it seems that greater influence was exercised by some of those of the fifteenth century. And it is questionable how much even the latter ousted the medieval translations, or substituted something of great importance for them. We shall confine ourselves to a quick survey of the new versions of the fifteenth century, which were due in almost equal measure to Greek scholars attracted to Italy and to the Italians whose Greek scholarship resulted from contact with them.

The first Italian translator was a pupil of Manuel Chrysoloras, Roberto de' Rossi, who in 1406 translated the *Posterior Analytics*. Probably the greatest and most influential translator at the beginning of this movement was Leonardo Bruni of Arezzo, translator of the Nicomachean Ethics, Politics, and Economics (1416-1438). Gianozzo Manetti added to new translations of the Nicomachean Ethics and Magna moralia the first version of the Eudemian Ethics (1455-1460), an effort soon followed by Gregorio of Citta di Castello (or Tifernate). Giovanni Tortelli again translated (ca. 1450) the *Posterior Analytics;* and in the 1480's Ermolao Barbaro translated, if his statements are to be taken literally, the whole of the logical works, the *Physics*, and the *Rhetoric* (only some if his versions remain). Before 1498 Giorgio Valla produced new translations of the *De caelo, Magna moralia*, and *Poetics*, and Lorenzo Laurenziano one of the *De inteipretatione*.

In the meantime, from the early 1450's, the Greeks who had entered into the heritage of Latin culture were competing, or leading the way, in translation. The greatest of all, as a man of culture, collector of books, theologian, ecclesiastic, and philosopher, was Iohannes Bessarion, who translated the *Metaphysics*. His vast collection of manuscripts, among them many Greek volumes of Aristotle, was the basis of the Library of St. Mark in Venice. The most productive were John Argyropulos, translator of the *Categories, De interpretatione, Posterior* (and part of the *Prior*) *Analytics, Physics, De anima, De Caelo, Metaphysics*, and *Nicomachean Ethics* (and the pseudo-Aristotelian *De mundo*, also translated shortly before by Rinucio Aretino), and George of Trebizond, translator of the *De animalibus, Physics, De caelo, De generatione et corruptione, De anima, Problemata*, and *Rhetoric*. Theodore of Gaza translated the *De animalibus* and Problemata, and Andronicus Callistus the *De generatione et corruptione*.

What had been done to a very limited extent in the fifteenth century was done on a large scale in the first half of the sixteenth, mainly by Italian scholars: the translation of Greek commentaries from the second to the fourteenth centuries. In this field the Renaissance obscured almost completely what had been done in the Middle Ages, something that, with a few exceptions, it failed utterly to do with the entrenched translations of Aristotle.

*The Oriental Transmission of Aristotle's Works*. The Greek philosophical schools of the fifth and sixth centuries were attended by people of the various nations surrounding the Mediterranean. Greek was the language of learning, but new languages were emerging to a high cultural level, especially as a consequence of the development of theology from the basic tenets and texts of the Christian faith. What had become necessary for the Greek-speaking theologian, a lay cultural basis, was necessary for the Syrian and for the Armenian. Apart from this, most probably, pure philosophical interest was spreading to other nations that were becoming proud of their nationhood. Thus, probably from the fifth century, and certainly from the sixth, Aristotelian texts started to be translated, and commentaries to be translated into, or originally written in, these languages.

The Armenian tradition, to some extent paralleled by or productive of a more limited Georgian tradition, has not been sufficiently investigated. Armenian culture continued in several parts of the world through the centuries--Armenia itself, India, Europe, and recently America-obviously depending on the culture of the surrounding nations but probably with some independence. A vast amount of unexplored manuscript material, stretching from the eighth century or earlier to the nineteenth century, is now concentrated in the National Library of Manuscripts in Yerevan, Armenian Soviet Socialist Republic. What is

known in print is confined to translations of Porphyry's *Isagoge*, the Categories and *De interpretatione*, the apocryphal *De mundo*, and Helias' commentary to the *Categories*.A semimythical David the Unconquered (David Invictus) of the fourth or fifth century is mentioned as the author of some of these translations.

The Syriac tradition, more limited in time and space, apparently was richer both in translations of works of Aristotle and in original elaboration; apart from this, it formed the basis of a considerable proportion of the Arabic texts of Aristotle and, through them, of some of the Latin versions. The Nestorian Probus (Probha), of the fifth century, is considered the author of the surviving translations of *De interpretatione* and of *Prior Analytics* I.1-7, which may well belong to an eighth-century author. But there is no reason to doubt the ascription of translations and commentaries to Sergius of Theodosiopolis (Resh'ayna). He was a student in Alexandria and later active in Monophysite ecclesiastical and political circles in Antioch and in Constantinople, where he died ca. 535. He translated into Syriac the *Categories* with the *Isagoge*, and the De mundo (all still preserved), and possibly an otherwise unknown work by Aristotle, On the Soul. Toward the end of the seventh century, the Jacobite Jacob of Edessa translated the Categories; shortly after, George, bishop of the Arabs (d. 724), produced a new version of this book, of the *De interpretatione*, and of the entire *Prior Analytics*. Probably the most influential Syriac translators were two Nestorians, Ḥunayn ibn Isḥāq (d.876)and his son Isḥāq ibn Ḥunayn (d.910 or 911). Ḥunayn translated into Syriac the *De interpretatione, De generatione et corruptione, Physics* 11 (with Alexander of Aphrodisias' commentary), Metaphysics XI, and parts of the Prior and Posterior Analytics; his son possibly finished the version of these last two works, and translated the Topics into Syriac. 'Abd al-Masih ibn Na'ima and Abu Bishr Matta translated the Sophistici elenchi. Ishaq and Abu Bishr Matta also are among the translators from Greek into Arabic. Other translations into Syriac, which cannot be assigned to a definite author, include the Poetics (probably by lshaq ibn Hunayn), the De animalibus, possibly the Meteorologics, and a number of Greek commentaries to Aristotelian works. Not the least important feature of these translations into Syriac is the fact that numerous Arabic versions were made from the Syriac, rather than from the Greek.

Arabic translations from Aristotle were made in the ninth and tenth centuries, some by Syriac scholars, among whom the most prominent was Ishaq ibn Hunayn. They were done in the latter part of the ninth century and at the beginning of the tenth, when Baghdad had become the great center of Arabic culture under al-Mamun. Of the many translations listed in the old Arabic bibliographies we shall mention only those that still exist. Those made by Isḥāq ibn Ḥunayn, presumably directly from the Greek, are *Categories, De interpretatione, Physics, De anima*, and *Metaphysics* II; by Yaḥyā ibn Abī-Manṣūr, Isa ben Zura, and ibn Naim, the *Sophistici elenchi* (Yaḥyā also translated part of *Metaphysics* XII); Abī 'Uthman ad-Dimashki and Ibrahim ibn 'Abdallāh, the *Topics;* Abu Bishr Matta, the Posterior Analytics and the Poetics (perhaps both through the lost Syriac version by Isḥāq ibn Ḥunayn); Yaḥyā ibn al Bitriq, the *De caelo, Meteorologics*, and *De animalibus;* Astat (Eustathius), Metaphysics III-X; Theodorus (Abū Qurra[?], the Prior Analytics; unknown translators, the *Rhetoric* and *Nicomachean Ethics* VII-X. Of the apocrypha, we have two translations of the *De mundo*, one of which was made by "Usha ibn Ibrahim al-Nafisi from the Syriac of Sergius of Theodosiopolis (Resh'ayna). Finally, it must be mentioned that it was in the Arab world that sections of Plotinus' work(or notes from his conversations) were edited under the title *Theology of Aristotle*, and thirty-one propositions from Proclus' *Elements of Theology* were commented upon and edited as Aristotle's *Book of Pure Goodness* (generally known under the title *De causis*, which it acquired in the Latin tradition).

*Elaborations of Aristotle's Works*. The transcriptions of the Greek texts, the translations into the several languages, and the multiplication of the copies of these translations were obviously only the first steps in the spread of Aristotle's pure or adulterated. The more permanent influence of those doctrines was established in the schools, through oral teaching, or on the margin of and outside the schools, through writings of different kinds at different levels. There would be, at the most elementary level, the division into chapters, possibly with short titles and very brief summaries; then occasional explanations of words and phrases in the margins or between the lines in the manuscripts of the actual Aristotelian texts (glosses or scholia), or more extensive summaries and explanations of points of particular interest at some moment or other in the history of thought.

At a higher level there would be systematic expositions or paraphrases, adhering closely to the original text but adapting the diction, the language, and the articulation of the arguments to the common scholastic pattern of this or that time, place, or school; then, expository commentaries, section by section, with or without introductory surveys and occasional recapitulations. The commentaries could aim at clarifying Aristotle's doctrine or adding doctrinal developments. criticisms, or digressions. The discussions would then take on an independent status: "questions about the *Physics,*""questions about the *De anima*," and so on. These would normally represent the most marked transition from the exposition of Aristotle's view-showevер critically they might be treated-to the original presentation of problems arising from this or that passage. Very often such *quaestiones* would not have more than an occasional, accidental connection with Aristotle: the titles of Aristotle's works would become like the headings of one or another of the main branches of philosophy, of the encyclopedia of knowledge, or of sciences. This soon led to the abandonment of the pretense of a connection with the "Philosopher's" works and doctrines or, in many cases, to the pretense of abandoning him and being original while remaining, in fact, under the strongest influence of what he had said.

Systematic works covering a wide province of philosophy, or even aiming at an exhaustive treatment of all its provinces, could take the form of a series of expositions or commentaries on the works of Aristotle, or organize the accumulated intellectual experience of the past and the original views of the author with great independence at at many stages, but with explicit or implicit reference Aristotle's corpus as it had been shaped into a whole-to a small extent by him and to a larger extent by his later followers.

Much of the philosophical literature from the first to the sixteenth centuries could be classified under headings corresponding to the ways in which Aristotle was explained, discussed, taken as a starting point for discussions, used as a model for great systematizations containing all kinds of details, or abandoned-either with or without criticism. In the Greek-speaking world, the vast commentaries by Alexander of Aphrodisias (third century) on the *Metaphysics*, the Analytics, Topics, and *Meteorologics;* those by Simplicius (sixth century) on the Categories, the *De caelo*, and the *Physics;* and those by John Philoponus (the Grammarian) on the *De anima* were among the most prominent examples of the developed, systematic, and critical commentaries of Aristotle's texts. They were matched in the Latin world of the sixth century by Boethius' commentaries on the *Categories* and *De interpretatione*, in the Arab world of the twelfth century by the "great" commentaries of Averroës, and in the Latin world of the twelfth and thirteenth centuries by those of Abailard, Robert Grosseteste, Aquinas, Giles of Rome, and many others. Themistius' paraphrases (fourth century) of the logical works and of the *De anima*, partly imitated or translated into Latin in his own time, had their counterparts in works by Syriac-, Armenian-, and Arabic-writing philosophers: al-Kindi in the ninth century, the Turk al-Fārābī in the tenth, the Persian Ibn Sīnā (Avicenna) in the eleventh, and Averroë;s in the twelfth contributed in this way much-needed information on Aristotle to those who would not read his works, but would like to learn something of his doctrines through simplified Arabic texts. *Summae* or *summulae* of the *Elenchi*, of the Physics, and of other works appeared in Latin in the twelfth and thirteenth centuries, under such names as that of Grosseteste, or have remained anonymous. The collections of scholia of Greek manuscripts were continued by such genres as *glossae* and *notulae:* such collections on the *Categories*, written in the ninth century, and on the *Posterior Analytics*, the *De anima*, and the *Meteorologics*, written between the end of the twelfth and the middle of the thirteenth centuries, became in many cases almost standard texts accompanying the "authoritative" but difficult texts of the great master. At the level of philosophical systems we find the great philosophical encyclopedia of Avicenna (eleventh century), organized on the basis of the Aristotelian corpus but enriched by the philosophical experience of Aristotelians, Platonists, and other thinkers of many centuries, and above all by the grand philosophical imagination and penetration of its author. On the other hand, in the Latin world Albertus Magnus (thirteenth century), a man of inexhaustible curiosity, and with a frantic passion for communicating as much as he knew or thought he knew as quickly as possible, followed up his discoveries in the books of others with his own cogitations and developments, and presented his encyclopedia of knowledge almost exclusively as an exposition-cum-commentary of the works by Aristotle or those ascribed to him. What he had learned from others-he was one of the most learned men of his times, and much of his reading derived from the Arabic-finds its place in this general plan.

Quaestiones(ζητήσει?) are found in the Greek philosophical literature, and one might be tempted to include in this class much of Plotinus' Enneads. But it is when impatience with systematic explanatory commentary (mildly or only occasionally critical) leads to independent treatment of problems that the *quaestio* comes into its own-first, perhaps, as in Abailard, in the course of the commentary itself; then, in the second half of the thirteenth and much more in the fourteenth and fifteenth centuries, independently of the commentaries. It is in many of these collections of *quaestiones* that we find the minds of philosophers, impregnated with Aristotelian concepts and methods, searching more deeply the validity of accepted statements, presenting new points of view, and inserting in the flow of speculation new discoveries, new deductions from known principles, and corrected inferences from ambiguous formulations.

*Aristotle's Influence on the Development of Civilization*. The influence exercised by Aristotle's writings varied from work to work and often varied for the several sections of one and the same work. It would be relatively easy to select those short writings which, in spite of their inferior and confused nature or their incompleteness-the *Categories* and the *De interpretatione* from the first century B.C. to the sixteenth, and the *Poetics* from the early sixteenth to the nineteenth-penetrated more deeply and widely into the minds of intelligent people than did the more extensive, organized, and imaginative works, such as De animalibus, De anima, and the Physics. Moreover, one could possibly select a limited number of passages that left their permanent mark because they were repeatedly quoted, learned by heart, and applied, rightly or wrongly, as proverbs, slogans, and acquired "truths" are applied. Most of all, it is possible, and essential for our purpose, to select those concepts that became common property of the civilized mind, however much they may have been elaborated and, in the course of time, transformed. And if these concepts are not all originally Aristotelian, if they have found their way into the several fields of culture in more than one (the Aristotelian) way, it is our contention that pressure of continuous study and repetition and use of those concepts in Aristotelian contexts, in the ways sketched above, are responsible more than anything else for their becoming so indispensable and fruitful.

It is enough to try to deprive our language of a certain number of words in order to see how much we might have to change the whole structure of our ways of thinking, of expressing, even of inquiring. A conceptual and historico-linguistic analysis of a definition like "mass is the quantity of matter" would show us that whatever was and is understood by these words owes much to the fact that the concepts of "quantity" and of "matter" were for two millennia inculcated into the minds of men and into their languages, more than in any other ways through the centuries, stim elating thoughts, experiments, and interpretations of facts, because some bits of the Metaphysics and of the Physics were the sine qua non condition of men's "knowledge" of the world. And if "potential" has assumed so many uses-from social and military contexts to electricity, dynamics, and what not-is it not because we have been trained to handle this term as an indispensable instrument to describe an infinite variety of situations that have something in common, as Aristotle repeated *ad nauseam*, when making "potency" one of the basis concepts for the understanding of the structure of the world? We have used, misused, abused, eliminated, and reinstated the concepts of "substance" and "essence," "Relation" and "analogy," "form,""cause," "alteration of qualities," are and "development from potentiality to actuality" all terms that have not yet stopped serving their purpose. A writer of a detailed history of science would be hard put if he tried to avoid having recourse to Aristotle for his understanding of how things progressed in connection with them. At the very root of much of our most treasured scientific development lies the quantification of qualities; this started in the form of a general problem set by the distinction between two out of the ten "Aristotelian categories" in conjunction with Aristotle's theory of the coming into being of new "substances." It may be

contended that, by his very distinction, Aristotle created difficulties and slowed progress. Perhaps there is something in that complaint; nevertheless, in this way he stimulated the search for truth and for formulations of more satisfactory hypotheses to fit, as he would say, τά Φαινόμενα—to fit what we see.

His exemplification of continuous and discontinuous quantities in the *Categories* may elicit an indulgent smile from those who lack any historical sense; and it would be impertinent to skip over twenty-two and a half centuries and say that here we are, faced by the same problems that worried Aristotle, but with more sophistication: continuous waves or discontinuous quanta? But how did it happen that the problems came to be seen in this way, with this kind of alternative? No doubt Aristotle was not the only ancient sage who taught the concept of continuity to the millennia to come, but no text in which the distinction-and the problems it brought with it-appeared was learned by heart, discussed and commented upon, or became the text for examinations and testing as often and as unavoidably as the *Categories*. Do things happen by chance, or through a chain of causality? Can we determine how and why this happens-is it "essential" that it should happen or is it "accidental"? Much scientific progress was achieved by testing and counter testing, under these, Aristotelian, headings, what the world presents to our perception and to our mind.

Again: classification, coordination, and subordination have been and are instruments of clear thinking, of productive procedures, of severe testing of results. The terms "species" and "genus" may be outmoded in some fields, but the fashion is recent; the words have changed, yet the concepts have remained. And with them we find, not even outmoded, "property" and "difference." We have been conditioned by these distinctions, by these terms, because we come from Aristotelian stock.

It is, in conclusion, significant of Aristotle's impact on the development of culture, and particularly of science, that among the more essential elements in our vocabulary there should be the following terms, coming directly from his Greek (transliterated in the Latin or later translations) or from the Latin versions, or from texts where some of these terms had to be changed in order to preserve some equivalence of meaning when they proved ambiguous: (*a*) *category* (*class, group,* etc.) and the names of the four categories actually discussed in the *Categoriae-substance (essence), quantity, quality, relation; (b) universal and individual, and the quinque votes* (another title for Porphyry's *Isagoge*, which developed a passage of Aristotle's Topics and was studied as the introduction to his logic)-*genus, species, difference, property, accident* (in the sense of accidental feature); (c) cause and the names or equivalents applied to the four causes until quite recent times-*efficient, final, material, and formal;* (d) couples of correlative terms, like matter-*form (structure), potency-act (energy), substance-accident*.

Terms like "induction" and "deduction," "definition" and "demonstration" have certainly become entrenched in our language from many sources apart from Aristotle's *Analytics*. But again, the extent of their use, the general understanding of their meaning and implications, and the application in all fields of science of the methods of research and exposition that those terms summarize depend possibly more on the persistent study of Aristotle than on any other single source. All the wild anti-Aristotelianism of the seventeenth century would have been more moderate if people had realized then, as it had been realized, for instance, in the thirteenth century, how aware Aristotle was that experience, direct perception and knowledge of individual facts, is the very basis of scientific knowledge. The anti-Aristotelians were much more Aristotelian than they thought in some aspects of their methods; and that was because they had, unconsciously, absorbed Aristotle's teaching, which had seeped through from the higher level of philosophical discussion to the common attitude of people looking for truth.

It has become a truism that observation of facts was recognized as the necessary beginning of science through a revolutionary attitude which had as its pioneers such people as Roger Bacon and Robert Grosseteste. One wonders whether many realize that -because he thought Aristotle to be very often right on important matters-Aquinas insisted that a problem which, for him and his contemporaries, was of the utmost importance-the problem of the existence of God-could be solved only by starting from the observation of facts around us. If, as it happened, Aquinas was going to carry the day with his very awkward "five ways," he was also going to boost very widely the value of the basic principle on which so much depended in the development of science: observe first, collect facts, and draw your conclusions after. And it is in the course of the discussion of the *Posterior Analytics* that probably one of the main steps forward in the methodology of science was made by Grosseteste around 1230: probably not so much-as has been maintained-in passing from "experience" to "experiment" as in the discrimination of the contributory factors of a certain effect, in the search for the really effective causes, as against the circumstantial, accidental state of affairs.

One further example of the permanence of Aristotle's teaching is provided by his insistence on the old saying that nature does nothing in vain. The development from this principle of the wrongly called "Ockham's razor" is the result of a series of refinements; it may be possible (or has it already been done?) to see through which steps this principle of finality and economy of nature has established itself in all but the most independent or anarchic scientific minds.

Above all, probably, Aristotle's explicitly stated methodical doubt as a condition for the discovery of truth and his exhaustive accumulation of "difficulties" (ἀποριαι) have trained generation after generation in the art of testing statements, of analyzing formulations, of trying to avoid sophistry. The picture of an Aristotelianism confined to teaching how to pile up syllogisms that either beg the question or, at best, make explicit what is already implicit in the premises is very far from the Aristotelianism of Aristotle, and hides most of what Aristotle has meant for the history of culture and science. It is through observation, ἀποριαι, reasoned and cautious argument, that he thought our statements should fit the phenomena (φαινόμενα): no wonder that Aquinas himself was not troubled by the possibility that geocentrism might prove to be less "valid" than heliocentrism.

It is much more difficult to discover, isolate, and follow up the influence of Aristotle's writings on the advancement of science considered in the several fields and, what counts more, in the solution of particular problems. It is also difficult to locate exactly in time and space the several steps by which methods of inquiry, learned directly or indirectly at the Aristotelian school, have been successfully applied as Aristotelian. Out of the vast amount of evidence existing, only a small fraction has been studied. Influences have hardly ever been the result of isolated texts or of individual authors; the accumulation of interpretations, refinements, new contributions, and variations in the presentation of problems has continued for centuries, and the more striking turning points are those at which the influence has been a *contrario*. Whether it is Simplicius (sixth century) commenting on the *De caelo*, and thus contributing to the methodical transformation of the study of the heavens, or William Harvey (eleven centuries later) taking as one of his basic texts for the study of the mechanics of the living body the *De motu animalium*, there is no doubt that we can rightly speak of Aristotle's influence on the advancement of astronomy and of physiology. But determining the exact point at which that influence can be located, in what precise sense it can be interpreted, and in what measure it can be calculated would require much more than a series of textual references.

It might be suggested that one precise point in history at which Aristotle's deductive theory in the *Posterior Analytics* contributed to the mathematization of nonmathematical sciences can be found in Robert Grosseteste's commentary on that work (ca. 1230). Aristotle had considered optics as a science dependent on mathematics (geometry), and in his discussion of two types of demon-stration, the *demonstratio propter quid*. For Grosseteste the whole of nature was fundamentally light, manifesting itself in different states. It could be argued, therefore, that Grosseteste would have inferred that Aristotle's examples revealed, more than he imagined, the mathematical structure of all natural (and supernatural) sciences. One can go further and, magnifying Grosseteste's influence, state that quantification in natural sciences has its roots in the *Posterior Analytics* as interpreted by Grosseteste in the frame of his metaphysics of light. This is the kind of fallacy that results from not realizing how difficult it is to discover and assess Aristotelian influences. Nothing has so far been shown-although much has been said-to prove that statement.

Among the few fields in which many necessary inquiries have been made (through commentaries to Aristotle, *quaestiones* arising from the *Physics*, and independent treatises with an Aristotelian background) to show how (by appropriate or forced interpretation, by intelligent criticism or the process of development) modern science has to some extent come out of the study of Aristotle are those of the theories of rectilinear movement (constant velocity and acceleration), of "essential" transformations consequent to quantitatively different degrees of qualities, and of the nature and basic qualities of matter in connection with gravity. The temptation must, of course, be resisted to see Aristotle's influence wherever some connection can he established, whether *prima facie* or after detailed consideration of chains of quotations, repetitions, and slight transformations. But the pioneering studies of Pierre Duhem, the detailed analyses and historical reconstructions by Anneliese Maier, Nardi, Weisheipl; the attempts at wider historical systematizations by Thorndike, Sarton, and Crombie; and the contributions by many scholars of the last thirty years confirm more and more the view that the debt of scientists to the Aristotelian tradition is far greater than is generally accepted.

*Setbacks in the Aristotelian Tradition*. The progress in the spread of Aristotelian studies had its obstacles and setbacks, at different times in different spheres and for a variety of reasons. These ranged from purely philosophical opposition to purely theological convictions and prejudices, and to the interference of political and political-ecclesiastical powers with the free flow of speculation and debate. The story of the setbacks could be considered as diverse and rich as that of the actual progress; we shall mention only some of the most famous, or notorious, examples.

In 529 Justinian ordered the closing down of all philosophical schools in Athens; such people as Simplicius and Damascius became political-philosophical refugees in the "unfaithful" Persian kingdom. Greek Aristotelian studies then had over two centuries of almost total eclipse.

A similar attack on philosophy, at a very "Aristotelian" stage, was carried out in 1195 by Caliph Ya'ub al-Mansur in southern Spain; one of the exiled victims was the great Averroes, who had, among other things, strongly defended philosophy against the religious mystical onslaught by al-Ghazali, the author of the Destruction of Philosophers. Whatever the reasons for the centuries-long eclipse of Arabic philosophy, the blow of 1195 was certainly one of the most effective contributions to it.

Much has been made by the historians of philosophy, and particularly of science, of the Roman Church's hostility to Aristotelianism, as made manifest by the decrees of 1210, 1215, and 1231-also confirmed later-"prohibiting" the study of Aristotle's works on natural philosophy and then of those on metaphysics. The prohibitions, confined first to Paris and then to a few other places, and soon limited in scope (the works in question were to be examined by a committee of specialists and, where necessary, revised), turned out to be probably one of the most important factors in the most powerful and permanent expansion of Aristotelian studies in the whole of history. Interest was intensified, obstacles were avoided or disregarded, and witch-hunting did not succeed in doing much more than alerting philosophers and scholars to the danger of expressing Aristotle's views as their own views, and of describing developments based on Aristotle's works as the truth rather than as logically compelling inferences from authoritative statements.

The real setbacks to the spread of Aristotelian studies-not necessarily of the kind of Aristotelian influence sketched above-came in the seventeenth and eighteenth centuries, when progress in scientific and historical knowledge; the interplay of the new interests with a sterilized, scholastic "Aristotelianism", a passion for grand philosophical systems; refined, systematic criticism of current beliefs; and the impact of new theological disputes filled the minds of thoughtful people with problems that either were not present in Aristotle's works or had now to be expressed in a differently articulated language.

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1. Original Works. This section will be limited to the more essential references. The others will be found in works cited below under "Secondary Literature."

The tradition of the Greek texts of Aristotle is documented mainly in their critical editions; for these see the article on his "Life and Works." For the medieval Latin tradition see, above all, the *Corpus philosophorum medii aevi, Aristoteles Latinus* (Bruges-Paris, 1952-), of which the following vols. have appeared: I.1-5, *Categoriae*, L. Minio-Paluello, ed. (1961); I.6-7,*Supplementa Categoriarum* (Porphyry's *Isagoge* and Pseudo-Gilbertus' *Liber sex principiorum)*, L. Minio-Paluello, ed. (1966); II.1-2, *De interpretatione*, L. Minio-Paluello, ed. (1965); III. 1-4, *Analytica priora*, L. Minio-Paluello, ed. (1962); IV. 1-4, *Analytica posteriora*, L. Minio-Paluello and B. G. Dod, eds. (1968); VII.2, *Physica* I ("Physica Vaticana"), A. Mansion, ed. (1957); XI. 1-2, *De mundo*, 2nd ed., W. L. Lorimer *et al*., eds. (1965); XVII.2.v, De generatione animalium, trans. Guillelmi, H. J. Drossaart Lulofs, ed. (1966); XXIX.I, Politica 1-11.11, 1st vers. by William of Moerbeke, P. Michaud-Quantin, ed. (1961); and XXXIII, Poetica, 2nd ed., trans. Guillelmi, with Hermann the German's version of Averroes' Poetria, L. Minio-Paluello, ed. (1968). V.1-3, Topica, L. Minio-Paluello, ed., is to appear in 1969. Older eds. of most of the translations or revisions of the thirteenth century appeared from 1475 on. Among other more recent eds., the following should be recorded : Politics, in F. Susemihl's ed. of Greek text (Leipzig, 1872); Rhetoric, in L. Spengel's ed. of Greek text (Leipzig, 1867); Metaphysica media, in Alberti Magni Opera omnia, XVI, B. Geyer, ed. (Munster, 1960- ); Metaphysica, trans. lacobi ("Metaphysica Vetustissima"), in Opera... Rogeri Baconi, XI, R. Steele, ed. (Oxford, 1932).

The best ed. of the Armenian texts of the *Categoriae, De interpretatione*, and *De mundo* was produced by F. C. Conybeare in *Anecdota Oxoniensia*, Classical Series I.vi (Oxford, 1892). George's Syriac version of *Categoriae, De Interpretatione*, and *Prior Analytics* was edited by G. Furlani in *Memorie dell'Accademia... dei Lincei* Classe scienze morali, VI.5, i and iii, and VI.6.iii (Rome, 1933-1937). Most of the surviving Arabic translations of the Middle Ages were first edited or reedited by Abdurrahman Badawi in the collection Studii Islamici (then Islamica) (Cairo 1948-): these include all the works of logic, the *Rhetoric, Poetics, De anima, De caelo*, and *Meteorologics*. Of other eds. the following should be mentioned: *Metaphysics* (missing parts of Bks. I and XII, and the whole of Bks. XI and XIII-XIV), M. Bouyges, ed. (Beirut, 1938-1952); and *Poetics*, J. Tkatsch, ed. (Vienna, 1928-1932).

The extant Greek commentaries were edited by H. Diels and his collaborators in *Commentaria in Aristotelem Graeca* (Berlin, 1882-): the medieval Latin trans, are being published in the *Corpus Latinum commentariorum in Aristotelem Graecorum* (Louvain, 1957-), thus far consisting of I. Themistius on De anima, II. Ammonius on De interpretatione, 111. Philoponus on De anima, and IV. Alexander on De sensu all e d. by G. Verbeke.

The one major commentary by Averroës that is preserved in Arabic, on the *Metaphysics*, was published with the Aristotelian text by Bouyges (see above). Many of the Latin medieval trans. of the longer and shorter commentaries by Averroës were printed several times in the fifteenth and sixteenth centuries (1st ed., Venice, 1483); new trans. from the Hebrew of some of the same commentaries and of others (most importantly, the long commentary on *Posterior Analytics*) were published in the sixteenth century (first comprehensive ed., Venice, 1551-1561). Critical eds. of the medieval Latin and Hebrew trans. of Averroës' commentaries are being published in the *Corpus philosophorum medii aevi, Corpus commentariorum Averrois in Aristotelem*, the most important of which is Michael scot's trans. of the long commentary on *De anima*, in Vol. VI,1, F. Stuart Crawford, ed. (Cambridge, Mass., 1953).

II. Secondary Literature. A list of Greek MSS of Aristotle's works and of those of his commentators, based manily on printed catlogs, was ed. by A. Wartelle, *Inventaire des manuscrits grecs d'Aristote et de ses commentateurs* (Paris, 1963), and supplemented by D. Harlfinger and J. Wiesner in Scriptorium, **18** , no. 2 (1964), 238-257. A descriptive catalog of all the known MSS of Aristotle's works is being prepared by P. Mo0rayx and his collaborators of the Aristotelian Archive at the University of Berlin. The best sources for knowledge of the printed tradition are still the general catalogs of the British Museum and of the Prussian libraries; for recent times, see also the catalog of the U.S. Library of Congress.

Nearly all the available basic information for the Latin tradition in the Middle Ages is collected in the three vols. of G. Lacombe, E. Franceschini, L. Minio-Paluello, *et al., Aristoteles Latinus, Codices:* I., Rome, 1939; II., Cambridge, 1955: Supplem. Alt., Bruges, 1961. The bibliography that is in these vols, includes all the works of importance on the subject. Additional information on individual works will be found in the intros, to the eds. of texts in the *Aristoteles Latinus* series. Special mention should be made of E. Franceschini, "Roberto Grossatesta, vescovo di Lincoln, e le sue traduzioni latine," in *Atti della Reale Istituto Veneto*, **93** , no. 2 (1933-1934), 1-138; G. Grabmann, *Guglielmo di Moerbeke, it traduttore delle opere di Aristotele* (Rome, 1946): J. M. Millás Vallicrosa, *Las traduciones orientales en los manuscritos de la Biblioteca Catedral de Toledo* (Madrid, 1942); L. Minio-Paluello, "Iacobus Veneticus Grecus, Canonist and Translator of Aristotle" in *Traditio*, 8 (1952), 265-304; "Note sull' Aristotele Latino medievale," in *Rivista di filosofia neo-scolastica*, 42 ff. (1950 ff.). For the printed eds. of medieval Latin trans., see the *Gasamtkatalog der Wiegendrucke* and the library catalogs cited above.

For the humanistic and Renaissance trans. into Latin, see E. Garin, *Le traduzioni umanistiche di Aristotele nel secolo XV*, Vol. VII in Accademia Fiorentian La Colombaria (Florence, 1951), and the *Gesamtkatalog* and the library catalogs.

For the study of Aristotle in the Middle Ages, M Grabmann's *Mittelalterliches Geistsleben*, 3 vols. (Munich, 1926-1956), and his earlier *Geschichte der scholastischen Methode* (Freiburg im Breisgau, 1909-1911) are of fundamental importance. Among the many works of a more limited scope, see F. Vasn Steenberghen, *Siger de Brabant d'après see oeuvres inédites, II: Siger dans I'histoire de I'Aristotélisme*, Vol. XII of Les Philosphes Belges (Louvain, 1942).

For the Armenian tradition, see conybeare's ed. mentioned above; the catalogs of the more important collecBodleian Library, Bibliothèque Nationale); and G. W. abgarian, *The Matenadaran* (Yerevan, 1962).

For the Syriac tradition, see A. Baumstark, *Geschichte der sayrischen Literatur* (Bonn, 1922); and many articles by G. Furlani, listed in the bibliog. of his writings in *Rivista degli studi orientali*, **32** (1957).

For the Arabic tradition, see C. Brockelmann, *Geschichte der arabischen Literatur*, 2nd ed., 2 vols, (Leiden, 1943-1949) and 3 vols. of supps. (Leiden, 1937-1942); R. Walzer, "Aristūṭālīs," in *Encyclopaedia of Islam*, 2nd ed., I 630-635; Abdurrahman Badawi, *Aristu'indal-'Arab* (Cairo, 1947); M. Steinschneider, "Die arabischen uebersetzungen aus dem Griechischen," in Zentralblatt Für Bibliothekswesen, **8** (1889) and **12** (1893), and "Die europaïschen Uebersetzungen aus dem Arabischen bis Mitte des 17 Jahrhunderts," in *Sitzungsberichte der Kaiserliche Akademie der Wissenschaften*, philos.-hist. Klasse, **149** no. 4, and **151, no.** 1.

For the Hebrew tradition, see M. Steinschneider, *Die hebraischen Uebersetzungen des Mittelaters und die Juden als Dolmesscher* (Berlin, 1893); and H. A. wolfson, "Plan for the Publication of *Corpus commentariorum Averrios in Aristotelem,"* in Speculum (1931), 412-427.

No comprehensive study of Aristotle's influence through the ages has ever been published. The standard histories of philosophy and science, general or specialized, contain much useful information, including bibliographies, e.g.; F. Ueberweg. *Geschichte der Philosophie*, 5 vols., 11th-13th eds. (Berlin, 1924-1928); E. Zeller, *Die Philosophie der Griechen*, 4th-7th eds. (1882-1920); I. Husik, *A History of Medieval Jewish Philosophy* (Philadelphia, 1916; 6th ed., 1946); G. Sarton, *Introduction to the History of Science*, 3 vols. (Baltimore, 1927-1948); Lynn Thorndike, *A History of Magic and Experimental Science*, 8 vols. (New York, 1923-1958); C. Singer, *Studies in the History and Method of Science* (Oxford, 1921); and A. C. Crombie, *Augustine to Galileo* (London, 1952).

Special problems, periods, or fields have been surveyed and analyzed in, e.g., P. Duhem, Le système du monde, 8 vols. (Paris, 1913-1916, 1954-1958), and Etudes sur Léonard *de Vinci* (Paris, 1906-1913); A. Maier, Metaphysische *Hintergrü;nde der spätscholastischen Naturphilosophie* (Rome, 1951), *Zwei Grundprobleme der scholastischen Naturphilosophie*, 2nd ed. (Rome, 1951), *An der Grenze von Scholastik und Naturwissenschaft*, 2nd ed. (Rome, 1952), and *Zwischen Philosophic and Mechanik* (Rome, 1958); A.C. Crombie, *Robert Grosseteste and the Origins of Experimental science* (Oxford, 1953); M. Clagett, *The Science of Mechanics in the Middle Ages* (Madison, Wis., 1959); and R. Lemay, *Abu Ma'shar and Latin Aristotelianism in the Twelfth Century* (Beirut, 1962).

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# Aristotle

Complete Dictionary of Scientific Biography


(*b*. Stagira in Chalcidice, 384 b.c.; *d* Chalcis, 322 b.c.)

*the most influential ancient exponent of the methodology and division of sciences; contributed to physics, physical astronomy, meteorology, psychology, biology*. The following article is in four parts; Method, Physics, and Cosmology; Natural History and Zoology; Anatomy and Physiology; Tradition and Influence.

**Method, Physics, and Cosmology.**

Aristotle's father served as personal physician to Amyntas II of Macedon, grandfather of Alexander the Great. Aristotle's interest in biology and in the use of dissection is sometimes traced to his father's profession, but any suggestion of a rigorous family training in medicine can be discounted. Both parents died while Aristotle was a boy, and his knowledge of human anatomy and physiology remained a notably weak spot in his biology. In 367, about the time of his seventeenth birthday, he came to Athens and became a member of Plato's Academy. Henceforth his career falls naturally into three periods. He remained with the Academy for twenty years. Then, when Plato died in 347, he left the city and stayed away for twelve years: his reason for going may have been professional, a dislike of philosophical tendencies represented in the Academy by Plato's nephew and successor, Speusippus, but more probably it was political, the new anti-Macedonian mood of the city. He returned in 335 when Athens had come under Macedonian rule, and had twelve more years of teaching and research there. This third period ended with the death of his pupil, Alexander the Great (323), and the revival of Macedon's enemies. Aristotle was faced with a charge of impiety and went again into voluntary exile. A few months later he died on his maternal estate in Chalcis.

His middle years away from Athens took him first to a court on the far side of the Aegean whose ruler, Hermeias, became his father-in-law; then (344) to the neighboring island Lesbos, probably at the suggestion of Theophrastus, a native of the island and henceforth a lifelong colleague; finally (342) back to Macedon as tutor to the young prince Alexander. After his return to Athens he lectured chiefly in the grounds of the Lyceum, a Gymnasium already popular with sophists and teachers. The Peripatetic school, as an institution comparable to the Academy, was probably not founded until after his death. But with some distinguished students and associates he collected a natural history museum and a library of maps and manuscripts (including his own essays and lecture notes), and organized a program of research which *inter alia* laid the foundation for all histories of Greek natural philosophy (see Theophrastus), mathematics and astronomy (see Eudemus), and medicine.

Recent discussion of his intellectual development has dwelt on the problem of distributing his works between and within the three periods of his career. But part of the stimulus to this inquiry was the supposed success with which Plato's dialogues had been put in chronological order, and the analogy with Plato is misleading. Everything that Aristotle polished for public reading in Plato's fashion has been lost, save for fragments and later reports. The writings that survive are a collection edited in the first century B.C. (see below, Aristotle : Tradition), allegedly from manuscripts long mislaid : a few items are spurious (among the scientific works Mechanica, Problemata, De mundo, De plantis), most are working documents produced in the course of Aristotle's teaching and research ; and the notes and essays composing them have been arranged and amended not only by their author but also by his ancient editors and interpreters. Sometimes an editorial title covers a batch of writings on connected topics of which some seem to supersede others (thus Physics VII seems an unfinished attempt at the argument for a prime mover which is carried out independently in Physics VIII) ; sometimes the title represents an open file, a text annotated with unabsorbed objections (e.g., the Topics) or with later and even post-Aristotelian observations (e .g ., the Historia anirnalium). On the other hand it cannot be assumed that inconsistencies are always chronological pointers. In De caelo 1-II he argues for a fifth element in addition to the traditional four (fire, air, water, earth) : unlike them, its natural motion is circular and it forms the divine and unchanging substance of the heavenly bodies. Yet in De caelo III-IV. as in the Physics, he discusses the elements without seeming to provide for any such fifth body, and these writings are accordingly sometimes thought to be earlier. But on another view of his methods (see below, on dialectic) it becomes more intelligible that he should try different and even discrepant approaches to a topic at the same time .

Such considerations do not make it impossible to reconstruct something of the course of his scientific thinking from the extant writings, together with what is known of his life. For instance it is sometimes said that his distinction between "essence" and "accident," or between defining and nondefining characteristics, must be rooted in the biological studies in which it plays an integral part. But the distinction is explored at greatest length in the *Topics*, a handbook of dialectical debate which dates substantially from his earlier years in the Academy, whereas the inquiries embodied in his biological works seem to come chiefly from his years abroad, since they refer relatively often to the Asiatic coast and Lesbos and seldom to southern Greece.

So this piece of conceptual apparatus was not produced by the work in biology. On the contrary, it was modified by that work: when Aristotle tries to reduce the definition of a species to one distinguishing mark (e.g., *Metaphysics* VII 12, VIII 6) he is a dialectician, facing a problem whose ancestry includes Plato's theory of Forms, but when he rejects such definitions in favor of a cluster of differentiae (*De partibus animalium* I 2–3) he writes as a working biologist, armed with a set of questions about breathing and sleeping, movement and nourishment, birth and death.

The starting point in tracing his scientific progress must therefore be his years in the Academy. Indeed without this starting point it is not possible to understand either his pronouncements on scientific theory or, what is more important, the gap between his theory and his practice.

*The Mathematical Model*. The Academy that Aristotle joined in 367 was distinguished from other Athenian schools by two interests: mathematics (including astronomy and harmonic theory, to the extent that these could be made mathematically respectable), and dialectic, the Socratic examination of the assumptions made in reasoning—including the assumptions of mathematicians and cosmologists. Briefly, Plato regarded the first kind of studies as merely preparatory and ancillary to the second; Aristotle, in the account of scientific and philosophical method that probably dates from his Academic years, reversed the priorities (*Posterior Analytics* I; *Topics* I 1–2). It was the mathematics he encountered that impressed him as providing the model for any well-organized science. The wórk on axiomatization which was to culminate in Euclid's *Elements* Elements was already far advanced, and for Aristotle the pattern of a science is an axiomatic system in which theorems are validly derived from basic principles, some proprietary to the science ("hypotheses" and "definitions," the second corresponding to Euclid's "definitions"), others having an application in more than one system ("axioms," corresponding to Euclid's "common notions"). The proof–theory which was characteristic of Greek mathematics (as against that of Babylon or Egypt) had developed in the attempt to show why various mathematical formulae worked in practice. Aristotle pitches on this as the chief aim of any science: it must not merely record but explain, and in explaining it must, so far as the special field of inquiry allows, generalize. Thus mathematical proof becomes Aristotle's first paradigm of scientific explanation; by contrast, the dialectic that Plato ranked higher the logical but free–ranging analysis of the beliefs and usage of "the many and the wise"–is allowed only to help in settling those basic principles of a science that cannot, without regress or circularity, be proved within the science itself. At any rate, this was the theory.

Aristotle duly adapts and enlarges the mathematical model to provide for the physical sciences. Mathematics, he holds, is itself a science (or rather a family of sciences) about the physical world, and not about a Platonic world of transcendent objects; but it abstracts from those characteristics of the world that are the special concern of physics—movement and change, and therewith time and location. So the nature and behavior of physical things will call for more sorts of explanation than mathematics recognizes. Faced with a man, or a tree, or a flame, one can ask what it is made of, its "matter"; what is its essential character or "form"; what external or internal agency produced it; and what the "end" or purpose of it is. The questions make good sense when applied to an artifact such as a statue, and Aristotle often introduces them by this analogy; but he holds that they can be extended to every kind of thing involved in regular natural change. The explanations they produce can be embodied in the formal proofs or even the basic definitions of a science (thus a lunar eclipse can be not merely accounted for, but defined, as the loss of light due to the interposition of the earth, and a biological species can be partly defined in terms of the purpose of some of its organs). Again, the regularities studied by physics may be unlike those of mathematics in an important respect: initially the *Posterior Analytics* depicts a science as deriving necessary conclusions from necessary premises, true in all cases (I ii and iv), but later (I xxx) the science is allowed to deal in generalizations that are true in most cases but not necessarily in all. Aristotle is adapting his model to make room for "a horse has four legs" as well as for "2 x 2 = 4." How he regards the exceptions to such generalizations is not altogether clear. In his discussions of "luck" and "chance" in *Physics* II, and of "accident" elsewhere, he seems to hold that a lucky or chance or accidental event can always, under some description, be subsumed under a generalization expressing some regularity. His introduction to the *Meteorologica* is sometimes cited to show that in his view sublunary happenings are inherently irregular; but he probably means that, while the laws of sublunary physics are commonly (though not always) framed to allow of exceptions, these exceptions are not themselves inexplicable. The matter is complicated by his failure to maintain a sharp distinction between laws that provide a necessary (and even uniquely necessary), and those that provide a sufficient, condition of the situation to be explained.

But in two respects the influence of mathematics on Aristotle's theory of science is radical and unmodified. First, the drive to axiomatize mathematics and its branches was in fact a drive for autonomy: the premises of the science were to determine what questions fell within the mathematician's competence and, no less important, what did not. This consequence Aristotle accepts for every field of knowledge: a section of *Posterior Analytics* I xii is given up to the problem, what questions can be properly put to the practitioner of such-and-such a science; and in I vii, trading on the rule "one science to one genus," he denounces arguments that poach outside their own field—which try, for instance, to deduce geometrical conclusions from arithmetical premises. He recognizes arithmetical proofs in harmonics and geometrical proofs in mechanics, but treats them as exceptions. The same impulse leads him to map all systematic knowledge into its departments—theoretical, practical, and productive—and to divide the first into metaphysics (or, as he once calls it, "theology"), mathematics, and physics, these in turn being marked out in subdivisions.

This picture of the autonomous deductive system has had a large influence on the interpreters of Aristotle's scientific work; yet it plays a small part in his inquiries, just because it is not a model for inquiry at all but for subsequent exposition. This is the second major respect in which it reflects mathematical procedure. In nearly all the surviving productions of Greek mathematics, traces of the workshop have been deliberately removed: proofs are found for theorems that were certainly first reached by other routes. So Aristotle's theoretical picture of a science shows it in its shop window (or what he often calls its

"didactic") form; but for the most part his inquiries are not at this stage of the business. This is a piece of good fortune for students of the subject, who have always lamented that no comparable record survives of presystematic research in mathematics proper (Archimedes' public letter to Eratosthenes—the *Ephodos*, or "Method"—is hardly such a record). As it is. Aristotle's model comes nearest to realization in the systematic astronomy of *De caelo* I-II (cf., e.g., I iii, "from what has been said, partly as premises and partly as things proved from these, it follows..."), and in the proof of a prime mover in *Physics* VIII. But these constructions are built on the presystematic analyses of *Physics* I-VI, analyses that are expressly undertaken to provide physics with its basic assumptions (cf. I i)and to define its basic concepts, change and time and location, infinity and continuity (III i). *Ex hypothesi* the latter discussions, which from Aristotle's pupils Eudemus and Strato onward have given the chief stimulus to physicists and philosophers of science, cannot be internal to the science whose premises they seek to establish. Their methods and data need not and do not fit the theoretical straitjacket, and in fact they rely heavily on the dialectic that theoretically has no place in the finished science.

*Dialectic and "Phenomena."* Conventionally Aristotle has been contrasted with Plato as the committed empiricist, anxious to "save the phenomena" by basing his theories on observation of the physical world. First the phenomena, then the theory to explain them: this Baconian formula he recommends not only for physics (and specifically for astronomy and biology) but for ethics and generally for all arts and sciences. But "phenomena," like many of his key terms, is a word with different uses in different contexts. In biology and meteorology the phenomena are commonly observations made by himself or taken from other sources (fishermen, travelers, etc.), and similar observations are evidently presupposed by that part of his astronomy that relies on the schemes of concentric celestial spheres proposed by Eudoxus and Callippus. But in the *Physics* when he expounds the principles of the subject, and in many of the arguments in the *De caelo* and *De generatione et corruptione* by which he settles the nature and interaction of the elements, and turns Eudoxus' elegant abstractions into a cumbrous physical (and theological) construction, the data on which he draws are mostly of another kind. The phenomena he now wants to save—or to give logical reasons (rather than empirical evidence) for scrapping—are the common convictions and common linguistic usage of his contemporaries, supplemented by the views of other thinkers. They are what he always represents as the materials of dialectic.

Thus when Aristotle tries to harden the idea of location for use in science (*Physics* IV 1–5) he sets out from our settled practice of locating a thing by giving its physical surroundings, and in particular from established ways of talking about one thing taking another's place. It is to save these that he treats any location as a container, and defines the place of X as the innermost static boundary of the body surrounding X. His definition turns out to be circular: moreover it carries the consequence that, since a point cannot lie within a boundary, it cannot strictly have (or be used to mark) a location. Yet we shall see later that his theories commit him to denying this.

Again, when he defines time as that aspect of change that enables it to be counted (*Physics* IV 10–14), what he wants to save and explain are the common ways of *telling* the time. This point, that he is neither inventing a new vocabulary nor assigning new theory-based uses to current words, must be borne in mind when one encounters such expressions as "force" and "average velocity" in versions of his dynamics. The word sometimes translated "force" (*dunamis*) is the common word for the "power" or "ability" of one thing to affect or be affected by another-to move or be moved, but also to heat or to soften or to be heated, and so forth. Aristotle makes it clear that this notion is what he is discussing in three celebrated passages (*Physics* VII 5, VIII 10, *De caelo* I 7) where later critics have discerned laws of proportionality connecting the force applied, the weight moved, and the time required for the force to move the weight a given distance. (Two of the texts do not mention weight at all.) A second term, *ischus*, sometimes rendered "force" in these contexts, is the common word for "strength," and it is this familiar notion that Aristotle is exploiting in the so-called laws of forced motion set out in *Physics* VII 5 and presupposed in VIII 10: he is relying on what a nontechnical audience would at once grant him concerning the comparative strengths of packhorses or (his example) gangs of shiphaulers. He says let *A* be the strength required to move a weight *B* over a distance *D* in time *T*; then (1) A will move 1/2 *B* over 2*D* in *T*; (2) *A* will move 1/2 *B* over *D* in 1/2 *T*; (3) 1/2 *A* will move 1/2 *B* over *D* in *T*; and (4) *A* will move *B* over 1/2 *D* in 1/2 *T*; but (5) it does not follow that *A* will move some multiple of *B* over a proportionate fraction of *D* in *T* or indeed in any time, since it does not follow that *A* will be sufficient to move that multiple of *B* at all. The conjunction of (4) with the initial assumption shows that Aristotle takes the speed of motion in this case to be uniform; so commentators have naturally thought of *A* as a force whose continued application to *B* is just sufficient to overcome the opposing forces of gravity, friction, and the medium. In such circumstances propositions (3) and (4) will yield results equivalent to those of Newtonian dynamics. But then the circumstances described in (1) and (2) should yield not just the doubling of a uniform velocity which Aristotle supposes, but acceleration up to some appropriate terminal velocity. Others have proposed to treat *A* as prefiguring the later idea not of *force* but of *work*, or else power, if these are defined in terms of the displacement of weight and not of force; and this has the advantage of leaving Aristotle discussing the case that is central to his dynamics—the carrying out of some finite task in a finite time—without importing the notion of action at an instant which, for reasons we shall see, he rejects. But Aristotle also assumes that, for a given type of agent, A is multiplied in direct ratio to the size or quantity of the agent; and to apply this to the work done would be, once more, to overlook the difference between conditions of uniform motion and of acceleration. The fact is that Aristotle is appealing to conventional ways of comparing the strength of haulers and beasts of burden, and for his purposes the acceleration periods involved with these are negligible. What matters is that we measure strength by the ability to perform certain finite tasks before fatigue sets in; hence, when Aristotle adduces these proportionalities in the *Physics*, he does so with a view to showing that the strength required for keeping the sky turning for all time would be immeasurable. Since such celestial revolutions do not in his view have to overcome any such resistance as that of gravity or a medium we are not entitled to read these notions into the formulae quoted. What then is the basis for these proportionalities? He does not quote empirical evidence in their support, and in their generalized form he could not do so; in the *Physics* and again in the *De caelo* he insists that they can be extended to cover "heating and any effect of one body on another," but the Greeks had no thermometer nor indeed any device (apart from the measurement of strings in harmonics) for

translating qualitative differences into quantitative measurements. Nor on the other hand does he present them as technical definitions of the concepts they introduce. He simply comments in the *Physics* that the rules of proportion require them to be true (and it may be noticed that he does not frame any of them as a function of more than two variables: the proportion is always a simple relation between two of the terms, the others remaining constant). He depends on this appeal, together with conventional ways of comparing strengths, to give him the steps he needs toward his conclusion about the strength of a prime mover; it is no part of the dialectic of his argument to coin hypotheses that require elaborate discussion in their own right.

It is part of the history of dynamics that, from Aristotle's immediate successors onward, these formulae were taken out of context, debated and refined, and finally jettisoned for an incomparably more exact and powerful set of concepts which owed little to dialectic in Aristotle's sense. That he did not intend his proportionalities for such close scrutiny becomes even clearer when we turn to his so-called laws of natural motion. Aristotle's universe is finite, spherical, and geocentric: outside it there can be no body nor even, therefore, any location or vacuum or time (*De caelo* I 9); within it there can be no vacuum (*Physics* IV 6–9). Natural motion is the unimpeded movement of its elements: centripetal or "downward" in the case of earth (whose place is at the center) and of water (whose place is next to earth), centrifugal or "upward" in the case of fire and (next below fire) air. These are the sublunary elements, capable of changing into each other (*De generatione et corruptione* II) and possessed of "heaviness" or "lightness" according as their natural motion is down or up. Above them all is the element whose existence Aristotle can prove only by a priori argument: ether, the substance of the spheres that carry the heavenly bodies. The natural motions of the first four elements are rectilinear and terminate, unless they are blocked, in the part of the universe that is the element's natural place; the motion of the fifth is circular and cannot be blocked, and it never leaves its natural place. These motions of free fall, free ascent, and free revolution are Aristotle's paradigms of regular movement, against which other motions can be seen as departures due to special agency or to the presence of more than one element in the moving body. On several occasions he sketches some proportional connection between the variables that occur in his analysis of such natural motions; generally he confines himself to rectilinear (i.e., sublunary) movement, as, for example, in *Physics* IV 8, the text that provoked a celebrated exchange between Simplicio and Salviati in Galileo's *Dialoghi*. There he writes: "We see a given weight of body moving faster than another for two reasons: either because of a difference in the medium traversed (e.g., water as against earth, water as against air), or, other things being equal, because of the greater weight or lightness of the moving body." Later he specifies that the proviso "other things being equal" is meant to cover identity of shape. Under the first heading, that of differences in the medium, he remarks that the motion of the medium must be taken into account as well as its density relative to others; but he is content to assume a static medium and propound, as always, a simple proportion in which the moving object's velocity varies inversely with the density of the medium. Two comments are relevant. First, in this as in almost all comparable contexts, the "laws of natural motion" are dispensable from the argument. Here Aristotle uses his proportionality to rebut the possibility of motion in a vacuum: such motion would encounter a medium of nil density and hence would have infinite velocity, which is impossible. But this is only one of several independent arguments for the same conclusion in the context. Next, the argument discounts acceleration (Aristotle does not consider the possibility of a body's speed in a vacuum remaining finite but increasing without limit, let alone that of its increasing to some finite terminal speed); yet he often insists that for the sublunary elements natural motion is always acceleration. (For this reason among others it is irrelevant to read his proportionalities of natural motion as an unwitting anticipation of Stokes's law.) But it was left to his successors during the next thousand years to quarrel over the way in which the ratios he formulated could be used to account for the steady acceleration he required in such natural motion; and where in the passage quoted he writes "we see," it was left to some nameless ancient scientist to make the experiment recorded by Philoponus and later by Galileo, of dropping different weights from the same height and noting that what we see does not answer to Aristotle's claim about their speed of descent. It was, to repeat, no part of the dialectic of his argument to give these proportionalities the rigor of scientific laws or present them as the record of exact observation.

On the other hand the existence of the natural motions themselves is basic to his cosmology. Plato had held that left to themselves, i.e., without divine governance, the four elements (he did not recognize a fifth) would move randomly in any direction: Aristotle denies this on behalf of the inherent regularity of the physical world. He makes the natural motions his "first hypotheses" in the *De caelo* and applies them over and again to the discussion of other problems. (The contrast between his carelessness over the proportionalities and the importance he attaches to the movements is sometimes read as showing that he wants to "eliminate mathematics from physics": but more on this later.)

This leads to a more general point which must be borne in mind in understanding his way of establishing physical theory. When he appeals to common views and usage in such contexts he is applying a favorite maxim, that in the search for explanations we must start from what is familiar of intelligible to us. (Once the science is set up, the deductions will proceed from principles "intelligible in themselves.") The same maxim governs his standard way of introducing concepts by extrapolating from some familiar, unpuzzling situation. Consider his distinction of "matter" and "form" in *Physics* I. He argues that any change implies a passage between two contrary attributes—from one to the other, or somewhere on a spectrum between the two—and that there must be a third thing to make this passage, a substrate which changes but survives the change. The situations to which he appeals are those from which this triadic analysis can be, so to speak, directly read off: a light object turning dark, an unmusical man becoming musical. But then the analysis is extended to cases progressively less amenable: he moves, via the detuning of an instrument and the shaping of a statue, to the birth of plants and animals and generally to the sort of situation that had exercised earlier thinkersthe emergence of a new individual, the apparent coming of something from nothing. (Not the emergence of a new *type*: Aristotle does not believe that new types emerge in nature, although he accepts the appearance of sports within or between existing types. In *Physics* II 8 he rejects a theory of evolution for putting the random occurrence of new types on the same footing with the reproduction of existing species, arguing that a theory that is not based on such regularities is not scientific physics.) *Ex nihilo nihil fit*; and even the emergence of a new individual must involve a substrate, "matter," which passes between two contrary conditions, the "privation" and the "form." But one effect of

Aristotle's extrapolation is to force a major conflict between his theories and most contemporary and subsequent physics. In his view, the question "What are the essential attributes of matter?" must go unanswered. There is no general answer, for the distinction between form and matter reappears on many levels: what serves as matter to a higher form may itself be analyzed into form and matter, as a brick which is material for a house can itself be analyzed into a shape and the clay on which the shape is imposed. More important, there is no answer even when the analysis reaches the basic elements—earth, air, fire, and water. For these can be transformed into each other, and since no change can be intelligibly pictured as a mere succession of discrete objects these too must be transformations of some residual subject, but one that now ex hypothesi has no permanent qualitative of quantitative determinations in its own right. Thus Aristotle rejects all theories that explain physical change by the rearrangement of some basic stuff of stuffs endowed with fixed characteristics. Atomism in particular he rebuts at length, arguing that movement in a vacuum is impossible (we have seen one argument for this) and that the concept of an extended indivisible body is mathematically indefensible. But although matter is not required to identify itself by any permanent first-order characteristics, it does have important second-order properties. Physics studies the regularities in change, and for a given sort of thing at a given level it is the matter that determines what kinds of change are open to it. In some respects the idea has more in common with the field theory that appears embryonically in the Stoics than with the crude atomism maintained by the Epicureans, but its chief influence was on metaphysics (especially Neoplatonism)rather than on scientific theory. By contrast, the correlative concept of *form*, the universal element in things that allows them to be known and classified and defined, remained powerful in science. Aristotle took it from Plato, but by way of a radical and very early critique of Plato's Ideas; for Aristotle the formal element is inseparable from the things classified, whereas Plato had promoted it to independent existence in a transcendent world contemplated by disembodied souls. For Aristotle the physical world is all; its members with their qualities and quantities and interrelations are the paradigms of reality and there are no disembodied souls.

The device of extrapolating from the familiar is evident again in his account of another of his four types of "cause," of explanation, viz. the "final," or teleological. In *Physics* II 8 he mentions some central examples of purposive activity—housebuilding, doctoring, writing—and then by stages moves on to discerning, comparable purposiveness in the behavior of spiders and ants, the growth of roots and leaves, the arrangement of the teeth. Again the process is one of weakening or discarding some of the conditions inherent in the original situations: the idea of purposiveness sheds its connection with those of having a skill and thinking out steps to an end (although Aristotle hopes to have it both ways, by representing natural sports and monsters as *mistakes*). The resultant "immanent teleology" moved his follower Theophrastus to protest at its thinness and facility, but its effectiveness as a heuristic device, particularly in biology, is beyond dispute.

It is worth noting that this tendency of Aristotle's to set out from some familiar situation, or rather from the most familiar and unpuzzling ways of describing such a situation, is something more than the general inclination of scientists to depend on "explanatory paradigms." Such paradigms in later science (e.g., classical mechanics) have commonly been limiting cases not encountered in common observation or discourse; Aristotle's choice of the familiar is a matter of dialectical method, presystematic by contrast with the finished science, but subject to rules of discussion which he was the first to codify. This, and not (as we shall see) any attempt to extrude mathematics from physics, is what separates his extant work in the field from the most characteristic achievements of the last four centuries. It had large consequences for dynamics. In replying to Zeno's paradox of the flying arrow he concedes Zeno's claim that nothing can be said to be moving at an instant, and insists only that it cannot be said to be stationary either. What preoccupies him is the requirement, embedded in common discourse, that any movement must take a certain time to cover a certain distance (and, as a corollary, that any stability must take a certain time but cover no distance); so he discounts even those hints that common discourse might have afforded of the derivative idea of motion, and therefore of velocity, at an instant. He has of course no such notion of a mathematical limit as the analysis of such cases requires, but in any event this notion came later than the recognition of the cases. It is illuminating to contrast the treatment of motion in the *Mechanica*, a work which used to carry Aristotle's name but which must be at least a generation later. There (*Mechanica* 1) circular motion is resolved into two components, one tangential and one centripetal (contrast Aristotle's refusal to assimilate circular and rectilinear movements, notably in *Physics* VII 4). And the remarkable suggestion is made that the proportion between these components need not be maintained for any time at all, since otherwise the motion would be in a straight line. Earlier the idea had been introduced of a point having motion and velocity, an idea that we shall find Aristotle using although his dialectical analysis of movement and location disallows it; here that idea is supplemented by the concept of a point having a given motion or complex of motions at an instant and not for any period, however small. The Mechanica is generally agreed to be a constructive development of hints and suggestions in Aristotle's writings; but the methods and purposes evident in his own discussions of motion inhibit him from such novel constructions in dynamics.

It is quite another thing to say, as is often said, that Aristotle wants to debar physics from any substantial use of the abstract proofs and constructions available to him in contemporary mathematics. It is a common fallacy that, whereas Plato had tried to make physics mathematical and quantitative, Aristotle aimed at keeping it qualitative.

*Mathematics and Physics*. Plato had tried to construct the physical world of two-dimensional and apparently weightless triangles. When Aristotle argues against this in the *De caelo* (III7) he observes; "The principles of perceptible things must be perceptible, of eternal things eternal, of perishable things perishable: in sum, the principles must be homogeneous with the subject-matter." These words, taken together with his prescriptions for the autonomy of sciences in the *Analytics*, are often quoted to show that any use of mathematical constructions in his physics must be adventitious or presystematic, dispensable from the science proper. The province of physics is the class of natural bodies regarded as having weight (or "lightness," in the case of air and fire), heat, and color and an innate tendency to move in a certain way. But these are properties that mathematics expressly excludes from its purview (*Metaphysics* K 3).

In fact, however, the division of sciences is not so absolute. When Aristotle contrasts mathematics and physics in *Physics* II he remarks that astronomy, which is one of the "more physical of the mathematical sciences," must be part of physics, since it would be absurd to debar the physicist from discussing the geometrical properties of the heavenly bodies. The distinction is that the physicist must, as the mathematician does not, treat these properties as the attributes of physical bodies that they are; i.e., he must be prepared to explain the application of his model. Given this tie-line a good deal of mathematical abstraction is evidently permissible. Aristotle holds that only extended bodies can strictly be said to have a location (i.e., to lie within a static perimeter) or to move, but he is often prepared to discount the extension of bodies. Thus in *Physics* IV 11, where he shows an isomorphic correspondence between continua representing time, motion, and the path traversed by the moving body, he correlates the moving object with points in time and space and for this purpose calls it "a point—or stone, or any such thing." In *Physics* V 4, he similarly argues from the motion of an unextended object, although it is to be noticed that he does not here or anywhere ease the transition from moving bodies to moving points by importing the idea of a center of gravity, which was to play so large a part in Archimedes' *Equilibrium of Planes*. In his meteorology, explaining the shape of halos and rainbows, he treats the luminary as a point source of light. In the biological works he often recurs to the question of the number of points at which a given type of animal moves; these "points" are in fact the major joints, but in *De motu animalium* 1 he makes it clear that he has a geometrical model in mind and is careful to explain what supplementary assumptions are necessary to adapting this model to the actual situation it illustrates. In the cosmology of the *De caelo* he similarly makes use of unextended loci, in contrast to his formal account of any location as a perimeter enclosing a volume. Like Archimedes a century later, he represents the center of the universe as a point when he proves that the surface of water is spherical, and again when he argues that earth moves so as to make its own (geometrical) center ultimately coincide with that of the universe. His attempt in *De caelo* IV 3 to interpret this in terms of perimeter locations is correct by his own principles, but confused.

This readiness to import abstract mathematical arguments and constructions into his account of the physical world is one side of the coin whose other face is his insistence that any mathematics must be directly applicable to the world. Thus, after arguing (partly on dialectical grounds, partly from his hypothesis of natural movements and natural places) that the universe must be finite in size, he adds that this does not put the mathematicians out of business, since they do not need or use the notion of a line infinite in extension: what they require is only the possibility of producing a line *n* in any required ratio with a given line *m*, and however large the ratio *n/m* it can always be physically exemplified for a suitable interpretation of *m*. The explanation holds good for such lemmata as that applied in Eudoxus' method of exhaustion, but not of some proportionalities he himself adduces earlier in the same context or in *De caelo* I. (These proportionalities are indeed used in, but they are not the subject of, *reductio ad absurdum* arguments. In the De caelo Aristotle even assumes that an infinite rotating body would contain a point at an infinite distance from its center and consequently moving at infinite speed.) The same concern to make mathematics applicable to the physical world without postulating an actual infinite is evident in his treatment of the sequence of natural numbers. The infinity characteristic of the sequence, and generally of any countable series whose members can be correlated with the series of numbers, consists just in the possibility of specifying a successor to any member of the sequence; "the infinite is that of which, as it is counted or measured off, it is always possible to take some part outside that already taken." This is true not only of the number series but of the parts produced by dividing any magnitude in a constant ratio; and since all physical bodies are in principle so divisible, the number series is assured of a physical application without requiring the existence at any time of an actually infinite set of objects: all that is required is the possibility of following any division with a subdivision.

This positivistic approach is often evident in Aristotle's work (e.g., in his analysis of the location of *A* as the inner static boundary of the body surrounding *A*), and it is closely connected with his method of building explanations on the familiar case. But here too Aristotle moves beyond the familiar case. when he argues that infinite divisibility is characteristic of bodies below the level of observation. His defense and exploration of such divisibility, as a defining characteristic of bodies and times and motions, is found in *Physics* VI, a book often saluted as his most original contribution to the analysis of the continuum. Yet it is worth noticing that in this book as in its two predecessors Aristotle's problems and the ideas he applies to their solution are over and again taken, with improvements, from the second part of *Plato's Parmenides*. The discussion is in that tradition of logical debate which Aristotle, like Plato, called "dialectic," and its problems are not those of accommodating theories to experimntally established facts (or vice versa) but logical puzzles generated by common discourse and conviction. (But then Aristotle thinks of common discourse and conviction as a repository of human experience.) So the argument illustrates Aristotle's anti-Platonic thesis that mathematics—represented again in this case by simple proportion theory—has standing as a science only to the extent that it can be directly applied to the description of physical phenomena. But the argument is no more framed as an advance in the mathematical theory itself than as a contribution to the observational data of physics.

Probably the best-known instance of an essentially mathematical construction incorporated into Aristotle's physics is the astronomical theory due to Eudoxus and improved by Callippus. In this theory the apparent motion of the "fixed stars" is represented by the rotation of one sphere about its diameter, while those of the sun, moon, and the five known planets are represented each by a different nest of concentric spheres. In such a nest the first sphere carries round a second whose poles are located on the first but with an axis inclined to that of the first; this second, rotating in turn about its poles, carries a third similarly connected to it, and so on in some cases to a fourth or (in Callippus' version) a fifth, the apparent motion of the heavenly body being the resultant motion of a point on the equator of the last sphere. To this set of abstract models, itself one of the five or six major advances in science, Aristotle makes additions of which the most important is the attempt to unify the separate nests of spheres into one connected physical system. To this end he intercalates reagent spheres designed to insulate the movement of each celestial body from the complex of motions propelling the body next above it. The only motion left uncanceled in this downward transmission is the rotation of the star sphere. It is generally agreed that Aristotle in *Metaphysics* XII 8 miscalculates the resulting number of agent and reagent spheres: he concludes that we need either fifty-five or forty-seven, the difference apparently representing one disagreement between the theories of Eudoxus and Callippus, but on the

latest computation (that of Hanson) the figures should be sixty-six and forty-nine. The mistake had no effect on the progress of astronomy: within a century astronomers had turned to a theory involving epicycles, and Aristotle's physical structure of concentric nonoverlapping spheres was superseded. On the other hand his basic picture of the geocentric universe and its elements, once freed from the special constructions he borrowed and adapted from Eudoxus, retained its authority and can be seen again in the introductory chapters of Ptolemy's Syntaxis.

*Conclusion*. These arguments and theories in what came to be called the exact sciences are drawn principally from the *Posterior Analytics, Topics, Physics, De caelo* and *De generatione*, works that are generally accepted as early and of which the first four at least probably date substantially from Aristotle's years in the Academy or soon after. The influence of the Academy is strong on them. They are marked by a large respect for mathematics and particularly for the techniques and effects of axiomatizing that subject, but they do not pretend to any mathematical discoveries, and in this they are close in spirit to Plato's writings. Even the preoccupation with physical change, its varieties and regularities and causes, and the use of dialectic in analyzing these, is a position to which Plato had been approaching in his later years. Aristotle the meticulous empiricist, amassing biological data or compiling the constitutions of 158 Greek states, is not yet in evidence. In these works the analyses neither start from nor are closely controlled by fresh inspections of the physical world. Nor is he liable to think his analyses endangered by such inspections: if his account of motion shows that any "forced" or "unnatural" movement requires an agent of motion in constant touch with the moving body, the movement of a projectile can be explained by inventing a set of unseen agents to fill the gap—successive stages of the medium itself, supposed to be capable of transmitting movement even after the initial agency has ceased acting. In all the illustrative examples cited in these works there is nothing comparable to even the half—controlled experiments in atomistic physics and harmonics of the following centuries. His main concerns were the methodology of the sciences, which he was the first to separate adequately on grounds of field and method; and the meticulous derivation of the technical equipment of these sciences from the common language and assumptions of men about the world they live in. His influence on science stemmed from an incomparable cleverness and sensitiveness to counterarguments, rather than from any breakthrough comparable to those of Eudoxus or Archimedes.

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# Aristotle: Natural History and Zoology

Complete Dictionary of Scientific Biography


It is not clear when Aristotle wrote his zoology, or how much of his natural history was his own work. This is unfortunate, for it might help us to interpret his philosophy if we knew whether he began theorizing in biology before or after his main philosophical formulations, and how many zoological specimens he himself collected and identified. Some believe that he began in youth, and that his theory of potentiality was directed originally at the problem of growth. Others (especially Jaeger) hold that his interest in factual research came late in life and that he turned to biology after founding the Lyceum. Most probably, however, it was in middle life, in the years 344–342 b.c., when he was living on Lesbos with Theophrastus; many of his data are reported from places in that area. This would imply that he wrote the zoology with his philosophical framework already established, and on the whole the internal evidence of the treatises bears this out. It follows that in order to understand his zoological theory, we must keep his philosophy in mind. Yet it may also be true that in thinking out his philosophy, he was conscious of biological problems in a general way.

The zoological treatises must represent many years' work, for they make up a fourth of the whole corpus, and both data and discussion are concisely presented. They owe little to Herodotus, Ctesias, Xenophon, or other extant literature; their possible debs to Democritus cannot be assessed, however, because his three zoological books are lost. Comparing the quality of Aristotle's data with previous writings, we must conclude that he sifted and rejected a great deal; even by modern standards of natural history his reports are cautious. The chief collection of data is the *Historia animalium*. Out of 560 species mentioned in all his zoology, 400 appear only in this work and only five are not included. The treatises, as we now have them, form a course of instruction in which the *Historia* is referred to as the descriptive textbook, intended to be studied first and then kept at hand. Internal evidence suggests, however, that it was in fact written after the others, and that most of it was not written by Aristotle himself. This implies that he wrote the theoretical treatises before the main collection of data. Not that the treatises lack supporting data, but most of the information was common knowledge, whereas the reports that read like new, firsthand observation are nearly all confined to the later parts of the *Historia*.

Biological data were normally quoted in cosmological arguments, not least in the Academy. The Academicians' interest was not so much in the animals for their own sake, but rather in using them as evidence for—and giving them a place within—a rational cosmology. There were two issues: to identify the formal groups of animals, and thus to classify them, and to explain their functioning as part of nature. Plato and Speusippus opposed the materialism of those like Democritus, whose lost books, entitled *Causes Concerning Animals*, were probably intended to explain biology in terms of atomism. Aristotle would have been familiar with these discussions since his youth, and his writings follow this essentially etiological approach. His earliest zoology is probably in the *De partibus animalium*, the *De incessu animalium*, and the *Parva naturalia* (all of which in their present form show signs of revision and editing), in which he sets out the"causes" of tissues and structures, and of such significant functions as locomotion, respiration, aging, and death. Here the a priori element in his theory appears strongly: for example, right is superior to left, and hence the right-hand side is the natural side to lead off with; organs properly exist in pairs, and hence the spleen (for which he found no function) exists as the partner of the liver. On the other hand, the teleological explanation, which is the main theme of *De partibus animalium*, is argued in a mature fashion with evidential support. This scientific maturity is even clearer in the next great treatise, *De generatione animalium*, in which he applies his concepts of form and matter, actuality and potentiality, to the problems of reproduction, inheritance, and growth of such inessential characters as color. On the question of classification he remains tentative and critical, as we would expect of one who rejected Plato's theory of Forms. He often returns to the problem in both early and late writings, but states no clear position.

His teleology differs from others. He argues it in *De partibus* I on the same grounds as in *Physics* B, where he states more of his opponents' case. He makes it clear that the "natural philosophers" (Empedocles, Anaxagoras, Democritus) were combating a popular teleology which presented the gods as purposive powers intervening in nature, so that "rain falls in order to make the crops grow." Against it they had argued that the "necessity" of natural causes was sufficient to explain events and that the crops happened to grow because the rain happened to fall, the real cause being the automatic interactions of the hot, the cold, and the other elements. In reply, Plato had posited a world soul and a creative "Demiurge." Aristotle, however, does not invoke a supernatural agency (for the relation between the cosmos and the Unmoved Mover is different), nor does he present nature as

a quasi-conscious entity capable of purpose: his personification of nature "who does nothing in vain" is no more than a rhetorical abbreviation for "each natural substance." Neither does he posit an extra factor in nature, as modern teleologists posit a *conatus* that is not reducible to physics.

The directiveness that Aristotle sees in nature is part of the natural interactions, so that the teleological explanation coexists with the causal explanation. But he bases the teleology not primarily on directiveness but on the existence of forms. To explain an organ, he says, we must first grasp the complete animal's form and functions, what it means to be that animal, its *ousia*. Our explanation will include both the "necessary" causes and the "end" toward which development tends. This is not the temporal end or a state of equilibrium between phases of activity; indeed, it may never be reached. It is the perfect condition of the whole animal, "for the sake of which" each part develops. Thus, Empedocles was wrong to suppose that the spine is vertebrated because it gets bent: on the contrary, vertebration is necessary to the animal's functioning, and was contained potentially in the parent's seed before the embryo's vertebrae were formed. He was also wrong to think that random necessity could be a primary cause, for it could not produce the general regularity of nature, let alone the absolute regularity of the stars. Necessity in nature is secondary, or, as Aristotle calls it, "hypothetical": on the hypothesis that an animal is coming into existence, certain materials must interact, but these materials do not of themselves produce the animal any more than bricks produce a house. As the house needs a builder and a plan, the animal needs a soul and a form—factors ignored by the materialists. But whereas builder and plan are separate, soul and form are identical. The final cause of the animal is the actualization of its form, and its primary efficient cause is its soul, which "uses" the necessary movements of the materials. Aristotle's teleology therefore rests upon his theory of substantial form. The definition of a substance is logically prior to the definition of its parts, and so the final cause is prior to the necessary cause. It is prior temporally as well as logically, for Aristotle believed that the world never began—so that hen has forever preceded egg.

Although he used Plato's language ("existence is prior to coming-into-existence" and necessity is "the concomitant cause"), Aristotle did not follow Plato in positing an overall teleology or in the dualism that the *Timaeus* set up between creator and material. The few passages where Aristotle seems to imply that some species exist for the sake of man, or act for the general good as opposed to their own, cannot be meant literally. What he probably meant was a balance of nature, in which species are interdependent. The final cause of each animal is its own complete state, and nothing more. And instead of Plato's dualism, Aristotle places finality within natural interactions, not as something imposed upon them.

Within sublunary nature there are continual fresh beginnings of movement for which there are no sufficient external causes. They may be stimulated from outside, but the source of the movements in plants and animals is their souls. Only in a general way is the Unmoved Mover the prime cause. As a final and formal cause it presents the perfection that lesser beings desire to imitate. It can therefore be argued, although it is never clearly stated by Aristotle, that nature's tendency toward actualization and the *orexis* within souls are ultimately oriented toward the Unmoved Mover's perfection. As an efficient cause, the Unmoved Mover promotes general growth and decay on earth because it elicits the sun's movements in the ecliptic, and these movements cause the alternation of summer and winter. These general causes, however, do not bring about the particular starts of motion in nature. Nor, again, are souls regarded as separable entities that inhabit bodies and direct them, as Plato thought and as Aristotle may once have thought but later rejected. In his mature view, found in his biology as well as in the *Metaphysics* and *De anima*, the soul (except, possibly, for the intellect) is not an independent substance but is the form of the body. On the other hand, it is not merely a resultant form, as in the "harmonia" theory, which Aristotle refuted; rather, it is both form and source of action. In plants it causes growth and reproduction; in animals it also causes sensation (here he differs from Plato, who thought that plants had sensation); in man the soul has a third faculty, intellect, and this is its only faculty that is not the form of body and could therefore be separable.

The concept of soul as both form and efficient cause may reflect a trace of ancient hylozoism. In Aristotle's view, finality pervades nature. If there is a cosmos, this implies that the elements not only have simple motions but also combine with modified motions. Both the simple motions and their modifications are hypothetically necessary and are natural. An animal contains many motions, all natural, that by a natural coordination tend toward a specific pattern. Its soul is both the tendency and the pattern. In nonliving substances, which have no soul, the tendency to form complexes is in their nature. Aristotle accepts as his data both the observable materials and the observable forms and species; therefore the movement of nature is simultaneously necessitated and endlike.

According to the *Metaphysics*, the form toward which animals grow is their species: individual differences arise from matter and consequently are unknowable to science. In Aristotle's earlier zoology we cannot tell whether he maintains this strict view, but in *De generatione animalium* his theory of reproduction implies that individuals differ in form to some extent. He does not say so, but repeats the doctrine of *De generatione et corruptione* that sublunary beings, which cannot achieve eternity as individuals, instead achieve it as species by reproduction. Nevertheless, Aristotle's discussion is in fact about an individual's reproduction of another animal "like itself." He starts from the long-standing controversy about the origin of seed. Do both male and female contribute seed? From what part or parts of the body does it come, and what does it contain? He analyzes the problem in terms of form and matter. The male alone makes seed from his blood; it contains potentially the sensitive soul and the adult form, but actually it contains no bodily parts (here he ridicules preformism and pangenesis). The female contributes only material (*the catamenia*), whose form is nutritive soul. When the male's form has been imposed upon the female material, the somatic part of the seed is sloughed away: all that is transmitted is soul, the source of form and motion. If the fetus develops regularly, the father's form will be actualized; failing that, the mother's failing that again, more distant ancestors successively, until eventually the form may be merely that of the species, or even just the genus *Animal* (that is, a monstrous brith).

This long and careful argument, which is supported by observed evidence, gives a brilliant impression of maturity and originality, and in several points goes beyond the biological arguments that we occasionally find in the philosophical works. Aristotle's view that the father's form is reproduced, as distinct from the species, can only mean that some individual differences are formal and apodictic. He also brings to scientific account other differences due to "necessity"—not only monstrous births but differences of coloration, voice, or sharpness of senses. Since he calls them "concomitants" arising from irregularities in the material, he may have regarded them as unpredictable, but they seem to be accountable after the event. He now argues not from the fixity of species but from the reproduction of forms. True, he does not contemplate the obsolescence or alteration of existing species (for he had no paleontology); but he does accept, within limits, the evidence for miscegenation's resulting in new forms. In fact, the emphasis on species becomes less, while the concept of necessity as hypothetical becomes more important and sophisticated than in the philosophical works, where necessity is either "simple" (axiomatic) or brute (material). The one exception among the biological works is the *Historia animalium*, from which the teleological explanation is absent. Although a discussion of causes is not to be expected here, nevertheless the account of characters and life histories involves some causal explanation; and it is noteworthy that this explanation is given only in material terms. No doubt this is because the Historia was mainly the work of Aristotle's successors, among whom Theophrastus ignores the final cause even in his *Causes of Plants*.

In explaining the "necessary" causes—the interaction of materials—Aristotle does not innovate so much as rationalize theories that were already current. He accepts from Plato's *Timaeus* the four elements—fire, air water, and earth—that were common to the medical writers and can be traced back through Empedocles into popular tradition. But the tradition had confused two notions: the cosmic regions of fire, air, water, and earth, and the seasonal powers of hot, cold, wet, and dry. The two sets do not exactly match, as is obvious in the ambiguous reports of Empedocles. Aristotle systematizes them by means of a formula that survived through the Middle Ages, treating fire, air, water, and earth as combinations of hot, cold, wet, and dry: fire is hot plus dry, air is hot plus wet, and so on. In his system hot, cold, wet, and dry are the primitive qualities of matter, but cannot exist in isolation. Fire, air, water, and earth are the simplest separable bodies, and are transformable into each other.

Like his predecessors, Aristotle regards the hot as the chief active power; its characteristic action is *pepsis* ("concoction"), which transforms food into blood and blood into flesh. By its opposite, the cold, he sometimes means merely the absence of hot, but more often a power in itself. The hot means more than temperature, which he calls "the hot according to touch." Another sort of hot is that possessed by pine wood, which is not hotter to the touch than other timber but contains more heat and therefore burns better. Animals have an innate heat upon which life depends. Their droppings still contain some of it, which generates flies. While the hot is the soul's chief agent in bringing about growth, cold is also needed to solidify things. Life the medical writers, Aristotle attaches importance to the due mingling (*krasis*) of hot and cold, which does not mean a point on a temperature scale but a mixture of two powers. He follows them in extending this notion to a general "right proportion" (*symmetria*) necessary for growth and health.

The other elements—the wet or watery, and the dry or earthy—are needed to provide the fluid and the solid parts of plants and animals. Whether Aristotle really intended a fifth element, *pneuma*, is debatable. The notion was current, and soon after him it became the chief element for the Pneumatic school of medicine and the Stoics. Aristotle had his own fifth substance in the outer heaven, the *aither*, and in *De generatione animalium* he compares it with the bodily *pneuma: pneuma* is the material of the animal seed, and conveys soul and the generative warmth, which he says is different from other heat. Yet he defines *pneuma* merely as warmed air, and since warmth has various powers for him, it is probable that he means no more. So he explains spontaneous generation by the presence of a warm soul-source in the materials.

The four elements combine to form the tissues, which Aristotle calls "made of like parts" (as flesh is divisible into flesh); and the tissues form the organs, which are "made of unlike parts" (hand is not divisible into hands). Taking this distinction from Plato, he uses it in finding homologies, but he makes only general statements about the processes. The hot concocts blood into flesh here, fat there, marrow or seed somewhere else; skin, hair, bone, nails, and horn all come from the earthy. He does not explain how. Medical literature of the time contains some practical investigations, such as the action of heat upon blood, and Aristotle occasionally refers to such evidence. In *Meteorologica* IV he goes further and analyzes the actions of hot and cold into evaporating, emulsifying, dissolving, condensing, and coagulating, and differentiates many types of earthy material. But this is a late work, and may not even be his. It seems, therefore, that in his biology Aristotle is content to take these theories in a general form from current tradition, although he is careful to rationalize them. For example, he will not allow Empedocles to say that spontaneous generation results from rottenness: new life comes not from disintegration but from concoction. The heart—not the brain, as many held—is the center of sensation and of the soul's motor impulses; as the first part to develop (observed in daily openings of a clutch of eggs), it is the source of the vital heat and innate *pnecana*. In it the blood is pneumatized and then flows out to nourish the tissues. (The distinction between arteries and veins is post-Aristotelian.) The lungs admit air to replenish the *pneuma* and to moderate the heat, an excess of which brings on senescence and death. Animals without lungs are cooled by the surrounding air or water: this suffices because they are "less perfect" and therefore cooler; also, their innate store of *pneuma* is sufficient.

Classification of animals remained a difficulty, and Aristotle suggested a solution by taking an animal's vital heat as an index of its superiority. Plato had proposed *diaeresis* (division), in which a major group is progressively divided by differentiae into genera and species. This method, used by Aristotle in his early logic and later by his successors, became the basis of Linnaean systematics. In his zoology, however, Aristotle criticizes it for splitting natural groups. He shows how groupings based on habitat and locomotion, and such characters as horns and rumination, cut across each other, while many animals belong to both sides of a formal division. He also criticizes the emphasis on morphology, which he holds subordinate to function. He prefers

to start from the natural genus, as defined by multiple characters, then to arrange it with other types, not in a genus-species hierarchy but in a *scala naturae* ranging from man through less perfect animals down through plants to lifeless compounds. In this he emphasizes the continuity of nature and the many borderline or overlapping types, such as the seal, the bat, and the testaceans. The degree of vital heat is indicated by method of reproduction, state at birth, respiration, posture, and other signs. But he does not produce an actual scheme, nor does he finally reject genus-species classification. For practical purposes Aristotle discusses the animals by major groups: the "blooded" (i.e., red-blooded)—man, viviparous quadrupeds, oviparous quadrupeds, cetaceans, fishes, birds; and the "bloodless"—mollusks, crustaceans, testaceans, and insects. But he points out that even these groups exclude many types, such as snakes and sponges. In fact, before any classification could succeed, far more information was needed. He may have felt this, for the *Historia animalium* was begun as a comparative study of characters, arranged under the headings *parts, activities, lives, dispositions* (i.e., psychology). Major groups were to be compared by "analogy" (as wing to fin), while within a group each structure would vary by "the more and the less" (as wings are longer or shorter).

This project, however, was not carried through; instead, the treatise became a running collection of data. As new information came in and new significant characteristics were distinguished, they were inserted at convenient places, as if into a filing cabinet. Book I gives a program of the characters to be discussed, and by comparing this with the later books, we can see that many of those proposed are never mentioned again while many more new characters come to be recognized, so much so that the whole plan of the treatise is altered. The latest additions, which can be identified in all books from the second onward, consist of dossiers or even complete descriptions of single animals, no doubt awaiting breakdown under appropriate character headings. Thus the work eventually begins to approximate a descriptive zoology, and this is how it has been taken ever since. But in judging Aristotle as a natural historian, we should remember that we are judging him as something that he never set out to be. Although the classificatory intention of the *Historia animalium* came to nothing, it remained essentially an analysis of differentiae, the ways in which animals "are like to and different from each other," in the words of the introduction. The data about animals are put there to illustrate characteristic differences, and except in the late and unassimilated additions there is no description of an animal for its own sake. The statements about a given animal are spread through the nine books of the treatise, which is arranged not by animals but by characters. It has repeated signposts helping the reader to find his way among characters, but there are none to help him find animals, and there is no index. Some animals are cited frequently to illustrate but one point-for example, the mole's blindness: Aristotle obviously examined the mole, for he describes a dissection of its concealed eyes, which is of great interest; but this is all he tells us of the mole. In fact, like all his treatises, the *Historia animalium* is a theoretical study. It is not so much about animals as about *Animal*—and the various ways it is differentiated in nature.

Aristotle names about 500 "kinds" of animals. Some of these comprise several varieties, which his reports sometimes distinguish but sometimes confuse. Altogether, between 550 and 600 species can be distinguished, and of these as many as 200 are mentioned in connection with only one character. He includes some thirty from such distant places as Libya, Ethiopia, the Red Sea, and even India. A very few are taken from travelers' tales, especially from Herodotus and Ctesias, and of these some are fabulous—for example, the flying snake and the martichoras, or manticore (a monster, perhaps derived from a garbled account of the Indian tiger, which became a favorite of the Middle Ages), of which he plainly indicates his suspicion. But most were to be seen in Greece in menageries and shows—certainly the bear, monkeys and apes, elephant, camel, and lion. Aristotle gives much information about all of these, for the very reason that they exhibited interesting differences. Some information is evidently hearsay: for example, he reports that the lion has no cervical vertebrae, which shows that he never examined a dead lion. But his remarks about the lion's appearance and gait show equally that he observed it in life. He describes the elephant's leg joints in order to contradict a popular belief that it sleeps standing against a tree.

However, the great majority of Aristotle's reports concern animals native to Greece, its islands, and the Greek colonies in Asia Minor. It is incorrect to accuse him of showing more interest in exotics than in what was at his own doorstep. If we compare the variety of information given on each animal, we find not only that the nearest animals are the most fully reported but also that he covers most of what was available to him. Among mammals, of which he mentions some eighty, by far the most information is given about the horse, dog, sheep, ox, and pig; next comes a group including the goat, donkey, mule, hare, deer, elephant, bear, camel, seal, and dolphin. Of 180 birds mentioned, the best-reported are the domestic fowl, the pigeons, and the partridge, and there is a good deal on the sparrow, swallow, blackbird, crows, larks, eagles, hawks, quail, and stork. On the other hand, over 100 birds are mentioned only once or twice, as examples of differences in feeding or nesting, and so on. The information on marine animals is especially good, although out of 130 fishes only twenty are cited in connection with more than a very few characters. Among over eighty insects, he gives considerable information about the flies, ants, wasps, and cicadas, and three long, separate discussions of the honeybee; there is a fair amount about the grasshoppers, gadflies, spiders, beetles, and chafers. It is true that he has relatively little on the gnats and mosquitoes, common though they were; but he reports their external structures, reproduction from larvae, feeding, and habitat—and there is, after all, little more that he could know, having no optical apparatus. Aristotle often complains that the smallness of some insects makes it impossible to discern their structures, especially the internal ones. Many features, in all groups of animals, are reported in a generalized form—"all two-winged insects have a proboscis and no rearward sting," "all fishes except selachians have gill covers"—so that if one is to assess what he knew about a given animal, these general statements have to be broken down and included. In some of them he generalizes further than the facts warrant, through faulty or deficient information.

The tests that Aristotle applies to reports are primarily observational checks, made either on the same type of animal or on "analogous" types. He shows himself well aware of the need for repeated observations, but he has not developed the refined technique of provoked and controlled observations that later (very much later) scientists learned to demand. Where observational checks are not available, he tests by inherent probability—that is, by reference to theory. The accusation that he

relies on a priori argument, and not on observation, is not well founded; on the contrary, like most Greek philosophers, with the exception of Plato, he is overready to accept uncontrolled observation and to jump to large conclusions.

His chief sources of information are fishermen, farmers, stockbreeders, and hunters; to a lesser extent travelers, menageries, augurs, and drug manufacturers; and he owes a very little to such previous writers as Herodotus, Ctesias, Xenophon, Empedocles, and Democritus. There are many faulty reports that he corrects from observation. His favorite method is the counterinstance. He refutes that the viper does not slough its skin simply by describing an observation of the sloughing. The legend that the hyena has the genitalia of both sexes (which in fact it can appear to have externally) is refuted by inspection and dissection, and here he indicates that many specimens were examined. Fishermen said that all mullets are generated spontaneously, but he has examples of mullets with eggs and with sperm (although he allows that one kind of mullet is spontaneous).

where such direct checks are not possible, he refers to analogous examples or to theory. He denies that the cuckoo is a metamorphosed hawk on the grounds that the hawk preys on the cuckoo, a thing never seen done by one bird to another of its own kind. Fishermen believed what Herodotus also said, that fishes are impregnated by swallowing the sperm; Aristotle denies this because there is no connection between stomach and uterus, and because fishes have been observed in coition—which, he remarks, is difficult to observe, and fishermen have missed it because they are not interested in acquiring knowledge. Here he has been misled by faulty observation that, unluckily, agreed with theory—a coincidence that accounts for many of the mistakes in his reports. He held that where there are separate male and female, there must be coition. He knew that the male fish sprinkles the eggs with sperm after spawning, but thought this an additional process of fertilization. Another famous example is the fishermen's report of hectocotylization—the extraordinary method by which a spermcarrying tentacle is inserted into the female's mantle cavity and then completely detached from the male (eventually proved true): Aristotle denies that the tentacle assists reproduction, because it is not connected with the body and the spermatic channel—he was wrong because his theory could not accommodate what is, after all, a surprising fact. But in another context he makes it clear that theory must always yield to reliable observation: after his long discussion of the reproduction of bees he makes a statement that fairly represents his own practice (*De generatione animalium* 760b27):

This, then, appears to be the method of reproduction of bees, according to theory together with the apparent facts. But the facts have not been satisfactorily ascertained, and if ever they are, then credence must be given to observation rather than to theory, and to theory only in so far as it agrees with what is observed.

Many of the reports, however, are from firsthand observation. He refers sometimes to "the dissections," evidently a collection of drawings and diagrams of internal organs; unfortunately nothing survives of them. Some of his data clearly come from deliberate dissection, while others come as clearly from casual observations in the kitchen or at augury. One of the best is a full-scale vivisection of a chameleon; and the internal organs of crabs, lobsters, cephalopods, and several fishes and birds are described from direct observation. Many of the exterior observations also presuppose a prolonged study. He speaks of lengthy investigations into the pairing of insects. He satisfies himself that birds produce wind eggs entirely in the absence of the cock. There are graphic accounts of courtship behavior, nest-building, and brood care. He records tests for sense perception in scallops, razor fish, and sponges. He watches the cuttlefish anchor itself to a rock by its two long arms when it is stormy. The detailing of structures in some crustaceans and shellfishes vividly suggests that the author is looking at the animal as he dictates. The sea urchin's mouth parts are still known as "Aristotle's lantern" from his description, and his statement that its eggs are larger at the full moon has only recently been confirmed for the Red Sea urchin. He is able to assert that two kinds of *Serranidae* are "always female" (they are in fact hermaphrodite). All such data require deliberate and patient observation. How much Aristotle himself did is not known, but it is clear enough that he caused reports to be collected and screened with great care.

The first main heading in the *Historia animalium* is "Parts of the Body." Aristotle methodically lists the external and internal structures, noting the significant differences between animal types. Through drawing an analogy between legs and fins, he holds that fishes are moved primarily by their fins; this error creates difficulties for his theory of locomotion, whereby the blooded animals are moved by two or four points and the bloodless by more than four. He classifies the forms of uterus by position: rearward and ventral in the viviparous quadrupeds, forward and dorsal in the birds and oviparous quadrupeds, rearward and dorsal in the oviparous fishes, and "in both ways" in the ovoviviparous fishes—that is, extending from a forward dorsal to a rearward ventral position, because they first produce eggs and then hatch them within the uterus. There are various mistakes, mostly concerning man (where dissection was impossible) or the rarer animals. He is prone to accept them when they fall in with theory, thus accepting that men have more sutures in the skull than women (possibly based on an unlucky observation of a female skull with sutures effaced in pregnancy), for it fits his theory that men need more heat regulation in the brain. He reports that if one blows down the windpipe, the air reaches the heart: again a faulty observation that agreed with theory (that the *pneuma* in the heart is replenished from the lungs). His account of the heart's three intercommunicating chambers, disastrous for later anatomy, was due to wrong observation in a difficult field, but it fell conveniently into his theory of the blood system.

Nevertheless, Aristotle is aware how easily observations can mislead. For example, he remarks that those who believed the lungs to be devoid of blood were misled by observing dissected animals from which the blood had escaped. Much of what he says of the lion is mistaken, as is his statement that the crocodile moves the upper jaw: in these cases external appearances have not been tested by inspection of the dead body. Some could have been better tested—for example, his reports of the incidence of the gall bladder are unreliable, probably because he trusted the augurs. But the great majority of data in this

section are accurate and shrewdly observed, especially the details of alimentary canal and reproductive organs, in which he took special theoretical interest.

Under "Lives and Activities" Aristotle compares differences in reproductive, feeding, migration, hibernation, and sloughing, and variations due to season, breeding, disease, age, and habitat. His theory of reproduction, applied to all groups of animals, is argued in *De generatione animalium;* the *Historia animalium* summarizes this and adds much more information about sexual behavior, breeding methods and seasons, gestation, incubation, and brood care. He distinguishes the viviparous quadrupeds theoretically by the degree of perfection in the young at birth, and he has many details of seal and dolphin as well as land animals. The next step down is to the ovoviviparous, such as the vipers, sharks, and dogfishes. In them he describes the egg;s development and its movement rearward to the position where the young are released within the uterus; in one dogfish (*Mustelus laevis*) he notes the placentoid structure, like that of mammals, which was not rediscovered until comparatively modern times. He mistakenly generalizes that all cartilaginous fishes are ovoviviparous. He divides the ovipara into those that lay perfected eggs (birds and quadrupeds) and those whose eggs develop after laying, requiring what he took to be a second fertilizing by the male. He describes minutely the development of the eggs of birds, fishes, cephalopods, and others by opening eggs at intervals during the whole incubation period. He records many special cases: for example, the way that *Syngnathus acus* carries its eggs in a pouch, which then splits to release them (although he does not observe that it is the male which carries them). The lowest mode of reproduction in his scale of "perfectedness" is spontaneous generation, which he attributes to all testaceans, many insects, the eel, and a few fishes. He describes the spawn of whelks, but judges it to be a budding-off comparable with that of plants, not a mass of eggs; otherwise, testaceans originate from various mixtures of mud and rotting substances, the type of animal being determined by the mixture. He considers that insects (except for one butterfly) produce grubs, not eggs, although one speaks of spiders' or bees' eggs, and so on, he says that what at first looks like an egg is really a motionless larva, on the (mistaken)grounds that the subsequent animal is formed out of the whole of it. The grubs of spiders, bees, cicadas, and others develop into the parental type, but those of flies and beetles do not develop further, and originate spontaneously from a variety of materials, which he lists. Gnats and mosquitoes do not even produce grubs, but themselves arise from grubs that are spontaneously generated. He describes many types of larval development through pupa to imago, including the change of the bloodworm into the gnat. His conclusion about the honeybee (which he says is a puzzle) is tentatively that the queen produces queens and workers, the workers produce the drones, and the drones produce nothing. His view here is not exactly parthenogenesis: he holds that bees contain both male and female principles, and therefore generate without coition.

The final section on "Characters," that is, animal psychology and intelligence, contains little imputation of motives: he records strictly the observed behavior. He compares animals in compatibility, rivalry, nesting and homemaking, and miscellaneous habits of defense and self-support. Among many, for example, he reports the nests made by the octopus and the wrasse, and the brood care by the male river catfish—recently rediscovered and named after him (*Parasilurus aristotelis*). He notes that the partridge makes two nests, on one of which the male sits; and his report that some partridges cackle and others whistle led to the discovery in 1962 that two populations (rock partridge and chukar) live side by side in Thrace. Among the honeybee's habits he seems to refer to the "dance language." The section is unfinished, and the treatise in its present form ends abruptly with a distinction between birds that take dust baths and those that take water baths.

The more complete descriptions, which have been inserted throughout the treatise and seem to be the latest additions, include those of the ape, chameleon, and wryneck, and extracts from Herodotus and Ctesias on the crocodile, hippopotamus, and martichoras. But most of the fabulous or unauthenticated reports are in a separate work called *Mirabilia*, where they were perhaps held awaiting corroboration: some of them—for example, the bison—are in both treatises. For entirely new animals, Aristotle no doubt required reliable eyewitnesses. But when it comes to details reportedof known animals, which is the subject matter of most of his reports, his first point of reference is the adult living animal in its natural environment. His standard of judgment is function rather than morphology, as he makes clear in *De partibus animalium*. The "analogies" that he seeks, and from which he constantly argues, are not structural but functional; and, wherever possible, his identification of differentiae is based on function. Because this is his aim in the *Historia*, he picks out the significant details better, for instance, than does Xenophon (whose excellent accounts of the hare and of horses provide the best contemporary comparison with Aristotle's reports). Its change of plan and lack of revision make the treatise seem incoherent and bewildering, but its comprehensiveness and acumen made it the outstanding descriptive zoology of ancient times, even though it was not intended to be primarily descriptive. It outlasted the work of such later encyclopedic compilers as Pliny, and combined with Aristotle's other zoological works it became—through the Arabic version translated into Latin by Michael Scot—the major ingredient in Albertus Magnus' *De anirnalibus*, which dominated the field until the sixteenth century.

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D. M. Balme



# Aristotle

Complete Dictionary of Scientific Biography


(*b*. Stagira in Chalcidice, 384 BCE; *d*. Chalcis, 322 BCE)

*theory of science*, *physics*, *cosmology*, *meteorology*, *psychology*, *biology*. For the original article on Aristotle see *DSB*, vol. 1.

The original *DSB* entry on Aristotle was penned by four notable scholars with different backgrounds and areas of expertise, who wrote autonomous essays on:

1. his scientific method, physics, and cosmology (G. E. L. Owen),
2. his natural history and zoology (David M. Balme),
3. his anatomy and physiology (Leonard G. Wilson), and
4. the Aristotelian tradition and its influence on the history of science (L. Minio-Paluello).

Since these entries were written, Aristotle's investigations of the natural world have been the object of a great deal of high-quality scholarship. One of the lessons of that scholarship, to which Balme was a major contributor, is that the above division of topics obscures more about Aristotle's natural science than it clarifies. The distinctions marked in the early twenty-first century by *zoology*,*natural history*, *anatomy*, and *physiology* map poorly on to Aristotle's investigation of animals; and the work that conventionally bears the English title *Physics* will be badly misunderstood by anyone who imagines it is Aristotle's attempt to do what is today called physics.

In this postscript, Aristotle's general theory of scientific knowledge (as presented primarily in his *Posterior Analytics*) will be discussed separately from his contributions to natural science. Within this latter group, those texts that present and defend Aristotle's distinctive *principles* for natural science (especially *Physica*, *Generatione et Corruptione*, and *De Partibus*

*Animalium I*) will be distinguished from the application of these principles to investigations of distinctive domains of the natural world (*Meteorologica, De Partibus Animalium II–IV, De Generatione Animalium I–V*,*Historia Animalium I–X, De Motu Animalium, De Incessu Animalium, Parva Naturalia, De Caelo I–IV*). The majority of Aristotle's contributions to natural science are devoted to the study of animals; and this reflects Aristotle's view that the study of living things is central to the investigation of nature. Therefore this postscript will focus on what is conventionally referred to as Aristotle's *biology*. Ideally, because Aristotle claimed that knowledge about the soul contributes greatly to the study of nature (402a4), this should also include his *De Anima* (*On the Soul*), but there will be only passing references to it.

**Theory of Science** . Beginning with the eighth "Symposium Aristotelicum," in 1978, the *Posterior Analytics*(*APo*.) has been studied more intensely than at any time since the Renaissance. That research led to revaluations of three assumptions of the previous *DSB* entry: (1) that there is a serious conflict between Aristotle's theory of science and his practice; (2) that this may be due to the theory taking mathematics, rather than natural science, as its model; and (3) that the *APo*. has little to say about scientific inquiry. Each of these views has now been seriously challenged.

To develop systematic views about scientific investigation, one first needs a concept of the goal to be achieved, and recent research suggests *APo*. *I* be thought of as Aristotle's articulation of that goal. The goal is a system of concepts and propositions organized hierarchically, ultimately resting on knowledge of the essential natures of the objects of an established kind and certain other necessary first principles. These definitions and principles form the basis of causal explanations of propositions identifying attributes that belong to the objects being investigated per se, in virtue of their natures. A system of formal proof and validity is outlined in the *Prior Analytics*, providing logical standards for scientific explanation. It should be possible to display scientific explanations as syllogisms in which the "middle term" identifies the cause in virtue of which an attribute belongs necessarily to its subject. For example, having interior angles equal to two right angles belongs to all triangles in virtue of something essential to being a triangle (*APo*. *I*. 4, 5). It belongs necessarily to all equilateral triangles as well—but only because they are triangles. The middle term of a scientific demonstration of this property will refer to that essential property of triangles in virtue of which it belongs to all triangles.

Aristotle, in *APo*. *II*, discussed how to achieve this goal: how to achieve knowledge of essences (expressed in definitions) and how the search for essences is related to the search for causal explanations (expressed in the form of demonstrations). Perceptual experience gives us a grasp of the target of inquiry that is not yet scientific knowledge as characterized in book I, but does provide a sufficient grasp on the subject to direct further inquiry. We may begin by asking whether there really is an object of inquiry with a nature and a stable set of properties to be explained (*APo*.*II*. 1, 89b23–25). Once we have grounds for believing that "thunder" signifies a single, recurrent natural phenomenon, for example, we may go on to inquire into its cause, which is precisely to find out what thunder really is (*APo*.*II*. 1, 89b29–31). The result can be expressed as a definition or as a demonstration. Thunder, which signifies a certain kind of noise in the clouds is, in essence, the noise caused by fire being extinguished in clouds. Such a noise is present whenever extinction of fire is present; thus when extinction of fire is present in the clouds, thunder is present in the clouds (*APo*.*II*. 10, 94a4–8).

In this discussion, thunder and eclipses are his primary examples of natural inquiry, but Aristotle also provided an extended biological example, the seasonal loss of leaves in broad-leaved plants. From experience, one learns that certain trees lose their leaves seasonally. The first step toward scientific understanding will be to determine whether this is a single phenomenon. Aristotle suggested that to determine this one must search for other properties shared by plants that lose their leaves, being broad-leaved, for example. Such correlations provide good reason to think that there is a kind to which leaf loss belongs as such. He closed chapter 16 of Book II with the following summary:

Hence in these cases the middle term and what it is explanatory of must be equal and must convert. For example, why do trees shed their leaves? If it is because of solidification of the moisture, then if a tree sheds it leaves solidification must hold, and if solidification holds—not of anything whatever but of a tree—then the tree must shed its leaves. (98b35–39)

Since the whole point of the example is that not all trees shed their leaves but only those with broad leaves, "tree" here must stand in for "trees with broad leaves." Something essential to being broad-leaved causes loss of leaves—Aristotle here suggested that there is a seasonal solidification of moisture at the leaf juncture (presumably cutting off nutrition to the leaves). As with thunder, a causal explanation of leaf loss is also an account of its essence (*APo*. *II*. 17, 99a22–23).

There is, then, a sophisticated theory of inquiry here, and research done since the publication of the *DSB* suggests that it accords rather well with the practices revealed in Aristotle's scientific investigation of animals. This research will now be briefly summarized.

**Foundations of Natural Science.** Four works in particular are devoted to the articulation and defense of Aristotle's distinctive set of principles for investigating the natural world: *Physics, On the Parts of Animals I, Generation and Corruption I*, and *On the Soul I –II*. Aristotle was at great pains to distinguish the science of nature from two other theoretical disciplines, mathematics and first philosophy (metaphysics)

. The work typically referred to as *Physics* is a collection of books aimed at articulating and defending a unique set of first principles and causes for the science of nature. In the original *DSB* entry, G. E. L. Owen stressed Aristotle's method of reviewing "the common convictions and common linguistic usage of his contemporaries, supplemented by the views of other

thinkers." Because, Aristotle claimed, these common convictions were "storehouses of experience," this "dialectical" methodology (which he also saw at work in *De Caelo* and *Generation and Corruption*) was aimed at "saving the phenomena."

There is no doubt that when Aristotle enters a domain that is well trodden, previous views on the topic being investigated are critically reviewed; but typically these views create impediments to progress, *aporiai*, not phenomena to be saved. The *Physics* is an extended argument aimed at overcoming those impediments and providing a new foundation for the science of nature.

Consider in outline the first four books of *Physics* (*Ph*.).

The chief concerns of Book I are first to defend the assumption that natural things are subject to change against the Eleatics and then to articulate the number and kind of principles required to properly characterize any kind of change. This involves a critical review of the assumptions of previous thinkers, but Aristotle's final position was profoundly different from those he rejected.

It must be, because Aristotle aimed to defend a kind of change rejected by virtually all his predecessors, the unqualified coming to be of a substantial being, such as the development of an animal or plant. In such cases, the stable subject underlying qualitative, quantitative or spatial change is now the outcome of a change, raising profound questions about what underlies the change.

Aristotle introduced his concepts of potentiality and actuality and matter and form in order to deal with this problem. (A full defense of unqualified generation comes in *Generation and Corruption I*, and in book *II* he applied the results to the transformation of the elements.)

With the general principles of change delineated, *Ph. II* chapter 1 argues that the distinctive mark of natural beings is that they have their own inherent sources and causes of change—indeed this is their nature (*physis*). The remainder of book *II* explores the implications of that account of nature. Chapter 2: What are the inherent sources in a natural being? (Answer: matter and form.)

Chapter 3: How many causes are there and of what sort? (Answer: four: matter, form, moving cause, end.) Chapters 4–6: Is chance to be included among the causes, as some have claimed? (Answer: no; but causality is involved in chance events). Chapter 7: Because there are only two natures, are all four of these causes involved in nature? (Answer: yes; but three of the four involve form and the fourth matter.) Chapter 8: In particular, how can either of these natures act for the sake of an end? (Answer: "Since nature is twofold, nature as matter and nature as form, and the latter is an end, and everything else is for the end, the cause as that for the sake of which must be form" [199a31–33].) Chapter 9: But can that view be compatible with things happening of necessity? (Answer: yes, because beside the necessity associated with matter there is a necessity associated with natural ends.) Once more, the entire book is an exploration of the presuppositions of Aristotle's unique and unprecedented views about what it is to have and to be a nature.

The introduction to *Ph.III–IV* (200b12–25) again stresses the foundational nature of this work. Because nature is a source of change, Aristotle explained, we need to be clear on exactly what change is. And because it will turn out that it is continuous, and the continuous is argued by some to be infinite, we must determine whether the infinite exists and if so in what sense. And because some hold that change requires place, time, and void, we must investigate these as well. This is, indeed, the program for the remainder of books *III–IV*.

In sum: the *Physics* has the character of what, in the early twenty-first century, would be called philosophy of science—explorations of concepts such as change, nature, causality, explanation, teleology, necessity, chance, space, time, and infinity. The exploration of nature requires that we be secure about our starting points; these books aim at establishing the proper starting points for any natural investigation. And while a preliminary step in each investigation is to review previous views on the subject, Aristotle's final position rarely saved the opinions of his predecessors or of common sense. Invariably Aristotle used innovative philosophical tools to forge an unprecedented position on the foundations of natural science.

*On the Parts of Animals I* (*PA I*) was yet another foundational work, in this case a philosophical exploration of the standards required for a successful scientific study of living things. Its continuity with *Ph.II* is often correctly noted. To cite just one example, the discussions of teleology and conditional necessity in these two works are the only theoretical discussions of these topics in the corpus, and they complement one another in detail. It is less commonly noted that this book is also the bridge between the account of scientific knowledge in the *Analytics* and Aristotle's actual presentation of the results of his investigations of animals. For example, he argued for the priority of goal causation to efficient causation on grounds it is by stating the goal that one identifies the defining nature in things that are generated (639b13–21). And during his defense of conditional necessity—the idea that certain materials and processes are necessary for the realization of an end—he noted that this implies a different manner of demonstration than in other theoretical sciences (639b22–640a9).

The form of an organism is assumed to be its soul (in the sense defended in the *De Anima*, the functional capacities for nutrition, reproduction, perception, locomotion, and thought). But after noting this, a model for biological explanation emerges that applies the general ideals of the *Analytics* to this domain: a small number of explanatorily basic features are present simply because that is what it is to be that sort of animal; one does not further explain why birds are flyers or fish swimmers. In all

other cases an attribute (such as a part or some feature of a part) must be shown to belong to the animals it belongs to either because its life requires or is made better by it, or because it is necessitated by the material nature of the animal.

*On the Parts of Animals I*, 2–3 follows with an attack on dichotomous division (as found in late Platonic dialogues and in fragments of Speusippus) as inadequate for organizing the biological world. Out of this attack emerges a new method of division, whereby general kinds (e.g., bird, fish, insect, soft-shelled animal) with many correlated differentiae are taken as the starting point of division. Division proceeds from these general differentiae (wing, leg) and articulates increasingly specific forms of each difference. If all birds have beaks, "beak" will stand at the head of a division into increasingly specific forms of beak. Division appears to play the same limited role of properly ordering and relating differences that it is given in *APo*., yet there are numerous innovations intended for biological application. One can see division of this kind in practice in the *Historia Animalium* (*HA*)*I–X*.

How are the general kinds assumed by division identified? Aristotle turned to this question in *PA I*. 4. By attending to what led people to formulate the concepts of *bird* and *fish*, we can identify the principles to be deployed. *Bird* refers to a collection of organisms sharing a set of perceptually apparent features (beak, a peculiar form of bipedalism, feathers, wings, flight, etc.) each of which vary along a number of perceptual continua (dimensions, texture, color, density, etc.). With respect to these shared features, birds differ only in degree from each other, while they differ in kind from, say, fish—lung and gill, or feather and scale differ in kind, not merely in degree. Thus division under each of these general features remains within a determinate range and it is by attending to these general, correlated features that the "great kinds" (*megista gene*) of animals are identified. Further study will uncover their natures, the living functions for the sake of which the parts are structured and arranged as they are.

*PA I*. 5 first provides a stirring defense of the value of the scientific study of life when carried out in the proper, philosophical spirit (644b22-645a36). Then (645b1–36) it integrates its results, showing how a division of biological functions, paralleling that of the system of animal parts: "So the body is in a way for the sake of the soul, and the parts are for the sake of the functions in relation to which each of them developed by nature" (645b18–20).

**Theory in Practice.** Recent work on the model of science in the *APo*. and on the theoretical foundations of natural science developed in *Physics* and *PA I* helps us better to understand the way Aristotle's scientific investigations are organized. The theory of inquiry in *APo*. *II* is explicitly invoked at the very beginning of a number of Aristotle's animal studies. *HA*, for example, opens by introducing the kinds of differences among animals to be studied, and then states the purpose of the investigation to come and where it fits in the entire scientific study of animals. We must, he said,

first grasp the differences and the attributes belonging to all animals. After this, we must attempt to discover the causes. For it is natural to carry out the investigation in this way, beginning with the inquiry into each thing; for from these inquiries it becomes clear both about which things the demonstration should be and from which things it should proceed. (*HA I*. 6, 491a7–14)

The term *inquiry* in this quote (and in what follows) translates *historia*, and throughout the biological works it is used to refer to the precausal stage of inquiry discussed in *APo*. That, rather than what we would call a natural history, is the purpose of the inquiry reported in *HA*. If "History of Animals" were not so entrenched as its title, it would be far better to refer to it as "Inquiries into Animals."

Understanding *HA* in light of *APo*. and *PA I* helps to explain a number of the puzzling features, some of which Balme pointed to in his contribution to the *DSB* entry: its organization around multiple, correlated differentiae rather than animal kinds; the virtual absence of the language of causal investigation, vocabulary that is pervasive in the other (causal) treatises; its interest in identifying great kinds (*megista gene*) and widest class generalizations (e.g., "all that breathe in and out—as many as take in air—all these have a lung, windpipe and esophagus" (*HA II*. 15, 506a2–3). A number of scholars in the nineteenth and twentieth centuries had argued that most or all of *HA* was written after Aristotle's death, and in his *DSB* entry Balme endorsed this claim. By the time he had prepared the introduction to the Loeb edition of *HA VII–X* (Balme, 1991), however, he had rejected these arguments, at least in part because of the realization that many of them depended on a misunderstanding of *HA*'s structure and purpose.

Conversely, looking back to what is reported in *HA*, the beginnings of *On Animal Locomotion* (704b7–10) and *PA II* (646a8–12) identify themselves as reporting the results of causal investigations, referring back to the "inquiries" (*historiai*) as accounts of the data in need of explanation. This is not mere window dressing. *PA II–IV* and *HA* are focused intently on giving accounts of the essential natures of the parts, specifying the functional differences for the sake of which the structural and material differences are present. *On the Generation of Animals* (*GA*) begins by explaining the differences among the parts related to generation in the first half of book *I*, and proceeds to a causal explanation of animal generation, organized according to the appropriate differentiae: live-bearing, egg-laying, or spontaneously generated. Approaching Aristotle's science through his own theory of science, rather than through our modern categories of natural history versus anatomy and physiology, has provided a better understanding of its goals and organization.

The discussion of anatomy and physiology contributed to *DSB* by L. G. Wilson focused on Aristotle's discussion of the vasculature and heart in *HA*. It provides valuable insights into Aristotle's likely method of dissection and its limitations. There

is, however, little said about cardiac function, or about Aristotle's general approach to the parts of animals. An analysis of Aristotle's causal theory of the heart illustrates his general method of causal investigation of animal parts.

Aristotle began by discussing what is true of all hearts as such, and then moves on to explain the differentiation of hearts in different kinds of blooded animals. Aristotle's general account of the heart concludes (1) that the heart is present for the sake of originating blood, (2) that it is also the primary perceptive part, and (3) that it is thus the primary organ of the perceptive capacity of soul, the capacity essential to being an animal (*PA III*. 4, 666a34–36). It is part of Aristotle's explicit theory that many animals that perceive lack hearts. *PA III*. 4, however, is part of the discussion of the internal organic parts of blooded animals. Aristotle turned to the bloodless animals in book *IV*, and when he did so he noted that they must have an analogue of the heart and blood (cf. *PA IV*. 5 678b1–7).

The definition of a heart and the explanation of why animals with hearts have hearts are intertwined in just the way *APo*. would lead us to expect. Once this general explanation for why all blooded animals have a heart was in place, he went on to explain differences in its location (666b1–12), sinews (666b13–20), number of cavities (666b21–35), "articulation" (667a6–11), size (667a11– 22), and even the relation of these differences to the animal's character (667a12–22). Just before concluding, he discussed the critical status of the heart for life and death (667a32–667b12).

As in his study of the heart, Aristotle's method of finding the widest class to which an attribute belongs per se in order to focus causal investigation can also be illustrated by his account of why certain animals have multiple stomachs (ruminants). Aristotle began by noting that this trait is correlated with cloven hoofs, horns, and a dearth of upper teeth, and this level of similarity is sufficient for Aristotle to seek a single explanation for it. Aristotle typically identified the animals with this complex of structures in common by a nominal phrase that literally translates as "the ones that do not have both rows of teeth (*ta mê amphôdonta*)" (cf. *PA III*. 2, 663b29–664a3, *III*. 14, 674a32–b18; *APo.II*. 14, 98a13–19). As with the *APo*. example of broad-leaved trees, this group is identified as a result of the search for that demonstration. The lack of teeth is due to the diversion of material suitable for teeth to make hoofs and horns. Because of the resulting lack of teeth, food enters the digestive track in a relatively unprocessed state, requiring a more complex system of stomachs to fully digest it.

Another grouping that Aristotle investigated that does not constitute a previously identified kind is the group of animals that possess lungs and also share a number of correlated features—windpipe, esophagus, neck, epiglottis (or equivalent)—all of which can be explained by reference to breathing. Aristotle concluded his discussion of the lung by claiming that, even though animals with a lung do not constitute an identified kind, the lung is nevertheless part of their being (*ousia*)—as much, he insisted, as having feathered wings is part of the being of birds (*PA III*. 6, 669b8-12).

**Tradition and Influence.** The entry of Minio-Paluello for the original *DSB* entry was comprehensive through 1970. However, between 1970 and the early twenty-first century there has been a revolution in our understanding of the Aristotelian tradition. Theophrastus, Aristotle's younger coworker and successor as head of the Lyceum, has been the subject of systematic and comprehensive investigation of primary sources and a related series of conferences, under the general guidance of William Fortenbaugh, during the past twenty-five years. Similarly, under the general guidance of Richard Sorabji, the Greek commentaries on Aristotle are being translated with annotation into English, introducing them to a new audience and leading to a significant scholarly reappraisal of their role in transmitting and reshaping Aristotle's ideas. Moreover, the systematic study of the Syriac-Arabic tradition reported on by Minio-Paluello, which not only transmitted Aristotelianism but transformed it in a variety of ways, has expanded. The Aristoteles Latinus and Aristoteles Semitico-Latinus Projects aim to publish editions of all the Latin, Syriac, Arabic, and Hebrew translations of Aristotle from Greek (as well as Latin translations of Syriac, Arabic, and Hebrew translations) and has already published many volumes of his scientific treatises. An annotated English translation of Albertus Magnus, *De Animalibus* has made this great work more widely available. These projects are only part of the transformation of the field of medieval philosophy due both to a wealth of newly edited texts and a deepening understanding of the historical influences on it and of the complexity of its relationship with Renaissance Aristotelianism.

Under the influence of scholars such as Charles Schmitt, Charles Lohr, and William Wallace, there has been an unprecedented growth in our understanding of the Aristotelian tradition in the Renaissance. This point is exemplified by briefly discussing what has happened during these intervening years in our understanding of the tradition and influence of Aristotle's "biological" works, many of them referred to collectively during the medieval period as *De Animalibus*.

The first chapter of Schmitt's groundbreaking *Aristotle and the Renaissance* bore the title "Renaissance Aristotelianisms." His work targeted the widespread tendency to, as he later put it, "lump all Aristotelian traditions together as part of the old medieval world" (p. 91) and to seek the roots of modernity in an eclectic mix of reactions against it. In the fourth chapter, on "Eclectic Aristotelianism," he spent a great deal of time discussing the many distinct ways, in various cultures, that Aristotelianism was comfortably infused with all sorts of other currents. In discussing Italy, for example, he mentioned the very different approaches of Pietro Pomponazzi and Agostino Nifo. During the past decade, Stefano Perfetti, of Pisa, has done a meticulous study of their respective commentaries on Aristotle's *De Partibus Animalium* (as well as that of Niccolò Tomeo), giving rich and concrete meaning to Schmitt's point. Though all three would claim to be part of an Aristotelian tradition, they brought to their studies differences in methods and philosophical assumptions that belie the uniformity that, even in 1983, historians of science took for granted.

Those works, which were based on the printed Latin translation of the biological works by Theodorus Gaza that first appeared in 1476, form part of the background to a broad and eclectic Aristotelian reaction to the Galenism that had dominated the

theory and practice of medicine. Gradually, practitioners of human dissection became the sources of empirical challenges to Galenic orthodoxy. In Aristotle's animal studies they found a radically different justification for dissection. The study of animals was a central part of natural philosophy, not a practice ancillary to medicine. It was a universal and comparative study of parts in whatever animals had them, not an art restricted to the investigation of health and disease in humans. Those who taught it, then, had the right to be considered professors of natural philosophy, and not merely "demonstrators."

This movement gained enormously from the assistance of artists and printers in the production of dramatically presented anatomical drawings and could point to texts in Aristotle to indicate an ancient origin for this practice. By the time William Harvey entered Padua (perhaps already prepared by reading the eclectic Aristotelianism of John Case in England) for his medical training in 1599, the likes of Andreas Vesalius and Realdo Colombo had transformed the subject. His own mentor, Fabricius ab'Aquapendente, was teaching and practicing philosophical anatomy—an anatomy that was universal in scope, comparative in method, and theoretical in its aims. It was the philosophical and theoretical basis for the art of medicine. Under an unmistakable Aristotelian influence, the places of the two disciplines had been reversed.

Schmitt saw Harvey, whose work on the movement of the heart and on animal generation is a high point of the new "experimental philosophy," as an exemplar of an eclecticism that integrated new developments within an Aristotelian framework. Another example of the same tendency is found in Aristotelians such as Christoph Clavius and Christopher Scheiner who, during the sixteenth and seventeenth centuries, drawing on Aristotle's discussions of the "more natural of the mathematical sciences" (optics, harmonics, astronomy, mechanics), embraced the application of mathematics to the study of nature.

In light of the scholarship on every aspect of the Aristotelian tradition since the 1970s, Minio-Paluello's statement in the original *DSB* entry that "Aristotle's influence [in the province of science] is very limited, or effective only in the sense that mistakes, eliciting opposition, criticism, and new solutions to old and new problems, are the starting point of scientific progress," (p. 267) needs to be seriously reconsidered.

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## STANFORD ENCYCLOPEDIA OF PHILOSOPHY SITES ON ARISTOTLE AND THE ARISTOTELIAN TRADITION

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***James G. Lennox***

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# Aristotle

International Encyclopedia of the Social Sciences


WORKS BY ARISTOTLE

SUPPLEMENTARY BIBLIOGRAPHY

Aristotle (384–322 b.c.), the greatest systematic philosopher of ancient Greece, was born in Stagira, an outlying city near Macedonia. He spent twenty years in Plato's Academy, leaving on Plato's death in 347, and later founded his own school in the Lyceum at Athens in 335/334. Part of the interval was spent as tutor to Alexander, son of Philip, king of Macedonia. Aristotle's father had been court physician to an earlier Macedonian king. As Macedonia advanced in its conquest of Greece, Aristotle's connections with the Macedonian monarchy roused Athenian hostility. In 323, in the anti-Macedonian reaction that followed Alexander's death, Aristotle was indicted on the charge of impiety and withdrew to Chalcis, where he died the next year.

His massive surviving works range over all fields of inquiry: logic and theory of science, physics, biology, psychology, metaphysics, ethics, politics, rhetoric, and aesthetics. In most of these he laid the basis for the subsequent development of the disciplines. The scope and analytic thoroughness of his works have made them perennially influential. In the late medieval world they constituted the major available corpus of science, and Dante characterized Aristotle as "the master of those who know." A reaction against his philosophy came with the rise of modern science, but his social and humanistic writings have maintained a continuous appeal.

Aristotle's distinctive contributions to social science are (*a*) a methodology of inquiry that focuses on man's rationality yet stresses the continuity of man and nature rather than a basic cleavage; (*b*) the integration of the ethical and the social, as contrasted with the dominant modern proposals of a value-free social science and an autonomous ethics; and (*c*) a systematic foundation for morals, politics, and social theory, and some basic concepts for economics, law, and education.

**Methodology and general outlook.** Aristotle's foundation work in logic, of which the syllogism is best known, analyzes general forms of inference. His conception of systematic knowledge is rationalistic, aiming at deductive organization, with primary premises stating the essence, and theorems deriving properties. Beyond essence and property lie incidental or accidental features, and there is no science of the accidental. The distinction between essential and accidental—for example, a man is essentially rational but only accidentally white—is not offered as a relative pragmatic one, but as corresponding to types actually present in nature or reality. Basic concepts and relations in each field are grasped directly as outcomes of an inductive process. Data are furnished by accumulated observation, common opinion, and traditional generalization; and theoretical principles emerge from analytic sifting of alternative explanations.

His explanatory approach is teleological, using the model of craftsmanship: nature works like the artist, although it operates unconsciously. The scientist must therefore look for materials, structure, causal agencies, and directive goals or functions. These concepts are answers to the questions: Out of what? What is it? From where? and For the sake of what? They have been called the material, formal, efficient, and final causes, respectively. In conscious action, the final cause may lie in a purpose beyond the object analyzed, but in natural processes it is the emerging form that guides development, for example, from acorn to oak or from embryo to adult. Even in physics, Aristotle sees the fall of a stone as the striving of its earthen nature to reach its natural place at the globe's center. Order has priority over disorder in Aristotle's outlook, as a consequence of the conception of indwelling nature; he rejects the view that change is primary and that all equilibrium analysis is only approximate and falsifying. There are real structures in things; the world is a plurality of what we would today call homeostatic systems, whose groundplan may be discovered and rationally formulated through a kind of structural—functional analysis. Like the world itself, the order is neither imposed from without nor evolved, but eternal.

*Matter* and *form* are relative analytic concepts. Dynamically, however, matter is construed as *potentiality* for determinate development or activity and form as culminating *actuality*. Thus, man's psychic life is seen as the actualization of his organism's potentialities. The soul (*psychē*) is to the body, says Aristotle, as the power to cut is to the axe. His focus is on the total interactive situation in which man and his specialized organs, the object and its special properties, and relevant features of the medium are brought into relation in the particular activity, whether it be eating, seeing, dreaming, or thinking. His method is thus a general field approach that enables him to correlate physical and physiological study with phenomenological and behavioral study. Philosophically, he avoided the sharp dualisms of body and mind, objective and subjective, that have beset modern psychology since Descartes gave a primary metaphysical role to matter and consciousness. Aristotle's analysis of human functions culminates in a view of man as distinctively rational, able to express his nature self-consciously and attain contemplative understanding of the orderly principles of different fields.

His methodology thus served admirably for discovering existent order—whether in classifying animal species or mapping constitutions of citystates—and for seeing the development by which the normal individual reaches mature form. It does not provide a method for dealing with evolutionary development in which the new emerges out of a seedbed of constant and incidental mutation.

**Ethics and politics** . Aristotle's teleological approach sees man striving toward one ultimate end, which Aristotle identifies as happiness. Since the good is defined as what all men aim at, the normative is not invoked transcendentally; rather it is systematically grounded in the needs, goal seeking, and possible outcomes of human social living. While theoretical contemplation is given the crowning role as man's highest activity, most of Aristotle's inquiry is directed to the practical good in man's social practices and relations. Ethics and politics are continuous. The one studies virtues as character formations, the other studies institutions; but both are concerned with finding ways in which the human make-up realizes fullest expression and how in less than ideal conditions this may be approximated. Aristotle's integration of the ethical and the social, of norm and fact, is thus not a failure to appreciate a much labored modern distinction but its implicit rejection, based on the assumed continuity of man and nature and an underlying teleology.

The *Politics* embodies Aristotle's conclusions from a study of the history and development of 158 constitutions, the constitution of Athens being the only one that survives. The *Politics* is more than political science. We find in it a concept of a natural order of human institutions, the projection of an ideal order, and the classification and analysis of existent sociopolitical forms and their evaluation to provide a practical program.

Although in Aristotle's own lifetime, his pupil, Alexander the Great, was building a vast empire and cosmopolitan philosophies of man were to appear, Aristotle himself expressed the conception of the older city-state. The *polis*, the organized small-city community, represents the natural fruition of man's sociality. The sophists had insisted on a dichotomy between nature and convention; Aristotle thus took his stand on the natural, rather than the conventional or contractual character of social relations. Direct participation in the constitutional processes of the *polis* is the essence of citizenship, and the megalopolitan society, with its lone isolated individuals, is contrary to nature. While in the *Ethics* Aristotle classified basic types of association in terms of the *individual* motivations of "utility," "pleasure," and "common ideals," in the *Politics* he studied the specific *social* relations: master–slave, husband–wife, parent–child, ruler–ruled. He was attentive to qualitative distinctions in the different relations rather than subsuming all political phenomena under a single concept of power or dominance-submission. The conservative potential in his natural order concept is seen in his defense of slavery and of the inferior position of women, as befitting a lower rationality, more capable of following a prescribed good than of actively understanding it.

The ideal order that Aristotle projected is an *aristocracy*, emphasizing the quality of men and apportioning rule according to merit. He regarded this not as inequality but as a proportionate type of equality, contrasting with *oligarchic* apportionment (according to wealth) and *democratic* apportionment (numerical or arithmetic equality). He did not expect conditions in most societies to be favorable for the ideal order, and his preponderant concern, therefore, was with the analysis and evaluation of existent forms.

The classification of constitutions is twofold: (*a*) a dichotomy between *genuine* forms, directed to the common interest, and *perverted* forms, exploitative on behalf of the ruling party; and (*b*) a numerical classification of rulers into one or few or many. This dual classification yields kingship, aristocracy, and polity (rule by numerous substantial citizens) as genuine forms and tyranny, oligarchy, and democracy as perversions on behalf of the monarchy, the wealthy, and the poor, respectively. Behind this formal classification lies an active concern with locating the vital operative differences in the character and organization of society. Thus he identified oligarchy as rule of the rich rather than merely of the few, and democracy, with its equalitarian slogans, as expressive of the interests of the poor. His examination of subtypes in each of the major divisions—for example, five varieties of kingship, five of democracy, four of oligarchy—reveals both their socioeconomic bases and the conditions under which they may be expected to function. Special detailed attention is paid to the sources of revolution, and, in an almost detached spirit, Aristotle suggested how particular forms may avoid it. A sense of inequality is seen as particularly conducive to revolution.

Aristotle took the central fact of political life in the states of his time to be the war between rich and poor. His prescription for harmony between citizens is *polity*—a kind of middle-class rule. This is congruent with his general opinion that correctness lies in the mean. In his theory of moral virtue, each virtue is construed as a mean between two vices, for example, courage is a mean between rashness and timidity, harmonizing natural feelings of fear and confidence into a stable pattern. In the *Politics,* the mean consists in balancing the opposite forces of oligarchy and democracy, so that both the arrogance of wealth and the despair of poverty may be avoided. Numerous governmental compromise devices similar to checks and balances are suggested by him. His general attitude to the democratic masses was far more favorable than might have been expected from a disciple of Plato. Aristotle did not regard the mass of men as having a dragonlike appetite that can only be repressed rather than assuaged. He saw appetite as plastic raw material for virtue or vice and men as capable of exercising considerable collective judgment on the effects of policies and the adequacy of rulers.

Aristotle's *Politics* has served as a foundation work for the whole Western tradition. It had a central influence from the thirteenth to the fifteenth century, notably in the political thought of Thomas Aquinas and subsequent Christian political thinkers and also in diverging lines such as the political Averroism of Marsilius of Padua. From the sixteenth century on, particular strands in the Aristotelian work stimulated various developments in politics: for example, his economic treatment of

politics influenced Harrington in the seventeenth century; sociological elements were taken up by Montesquieu in the eighteenth century; and his concept of community influenced idealist political philosophies such as those of T. H. Green and Bosanquet in the nineteenth century. Apart from the specific content of Aristotle's work, his general concept of a natural order for man with permanent institutional forms has attracted antirelativist and antievolutionary political theorists. On the contemporary scene, it is often fused with attempted revivals of natural law.

**Economic concepts** . In Aristotle's discussions of household management, of the art of acquisition, and of conflicts over property forms, we find basic analyses of production, distribution, and exchange. Aristotle recognized that different modes of production yield different ways of life, and he was conscious of the limits imposed by productive processes; for example, he fantasied an automation myth, in which shuttles move of themselves, as the one condition that would render slavery unnecessary. His general preference was for the society of agricultural estates, not highly intensified commercial society. In analyzing exchange, he distinguished in effect between use value and exchange value and offered a theory of money as a conventional device for indirect exchange. This condemnation of the use of money to produce more money in usury, which he saw as an unnatural distortion of ends, had great influence on medieval views of this subject. Against Plato, he defended private property, largely for its influence on character and the promotion of responsibility; but he was ready to allow considerable social demands on private property for public purposes [*see*Economic thought, *article on*ancient and medieval thought].

**Legal concepts** . Aristotle seems to have been especially interested in legal concepts. In the *Ethics,* he distinguished *distributive* justice, and the different principles of distribution in different types of constitutions, from *corrective* justice, which restores the balance upset by man's wrongdoing. His concept of natural justice, distinguished from that of conventional regulations by its universal force, is a precursor of much subsequent natural law theory. A concept of equity is advanced to meet the complexity of particular conditions and the approximate character of legislative enactment. In the *Politics*, rule of law is preferred to rule of the legislator, chiefly as a protective device against corruption. The *Rhetoric*, essentially a handbook of training in legislative and judicial controversy, includes much on specific legal method and legal argumentation, combining psychological, ethical, logical, and stylistic materials. In this work, all the tricks of the trade are revealed, but not without a central moral focus on the public's welfare.

**Education** . Aristotle's moral and political writings include considerable treatment of educational themes. Moral virtues are to be developed by practice, with a master as model, rather than through intellectual learning. The process of learning culminates in the development of the facility to make moral decisions, the sensitively cultivated perceptions of men of "practical wisdom." Similarly, the propaedeutic role of laws and institutions is as strong in Aristotle's thought as it was in that of Plato or John Stuart Mill. The unfinished, last part of the *Politics* deals specifically with education. Tying his theory of education to an analysis of human psychology and the ethical theory of the good, he urges that industry be regarded as only a means to leisure and war as only a means to peace. Hence public education is primarily turned to the activities of peaceful leisure, and its goals embrace training for character, citizenship, and cultural pursuits. Cultivation of rational ability and critical judgment is pivotal. For example, Aristotle asked whether liberal education should include learning to play a musical instrument; he concluded that it should, but only up to the point necessary for acquiring sound judgment of musical performance.

Abraham Edel

[*For the historical context of Aristotle's work, see*Economic thought, *article on*ancient and medieval thought*and the biography of*Plato. *For discussion of the influence of his ideas, see*Justice; Natural law; Political theory; *and the biographies of*Aquinas; Bosanquet; Green; Harrington; Marsilius of Padua; Montesquieu.]

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# Aristotle

Encyclopedia of World Biography


**The Greek philosopher and scientist Aristotle (384-322 B.C.) organized all knowledge of his time into a coherent whole which served as the basis for much of the science and philosophy of Hellenistic and Roman times and even affected medieval science and philosophy.**

Aristotle was born in the small Greek town of Stagiros (later Stagira) in the northern Greek district of Chalcidice. His father, Nicomachus, was a physician who had important social connections, and Aristotle's interest in science was surely spurred by his father's work, although Aristotle does not display a particularly keen interest in medicine as such. The events of his early life are not clear, but it is possible that his father served at the Macedonian court as physician to Amyntas II and that Aristotle spent part of his youth there.

At the age of 17 Aristotle joined Plato's circle at the Academy in Athens. There he remained for 20 years, and although his respect and admiration for Plato was always great, differences developed which ultimately caused a breach. On Plato's death in 348/347 B.C. Aristotle left for Assos in Mysia (in Asia Minor), where he and Xenocrates joined a small circle of Platonists who had already settled there under Hermias, the ruler of Atarneus. Aristotle married Pythias, the niece of Hermias, and in a fine hymn expressed his shock and dismay over Hermias's death at the hands of the Persians some time thereafter.

After 3 years in Assos with Theophrastus and Xenocrates, Aristotle went to Mytilene for 2 years. Later, Theophrastus and Aristotle made their way to the court of Philip of Macedon, where Aristotle became tutor to Alexander, who later gained immortality by becoming master of the whole Persian Empire. Scant information remains regarding the specific contents of Alexander's education at the hands of Aristotle, but it would be interesting to know what political advice Aristotle imparted to the young Alexander. The only indication of such advice is found in the fragment of a letter in which the philosopher tells Alexander that he ought to be the leader of the Greeks but the *master* of the barbarians (foreigners).

# Peripatetic School

Aristotle returned to Athens in 335/334. Under the protection of Antipater, Alexander's representative in Athens, he established a philosophical school of his own in the gymnasium Lyceum, located near a shrine of Apollo Lyceus. The school derived its name, Peripatetic, from the colonnaded walk (*peripatos*). Members took meals in common, and certain formalities were established which members had to observe. The lectures were divided into morning and afternoon sessions, the more difficult ones given in the morning and the easier and more popular ones in the afternoon. Aristotle himself led the school until the death of Alexander in 323, at which time he felt it expedient to leave Athens, fearing for his safety because of his close association with the Macedonians. He went to Chalcis, where he died the following year of a gastric ailment. His will, preserved in the writings of Diogenes Laertius, provided for his daughter, Pythias, and his son, Nicomachus, as well as for his slaves.

# His Writings

Aristotle produced a large number of writings, but relatively few have survived. Because of the great weight of his authority it was inevitable that several spurious treatises should find their way into the corpus of his work. His earliest writings, consisting for the most part of dialogues, were produced under the influence of Plato and the Academy. Most of these are lost, although the titles are known from the writings of Diogenes Laertius and from one of several *Lives* to come down from antiquity. They include his *Rhetoric, Eudemus* (*On the Soul*), *Protrepticus, On Philosophy, Alexander, On Monarchy, Politicus, Sophistes, Menexenus, Symposium, On Justice, On the Poets, Nerinthus, Eroticus, On Wealth, On Prayer, On Good Birth, On Pleasure, and On Education*. These were exoteric works written for the public, and they deal with popular philosophical themes. The dialogues of Plato were undoubtedly the inspiration for some of them, although the divergence in thought between Plato and his pupil—which was to become apparent later—reveals itself to a certain extent in these works too.

A second group of writings is made up of collections of scientific and historical material, among the most important of which is the surviving fragment of the *Constitution of the Athenians*. This formed part of the large collection of *Constitutions,* which Aristotle and his students collected and studied for the purpose of analyzing various political theories. The discovery of the *Constitution of the Athenians* in Egypt in 1890 shed new light not only on the nature of the Athenian democracy of the 5th century B.C., but also on the difference in quality between the historical and scientific works of Aristotle and his successors. The prejudices and errors shown in the *Constitution* reveal a mind influenced by Plato and aristocratic social prejudices, while the factual discrepancies reveal the unreliable historical sources which Aristotle used for this type of treatise. Other works in this category are the *Pythian Victors, Barbarian Customs, Didascaliai* (lists of dramatic performances at Athens), *Homeric Questions, Problems,* and *Olympian Victors*.

The last group of writings is made up of those that have actually survived, and they consist of both philosophical and scientific works. Among them are *Prior Analytics, Posterior Analytics, Topics, Sophistic Arguments, Physics, On Heaven, On Generation and Corruption, Meteorology, On the Soul, History of Animals, On the Origin of Animals, Metaphysics, Nicomachean Ethics, Eudemian Ethics, Politics, Poetics, On Interpretation, On the Movement of Animals, On Feeling and the Senses, On Memory and Recollection, On Dreams, On a Dream, On Divination through Dreams, On the Long and Short Life, On Life and Death,* and *On Breathing*.

Upon the death of Theophrastus, who had kept Aristotle's manuscripts after the master's death in 322, these works were hidden away in a cellar in the Troad and not brought to light again until the beginning of the 1st century B.C., when they were taken to Rome and edited by Andronicus. Our texts derive from Andronicus's recension and probably do not represent works which Aristotle himself prepared for publication. The peculiarly clipped language in which they are written indicates that they are lecture notes of some sort organized from oral discussions of the material by Aristotle. From the time of his death until the rediscovery of these writings, Aristotle was best known for the works which today are the lost writings. Ironically, modern scholars find themselves in possession of works which their ancient counterparts lacked for several centuries, while the works extant in antiquity are lost today.

# Philosophical and Scientific Systems

The extant writings, however, are sufficient to show the quality of Aristotle's achievement. The *Topics* and the *Analytics* deal with logic and dialectic and reveal Aristotle's contributions to the development of the syllogism and inductive inference. His view of nature is set forth in the *Physics* and the *Metaphysics,* and we see the premise established in these works which marks the most serious difference between Aristotelianism and Platonism: that all investigation must begin with what the senses record and must move only from that point to abstract thought. As a result of this process of intellectualizing, God, who for Plato is eternal Beauty and Goodness, is for Aristotle the Unmoved Mover, Thought contemplating Itself, the highest form of being which is completely lacking in materiality. Aristotle's God neither created nor consciously controls the universe, although the universe is affected by Him (it). Man is the only creature capable of thought even remotely resembling that of the Unmoved Mover, so man's highest goal is to reason abstractly, and he is more truly human to the extent that he achieves that goal.

But such a conclusion does not lead Aristotle to the moralist position taken by Plato, or by the Stoics or Epicureans in later times. Aristotle views men and their affairs from a cooler and more pragmatic point of view, and in the *Nicomachean Ethics* he analyzes the human situation from the point of view of reality as his researches reveal it to him. Man cannot be happy without the usual necessities of physical life, but those necessities do not suffice for true happiness. Since only the philosopher achieves a level of intellectual activity which might be taken seriously, it is the philosopher who achieves true human happiness through the use of his acutely developed ability to think abstractly.

Aristotle's work was often misunderstood in later times. The cardinal sin which later generations committed against this most dynamic of thinkers was to ascribe to his views a rigidity and certainty which they never had. The scientific and philosophical systems set forth in his writings are not conclusions which must be taken as absolute truth, but rather tentative positions arrived at through careful observation and analysis. Modern scholarship has helped to show the vitality of Aristotle's mind, but in the stagnant intellectual climate of imperial Rome and the totally unscientific Christian Middle Ages Aristotle's views on nature and science were taken as a complete system. As a result, his prestige was enormous but not for any reason that would have pleased him.

Aristotle shares with his master, Plato, the role of synthesizer and catalyst. Each of these two giants showed how the probings of the Pre-Socratics fell short of their goals, and each constructed philosophical systems on premises which they considered sound. Plato had a more direct influence on the development of that great mystical movement in late antiquity, Neoplatonism, and Aristotle had a more profound effect on science. Antiquity produced no greater minds than those of Plato and Aristotle, and the intellectual history of the West would be radically different without them.

# Further Reading

Translations of the individual works of Aristotle are too numerous to mention, but a useful starting point is *Works,* translated under the editorship of W.D. Ross (12 vols., 1908-1952). A one-volume *Basic Works* was edited by Richard McKeon (1941). One of the best short introductions to Aristotle's writings is Geoffrey R.G. Mure, *Aristotle* (1964), highly readable but more limited in depth than the useful works of W.D. Ross, *Aristotle* (1923; 5th ed. rev. 1953) and *The Development of Aristotle's Thought* (1957). Other useful general works include D.J. Allan, *The Philosophy of Aristotle* (1952), and John Herman Randall, *Aristotle* (1960). For historical background see M.L.W. Laistner, *A History of the Greek World, from 479 to 323 B.C.* (1957). □



# Aristotle

Encyclopedia of Science and Religion


The great monotheistic religions have regarded Aristotle's philosophy with both appreciation and hostility. Christian, Islamic, and Jewish theologians generally approved of his well-ordered, teleological world in which final causes ordained that natural processes were directed toward the fulfillment of particular ends. Yet Aristotle rejected various important monotheistic tenants, including the belief that God is the ultimate cause of the existence of the world, the resurrection of the body, and the full immortality of the soul. As unqualified believers in these latter doctrines, Christians were particularly compelled to repudiate Aristotle. Theologians thus tended to reject or reinterpret what they took to be Aristotle's offensive opinions while generally accepting his larger natural philosophy.

# Life and work

Aristotle was born in the town of Chalcidice in northern Greece in 384 b.c.e. His father was a physician to the King of Macedon. In 367, at the age of seventeen, Aristotle was sent to Athens to study at Plato's Academy, where he remained for twenty years, until Plato's death in 347. Since he was not chosen to replace Plato as the head of the Academy, Aristotle began a period of travel in Asia Minor, living for awhile in Assos (where he married a woman named Pythias) and then Lesbos until 342, when he accepted King Philip of Macedon's invitation to tutor his son, the future Alexander the Great, then fourteen years old. When Alexander succeeded his father as ruler in 335, Aristotle returned to Athens where he founded his famous school, the Lyceum. Thus began Aristotle's most productive period, which endured until 323, when news of the death of Alexander the Great provoked anti-Macedonian feelings in Athens. A false charge of impiety was made against Aristotle, who then fled Athens to Chalcis in Euboea, where he died in the following year, at the age of sixty-two.

It would be difficult to exaggerate the importance of Aristotle in the history of Western civilization. Not only were his numerous works a dominant factor in at least three civilizations (the Byzantine Empire, Islam, and the Latin West) using three different languages (Greek, Arabic, and Latin, respectively), but his works and ideas remained influential for approximately two thousand years. Aristotle's enormous influence derives not only from his overall brilliance, but also from the fact that he wrote treatises on a remarkable range of topics, which included metaphysics, logic, natural philosophy, biology, ethics, psychology, rhetoric, poetics, politics, and economics (or household management). He is regarded as the founder of two disciplines, logic and biology. The first book of Aristotle's *Metaphysics* is the first history of philosophy as well as the first history of science, while his *Posterior Analytics* is regarded as the first treatise on the philosophy, or methodology, of science. Finally, in six or seven treatises, Aristotle described the structure and operation of the world, thereby formulating a natural philosophy that served as the primary guide for natural philosophers from late antiquity to the seventeenth century in Western Europe, when it was displaced by a new world view associated with Nicolaus Copernicus, Galileo Galilei, Isaac Newton, and many others.

Aristotle reveals a scientific temperament in all his treatises, always emphasizing reason and reasoned argument. He was highly analytic, dividing and categorizing before arriving at important principles and generalizations. He always gives the impression of objectivity and detachment. In coping with any particular problem, Aristotle considered alternative solutions as carefully as possible before resolving the problem.

# Aristotle and the divine

Aristotle's views about religion and divinity play a role in his overall conception of the cosmos and its workings. In Book Eight of his *Physics,* he describes what he calls the "Unmoved Mover" or "Prime Mover," which is the ultimate source, or cause, of motion in the universe, but is itself unmoved. For Aristotle this is God, who dwells at the circumference of the universe and causes motion by being loved. The closer to the Unmoved Mover a body is, the more quickly it moves. Although the Unmoved Mover is God, it did not create the world, which Aristotle regarded as uncreated and eternal. As the prime mover, God enjoys the best kind of life, being completely unaware of anything external to itself and, being the most worthy object of thought, thinks only of itself.

Aristotle's God was clearly not a divinity to be worshipped. Apart from serving as the ultimate source of motion, God, ignorant of the world's existence, could play no meaningful role in Aristotle's natural philosophy. Nevertheless, Aristotle seems to have had a strong sense of the divine, which manifested itself in a sense of wonderment and reverence for the universe.

Aristotle's sense of God was unacceptable to Christians, Muslims, and Jews. Although Plato's concept of a God who created from pre-existent matter was also unacceptable, it was far more palatable to monotheists than was Aristotle's Unmoved Mover, who did not create the world. Indeed, it could not have created the world because, argued Aristotle, the world is eternal, without beginning or end. Aristotle insisted that the material world could not have come into being from another material

entity, say *B*. For if it did, one would have to ask from whence did *B* come? Such an argument would lead to the absurdity of an infinite regression, prompting Aristotle to argue that the world has always existed, an interpretation that posed further problems for Muslims and Christians. Consistent with his assumption of an eternal world, Aristotle regarded creation from nothing as impossible.

Aristotle's concept of nature was fully compatible with those of the major religions. Indeed he provided basic interpretations that were widely adopted. Aristotle distinguished four operative causes in nature:

1. the material cause, or that from which something is composed;
2. the efficient cause, or the agent that made something come into being;
3. the formal cause, or the characteristics that make it what it is; and
4. the final cause, or the purpose for which something exists.

It is the last cause that makes Aristotle's system teleological. Although he did not believe that conscious purposes existed in nature, he was convinced that processes in nature aim toward an end or goal and that "nature does nothing in vain." It is therefore appropriate to characterize Aristotle's natural philosophy and science as teleological, a view of nature's operations that fits nicely into the Christian conception of God's creation.

The manner in which Aristotle argued and rendered judgments provoked Christian theologians in the Middle Ages. On a number of issues, Aristotle produced arguments about the physical world that led him to conclude the impossibility of certain phenomena. For example, in the fourth book of *Physics,* Aristotle argued that the existence of a vacuum is impossible inside or outside of our world. Space is always full of matter, which resists the motion of bodies. In the absence of matter in a vacuum, resistance to motion of any kind would be impossible. Without resistance to its motion, a body would move instantaneously, which is impossible.

In the first book of his treatise *On the Heavens,* Aristotle showed the impossibility of the existence of other worlds. Our world, Aristotle argued, contains all the matter there is, with no surplus left to form one or more other worlds, from which he concludes that "there is not now a plurality of worlds, nor has there been, nor could there be."

Aristotle also argued that without exception all accidental properties—that is, properties that are not essential for the existence of a thing—such as colors, the height of an individual, the size of one's foot, and so on, had of necessity to inhere in the substances of which they were the property. It was impossible that an accidental property exist independently of its subject.

In these, and similar instances, Christians were alarmed at the implications of Aristotle's arguments, for it seemed to place limits on God's absolute power to do whatever God pleased, short of a logical contradiction. Did those who accepted Aristotle's natural philosophy and metaphysics believe that God could not supernaturally create a vacuum just because Aristotle had argued that it was naturally impossible? Did they believe that God could not create other worlds if God wished, simply because Aristotle had argued that other worlds were impossible? And did they regard Aristotle's argument as unqualifiedly true when he declared it impossible that accidents of a substance could exist independently of that substance? The latter claim violated the doctrine of the Eucharist, namely that when God transforms the bread and wine of the Mass into the body and blood of Christ, the accidents of the bread and wine continue to exist without inhering in any substances. The uneasiness with limitations on God's absolute power led theologians in the thirteenth century to place restrictions on Aristotle's natural philosophy. Despite the attempt to circumscribe Aristotle's ideas, the effort did not in any way dampen the enthusiasm with which his works were received in the Latin West, where, during the fourteenth to early seventeenth centuries, they functioned as the curriculum in the arts faculties of virtually all of the sixty to seventy universities that had come into existence by that time.

# Conclusion

Why did the works of Aristotle become so popular in the West despite the many ideas he had proposed that were offensive to Christians and Christianity? The answer is quite simple: His collected works ranged over many themes and subjects and were therefore too valuable to ignore. Moreover, no rival body of literature existed that could pose even a remote challenge to it. By the early seventeenth century, however, numerous new currents of thought came together to subvert Aristotle's natural philosophy, which was largely overwhelmed and by-passed by the end of the seventeenth century.

*See also* Galileo Galilei; God; Islam; Metaphysics; Newton, Isaac; Plato; Teleology

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# Aristotle (384–322 B.C.E.)

Encyclopedia of Education


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Aristotle, the Greek philosopher and scientist, was born in Stagira, a town in Chalcidice. At the age of seventeen he became a member of the Greek philosopher Plato's school, where he stayed for twenty years. After Plato's death in 348 **b.c.e.** Aristotle taught philosophy, first at Atarneus in Asia Minor, then in Mytilene on the island of Lesbos. Then he became tutor of Alexander the Great at the court of Macedonia. In 335 or 334 **b.c.e.** he returned to Athens and founded a school called the Lyceum.

Aristotle's first writings were dialogues modeled on Plato's examples; a few have survived in fragmentary form. The main body of writings that have come down to us consists of treatises on a wide range of subjects; these were probably presented as lectures, and some may be notes on lectures taken by students. These treatises lay unused in Western Europe after the collapse of the Roman Empire in the sixth century **c.e.** , until they were recovered in the Middle Ages and studied by Muslim, Jewish, and Christian thinkers. The large scope of the treatises, together with the extraordinary intellect of their author, gained for Aristotle the title, "the master of those who know."

The treatises are investigative reports, describing a method of inquiry and the results reached. Each treatise includes: (1) a statement of the aim of the subject matter; (2) a consideration of other thinkers' ideas; (3) an examination of proposed principles with the aim of determining the one that has the best prospect of explaining the subject matter; (4) a search for the facts that illustrate the proposed principle; and (5) an explanation of the subject matter by showing how the proposed principle explains the observed facts. The treatises were essential to the work of the Lyceum, which was a school, a research institution, a library, and a museum. Aristotle and his students compiled a *List of Pythian Winners* ; researched the records of dramatic performances at Athens; collected 158 constitutions, of which only *The Constitution of Athens* has survived; prepared a literary and philological study called *Homeric Problems;* and put together a collection of maps and a museum of objects to serve as illustrations for lectures.

Aristotle's writings on logic worked out an art of discourse, a tool for finding out the structure of the world. The other subject matters of Aristotle's treatises are of three kinds: (1) the theoretical sciences–metaphysics, mathematics, and physics–aim to know for the sake of knowing; (2) the productive sciences–such as poetics and rhetoric–aim to know for the sake of making useful or beautiful things; and (3) the practical sciences–ethics and politics–aim to know for the sake of doing, or for conduct. Aristotle said that the theoretical sciences are capable of being understood by principles which are certain and cannot be other than they are; as objects of study their subject matters are necessary and eternal. The productive sciences and the practical sciences are capable of being understood by principles that are less than certain; as objects of study their subject matters are contingent.

Thus Aristotle's idea was that distinct sciences exist, the nature of each to be determined by principles found in the midst of the subject matter that is peculiarly its own. A plurality of subject matters exists, and there is a corresponding plurality of principles explaining sets of facts belonging to each subject matter. What is learned in any subject matter may be useful in studying others; yet there is no hierarchy of subject matters in which the principles of the highest in the order of Being explain the principles of all the others.

# Education for a Common End

Unlike Plato's *Republic* and *Laws,* Aristotle's treatises do not contain lengthy discussions of education. His most explicit discussion of education, in Books 7 and 8 of the *Politics,* ends without being completed. Yet, like Plato, Aristotle's educational thinking was inseparable from his account of pursuing the highest good for human beings in the life of a community. The science of politics takes into account the conduct of the individual as inseparable from the conduct of the community. Thus Aristotle holds that ethics is a part of politics; and equally, politics is a part of ethics. This leads him to argue that the end of individuals and states is the same. Inasmuch as human beings cannot realize their potentiality apart from the social life that is necessary for shaping their mind and character, an investigation into the nature of society is a necessary companion to an investigation into the nature of ethics. The good life is inescapably a social life–a life of conduct in a community. For Aristotle, "the Good of man must be the end of the science of Politics" (1975,1.2.1094b 7–8). In community life, the activity of doing cannot bring into existence something apart from doing; it can only "end" in further doing. And education, as one of the activities of doing, does not "produce" anything apart from education, but must be a continuing process that has no end except further education.

In Aristotle's explicit remarks about the aims of education, it is clear that, like all activities in pursuit of the good life, education is "practical" in that it is a way of conduct, of taking action. At the same time, in pursuing the good life, the aim is to know the nature of the best state and the highest virtues of which human beings are capable. Such knowledge enables us to have a sense of what is possible in education. Educational activity is also a "craft" in the sense that determining the means appropriate for pursuing that which we think is possible is a kind of making as well as a kind of doing. It is commonplace to say that, in doing, we try to "make things happen." Education is an attempt to find the kind of unity of doing and making that enables individuals to grow, ethically and socially.

The *Politics* ends by citing three aims of education: the possible, the appropriate, and the "happy mean." The idea of a happy mean is developed in the *Nicomachean Ethics*. There human conduct is held to consist of two kinds of virtues, moral and intellectual; moral virtues are learned by habit, while intellectual virtues are learned through teaching. As examples, while humans are not temperate or courageous by nature, they have the potentiality to become temperate and courageous. By taking on appropriate habits, their potentialities can be actualized; by conducting themselves appropriately they can learn to actualize their moral virtues. Thus children learn the moral virtues before they know what they are doing or why they are doing it. Just because young children cannot control their conduct by intellectual principles, Aristotle emphasizes habit in training them. First, children must learn the moral virtues; later, when their intellectual powers have matured, they may learn to conduct themselves according to reason by exercising the intellectual virtues.

Arguing that the state is a plurality that should be made into a community by education, Aristotle insisted that states should be responsible for educating their citizens. In the *Politics,* Book 8, he makes four arguments for public education: (1) from constitutional requirements; (2) from the origins of virtue; (3) from a common end to be sought by all citizens; and (4) from the inseparability of the individual and the community. In most states in the Greek world before Aristotle's time, private education had prevailed.

Finally, Aristotle's enduring legacy in education may be characterized as threefold. First is his conception of distinct subject matters, the particular nature and conclusions reached in each to be determined as the facts of its subject matter take their places in the thinking and conduct of the investigator. Second is his insistence on the conjoint activities of ethics and politics, aiming to gain the practical wisdom that can be realized only insofar as citizens strive for the highest good in the context of a community of shared ends. This means that the end of ethics and politics is an educational end. And, third, the education that states need is public education.

Although thinkers may know in a preliminary way what the highest good is–that which is required by reason–they will not actually find out what it is until they learn to live in cooperation with the highest principles of reason. The highest good is never completely known because the pursuit of it leads to further action, which has no end but more and more action. The contingent nature of social existence makes it necessary to find out what is good for us in what we do; we cannot truly learn what it is apart from conduct. While reason is a part of conduct, alone it is not sufficient for realizing the highest good. Only by our conduct can we find out what our possibilities are; and only by further conduct can we strive to make those possibilities actual.

***See also:*** Philosophy of Education**.**

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# Aristotle

UXL Encyclopedia of World Biography


**Born: c. 384 b.c.e.**
**Chalcidice, Greece**
**Died: c. 322 b.c.e.**
**Chalcis, Greece**
*Greek philosopher and scientist*

The Greek philosopher and scientist Aristotle created the scientific method, the process used for scientific investigation. His influence served as the basis for much of the science and philosophy of Hellenistic (Ancient Greek) and Roman times, and even affected science and philosophy thousands of years later.

## *Early life*

Aristotle was born in the small Greek town of Stagiros (later Stagira) in the northern Greek district of Chalcidice. His father, Nicomachus, was a physician who had important social connections. Aristotle's interest in science was surely inspired by his father's work, although Aristotle did not display a particularly keen interest in medicine. The events of his early life are not clear. It is possible that his father served at the Macedonian court (the political leaders of Macedonia, an ancient empire) as physician to Amyntas II (died c. 370 b.c.e.) and that Aristotle spent part of his youth there.

At the age of seventeen Aristotle went to Athens, Greece, and joined Plato's (c. 428–c. 348 b.c.e.) circle at the Academy, a school for philosophers. There he remained for twenty years. Although his respect and admiration for Plato was always great, differences developed which ultimately caused a break in their relationship. Upon Plato's death Aristotle left for Assos in Mysia (in Asia Minor, today known as Turkey), where he and Xenocrates (c. 396–c. 314 b.c.e.) joined a small circle of Platonists (followers of Plato) who had already settled there under Hermias, the ruler of Atarneus. Aristotle married the niece of Hermias, a woman named Pythias, who was killed by the Persians some time thereafter.

In 342 b.c.e. Aristotle made his way to the court of Philip of Macedon (c. 382–c. 336 b.c.e.). There Aristotle became tutor to Alexander (c. 356–c. 323 b.c.e.), who would become master of the whole Persian Empire as Alexander the Great. Little information remains regarding the specific contents of Alexander's education at the hands of Aristotle, but it would be interesting to know what political advice Aristotle gave to the young Alexander. The only indication of such advice is found in the fragment of a letter in which the philosopher tells Alexander that he ought to be the leader of the Greeks but the master of the barbarians (foreigners).

## *Peripatetic School*

Aristotle returned to Athens around 335 b.c.e. Under the protection of Antipater (c. 397–c. 319 b.c.e.), Alexander's representative in Athens, Aristotle established a philosophical school of his own, the Lyceum, located near a shrine of Apollo Lyceus. Also known as the Peripatetic School, the school took its name from its colonnaded walk (a walk with a series of columns on either side). The lectures were divided into morning and afternoon sessions. The more difficult ones were given in the morning, and the easier and more popular ones were given in the afternoon. Aristotle himself led the school until the death of Alexander in 323 b.c.e., when he left Athens, fearing for his safety because of his close association with the Macedonians. He went to Chalcis, Greece, where he died the following year of intestinal problems. His will, preserved in the writings of Diogenes Laertius (third century c.e.), provided for his daughter, Pythias, and his son, Nicomachus, as well as for his slaves.

## *His writings*

Aristotle produced a large number of writings, but few have survived. His earliest writings, consisting for the most part of dialogues (writings in the form of conversation), were produced under the influence of Plato and the Academy. Most of these are lost, although the titles are known from the writings of Diogenes Laertius and from others. Among these important works are *Rhetoric, Eudemus (On the Soul), On Philosophy, Alexander, Sophistes, On Justice, Wealth, On Prayer,* and *On Education*. They were a wide variety of works written for the public, and they dealt with popular philosophical themes. The dialogues of Plato were undoubtedly the inspiration for some of them, although the fall out between Plato and Aristotle reveals itself to a certain extent in these works, too.

A second group of writings is made up of collections of scientific and historical material, among the most important of which is the surviving fragment of the *Constitution of the Athenians*. This formed part of the large collection of *Constitutions,* which Aristotle and his students collected and studied for the purpose of analyzing various political theories. The discovery of the *Constitution of the Athenians* in Egypt in 1890 shed new light on the nature of the Athenian democracy (a government of elected officials) of Aristotle's time. It also revealed the difference in quality between the historical and scientific works of Aristotle and those that followed.

Theophrastus (c. 372–c. 287 b.c.e.) had kept Aristotle's manuscripts after the master's death in 322 b.c.e. When Theophrastus died Aristotle's works were hidden away and not brought to light again until the beginning of the first century b.c.e. They were then taken to Rome and edited by Andronicus (first century b.c.e.). The texts that survive today come from Andronicus's revisions and probably do not represent works that Aristotle himself prepared for publication. From the time of his death until the rediscovery of these writings, Aristotle was best known for the works that today are known as the lost writings.

# *Philosophical and scientific systems*

The writings that did survive, however, are sufficient to show the quality of Aristotle's achievement. The *Topics and the Analytics* deal with logic (the study of reasoning) and dialectic (a method of argument) and reveal Aristotle's contributions to the development of debate. His view of nature is set forth in the *Physics and the Metaphysics,* which mark the most serious difference between Aristotelianism and Platonism: that all investigation must begin with what the senses record and must move only from that point to thought. As a result of this process of intellectualizing, God, who for Plato represents beauty and goodness, is for Aristotle the highest form of being and is completely lacking in materiality. Aristotle's God neither created nor controls the universe, although the universe is affected by this God. Man is the only creature capable of thought even remotely resembling that of God, so man's highest goal is to reason abstractly, like God, and he is more truly human to the extent that he achieves that goal.

Aristotle's work was often misunderstood in later times. The scientific and philosophical systems set forth in his writings are not conclusions that must be taken as the final answer, but rather experimental positions arrived at through careful observation and analysis. During the slow intellectual climate of the Roman Empire, which ruled over much of Europe for hundreds of years after Aristotle died, and the totally unscientific Christian Middle Ages (476–1453), Aristotle's views on nature and science were taken as a complete system. As a result, his influence was enormous but not for any reason that would have pleased him.

Aristotle shares with his master, Plato, the role of stimulating human thought. Plato had a more direct influence on the development of that great spiritual movement in late antiquity (years before the Middle Ages), and Aristotle had a greater effect on science. Antiquity produced no greater minds than those of Plato and Aristotle. The intellectual history of the West would be extremely different without them.

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# Aristotle (384-322 B.C.E.)

Encyclopedia of Children and Childhood in History and Society


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The Greek philosopher and scientist Aristotle was born in Stagira, a town in Chalcidice. For twenty years he was a member of Plato's school. He then taught philosophy at Atarneus in Asia Minor, in Mytilene on the island of Lesbos, and tutored the future Alexander the Great. In 335 to 334 he founded a school called the Lyceum in Athens.

Like Plato, Aristotle departed from the prevailing idea of childhood in Greek antiquity, according to which children were treated as miniature adults and schooled in adult literature as if their minds were able to function like those of adults. Aristotle's ideas on childhood are found, for the most part, in the *Nicomachean Ethics* and *Politics,* in which the aim is to strive for the highest good, happiness, in a city-state. His ethical and political writings are interrelated parts of a whole: because human beings are by nature political (we would say *social* ) animals, one cannot become happy apart from a community. People become individuals as participating members of a social context by sharing certain ends with others and working with them to realize those ends.

Aristotle insists that the conduct by which we strive for the highest good is learned; it is not inborn. That conduct comes about as the consequence of growing, as experienced adults attempt to acknowledge (1) the nature of children who are to be educated toward the best conduct of which they are capable, and (2) the nature of educated adults who have gained some measure of that conduct. Children, Aristotle holds, are incapable of happiness inasmuch as they have not developed the ability to use their intelligence to guide their actions. Children live as their desires impel them; as their development is incomplete, so their desires may lead them to harmful consequences. The behavior of children is akin to that of licentiousness in adults, Aristotle says; but while adults are capable of knowing that they are licentious, children are not.

Children should be trained in the direction of virtuous conduct but cannot engage in such conduct until their intellects develop in such manner that they can determine which means to employ in the pursuit of moral and social ends. This is why children need teachers who conduct themselves according to high moral principles. Training children's desires is not just for the sake of their desires; the training is ultimately for the sake of their developing intellects. As a corollary, one may say that training their bodies is not just for the sake of their bodies, but ultimately for the sake of the souls that are being shaped.

The difficulties in educating children's desires for the sake of their intellects, and in educating their bodies for the sake of their souls, are many. For one thing, the intellects of children's teachers can miss the highest principles of morality, with the result that children may be trained incorrectly. For another thing, certain desires of children, if left unattended by wiser adults, get in the way of proper growth. Aristotle generalizes this difficulty in a memorable passage in the *Eudemian Ethics,* saying that while the good is simple, the bad comes in many shapes. With these difficulties in mind, it is clear that training children's desires and bodies so that they may be enabled to gain some measure of virtuous conduct is a difficult undertaking, fraught with many obstacles stemming from children's desires as well as from the shortcomings of their teachers. In one passage, Aristotle calls learning a *painful* process.

While Aristotle departed from the idea that children may be viewed as miniature adults and thus cannot be expected to engage meaningfully in adult intellectual activities, he was not "permissive" in a modern sense. He did not believe that it should be left to children to determine what they are to do; rather, educated adults, even if they have missed the highest principles of morality, should have some sense of what children can and should do. With this in mind, Aristotle argues that the kind of games children play, as well as the stories appropriate for them, are to be determined by educational officials. Most games, Aristotle holds, ought to be imitations of serious occupations of later life; while children cannot reason as adults are expected to do, they can imitate certain activities without knowing why they are engaged in them. If their education succeeds in realizing the moral aims of their teachers, they can understand the reasons for those activities when they become adults. Their training in childhood is for ultimate happiness, even though children are incapable of happiness: the aim is to enable them to *become happy*.

Private education prevailed in the Greek states in Aristotle's time. Aristotle opposed this practice, arguing that it is an injustice for states to punish citizens who had not been educated in the ways of right conduct. He insisted that states should be responsible for educating their citizens. Pointing out that the state is a plurality that should be made into a community by education, Aristotle argued that public education should strive to work toward common ends to be sought by all citizens, and that the inseparability of the individual and the community constitutes an essential condition requiring public education. Thus the social and moral unity that Aristotle encompassed in his *Nicomachean Ethics* and *Politics* is to be forged and maintained as a *public* responsibility. In this context, the educational officials responsible for determining children's games and stories serve to establish and maintain the public good.

Aristotle connects the pursuit of philosophy with the musical education of children by pointing out that the tunes and modes of musical education must have *ethical* value. Hecloses the *Politics* by holding that we must be mindful of three aims of education–the happy mean, the possible, and the appropriate. In keeping with his idea that while children are incapable of happiness, education should strive for them to become happy as adults, Aristotle reminds us that what is possible and appropriate for adults is not so for children. What is possible and appropriate for children is for the sake of what they are capable of becoming.

*See also:* **Ancient Greece and Rome; Plato.**

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# Aristotle: Anatomy and Physiology

Complete Dictionary of Scientific Biography


In his discussion of animals Aristotle gives great importance to the heart, the blood vessels, and the blood, making the possession of blood the basis for distinguishing one great class of animals, those with blood, from those without blood (roughly the vertebrates and invertebrates). In giving this fundamental position to the heart and blood Aristotle departs from the physiological ideas of the Hippocratic writers; in doing so he seems to have been influenced by the ideas of the Italo-Sicilian-Greek medical thinkers. The stopping of the heartbeat was a certain sign of death and thereafter the body rapidly cooled and became stiff and lifeless. In the developing chick Aristotle saw the beating heart as the first manifestation of life. From this beating heart he saw blood vessels grow out over the yolk, and within the skein of blood vessels thus formed, the body of the young chick gradually emerged. Aristotle emphasized that the heart is the center and the origin of all the blood vessels. he considered that the blood was formed in the heart and passed out from it, because from the moment that the heart became visible it was seen to contain blood and as the network of blood vessels spread out from it, in the embryo chick, the blood accompanied them.

Since the heart, blood, and blood vessels were so fundamental to the bodies of animals Aristotle undertook to discuss them first in his *Historia animalium*. Possibly because of his belief in their fundamental importance he gave one of the earliest accurate descriptions of the blood vessels as a system extending throughout the body, but with its center in the heart. References to the blood vessels by Greek writers before Aristotle emphasized superficial veins, most easily visible in emaciated men, which might be used in bloodletting. Their accounts of the internal arrangement of the blood vessels were extremely vague and fragmentary. By his full and accurate account of the cardiovascular system Aristotle may be considered a founder of detailed anatomical study.

The basis for Aristotle's success in the dissection of the blood vessels was that instead of stunning the animal and bleeding it, in the manner of butchers, he first allowed it to starve to emaciation and then strangled it, thereby retaining in the dead animal all of the blood within the blood vessels. This treatment of the animal had, however, certain physiological consequences which were to influence the character of his observations. The animal killed by strangulation dies in a state of shock which produces a constriction of the small arteries and arterioles in the lungs, thereby cutting off the supply of blood to the left side of the heart. The left ventricle of the heart contracts to empty itself of blood and cannot be refilled. Moreover, the elastic muscle walls of the arterial system contract to squeeze the blood they contain through the capillaries into the veins. Almost all the blood in the body, therefore, accumulates in the venous system, leaving the left side of the heart and the arteries nearly empty. The right side of the heart, on the other hand, is enormously swollen and engorged with blood. When the heart relaxes in death the pressure of blood in the veins will keep open the right auriculoventricular aperture. The flaps of the tricuspid valve will be pressed back against the wall of the ventricle and will be relatively inconspicuous. As a result of these circumstances the right auricle and ventricle will appear as one large chamber continuous with the superior and inferior venae cavae. Instead of four cavities, the heart will appear to have only three, the largest of which will be the united right auricle and ventricle, while the two others will be the left ventricle and the left auricle. Thus to Aristotle the vena cava or "great blood vessel" appeared as a single continuous vessel that broadened in the heart "as a river that widens out in a lake" (*Historia animalium* 513b5, Thompson, trans.). The aorta he saw arising from the middle chamber of the heart and noted that it was more sinewy than the "great blood vessel."

Aristotle did not distinguish between arteries and veins and applied the same term, *phleps* (φλεψ), to both. Neither did he describe the heart valves. He saw the pulmonary artery extending from the "largest chamber on the right" (the right ventricle) upward toward the lung, and he described how in the lung the branches of the pulmonary artery are distributed throughout its flesh and everywhere lie alongside the branches of the tubes (bronchioles) that extend from the windpipe. He traced the main branches of both the venous and arterial systems and described the blood vessels, at least in outline, as a system coextensive with the body, having a shape "like a sketch of a manikin" (*ibid*., 515a34-515b2).

Aristotle interpreted the pulsation of the heart as the result of a kind of boiling movement in the blood which caused it to press against the walls of the heart and to pour out into the blood vessels. The heart walls were thick in order to contain the innate heat generated in it and the heat of the heart produced respiration by causing the lungs to expand and cool air to rush in. The entering air cooled the lungs so that they again subsided and the air, warmed now by the heat taken up from the blood, was expired. Thus for Aristotle respiration served the purpose of cooling and moderating the heat of the blood and the heart.

Aristotle considered the brain to be cold and to exert a cooling influence on the body in opposition to the heating influence of the heart. Since he did not know of the existence of the nervous system as a system extending throughout the body in a manner similar to the blood vessels, he could not conceive of the brain as having the same kind of central role as the heart.

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Leonard G. Wilson



# Aristotle

The Columbia Encyclopedia, 6th ed.



Aristotle (ăr´Ĭstŏt´əl), 384–322 BC, Greek philosopher, b. Stagira. He is sometimes called the Stagirite.

**Life**

Aristotle's father, Nicomachus, was a noted physician. Aristotle studied (367–347 BC) under Plato at the Academy and there wrote many dialogues that were praised for their eloquence. Only fragments of these dialogues are extant. He tutored (342–c.339 BC) Alexander the Great at the Macedonian court, left to live in Stagira, and then returned to Athens. In 335 BC he opened a school in the Lyceum; some distinguished members of the Academy followed him. His practice of lecturing in the Lyceum's portico, or covered walking place (*peripatos*), gave his school the name Peripatetic. During the anti-Macedonian agitation after Alexander's death, Aristotle fled in 323 BC to Chalcis, where he died.

**Works**

Aristotle's extant writings consist largely of his written versions of his lectures; some passages appear to be interpolations of notes made by his students; the texts were edited and given their present form by Andronicus of Rhodes in the 1st cent. BC Chief among them are the *Organum,* consisting of six treatises on logic; *Physics; Metaphysics; De Anima* [on the soul]; *Nicomachean Ethics* and *Eudemian Ethics;De Poetica* [poetics]; *Rhetoric;* and a series of works on biology and physics. In the late 19th cent. his *Constitution of Athens,* an account of Athenian government, was found.

**Philosophy**

**Logic and Metaphysics**

Aristotle placed great emphasis in his school on direct observation of nature, and in science he taught that theory must follow fact. He considered philosophy to be the discerning of the self-evident, changeless first principles that form the basis of all knowledge. Logic was for Aristotle the necessary tool of any inquiry, and the syllogism was the sequence that all logical thought follows. He introduced the notion of category into logic and taught that reality could be classified according to several categories—substance (the primary category), quality, quantity, relation, determination in time and space, action, passion or passivity, position, and condition.

Aristotle also taught that knowledge of a thing, beyond its classification and description, requires an explanation of causality, or why it is. He posited four causes or principles of explanation: the material cause (the substance of which the thing is made); the formal cause (its design); the efficient cause (its maker or builder); and the final cause (its purpose or function). In modern thought the efficient cause is generally considered the central explanation of a thing, but for Aristotle the final cause had primacy.

He used this account of causes to examine the relation of form to matter, and in his conclusions differed sharply from those of his teacher, Plato. Aristotle believed that a form, with the exception of the Prime Mover, or God, had no separate existence, but rather was immanent in matter. Thus, in the Aristotelian system, form and matter together constitute concrete individual realities; the Platonic system holds that a concrete reality partakes of a form (the ideal) but does not embody it. Aristotle believed that form caused matter to move and defined motion as the process by which the potentiality of matter (the thing itself) became the actuality of form (motion itself). He held that the Prime Mover alone was pure form and as the "unmoved mover" and final cause was the goal of all motion.

**Ethics and Other Aspects**

Aristotle's ethical theory reflects his metaphysics. Following Plato, he argued that the goodness or virtue of a thing lay in the realization of its specific nature. The highest good for humans is the complete and habitual exercise of the specifically human function—rationality. Rationality is exercised through the practice of two kinds of virtue, moral and intellectual. Aristotle emphasized the traditional Greek notion of moral virtue as the mean between extremes. Well-being (*eudaemonia*) is the pursuit not of pleasure (hedonism) but rather of the Good, a composite ideal, consisting of contemplation (the intellectual life) and, subordinate to that, engagement in politics (the moral life). In the *Politics,* Aristotle holds that, by nature, humans form political associations, and he explores the best forms these may take. For Aristotle's aesthetic views, which are set forth in the *Poetics,* see tragedy.

**Aristotelianism**

After the decline of Rome, Aristotle's work was lost in the West. However, in the 9th cent., Arab scholars introduced Aristotle to Islam, and Muslim theology, philosophy, and natural science all took on an Aristotelian cast. It was largely through Arab and Jewish scholars that Aristotelian thought was reintroduced in the West. His works became the basis of medieval scholasticism; much of Roman Catholic theology shows, through St. Thomas Aquinas, Aristotelian influence. There has also been a revival of Aristotelian influence on philosophy in the 20th cent. His teleological approach has continued to be central to biology, but it was banished from physics by the scientific revolution of the 17th cent. His work in astronomy, later elaborated by Ptolemy, was controverted by the investigations of Copernicus and Galileo.

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# Aristotle

International Encyclopedia of the Social Sciences


BIBLIOGRAPHY

Aristotle was born near the Greek village of Stagira. While he was still a young man, this area came under the control of the kingdom of Macedonia. Aristotle's father was a physician in the royal Macedonian court, which led to the son's early interest in biology and, later, to his becoming the tutor of Alexander the Great (356-323 bce). At the age of eighteen, Aristotle departed for Athens, where he attended Plato's Academy for twenty years. After Plato's death, Aristotle spent a couple of years in Asia Minor, where he married and engaged in biological research. When Alexander became king of Macedonia in 336 bce, Aristotle returned to Athens, where he established the Lyceum, a rival school to Plato's Academy. Plato's Academy continued until it was closed by Emperor Justinian in the sixth century ce. After Alexander's death in 323 bce, Aristotle came under suspicion as an agent of Macedonia and was forced to flee Athens.

Aristotle's works may be broadly classified into those dealing with the theoretical sciences (e.g., physics, mathematics, and metaphysics) and those dealing with the practical sciences (e.g., ethics, political science, rhetoric, and poetics). Informing all of Aristotle's works is his approach to logic. The six logical works are the *Categories, On Interpretation*, the *Prior Analytics*, the *Posterior Analytics*, the *Topics*, and *On Sophistical Refutations*. These works are traditionally collected together under the title of the *Organon*. Important works in the theoretical sciences are the *Physics, On the Soul,* and the *Metaphysics*. In the practical sciences, the *Nichomachean Ethics*, *Politics*, and *Poetics* are particularly noteworthy. All of these works have been influential, in varying degrees, in the development of the modern social sciences. But Aristotle's influence has been particularly important in the development of political science, and the seminal works here are the *Nichomachean Ethics* and the *Politics*.

In most of the contemporary social sciences a fact-value dichotomy is observed. That is, the researcher must carefully distinguish between facts based on empirical observation and values based on personal preferences. This distinction is denied in Aristotle's works, however, and one must read the *Nichomachean Ethics* and the *Politics* as one extended work. Thus, Aristotle distinguishes six types of states, according to qualitative as well as quantitative considerations. Monarchy is the rule of one in the interest of all, while tyranny is a corrupted form of monarchy. Similarly, aristocracy is the rule of the few in the interest of all, while oligarchy is the selfish rule of the few. Polity, finally, is the rule of the many in the interest of all, while democracy is the decayed rule of the many in their own interest. To Aristotle, human beings are political by nature, for they develop in association with others—beginning with the household, progressing through a village organization, and coming to full maturity in the *polis*, or city-state. This teleological approach to the human or social sciences pervades all of Aristotle's writings on the practical sciences.

Aristotle's influence in Western civilization is such that he was considered "the philosopher" throughout the Middle Ages. His influence has also been considerable in Christian theology, especially through the works of Thomas Aquinas (1225-1274); in philosophy, especially in his teachings regarding intellectual and moral virtues; in the physical sciences, notably as the target of extensive criticism by modern giants such as Galileo Galilei (1564-1642); and in the modern social sciences, with particular reference to political science.

**SEE ALSO** *Philosophy; Plato; Political Science*

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***Timothy Hoye***



# Aristotle

Animal Sciences


Philosopher
384 B. C. E. -322 B. C. E.

Aristotle, Greek philosopher and scientist, was born in 384 B. C. E. in Stagira, northern Greece. He died in 322 B. C. E. He is considered one of the most influential thinkers in history.

Aristotle's father was the physician to the king of Macedonia. Being a doctor's son most likely influenced his strong interest in science. Upon the death of his father in 367 B. C. E. , Aristotle was sent to the Academy of Plato in Athens. He remained there for twenty years, first as a student, then as a teacher. He studied a wide variety of subjects, earning the nickname "the reader." After Plato's death, Aristotle left Athens and traveled about for twelve years. For a number of years during this time, he tutored Alexander the Great, the son of Phillip II of Macedonia. Aristotle married once or twice and had two children. At the age of fifty, he returned to Athens and founded his own school, the Lyceum. There, for twelve years, Aristotle studied a wide range of subjects, especially nature. When Alexander the Great died in 323 B. C. E. , Aristotle feared political persecution, so he left Athens. He moved to Chalcis in central Greece, where he lived for a year until his death.

Aristotle made many important contributions to biology. He was the first to classify animals. He grouped animals as having blood or not in his most basic classification. His observations led to the knowledge that mammals are warm-blooded, have lungs, breathe air, and suckle their young. In classifying animals, Aristotle realized that they should not be grouped based only on their external parts. Instead, he understood that even animals that appeared very different could be related. Aristotle identified four means of reproduction: the **abiogenetic** origin of life from nonliving mud; **budding** (**asexual reproduction** );

**sexual reproduction** without **copulation** ; and sexual reproduction with copulation. Aristotle did not believe in natural selection, or survival of the fittest. Instead, he believed in teleology, that plants and animals have natural goals. Their form could be fully understood only when those goals were known. Aristotle believed that all organisms are perfectly adapted to their surroundings. His observations led to the principle that general structures appear before specialized ones, and that tissue forms before organs.

Aristotle's theory is in opposition to Charles Darwin's "theory of evolution by natural selection." Darwin argued that random genetic **mutations** produced slightly different characteristics in members of a species. Those individuals with advantageous traits would reproduce more successfully than those without them, resulting in a constantly evolving population. Darwin's ideas of constant change, chance, and chaos are in contrast with Aristotle's explanation of biology through order and purpose.

Although it is known that Aristotle wrote a huge amount of material, most of it has been lost. The few documents that remain appear to be notes he used for teaching. Also, it is not certain whether some of the books attributed to him were actually written by him or by others who were summarizing his writings and teachings.

Aristotle made lasting contributions in fields other than the natural sciences. These were philosophy, logic, ethics, and psychology.

*Denise Prendergast*

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# Aristotle

West's Encyclopedia of American Law


Aristotle was born in 384 b.c., in Stagira, Greece. He achieved prominence as an eminent philosopher who greatly influenced the basic principles of philosophy and whose ideologies are still practiced today.

Aristotle was a student of the renowned philosopher Plato and tutored Alexander the Great, who became King of Macedonia in 336 b.c.

Aristotle established his own school in the Lyceum, near Athens, in 335 b.c. He often lectured his students in the portico, or walking place, of the Lyceum. The school was subsequently called Peripatetic, after the Greek word *peripatos* for "walking place."

In 323 b.c. the reign of Alexander ended with his death, and Aristotle sought refuge at Chalcis.

Aristotle formulated numerous beliefs about the reasoning power of humans and the essence of being. He stressed the importance of nature and instructed his pupils to closely study natural phenomena. When teaching science, he believed that all ideas must be supported by explanations based upon facts.

Concerning the realm of politics, Aristotle propounded that humans are inherently political and demonstrate an essential part of their humanity when participating in civic affairs.

Philosophy was a subject of great interest to Aristotle, and he theorized that philosophy was the foundation of the ability to understand the basic axioms that comprise knowledge. In order to study and question completely, Aristotle viewed logic as the basic means of reasoning. To think logically, one had to apply the syllogism, which was a form of thought comprised of two premises that led to a conclusion; Aristotle taught that this form can be applied to all logical reasoning.

"Man is by nature a political animal."
—Aristotle

To understand reality, Aristotle theorized that it must be categorized as substance, quality, quantity, relation, determination in time and space, action, passion or passivity, position, and condition. To know and understand the reality of an object required an explanation of its material cause, which is why it exists or its composition;

its formal cause, or its design; its efficient cause, or its creator; and its final cause, or its reason for being.

Aristotle agreed with his mentor, Plato, concerning the field of ethics. The goodness of a being depended upon the extent to which that being achieved its highest potential. For humans, the ultimate good is the continual use and development of their reasoning powers to fullest capacity. To effect fulfillment and contentment, humans must follow a life of contemplation, rather than pleasure.

The fundamental source of Aristotle's theories were his lectures to his students, which were compiled into several volumes. They include *Organum*, which discusses logic; *Physics; Metaphysics; De Anima*, concerning the soul; *Rhetoric; Politics; Nichomachean Ethics and Eudemian Ethics*, involving principles of conduct; and *De Poetica*, or poetics.

He also wrote *Constitution of Athens*, a description of the foundations of the government of Athens. The work was discovered in the late nineteenth century.

Aristotle died in 322 b.c., in Chalcis, Greece.

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# Aristotle

World Encyclopedia


**Aristotle** (384–322 bc) Greek philosopher, founder of the science of logic and one of the greatest figures in Western philosophy, b. Macedonia. Aristotle studied (367–347 bc) under Plato at the Academy in Athens. After Plato's death he tutored the young Alexander the Great, before founding the Lyceum (335 bc). Anti-Macedonian disturbances forced Aristotle to flee (323 bc) to Chalcis on the island of Euboea, where he died. In direct opposition to Plato's idealism, Aristotle's metaphysics is based on the principle that all knowledge proceeds directly from observation of the particular. Aristotle argued that a particular object can only be explained through an understanding of causality. He outlined four causes: the *material* cause (an object's substance); *formal* cause (design); *efficient* cause (maker) and the *final* cause (function). For Aristotle this final cause was the primary one. Form was inherent in matter. His ethical philosophy stressed the exercise of rationality in political and intellectual life. Aristotle's writings cover nearly every branch of human knowledge, from statecraft to astronomy. His principal works are the Organon (six treatises on logic and syllogism); Politics (the conduct of the state); Poetics (analysis of poetry and tragedy) and Rhetoric. After the decline of the Roman Empire, Aristotle was forgotten by the West. But he had a profound effect on the development of Islamic philosophy, and it was through Arab scholarship that his thought filtered into medieval Christian scholasticism and in particular the work of Saint Thomas Aquinas.

http://www.utm.edu/research/iep/a/aristotl.htm

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# Aristotle

The Concise Oxford Dictionary of World Religions


**Aristotle** (384–322 BCE). Greek philosopher whose influence on W. theology and philosophy has been prodigious—though it was not so much by a strict exegesis of his ideas as by an eclectic adaptation combined particularly with Neoplatonism. But the influence and adaptation are not surprising. In his own thought, a theology or science of God is the primary form of knowledge, partly because God is the source (*arche*) of all things, and partly because God alone possesses knowledge in the highest degree. The human desire to know is thus the highest truth of our being, and is potentially a sharing in God's knowledge of himself. This aspiration may in the past have been handed down in myth, but through *nous* (intellect or intelligence which is the essence of God's nature) humans attain to God. The insistence on the rationality of God and of the human possibility of entering into union with God through *nous* laid foundations for a theological and rational spirituality which flourished especially in Islam—albeit by then in a form which was Platonic. The real influence of Aristotle on W. Christian theology came in the 13th cent., mediated by Jews and Muslims, becoming a source of controversy (Aristotelianism was condemned in Paris in 1277), but providing nevertheless the philosophical basis for scholasticism, especially in St Thomas Aquinas.



# Aristotle

The Oxford Dictionary of Phrase and Fable


**Aristotle** (384–322 bc), Greek philosopher and scientist. A pupil of Plato and tutor to Alexander the Great, he founded a school (the Lyceum) outside Athens. He is one of the most influential thinkers in the history of Western thought and his work

was central to Arabic and medieval philosophy. His surviving works cover a vast range of subjects, including logic, ethics, metaphysics, politics, natural science, and physics.

*Aristotelian logic* is the traditional system of logic expounded by Aristotle and developed in the Middle Ages, concerned chiefly with deductive reasoning as expressed in syllogisms.
Aristotle's lantern a conical structure of calcareous plates and muscles supporting the rasping teeth of a sea urchin. The term derives from Aristotle's Historia Animalium, where the body of the echinus is said to be shaped like the frame of a lantern.



# Aristotle

Oxford Dictionary of Rhymes


**Aristotle** •**battle**, cattle, chattel, embattle, prattle, rattle, Seattle, tattle •fractal •**cantle**, covenantal, mantel, mantle, Prandtl •pastel • Fremantle • tittle-tattle •**startle**, stratal •Nahuatl •**fettle**, kettle, metal, mettle, nettle, petal, Popocatépetl, settle •**dialectal**, rectal •**dental**, gentle, mental, Oriental, parental, rental •transeptal •**festal**, vestal •gunmetal •**antenatal**, fatal, hiatal, natal, neonatal, ratel •**beetle**, betel, chital, decretal, fetal •blackbeetle •**acquittal**, belittle, brittle, committal, embrittle, it'll, kittle, little, remittal, skittle, spittle, tittle, victual, whittle •**edictal**, rictal •**lintel**, pintle, quintal •**Bristol**, Chrystal, crystal, pistol •varietal • coital • phenobarbital •orbital • pedestal • sagittal • vegetal •digital • skeletal • Doolittle •**congenital**, genital, primogenital, urogenital •capital • lickspittle • hospital • marital •**entitle**, mistitle, recital, requital, title, vital •subtitle • surtitle •**axolotl**, bottle, dottle, glottal, mottle, pottle, throttle, wattle •**fontal**, horizontal •**hostel**, intercostal, Pentecostal •greenbottle • bluebottle • Aristotle •**chortle**, immortal, mortal, portal •Borstal •**anecdotal**, sacerdotal, teetotal, total •**coastal**, postal •subtotal •**brutal**, footle, pootle, refutal, rootle, tootle •**buttle**, cuttle, rebuttal, scuttle, shuttle, subtle, surrebuttal •**buntal**, contrapuntal, frontal •crustal • societal • pivotal •**hurtle**, kirtle, myrtle, turtle

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# Aristotle

Encyclopedia of Religion


**ARISTOTLE** (384–322 bce), along with Plato, was the greatest philosopher of antiquity. His influence on Western philosophical and scientific culture has been enormous, and even in the twenty-first century in many fields of knowledge (metaphysics, logic, ethics, biology, and psychology) the name of Aristotle represents an important point of reference.

# Life and Works

Aristotle was born in the city of Stagira in northern Greece and at the age of seventeen moved to Athens, where for about twenty years he attended the Academy, the school founded by Plato. There he obtained an extensive and liberal education, ranging from logic to natural philosophy, from metaphysics to astronomy. From 360 bce onward he held regular courses and seminars within the Academy. After the death of Plato in 348 bce, Aristotle left Athens and the Academy, traveling to Atarneus, Assus, and Mytilene and then to Pella, where he was the tutor of Alexander the Great, the future ruler of Greece, for about three years. During this period Aristotle concentrated his efforts on the study of biology and zoology and produced his scientific works. From 335 bce he was once again back in Athens, where he founded the Lyceum, a school that rivaled the institution established by Plato and headed at that time by Xenocrates. The composition or definitive arrangement of Aristotle's major scholarly works may be dated to this period of teaching at the Lyceum.

The writings of Aristotle are traditionally divided into two groups: those intended for publication, the so-called exoteric works (*exoterikoi logoi* ), and those written for internal use in the school and thus termed acroamatic (from *akroasis*, what is heard, thus heard in a lesson) or esoteric. The first group includes dialogues, such as the *Protrepticus* (an exhortation to philosophy), *On Philosophy*, and *Eudemus*, as well as doctrinal and polemical works, such as *On the Good* and *On Ideas* ; the second includes the major treatises written for his school, such as *Metaphysics, Physics, On the Heaven, Nicomachean Ethics, Eudemian Ethics, On the Soul, Rhetorics, Poetics*, the works on biology and zoology (*On the Parts of Animals, The History of Animals* ), and the works of logic (*Categories, Topics, Analytics* ). By a quirk of fate only those works not intended for publication, that is, the acroamatic or esoteric texts, still exist, whereas none of the works published by Aristotle has survived. Knowledge of these relies upon quotations from later writers.

# The Theology of the Young Aristotle

In the twentieth century there were a number of studies concerning the so-called theology of the young Aristotle. In the dialogue *On Philosophy*, Aristotle probably alluded to two divinities, one cosmic, represented by the heavens (alive and composed of ether), the other metacosmic, in all probability represented by the unmoved prime mover, "Thought of Thought." In any case it seems certain that he laid down a clear order of importance between the two divinities, making the metacosmic

divinity, that is the prime mover, superior to the heavens, whose very movement depended upon the unmoved mover. In the *Eudemus* he developed a theory of the soul, even if it is unclear whether in this dialogue Aristotle supported a radical dualism between body and soul like that of Plato or presented the idea of the soul as a form and function of the body just as in the work *On the Soul*. The *Protrepticus* finally contained proof of the superiority of the contemplative or speculative life, that is to say the truly philosophical way of life. The latter was considered divine, because it reveals man as like God, who is Thought, that is pure contemplative activity. The *Protrepticus* also contained an important argument in support of the unavoidable nature of philosophy, because even the rejection of the same requires its use in argument and thus "playing philosophy."

# Nature and Its Principles

The starting point of Aristotle's philosophical thinking can be identified in the rejection of the theory of the forms put forward by Plato. Even during the years he spent at the Academy, Aristotle distanced himself from the theories of his teacher. Moving from a systematic analysis of language, especially predicative language, Aristotle singled out the primary meaning of being, upon which everything else somehow depends. This first meaning is represented by the category of substance (*ousia* ), which in its purest form is identified with the particular individual. In order to be able to describe a particular reality as old (quality), as 170 centimeters tall (quantity), as in the Lyceum (place), as married to Xanthippe (relation) one must recognize the existence of an individual, in this case Socrates, all these attributes pertain to or are inherent in him. In its fullest meaning therefore being is not that of ideas, that is, of universals, but rather of substances, namely particular individuals or things (Socrates, a dog, the computer used to type these words).

The concept of substance expressed in the *Categories* is presumed in the analysis of the principles and causes of nature (*physis* ) developed in the first two books of the *Physics*. Here too Aristotle starts by rejecting the Platonic theory of forms, especially the claim that the causes of the existence of sense objects may be seen in forms. According to Aristotle the common condition of all natural reality consists of motion, namely in the fact that all natural beings are subject to processes of reproduction and decay, of alteration, modification, and movement, and that they contain within themselves the cause of this change. Platonic forms, which are unmoved and separate, cannot in fact be the causes of natural reality because they are not able to explain the essential characteristic of the latter, namely that they are subject to movement (kinesis) and change *(metabolē)*.

In his study of the principles of motion, Aristotle begins by recognizing, in common with many of his predecessors, that they are represented by opposites (love and strife, thick and thin, night and day). Because they do not, however, intersect with each other, it is necessary to recognize a third principle. Furthermore in order to talk about becoming, something must become, and in particular there is a certain reality that remains constant during the process of becoming. Aristotle thus divides any natural event into three constituent parts: the start is characterized by the absence or lack (*steresis* ) of the form the object is to attain; the end in which the reality concerned takes on the form (*eidos* ) with which the process ends or is fulfilled; and a third element that remains unchanged during the process and provides its unitary aspect, that is, the subject or underlying substrate (*hypokeimenon* ). If the event to be described is the process of Socrates growing old, the *steresis* is Socrates when he is not old, the form is Socrates when he is old, and the underlying substrate or subject is Socrates himself.

It is important to understand that according to the Aristotelian concept the principles of becoming are not things but rather aspects of the things, points of view through which it is possible to analyze the mechanisms of change (*Physics*, I). A similar function is elaborated upon from the concepts of potentiality (*dynamis* ) and actuality (*energeia, entelecheia* ). These make natural processes intelligible and can be considered the realization of an already existing potentiality. Aristotle thus introduces the dimension of finalism and teleology into the analysis of the nature of becoming. Being and becoming of things may be analyzed from a causal perspective, because knowledge is the knowledge of cause (*aitia* ). According to Aristotle there are four kinds of cause: material cause, that is, the matter (*hyle* ) from which something is made; formal cause, that is, its form (*eidos* ) and its organizing principle; efficient cause, that is, the moving principle (*to kinoun* ); and final cause, that is, the purpose (telos) why something is what it is or an event takes place (*Physics*, II).

The kind of motion characteristic of natural realities also depends upon the elements of which they are composed. Those that belong to the sublunar world are made of four traditional elements (earth, air, fire, and water). That is to say they are subject to decay and naturally inclined to move in straight lines. Heavenly bodies, meaning the stars, are made of a fifth element, the well-known ether, which is the reason for their incorruptibility and the circular motion they have.

# "First Philosophy"

Aristotle called physics "second philosophy" to distinguish it from "first philosophy," that is, from the branch of study that has been given the name "metaphysics" by Western tradition. "First philosophy" (*prote philosophia* ) can be distinguished from physics on two grounds: (a) the universality of its object, which is not a single aspect of being but rather the study of "being as such," and (b) on account of the value and elevated nature of this object, which is ontologically superior to the realities of the physical world. In modern philosophy these two have been given the names *metaphysica generalis* (or ontology) and *metaphysica specialis* (or theology). Thus a philosopher such as Martin Heidegger held Aristotle responsible for founding ontotheology, namely Western metaphysics. Studies have shown nonetheless Aristotle's first philosophy was neither one thing nor the other. Rather, it was essentially a theory of substance because substance is the most important of the meanings of being. Being can be spoken of with many meanings (*to on pollachōs legetai* ), but all relate to one principal meaning, that of

substance (*Metaphysics*, IV). This idea has been called *focal meaning*, because it regards the meanings of being on the basis of the relationship with one unique principal meaning (*pros hen* Relation). The task of first philosophy is also to investigate what belongs to being as such, that is, its common attributes, such as unity and multiplicity, identity and diversity (medieval transcendentals). Furthermore it should also study the principle common to all demonstrations and therefore to all being: the principle of noncontradiction. This cannot be proved directly (because it is the basis of every proof), but it can be dialectically demonstrated that it is impossible to refute (*Metaphysics*, IV).

First philosophy is transformed into a theory of substance (*Metaphysics*, VII–IX), because substance is the first meaning of being. For Aristotle substance is the specific individual composed of form and matter. Yet still more substance is the form (*eidos* ) that determines the being-as-it-is of a particular matter. In this sense substance as form or essence is the cause of being of the individual (*Metaphysics*, VII). In contrast to the Platonic forms, the Aristotelian substances-forms are not universal but rather individual, that is, they belong individually to the things of which they are forms. Form is therefore the organizing principle of matter. In terms of definition the forms of individuals of the same species are identical, but in numerical terms each individual has its own form. In the case of living beings the form is the soul, which represents the organizing vital principle of the body (*On the Soul*, I–II). Contrary to Plato, Aristotle considers the soul inseparable from the body, even if he does concede the possibility that part of it, the famous active intellect (*nous poietikos* ), is independent of the body—arising in it from outside—and perhaps immortal (*On the Soul*, III). In any case the active intellect is not the unmoved prime mover, as Alexander of Aphrodisia thought.

The most famous idea of Aristotle is in Book XII of the *Metaphysics* and concerns the "immovable prime mover." This probably dates back to his youth and is not easy to reconcile with subsequent teachings. The observation of the eternity of motion and time caused Aristotle to postulate the existence of eternal principles, which are the cause of the eternal nature of physical motion. The latter finds its most elevated expression in the motion of the heavens. Aristotle observes that the cause of eternal motion must be an active and unmoved reality, otherwise it would itself require a principle and so on ad infinitum. Since the highest and most noble activity consists of thought (*noēsis* ), this principle must be identified with thought and in precise terms with the thought of the most elevated object, that is, itself. The principle of motion must be "thought of thought" (*noēsis noēseōs* ). Aristotle calls this being God (*theos* ) as well as living an eternal and perfect life like the gods. The traditional interpretation attributes final causality to the unmoved mover. He moves the first heaven, that is the heaven of fixed stars, in which he is loved. This is possible because the heavens (or the celestial spheres) are given a soul, which longs for and loves the immovable mover, and via their circular motion the heavens try to imitate the absolute immobility of the latter as far as possible. In the twentieth century there was a new interpretation, according to which the unmoved mover does not move as a final cause but rather as a cause of motion, that is, efficient. He moves in the same way as the soul, except that the unmoved mover is transcendent with regard to the heavens, whereas the soul is immanent to what moves.

In Book VI of the *Metaphysics*, Aristotle attempts to bring together the two perspectives of "first philosophy," namely its universality and the value of its object. He asserts that "first philosophy" is first because its object consists of unmoved substances and is thus also universal, and its task will be to investigate being as such and its characteristics.

# Ethics and Politics: Happiness

Physics, "first philosophy," and mathematics are theoretical sciences; their aim is in essence a dispassionate knowledge of reality. For Aristotle beside theoretical exist practical disciplines, that is, directed toward action (praxis). These comprise the fields of ethics (relating to individual moral action) and politics (concerning the action of the community). The ultimate aim of action is, according to Aristotle, the attainment of happiness (*eudaimonia* ) (*Nicomachean Ethics*, I). For human beings the condition of happiness corresponds to the fulfillment of the highest form of life, that is, the one related to the highest function of the soul. The rational soul has two parts, the calculating part (*logistikon* ) and the scientific part (*epistemonikon* ). A particular virtue corresponds to each of these: respectively practical wisdom (*phronesis* ) and theoretical wisdom (*sophia* ). Both are dianoetic virtues, that is, they concern thought (*dianoia* ) (*Nicomachean Ethics*, VI). Because a part of the soul had to do with the emotions and passions, it is necessary to recognize corresponding virtues here. This means the famous ethical virtues of courage, temperance, and liberality. Each of these represents the golden mean between two extremes, excess and deficiency (*Nicomachean Ethics*, II). Of the two dianoetic virtues, *sophia* concerns those aspects of reality that cannot be other than they are, that is, what is essential: it represents a kind of theoretical reason. When they achieve the highest form of life, contemplation, human beings are similar to God, who is, however, greater, because he lives eternally in that single state that people may only attain for a limited time (*Nicomachean Ethics*, X).

*Phronesis*, on the other hand, deals with those things that can be other than they are, that is, contingent reality: in this sense it represents practical reasoning. According to Aristotle the supreme practical virtue, *phronesis*, consists in the ability to establish suitable means to achieve determined ends. However, the latter seem to be set outside the deliberative dimension of practical philosophy. The identification of ends depends upon an act of the will (*boulesis* ), which is independent of *phronesis*. For Aristotle indeed the determination of the ends of praxis by the will belongs to the realm of inclinations and desire, which are not subject to practical reasoning. This position has led some contemporary interpreters to charge Aristotelian ethics with making conservative assumptions, as it does not seem to possess rational criteria to legitimize the selection of the ends of action and risks basing the scope of ends on accepted prevalent values in a particular society. This discussion belongs to the so-called re-establishment of practical philosophy.

"Man is by nature a political animal" (*Politics*, III) is a statement that inicates that the social aspect is essential for the attainment of well-being. The two basic units of social life are the family and the state, that is the polis. The family consists of not only husband, wife, and children but also the slaves and the household generally (*oikos* ) and its property. To Aristotle women were naturally subordinate to men, children to their father, and slaves to their master. The purpose of the family was the preservation of the human species and property. The states have different kinds of constitutions, depending upon whether they are governed by an individual, a restricted group, or the entire citizen body. The first of these is a monarchy, the second an aristocracy, and the third a *politeia*, that is, the positive form of democracy. Each of these three kinds of constitutions also has a debased form, which occurs when those who govern do so in their own interest rather than that of the citizens as a whole. These are tyranny, oligarchy, and debased democracy, that is, rule by demagogues.

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# Aristotle

New Catholic Encyclopedia


Philosopher of Stagira, a Greek colony in the Chalcidic Peninsula, and hence referred to as the Stagirite; b. summer of 384 b.c.; d. Chalcis in Euboea, autumn of 322 b.c. For 20 years a student of plato, Aristotle broke with Plato's successors in the Academy and founded his own school, later known as the Peripatetics. Very influential in the whole of Western philosophy, especially with the scholastics of the 13th century, his thought is notable for its development of logic; its elucidation of the four causes and the related doctrines of matter and form, and potency and act; its ethical teaching on the moral virtues; and the political notion of the common good. His writings are important also in the history of literature and of the natural sciences.

# Biography

Nothing is known directly of Aristotle's boyhood, though his ancestry was thoroughly Greek. His father, Nicomachus, was described as a descendant of the Machaon Asclepiadae, thus indicating aristocratic birth and medical interests. As physician and personal friend of Amyntas (II or III), father of Philip of Macedon, Nicomachus lived at the Macedonian court. Aristotle's mother, Phaestis, of a colonizing family from Chalcis in Euboea, was also represented as of Aesculapian lineage.

**Early Life.** Both parents died while Aristotle was a minor, and the charge of his education devolved upon a certain Proxenus, probably a close relative. At about 17 Aristotle arrived at Athens. During the next 20 years, his "first Athenian period," he associated with the great philosopher Plato, head of the already highly organized and well-known Academy. His writings show that he acquired a deep and solid background in Platonic philosophy during his formative days. He engaged in teaching, and at a certain time he is reported to have suddenly changed his method of instruction to emphasize rhetorical training, in order to compete with the rival school of Isocrates. His prolific career as a writer began with *Gryllus,* a work on rhetoric named after Xenophon's son, which may be dated about 361 b.c., when Aristotle was about 23. Another work, *Eudemus,* suggests dating about 353, when he was about 30.

Early in 347, possibly before Plato's death in the first half of that year, Aristotle left Athens, perhaps because of a surge of anti-Macedonian sentiment, and spent the next three years at the court of Hermias, ruler of Atarneus and Assos, coastal towns of Asia Minor facing the island of Lesbos. Hermias had been interested in Plato's work and was most cordial in his hospitality to Aristotle, giving him in marriage Pythias, his niece and adopted daughter. Of this marriage was born a daughter, named Pythias. Aristotle had a son also, called Nicomachus. In his will the two children are viewed in the same legal status. A later report, claiming that Nicomachus was Aristotle's son by Herpyllis, one of his domestics, was taken from the noted but adversely disposed historian Timaeus and has the earmarks of a calumny circulated in a program of defamation after the Stagirite's death. Sometime during 345-344 b.c. Aristotle left the court of Hermias for Mytilene on nearby Lesbos. In 343-342 he was summoned to Macedon to tutor Alexander. His stay there lasted until a short time after Alexander's succession to the throne at about 20 in the summer of 336. Geographical indications suggest that Aristotle conducted his extensive research in natural history mainly during these years in Asia Minor and Macedon.

**Aristotle's School.** In 335 or 334, probably in the spring of 334, Aristotle returned to Athens and remained there until near the end of 323 or early 322. These years are known as his "second Athenian period," or *Meisterjahre*. During this remarkably short span of about 12 years he gave definite shape to a philosophical tradition that was to carry his name and intellectual seal through the subsequent centuries. While absent in Macedon, he had been proposed for election as head of the Platonic school after the death of its second scholarch, Speusippus, but Xenocrates received a plurality of votes over two other members. The two withdrew from the Platonic circle, and Aristotle, on his return to Athens, began to teach in the Lyceum, another public park. From the Lyceum gatherings an organized philosophical school developed. By the next century it was known as the *peripatos;* its adherents, as Peripatetics. The original force of *peripatos* as its designation is obscure. Etymologically signifying a "walking about," the word had come to mean a place for walking about, a discussion carried on during a stroll, school discussions or lectures in general, or a place in which school activity was conducted. As applied to the Peripatetic school, it most likely came from the place where the gatherings were held. Theophrastus, Aristotle's successor, left in his will "the garden and the *peripatos,* " with houses adjoining the garden, to the common possession of a group of associates for use in philosophic pursuits. He likewise provided for the upkeep of the *peripatos,* showing that a place was meant. Theophrastus had drawn exceptionally large numbers of hearers to his own discussions, so it is not surprising that the place in which his discussions were conducted should have become known as "the" *peripatos,* outstanding among centers referred to at Athens as *peripatoi*. Privately owned by Theophrastus, it could hardly have been located in the Lyceum. The explanation that Aristotle and his associates walked up and down while engaged in philosophical discussions, though circulated about 200 b.c., appears in an unreliable context and seems to have been a guess based on the etymology of the term Peripatetic. Though connection with a *peripatos* is traceable to Theophrastus rather than to Aristotle, a comparison of the writings of the two men shows that the structure and methods of thought and the teachings characteristic of the Peripatetics are attributable to Aristotle himself.

The immense amount of work that he accomplished and the influence apparent in his followers mark these years as a period of indefatigable, penetrating, well-organized intellectual labor carried on in common with a closely associated group of companions and disciples.

**Retirement.** After the death of Alexander in June 323 b.c., Aristotle was exposed to a wave of anti-Macedonian feeling, possibly for a second time. A charge of impiety, reported to have been based on a hymn and inscription written in memory of his deceased father-inlaw, Hermias, was laid against him. By the early spring of 322 he had retired to Chalcis; and by October, just past 62, he had died of what was vaguely called a stomach illness. In his will, Aristotle makes arrangements for disposing of slaves and goods that imply considerable family wealth, making possible his life of cultural and scholarly pursuits. The warm, high-minded, urbane, and understanding personality manifested in the will shines on occasion through his usually objective writings. Derogatory views of his character stem from a deliberate campaign to belittle his reputation during the decades following his death. Some later reports about unattractiveness in physical appearance, though handed down only as hearsay, possibly stem from reliable sources. Other adverse reports, for instance that he spoke with a lisp, that he was ungrateful and disloyal to his teacher, that he was profligate, that he turned to philosophy too late in life, and that he ended his life by drinking poison, have by careful criticism of their origins been shown to be without foundation.

# Philosophical Teaching

Philosophy had for Aristotle a much wider ambit than it has today. It included rhetoric, poetics, mathematics, natural science, and political science, as well as logic, philosophy of nature, metaphysics, and ethics. Aristotle himself was a pioneer in making a systematic classification of all fields of knowledge. Though he called logic a science, Aristotle did not list it in his formal classification but regarded it as a preparation and instrument for science proper. science (*scientia* ) itself meant for Aristotle universal and necessary knowledge through causes. Metaphysics, natural philosophy, and ethics were accordingly sciences as he understood the term. His division of the sciences was based on their purposes and starting points (see sciences, classification of). One broad type, proceeding from starting points in the things known, aimed at knowledge alone. As a scrutiny or contemplation (*theoria* ) of things it was called theoretical science, either natural, mathematical, or theological. The other type had its starting point in the knower, and it aimed at action or at production. If the starting point was free choice, the aim was confined to human conduct and Aristotle called the science practical. If the starting point was a conception of something to be made, the aim was a product different from the action itself, and he called the science productive. Practical and productive sciences, accordingly, aimed at something over and above knowledge.

**Logic.** Aristotle may be called the founder of logic, as logic was handed down to later Christian culture, although the Megarians before him had already inaugurated a tradition in logic (see logic, history of). One of their leaders, Eubulides of Miletus, is reported to have kept up controversial attacks on the Stagirite. In such a milieu, against the background of Platonic dialectic, a scientific logic achieved full development in Aristotle. He called it "analytics"—an unraveling, as it were, of the complicated processes of human thought. It regarded particular sensible things, in which all human cognition originates, as knowable under universal aspects. The proximate universal is the species. Continually widening generic aspects follow, until the most universal, those that cannot be divided into further genera, are reached. Individual horses, for instance, are seen; they are known specifically as horses, generically as animals, and so on to wider generalizations. Aristotle called this process induction ([symbol omitted]παγωγή), meaning that by a consideration of particulars the mind is "led to" the universal content present in the particular or the less general. Under each supreme genus the inferior genera are arranged in columns named categories. As supreme logical genera Aristotle lists substance and nine accidents (see categories of being). He also catalogues some features that are not confined to any one category. Often a notion appears as belonging immediately to a subject and is at once predicated of it, for instance that an ox is an animal or that a man is running. In this immediate intuition (*nous* ) the basic premises for reasoning are grasped.

Because of their relatively increasing degrees of universality, two notions that do not immediately show connection may each be seen as related to a third in a way that involves relationships with each other. Three such notions form the basis of reasoning, or the syllogism. The three notions, called the terms, are arranged in three propositions, two of which are known as the premises and the third as the conclusion. Exact rules are elaborated for arranging the terms so that their varying degrees of universality allow a conclusion to be drawn. Affirmative and negative premises make possible different types of reasoning, or figures of the syllogism. Particular premises, and the notes of possibility or necessity, add complications. If reasoning proceeds according to a correct figure from true and immediately known premises, it is called demonstration and yields scientific knowledge. If demonstrative reasoning is based on the proximate cause of what is concluded, it gives the most perfect type of science, "knowledge of the reasoned fact" (Gr. [symbol omitted]πιστήμη διότι, Lat. *scientia propter quid* ). If demonstrative reasoning is based on an effect, or in negative demonstration upon a remote cause (e.g., a wall does not breathe because it is not an animal), it gives only "knowledge of the fact" (Gr. επιστήμη ἄτι, Lat. *scientia quia* ). If reasoning proceeds from premises that are merely probable, it is called dialectical. dialectics is important for the inductive process by which the mind gradually focuses attention on universal aspects of things and so comes to grasp the immediate indemonstrable premises of scientific reasoning. All truths cannot be demonstrated, since demonstration itself requires indemonstrable premises.

This logic, very evidently, has as its operative unit the universal (see universals). It is therefore labeled today a "class logic," in contrast to propositional logics. It was consistently viewed by Aristotle not as self-sufficient but as meant to guarantee scientific procedure in other branches of knowledge. Although pedagogically it came before the other sciences, it was not

given any commanding rank over them. Their proper intelligibility was already constituted in priority to any logical activity of the human mind.

**Philosophy of Nature.** One type of theoretical science deals with things that are mobile and that have their intelligible content or form inseparable from matter. These things constitute the sensible universe. They may be approached from the standpoint of their changeableness, or mobility. change, or motion, requires a subject that loses one form (understood as an intelligible aspect) and acquires another. If the forms lost and acquired are accidents, such as quantity, quality, or place, the change is accidental. Change in the category of substance, called substantial change or generation-corruption, correspondingly involves a subject that loses one form and acquires another. Since form in the category of substance is the basic form in the thing, its subject as such has no form or intelligibility whatever. This subject, because able to receive form, is potency, or primary matter (see matter and form). In contrast, the intelligible aspect, or form, is actuality (ἐνέργεια) and perfection, or entelechy (ἐντελέχεια). Change, or motion, is defined as the actuality of something existent in potency precisely as it is in potency. The actuality, or intelligible aspect, present in the changing thing is there in the status of potency to further act. The notions of potency and act, taken originally from analysis of change, run through all of Aristotelian philosophy (see potency and act).

*Nature*. Since sensible things are changeable, they are composed of matter and form. Each of these components is called nature, and things formed by their composition are natural. Nature is itself defined, from the viewpoint of sensible change, as a primary principle of motion and rest. Matter and form are two of a natural thing's causes. The other two causes are the agent and the end, or purpose. In later Peripatetic tradition the four causes are named, respectively, material, formal, efficient, and final. On the basis of these causes Aristotle investigates themes such as chance, place, time, the void, and the infinite. Motion and time emerge as eternal of their very nature. They exist in an indivisible, but are unable to start or end in an indivisible, and so always require both previous and subsequent parts. An examination of the nature of motion and a survey of its instances show that everything in motion is being moved by something else; therefore an infinite regress in moved movers cannot account for any motion (see motion, first cause of). In a self-mover, one part has to remain unmoved while moving the whole. Most unmoved movers are perishable; but since motion is eternal, the primary mover of the sensible universe will have to be eternal. Located at the circumference of the universe, such a mover imparts rotatory motion only, the one motion that is unchangeable in direction. The heavens are regarded as animated. They are imperishable, because their one observable motion, the circular, leaves no room for alteration or perishing. Their matter is accordingly distinguished from the traditional sublunar elements (earth, water, air, and fire) and is characterized as a further nature called ether (αἰθήϱ).

*Soul*. soul is the basic actuality of a natural organic body. In sentient things soul is the principle not only of movement and growth, but also of sensation and appe tite. In man it is also the principle of intellection and volition. Actual knowledge, both of sense and of intellect, consists in a peculiarly cognitional identity of knowing subject and thing known. From this viewpoint "the soul is in a certain way all things." In man the intellect is called a part of the soul and is divided into passive intellect and agent intellect, or intellect that produces. The passive intellect perishes in death. The agent intellect is not only imperishable but is "separate" from matter; as a form separate from matter it is not a subject for natural philosophy. Such teaching on the human soul is brief and somewhat obscure. It does not seem to allow the imperishable intellect, after death, any recollection of happenings in the body, and if so, precludes personal immortality.

*Other Sciences*. For Aristotle, natural philosophy included qualitative procedures that are now assigned to botany, zoology, experimental psychology, and other such studies. These qualitative procedures he regarded as giving only "knowledge of the fact." Knowledge through the basic causes, matter and form, was in contrast the most scientific of physical knowledge. If there were no immaterial beings, it would constitute for Aristotle the absolutely highest type of science, higher than any mathematical procedure.

**Mathematics.** Mathematics in the Aristotelian explanation was a theoretical science dealing with objects immobile but not existent outside mobile things, for instance numbers, lines, surfaces, and mathematical solids. By a process called abstraction, the mathematician may, without falsification, consider these as though they had existence separate from sensible bodies. Since there could be many individual instances of the same mathematical form, some kind of matter was required to explain the multiplicity. It was called intelligible matter, in contradistinction to sensible matter in real bodies. Sciences such as optics, harmonics, astronomy, and mechanics he regarded as essentially mathematical sciences, though as the "more physical" of those sciences. In contrast to qualitative procedures, they explained bodies through "knowledge of the reasoned fact." For further details of Aristotle's teaching on mathematics, see H. G. Apostle, *Aristotle's Philosophy of Mathematics* (Chicago 1952).

**Metaphysics.** Things entirely immobile and in their existence completely separate from matter Aristotle regarded as divine, hence coming under theological science. He based his proof of their real existence on the eternity of motion established in natural philosophy. Since the unmoved physical movers impart motion eternally, the ultimate ground of that eternity must be a substance entirely actual and so without matter. Any potency in it would mean that motion could in some way cease to be. Such substance is real form without matter, real actuality without potency. It causes motion only by being desired. It is so completely self-contained that it cannot know anything outside itself, since any dependence whatsoever on something outside itself would mean imperfection and so potentiality. It is a plurality, because there has to be one such substance for every original astronomical movement. It is a thinking that has itself as its object, and so may be described as a "thinking on thinking." It is the highest and most divine life. The science treating it is "first philosophy," and so is universal in scope, the science of being as being. Accidents are beings only in reference to prior, relatively permanent substance, while in sensible substance itself form is primary substance and the cause of being to both matter and composite. But the primary instance of substance without qualification is simple substance. According to the movement of Aristotle's metaphysics in relating

secondary to primary instances, and against a background in which being meant permanence in contrast to becoming, theological science as first philosophy could readily be understood as the science that treats universally of beings as beings. Among modern commentators, however, there is much disagreement on the way Aristotle conceived metaphysics and on the nature of the unmoved movers dealt with respectively in natural and first philosophy.

The title "metaphysics" does not appear in Aristotle's writings, but seems to date back to his immediate disciples. In the Aristotelian setting it meant that the things "beyond" the physical were investigated "after" natural philosophy (Reiner). The proposal that the term "metaphysics" was merely editorial in origin (Buhle) is an unsupported conjecture of the late 18th century.

**Ethics and Politics.** Moral philosophy is called political by Aristotle on the ground that the supreme human good is the same for individual and for city-state. Its subject matter is human conduct, and its aim is to achieve the good. This good, continually fluctuating, always consists in a mean between two ever-varying extremes of excess and defect. The mean is determined in each individual case by a judgment of the prudent man. Since the good is always a mean, it can serve as a universal that makes possible the type of reasoning proper to practical science. To be prudent, a man needs the moral virtues, of which the three basic are temperance, fortitude, and justice. Yet to have these one must have the intellectual virtue of prudence (φρόνησις) for determining their mean.

These four virtues have to be inculcated simultaneously by correct education from earliest youth. Good laws and customs are therefore all-important in the formation of the correct ethical starting points. If accompanied by bodily welfare, good fortune, sufficient riches, and friends—all spread through a complete lifetime—the virtues make possible a life of contemplation. Contemplation is the highest human activity, thinking on the highest knowable objects. It is felicity (ε[symbol omitted]δαιμονία), the chief good (see eudaemonism). To its attainment all other activity, individual and social, is to be orientated. It is self-sufficient and in its own way divine, and gives the greatest of pleasure. Other ways of virtuous living give only secondary degrees of happiness. Some men are fashioned by nature itself to work with their bodies, as instruments under the guidance of others; slavery for such men is therefore natural. True forms of government aim at the common good, instead of at the good of a particular class.

**Poetics and Rhetoric.** Aristotle develops the "productive" sciences in his treatises on poetics and rhetoric. see poetics (aristotelian). In his poetics he makes "re-presenting" (*mimesis* ) the basis of fine art. Concentrating on tragedy, he exploits this view especially in regard to the elaboration of plot. To tragedy he assigns the much-debated function of catharsis, variously interpreted as a purification either of the tragic events (G. F. Else) or of the spectators' emotions. In his rhetoric he investigates persuasive arguments and their use through proper delivery, style, and composition.

# Development, Works, and Influence

In Aristotle's philosophy a number of items may easily be characterized as Platonic, in contrast to distinctively Peripatetic thought. In the 19th century Platonic passages were at times excised as unauthentic or labeled as inherent contradictions in Aristotle's basic thought. In the first half of the 20th century a development theory, outlined by Thomas Case and elaborated in detail by Werner Jaeger, represented the Stagirite's thought as noticeably Platonic in the earliest writings, then gradually changing until it culminated during his mature period in a philosophy characteristically his own. Shadings and changes were added to this theory by other interpreters. It was carried to its extreme in the stand that Aristotle's own thought always remained Platonic, with all the characteristically Peripatetic philosophy coming from Theophrastus (Zürcher). A later reaction has explained the development in the opposite direction—Aristotle began strongly in his own characteristic way of thinking, then strove through the years to become a Platonist (I. Düring). No development theory has proved satisfactory, nor has any adherence of Aristotle to Platonic elements inconsistent with his own proper thought been sufficiently established.

**Writings.** In later antiquity Aristotle's writings, filling several hundred rolls, were distinguished in three broad classes: hypomnematic, exoteric, and acroamatic. The hypomnematic were notes to aid the memory and prepare for further work. The exoteric, written in dialogue and other current literary forms, were meant for the general reading public. Only fragments of them are extant. No reason why they ceased to be copied has been handed down in Greek tradition. Outstanding titles were *On Philosophy, Protrepticus, Eudemus, On Justice,* and *On Ideas*. The third class consisted of treatises (λόγοι, μέθοδοι, πραγματείαι) meant for school use and written in a concise style peculiar to their own literary genre. To this class belong the surviving works of Aristotle.

The *Categories, On Interpretation, Prior Analytics, Posterior Analytics, Topics,* and *Sophistical Refutations* contain the Aristotelian logic. In later Greek tradition they became known as the *Organon,* or instrument for learning. The general topics of natural philosophy are investigated in the *Physics,* and more particular phases in *On the Heavens, On Generation and Corruption, Meteorology, On the Soul,* and in a group of shorter treatises known since the Middle Ages as *Parva Naturalia*. The animal kingdom is studied in five works: *History of Animals, Parts of Animals, Generation of Animals, Progression of Animals,* and *Movement of Animals*. The collection later known as the *Metaphysics* contains the treatises on first philosophy. The Aristotelian ethics has come down in three redactions, the *Nicomachean Ethics* (seemingly named from some unknown connection with Aristotle's son, Nicomachus), the *Eudemian Ethics* (seemingly named from Eudemus of Rhodes or, as Dirlmeier suggests, from Eudemus of Cyprus), and though of still disputed authenticity, the *Magna Moralia*. The treatment in the *Nicomachean Ethics* is continued in the *Politics*. A study of constitutions of various cities intervened; of these only the

*Constitution of Athens,* recovered from Egyptian papyruses during the last quarter of the 19th century, is extant. The *Rhetoric* and the *Poetics* round out the list of surviving works.

A number of these treatises, missing in the earliest catalogue, seem to have been recovered only with the finding of Theophrastus's personal library, buried for nearly 200 years in a cellar at Scepsis in Asia Minor. A few works that would come under Aristotle's notion of mathematics were listed in the ancient catalogues, but none has survived.

Since the acroamatic writings were school λόγοι, they were open to additions and to change in arrangement as long as Aristotle continued his teaching career. This circumstance renders dating difficult and uncertain. As yet no satisfactory overall chronology has been established. For scholarly use the fragments, edited traditionally according to the order given them by Rose under the pseudepigrapha, should be divided into three classes: (1) those ascribed with sufficient certainty to a definite work, followed by fragments that may be attached to these; (2) those attributed with sufficient certainty to Aristotle but not to any definite work; and (3) those whose attribution to Aristotle has been alleged but remains doubtful (Wil-pert).

**Influence.** Aristotle's philosophy continued to be taught at Athens under a succession of scholarchs that can be traced quite definitely into the 1st century b.c., and nebulously into the 3rd century a.d. After the death of Theophrastus the school seems to have had less widespread influence than its rivals. Upon the edition of the Stagirite's works by Andronicus of Rhodes in the 1st century b.c., the extensive Greek commentaries began; and they continued down to the 14th century a.d. Among the Christian Church Fathers, the attitude toward Aristotle was not favorable. His logic became influential in the early Middle Ages through boethius. His metaphysics and natural philosophy (in spite of several ecclesiastical prohibitions) and his ethical and political doctrines came to provide the framework for philosophical thought during the 13th century. They earned for Aristotle his rank as "The Philosopher," and with Dante the title of "the master of those who know." His doctrines were made to fit into various Christian interpretations. The Renaissance and the Reformation reacted violently against the scholastic Aristotle, although since the Renaissance the *Poetics* has served as a fundamental text in literary criticism. The rapidly developing quantitative physics and chemistry struggled bitterly to throw off the yoke of qualitative methods that had become traditional in the wake of Aristotelian doctrine, even though the Stagirite's teaching, if it had been rightly understood, could have provided a welcome abode for these new sciences under its mathematical divisions, as it had done for the ancient astronomy, optics, harmonics, and mechanics. Early in the 19th century, a keen philological interest in Aristotle took hold, and it developed increasingly in the 20th century. Along with the revival of interest in scholasticism, this has led to renewed philosophical appreciation of the Stagirite's doctrines, giving assurance that Aristotle's wisdom will continue to be digested with increasing profit by Western culture. Its outstanding importance for the Church lies in the help its fundamental principles can give to the structure of Christian philosophy and theology, even though Aristotle himself developed these principles in a thoroughly pagan atmosphere.

*See Also:* aristotelianism; greek philosophy; scholasticism.

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[j. owens]

# Aristotle

Gale Contextual Encyclopedia of World Literature


BORN: *384 b.c.e., Stagira, Greece*

DIED: *322 b.c.e., Chalcis, Greece*

NATIONALITY: *Greek*

GENRE: *Treatises, notes*

MAJOR WORKS:
*Inquiry into Animals*
*Nicomachean Ethics*
*Rhetoric*
*Politics*
*Metaphysics*
*On the Soul*

# Overview

Aristotle's importance may be greater than that of any other philosopher, not only because what he said was taken as an almost unquestionable authority during the formative periods of Western culture, but also because he

addressed so many different fields of learning. His ideas influenced practically every field of intellectual endeavor, from philosophy and theology to science and literature. Aristotle's works defined the basic categories of thought and formulated the fundamental rules of inference, in effect becoming the Western tradition's basis for thought. In addition, Aristotle's literary views, discussed in his *Poetics,* dominated literary criticism from antiquity until modern times, setting a standard for any theoretical approach to literature.

# Works in Biographical and Historical Context

***Early Love of Science*** Aristotle was born in Stagira, a small town in northern Greece located on the peninsula known as the Chalcidice, in the summer of 384 b.c.e. Aristotle's father, Nicomachus, was the royal doctor for the Macedonian king, Amyntas II. Young Aristotle is believed to have spent part of his childhood living with his father at the royal court in the Macedonian capital of Pella. This early connection with the Macedonian court would have a major impact on later events in his life. As a doctor's son, he was probably trained in first-aid techniques and basic drug therapy from an early age. This early training may have contributed to his love of science in general, his orderly approach to learning (evident in the highly structured nature of his works), and to his special interest in biology (clear in *Inquiry into Animals).* Both of Aristotle's parents died when he was young, and Proxenus, an older relative, became his guardian.

***Plato and the Academy*** At age seventeen, Aristotle was sent to Athens to attend the most famous school in Greece, the Academy of the great philosopher Plato. At the time, Athens was the intellectual center of the world, and Plato's Academy was the center of Athens. Aristotle won recognition as the master's most brilliant student, and his energetic gathering of research and general love of books led Plato to nickname him "the reader." During his time at the Academy, Aristotle studied mathematics and dialectic, a form of argumentative reasoning. Although Aristotle was both a student and a close friend of Plato's, the strength and independence of his own mind suggests that he was never simply a follower of his teacher. Aristotle spent twenty years at the Academy, until Plato's death in 347 b.c.e.

***A School of His Own*** Aristotle left Athens soon after Plato's death in 347 b.c.e. He settled near a Greek city called Atarneus in northern Asia Minor (now Turkey). The city's ruler, Hermias, was an avid student of philosophy who had supported Plato's Academy. He invited Aristotle and some other Academy members to set up a similar school in nearby Assos, where he provided them with everything they needed to pursue their studies. Aristotle later married Hermias's niece, Pythias, and the couple had two children, a daughter and a son.

It was in Assos that Aristotle finally stepped out of Plato's shadow and began the work that truly reflected his own interests. Instead of puzzling only over the fact that things existed at all (one of Plato's favorite areas of inquiry), he began to focus on the nature and function of the things themselves. He observed animals in their natural environments and carefully recorded his findings. The result, a huge collection of notes and longer writings, is today called the *Inquiry into Animals*. It describes in great detail the bodies, habitats, and behavior of an astonishing variety of animals, from whales to woodpeckers and from insects to elephants.

***Tutor to Alexander the Great*** After Hermias's territory was overrun by the Persians, Aristotle moved to Mytilene. King Philip II of Macedonia, known for his prodigious military skills and expansionist plans, invited Aristotle to accept the post of tutor to his son Alexander. Philip was impressed with Aristotle's reputation and family connections to Macedonia. Aristotle accepted, and served in the position for three years, teaching the boy rhetoric, literature, science, medicine, and philosophy. According to legend, Aristotle presented his pupil with a copy of the ancient Greek epic the *Iliad,* which became Alexander's most prized possession: he slept with it under his pillow. Alexander went on to become one of the most successful military commanders in history, conquering an empire stretching from modern-day Italy to India within a span of ten years.

***The Lyceum*** In 335 b.c.e., Aristotle returned to Athens and opened his own school, one that rivaled Plato's Academy. Since it was located at the temple of Apollo the Lycian—Lycia was an area in Asia Minor associated with the god Apollo—the school was called the Lyceum. And because Aristotle often walked up and down a covered courtyard or *peripatos* while lecturing, he and his followers were referred to as "Peripatetics." The students and other teachers followed the rules of Aristotle, ate their meals together, and once a month gathered for a symposium, a party of sorts, with a focus of intellectual discussion. At the same time, Aristotle continued writing what was to become an expansive body of work that encompassed the various branches of science, literature, philosophy, and history.

***Death of Pupil and Teacher*** In 323 b.c.e., Alexander the Great died unexpectedly at the age of thirty-two. He had left no clear instructions for the management of his empire, which quickly dissolved into chaos. In Athens, anti-Macedonian sentiment boiled over and riots broke out. Aristotle, aware that his close connections to the Macedonia court and to Alexander in particular could put his life in danger, left Athens for the island of Euboea. He died there in 322 b.c.e. of a digestive ailment. Some historians have suggested that he was poisoned, but the cause of death is uncertain.

# Works in Literary Context

After his death, Aristotle's manuscripts were hidden in a cellar in present-day Turkey by the heirs of one of his students and not brought to light again until the beginning of the first century b.c.e., when they were taken to Rome and edited by Andronicus. Andronicus's revisions probably do not represent works that Aristotle himself prepared for publication. The peculiarly clipped language in which they are written indicates that they are lecture notes organized from oral discussions of the material by Aristotle. Nevertheless, Aristotle's work had incalculable influence on Western thought for centuries to come, shaping the way artists, writers, architects, doctors, scientists, kings, queens, and even priests approached their work.

## LITERARY AND HISTORICAL CONTEMPORARIES

Aristotle's famous contemporaries include:

**Socrates** (370 b.c.e.–399 b.c.e.): Although a few people practiced something like philosophy before Socrates, his prolific career as a teacher, orator, and defender of philosophy justify his being called "The Father of Philosophy."

**Alexander of Macedonia** (also known as Alexander the Great) (356 b.c.e.–323 b.c.e.): This Macedonian king vastly increased the size of his kingdom and built a lasting reputation as a conqueror during the thirty-three years of his life.

**Aristophanes** (456 b.c.e.–ca. 386 b.c.e.): This Athenian comic playwright authored Lysistrata, a comedy that deals openly with sex, feminism, and pacifism.

**Democritus** (460 b.c.e.–370 b.c.e.): This Greek philosopher's most important theory is that all matter is composed of atoms.

**Xenophon** (431 b.c.e.–355 b.c.e.): This Greek historian's work gives us a window into the lives of the Greeks during his lifetime.

***Philosophy*** Analysts throughout the centuries have asserted that Aristotle's philosophy is systematic, universal, and epoch-making. Trained in the Platonic tradition, Aristotle nevertheless rejected his teacher's theory of Ideas. True, in formulating his ontology, or doctrine of being, Aristotle views each individual concrete thing as a blend of matter and form. While the Aristotelian concept of form superficially resembles Plato's Ideas, the forms, as W. G. de Burgh observed, "do not exist…in a super-sensible heaven, cut adrift from the actual world of our experience…. Thus for Aristotle it is the concrete individual, not the mere universal, that has substantial being." The basic task of philosophy, according to Aristotle, is to explain why and how things are what they are. In order to learn why

something exists, Aristotle insists that one must identify four fundamental causes. Using the example of a sculpture, Aristotle defines these causes as material (the artist's medium), efficient (an artistic conception translated into the sculptor's physical manipulation of his medium), formal (the form the artist strives to externalize), and final (the end-product of the creative process). This "conception of form as the end or purpose of development, in contrast to undeveloped matter," de Burgh has written, "is the fundamental thought of all Aristotle's philosophy."

***Literature and Oratory*** Aristotle's ideas on literature and oratory are presented in two works: the *Poetics* and the *Rhetoric*. While the latter work focuses on the formal, linguistic, and stylistic rules for effective persuasion in verbal discussion or written argument, the hugely influential *Poetics* presents a literary theory that no subsequent critical discussion could ignore. Unfortunately, the *Poetics* exists in fragments, without the important discussions—on subjects such as catharsis and the comic—referred to in other works. Offering a full treatment of tragedy, with marginal attention to other literary genres, the *Poetics* nevertheless constitutes a comprehensive philosophy of art. Like Plato, Aristotle defined art as "mimesis," or imitation, but refined the Platonic conception of art by introducing different types of imitation. According to Aristotle, epic and tragedy portray human beings as nobler than they truly are; comedy does the opposite; and the plastic arts (art that does not involve writing or composing—sculpture, for example) strive toward plain imitation. As his description of tragedy indicates, Aristotle does not separate aesthetical from ethical judgments, and his discussion of tragic characters in the *Poetics* includes explicit statements about their morality.

***Metaphysics Through the Years*** Though the discourses in the *Metaphysics* are not finished works, they are sufficiently complete to show what Aristotle conceives to be the basic problems that confront a science of First Philosophy and to indicate how he thinks one should attempt to resolve these problems. The influence of this work has been enormous, both because it lays out a problem for a study of metaphysics and because it provides a persuasive way of thinking about the issues. Such medieval philosophers as Saint Thomas Aquinas (1224–1275) attempted to integrate their Christian beliefs into this framework, a synthesis that inevitably modified both the Christian dogmas and the Aristotelian system. Though modern philosophers beginning with René Descartes were anxious to reject the Aristotelian beliefs that were part of their scholastic education, much of the Aristotelian vocabulary, such as the notions of substance and attributes, remained. Many of the problems Aristotle discusses in this work remain unresolved by philosophers today. Questions about the meaning of being or the nature of universals and one's knowledge of them are still vexing philosophical issues.

***Biology*** Aristotle contributed much to the field of biology, especially through his early work on classification. He realized that scientists had to observe an array of characteristics, not just one, as a basis for grouping, and scientists consider him to be the first person to group organisms in ways that made sense. He did not believe in evolution, but as a careful student of nature, he separated living things according to their complexity, according to a scale of nature. He assigned each increasingly complex form of life a step on a ladder. In the eighteenth century, Carl Linnaeus (1707–1778) developed a system whereby all organisms were named according to genus and species, expanding and refining Aristotle's basic idea. Linnaeus said, "God creates, Linnaeus arranges." His system of classification remains in use today.

## COMMON HUMAN EXPERIENCE

Although much of what is read about Aristotle has to do with his impact on science and logic, one should remember that he was among a number of thinkers who developed a "golden mean" concept for living. Essentially, the golden mean has to do with moderation. For instance, a coward is a person who flees from the least sign of danger, a courageous person is a person who has an appropriate level of fear in a dangerous situation, and a rash person is one who rushes into a dangerous situation that he or she is ill-equipped to deal with. The courageous person is the one who illustrates the golden mean best because this person is neither too frightened nor too rash. This individual has exercised ethical reasoning. Other works that deal with ethics include:

*Atlas Shrugged* (1957), a novel by Ayn Rand. This novel analyzes the responsibility of great individual thinkers and innovators to the society in which they live.

*Summa Theologica* (c. 1274), a theological work by Thomas Aquinas. This treatise, written by a priest and Aristotle scholar, analyzes the virtues of fortitude and prudence, especially as they relate to man's relationship with God.

*On the Genealogy of Morality* (1887), a book by Friedrich Nietzsche. In this text, Nietzsche attempts to provide a history of morality (or ethics) and to theorize the psychological origins of various systems of belief about morality.

# Works in Critical Context

Traditionally readers of Aristotle have been impressed most by the systematic nature of his work, and accordingly they have treated the whole of it as expressing a single body of doctrine. In recent decades, however, much scholarship has been devoted to exploring the

development of Aristotle's thought. The underlying assumption of this approach is that at one time Aristotle more or less agreed with his teacher Plato, but gradually began to articulate his own views. Such studies have focused on the relative influence Plato's views seem to have had on Aristotle in a given work as a way of assessing his intellectual development.

In Werner Jaeger's book *Aristotle: Fundamentals of the History of His Development* (1948), the work that pioneered these developmental studies, Jaeger argues that Aristotle's thought is divided into three periods that roughly correspond to the three main periods of his life. In his years at the Academy, Aristotle's views on the soul and on ethics, which may be found in surviving fragments, are thoroughly Platonic. After Plato's death Aristotle left the Academy and began to develop his own metaphysical and epistemological views. His return to Athens and founding of the school at the Lyceum marks a third period in his development, in which he turned from the philosophical problems he inherited from Plato and embarked upon a program of empirical research. This period thus includes his biological works as well as the lost collection of political constitutions. Further research has discredited some of Jaeger's conclusions, but most studies of Aristotle's development continue to assume with Jaeger that his thought progresses steadily away from Platonism.

***Poetics*** In Aristotle's time the influence of the *Poetics* did not extend beyond his own school, and, unlike his scientific and philosophical works, the book was rediscovered relatively late, during the Italian Renaissance. But its impact then became significant, especially upon the literature and literary criticism in France and England in the seventeenth and eighteenth centuries. The principles of poetry and drama in the *Poetics* were considered by many during this period to be the correct rational principles to which literary works should conform. Much of the *Poetics* was still an authoritative source for literary principles well into the nineteenth century. The *Poetics* was used, for example, to argue for clearly defined literary genres as we know them today.

***Rhetoric*** Many of those who practiced and taught rhetoric in Greece in the fifth and fourth centuries b.c.e. wrote books about the art of rhetoric. Aristotle's *Rhetoric* is written within this tradition; but his work is the first and only systematic treatment of rhetoric in this period. It is unlikely that the *Rhetoric* had a significant influence as a handbook for public speaking among Aristotle's contemporaries, because by the time it was written political oratory was in decline. Though the work itself is not polemical, it no doubt served also to distinguish Aristotle's views on rhetoric from those of his rival Isocrates. Cicero and other Romans studied the *Rhetoric*. For them it is likely that its rhetorical principles were instructive as practical guidelines for oratory. When humanistic learning was revived during the Renaissance, the *Rhetoric* formed the basis for the study of rhetoric. The Aristotelian rhetorical model is still commonly taught in introductory writing courses at the high-school and college level.

# Responses to Literature

1. Can you think of a situation in which “the golden mean” is not the best method for determining what one should do? Since perceptions or measures of moderation will vary from person to person, what factors decide where the golden mean lies? Drawing from what you know about Aristotle's philosophy, as well as those of great thinkers throughout the ages, explain and defend your answers.
2. For many years, Aristotle's reputation as a philosopher was so strong that he was often referred to simply as “The Philosopher.” To modern ears, his work sounds much more like science than philosophy. What are some of the differences between the kind of philosophy Aristotle participated in and the kind of philosophy practiced by philosophers in the twenty-first century?
3. Explain Aristotle's statement from *Poetics* that “all art is the imitation of nature.” Provide evidence from literature, musical composition, and the plastic arts.

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# Aristotle

World Eras


**384-322 b.c.e.**

**Philosopher and scientist**

Sources

**Significance.** Aristotle is one of the greatest intellectual figures in history. More than any other ancient Greek thinker, he helped define Western rationalism and scientific methodology. In fact, until the end of the seventeenth century, Western intellectual culture was labeled Aristotelian. His greatest achievements were in the study of formal logic and pioneering the field of zoology, in which his theories were not replaced until the 1800s.

**Student and Teacher.** Born in 384 b.c.e. at Stagira, a small coastal town in northern Greece, Aristotle grew up in an environment that offered him many rich opportunities to observe and think about the natural world. His father, Nicomachus, was court physician to Amyntas II, king of Macedonia. His later interest in biology has often been attributed to his father's influence upon him. At the age of seventeen, Aristotle went to Athens to study under the famous Plato, with whom he stayed for the next twenty years. After Plato's death in 348 or 347, Aristotle spent some years in the islands of the eastern Aegean, apparently studying and collecting specimens of plant and animal life. He was then invited back to the royal court of Macedon to serve as tutor to the young prince Alexander, known to later ages as Alexander the Great. In 335, Aristotle returned to Athens and there established an institute called the Lyceum, where he worked and taught until his death in 322.

**Works.** The interests of Aristotle were vast, and he wrote on many subjects, including biology, botany, chemistry, ethics, history, literary theory, logic, physics, political theory, psychology, metaphysics, rhetoric, and zoology. Most of his extant works are edited compilations of lectures he delivered at the Lyceum. Among his major works written before 335 b.c.e. are *On the Heavens, History of Animals, Parts of Animals, Physics, Progression of Animals*, and *On Sophistical Refutations*. His major works written after 335 b.c.e. include *Categories, Metaphysics, Nicomachean Ethics, On the Soul, Poetics, Politics, Prior Analytics, Posterior Analytics*, and *Rhetoric*.

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# Aristotle

Science and Its Times: Understanding the Social Significance of Scientific Discovery


**384-322 b.c.**

**Greek Philosopher**

By any measure, Aristotle ranks as one of the greatest geniuses who ever lived. He completely reworked Plato's philosophy and established it on a firm systematic basis. He formulated the disciplines of logic, psychology, and embryology, and made important contributions to the study of zoology, medicine, anatomy, physiology, and other life sciences.

Aristotle was born in the coastal town of Stagira in northern Greece. His father Nicomachus was court physician to King Amyntas III of Macedonia. His mother Phaestis was from a prominent family in Chalcis on the Greek island of Euboea. Both parents died when Aristotle was young. He was then raised by his scholarly uncle Proxenus, who gave the boy a wide-ranging education.

At the age of 17, Aristotle enrolled in the Academy of Plato in Athens. He was Plato's student and associate for 20 years, until Plato died in 347 b.c. Disappointed in Speusippus, who followed Plato as head of the Academy, Aristotle accepted the invitation of Hermeias to teach in Assos, Turkey. He married Hermeias's daughter Pythias and they had one daughter, also called Pythias. In 345 b.c. Aristotle moved to the Greek island of Lesbos where he began a collaboration with Theophrastus (372-287 b.c.), who became his most gifted disciple.

In 343 b.c. King Philip II of Macedonia hired Aristotle to tutor his 13-year-old son Alexander, who was later called Alexander the Great. Aristotle taught Alexander until 340 b.c., when the prince became king. Alexander remained Aristotle's friend and protector, and from 335 b.c. sent him biological specimens from all the lands he conquered.

Sometime between 340 b.c. and 336 b.c. Aristotle moved back to his hometown of Stagira, but he returned to Athens in 335 b.c. After his return, Aristotle founded his own school, the Lyceum, to rival the Academy. Aristotle's school of philosophy is known as Peripatetic, either because he had the habit of strolling around while he lectured (peripatetic is from the Greek verb *peripatein* meaning "to walk back and forth," or from the fact that his instruction was given in the *peripatos,* the covered walkway of the gymnasium. His wife Pythias having died, Aristotle had a liaison with a Stagirite woman, Herpyllis. They named their son Nicomachus after Aristotle's father.

When Alexander the Great died in 323 b.c., anti-Macedonian agitation broke out in Athens. Aristotle, who had long-standing Macedonian connections and was a friend of the Macedonian regent of Athens, felt himself in danger. He retired to his mother's family's home on the island of Euboea, reportedly stating that he was leaving Athens to save the Athenians from sinning twice against philosophy (referring to Socrates as the earlier victim). He died of a stomach disease a year later.

Although Aristotle wrote in Greek, we refer to the titles of his books in either Latin or English. No chronological ordering of his works is possible. Less than half of what he wrote survives, and much of it was probably written by students transcribing his lectures.

In the areas of natural science and its philosophy, Aristotle wrote *Physics, On Generation and Corruption, On the Sky, Meteorology,* and *On Breath*. His works on zoology include *History of Animals, On the Parts of Animals, On the Motion of Animals, On the Generation of Animals,* and *On the Gait of Animals*. Eight of his shorter works on life science (*On Sense and Sensible Objects, On Memory and Recollection, On Sleep and Waking, On Dreams, On Divination by Dreams, On Length and Shortness of Life, On Youth and Age,* and *On Respiration*) are collectively called *Parva Naturalia*.

Aristotle wrote four books about ethics, *Nicomachean Ethics, Eudemian Ethics, Magna Moralia,* and *Politics,* and two about the philosophy of art, *Rhetoric* and *Poetics*. His six books on logic, *Categories, On Interpretation, Prior Analytics, Posterior Analytics, Topics,* and *On Sophistical Refutations,* are collectively called the *Organon*. His *On the Soul* is regarded as the world's first book about psychology. His *Metaphysics,* a work of pure philosophical speculation grounded in empirical observations, has had a tremendous influence on Western philosophy and theology.

**ERIC V.D. LUFT**



# Aristotle

Science and Its Times: Understanding the Social Significance of Scientific Discovery


**384-322 b.c.**

Greek philosopher who is considered the most influential ancient philosopher of the sciences. Aristotle wrote founding texts in physics, astronomy, meteorology, psychology, and biology. A student of Plato and a member of the Academy, his writings often contradicted his teacher's ideas, and he founded a rival center of learning, the Lyceum. Later thinkers venerated Aristotle's words, and they were copied, revised, Christianized, twisted, and eventually criticized and overthrown in the late Renaissance. He also wrote on numerous other topics, including rhetoric, politics, and ethics.

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# Aristotle

Arts and Humanities Through the Eras


## Importance.

Aristotle (384–322 b.c.e.) was a philosopher whose achievement has been fundamental to the subsequent development of Western philosophy. No field of knowledge was beyond his purview, and for 2,000 years, his influence on European thought was supreme. It eventually became a straitjacket; from the start of the seventeenth century c.e., almost every new direction in the humanities and science had to start by overthrowing some Aristotelean doctrine, for after Aristotle, Europe never produced even his approximate equal until the Renaissance. Hence Aristotle's philosophy ultimately became unchallenged doctrine and his writings remained "holy writ" for a thousand years. That was not Aristotle's fault, however, but the fault of his disciples in the medieval period. In his own day, he set philosophy in a new direction. He learned from Plato, but he tempered Plato with common sense. He emphasized research and observation, and although he never developed the modern scientific experiment, he was groping in that direction. Politics was one of his interests, but he did not waste his time on utopias; rather he examined governments that actually existed in the Mediterranean world and analyzed how they functioned. His reality was not divided into "Being" and "Becoming" as Plato's was, the first of which was real and the second only apparently real. Instead the two realities were fused and thus one could gain knowledge by observation, for what one observed was real. This was a necessary step before philosophers could develop anything similar to the modern scientific method.

## Student of Plato.

The acquisition of knowledge by observation may have been something that Aristotle learned from his father, who was the court physician of Amyntas II, king of Macedon, for by now, the medical fraternity had developed observation into a fine art in order to diagnose diseases. Physicians belonging to the medical fraternity of the Asclepiadae regularly taught their sons dissections, but Aristotle probably missed this training, for both his parents died while he was quite young. When he was about seventeen years old, he joined Plato's Academy. He spent almost twenty years there, but though he never ceased to show affection and respect for Plato, he became less and less comfortable with Plato's philosophy. Plato as he grew older placed increasing emphasis on mathematics and the trend continued at the Academy following his death. Aristotle, who must have suffered some natural disappointment at being passed over for the headship of the Academy, decided to leave it to conduct research in biology at Assos in the region of Troy. Following some time spent in Lesbos, he accepted the invitation—with a suitably generous salary attached—from King Philip II of Macedon to tutor his son, Alexander, who was fourteen years old. Alexander was under his tutelage for two years. Like Plato, Aristotle believed that there could be no good government until kings were philosophers or philosophers kings. Then in 336 b.c.e., Philip of Macedon was assassinated, and Alexander embarked on a series of military campaigns that would change the course of history in the Greek world. About a year later, Aristotle returned to Athens after an absence of about thirteen years and founded a school, the Lyceum.

## Aristotle's Writings.

Approximately two-thirds of all of Aristotle's writings are lost. During his twenty years at Plato's Academy before Plato's death, Aristotle wrote dialogues, borrowing the literary form from Plato, and they were much admired in the ancient world. None have survived but it is possible to ascertain the subject matter of some of them. He wrote on rhetoric, the art of public speaking, where Aristotle probably pointed out the importance of logic. Although Aristotle had written a dialogue during his Academy days accepting Plato's views on the soul—that is, that it existed before birth and, after birth, it could recall the ideal forms from its previous life—his dialogue *On Philosophy*, most likely written after Aristotle left the Academy, dealt with the progress of mankind and indicated that Aristotle was already unhappy with Plato's Theory of Forms. Aristotle also wrote collections of historical or scientific information, sometimes done in collaboration with students, or perhaps even done by students as assignments. One example from this group has survived: an essay on the Athenian constitution, a copy of which was unearthed in Egypt in 1890, copied on to the back of a tax register of the Roman period. One group of writings which did

survive is composed of treatises which were never prepared for publication, possibly Aristotle's lecture notes. They show an enormous range of subjects, indicating that nothing was too great or small to arouse his interest.

# The Organization of Knowledge.

Aristotle had an orderly mind and classified all knowledge into three categories: the productive, the practical, and the theoretical. Productive sciences have to do with making things, and their practitioners include engineers, farmers, artists, and the like. Practical sciences are concerned with how men act in various situations. They are the subject of Aristotle's treatises titled *Ethics* and *Politics*. Theoretical knowledge has as its goal the discovery of truth. This category includes theology, mathematics, and natural science with their various subdivisions.

# Aristotle on Cause.

In modern thinking, the causes of something that comes into existence are the factors—both the components and the agents—that are responsible for the thing being what it is. Aristotle's "cause" had a wider meaning; it can be translated as the "dimensions of reality." Aristotle looked at an object and asked "Why? How? What for? What's its material?", which broadened the philosophical discussion that began with the Milesian philosophers back in the sixth century b.c.e. That group concerned themselves only with the material. The underlying substance of the universe was water, according to Thales, and air, according to Anaximenes. Later the Pythagoreans concerned themselves with "why?"—that is, what is the pattern that makes a thing what it is? Aristotle took the discussion a step further in pointing out that "how?" is also important: who made the object what it is, and what for?, i.e. what was the purpose in making the object. Thus everything has four causes. There is the material cause: the stuff from which it is made. For that Aristotle had to find a new term, and the term he used was *hyle* which means "wood," but Aristotle used it for substance in general. There is the formal cause, which is the pattern. There is the efficient cause: the maker of the thing, whether it is a living thing like a dog or a person, or something inert like a table. The fourth cause is the final cause, which answers the question "what for?" What is the purpose for which a thing is made? Let us take a chest of drawers as an example. The material cause is the wood from which it is made. The efficient cause is the carpenter who made it, and the formal cause is the pattern that the carpenter followed. Then there is the question "what for?"—the teleological question. The purpose of the chest of drawers is to store clothes. Apply the same logic to Bowser, the family dog. The material cause is the flesh from which Bowser is made. The formal cause is not a blueprint; rather it is a species, the sort of thing we find in nature. Bowser is classified by biologists as a dog. Then there is the efficient cause: Bowser was not manufactured, rather he was generated by parents of the same species as himself. Finally there is the teleological question. Aristotle believed that everything, even the stars, had a goal that, in theory at least, could be discovered. Bowser has an inner nature what directs him to grow from a puppy into a mature dog that will become a family pet. That is Bowser's goal. Aristotle applied these principles even to the universe where he asserted that the final cause is what he calls the "prime mover"—not a mechanical force, but an object of desire. It is "God," but though Aristotle often calls his prime mover "God" it is not really a religious God. It is a divine force that exercises a continual attraction for everything in the universe, and this magnetism of the "prime mover" is the reason for the movement that we can see of the constellations in the night sky. They continually seek the final perfection of the "prime mover" that will allow them to rest, and they will never attain it. Aristotle's "prime mover" is closer to "Mother Nature" than it is to any god of religion, whether pagan or non-pagan.

# Aristotle the Logician.

Aristotle was proud of his logic; in fact, he claimed to have produced a complete, perfect logic. Essentially he began with a proposition, which is a statement that is either true or false. If it is true, it refers either to a universal truth or a particular one, and similarly, if it is false, it must point either to a particular falsehood or a universal untruth. For instance, the sentence "All mammals are viviparous" is a general proposition. It means that all mammals reproduce through live births. Since Aristotle himself used letters instead of things to express propositions, we can express the sentence as "All X are Y." There are four types of these simple propositions: the universal affirmative ("All X are Y"), the universal negative ("All X are not Y"), the particular affirmative ("Some X are Y"), and the particular negative ("Some X are not Y"). These four types of propositions can be further subdivided into three modes: that X is always Y, that X is of necessity Y, and that X is possibly Y. Once a proposition is proven true, it is possible to make a deduction using a form of argument called a "syllogism," from the Greek *sullogismos*. A syllogism is an argument whereby, if certain things are assumed as true, then something different from what is assumed can be deduced. An example would be, "All humans are mortal. John Doe is a human. Therefore John Doe is a mortal." The argument proceeds from a general proposition that is accepted as true, to a particular conclusion. Aristotle thought that he had discovered the key to deductive inference. Later philosophers developed Aristotle's logic into a separate field of its own, which it never was for Aristotle, and for better or worse, it became one of his most important legacies to our intellectual tradition.

# Aristotle's Achievement.

Before Aristotle, Greek philosophy had developed a profound distrust of the evidence of our senses. Parmenides and the Eleatic School were an extreme example. They held that the world perceived through the senses was not the real world. Heraclitus argued that constant change took place in the world. Plato held that the things seen in the visible world were only

imperfect copies of ideal "Forms" in an invisible world. Aristotle's study of biology, however, must have quickly demonstrated to him that if a person was to acquire knowledge about plants and animals, he would have to trust his senses. If he was to do research, he would have to observe, and study the observations of others. There is a certain common sense about Aristotle's teachings. Aristotle continued to believe in the unity of knowledge, yet after him, researchers tended to specialize. Theophrastus, who succeeded him as head of the Lyceum, was a notable botanist. Aristoxenus, one of the most brilliant researchers at the Lyceum, wrote on music. Aristotle's Lyceum was the forebear of modern institutes for research and advanced study.

# ARISTOTLE as a Biologist

Much of the research which went into Aristotle's two monumental scientific works, the *Dissections* and the *History of Animals*, was done in the nearly thirteen years between the time he left Athens after Plato's death and his return. The *Dissections* has not survived. Its subject was the internal structure of animals, and may have consisted largely of diagrams. The *History of Animals* did survive, however, and is a pioneering study of animals, of their appearance, their methods of reproduction, their behavior, and habitat. It covers all living creatures from sheep and goats, to tortoises and crocodiles, octopods and oysters, and, of course, human beings. To modern researchers, Aristotle sometimes seems naive and pedantic. Modern biological textbooks do not bother to point out that humans have necks between their heads and their torsos, but Aristotle felt that if he was to be thorough that fact should be noted. His description of the European bison gives good grounds for suspicion that he had never seen one. He claims that when it was hunted, it defended itself kicking and discharging its excrement over a distance of eight yards and the excrement was so corrosive that it could burn the hair off the hunting hounds. Aristotle's observations are inexact—he did not usually measure or weigh his specimens, though there seems to have been some exceptions—and he did not discover the experimental method that is the basic procedure of modern science. He used second-hand information: for instance, he asked beekeepers about bees and fishers about fish, and for human anatomy, he relied on the expertise of the Greek medical profession. Yet research in biology was in its infancy, and Aristotle deserves respect as a pioneer.

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# Aristotle

Arts and Humanities Through the Eras


384 b.c.e.–322 b.c.e.

*Philosopher*
*Teacher*
*Biologist*

# Early Development.

Aristotle was born in 384 b.c.e. in Stagira, Chalcidice, the projection of land that forms the eastern edge of the Thermaic Gulf in the northern Aegean Sea. His father Nicomachus was the court physician of King Amyntas II, the father of Philip II of Macedon who would eventually make Macedon the dominant power in Greece. Aristotle may have spent part of his boyhood at the Macedonian court at Pella, and acquired his interest in physical science in his father's surgery. At age seventeen, he travelled to Athens and entered Plato's Academy where he remained until Plato's death in 348 or 347 b.c.e., first as a student, then as a teacher and research associate. When Plato died, Aristotle left Athens, perhaps because he was disappointed at not being named Plato's successor as head of the Academy. In any case, the new head, Speusippus, represented the trend of later Platonic thought to make philosophy into a branch of mathematics, for which Aristotle had no sympathy. Aristotle went to the court of Hermias, a former student at the Academy who extended his hospitality to a small circle of philosophers, and Aristotle married his niece. Hermeias was a eunuch and a tyrant who ruled Atarneus and Assos in the Troad (the region around ancient Troy), on the fringe of the Persian Empire; in 341 b.c.e. he was betrayed to the Persians who captured him, tortured him and put him to death. In his memory, Aristotle wrote a hymn to virtue. The execution of Hermias may account for Artistotle's prejudice against the Persians which is apparent in his treatise, the *Politics*.

# Founded the Lyceum.

Aristotle himself moved to Lesbos, and it is during his stay at Assos and Lesbos that he did much of his research into the natural sciences which laid the foundation for the modern study of biology. Then about 343 b.c.e. Philip II of Macedon asked him to come to Pella as tutor to his son Alexander. The appointment ended when Philip appointed Alexander regent in 340, and Aristotle probably went back to Stagira. The year after Philip's death in 336 b.c.e., Aristotle returned to Athens and leased some buildings—as a non-citizen he could not buy property—and founded a school where he gave lectures and collected books and artifacts to illustrate his lectures, especially his lectures on zoology. The school was in a grove sacred to Apollo Lyceius and the Muses, and it took the name, the Lyceum, from Apollo Lyceius. The buildings which Aristotle rented there included a courtyard with a colonnade called a *peripatos* where Aristotle loved to walk with his students, and from it, the Aristoteleans got the name "Peripatetics" by which they were known in later centuries. There Aristotle built a library and a museum; Alexander the Great is supposed to have given him a grant of 800 talents—a enormous sum by the standards of the day—to fund the collection and ordered information to be sent to him about any new species discovered in the course of his conquests. When Alexander died in 323 b.c.e. Athens was swept up in a wave of anti-Macedonian feeling, and Aristotle's close connections with Macedon put him in danger. He prudently withdrew to Chalcis on the island of Euboea where his family had an estate, and he died there less than a year later.

# Research Lost.

Much of Aristotle's work is lost. As a young research associate at Plato's Academy, he wrote a number of dialogues that were much admired for their style, but none survive. He also produced memoranda and collections of materials for treatises. At the Lyceum, he organized large-scale research; he assigned his students the task of producing research essays on the constitutions of 158 Greek states and of these one survives: a papyrus found in Egypt at the end of the nineteenth century contains most of the *Athenaion Politeia* (The Constitution of Athens), which is probably one of these research essays. Aristotle's surviving works include the scientific and philosophic treatises, perhaps about one-third of his total output.

# Diverged From Plato

Aristotle began as a student of Plato but he soon diverged from his master. He could not accept Plato's Theory of Forms, which held that physical objects in the world such as chairs, horses, and men are imitations of perfect realities which exist separate from the human sphere, and among these perfect realities were abstractions such as pure Goodness and pure Beauty. For Aristotle, these "Forms" did not exist apart from the substances from which they were formed. He pointed out that if the substances did not exist, the Forms could not exist. Thus a horse is recognizable, for instance, because a number of horses exist and their characteristics are known. This is true of all species, whether plants or animals or even types of government, and thus by collecting data about them, and classifying them, real knowledge can be acquired. Aristotle would have said that a political scientist who wanted to acquire skill in the art of governing should not formulate constitutions for imaginary utopias, but rather should imagine the actual constitutions of states in the Mediterranean world.

# Achievement In Deductive Logic.

One of Aristotle's major achievements was in the field of deductive logic—the process of reasoning from a premise to a logical conclusion, or from a known principle to one that is unknown. Aristotle no doubt spent a great deal of thought perfecting his logic, and he was proud of the results, but for him it was always a means to an end, and the end was a solution to the old problem: how can anyone know anything for certain? Aristotle always regarded his logic as a tool that he might use to separate wrong arguments from sound ones. His logic was taken up with enthusiasm by the medieval philosophers who used it to make rigorously accurate deductions from one or more first principles that were taken as self-evidently true. The problem with this method of reasoning was that the first principle really must be true; otherwise the deduction would be wrong. However, Aristotle, unlike the medieval philosophers that came centuries after him, did not himself accept first principles as true without examining them carefully.

# The Lyceum After His Death.

After Aristotle died in 322 b.c.e., Theophrastus became the head of the Lyceum and it flourished under his leadership. Theophrastus himself carried on research in botany; Eudemus of Rhodes wrote on the researches into science, including arithmetic, geometry and theology; and the brilliant researcher Aristoxenus wrote on music—parts of his works on harmonics and rhythm have survived. After Theophrastus' death, a series of lesser philosophers became heads, or "scholarchs," as they were called, but the Lyceum was increasingly overshadowed by rival schools. It probably ceased to exist after the sack of Athens by the Roman general Sulla in 86 b.c.e. Although the school did not survive, Aristotle's influence did, particularly after the publication if an edition of his works by Andronicus of Rhodes in 40 b.c.e.

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# Aristotle

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**BORN:** 384 bce • Stagira, Chalcidice, Greece

**DIED:** March 7, 322 bce • Chalcis, Euboea, Greece

***Greek philosopher; biologist; scientist; educator; writer***

Aristotle, and his teacher **Plato** (c. 427–347 bce; see entry) were the most famous of the classic Greek philosophers. The word *philosophia* means "love of wisdom," a concept embraced with great energy by men such as these. Aristotle wrote not only on philosophical and logical matters, but also on biology, the natural sciences, ethics, politics, poetry, drama, economics, meteorology (the study of weather), astronomy (the study of the planets and stars), theology (the study of religion), and psychology (the study of the mind). Most significantly, he was the first to treat many of these areas of knowledge as subjects worthy of individual study. His existing writings fill more than two thousand pages, and that is thought to be only a small portion of his total work.

"The whole is more than the sum of its parts."

Plato searched for the ultimate reality behind existence. Aristotle found such a reality in existence itself and set out with excitement to organize and categorize it all. His classification system for animals was the model used for almost two thousand years. The same desire for order influenced Aristotle's approach to human conduct. He felt that achieving happiness was humanity's chief goal, and he organized all human behavior into a pyramid detailing the actions that led to this supreme goal for the individual.

Aristotle, perhaps more than any other great thinker, paved the way for the development of Western intellectual study. Though many of his conclusions on natural sciences—for example, the sun revolves around the earth—have been proved false, his ideas and methods are still used by modern-day thinkers. His greatest accomplishments were the formation of a system for studying formal logic and the establishment of the study of zoology, the branch of biology dealing with animals. His work in ethics, or proper behavior, was also significant. Many of his ideas were later adapted by the Arab philosopher Averroës (1126–1198); the Jewish scholar **Maimonides** (1135–1204; see entry); the Scholastics, or medieval church scholars, such as Thomas Aquinas (1224–1274); and by rationalist thinkers (those who believe in reason over experience) such as Thomas Jefferson (1743–1826), who drafted the United States Constitution and served as the country's third president.

# The doctor's son

Aristotle was born in the small town of Stagira, in the northern Greek province of Chalcidice, in 384 bce. His mother's name was Phaestis, and she came from Chalcis in the province of Euboea. His father, Nicomachus, was a doctor. Nicomachus probably intended to hand down his medical skills to his son, as was the tradition of the time, so as a young boy Aristotle most likely studied biology and anatomy. The family later moved to the neighboring province of Macedonia, a powerful district in Greece, and Nicomachus soon won an appointment as court physician to the king, Amyntas III. It is not known if Aristotle accompanied his father to Pella, the capital city of Macedonia, but it is clear from historical records that he became friends as a youth with the king's son, Philip (382–336 bce), who later became King Philip II of Macedon.

Aristotle's life changed greatly when he was ten. His father died, and his mother passed away not long after. He was put into the care of his uncle, Proxenus, who saw to the youngster's further education in the humanities. Aristotle studied Greek, rhetoric (the study of the use of language), and poetry. He had already been taught the sciences by his father. At about the age of seventeen, in 367 bce, Aristotle was sent to Athens, where he became a student in the Academy, the educational institution established by Plato about two decades earlier. Aristotle remained at the Academy for twenty years, as both student and teacher, lecturing and writing on rhetoric.

With the death of Plato in 347 bce, Aristotle finally left the Academy. There are several explanations for this move. Some say it is because he was passed over for head of the Academy in favor of Plato's nephew, with whom Aristotle had philosophical differences. Aristotle's connections to the Macedonian court may also have been a factor in his decision to leave. Phillip II came to the throne in 359 bce, and his kingdom was a challenge to the power of Athens. Anti-Macedonia sentiment was strong in Athens as a result, and some thought that Aristotle left the city because of it.

# The wandering scholar

Aristotle found a more welcoming environment on the coast of Asia Minor at Assus, where the ruler, Hermias of Atarneus, a former soldier, wanted to establish the system of Greek learning. Hermias not only offered Aristotle a school to head, but also provided a bride for him. Aristotle married Hermias's niece and adopted daughter, Pythias. The couple was married for ten years and had a daughter.

Aristotle worked on part of his book, *Politics*, in Assus, sketching out his ideas about the purpose of the city-state, which he believed was to provide an atmosphere where philosophy could thrive. Aristotle was in favor of rule by an enlightened oligarchy, or a small and dominant class of well-educated rulers, who had the best interests of the people at heart. He said the kings of such an oligarchy should, however, be willing to take the advice of wise philosophers.

Aristotle and his followers also began to collect observations on the physical structures of animals that helped lay the foundations of biological sciences. Aristotle continued these studies when he left Assus for the neighboring island of Lesbos (modern-day Mytilene). His move was the result of political events; an uprising had led to the execution of Assus's ruler and Aristotle's protector, Hermias. Aristotle stayed on Lesbos for a year, gathering a group of scholars around him. He continued his studies in animal life, developing his theory that all plants and animals have goals or natural ends. To Aristotle, such ends must be understood in order to comprehend the animal's physical structures fully. Such belief is called teleology, and it assumes there is some sort of organizing principle at work in the cosmos. It was during this time that Aristotle also formed his idea that the soul was the most important part of an individual, and that it joined with the body to form the whole. This differed from Plato's belief in a more universal soul that was only a temporary part of an individual.

By 343 bce Aristotle had returned to the Macedonian capital, Pella, where he remained for several years. Some accounts have Aristotle tutoring the thirteen-year-old son of Philip II, Alexander (356–323 bce). Later this boy became known as Alexander the Great, and he conquered much of Asia, bringing it under Greek rule. Other historians note, however, that these stories of Aristotle and Alexander only arose much later in history. In fact, the two were very much opposites. Aristotle loved the concept of the city-state, but Alexander later destroyed such localized governments in order to rule over them.

Aristotle assembled a group of followers in Pella and took them with him when he left the capital for his hometown, Stagira, in 340 bce. After the death of his wife, Aristotle formed a lifelong relationship with a woman named Herpyllis, and they had a son together, Nicomachus, named after Aristotle's father. He remained in Stagira until 335 bce, when he returned to Athens. He was nearly fifty, which was considered quite old as the life expectancy of most Greeks at the time was around twenty.

# Founds the Lyceum

In Aristotle's absence from Athens, the leadership of the Academy had passed to an old friend, Xenocrates of Chalcedony. Aristotle began teaching at a location near the temple of Apollo Lyceus, just outside Athens in a grove of olive trees. The school was called the Lyceum, after its temple location. A shaded walkway, the *peripatos*, was a favored place of instruction for Aristotle, who liked to walk as he lectured. Because of this, the school also became known as the Peripatetic School, as *peripatoi* means "to walk." Aristotle believed that a person could not really claim to know a subject until he could teach it to another. For the next twelve years, he lectured at the school while he continued his research.

The wide variety of subject matter offered for study made Aristotle's Lyceum different from the Academy founded by Plato. Indeed, because of the many subjects Aristotle taught, and also because of his emphasis on observation and research, many consider the Lyceum to be the first true university in history. Aristotle also founded a library and museum at the Lyceum, further enhancing its reputation.

It was during his years at the Lyceum that Aristotle composed most of his writings. Many of these works are in the form of dialogues, a model Plato had originated, in which theories and ideas are presented and explained in popular language in the form of a conversation between two people. He also wrote many treatises, or systematic explanations of a subject, in more formal and technical language.

After the death of Alexander the Great in 323 bce, anti-Macedonian sentiment again became high in Athens. The people of Athens blamed Macedonians like Alexander and his father for taking away their power as a city-state. Aristotle again became the focus for some of this negative sentiment. Like another well-known philosopher before him, Socrates (470–399 bce), Aristotle was charged with impiety, or disbelief in the gods. Instead of facing his accusers, Aristotle left Athens, saying that he would not give the Athenians a chance to sin against philosophy again, for Socrates had been put to death as a result of his trial. Aristotle went to his mother's estate in Chalcis on the island of Euboea. The next year, 322 bce, Aristotle developed stomach problems and died.

# The works

Historians think it likely that Aristotle authored more than 170 books. Of these, only about thirty are still in existence. These works cover Aristotle's wide range of interests, but it is uncertain if they were ever meant to be published, as they resemble working papers and lecture notes rather than perfected pieces. The polished works meant for publication have largely been lost. No real chronology or timeline can be established for Aristotle's works, so they are usually organized by subject or discipline. Although Aristotle wrote about many different theories, a central theme in his work is his belief that reality and the fundamentals of existence can only be understood by careful observation and categorization.

Aristotle was essentially an empiricist, or someone who believes knowledge should be gained through experience and experimentation. He not only used observation to learn about an object or being, but also studied what others had said about it. He was an advocate of two different types of reasoning. In deductive reasoning, he would take a general idea, such as "all birds can fly" and conclude that, based on this, if he saw a bird, it could fly. In inductive reasoning, he approached the argument in reverse order, going from a specific statement to a general idea. "This particular bird can fly," Aristotle might have said, "therefore all birds can fly."

# Aristotle the Man

It is difficult to get an accurate picture of Aristotle as a normal human being, rather than as a giant of thought. The busts and engravings that still exist show a rather handsome and elegant individual. Some writings, however, describe Aristotle in less flattering terms. According to these descriptions, he had very thin legs, small eyes, suffered from poor digestion, and spoke with a lisp. These reports also say he wore fashionable clothing to compensate for his physical defects. His cloak and sandals were always of the finest materials. He wore finger rings and kept his hair cut short. Whether or not he lisped, he was known as a fine public speaker, and was clear, witty, and persuasive in his lectures and in conversation. It is believed that he was comfortable financially, and his family's holdings in Stagira allowed him to indulge his passion for collecting books. Aristotle appears to have been devoted to his family, and he made continual references to them in his will.

## Logic and the sciences

Aristotle published six discussions on logic collected in the *Organon* ("a tool or instrument of thought"). He intended this work to provide his readers with a universal method of reasoning whose use would make it possible to learn everything there was to know about reality. Aristotle's primary work in philosophy is the *Metaphysics*. In the twelve books of *Metaphysics* Aristotle rejects Plato's idea of abstract and universal forms. He lays out his reasoning for the eternal existence of substance.

In *Physics*, Aristotle details one of his most important ideas, the Four Causes, which forms the core of modern Western scientific thought. Aristotle said that in order understand an object, a person must be able to answer four questions about it. The first cause, or descriptive trait, is the material out of which the thing is made. Next is the formal cause, or the pattern, structure, or model of the thing. The efficient cause is how the thing came into being, or was created. The final cause is the goal, function, or purpose of the object. Aristotle also addressed social issues and politics in *Politics*, literary art in *Poetics*, and the use of persuasive language in *Rhetoric*.

## Ethics

Two of Aristotle's works, *Eudemian Ethics* and *Nicomachean Ethics*, deal with moral behavior. In these works, Aristotle discussed how moral responsibility is assumed by individuals, the ways such moral responsibility was evaluated, the nature of friendship, and how to achieve happiness in human life. The major question Aristotle sought to answer was what was necessary for an individual to be a good person. Aristotle concluded that ethics are man-made rather than passed down by a supernatural being or god. He also felt that whether an action was right or wrong varied according to the situation, which was a new concept at the time. This belief made him suspicious of strict and unchanging principles. (An example of a strict, unchanging principle is the Christian commandment "Thou shall not kill.")

Aristotle called his belief that all actions needed to be judged according to the situation "equity." This has become a guiding principle in the modern-day legal system and is also integral to parts of Christianity. In the modern legal system and in Christianity, the condition of guilt or of committing a sin depends in part on a person's intent. For example, in law, murdering someone with intent and not in self defense is called homicide and is punished more severely than causing a death accidentally,

which is called manslaughter. Aristotle believed that happiness was the primary goal of mankind. He claimed that such happiness could be found in doing good deeds, because virtuous activity, rather than a focus on mindless amusement, led to a life of real value. For Aristotle, intellectual thought was the highest form of moral activity because it was what human beings were best suited for. He believed it was the ultimate cause or reason for being. This system of thought has formed the core of Western intellectual study for more than two thousand years.

# For More Information


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# Aristotle

Baker's Biographical Dictionary of Musicians


Aristotle, great Greek philosopher, logician, and scientist; b. Stagira, 384 B.C.; d. Chalcis, 322 B.C. His writings on music are included in K. von Jan, *Musici scriptores Graeci* (1895).

**—Nicolas Slonimsky/Laura Kuhn/Dennis McIntire**



# Aristotle (384-322 B.C.E.)

Learning and Memory


Aristotle was born in northern Greece, in the town of Stagira, in 384 B.C.E. At seventeen, he went to Athens and became a student in Plato's Academy, where he remained for twenty years. Although greatly influenced by Plato and by the pre-Socratic philosophers, especially Empedocles, Aristotle was a highly original thinker and a disciple of no one. In 347 B.C.E. he left Athens and traveled extensively in Asia Minor, becoming tutor to Alexander the Great in 342 B.C.E. Seven years later he returned to Athens and began his own school, the Lyceum. After the death of Alexander the Great in 323 B.C.E., he left Athens, and he died the following year in Khalkís, a few miles north of Athens.

In his main work on memory, *De memoria et reminiscentia*, Aristotle tries to dissect out the central phenomena to be explained, and suggests mechanical explanations of a general sort to account for them. In his scientific works, Aristotle typically seeks the reality behind the appearances, and he expects that the reality may be different from what it seems. This is especially forward-looking in the case of mental phenomena, where subsequent thinkers, such as René Descartes (in the seventeenth century) and Zeno Vendler (in the late twentieth century), insist that mental reality must be exactly as it seems. Aristotle's collection of memory phenomena displays some systematicity, and with characteristic insight, he lights on several basically correct classifications. Nevertheless, to modern eyes some of his collection is a bit of a jumble, and the mechanical explanations tendered are so implausible that they must have been no more than helpful metaphors to him.

Aristotle's relentlessly naturalistic perspective, however, gives him a decidedly modern stamp. That is, he sought physical rather than supernatural or spiritual explanations for memory phenomena, and he well knew the importance of observations even though his own were occasionally mere assumptions. (For example, he thought women had fewer teeth than men.) In the absence of a developed biology, experimental psychology, or neuroscience, he could hardly be expected either to envisage explanations in terms of neuronal connectivity or to know how to penetrate learning phenomena at the behavioral level.

# Observations and Explanations

In commenting upon memory and learning phenomena, Aristotle's fundamental distinction is between recalling information to mind and storing information, or, as he puts it, between remembering, which is "the reinstatement in consciousness of something that was there before" (451b6), and memory, "the existence, potentially, in the mind" (452a10), of an earlier perception or conception. In modern parlance, this is the distinction between remembering in the occurrent sense and remembering in the "stored" or dispositional sense. The central problems, in Aristotle's view, are to explain three things: 1. how a perception of a state of affairs can be stored, 2. how it can be brought to mind later, and 3. how it happens that, when it is brought to mind, the relation between the representation and the original state of affairs, now absent, is such that the first is a memory of the second and is known to be such. In contemporary dress, these are the problems of information storage, information retrieval, and the general problem of how representations represent.

Aristotle tries to explain information storage by appeal to the analogy of imprinting soft wax with a seal. He reasons that sense perception is somehow like a picture and that it is the perception picture that stamps its likeness to create a memory. Apparently the perception is stamped on the soul (Aristotle has a physical, not a supernatural, conception of the soul), or at any rate, it is stamped on some sort of physical stuff that can be in causal interaction with it and can take on some of its properties. This helps address the representation problem. The imprint (memory representation) resembles, physically, the perception (perceptual representation), which in turn resembles, physically, that of which it is a perception. So by transitivity of resemblance, there is a correlation between stored representation and original state of affairs. Aristotle's conclusion that there must be a resemblance was taken as axiomatic by most subsequent thinkers, and they searched for the parameters of physical resemblance. Research since the 1970s, especially in computer science and neuroscience, has revealed that representation does not require resemblance in any straightforward sense, a radical departure from earlier theories.

In asking how representations represent, Aristotle identified a truly fundamental problem. Still only partially solved, it remains a central problem, though it is now addressed within the framework of modern psychology, philosophy, neuroscience, and computer science.

Understanding the importance of broad systematicity in a theory, Aristotle tests a theory's strength by seeing how much can be encompassed within its ambit. Thus he claims that the stuff that receives the imprint may have varying degrees of imprintability. Explanations are then forthcoming for one's poor recollection of early childhood and for declining memory in the elderly: In very young children the stuff is too much like running water to take the imprint; in older humans, the stuff hardens and no longer is very impressible. Extending this idea further, Aristotle thinks a related explanation will apply to his observation that those who are "too quick" and those who are "too slow" also have poor memories. Exactly what phenomenon he is addressing here is unclear, and this may be one of those inexplicable Aristotelian "observations" that need a much broadened base of data.

The representation problem, Aristotle notices, has a further dimension. When an image from memory comes to mind, how do we know that it is a memory, rather than a thought or image without relation to bygone events? That is, how does the occurrent presentation carry the information that it is a memory? His answer has two parts. First, sometimes we do get confused, and we think a presentation is a memory when it is not (false memory); and sometimes we have a memory presentation but are unaware that it is a memory. So the system is imperfect. Second, when the system does work, it is because for animals with memory, "the organ whereby they perceive time is also that whereby they remember" (449b30). The idea here is that when perceptions are stored as memories, they are also somehow indexed as to time, so that the imprint bears not only the perception's shape but also its "whenness."

Retrieval appears to require something like an image or an iconic presentation that resembles the original perception. The mechanism of retrieval should, one surmises, have to do with something taking up the stored imprint and re-presenting it, but in fact Aristotle says nothing of this. Instead he discusses the phenomenon of association, noting that events experienced together are often remembered together. He explains associated recollections by saying that the "movement" of a perception causes the "movement" of the memory. He sees, therefore, that part of the theory of storage will include the relations between associated memories, but he neither provides an account of those storage relations nor elaborates on how information is retrieved by the "movements" (451b15-30).

In *Historia animalium* Aristotle suggests that humans and animals differ in that humans alone can remember something at will (488b25), though he also notes in *De memoria et reminiscentia* that recollections can occur without effort. Indeed, he observes that melancholics often have obsessive memories, try though they might to repress them. In the physicalist spirit, he conjectures that melancholics have more moisture around their sense perception center, which is easily set in motion, thus explaining the memory's being presented again and again despite one's will.

Aristotle believed that animals differ in whether they have the capacity to store their perceptions; animals with the capacity to do so have genuine knowledge of their world, whereas animals lacking the capacity merely respond to their current perceptions on the basis of their innate dispositions. The advantage of storing perceptions is that the stored items may come to have systematic relations among themselves, with the result that the animal can recognize different individuals as belonging to the same category. In humans this means, for example, that a pine tree, a yew, and an olive tree may all be recognized as similar despite differences in shape, size, and color. He says that the soul is so constituted that the universal "tree" can be developed from the stored perceptions of individually distinct items. A slug, on the other hand, lacks the capacity to generalize across individuals because it lacks the capacity to store information.

In Aristotle's view, storing information provides the similarity substructure that underpins both scientific categorization and the skilled knowledge displayed by craftsmen who can make many different clay pots or ship's captains who can sail under many different conditions. In modern guise, his idea is that generalization to items that are relevantly similar but incidentally different, both perceptually and behaviorally, requires information storage. Additionally, he regards this capacity as enabling experience, the reason being that experience requires understanding, which in turn requires categorization of perceptions. Consequently, animals such as humans have genuine experience; animals such as slugs do not (*Posterior Analytics*, 99b36;l00a5).

# Conclusion

Any inclination to feel smug about Aristotle's shortcomings should be tempered by noting that even current classifications of learning phenomena are controversial and tentative, and experimental psychologists are sometimes chided for doing little more than codifying common sense. Nor, of course, should Aristotle himself be blamed for the slavish adoption of his every word by uncritical monks in the Middle Ages. Aristotle the scientist-philosopher was anything but dogmatic. Twentieth-century physical explanations—although not mechanical, but electrical and biochemical—sit well with his abiding naturalism.

For a long period in the history of thought, Aristotle's views on nearly everything were taken as authoritative. His *Metaphysics* probably had the greatest impact; however, the work on memory was not especially influential.

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