Jan Klein · Norman Klein

Solitude of a Humble Genius - Gregor Johann Mendel: Volume 1

Formative Years

Springer

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The Unfathomable Mendel

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Springer

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Additional material to this book can be downloaded from http://extras.springer.com

ISBN 978-3-642-35253-9 ISBN 978-3-642-35254-6 (eBook)
DOI 10.1007/978-3-642-35254-6
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013948128

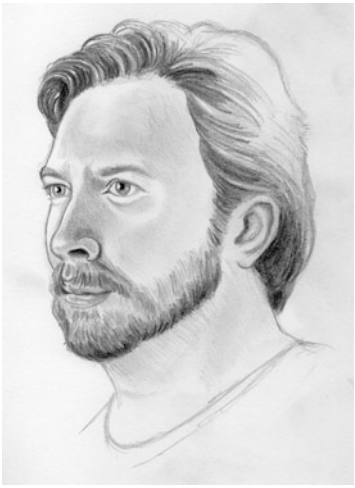
Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

We dedicate this work to Dr. Anna Matalová in recognition of her extraordinary contribution to Mendel scholarship. As a continuator of the Czech tradition of Mendel study founded by Jaroslav Kříženecký and Vítězslav Orel, Dr. Matalová was the head of the renowned Mendelianum of the Moravian Museum at Brno until her retirement. She served as the Editor-in-Chief of the Folia Mendeliana, a journal devoted exclusively to the study of Mendel. She organized several Mendel Forums, meetings that brought together Mendel experts from different parts of the world. She shared graciously her knowledge of Mendel, which is second to none, with many pilgrims to the founding place of genetics. Above all, however, she has made numerous portentous contributions revealing new aspects of Mendel's life and work. We owe Dr. Matalová the stimulus that brought us on the path to this present work. She has infected us with her enthusiasm for Mendel for which we are extremely grateful.

About the Authors

Jan Klein is the director emeritus of the Max Planck Society for the Advancement of Science and Frances R. and Helen M. Pentz Visiting Professor of Science, Department of Biology, Pennsylvania State University. Several happenstances seem to have predestined him to become ultimately Mendel's biographer. He was born in a small Silesian village, a mere cycling distance from Hynčice, Mendel's birthplace. Like Mendel, he also grew up on small farm and studied at the same school as Mendel, the *Gymnasium* in Opava. He earned a PhD in genetics, to which he then devoted his research career. And he is the recipient of two Mendel medals, one awarded by the Moravian Museum at Brno and the other by the Czech Academy of Sciences at Praha.



Norman Klein is a freelance illustrator, who holds a Master of Fine Arts degree in Illustration and Animation with a Minor in Graphic Design and Art History. He lives in Miami, Florida.

Acknowledgments

This book would not have come into existence without the help of many individuals and some institutions. Below we name some of these and specify for what we are particularly thankful to them.

NK

I would like to thank my parents, who have made all this possible, not just in the obvious sense, but through their unwavering support and belief. My mom, who, if there are any saints walking this earth, is surely one of them. My dad, for giving me the opportunity to come on board this unique project and for pushing me to new heights of endeavor.

My brothers, Daniel and Paul, without whose support, encouragement and sense of humor, I would have packed it in long ago. . .Even if one of them is an Arsenal fan!

And Sharokina, for providing welcome opinions and research, over the many years this project has been going on. . .Not to mention putting up with the artistic temperament!

Thank you all, from the bottom of my heart.

JK

I thank:

Paul Klein for his gentle editing and for movie tips as an antidote to an overdose of Mendel. Dr. Dagmar Klein, University of Miami, Miami, FL, for consultations concerning Moravian cuisine. Drs. *Akie Sato* and *Noriyuki Kuroda* of Tsurumi University, Japan, for help in taming my Mac; and *Akie* also for her friendship, discussions, and assistance in the preparation of the manuscript. *Milada Horáková* and Ing. *Zdeněk Horák*, Praha, for their friendship, hospitality, searches for hidden information, and connections. Prof. *Masatoshi Nei*, Penn State University, for never-ending debates and for access to his office facilities. Drs. *Nikolas Nikolaidis* and *Dimitra Chalkia*, the former of the California State University Fullerton, for their friendship and disputations about Greek, Greeks, and Greece, but not only. Mgr. *Antonio Rivas*, Prior of the St. Thomas Abbey, Praha, for his live demonstration of the Augustinian habit, answering many questions, and for a Catalogue listing

Augustinian friars at Staré Brno in Mendel's time. Dr. *Josef Mrowetz*, Stuttgart, for friendship, help in interpreting Hölderlin, Janáček, and other conundrums. *Lynne Yakes*, Tübingen, for providing a somewhat different interpretation of Hölderlin and for editorial assistance in the prehistoric phase of this book's inception. Dr. *Herbert Tichy*, Tübingen, for information about Mendels in southern Germany; *Daniela Čáslavská*, for reminding me how I once was and for help in a search for Alžběta Rejčka's likeness. Dr. *Eva Mrhačová*, Ostravská univerzita, the fourth of the three musketeers, who once studied at Mendel's *Gymnasium* in Opava, for her help in sorting out Mendel's ancestors, and for information about Mendel that was new to me. Prof. *Milan Myška*, Ostravská univerzita, for his works on the history of Opava's *Gymnasium*. Drs. Colm Óh Uigin and *Tomoko Steen*, the former at NCI-Frederick and the latter of the Library of Congress, Washington, DC, for listening to my endless discourses on Aristotle and Mendel, and for helping me to access important material; Colm also estimated the degree of Slavic admixture in Mendel's genome. And *Val Berzins*, for reading and criticizing nearly all the chapters.

My special thanks go to the staff of the *Penn State University Libraries*. Never before have I depended so much on a library as when writing this book. And never before have I encountered a library that responded so perfectly to my needs as this one: well organized, efficient, friendly, and helpful—a pleasure to deal with. I particularly value the service of the Interlibrary Loan Department, which I often challenged with a request that was not easy to fulfill; yet it always acquitted itself of the task with flying colors. Many thanks for the help!

JK, NK, and PK

Retracing Mendel's travels along the Amber Route, we were assisted at the different stations by persons to whom we would like to express our gratitude.

Vražné/Hynčice: Ing. *Vladimír Nippert,* mayor, Obecní úřad, for enabling us to visit the Mendel estate while in the process of reconstruction and for answering many questions about Mendel's native house and the region.

Lipník nad Bečvou: *Božena Musilová*, librarian, Městská knihovna, for taking us on a memorable tour through the city, including braving a climb of a dilapidated church tower; and for her information about the Piarist school in Mendel's time.

Opava: *Jana Indrová*, librarian, Zemský archiv, for letting us examine the parish register recording the births of Johann Mendel and his four sisters. Ing. *Antonín Klein* and *Milena Kleinová* for old newspaper articles on Mendel.

Olomouc: Prof. *Vítězslav Bičík*, Palacký University, for walking us through the city and arranging appointments for us. Dr. *Pavel Urbášek*, head of the University Archive, for access to the *General Katalog der Schüller*, photocopies of the relevant pages, and for answering our questions. Prof. *Jiří Fiala*, Palacký University, for consultation and publications regarding the university's history.

Brno. Dr. *Anna Matalová*, for a tour of the *Mendelianum* when it was still located in the St. Thomas Abbey at Staré Brno, for showing us the Mendel relics, and for supplying us with fundamental Mendelian literature. Dr. *Jiří Sekerák*, for keeping open our channel to the new *Mendelianum* and so to the original sources.

And Ing. *Radan Kvěť*, for being our guide through the city, for his perduring interest in our writing, and for reading and commenting on our manuscript-*Vienna*: Dr. Robert Stangl, *Universitätsbibliothek, Institut für Botanik und Botanischer Garten der Universität Wien*, for a photograph of the *Botanisches Museum*.

Special thanks are also due to Dr. *Andrea Schlitzberger* of the Springer-Verlag for being so patient and not giving up on us.

Prologue

Si puo? Signore, Signori[1]—as we present this book to the reader, we are reminded of a story about the Moravian composer Leoš Janáček. It is said that one day he came into a bookstore in Brno demanding "that history of the Bohemian brewery." Perplexed and not knowing about the existence of such a book the apprentice consulted the owner of the establishment. The proprietor, familiar with the maestro's sense of humor, thought only for a short while and then pulled out from the stacks a four-volume biography of Bedřich Smetana by a Czech musicologist known for his tendency to cover auxiliary material at great depth. After the maestro left the store, the proprietor explained to the astonished apprentice that Janáček alluded ironically to the fact that the musicologist devoted much of the first volume of his biography to the history of Bohemian beer brewing because several generations of Smetana's ancestors happened to be brewers.

The present book is not about brewing beer—but booksellers beware: If customers ask for treatises on Aristotle, the history of Europe, or the life of Silesian peasants, they might be referring facetiously to our book, for we deal with these topics to an extent that some readers might find disproportionate. We do not apologize for casting our nets so broadly for we intend to catch fishes that might have eluded other biographers. We use the broad approach, for example, to point out that Mendel really starts where Aristotle left the subject some 2,000 years ago and thus give the proper perspective on the achievements of both Aristotle and Mendel. Or, to drive home the message that Mendel was neither of German, Austrian, or Czech nationality, as various writers claim depending on their own nationality, but a Silesian. Suspecting that you might not know much about Silesia, we try to give you a taste of the complexities involved in the formation of present-day European nations. This particular chapter also serves to demonstrate the falsity of the assumption that language-based nationality classifications always mirror the genetic compositions of the nations involved. And the third case of our broad net-casting—the detailed incursion into Mendel's youth and his peasant roots—is meant to dispel

[1] "By your leave, Ladies and Gentlemen." Tonio in Ruggiero Leoncavallo's *I Pagliacci*.

the common perception that his rustic origin has disadvantaged his intellectual development. We argue, on the contrary, that it endowed him with a healthy dose of rationality, which made him immune to the Romantic fever of the century into which he was born. It enabled him to see through the Romantic haze and thus to keep his feet firmly on the ground, when all around him others were engaging in flights of fancy. Alas, the same endowment alienated him intellectually from the establishment with the result of a nearly total lack of reaction to his discovery.

We think that the three words we have chosen for the title of our book—solitude, humbleness, and genius—characterize Mendel best. By "solitude" we do not mean isolation in terms of social interactions for Mendel's behavior showed no such tendency. On the contrary, his colleagues at the Abbey in which he lived and the schools in which he taught, as well as the student whom he taught all perceived him as a congenial and amiable person. It was through his research that he had ended up being alone, without a single person who could understand the direction on which he set out. This solitude, which lasted for the last 30 years of his life, was exacerbated by social isolation in his last decade, and then continued, after his death, until the end of the century. It looked as if the world would never learn about his discovery.

On Mendel's humbleness agree all those who had known him and whose testimony has been recorded. Their characterization of Mendel is not a mere charity to the deceased *à la de motuis nihil nisil bonum* (of the dead nothing but good) for it is supported by all the facts we know about his life. Indeed, the long neglect of his discovery supports Mendel's humbleness best. There are historians who argue that had Mendel been cognizant of discovering the laws of heredity, as they are now commonly attributed to him, he would have said so and would have advertised vigorously his discovery. Since he does not mention any such laws and does not even use the word "heredity" in his main works, he was, according to these historians, apparently unaware of the significance of his results. These modern-day critics, living at times which consider self-promotion a virtue and invasively malignant advertisement a good thing, do not seem to understand that Mendel was brought up in a family in which the dictum "self-praise stinks" was part of their moral code. He therefore must have had an aversion toward dishonest generalization of what his data revealed. It was his humbleness that restricted his interpretations to what his data actually demonstrated.

Finally, by "genius" we do not mean the Romantic vision of a demonic individual bearing his head above the clouds and uttering bits of wisdom to the commoners as if casting pearls before swine. Mendel was not at all of this type; his genius was cryptic, hidden to the extent that none of his contemporaries might have thought of him as being a genius. Indeed, some of the historians mentioned above deny Mendel being a genius and try to present him instead as a lucky fumbler who did not know what he was doing and by chance arrived at results whose meaning he did not fully grasp. This, however is a minority view held by scholars who apparently have only a superficial knowledge of Mendel. By contrast to them, all scientists who have read Mendel's *magnum opus* have been awe-stricken by it and hold it for a work of a genius. We expand on all these points in the text at the appropriate places.

To appreciate fully Mendel's contribution and the greatness of his genius it is necessary to understand what he did, how he did it, and to view his work in the context of what was known and believed in his time. It is for this reason that in this book we place so much emphasis on providing the necessary backgrounds and contexts wherever they might help to understand the issues involved.

A few *technical comments* regarding this book: The text of each chapter is divided into sections and subsections, which will enable readers to choose parts they want to read and others they might want to skip. Nearly all *figures* are hand-drawn by N.K. They are either original or based on old anonymous prints; where the author of the original is known, proper attribution is given. An additional figure (Fig. S1) appears as *supplementary material* online and can be downloaded from http://extras.springer.com/2013/978-3-642-35253-9.

State College, January 2013 Jan Klein
Key Biscayne, January 2013 Norman Klein

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Prelude: Heredity, Sex, and Species: The Greek View

1

Τηλέμαχ', οὐδ' ὄπιθεν κακὸς ἔσσεαι οὐδ' ἀνοήμων·
εἰ δή τοι σοῦ πατρὸς ἐνέστακται μένος ἠῦ,
οἷος κεῖνος ἔην τελέσαι ἔργον τε ἔπος τε,
οὔ τοι ἔπειθ' ἁλίη ὁδὸς ἔσσεται οὐδ' ἀτέλεστος.

Homer: *Odyssey*[1]

October has a special significance to the modern scientist, because in this month the Karolinska Institutet in Stockholm announces the year's winners of the Nobel Prizes in three scientific disciplines (as well as in other fields)—medicine and biology, chemistry, and physics. Those scientists who believe that they have made breakthrough discoveries in one of these disciplines await the announcements with hope and trepidation, all others with curiosity. For although there are other awards that recognize the significance of scientific discoveries, none of them carry the prestige that a Nobel Prize does. The accolade is accompanied by great media interest, which then usually lasts until the actual awards ceremony in December. The laureates, however, continue to enjoy a special status among their peers afterward, which often leads to a small avalanche of other awards. They also become adornments to the institutions with which they are affiliated, as well as to their native towns and nations. Outspoken laureates become media gurus, to whom journalists like to turn to for their comments on a variety of political, social, and scientific issues. They remain in the limelight for as long as they are willing to cooperate with the news hunters. For the rest of the laureates, the limelight fades gradually. Nevertheless, they are assured of immortality, even if it may only be restricted to a mentioning of a name followed by a few explanatory lines in a larger encyclopedia. For fame is fickle and the memory of humankind proverbially short—and it is not too difficult to understand why. Nobel Prizes in the three disciplines mentioned have been awarded yearly, with a few exceptions, since their inception at the beginning of the twentieth century. As there are one to three laureates in each discipline each year, in the more than 100 years of award giving, the awardees have grown into a small crowd. Who could remember all their names and accomplishments? Even the practitioners of the three disciplines can at best name fewer laureates than they have fingers on one

J. Klein and N. Klein, *Solitude of a Humble Genius - Gregor Johann Mendel: Volume 1*,
DOI 10.1007/978-3-642-35254-6_1, © Springer-Verlag Berlin Heidelberg 2013

hand. And so all we can expect the active memory of humankind to retain are but a few names that stick out far above the Nobel Prize standard. These are the names of scientists, whose discoveries have changed or have led to a change in the way that humanity views the world. They are scientists like Albert Einstein, Max Planck, and Niels Bohr in the twentieth century; Charles Darwin, Alfred Russel Wallace, and Gregor Johann Mendel in the nineteenth century; Isaac Newton in the eighteenth century; Galileo Galilei in the seventeenth century; and Nicolaus Copernicus in the sixteenth century, when modern science began to emerge.

The inclusion of Mendel in this absolutely top class of scientific giants might surprise some readers, who may be used to thinking of him as a good-natured, pious monk, toiling for years in his small garden, crossing pea plants, until he stumbled upon the observation that their characters segregated at specific ratios. We shall argue in this book that this portrayal of him is nothing more than a myth. We shall argue also against the slander that he cheated, as some biographers have declared, and against the variety of postmodernist claims of Mendel not being a Mendelian (carrying his experiments to disprove Darwin, not carrying any experiments at all, and so on and so forth). We shall show all of these claims to be nonsensical, due to those authors' insufficient knowledge of Mendel's work and of the circumstances under which he labored. We shall show Mendel as being aware of the implications of his discovery, which did nothing less than overturn the more than 2000 year long dominance of the Aristotelian view of heredity and replace it with a modern corpuscular view. But before we turn to Mendel, his life, and his work, we must explain what exactly this old view was and why it prevailed until Mendel's time. What follows will not be easy to read, for it will take us to the heart of Aristotle's philosophy. Hopefully, a reader who perseveres through these difficult parts will come out rewarded with an understanding of the background against which Mendel's achievement must be pitted in order to grasp its real significance. But first a cartoonist's view of the central issue.

Heredity Counter Generation

On a sunny Sunday afternoon a young couple strolls through a park with their newborn son in a baby carriage. As they meet a family friend, he leans over the carriage and exclaims: "How cute! He looks just like his father!" (Fig. 1.1). This scene, which must have played itself out time and again in various versions through the ages, epitomizes one of the most profound mysteries of life: the mystery of *generation* or *reproduction*. These two words derive from the Latin verbs *generare* and *producere*, respectively, both of which mean, "to bring forth," "to give rise," "to bring into being," "to beget," "to procreate," or "to give birth." The addition of the prefix *re-* to *producere* emphasizes a second meaning of both words, namely, that besides the act of bringing forth, they also imply a *resemblance* between that which is brought forth and its originator. In the processes of life, the originator is the *parent* and that which originates the *progeny* or *offspring*. The second meaning of generation (reproduction) is most succinctly expressed by the phrase "like begets

Fig. 1.1 Cuckoo's egg or the incorruptibility of heredity

like." The begetting can be either *sexual* (i.e., involving the union of male and female germ cells) or *asexual* (i.e., not involving such a union). The resemblance between the offspring and its parent has two aspects. The one aspect is that the new individual is normally of the same *kind* (*genus* in Latin) or *species* as the parent (the human species in Fig. 1.1). The second aspect is that within a given species, the offspring resembles the biological parent in a particular feature (the bulbar nose in Fig. 1.1) which is absent in many other individuals of that species. Let us call this transmissible feature *character*, and the phenomenon of transmission *heredity* or *inheritance*. We see immediately how the terms sex, species, and heredity tie neatly together in the concept of generation (reproduction). This concept was developed in ancient Greece in the fifth century Before the Current Era (BCE) by Aristotle and then incorporated into the foundation of Western thought. There it persisted, virtually unchallenged, until the nineteenth century. In that century, however, it underwent a radical reinterpretation, when the speculations on which it rested were subjected to experimental verification. The term "generation" was then largely abandoned in its original meaning (though it eventually acquired other meanings). The three components of generation (sex, species, and heredity) developed into separate sciences: reproduction together with developmental biology, evolutionary biology, and genetics, respectively. The man, who single-handedly accomplished

this transition from generation to genetics, was Gregor Johann Mendel. If we are to appreciate fully the significance and greatness of his accomplishment, we must try to grasp the circumstances under which the generation concept arose and also go into some detail of the concept itself. The aim of this chapter is to do just that. Here we give a brief introduction to the intellectual climate in which the ancient Greek philosophy emerged, followed by an equally brief description of two of its themes which are relevant to the present discussion, and then devote the rest of the chapter to Aristotle's generation concept.

The Mutiny of Reason

In the seventh century BCE, what later came to be called Greece was a loose conglomerate of independent, competing, and sometimes warring city-states strewn on the coast along the Mediterranean Sea. Only a common language, shared gods, and similar culture united the city-states. Like other peoples of that time, the Greeks used gods to explain phenomena and events they could not explain otherwise. Thus, they attributed thunderstorms to Zeus sailing the thunderclouds and hurling thunderbolts; earthquakes to Poseidon stomping his feet and thrusting his trident into the ground; winds to Boreas, Zephyr, Notus, and Eurus, each blowing his breath in a different direction; and so on. These explanations were so simple that even the dimmest person could grasp them and so make sense of the world. But for some people, they seemed a bit too simple. Toward the end of the seventh century BCE, a group of savants initiated a movement that expressed dissatisfaction with the traditional view of the world and developed a new view, from which gods were largely expelled. Two words then came to differentiate the traditional and the new views: *mythos* and *logos*. Initially the words had a similar meaning, but as they evolved, they acquired diametrically opposite connotations.[2] The Greek word *mythos* originally meant "speech" or "thought" but gradually came to stand for "a traditional story of ostensibly historical events that serves to unfold part of the world view of a people or explain a practice, belief, or natural phenomenon".[3] The term *logos* might have originally meant "word" or anything connected with the use of words, for example, a "narration." In this sense it was used interchangeably with *mythos*.[2] Later, however, it assumed a new meaning. As the Romans began translating Greek texts into Latin, they rendered *logos* as *ratio*, in certain contexts. This Latin noun was derived from the verb *reri*, which originally meant "to calculate," and later also processes mentally resembling calculation, such as "to reckon," "to think," and especially to think in a particular way—"to reason." *Logos* thus came to be translated as *ratio*, in the sense of "reason" and *reasoning*. In this special sense, "reason" became nearly synonymous with "cause," and "reasoning" came to mean the kind of thinking in which thoughts followed each other in a cause and effect combination. Other names that came into use for this form of thinking were *rational* and *logical*. These two terms, however, had originally slightly different meanings. As Greek savants established certain rules of thinking and termed the study of these rules *logike* (logic), *logical* became the kind of thinking that adhered to the principles of logic.[3] The Greeks began thinking logically

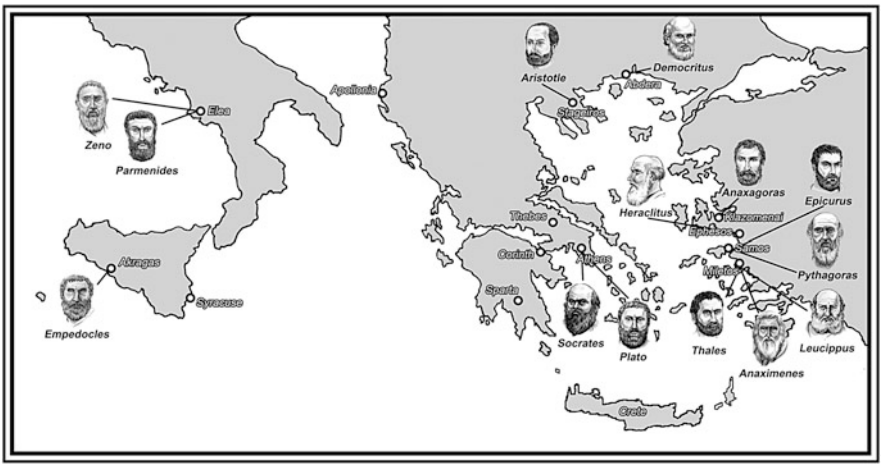

Fig. 1.2 *Frogs about a pond*: the geography of ancient Greek philosophy. The quote is from Plato's *Phaedo*; the "frogs" are the ancient Greeks and the "pond" the Mediterranean Sea, which they colonized

already when they were still in the mythological period of their development.[4] They then conceived stories that were myths by their function (explanation combined with an entertainment) and because they moved back and forth between natural and supernatural but had a tendency toward rationality. Poetic and rational thinking mixed freely in these myths, and it was only a question of time for the rational mode of thinking to prevail over the poetic.

The prosperity of the upper classes, the propensity of the Greeks to use rational thinking, and the absence of organized clergy had led to the rise of a breed of self-supporting freethinkers engaged in an intellectual intercourse that resembled an soccer game. The object of the game was to score points not with a ball but with thoughts challenging the opponents to a response. The game was conducted by verbal exchanges at gatherings or symposia,[5] at schools founded by leading savants, and by means of papyrus scrolls on which the authors recorded their thoughts in writing. One of the first such schools arose in the Greek colony of Miletus, an ancient port on the western coast of Asia Minor (Fig. 1.2). The founder of this *Milesian school*, Thales of Miletus (c. 624–c. 543 BCE), and his followers Anaximander of Miletus (c. 610–c. 546 BCE), Anaximenes of Miletus (c. 585–c. 525 BCE), and others focused their inquiries on nature, which the ancient Greeks called *physis*. Their means of inquiry were observation and rational thinking aimed at explaining the world by the operation of natural (material, physical) agents. Because of their focus on *physis*, they came to be known as *physiologoi* (singular *physiologos*), "those who spoke about nature." They were contrasted with *theologoi* (singular *theologos*), "those who spoke of gods," the thinkers who evoked gods (*theoi*) to explain the operation of the world. Together, the *physiologoi* and *theologoi* began to be spoken of as *philosophoi* (singular *philosophos*),[6] "those who loved wisdom." Since the word

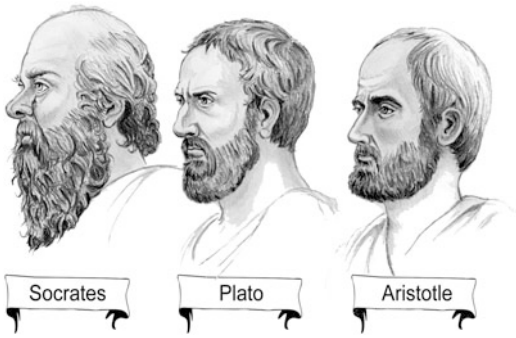

Fig. 1.3 The Athenian Troika

"physiologists" ultimately acquired a more specific meaning, to avoid confusion, we will refer to the ancient physiologists as *philosophers*. The philosophers focused on two fundamental questions regarding the nature of *reality* (i.e., that what is): first, What is? and second, Does it change and if so how? Since the interest in this chapter is the origin of new individuals (genesis, generation), we begin with the second question and come to the first later. Moreover, we restrict our attention to those philosophers, who made the most significant contributions to this subject. They are Heraclitus, Parmenides, and the Athnian Troika – Socrates, Plato, and Aristotle (Fig. 1.3).

Change or No Change?

For the ancient Greeks, "change" was nearly synonymous with "motion." The common view of change was that it represented a transformation of one thing (*A*) into a different thing (*B*). During the transformation, thing *A* ceased to exist and a new thing, *B*, came into being. The process thus involved three states: *Being* (the existence of thing *A*), *Becoming* (the coming into being of thing *B*), and *non-Being* (the cessation of *A's* existence). Early in Greek philosophy emerged two diametrically opposite views of change—that of Heraclitus and that of Parmenides. Heraclitus denied the existence of Being and proclaimed all existence for Becoming. Parmenides, in contrast, denied Becoming and held all existence for Being. Expressed simplistically, Heraclitus claimed that all is change all the time, whereas Parmenides maintained that there is no change in the world at any time. To a commonsense person, these extreme views are both preposterous, for it is apparent that some things change, while others persist. But some ancient Greek philosophers were not commonsense people. Heraclitus of Ephesus (c. 535–c. 475 BCE)[7] argued that things appearing to persist in reality change so slowly that we do not notice it. Rocks crumble, mountains erode, metals corrode, and living things age and die. There is nothing in the terrestrial realm that lasts forever. There is never anything of which we can say that it *is*, because while we think of it as a particular thing A, it has already become something else. There is no Being, there is only

Becoming. If, however, everything flows, as Heraclitus says, then you cannot ever say that something is or is not. What remains constant in the ever-changing world is not the substance or substrate but a process—the process of change. As things change, substances perish, so that there is no single substance or element that is common to all things, not even water or air, which the Milesians held for just such substances. When water changes to air, it "dies" in the process and there is nothing left of it in the air, and the same applies to a change in the reverse direction. Change is so ubiquitous that it itself must be regarded as the real nature of reality.

Like Heraclitus, Parmenides of Elea (flourished in the early fifth century BCE)[8] challenged the commonsense view of change but from a very different position, in which he arrived at the conclusion that change is a logical impossibility. Here is his argument: We start with the statements that *A (Being) is*, whereas *B (non-Being) is not*. The latter statement, however, is nonsense, says Parmenides. Stating that something is not is talking about nothingness, but about nothing there is nothing to be said. As for the former statement, it asserts that *A* is *A* and nothing else. If we then say that *A* is changing into *B*, we must ask: Where does the *B* come from? There are two possibilities. Either it comes from nothing, but this cannot be because we just said that about nothing there is nothing to be said. Or *B* comes from *A*, but this is also impossible because we also said that *A* is *A* and nothing else, otherwise it would not be *A*. If *A* had a trace of *B* in it, then saying that *A* is *A* would not be true, and saying that *A* is *A* and *B* would violate the logical law of contradiction, which asserts that something cannot be two things at the same time. Hence *A* cannot logically change into anything ever. In fact, there is nothing in the world that can change into something else. Not only that, but also there can only be one thing in the world, only One Being, for where would the other Beings come from? Not from nothingness and not from traces of other Beings in the One Being. Furthermore, if the One Being is without a trace of other Beings, it can be said to be homogeneous, exactly alike throughout. Also, since a Being can never change, it remains forever the same, undifferentiated and featureless. Since it cannot come into Being from non-Being and since it cannot turn into non-Being, the One Being is eternal. For the One, time does not exist; the One has no past and no future—it only is. Since it is full everywhere and since it cannot move (remember: motion is a change!), it cannot go anywhere. Parmenides' is a very unappealing vision of the world. Unmoving, unvarying, featureless, uneventful, his is a world without a past and with no future, without evil but also without goodness, without sadness but also without joy. Parmenides' logic seems impeccable, except for the mysteries of where the philosopher himself fits into this picture and how the illusion of many different things arises. Obviously, the senses are deluding us, but in the world of One, there should not be any senses in the first place nor should there be individuals endowed with senses. Is the One dreaming up the world of many? Is it hallucinating? Obviously not, for the same ironclad logic that leads to the One also forbids it to display any activity.

Rather than siding with Heraclitus or Parmenides, most contemporaneous Greek philosophers tried to find a compromise solution between these two extreme views. Generally, the solution had the form of postulating two components of reality, one

fixed and the other changing. The function of the fixed component was to provide continuity and so dodge the accusation of an *ex nihilo* generation. The second component served to introduce the actual change on the background of the fixed component. The various proposals varied in the degree of sophistication, some of them being no more than a charade obscuring but not solving the real problem. Others, on the other hand, had to be taken seriously by Parmenides himself. Among the latter were two proposals, which had a long-lasting influence on Western thought—those of Plato and Aristotle.

Plato's Myth

Plato (c. 428/427–347)[9] admitted that the physical world is changing constantly but at the same time postulated the existence of another world characterized by constancy and permanence. Since the other world overstepped or transcended the physical world, it came to be called *transcendental*. Plato's postulate of a nonphysical realm might have been inspired by his teacher Socrates (c. 469/470–399 BCE).[10] The latter was interested in defining ethical concepts, but when he stopped people on the street and asked, for example, "What is courage?" he commonly got answers such as "Courage is when a person saves a child from a burning house" or "Courage is when a soldier risks his life to bring his wounded comrade into safety." These, of course, were not definitions but merely instances of courageous behavior. Socrates realized, nevertheless, that they pointed at something shared by all of them and that this shared feature was the definition of courage. Plato extended these thoughts to physical objects such as tables or chairs and realized that all objects of the same kind shared a common denominator which he called Idea—"tablehood" in the case of tables, "chairhood" in the case of chairs, and so on. There was, however, no tablehood anywhere in the physical world; there only were particular tables, and the same was true for the chairhood and the particular chairs, as well as for all the other kinds of physical objects and their Ideas. Where then were the Ideas? Since they were not physical, they had to be immaterial and had to occupy a world of their own, a world without space and time—the transcendental realm. The absence of time made the Ideas timeless and changeless, in contrast to the material objects of the physical world, which were all subject to corruption and death. Being eternal and incorruptible made the Ideas perfect, again in contrast to the physical objects, which had various imperfections in comparison to their corresponding Ideas. Since the physical objects of a given kind resembled, if only imperfectly, their corresponding Idea, there had to be some sort of "communication" between the physical and transcendental realm. Plato suggested that the Ideas "participated" in the generation of each physical object, when it came into being. He did not specify what the participation amounted to, but some of his interpreters compared the process to imprinting a seal onto a blob of warm wax. The seal corresponded to the Idea with an ideally executed original pattern; the imperfectly imprinted pattern corresponded to a particular physical object, and the wax to what Plato called a "receptacle," presumably matter. Indeed, since Plato some philosophers hold matter