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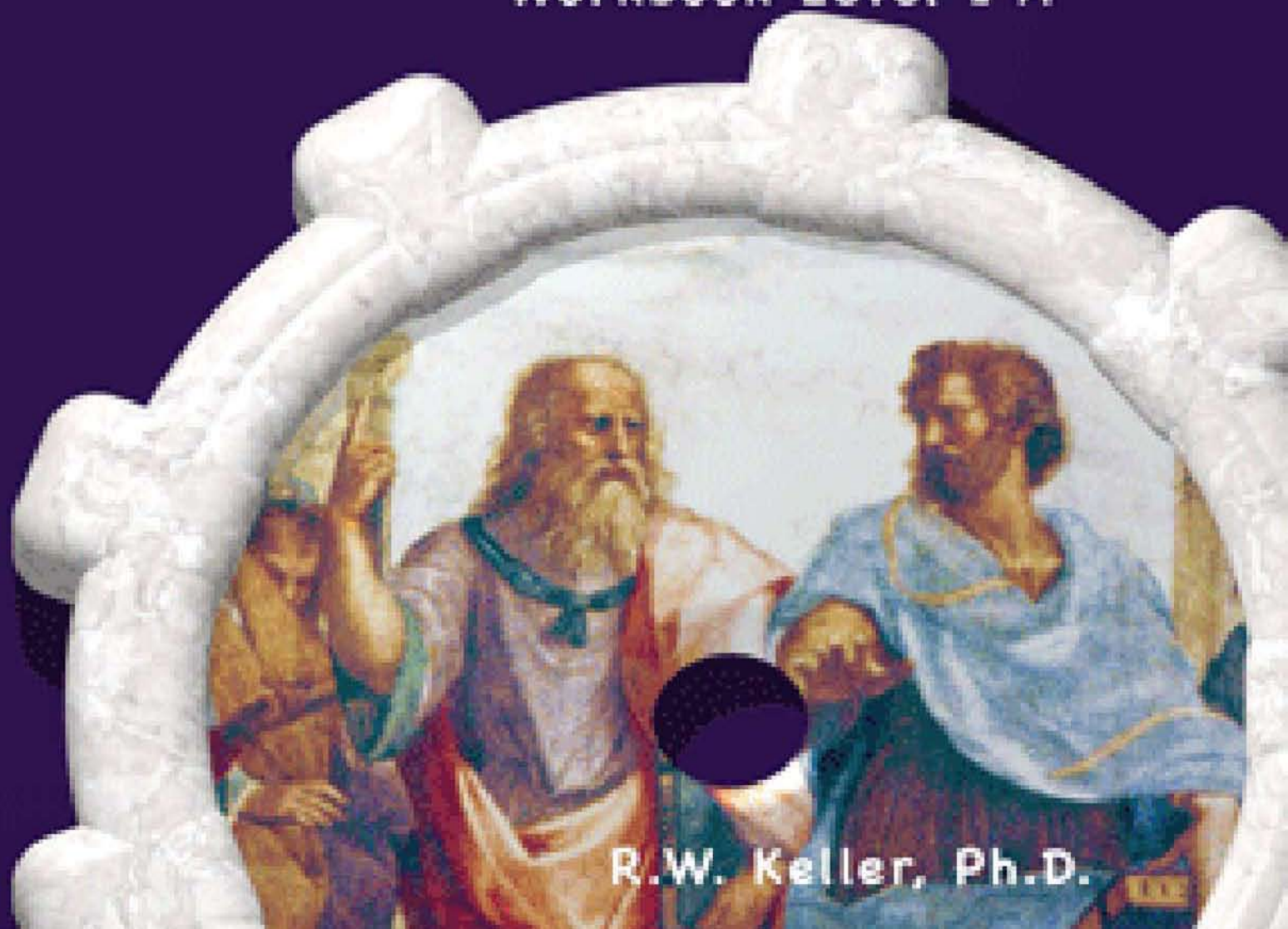


Kids-4-Kids

Chemistry Connects to

Philosophy

Workbook Level I A



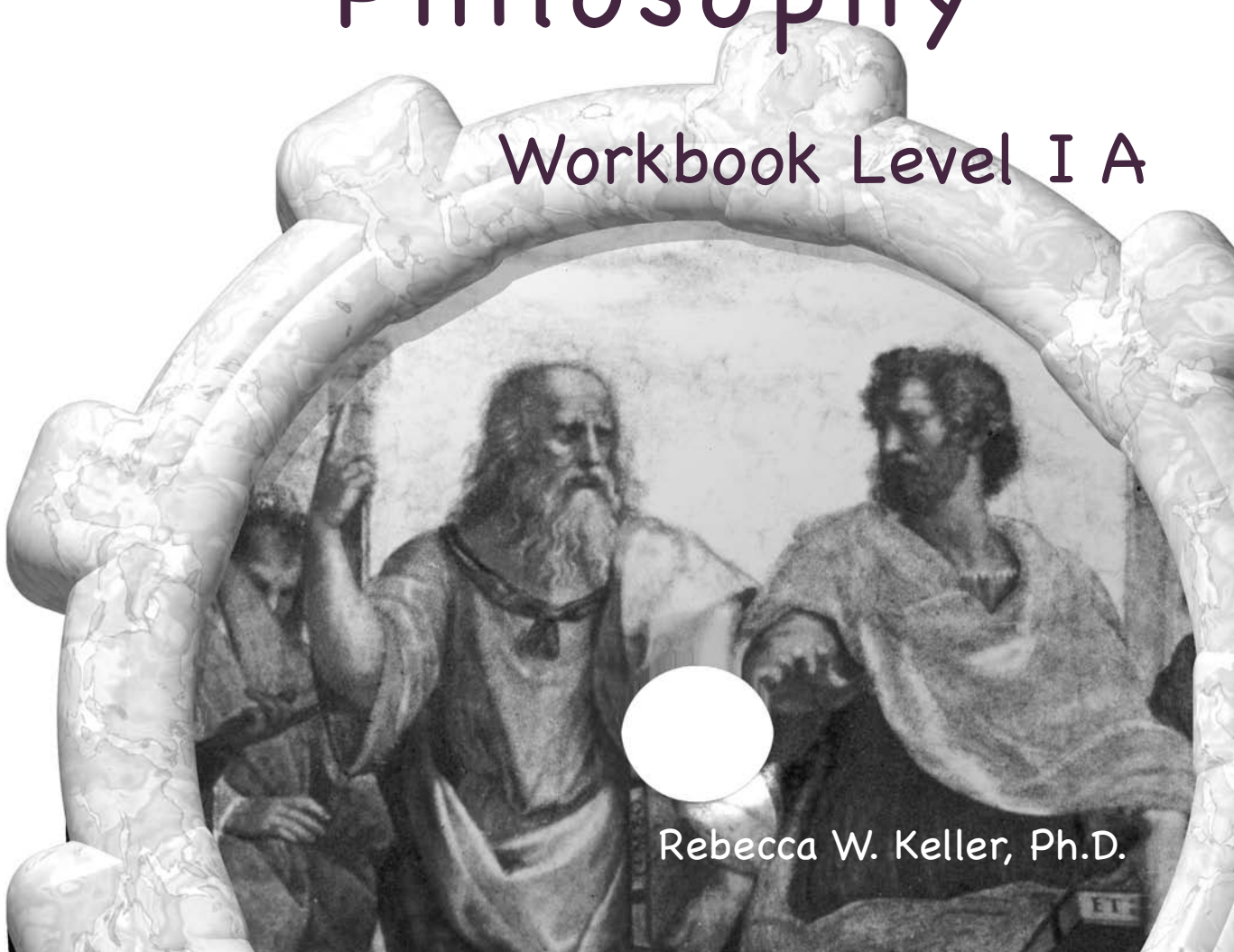
R.W. Keller, Ph.D.

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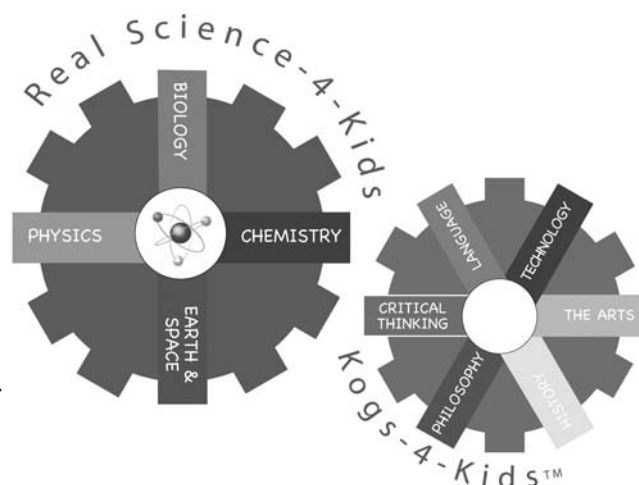
Chemistry Connects to Philosophy

Workbook Level I A



Rebecca W. Keller, Ph.D.

Cover design: David Keller
Opening page: David Keller
Illustrations: Janet Money maker, Rebecca Keller
(unless otherwise noted)
Support Writer: Don Calbreath
Play writer: Dave R. Megill
Editing: Angie Sauberan
Page layout: Kimberly Keller



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Real Science-4-Kids/ Kogs-4-Kids : Chemistry Connects to Philosophy: Level I A

ISBN: 9780979945977

Published by Gravitas Publications, Inc.
P.O. Box 4790
Albuquerque, NM
87196-4790
www.gravitaspublications.com

Printed in the United States of America

Special thanks to G.E. McEwan for valuable input.





Introduction

Philosophy

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I.1 What is science?

What is science? Have you ever wondered what science really is or what it is that scientists really do? I am sure you have seen the scientist in the white lab coat who is working furiously with colored test tubes and looking for new discoveries. But is that all there is to science?



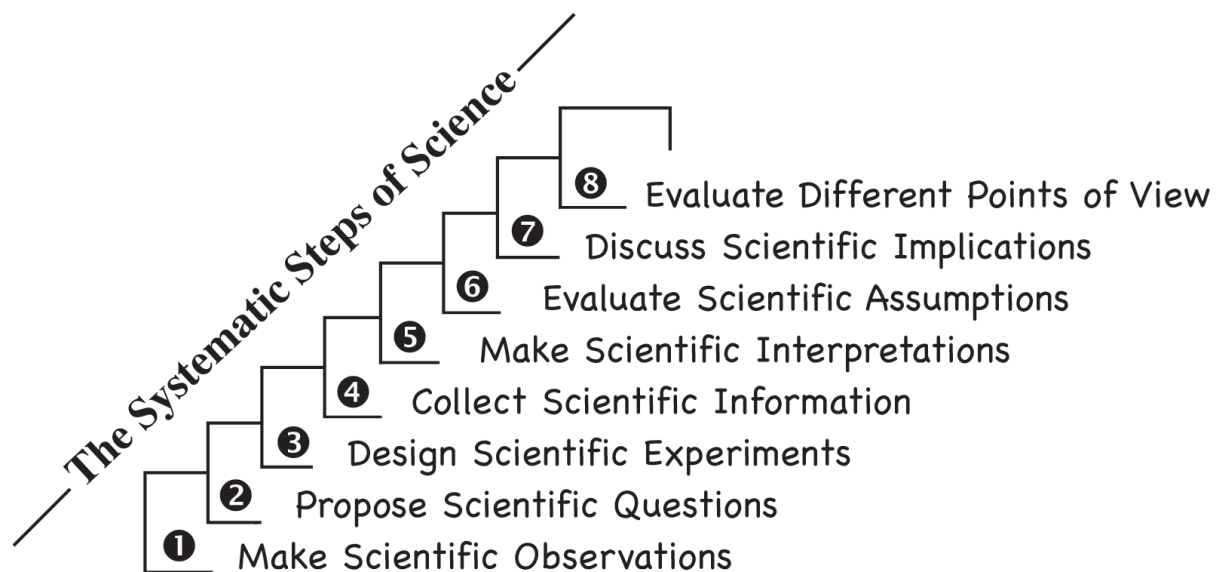
Ask yourself, What is science? Then ask your mom or dad and your teacher to give you a definition of science. What did they say? Did you get different answers? If you are having trouble really putting your finger on a definition of science, don't feel bad. The term "science" is hard to define because science involves many different aspects of learning. It involves making observations about nature and designing experiments. It also involves making conclusions and trying to better understand the world we live in.

This is one way to define science:

Science is a systematic way to study the world in which we live.

What does this mean? What is a “systematic way?” Simply put, scientists use systematic, or particular, methods, such as **observation** and **experimentation**, to gain a better understanding of the world around us. Scientists collect information, or **data**, and then they use this data to make conclusions and predictions about how the world works. In today’s modern world, scientists also use instrumentation to help them make observations that they can’t observe with their senses alone.

There are many ways to define science, but all definitions of science include several systematic steps for the process of scientific inquiry. These include ①making scientific observations, ②proposing scientific questions, ③designing scientific experiments, ④collecting scientific information, ⑤making scientific interpretations, ⑥evaluating scientific assumptions, ⑦discussing scientific implications, and ⑧evaluating different points of view.



The word “science” is a relatively modern word. That is, you won’t find the word “science” in any written documents before about 1400 A.D. The word “science” comes to us from the Latin word *scire*, which means “to know.” The word “scientist” was introduced in 1834 by a British scholar named **William Whewell** (1794–1866). Before this time, people who studied science were called “natural philosophers.”



Where does science come from? Today’s modern science is really a combination of the three different ways that ancient people investigated the world around them. Ancient people first explored the world around them by exploring ideas. Then they explored by observing the things around them. Then they applied their ideas and observations, and they created inventions to help them further explore. Hence, modern science is really a combination of **science as ideas**, **science as discovery**, and **science as invention**. Science as ideas is now called **philosophy**. Science as discovery is now called a particular scientific discipline, such as **chemistry** or **biology**. And science as invention is now called **technology**.

I.2 What is philosophy?

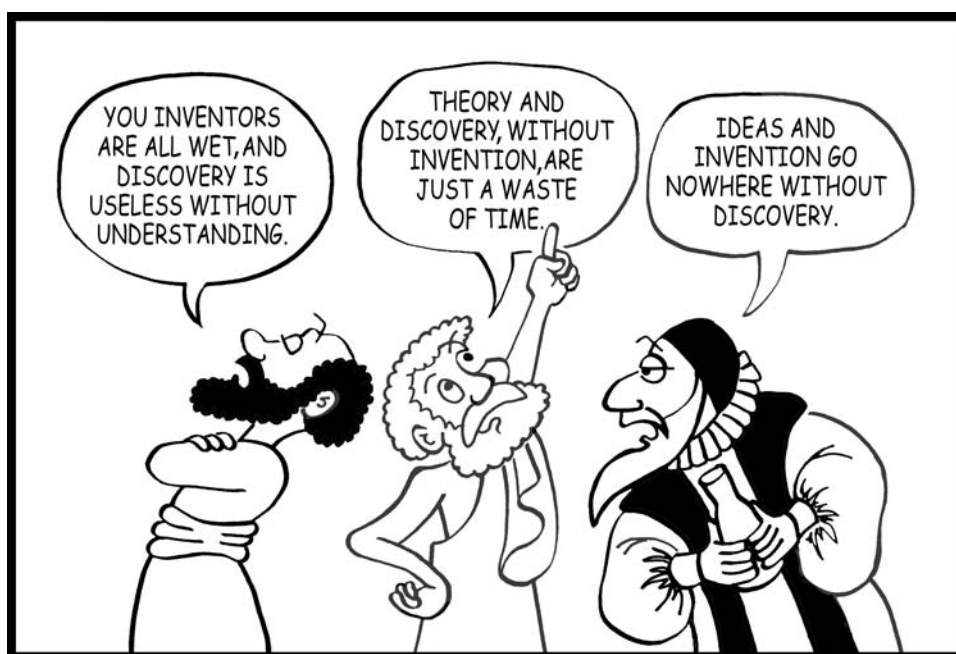
When we talk about philosophy, we are really referring to the thoughts and ideas that began in the area surrounding the Aegean Sea around 600 B.C. The word “philosophy” comes from the Greek words *philein*, which means “to love,” and *soph*, which means “wisdom.” So “philosophy” literally means the “love of wisdom.”



The earliest philosophers were clustered around the Mediterranean Sea, most notably ancient Greece. However, activities that we would today associate with modern science were happening all over the world. Ancient peoples, such as the Egyptians and Native

South Americans, were observing the sky and making mathematical calculations. The Chinese were doing primitive forms of chemistry with mercury and sulfur. And the Native North Americans were testing plants in order to discover which were capable of healing disease and sickness. Today we associate all of these activities, or technologies, with "science."

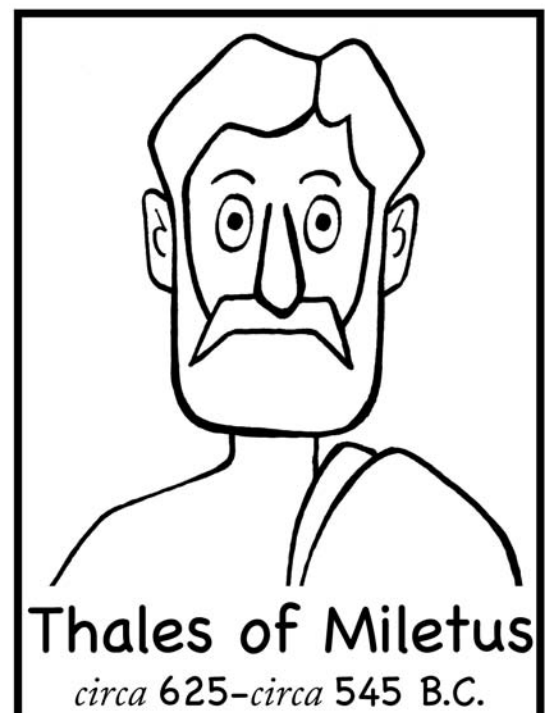
Before the 15th century, ideas about science (philosophy) and scientific inventions (technology) were largely separate. Philosophers didn't much care for the crafts of inventors, and inventors didn't much care for the lofty ideas of philosophers. These two aspects of modern science did not really overlap in ancient times. Also, chemistry was largely performed by alchemists who didn't overlap with either the philosophers or the inventors.

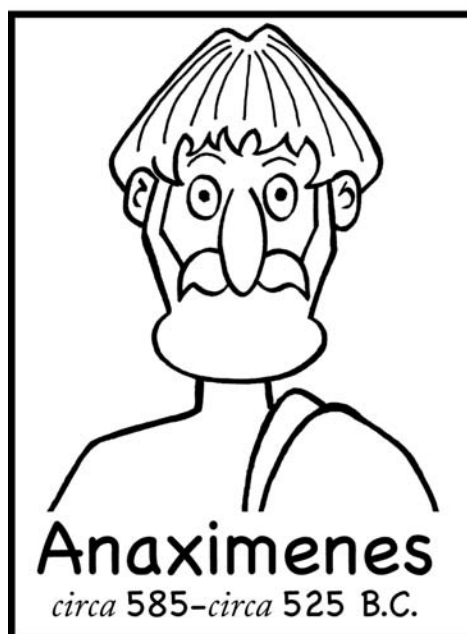
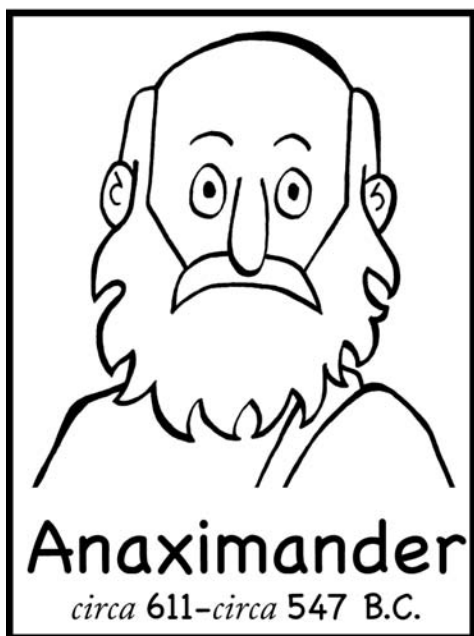


However, after the 15th century, the philosophical ideas that started in Greece began to merge with the technological discoveries being made by people all over the world. The discoveries made by alchemists began to play a role in both invention and philosophy. For example, with the invention of the telescope, observations about the sky, planets, and stars, that ancient peoples had been gathering for many years, were combined with both math and philosophy that came from Greece and the Middle East. This gave us our current understanding of the planets and solar system. From this time forward, modern science exploded as new discoveries and inventions were put together with philosophical ideas. Science as ideas, science as discovery, and science as invention began to merge together, giving us what we know today as *modern science*.

I.3 Greek philosophers

As we mentioned earlier, scientific thinking got its start in the area around the Aegean Sea with the Greek philosophers. **Thales of Miletus** (*circa 625–circa 545 B.C.*) was the first Greek philosopher. After Thales of Miletus, there were **Anaximander** (*circa 611–circa 547 B.C.*) and **Anaximenes** (*circa 585–circa 525 B.C.*), both from Miletus. Then there were **Heraclitus** of **Ephesus** (*circa 540–circa 475 B.C.*), **Pythagoras of Samos** (*circa 580–circa*

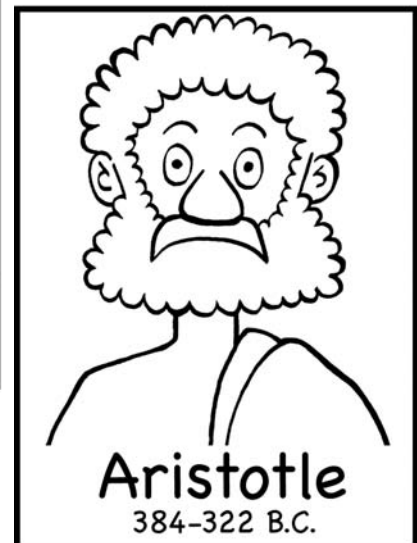
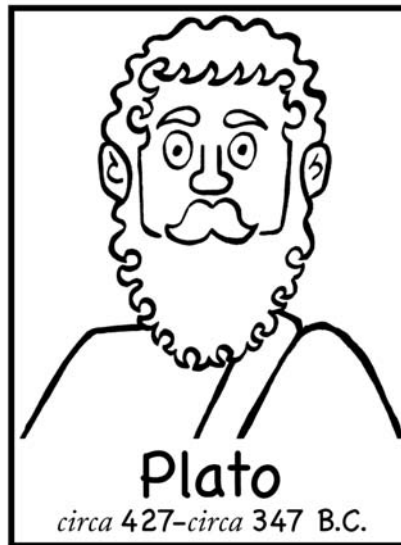
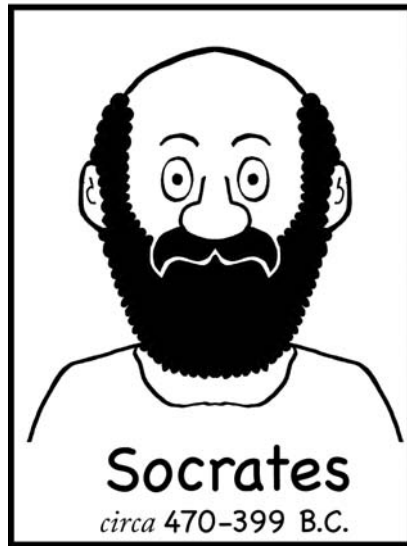




500 B.C.), **Parmenides of Elea** (*circa 515–circa 450*), **Empedocles of Acragas** (*circa 490–circa 430 B.C.*), **Leucippus of Miletus** (*circa 480–circa 420*), and **Democritus of Abdera** (*circa 460–circa 370 B.C.*)! What a lot of long names to remember! However, all of these philosophers, in one way or another, had something to offer to science, and we will learn more about them later.

I.4 Socrates, Plato, and Aristotle

However, the three Greek philosophers that had the biggest influence on science and philosophy were **Socrates** (*circa 470–399 B.C.*), **Plato** (*circa 427–circa 347 B.C.*), and **Aristotle** (384–322 B.C.). Both Socrates and Plato came from Athens. Aristotle was from Stagira and was the student of Plato. Plato was the student of Socrates. Socrates did not like to study the natural world. He liked to think about human nature instead. Socrates didn't think there was anything valuable to learn by looking at nature.



Plato, however, did like to look at nature, and he thought it was important. He began the first school dedicated to both philosophy and natural philosophy. His school was called the Academy. It was located in Athens, and it survived for over 800 years. Plato's most famous student was Aristotle. After Aristotle had studied at the Academy for almost twenty years, he was asked to tutor Alexander, the son of King Philip II of Macedonia. Alexander would go on to become Alexander the Great. Aristotle took the study of natural philosophy even further than his teacher, Plato. Aristotle's work, which included logic, physics, cosmology, anatomy, and even ethics, marked the beginning of a 2000 year history of Aristotelian thought, which dominated much of the Western world.

What is most interesting about these philosophers was not that they got everything right. In fact, many of the ideas they had were simply wrong! However, what they contributed to science was the idea of taking a *rational* and *objective* approach to understanding how the world functions. What we will soon discover is that science progresses through a series of disagreements about how things “are.” By using reason, logic, and observation, we can uncover many “facts” about how the world around us works, what it is made of, and how it came into being.

I.5 How science affects philosophy

Philosophers ask the “big” questions. Why is there something, and not nothing at all? Since we are something, where did we come from? What is the meaning of life? What is life? How is life defined? What is the nature of knowledge? How can we know? How do we know that we know? Science, as we have defined it here, is a systematic way of studying the world around us. Scientists collect scientific information, and from that information, they draw conclusions about the world we live in. As scientific information has been collected and understood, some of the questions that philosophers debated in the past, have changed. We no longer debate about the existence of matter. Nor do we debate whether matter is composed of atoms. Scientists have been able to observe and understand some aspects of the nature of matter, like atoms. But other questions, like how did the matter get here in the first place, are still being debated. So science can affect how we think about the world around us.

I.6 How philosophy affects science

But what we think also affects how we do science. If Democritus (a philosopher) hadn't thought that atoms existed, Dalton (a scientist) might not have looked for them. If Aristotle (a philosopher) hadn't thought that the world might be ordered, and that natural laws might exist in an ordered world, Newton (a scientist) might not have looked for such laws. So philosophy, or how we think about the world around us, can affect the science we do. As our thinking changes, scientists will perform different experiments, and they will likely change direction in their search for new discoveries.

I.7 Arguing philosophers

We have seen that philosophy got started in the area around the Aegean Sea around 600 B.C. with Thales of Miletus, but have you ever wondered why? Why did these people develop "philosophy" in the first place? There are several different reasons. One reason that philosophy took off in Greece is that the philosophers liked to argue about everything, especially politics! The Greek philosophers are famous for arguing! They mostly argued about law and justice, but they also argued about government. They used skills, like logic and reason, for their arguments. Eventually, they started arguing about how nature worked. They used the skills of logic and reason for their arguments about nature, and as a result, they started "scientific thinking."

An argument is not just a fight. In fact, the word argue comes from the Latin word *arguere*, which means “to make clear or prove.” So an argument is a discussion in which each person tries to prove that he or she is right about something. You might argue with your brother over whose turn it is to have the front seat in your car. If you were a Greek philosopher, you would use logic and reason to prove to your brother that his reasons are flawed, and you would claim the front seat for yourself!

Many people, including scientists and philosophers, are uncomfortable with arguing. They see the world in one way, and they insist that everyone see the world in the same way and often discourage argument and debate. But argument and debate are healthy for science and philosophy. Science, and ways of thinking about and interpreting science, need to be continually challenged, because many new scientific discoveries come from challenging previous scientific conclusions. In this workbook, you will learn about the differing philosophical ideas that shaped our current scientific thinking. You will also learn about the arguments that philosophers and scientists have had over the last several thousand years, as we have been trying to understand the world around us.

I.8 Activity

The Nature of Truth A Philosophy Play By D.R. Megill

ARISTOTLE believed that it is important to study nature to arrive at the truth

SOCRATES believed that it is more important to study truth to understand nature

PLATO believed in studying both truth and nature

Socrates and Aristotle are standing on the steps of the Lyceum. They are deep in argument.

ARISTOTLE: I simply mean that, without a close observation of nature, we can't learn anything.

SOCRATES: I understand that is your point, but what is the nature of nature, and what is the nature of what you wish to learn?

ARISTOTLE: Nature is the physical world around us, as well as the mechanics that control it.

SOCRATES: Indeed, I can work with that definition. But as for my second question, since you know so much of this nature, what is it that you wish to learn from observing it?

ARISTOTLE: Well, I wish to learn how it works and why it works. For example, look at this bug, which crosses in front of us. From observing it, we can learn the manner in which bugs move and eat and reproduce and so on.

SOCRATES: Indeed, you are, no doubt, more wise than I in these aspects of nature, but

ARISTOTLE: I am not fooled by your pretences of humility, Socrates. If you think me a fool, just say so.

SOCRATES: *(softens his tone and speaks sincerely)* I do not think you are a fool, Aristotle. I think many things, but not that. I only meant to say that it appears that you are simply saying that from observing the world around us and the way it works, we can learn about the world around us and the way it works. This is hardly arguable, but tell me, Aristotle, do you think it is more important to know how bugs move or to know what moves people?

ARISTOTLE: Ah, but by observing how bugs move, we may learn of more efficient ways to move people. We can observe differences in movement between the snake, which slithers along on no legs; the fish, which swims; the bird, which flies; and the eight-legged spiders, which crawl. These differences may help us design something yet more ingenious than the wheel itself. Such observations reap profit in technology, Socrates.

SOCRATES: With that segue, let me say that I meant not the locomotion of the body, but what moves the soul and the mind. What does nature tell us about love or justice or piety? Are these things not of inestimably more value, Aristotle? Are these not the true questions of a philosopher?

ARISTOTLE: Indeed, Socrates, you make a good point. But even these things we cannot question directly, for they will not give us an answer. It is only their reactions that we see. So here still, we learn only from the observation of nature.

SOCRATES: Is it not possible, good Aristotle, that we learn these things best not from observation, but from thought, from logic (as you have been so good to name and define for us). It is from rational truths that we will understand what we observe.

(Plato exits the Lyceum and comes upon Socrates and Aristotle. He rolls his eyes when he sees them.)

PLATO: Are you guys still arguing about this? This was the conversation you were having when I went inside. I've had time to teach three math classes and two philosophy classes, engage in some boxing, and meet with the Olympics Committee, and you two are no further along than when I left!

SOCRATES: *(smiles)* Ah, dear Plato, you have always been a most impatient and busy fellow. You know that such discussions must follow their own course and must not be rushed

to premature conclusions. What say you, Plato? Is it more important to study nature to arrive at the truth or to study truth to arrive at a better understanding of nature?

PLATO: *(sighs)* I don't know why I do this. Neither of you will cease your endless arguing. If eternal things are truly the most valuable, Socrates, you two are assured of a place of value, for your arguments are endless, and the two of you will probably be having this argument across all time! I honestly don't know the answer to your question, but it seems to me that there are eternal things, a point that neither of you actually dispute. Anyway, it seems to me that these eternal things are very important: love, justice, piety, even the gods themselves (or Himself – if as Socrates suggests, there be only one), and so forth. It seems further that the pursuit of these things is the most important pursuit of the philosopher.

SOCRATES: Indeed, you have been a better pupil than your teacher ought to have produced, Plato.

PLATO: But, it also seems to me that a study of nature does teach us about these things. Why, for example, does a rose look and smell pleasing to us? Does it benefit the rose that we like it? Does it benefit us physically that we enjoy its smell? Or, because it is so unnecessarily pleasant to us, does it perhaps tell us of the goodness of providence? I think it may. Thus such studies may teach us of order, justice, goodness, love, and even God himself. So is it useful to study nature? I say yes.

ARISTOTLE: Indeed, you seem to have overreached your own teacher.

PLATO: But it is not useful to study nature only for its own sake. Rather, it is important to study nature in order to understand the universal ideas and truths that Socrates proclaims, but that you too soon dismiss, Aristotle.

SOCRATES: So, friend Aristotle, you see that I have at least one witness to my position that the study of the universals is what matters most.

ARISTOTLE: It seems to me, Socrates, that surprisingly, for being your student, Plato rather leans toward my way of thinking.

SOCRATES: Hmm, perhaps your skills of observation are not quite waxing in your waning years. Or perhaps it is my poor ears that are growing deafer, but I heard him differently. Be that as it may, enlighten me further. Let me ask you a few questions. What is the nature of the nature that you observe? And when you observe, do you use the nature of your eyes or the curiosity of your soul? And furthermore. . . .

PLATO: *(laughs)* Well, you guys enjoy your argument. I'm going to explore the nature of a fine meal at the Gyros down the way. Plato exits laughing while Aristotle and Socrates continue their argument.

(end)

I.9 Discussion questions

1. Think about a situation where you needed to argue your side with a sibling or friend. Describe how you feel as you think about arguing your side. Do you feel calm or anxious? Do you feel excited or scared? Describe what happens in your body as you think about arguing your side. What do you think would help you to stay calm as you try to make your argument?

2. Think about a situation where you needed to argue your side with a parent, teacher, or another adult. Describe how you feel as you think about arguing your side. Do you feel calm or anxious? Do you feel excited or scared? Describe what happens in your body as you think about arguing your side. What do you think would help you to stay calm as you try to make your argument?

3. Is it easier to argue your side with a friend/sibling or with a parent/other adult? Why?

4. Imagine that you are a young Einstein working as a patent clerk in a patent office. You come up with a radical new idea for how light and matter interact. How would you argue for your discovery, which goes against the standard scientific theories of the day and is opposed by many established scientists?



The Elements Philosophy

- 1.1 Introduction
- 1.2 Famous philosophers
- 1.3 What are things made of?
- 1.4 Democritus and Leucippus
- 1.5 Activity
- 1.6 Discussion questions

1.1 Introduction

Humans have always asked questions about the “stuff” around them. Some of the questions were practical, such as asking what we could use for food or clothing. Other questions were concerned with what we could use to build shelter. Money is always important, so gold and silver were of great interest.



Other questions humans have asked have dealt with more basic issues. What is all this “stuff” made of? In modern times, we are able to go into a laboratory and measure what is in a particular material. However, this ability was not available until the last couple of centuries. The ancient philosophers thought a lot about many issues. In the introduction, we learned that the word “philosopher” comes from two Greek words, and it means “love of wisdom.” Philosophers ask difficult questions and try to answer them.

Philosophers think and discuss questions. They don't go into the lab to find answers. For many centuries, there were no labs to do research in. Thinking about questions was the only approach available.

1.2 Famous philosophers

Thales of Miletus (*circa 625–circa 545 B.C.*)

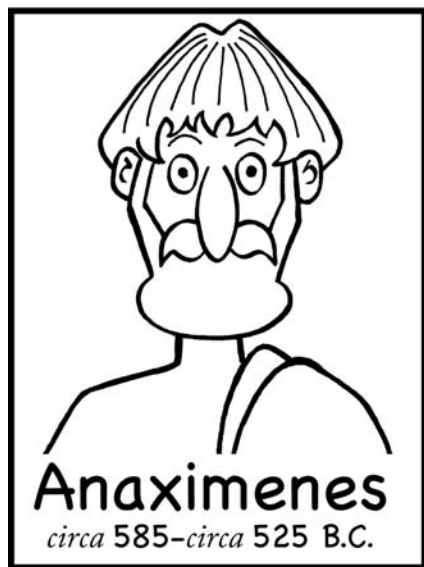
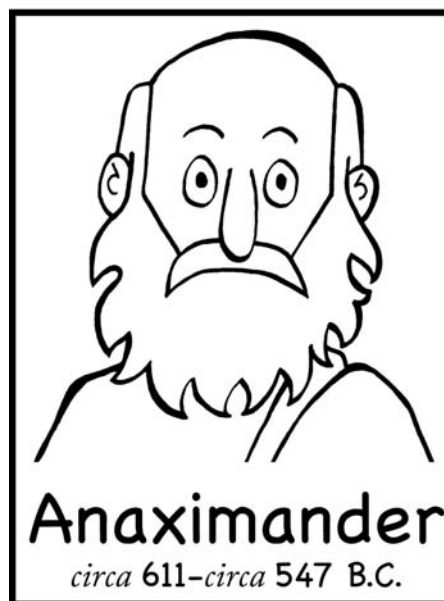
The first person that we know about that asked questions about matter was Thales, a Greek philosopher. He did a lot of work in astronomy and mathematics. He was born in a small trading town on the Aegean Coast called Miletus. Thales is believed to have traveled to Egypt, where he learned geometry and astronomy from the Egyptians. He is credited with bringing this knowledge back to Greece. He used what he knew about the stars to his advantage. One story has it that he bought olive presses because he predicted a large olive harvest. He was right! He made lots of money selling olive oil to everyone!

Thales believed that water was the fundamental unit of matter. He thought that everything in the universe came from water. Thales also felt that water could turn into earth and other types of matter.

Thales was one of the first people to describe astronomy and other sciences as natural behaviors. He did not believe that the gods had any influence on the earth, the weather, the tides, or the stars.

Anaximander (*circa 611–circa 547 B.C.*)

Many of the philosophers, which lived during the time that Anaximander was alive, were looking for the essence (the true nature of a thing) of all things. What is everything composed of? Anaximander came up with the idea of “the boundless,” or “the ultimate.” Unfortunately, he never explained what that was. This was not a lot of help to people. Anaximander also studied astronomy. He believed that the earth was hung out in space. He also tried to explain why the earth did not fall. The idea had to do with balance among all the celestial bodies.

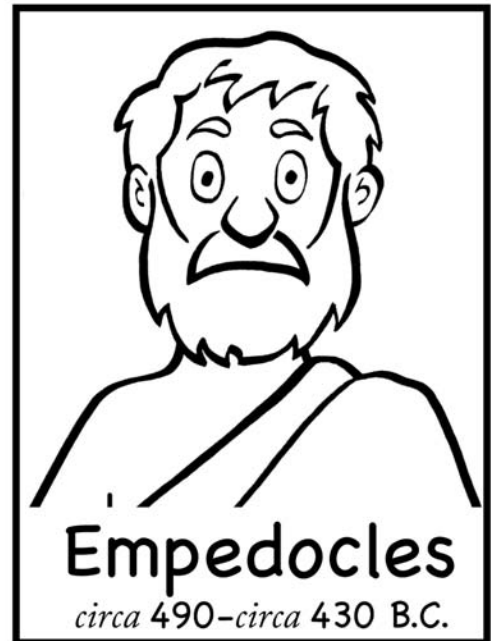
**Anaximenes** (*circa 585–circa 525 B.C.*)

In contrast to Thales, Anaximenes believed that air was the basic substance of matter. According to Anaximenes, when air was thinned, it could become fire. In addition, if air was condensed, it would become wind and clouds. And more condensing would compress air into water, earth, and even stone. Many natural processes were “explained” by Anaximenes’s theory

that air was the basic substance of matter. For example, he believed that thunder and lightning came from wind breaking out of clouds, that rainbows occurred when the sun’s rays hit the clouds, and that earthquakes took place when the ground dried out after a rainstorm.

Empedocles (*circa 490–circa 430 B.C.*)

Empedocles was all things to all people. Some people believed he was a great healer. Others thought he was a magician. He had some convinced he was a living god. And others believed he was a total fake. The “periodic table” of earth, air, fire, and water came from Empedocles. He believed that these four “roots” made up all matter. He believed that even living creatures were composed of these materials.

**Leucippus** (*circa 480–circa 420 B.C.*)

We don't know much about Leucippus. He apparently was the first person to suggest the idea of empty space. (Today, we would call this a “vacuum.”) He also developed the idea of atoms. Leucippus believed that the different atoms had different sizes and weights. We now know this to be true.

Democritus (*circa 460–circa 370 B.C.*)

Probably one of the first weather forecasters, Democritus had people convinced that he could predict the future. He was a student of Leucippus, and he is an example of a pupil that is better known than his teacher. He studied a lot of natural objects, and he gave public lectures.

The Greek philosophers debated about a lot of things. One of their debates had to do with sand on the beach. They asked the following questions: Can you divide a grain of sand indefinitely? and Is there a point where you have to stop breaking the grain in half?

Most of the philosophers believed that you could divide the grain of sand continuously, without ever stopping. Democritus, however, believed that there was a point at which the grain of sand could no longer be broken into smaller pieces. He called this smallest piece of matter the **atom**, meaning “indivisible.”

Many philosophers thought about moral ideas along with their science. Democritus also did this. He believed that happiness came from an even temperament. From this idea, he came up with his list of what was right and what was wrong.

1.3 What are things made of?

The early Greek philosophers had many arguments over many centuries. They argued about how the world works, how it was made, and how it came into being. Modern natural philosophers, or scientists, still use reason, logic, and observation to argue about many of the same questions that the Greek philosophers argued about some 2500 years ago.

One of the topics that these early Greek philosophers disagreed about was what the world was made of. They each had their own ideas.

As we saw earlier, Thales thought that everything was made of water. He believed that water was the “primary substance” of all things. He thought that water could not be divided any further. Today we know that water is made of two hydrogen atoms and one oxygen atom.

Anaximander rejected water as the primary substance. As we saw earlier, he thought that everything was made of something that he called “the boundless.” Nobody is really sure what Anaximander meant by “the boundless,” and this caused problems for him.

Anaximenes didn’t agree with either Thales or Anaximander. He rejected both water and “the boundless” as the primary substance. He believed that air was the primary substance.

Empedocles disagreed with everyone, and he said that all of the things in the world were made up of not just one substance, but of four: earth, air, fire, and water.

1.4 Democritus and Leucippus

There were two other philosophers, Democritus and Leucippus, who didn’t agree with any of the other philosophers. Democritus and Leucippus thought that the world was made up of “atoms.” They had trouble explaining exactly what atoms were because they didn’t know anything about them. However, they thought that all things were made of one type of thing, which they called an atom. They thought that atoms could be combined, like legos, to make larger things.

Today we know that Democritus and Leucippus were right and that the other philosophers were wrong. But Democritus and Leucippus didn't get very many people to agree with them. Atoms were not considered a serious possibility until the 17th century, almost 2000 years later! Let's meet some of these philosophers in a *hypothetical* argument. Hypothetical means that it didn't really happen this way—it's just pretend and just for fun!



1.5 Activity

The Mystery of Substance A Philosophy Play By D. R. Megill

ANAXIMANDER—believed everything is made up of “the boundless”

ANAXIMENES believed everything is made up of air

THALES believed everything is made up of water

DEMOCRITUS believed everything is made up of atoms

Anaximander, Anaximenes, and Thales are having a heated argument. They are standing in a circle in the center of the city. Democritus is sitting on the ground building, or playing, with some sort of weird, unrecognizable materials [legos]. It appears that Democritus is barely listening.

THALES: But it's obvious that everything comes from water! The very nature of life speaks to this. We could not live without water! Notice what happens when water is absent from a land for any period of time! It becomes barren, empty. Everything dies. Other forms of life come from water too: fish, frogs, and so on. Even our friend Democritus here on the ground (What are you doing, Dem?) must come from water.

ANAXIMANDER: But surely you see that there are things that could not possibly come from water. Things like earth and fire most certainly do not come from water.

THALES: Hmmm. Yes, fire presents a difficulty, considering that water destroys fire.

ANAXIMENES: I think you may have water on the brain, Thales. Rain drops from air. Thus, I am convinced by this, and by other proofs, that air is the source of all things! Air may take on different forms according to its different properties. In a rarefied form, it could even become fire. Fire can be destroyed not only by the addition of water, but more importantly, by the subtraction of air. This again, is proof of my point!

ANAXIMANDER: If Thales's head is full of water, does that mean yours is full of air, friend Anaximenes? I fear you are both wrong, but I don't fault you for it. It is very difficult to identify what things are made of.

THALES: You feel, no doubt, that you have done so?

ANAXIMANDER: Truth be told, yes, I have. It is hard to identify because we do not see it. We see only the parts into which it has been broken. Obviously, if it is the substance from which all things come, we cannot expect to see it in its initial form. We can, though, guess its nature from that which we do see. Tell me, what is true of everything?

ANAXIMENES: Everything has a purpose, I suppose.

THALES: (*looking down at Democritus on the ground*) Democritus here proves otherwise, Anaximenes. He serves no purpose at all, except to tinker with his strange objects.

ANAXIMANDER: No, no, I will tell you what is true of all things. Everything has an opposite! Everything is equally balanced and measured by its opposite. If we could put all these things of opposite nature together, we would get a picture of a perfectly balanced, limitless substance. I call it, therefore, the boundless.

THALES: But what is the boundless, Nax?

ANAXIMANDER: I just told you. It is the thing from which all other things come.

ANAXIMENES: No, you just described it. What is it?

DEMOCRITUS: (*laughing in derision and without looking up*) You will never get the answer to that, my friends. He does not know! He is trying to befuddle you with fancy talk and imprecise terms. He speaks of a boundless, but it is only his imagination that is boundless, not his reasoning. You ask what all things are made of, and he answers that it is that from which all others come. Round and round it goes; where it stops, nobody knows.

ANAXIMANDER: I suppose you could do better then!

DEMOCRITUS: If you truly care to listen to the truth, you would be one of very few.

THALES: Well, I say we let him try, but for Zeus's sake, please stand up and look at us when you talk, as civil people do.

DEMOCRITUS: Well, I never claimed to be civil, but perhaps the argument will be a good break from my current exploration. (*standing up*) You are familiar, I hope, with the only reasonable man in Miletus, Leucippus.

ANAXIMANDER: Of course.

DEMOCRITUS: Well then, if you are familiar with Leucippus, perhaps this will sound familiar to you. I have only followed Leucippus's reasoning and observations to their obvious conclusion. There are two distinct problems. One is the problem of change, and the other is the problem of divisibility.

ANAXIMENES: What?

DEMOCRITUS: Things change. Haven't you noticed? How does a thing change from a basic substance into another thing? How can such a change be possible? As Empedocles of Elea has argued, change is rationally impossible, as it requires the existence of what is not.

ANAXIMANDER: And you accuse me of being obscure!

DEMOCRITUS: Let's leave the problem of change for now, and let's examine the other problem: divisibility. Imagine any element that you regard as the basic substance of things. It matters not what it is. Just imagine it. Now, divide it in half.

THALES: What? But what does that . . .

DEMOCRITUS: Can you do it? Can you picture dividing that substance in half?

THALES: Well, yes, of course, but . . .

DEMOCRITUS: Then that cannot be the basic substance. If it can be divided at all, it is not yet the basic substance. Rather, the two halves that you divided it into are the basic substances. Right?

THALES: Well, yes, you're right. But then, of course, that could be divided again.

DEMOCRITUS: Exactly! I am saying that, by definition, the most basic substance must be that which is no longer divisible.

ANAXIMENES: But no one has ever seen such a thing.

DEMOCRITUS: Of course no one has ever seen such a thing. Such a thing would be invisible to the naked eye. However, when combined with others of its kind, they would become visible. As you can see, the combinations by which these "indivisibles," or atoms, could combine would be virtually numberless, and by combining in different ways, they would make different things. This would explain the appearance of change by things that ultimately do not change.

THALES: Your ideas are nonsense, Democritus.

Democritus begins laughing.

ANAXIMANDER: You are entertaining, Democritus, but obviously, going mad. It's clear by the way you go about laughing at everything all the time.

DEMOCRITUS: If you could see how ridiculous you all are, you and all the others, you would laugh too.

ANAXIMENES: I fear my friends are right. You are clearly either crazy or stupid. These toys of yours, Democritus, what are they?

DEMOCRITUS: I knew you would not listen. Now, if you don't mind, I'd like to get back to my current exploration. (*Democritus kneels back down on the ground.*) If you must know, my nephew invented these. They are a good example of my atomic ideas. These little pieces can be rearranged into various shapes and can be used over and over without any seeming decay. My nephew has named them after his father, my brother, Legosus.

THALES: You have to admit, guys, that water is almost as indivisible as Democritus. I told you I was right.

Anaximander, Anaximenes, and Thales begin walking away from Democritus.

ANAXIMENES: (to Thales) You are as crazy as he is.

ANAXIMANDER: I'm telling you, it's the boundless. Let me show you.

(end)

1.6 Discussion questions

1. According to Democritus, what is the primary substance? Explain his description.

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

2. Do the other philosophers believe Democritus? Why or why not?

3. Imagine that you are on a new planet. Everything on this planet is made of candy. What proofs would you use to argue to your friends that the basic substance of this planet is candy?

[illegible]