# Aristotle Leads the Way

## INTRODUCTION – UNIT II

### Schedule

| Lesson | Text | Activity/Concept |
|---|---|---|
| 1 | Chapter 9, "Pythagoras Knows It's Round" | Pythagoras's cosmology and his theorem |
| 2 | Chapter 10, "Getting Atom" | Democritus's theory of atoms, difference between hypothesis, theory, and fact; demonstrating molecular motion |
| 3 | Chapter 11, "Aristotle and His Teacher" | Plato's and Aristotle's contributions to science |
| 4 | Chapter 12, "Does It Change? No Way, Says A" | Aristotle's Earth-centered model of the universe |
| 5 | Chapter 12 Feature, "Why Mars Is A Little Loopy" | Retrograde motion |
| 6 | Chapter 13, "Aristarchus Got It Right—Well, Almost!" | Aristarchus's belief that the Earth orbits a stationary Sun; Moon activity |
| 7 | Chapter 13 Sidebar, "Changing Seasons" | The Earth's tilt causes seasons |
| 8 | Preparation for Assessments | |
| 9 | Assessments | |

## Materials

### Lesson 1

**For the teacher**
transparency masters
*The Pythagorean Theorem*
*Scientists Speak: Pythagoras*
*Professor Quest cartoon #8*

**For the classroom**
photocopy of
*Scientists Speak: Pythagoras*

**For each student**
ruler

### Lesson 2

**For the teacher**
transparency masters
*Scientists Speak: Democritus*
*Professor Quest cartoon #9*

**For the classroom**
photocopy of
*Scientists Speak: Democritus*

**For each team**
two clear plastic cups
hot and cold water
a few drops of food coloring

### Lesson 3

**For the teacher**
transparency masters
*Scientists Speak: Aristotle*
*Scientists Speak: Plato*
*Professor Quest cartoon #10*

**For the classroom**
photocopies of
*Scientists Speak: Aristotle*
*Scientists Speak: Plato*

### Lesson 4

**For the teacher**
transparencies
*Scientists Speak: Aristotle*
*Professor Quest cartoon #11*

For the classroom
photocopy of
*Scientists Speak: Aristotle*

### Lesson 5

**For the teacher**
transparency master
*Professor Quest cartoon #12*

### Lesson 6

**For the teacher**
transparency masters
*Scientists Speak: Aristarchus*
*Professor Quest cartoon #13*

**For the classroom**
photocopy of
*Scientists Speak: Aristarchus*

### Lesson 7

**For the teacher**
transparency master
*Professor Quest cartoon #14*
a daily newspaper showing sunrise/sunset times

### Lesson 8

**For each team**
index cards (at least 24 per team)

## Background

The ancient Greeks, using nothing but the human eye and reason, made astounding discoveries. It took centuries to improve upon—or, in the case of Aristotle's cosmological misconceptions—disprove their theories. Believing that the universe was orderly and knowable, they set out to fathom its mysteries even without technological aid. A survey of ancient Greek cosmological beliefs is like a walk through a carnival midway museum: the preposterous (Pythagoras's bent toward number-worshiping, bean-beatifying communes); the presumptuous (Aristotle's Earth-centered cosmology and fifty-four rotating spheres); and the prescient

(Democritus's theory of atoms and Aristarchus's celestial calculations). They wedded math to science and provided the framework for future scientific discovery.

In the sixth century B.C.E., Pythagoras posited that the universe could be best understood through mathematics. Foreshadowing modern string theory, he extrapolated on his experiments with the mathematics of music to theorize that all the parts of the universe interact like instruments in an orchestra. Denying the popular stationary Earth concept, Pythagoras proposed that the Earth, Sun, and the planets all circle a large fireball. Celestial musings aside, Pythagoras is best remembered for the mathematical theorem that bears his name.

Two hundred years later, Democritus looked not to grand, cosmological macro mysteries but to the basic building blocks that undergird life. He theorized that atoms were the smallest substances in the universe and envisioned hard, solid, irreducible particles perpetually in motion. But lacking equipment to prove or disprove such theories, who could know for sure? His fellow philosophers turned instead to the study of reasoning. Plato searched for beauty, truth, perfection, and ideal forms. His pupil Aristotle, a great observer and synthesizer, attempted to create one theory to classify all knowledge. His mind ranged over the fields of biology, chemistry, astronomy, light, vision, and the study of logic, with remarkable results. His cosmological beliefs, however, steered astronomy off course for centuries. His Earth-centered universe featured special heavenly crystal spheres, perfectly circular orbits, and a celestial world composed of a unique element called "aether." Aristotle rejected Democritus's theory of atoms, arguing that everything on Earth was composed of four imperfect elements—air, earth, fire, and water. People still taught this into the nineteenth century—not a bad shelf life for a faulty proposition.

Aristarchus broke from tradition to hypothesize that the Earth revolved around a larger, stationary Sun. He also figured out that the Earth rotates on an inclined axis to cause day and night and seasons. Amazingly, he came within a fraction of correctly calculating the size of the Moon and the exact tilt of the Earth. Unfortunately, it took 1,700 years for his ideas to catch on; not until the fifteenth century did a monk named Copernicus resurrect and champion Aristarchus's ideas.

## Math Session

Unit II, lesson 1, includes a math activity in which students work with the Pythagorean Theorem.

## Science Session

In lesson 5, "Why Mars Is A Little Loopy," students demonstrate retrograde motion. In lesson 7, "Changing Seasons," students demonstrate how the Earth's rotation on an inclined axis affects the length of days and the amount of sunlight received, and how the Earth's tilt causes seasons.

## Assessment

Unit II offers three assessment activities.

- Cooperative Team Learning — Teams compose and perform a science story rap.
- Students use a web to organize and write an essay that compares or contrasts two cosmologies (open book).
- Students demonstrate mastery through a multiple choice and short answer assessment (closed book).

## Standards

### National Science Education Standards

**Science as Inquiry**

- Mathematics is important in all aspects of scientific inquiry.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.

### Earth and Space Science

**Earth in the Solar System**

- The Earth is the third planet from the Sun in a system that includes the Moon, the Sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The Sun, an

average star, is the central and largest body in the solar system.
- Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the Moon, and eclipses.
- The Sun is the major source of energy for phenomena on the Earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the Sun's energy hitting the surface, due to the tilt of the Earth's rotation on its axis and the length of the day.

**Science and Technology**

- Many different people in different cultures have made and continue to make contributions to science and technology.

### History and Nature of Science

**Science as a Human Endeavor**

- Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.

**History of Science**

- Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society.
- In historical perspective, science has been practiced by different individuals in different cultures. In looking at the history of many peoples, one finds that scientists and engineers of high achievement are considered to be among the most valued contributors to their culture.
- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

## Benchmarks for Science Literacy

### The Nature of Science

**1A The Scientific World View**

- Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
- Some scientific knowledge is very old and yet is still applicable today.

**1C The Scientific Enterprise**

- Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.

### The Physical Setting

**4B The Earth**

- Like all planets and stars, the Earth is approximately spherical in shape. The rotation of the Earth on its axis every 24 hours produces the night-and-day cycle. To people on Earth, this turning of the planet makes it seem as though the Sun, Moon, planets, and stars are orbiting the Earth once a day.

**4D Structure of Matter**

- Scientific ideas about elements were borrowed from some Greek philosophers of 2,000 years earlier, who believed that everything was made from four basic substances: air, earth, fire, and water. It was the combinations of these "elements" in different proportions that gave other substances their observable properties. The Greeks were wrong about those four, but now over 100 different elements have been identified, some rare and some plentiful, out of which everything is made. Because most elements tend to combine with others, few elements are found in their pure form.

### Historical Perspectives

**10 F Understanding Fire**

- From the earliest times until now, people have believed that even though millions of different kinds of material seem to exist in the world, most things must be made up of combinations of just a few basic kinds of things. There has not always been agreement, however, on what those basic kinds of things are. One theory long ago was that the basic substances were earth, water air, and fire. Scientist now know that these are not the basic substances. But the old theory seemed to explain many observations about the world.

### Habits of Mind

**12B Computation and Estimation**

- Calculate the circumference and areas of rectangles, triangles, and circles, and the volumes of rectangular solids.

**12D Communication Skills**

- Organize information in simple tables and graphs and identify relationships they reveal.
- Locate information in reference books, back issues of newspapers and magazines, compact disks and computer databases.

**12E Critical Response Skills**

- Be aware that there may be more than one good way to interpret a given set of findings.
- Notice and criticize the reasoning in an argument in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given.

# "Aristotle and His Teacher"

## Theme

"For in all natural things there is something wondrous."

Aristotle
(384 – 322 B.C.E.)

## Goal

Students will understand that while Plato searched for beauty, truth, perfection and ideal forms, his student Aristotle organized, analyzed, and connected knowledge in the sciences and other fields.

## Who?

**Plato** — a fourth-century-B.C.E. Greek philosopher who sought perfection or ideal forms

**Alexander** — (Alexander the Great) a prince of Macedonia whom Aristotle tutored

**Aristotle** — a fourth-century-B.C.E. Greek philosopher who organized, analyzed, and connected knowledge; developed a system of logic; and studied biology, astronomy, and other sciences as well as the arts, ethics, and religion

## What?

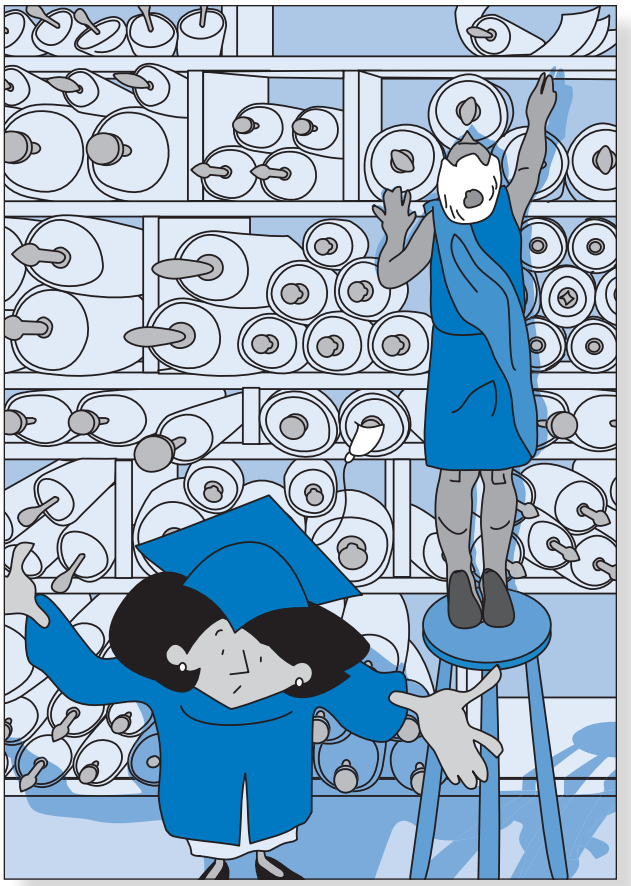
**logic** — the science of correct reasoning

**natural philosophy** — to the Greeks, the study of the natural world; what we call science

**synthesizer** — someone or something who combines separate elements into one complex whole

## Where?

**Stagira** — the Greek city where Aristotle was born



*"All this organizing and classifying! Do you think it will ever stop?!!"*

**Athens** — a leading city-state in Greece, site of Plato's school of philosophy

## When?

**384 – 322 B.C.E.** — life of Aristotle

**427 – 347 B.C.E.** — life of Plato

## Groundwork

- Read chapter 11, "Aristotle and His Teacher"
- Gather the materials listed for lesson 3 in the unit introduction.

## Consider the Quotation

1) Direct students' attention to the theme quotation on page 35 in the *Student's Quest Guide.*

2) Ask students to paraphrase this quotation to be sure they understand its meaning.

3) Write student versions on chart paper or the chalkboard.

4) Tell students that in the chapter they will read today, "Aristotle and His Teacher," they will learn about two ancient Greeks who lived over 2,300 years ago.

5) Display the transparencies S*cientists Speak: Aristotle* and *Scientists Speak: Plato* and tape the photocopies to the chalkboard. Ask students to prepare during their reading and discussions to put words in the mouths of Aristotle and Plato.

## Directed Reading

**Read to find the meaning and significance of *Who? What? Where?* list**

1) Students browse through chapter 11 to look at illustrations and sidebars. Ask students to pose questions for their reading based on the theme quotation and their brief browsing. Write students' questions on chart paper or on the chalkboard.

2) Direct students' attention to *Who? What? Where? When?* on page 35 in the Student's Quest Guide. Call attention to the map on page 96 to locate Stagira and Athens.

3) Students pair read chapter 11 to answer questions posed earlier.

4) Students revisit the questions posed earlier in class. Class discussion should include most of the following points.

*Plato looked for beauty, truth, and clarity. He searched for ideal forms and perfection. He was especially interested in the life of the mind and mathematics. He later devoted himself to philosophy, writing, and teaching. Aristotle organized, analyzed, and connected knowledge. He is called a "great synthesizer" because he took the ideas of his predecessors and attempted to create one theory to explain and classify all knowledge. Aristotle studied biology, chemistry, astronomy, light, vision, and other topics. He developed a system of logic. Aristotle looked for truth in both thought and observation.*

7) Display the transparency *Scientists Speak: Plato* on the overhead. What was his most important idea? Students review chapter 11 to decide what to put in Plato's mouth.

8) Display the transparency *Scientists Speak: Aristotle* on the overhead. What was his most important contribution to science? Students review chapter 11 to decide what to put in Aristotle's mouth.

9) Write students' suggestions on the chalkboard so that the class can formulate the best statements to put in Plato and Aristotle's mouth.

10) Write the statements in the speech balloon on the transparencies. Ask a volunteer to copy them onto the photocopies and hang Plato and Aristotle on the time line.

## Classwide Activity/ Cooperative Team Learning

**Compare and contrast Plato and Aristotle in a class debate**

1) Working with teammates, students review the chapter to compare and contrast Plato and Aristotle. Students consider how each man would have answered the three

questions on their quest sheets, *Plato and Aristotle: Two Great Minds*.

2) After completing their quest sheets, students pick one team member to serve as either a Platonist or an Aristotelian in a classroom discussion.

3) Arrange several chairs in the front of the classroom for the two groups to discuss and debate their viewpoints. A moderator can pose the three questions to the two groups.

4) If time permits, allow students to pose additional questions to the panelists.

## Conclusion

1) Display the *Professor Quest cartoon #10* on the overhead projector.

2) Ask students to relate the cartoon to the theme of the lesson.

## Homework

Students write a brief paragraph in their journals using the *Who? What? Where? When?* vocabulary in this lesson. Their paragraphs should summarize the main ideas of the chapter.

Alternative assignment: Write a journal entry addressing the following question: How might either Plato or Aristotle approach a current ethical issue, such as cloning? How might their philosophies influence them?

## Curriculum Links

**History link** — Using library and Internet resources, students research the history of the Linnaean classification system. How might Aristotle respond to this system if he could see it today?

**History link** — Aristotle's father was a doctor. Students use Internet and library resources to research medicine during the classical Greek period.

**Science link** — Using library and Internet resources, students list the scientific classification of ten plants or animals in the Linnaean classification system.

**Language Arts link** — Using library and Internet sources, students research classical Greek literature by Ovid, Aesop, Aeschylus, and others.

## References

Hakim, Joy. 2004. *The Story of Science: Aristotle Leads the Way*. Washington, DC: Smithsonian Books.

Hawking, Stephen. 1986. *The Illustrated A Brief History of Time*. New York: Bantam.

"Scientific Classification." *Wikipedia*. http://www.wikipedia.org/wiki/Scientific_classification. Access date April 2003.

Drumm, Laura. "Scientific Classification." *National Marine Mammal Laboratory*. http://nmml.afsc.noaa.gov/education/taxonomy.htm. Access date April 2003.

## QUEST SHEET KEY *Student's Quest Guide* page 36

### Plato and Aristotle: Two Great Minds

| | Plato | Aristotle |
|---|---|---|
| How shall I contribute to knowledge? What will I study? | *philosophy, writing, teaching* | *science, the world around me, poetry, art, music, math, ethics, religion, warfare* |
| How can I find (or learn about) truth? | *by logic or reasoning* | *by both observation and reasoning*<br>*by organizing, classifying, and connecting knowledge* |
| What do I value? What is important to me? | *perfection, ideal forms—beauty, truth, harmony*<br>*the life of the mind*<br>*mathematics* | *How is the whole put together?* |

## Scientists Speak *Student's Quest Guide* page 37

### Plato (427 – 347 B.C.E.)

## Scientists Speak

### Aristotle (384 – 322 B.C.E.)