Chapter 3
The Science of Astronomy

3.1 The Ancient Roots of Science
Our goals for learning:
- In what ways do all humans employ scientific thinking?
- How did astronomical observations benefit ancient societies?
- What did ancient civilizations achieve in astronomy?

In what ways do all humans employ scientific thinking?
- Scientific thinking is based on everyday ideas of observation and trial-and-error experiments.

How did astronomical observations benefit ancient societies?
- Keeping track of time and seasons
  – for practical purposes, including agriculture
  – for religious and ceremonial purposes
- Aid to navigation
Ancient people of central Africa (6500 BC) could predict seasons from the orientation of the crescent moon.

What did ancient civilizations achieve in astronomy?

• daily timekeeping
• tracking the seasons and calendar
• monitoring lunar cycles
• monitoring planets and stars
• predicting eclipses
• and more…

Days of week were named for Sun, Moon, and visible planets:

<table>
<thead>
<tr>
<th>Object</th>
<th>Egyptian Name</th>
<th>English</th>
<th>French</th>
<th>Spanish</th>
</tr>
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<tbody>
<tr>
<td>Sun</td>
<td>Sun</td>
<td>Sunday</td>
<td>dimanche</td>
<td>domingo</td>
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<tr>
<td>Moon</td>
<td>Moon</td>
<td>Monday</td>
<td>lundi</td>
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<tr>
<td>Mars</td>
<td>Tiw</td>
<td>Tuesday</td>
<td>mardi</td>
<td>martes</td>
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<td>Mercury</td>
<td>Woden</td>
<td>Wednesday</td>
<td>mercredi</td>
<td>miércoles</td>
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<tr>
<td>Jupiter</td>
<td>Thor</td>
<td>Thursday</td>
<td>jeudi</td>
<td>jueves</td>
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<tr>
<td>Venus</td>
<td>Eria</td>
<td>Friday</td>
<td>vendredi</td>
<td>viernes</td>
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<tr>
<td>Saturn</td>
<td>Saturn</td>
<td>Saturday</td>
<td>samedi</td>
<td>sábado</td>
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• Egyptian obelisk: shadows tell time of day.
England: Stonehenge (completed around 1550 B.C.)

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Mexico: model of the Templo Mayor

SW United States: “Sun Dagger” marks summer solstice
Scotland: 4,000-year-old stone circle; Moon rises as shown here every 18.6 years.

Yucatan, Mexico: Mayan Observatory at Chichen Itza

Peru: lines and patterns, some aligned with stars.

Wyoming: Big Horn Medicine Wheel
South Pacific: Polynesians were very skilled in the art of celestial navigation.

France: Cave paintings from 18,000 B.C. may suggest knowledge of lunar phases (29 dots).

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China: Earliest known records of supernova explosions (1400 B.C.)

Bone or tortoise shell inscription from the 14th century B.C.

"On the Xinwei day, the new star dwindled."

"On the Jisi day, the 7th day of the month, a big new star appeared in the company of the Ho star."

"On the Xinwei day the new star dwindled."

3.2 Ancient Greek Science

Our goals for learning:

- Why does modern science trace its roots to the Greeks?
- How did the Greeks explain planetary motion?
- How did Islamic scientists preserve and extend Greek science?
Our mathematical and scientific heritage originated with the civilizations of the Middle East.

Greeks were the first people known to make models of nature. They tried to explain patterns in nature without resorting to myth or the supernatural.

Why does modern science trace its roots to the Greeks?

Special Topic: Eratosthenes measures the Earth (c. 240 BC)

Measurements:
Syene to Alexandria
distance ≈ 5000 stadia
angle = 7°

Calculate circumference of Earth:
7/360 × (circum. Earth) = 5000 stadia
⇒ circum. Earth = 5000 × 360/7 stadia ≈ 250,000 stadia

Compare to modern value (≈ 40,100 km):
Greek stadium ≈ 1/6 km ⇒ 250,000 stadia ≈ 42,000 km
How did the Greeks explain planetary motion?

Underpinnings of the Greek geocentric model:

• Earth at the center of the universe
• Heavens must be “perfect”: objects moving on perfect spheres or in perfect circles.

Aristotle

But this made it difficult to explain apparent retrograde motion of planets...

Review: Over a period of 10 weeks, Mars appears to stop, back up, then go forward again.

The most sophisticated geocentric model was that of Ptolemy (A.D. 100-170) — the Ptolemaic model:

• Sufficiently accurate to remain in use for 1,500 years.
• Arabic translation of Ptolemy’s work named Almagest (“the greatest compilation”)

So how does the Ptolemaic model explain retrograde motion?

Planets really do go backward in this model.
Thought Question
Which of the following is NOT a fundamental difference between the geocentric and Sun-centered models of the solar system?

A. Earth is stationary in the geocentric model but moves around Sun in Sun-centered model.
B. Retrograde motion is real (planets really go backward) in geocentric model but only apparent (planets don’t really turn around) in Sun-centered model.
C. Stellar parallax is expected in the Sun-centered model but not in the Earth-centered model.
D. The geocentric model is useless for predicting planetary positions in the sky, while even the earliest Sun-centered models worked almost perfectly.

How did Islamic scientists preserve and extend Greek science?

• Muslim world preserved and enhanced the knowledge they received from the Greeks
• Al-Mamun’s House of Wisdom in Baghdad was a great center of learning around A.D. 800
• With the fall of Constantinople (Istanbul) in 1453, Eastern scholars headed west to Europe, carrying knowledge that helped ignite the European Renaissance.

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