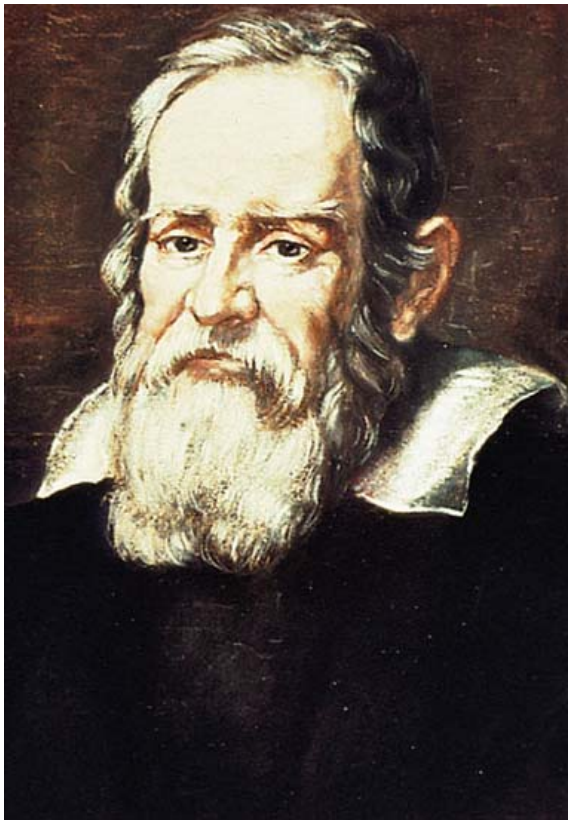
Chapter 3
The Science of Astronomy

continued

How did Galileo solidify the Copernican revolution?



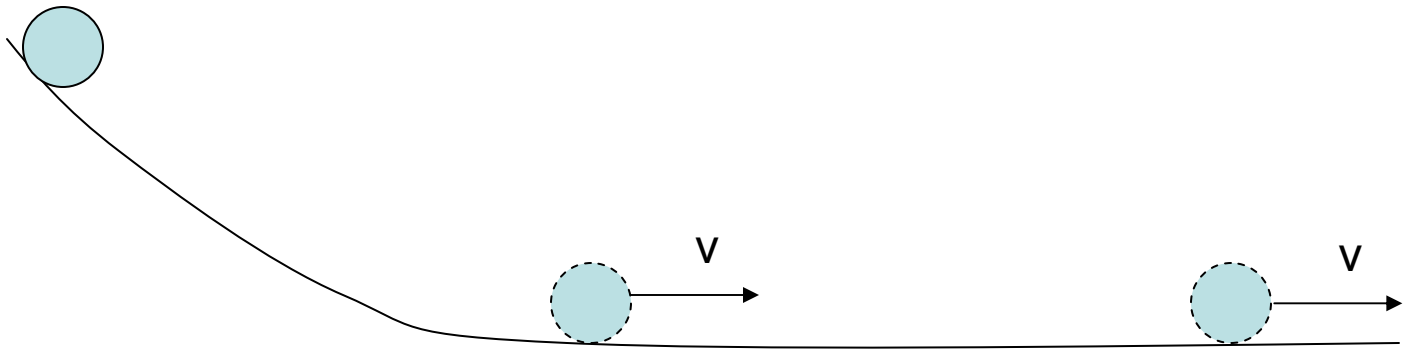
Galileo (1564-1642) overcame major objections to Copernican view. Three key objections rooted in Aristotelian view were:

1. Earth could not be moving because objects in air would be left behind.
2. Non-circular orbits are not "perfect" as heavens should be.
3. If Earth were really orbiting Sun, we'd detect stellar parallax.

Overcoming the first objection (nature of motion):

Galileo's experiments showed that objects in air would stay with a moving Earth.

- Aristotle thought that all objects naturally come to rest.
- Galileo showed that objects will stay in motion unless a force acts to slow them down (Newton's first law of motion).



Overcoming the second objection (heavenly perfection):

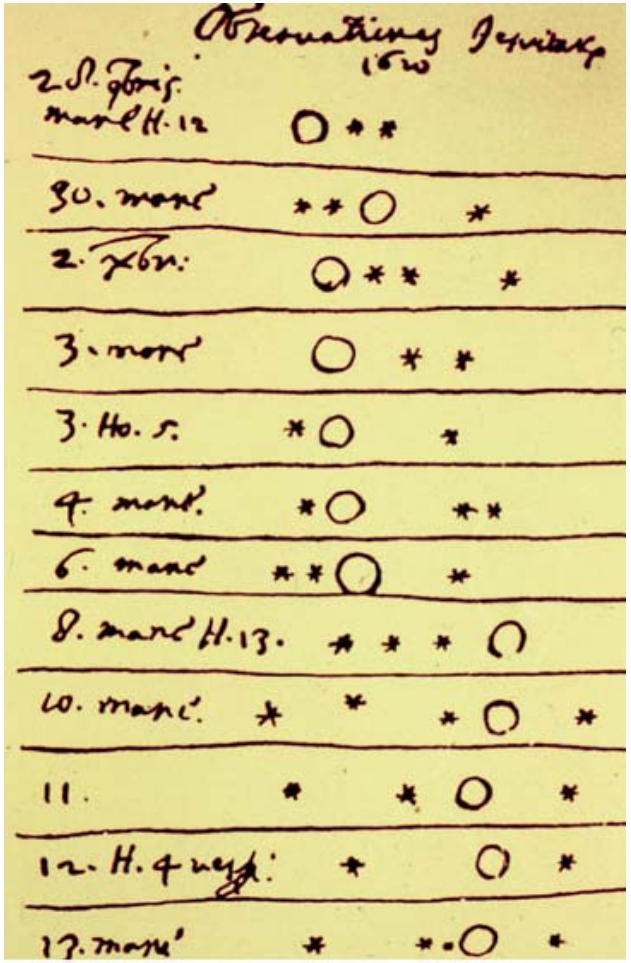
- Tycho's observations of comet and supernova already challenged this idea.
- Using his telescope, Galileo saw:
  - ✓ sunspots on Sun ("imperfections")
  - ✓ mountains and valleys on the Moon (proving it is not a perfect sphere)

Overcoming the third objection (parallax):

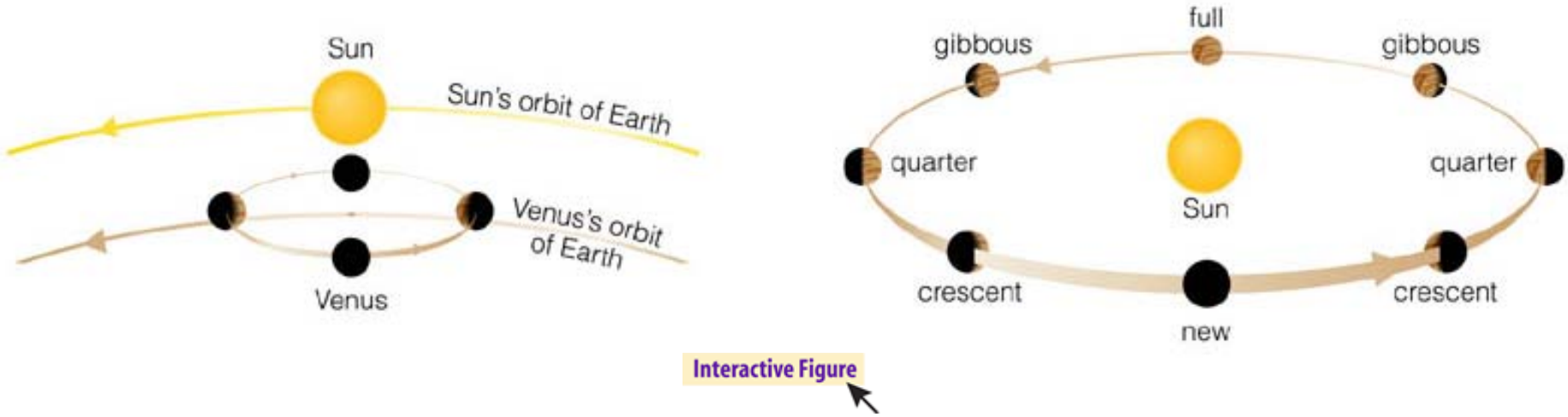
- Tycho *thought* he had measured stellar distances, so lack of parallax seemed to rule out an orbiting Earth.

- Galileo showed stars must be much farther than Tycho thought — in part by using his telescope to see the Milky Way is countless individual stars.

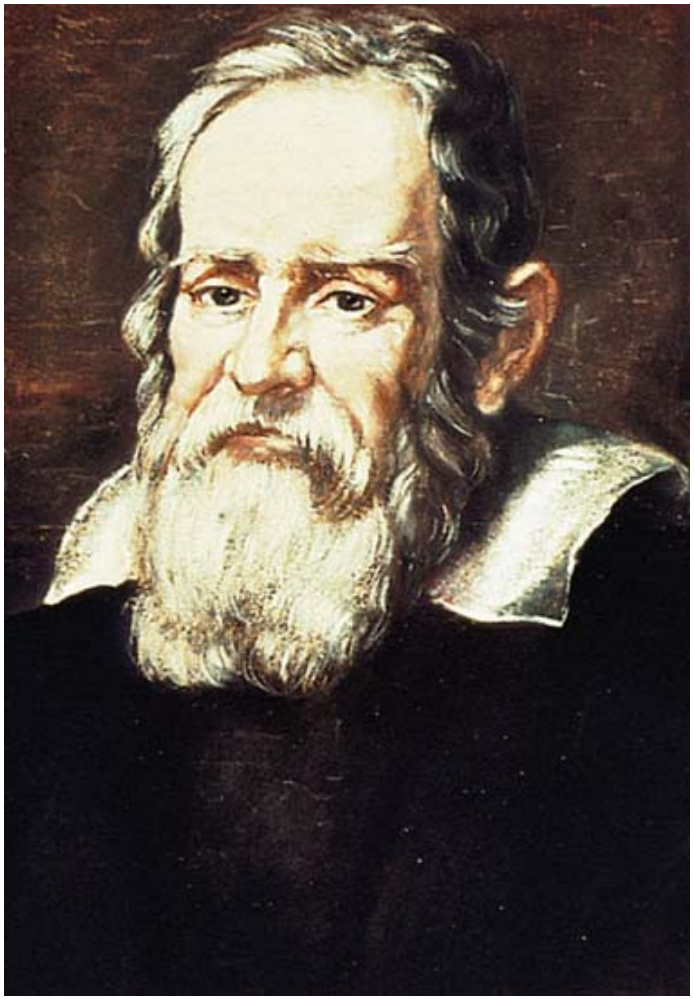
✓ If stars were much farther away, then lack of detectable parallax was no longer so troubling.



Galileo also saw four moons orbiting Jupiter, proving that not all objects orbit the Earth…



… and his observations of phases of Venus proved that it orbits the Sun and not Earth.



Galileo Galilei

The Catholic Church ordered Galileo to recant his claim that Earth orbits the Sun in 1633

His book on the subject was removed from the Church's index of banned books in 1824

Galileo was formally vindicated by the Church in 1989

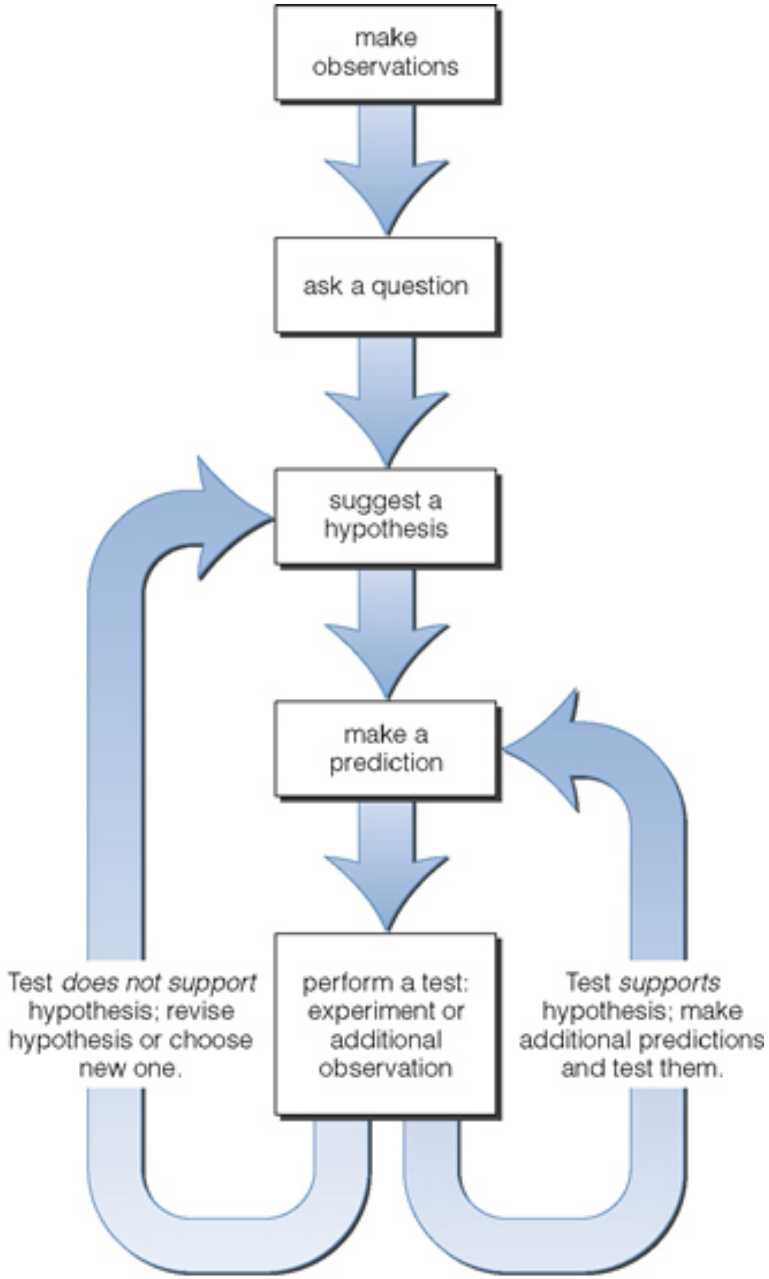
3.4 The Nature of Science

Our goals for learning:

- How can we distinguish science from nonscience?
- What is a scientific theory?

How can we distinguish science from non-science?

- Defining science can be surprisingly difficult.
- *Science* from the Latin *scientia*, meaning “knowledge.”
- But not all knowledge comes from science…



The idealized scientific method

- Based on proposing and testing hypotheses
- **hypothesis** = educated guess

But science rarely proceeds in this idealized way… For example:

- Sometimes we start by “just looking” then coming up with possible explanations.

- Sometimes we follow our intuition rather than a particular line of evidence.

Hallmarks of Science: #1

Modern science seeks *explanations* for observed phenomena that rely solely on *natural causes*.

(A scientific model cannot include divine intervention)

Hallmarks of Science: #2

Science progresses through the *creation and testing of models* of nature that explain the observations as simply as possible.

(Simplicity = “Occam’s razor”)

Hallmarks of Science: #3

A scientific model must make *testable predictions* about natural phenomena that would force us to revise or abandon the model if the predictions do not agree with observations.

(a good theory is “falsifiable”)

What is a scientific theory?

- The word theory has a different meaning in science than in everyday life.
- In science, a theory is NOT the same as a hypothesis, rather:
- A ***scientific theory*** must:
  - ✓ Explain a wide variety of observations with a few simple principles, AND
  - ✓ Must be supported by a large, compelling body of evidence.
  - ✓ Must NOT have failed any crucial test of its validity.

Theories that have stood the test of time and evidence

- Evolution
- The big bang
- Special and general relativity
- Quantum mechanics
- Plate tectonics

Dozens of theories you have never heard about were once respectable among scientists, but eventually discarded because data contradicted their predictions

Thought Question

Darwin's theory of evolution meets all the criteria of a scientific theory. This means:

A. Scientific opinion is about evenly split as to whether evolution really happened.

B. Scientific opinion runs about 90% in favor of the theory of evolution and about 10% opposed.

C. After more than 100 years of putting Darwin's theory to the test, the theory stands stronger than ever, having successfully met every scientific challenge to its validity.

D. There is no longer any doubt that the theory of evolution is absolutely true.

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