ASTR 101 B: The Sky and the Scale of the Universe

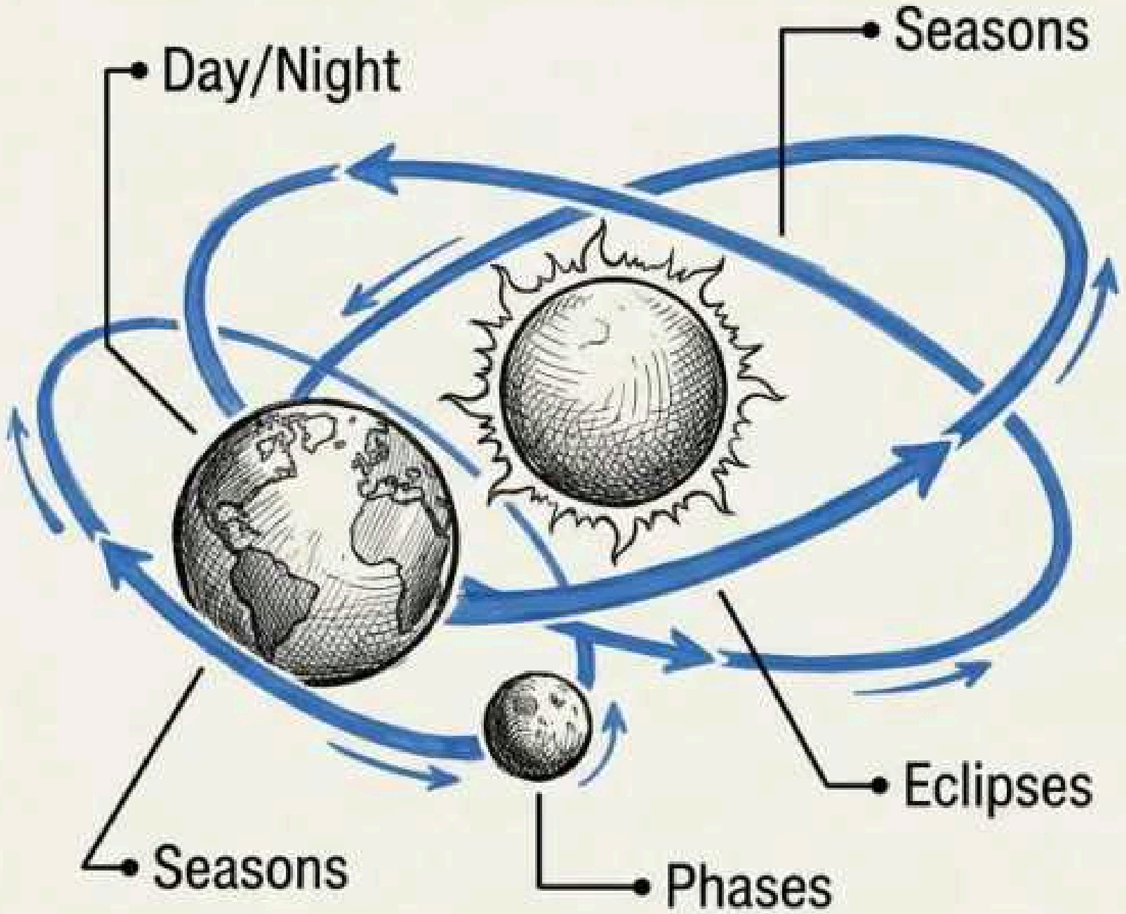
Lecture 1



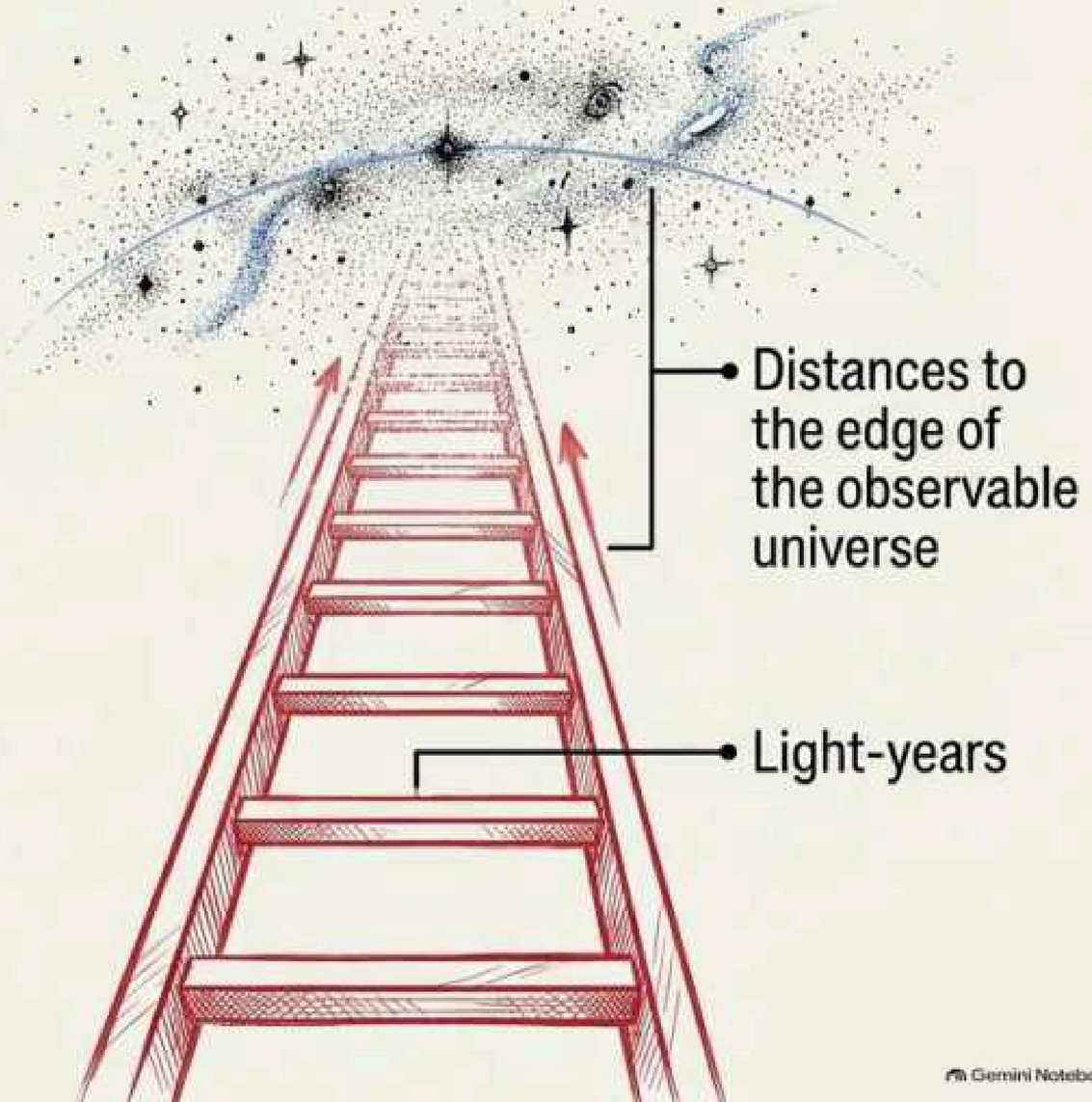
Day, seasons, Moon phases and eclipses;
light-years and the ladder of cosmic distances.

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Part 1: The Sky from Earth

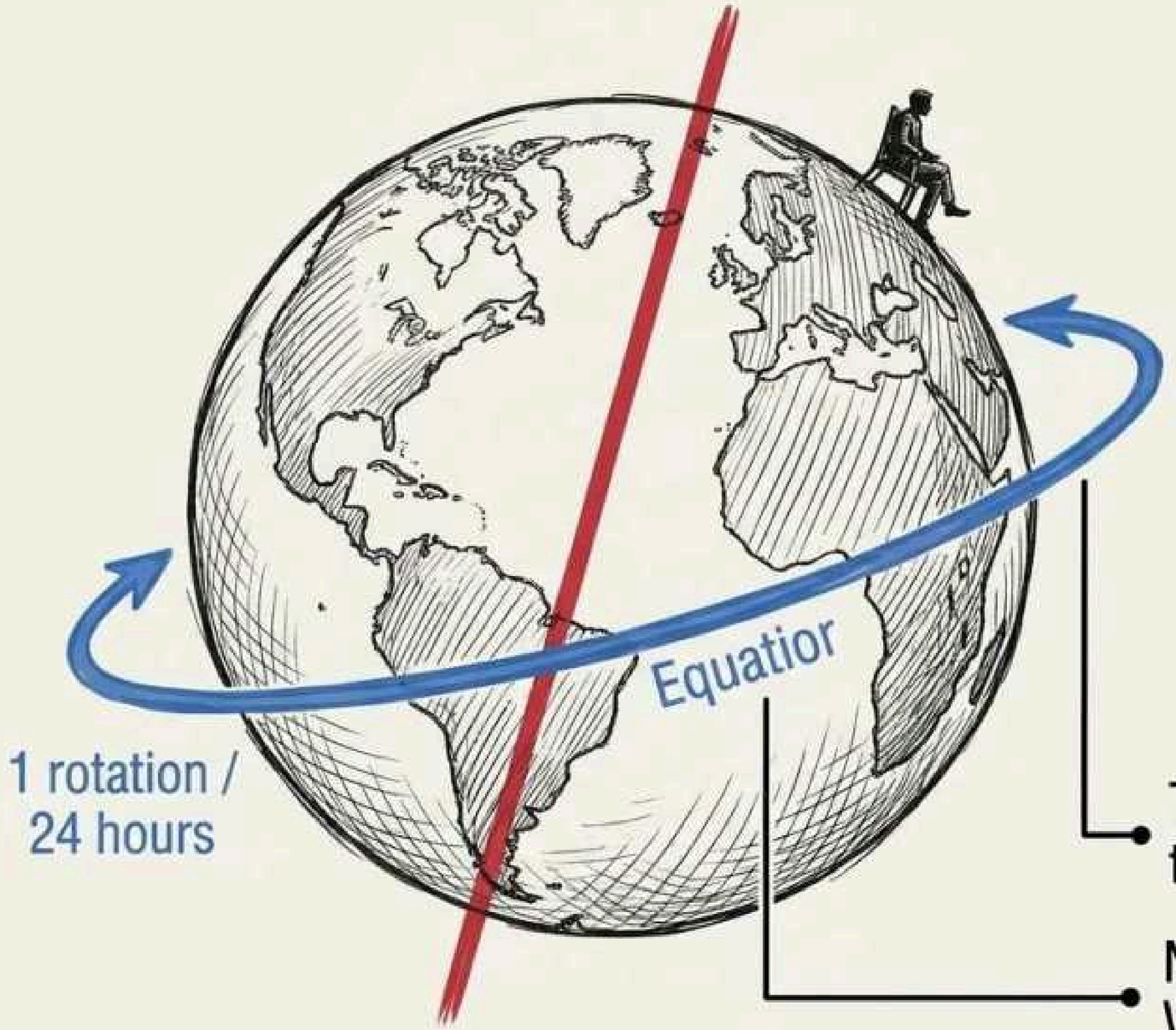


Part 2: The Cosmic Ladder

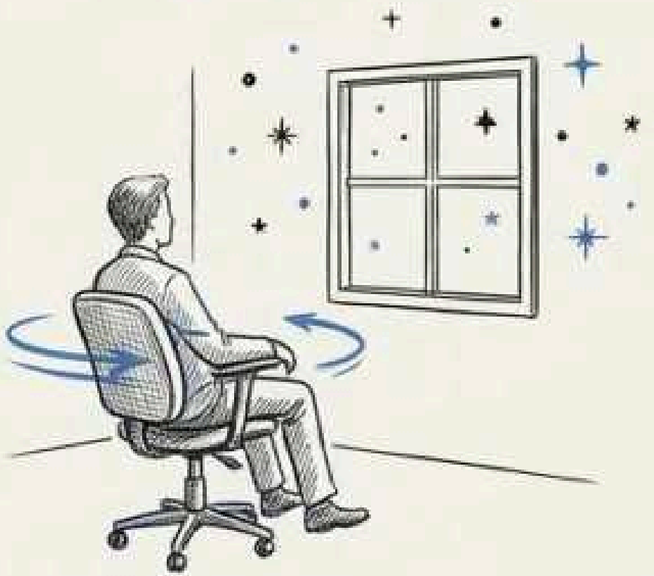


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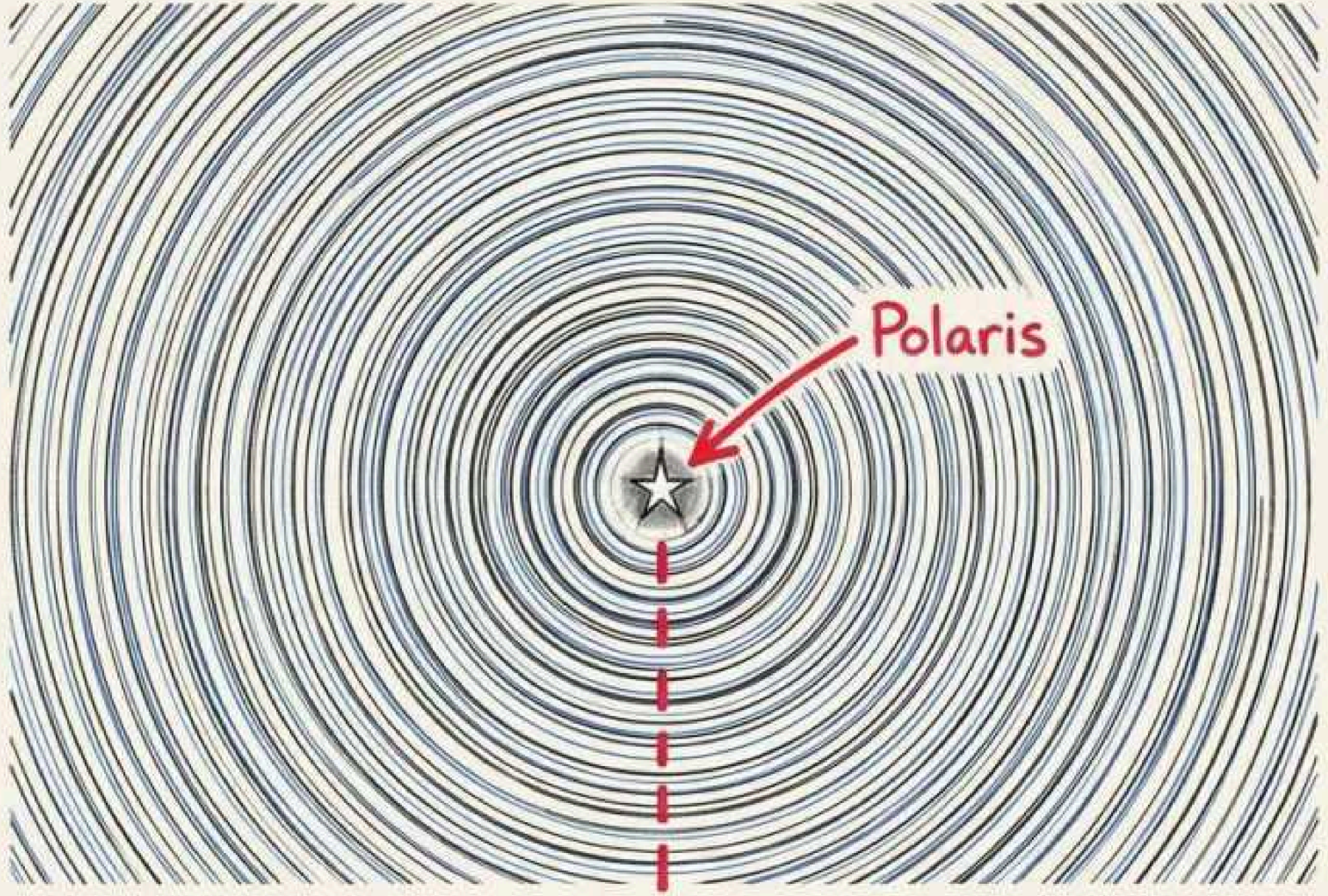
Rotating Chair Metaphor



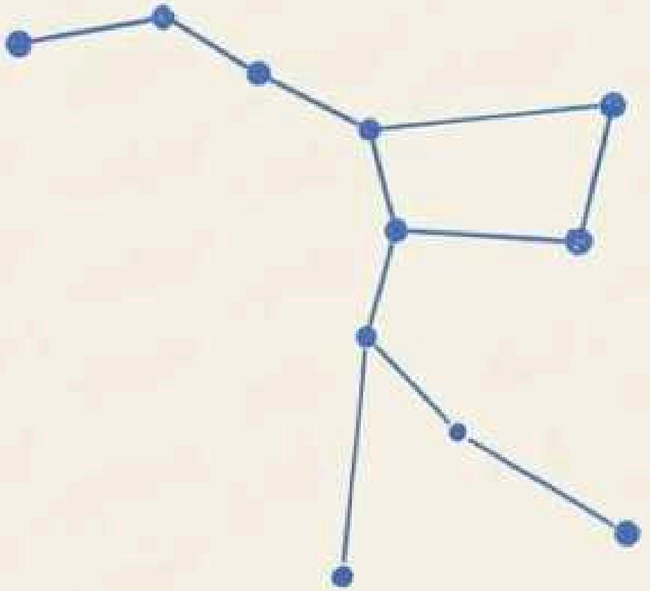
The Sun, Moon, and stars appear to move East to West.

Nothing in the sky is turning around us. We are the ones turning.

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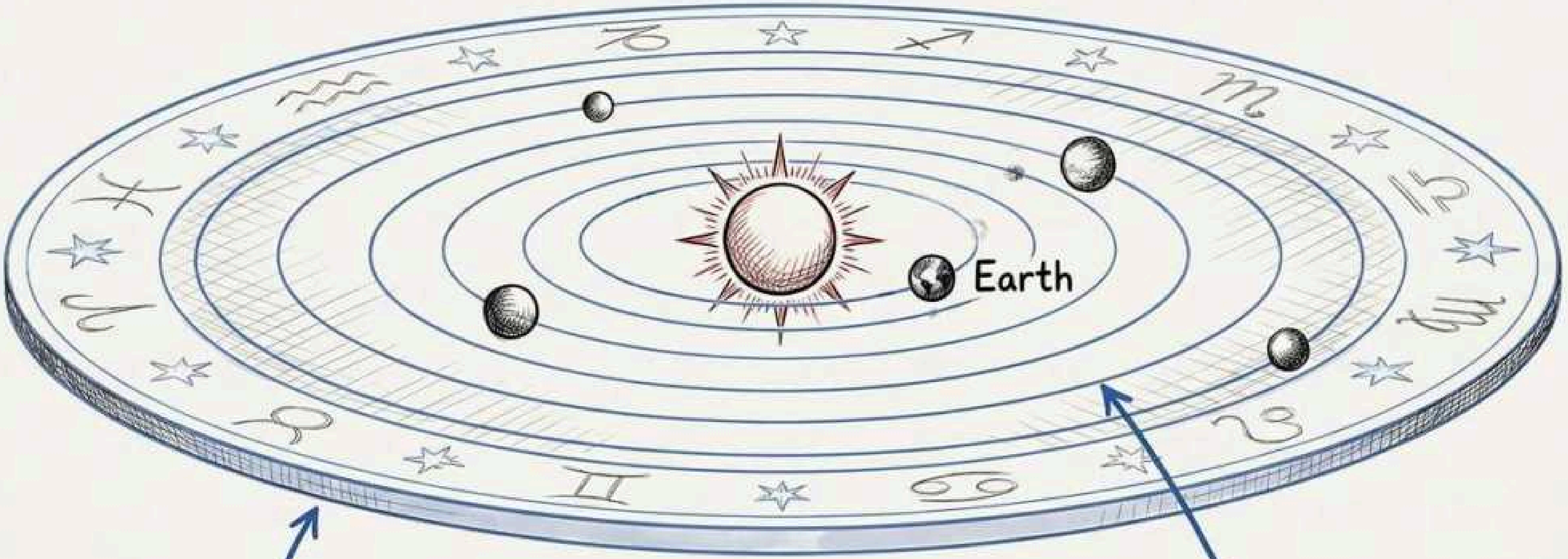




Stars circle a fixed point above the North Pole.

Extreme distance = fixed patterns for thousands of years.

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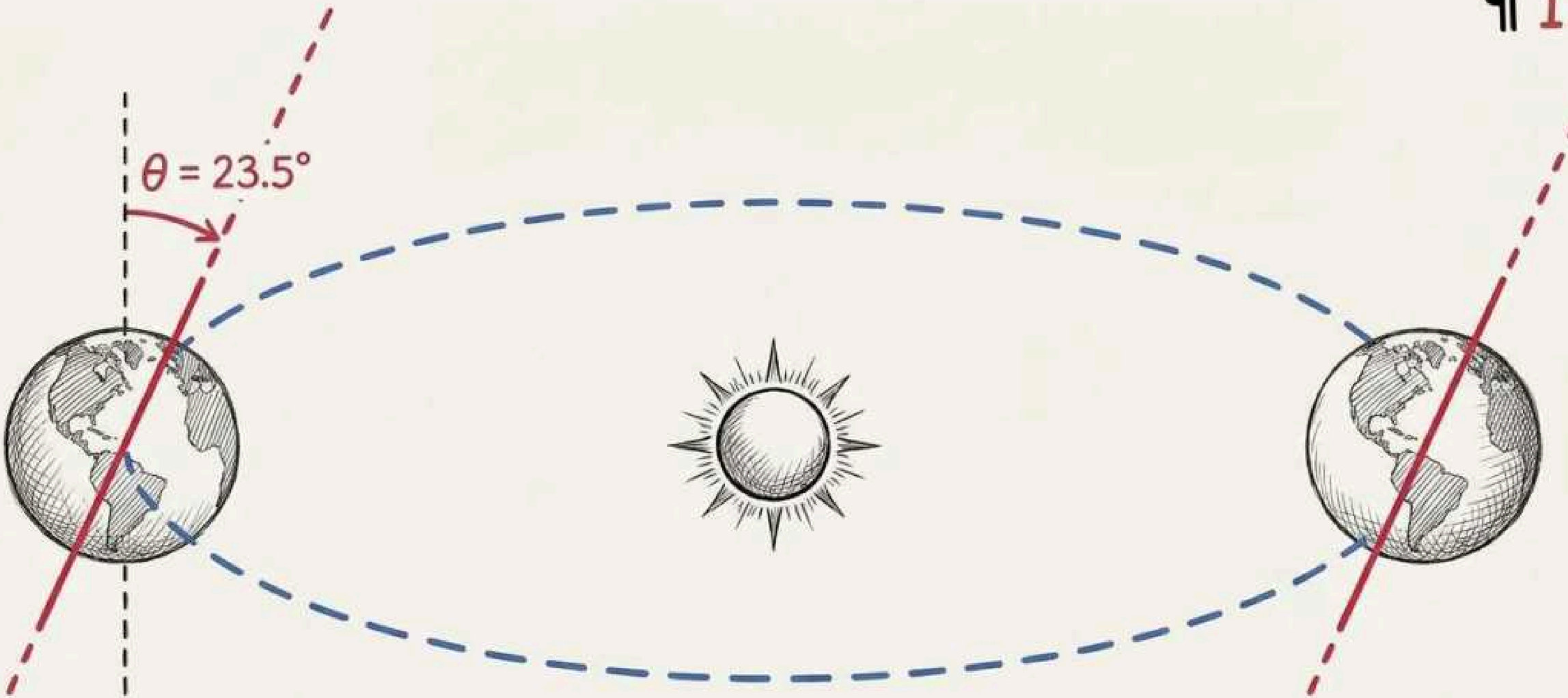


The Ecliptic:
The Sun's apparent path over a year.

Planets (Greek for "wanderers"):
Drift against fixed stars because they orbit in this same nearly flat plane.

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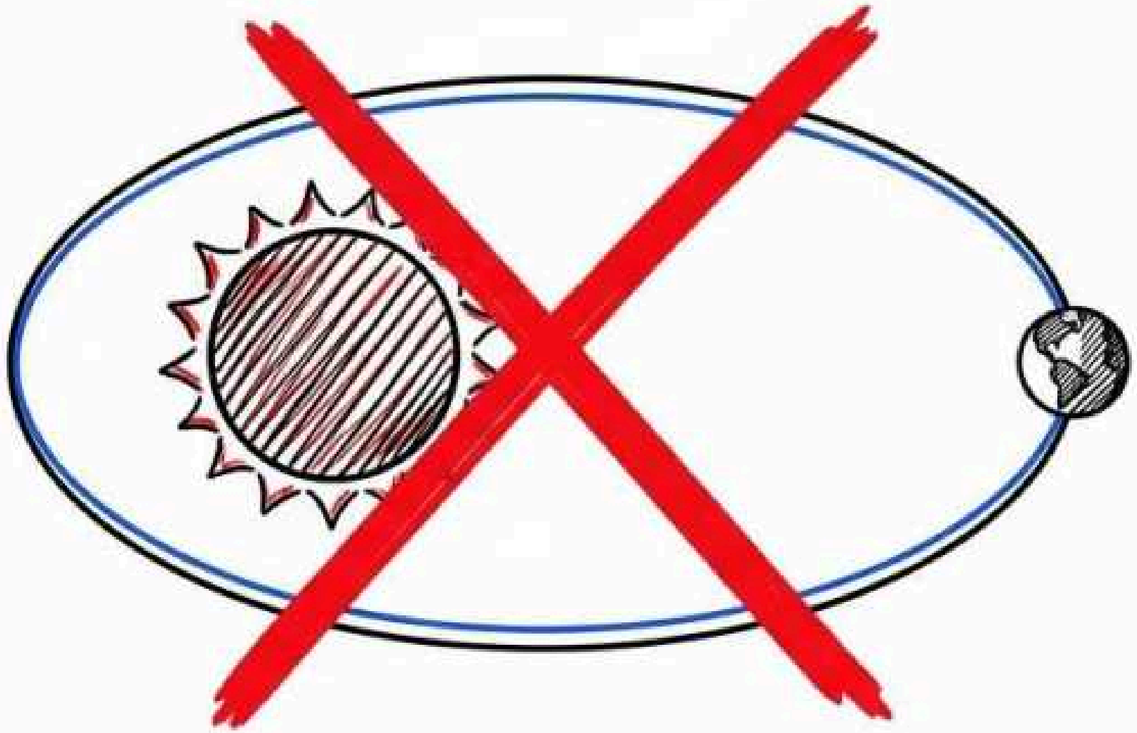


Northern Hemisphere
leans toward the Sun.

Northern Hemisphere
leans away from the Sun.

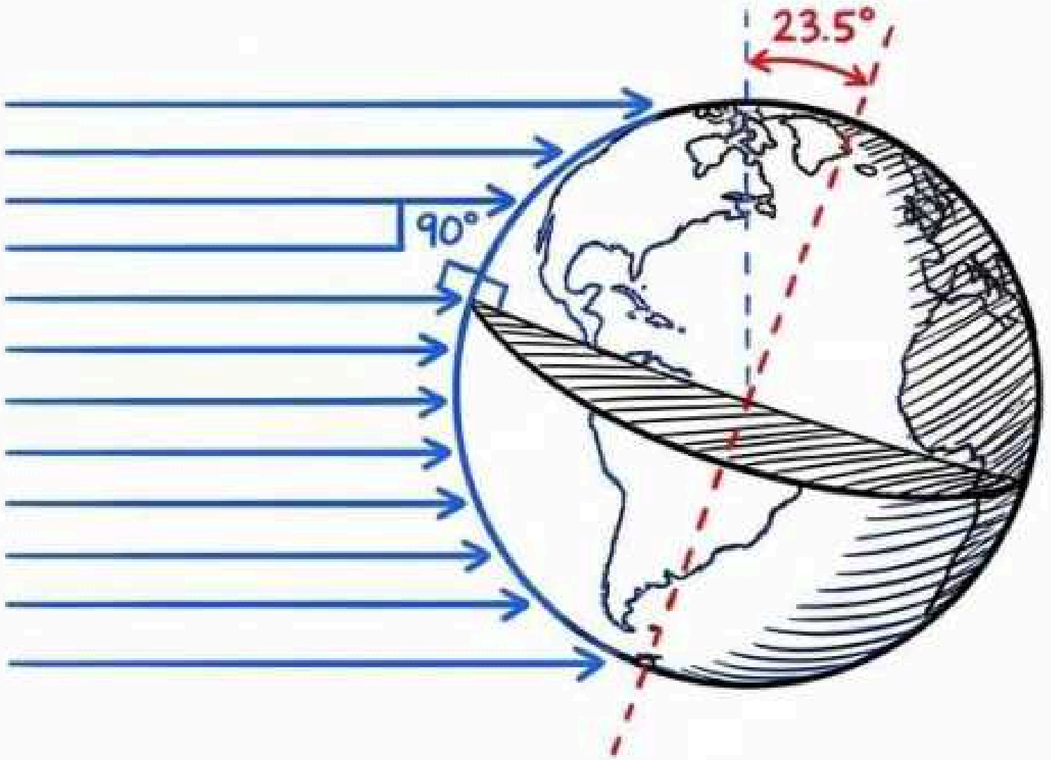
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Myth: Distance



Myth: Earth gets closer to the Sun in summer. (Fact: Earth is actually closest to the Sun in early January).

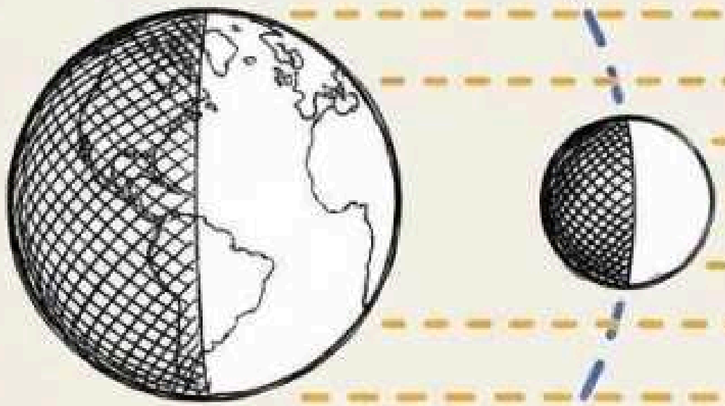
Fact: Direct Light



Fact: The 23.5° tilt dictates the angle of direct sunlight and length of days.

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- Orbit: ~1 month.
- Rule 1: Half of the Moon is ALWAYS lit by the Sun.
- New Moon: We see almost none of the lit half.



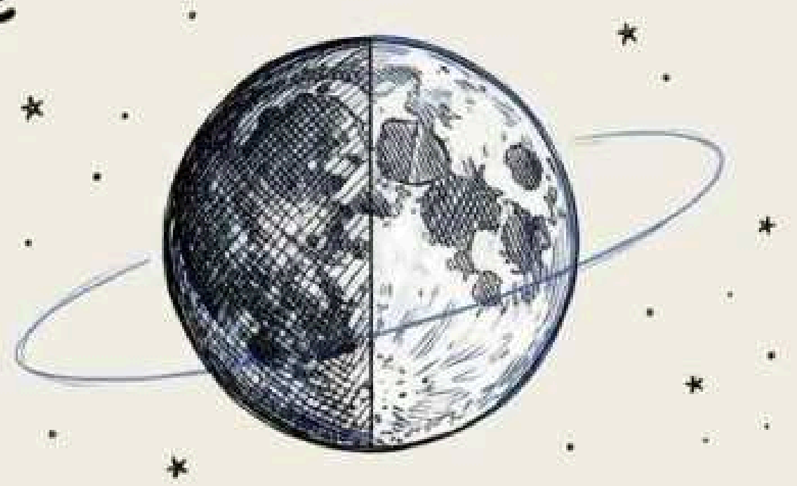
- Full Moon: Earth is between Moon and Sun; we see all of the lit half.

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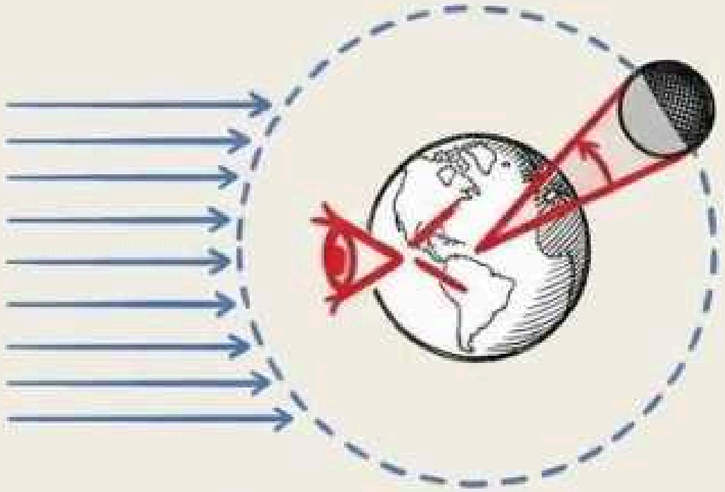
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What you see

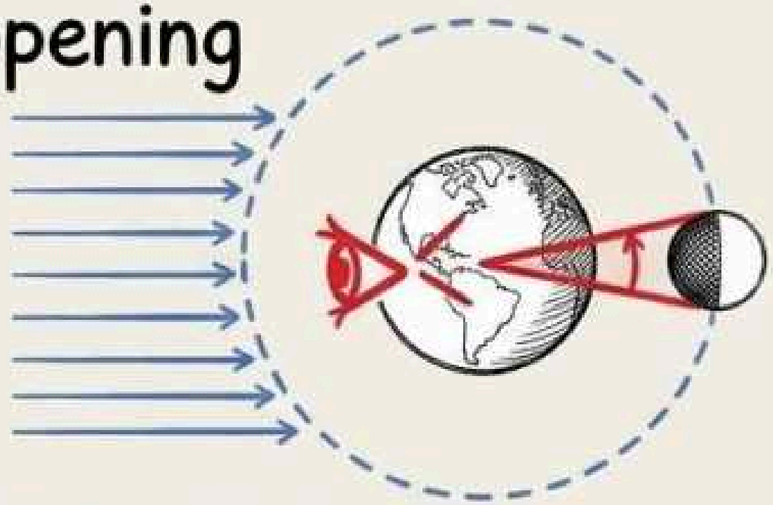




What is happening



Viewing angle:
Oblique

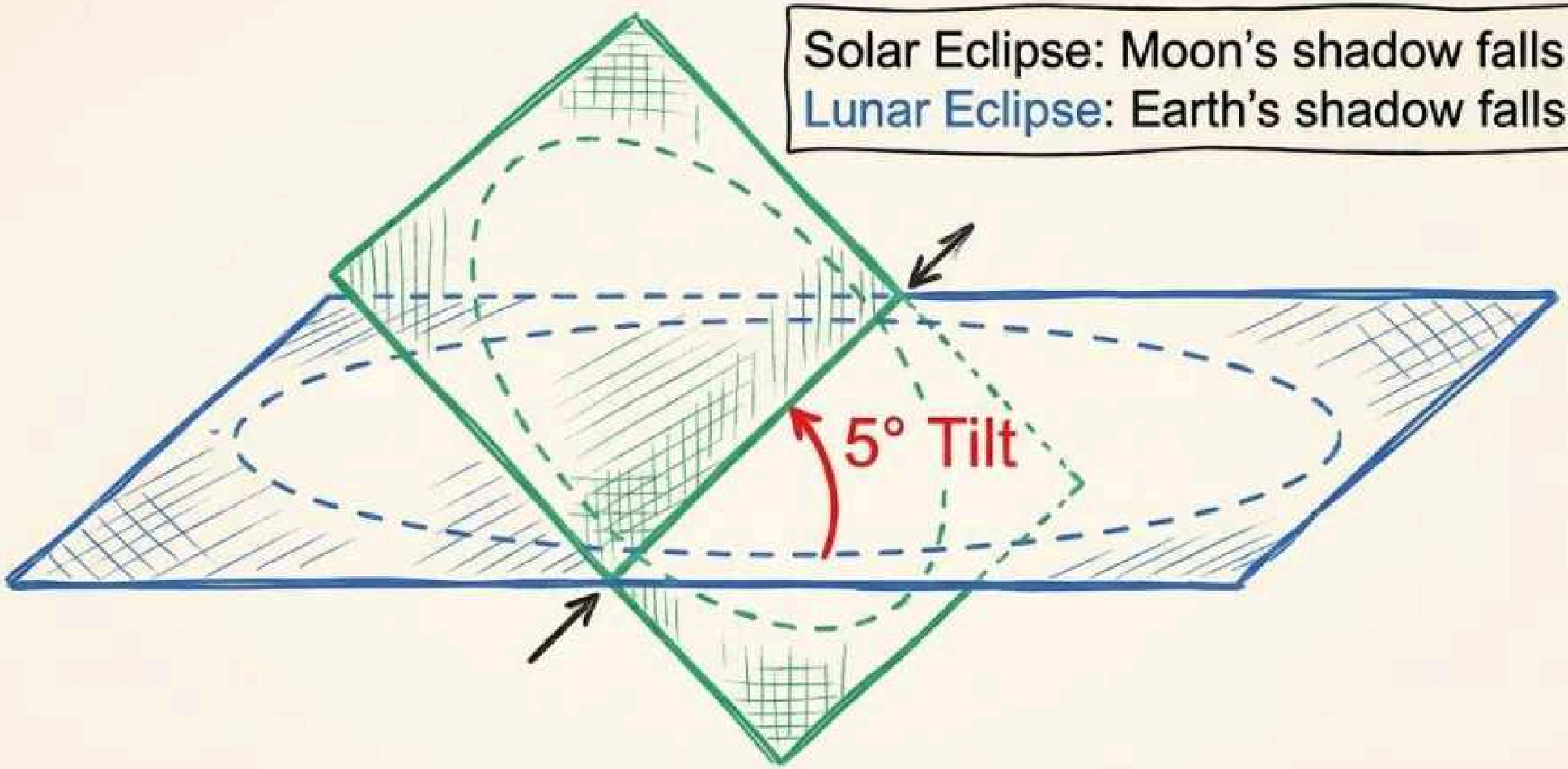


Viewing angle:
Perpendicular

Common Misconception: Phases are caused by the Earth's shadow. FALSE.
Fact: A phase is simply the viewing angle of the Moon's lit side.

Cycle length: 2

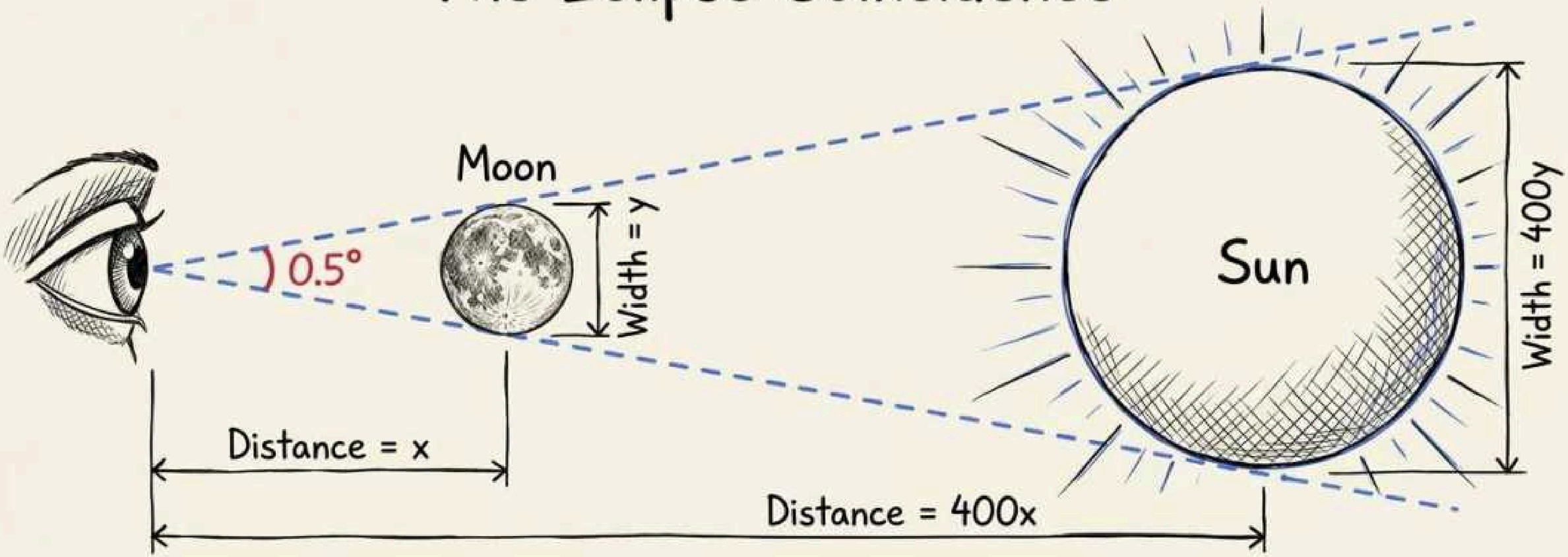
Solar Eclipse: Moon's shadow falls on Earth.
Lunar Eclipse: Earth's shadow falls on Moon.



Why not every month? The 5° tilt means the three bodies seldom line up perfectly.

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The Eclipse Coincidence



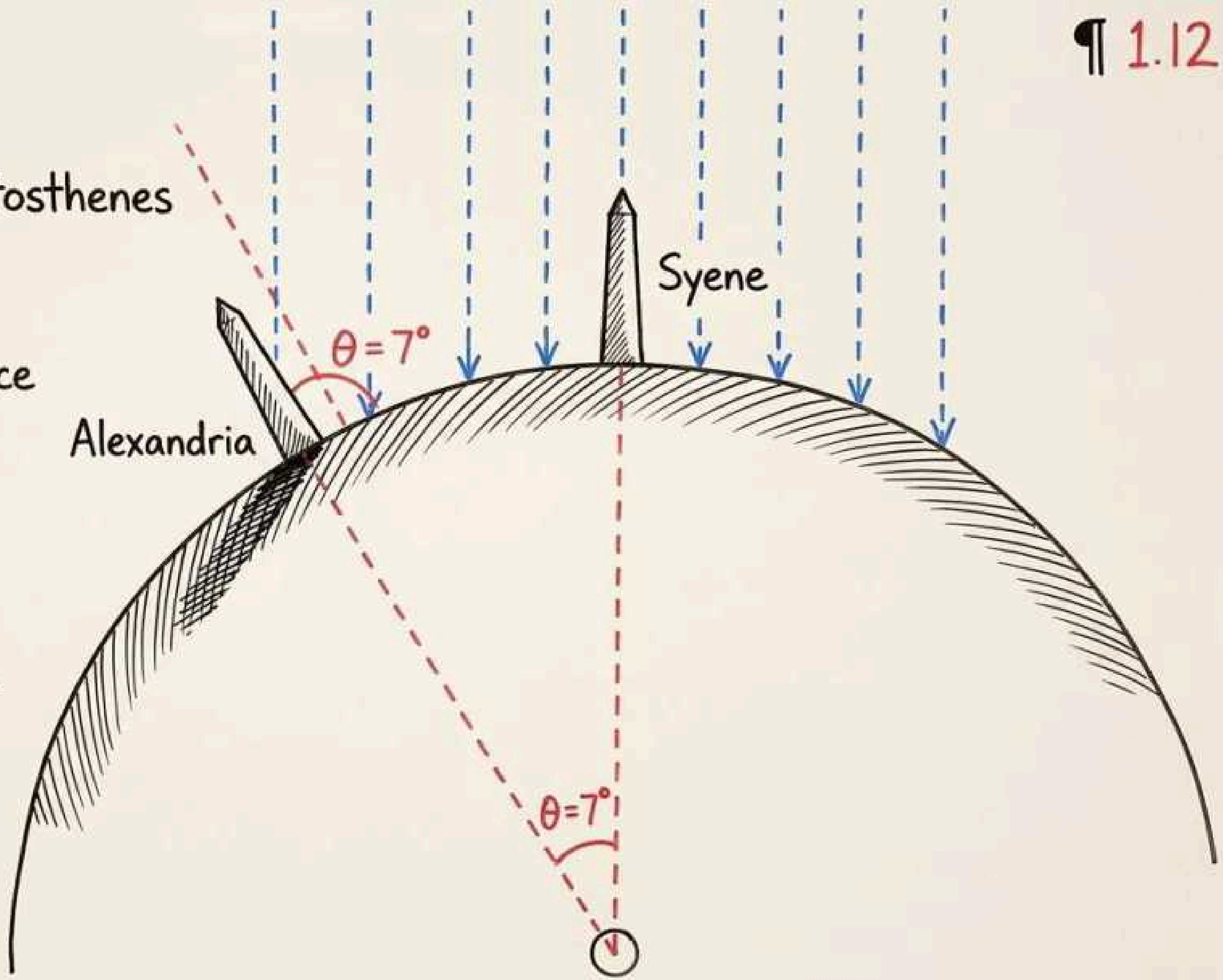
Because the Sun is 400x wider AND 400x farther away, they appear the exact same size in our sky.

Future note: The Moon is drifting away; this coincidence is temporary.

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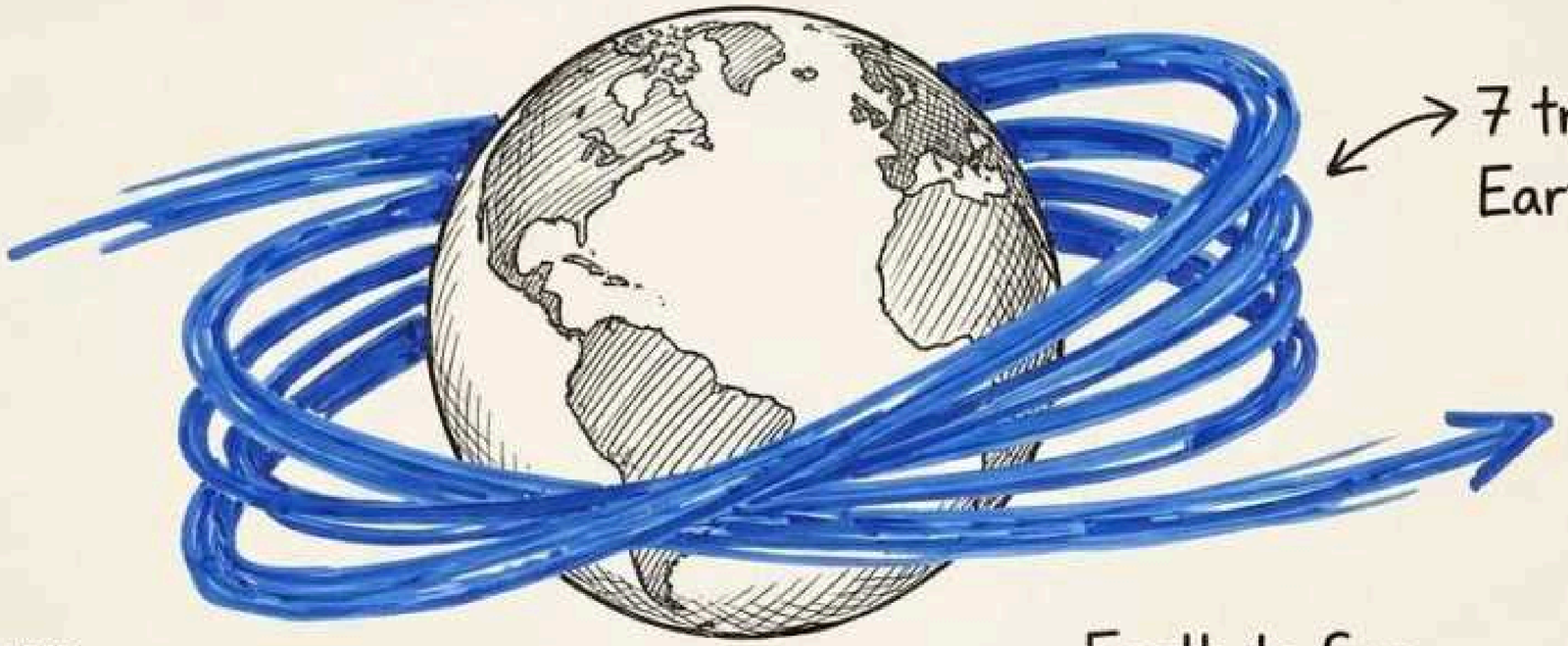
> 2,000 years ago: Eratosthenes measures the Earth.

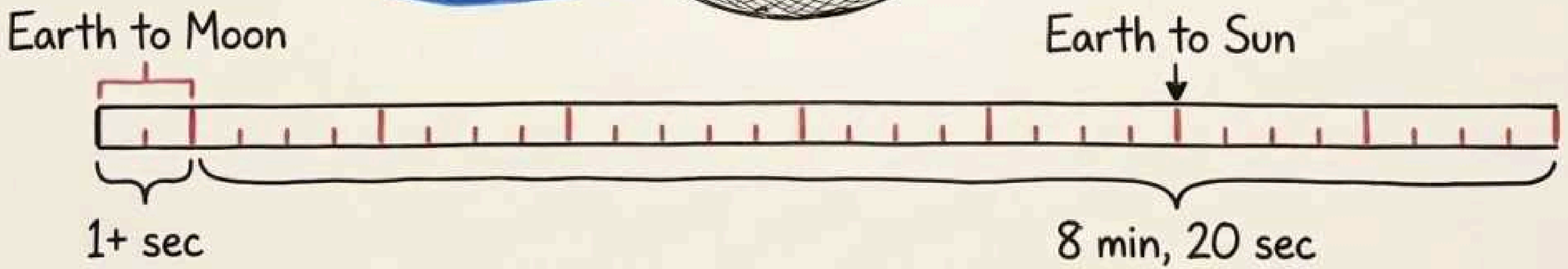
By measuring the distance between towns and the shadow angle, he calculated the Earth's circumference within a few percent of the true value.



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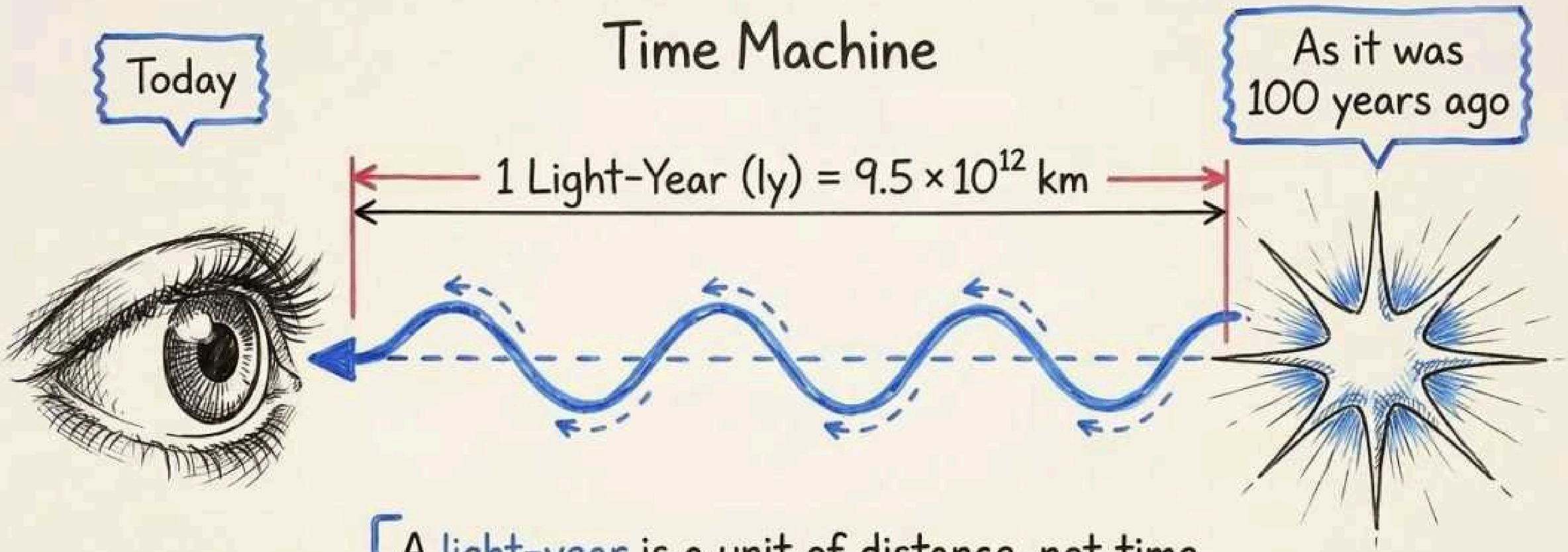
C = 300,000 km/s





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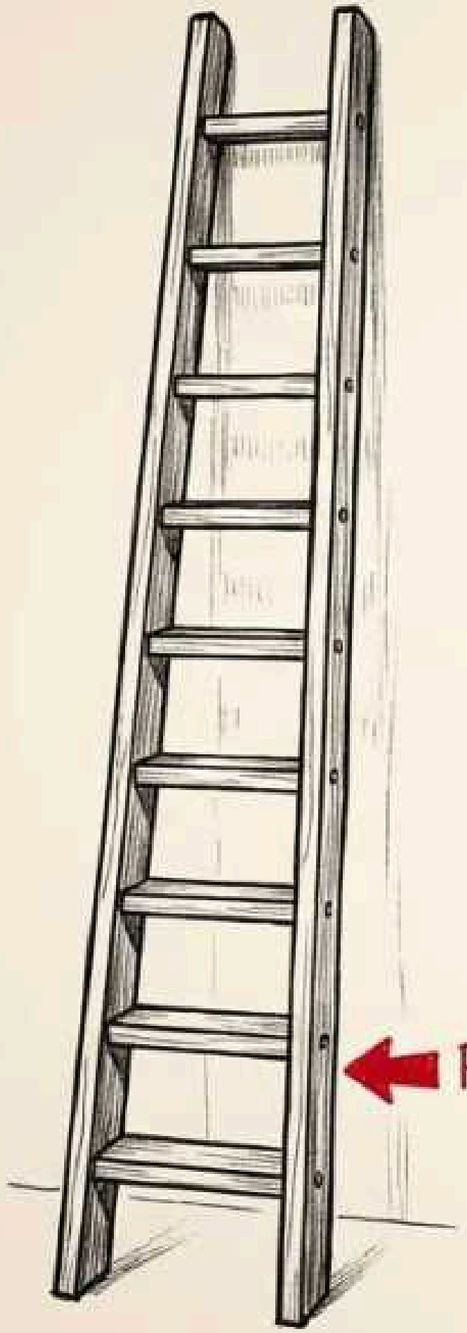
Time Machine



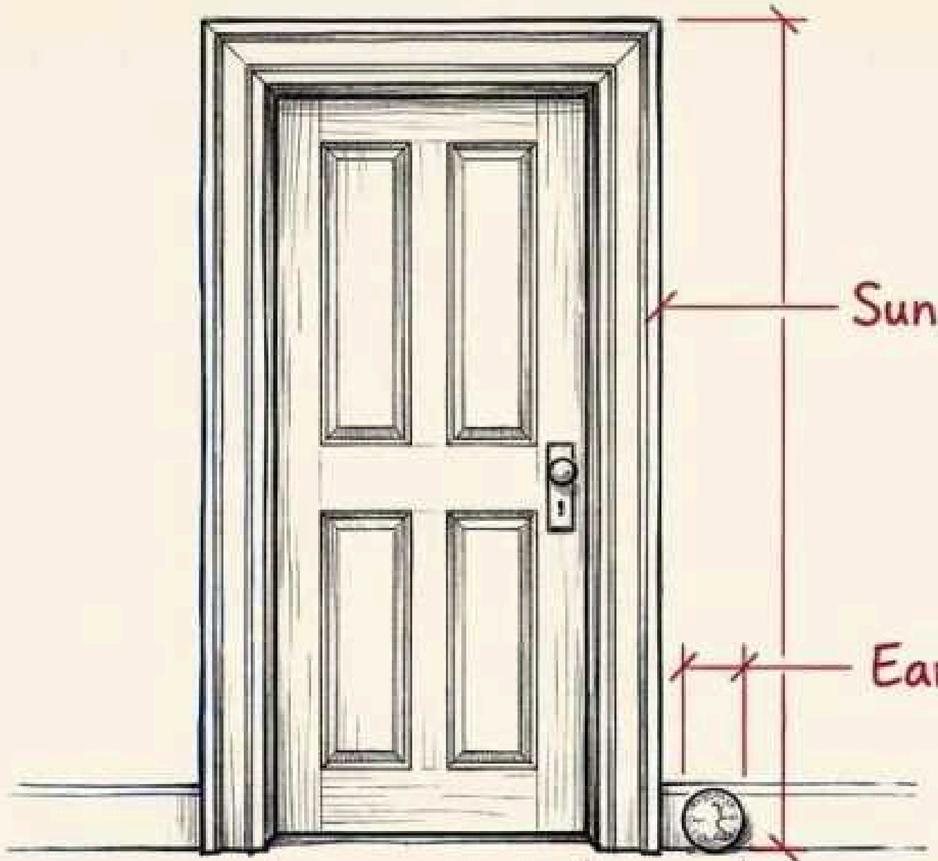
A light-year is a unit of distance, not time.

Looking far away = looking into the past.
Seeing a star 100 ly away means seeing light that traveled for 100 years.

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Rung 1: Solar System



Sun width: 1,392,700 km

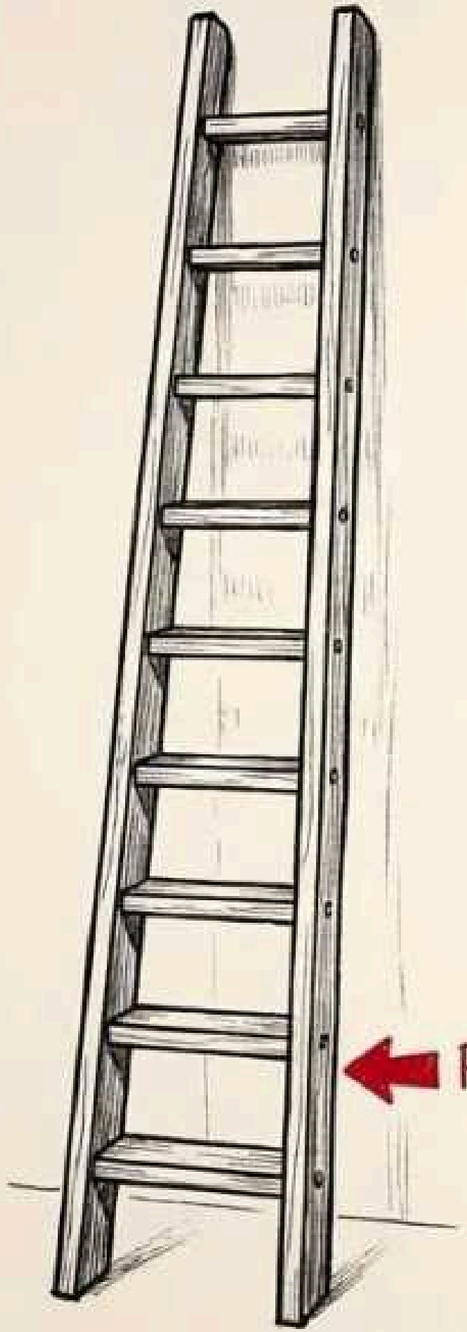
Earth width: 13,000 km

Earth-Moon: 384,000 km

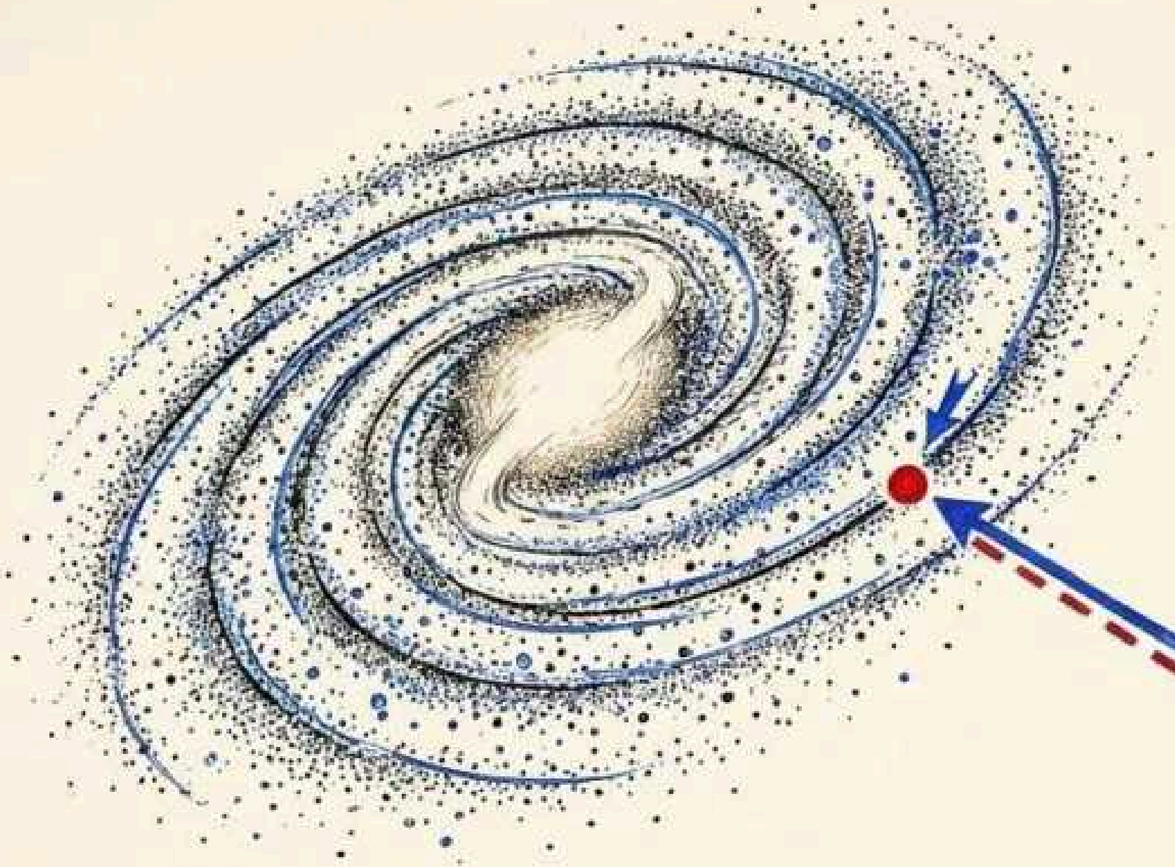
Earth-Sun: 150,000,000 km (1 Astronomical Unit / AU)

The Sun is 109x wider than Earth. If the Sun were a front door, the Earth would be a small coin.

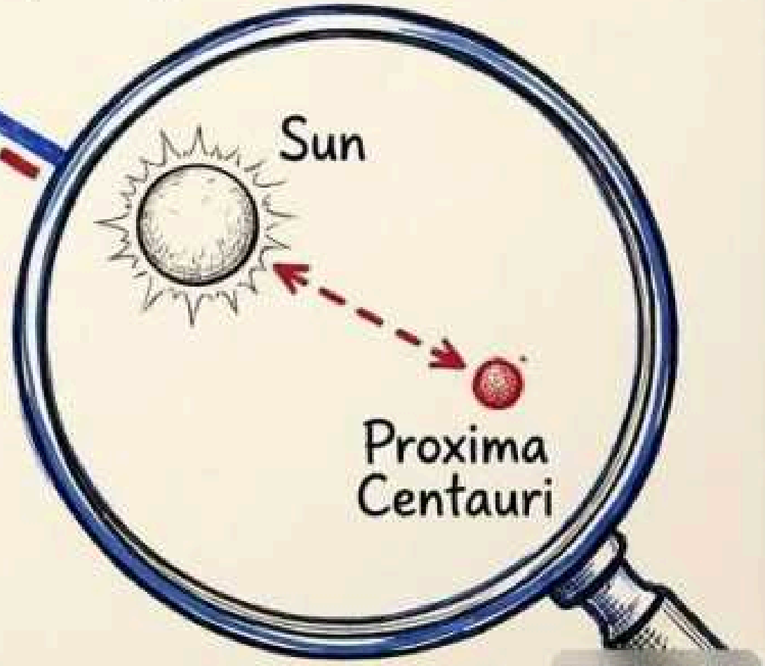
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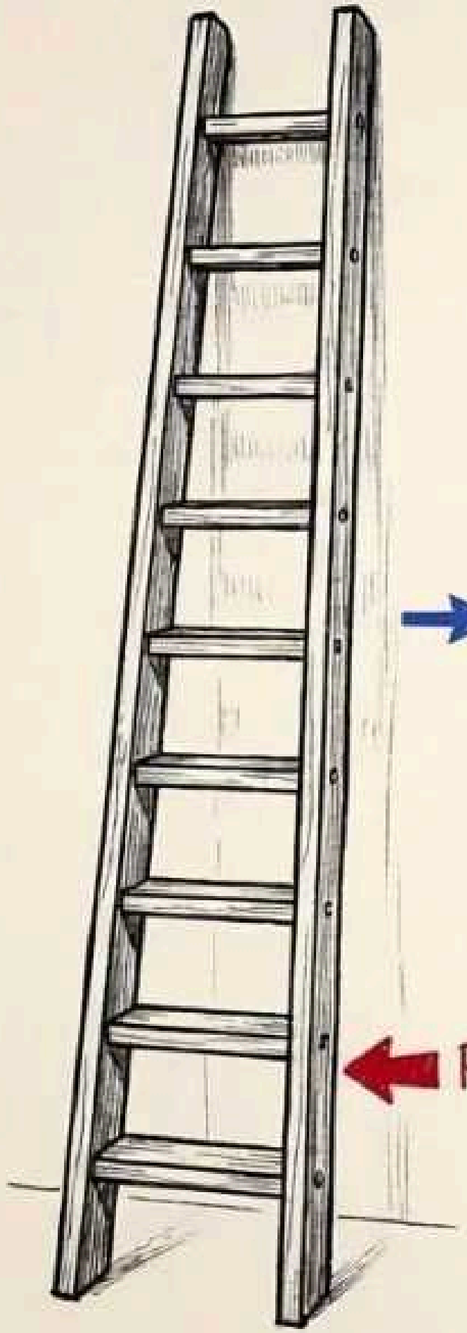
Rung 2: The Galaxy



- Nearest Star (Proxima Centauri): 4.2 ly away (Tens of thousands of years by spacecraft).
- Visible Night Sky Stars: Mostly within a few thousand ly.
- Milky Way Disk: 100,000 ly across.

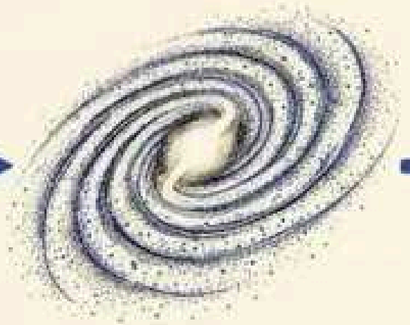


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Rung 3: The Cosmic Web

Galaxy



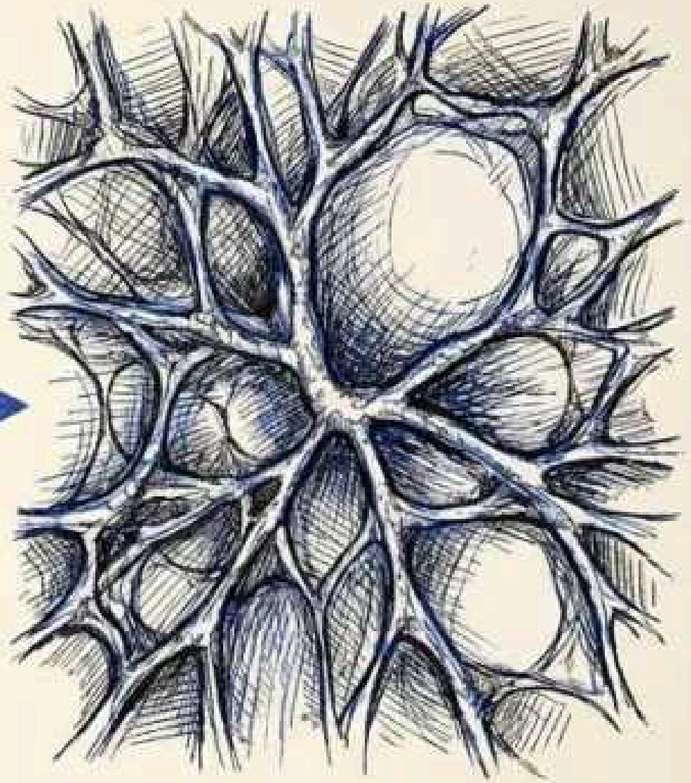
Group



Cluster



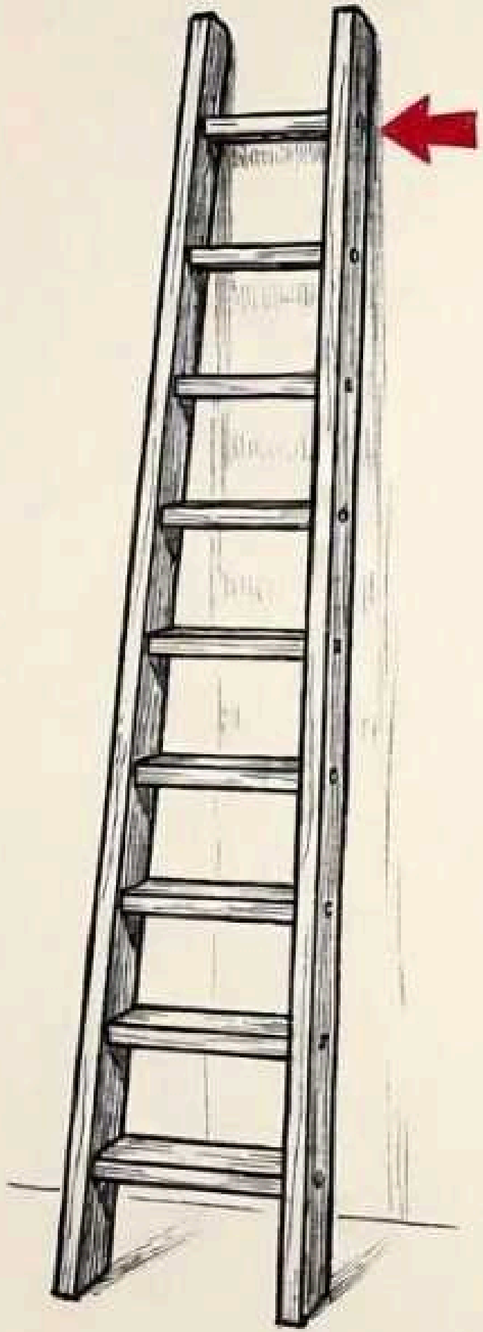
The Cosmic Web



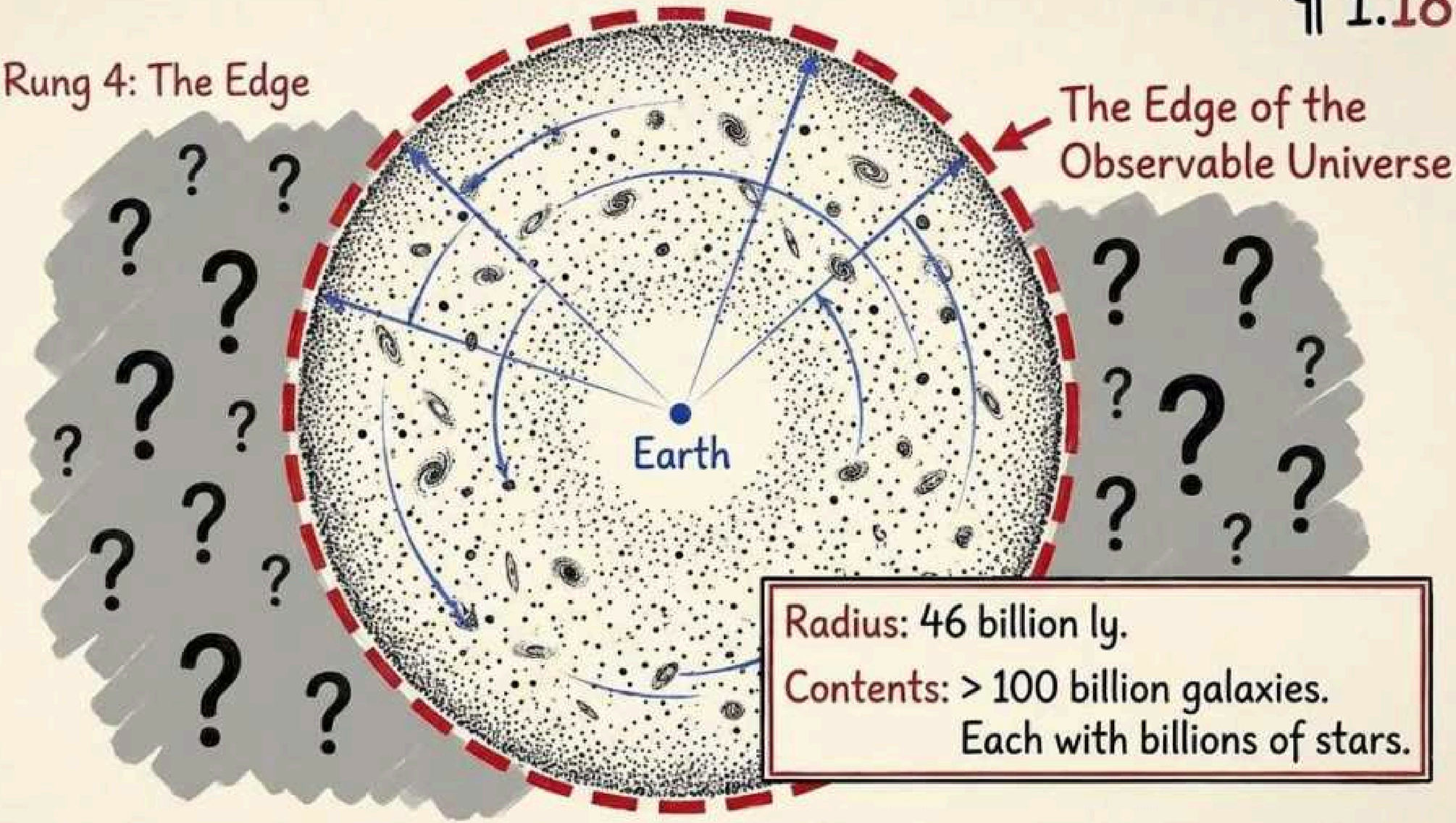
Nearest large neighbor (Andromeda):
2.5 million ly away
(Visible as a faint smudge).

Galaxies gather into groups, clusters, great filaments, and walls to form the cosmic web.

Gemini Notebook

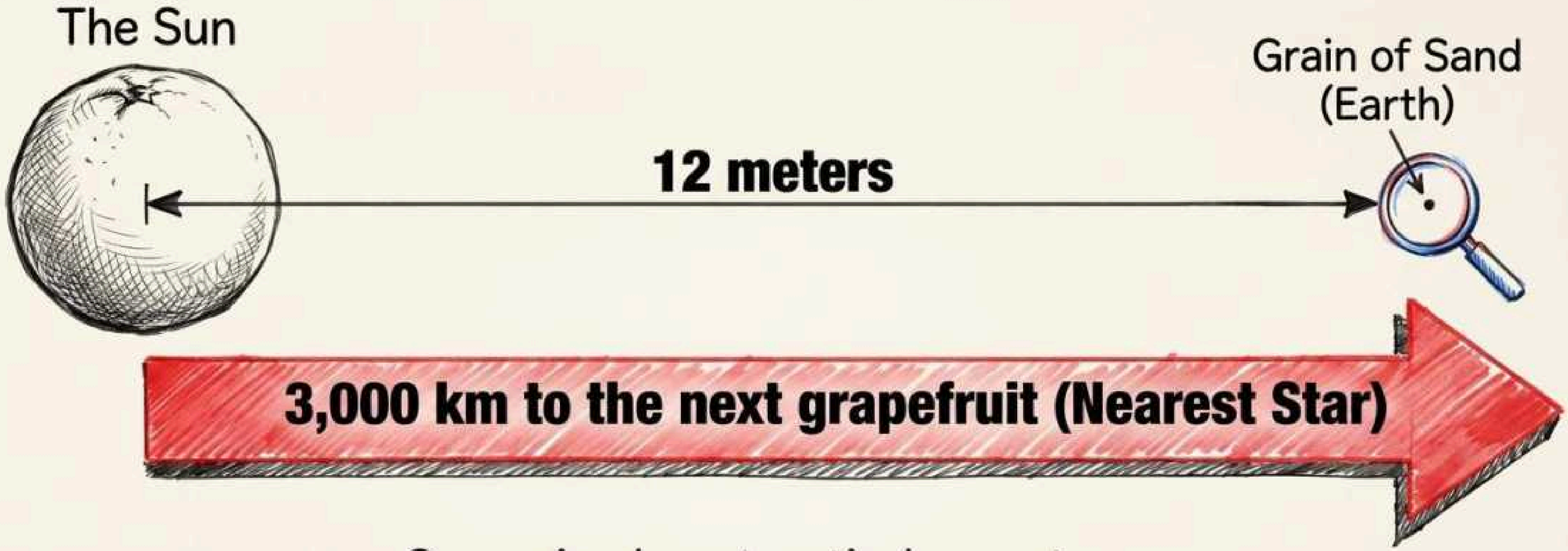


Rung 4: The Edge



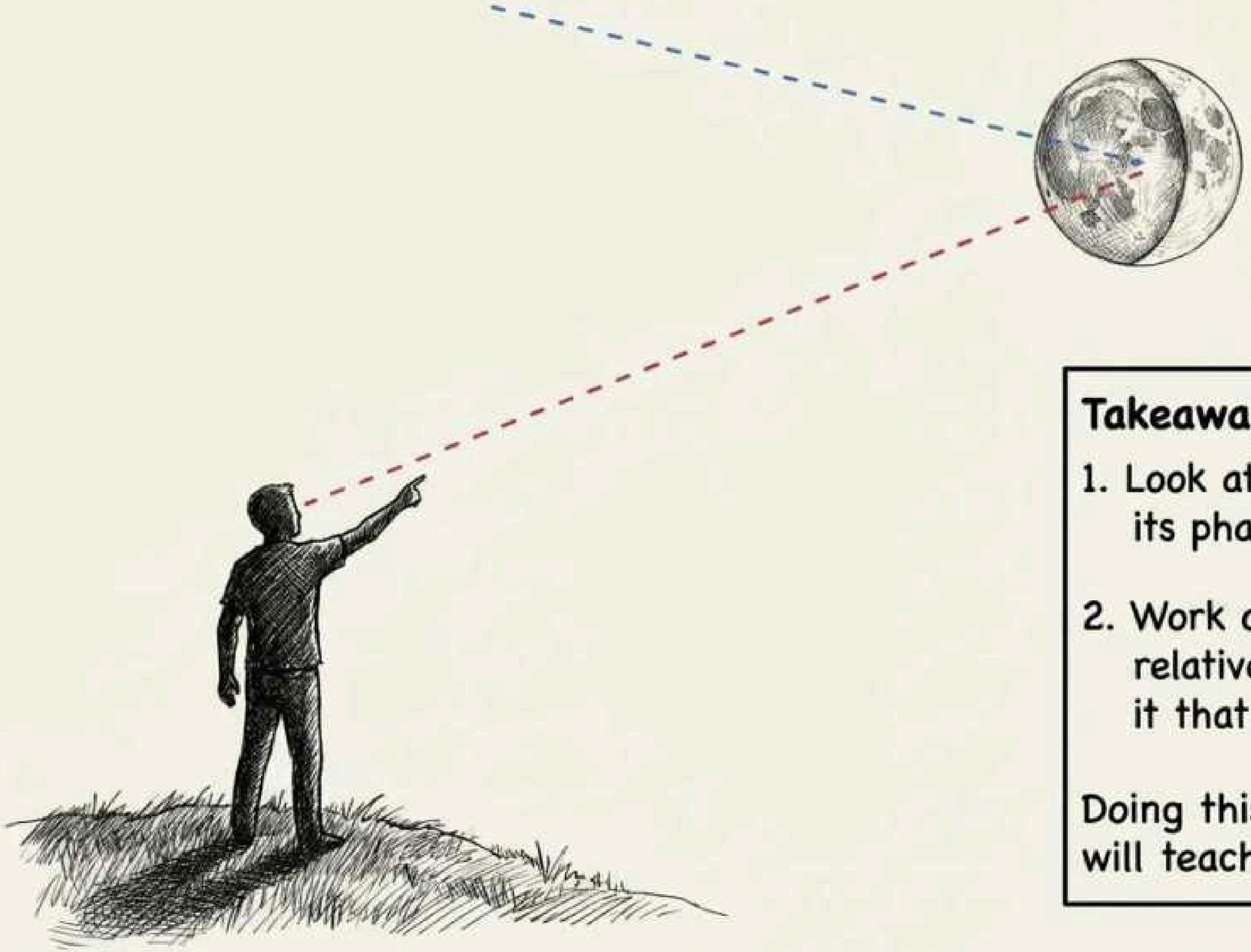
We can only see parts of the universe whose light has had time to reach us. Beyond this edge, light has not reached us.

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Space is almost entirely empty.
The surprise is not that things are far apart,
but that anything is there at all.

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Takeaway Assignment:

1. Look at the Moon tonight and name its phase.

2. Work out where the Sun must be, relative to you and the Moon, to light it that way.

Doing this once with your own eyes will teach you more than any diagram.

Next time: A tour of the Solar System and the laws that govern it.

Gemini Notebook