DISTANCE

- “Really, Really Far” is a bit too arbitrary
- m, cm, in, ft, mi, km all pretty small
- In Solar System –
  - Astronomical Unit (AU)
    - Avg. distance from Earth to Sun
    - 1.5×10^{11}m or 93×10^{6} miles
  - Venus is 0.7 AU from Sun, Mars 1.5 AU, Pluto 39 AU

BIGGER DISTANCES

- Further out, we use “Light Years”
  - The distance Light goes in one Year
    - Light goes 186,000 miles/second
    - A year has 3.16×10^{7} seconds
    - So a light year is 5.85×10^{12} miles
    - 63,000 AU
    - 9.46×10^{15} m
    - Nearest other Star: Proxima Centauri, 4.22 ly
    - Milky Way Galaxy: ~100,000 ly across

POWERS OF 10

- Notice the Scientific Notation:
  - $93 \times 10^6 = 93{,}000{,}000 = 93$ million miles
  - $63{,}000 = 6.3 \times 10^4$ AU/ly
- It makes big numbers easier to work with
- For example:
  - 1 ly = 1.85×10^5 miles/s times 3.16×10^7 s/yr = 5.85×10^{12} miles

LOOKING BACK IN TIME

- Light travels at a constant, finite speed (300,000 km/s).

Destination	Light travel time
Moon	1 second
Sun	8 minutes
Sirius	8 years
Andromeda Galaxy	2.5 million years

- Thus, we see objects as they were in the past:

The farther away we look in distance,
the further back we look in time.

TIME MACHINE

- So this is what Andromeda looked like 2.5 million years ago

M31, the great galaxy in Andromeda

HISTORY OF THE UNIVERSE

- This “time Machine” feature helps us understand the history of the universe, where things came from, where they’re going
- Much more later in the class, but to keep in mind, here’s a short summary…

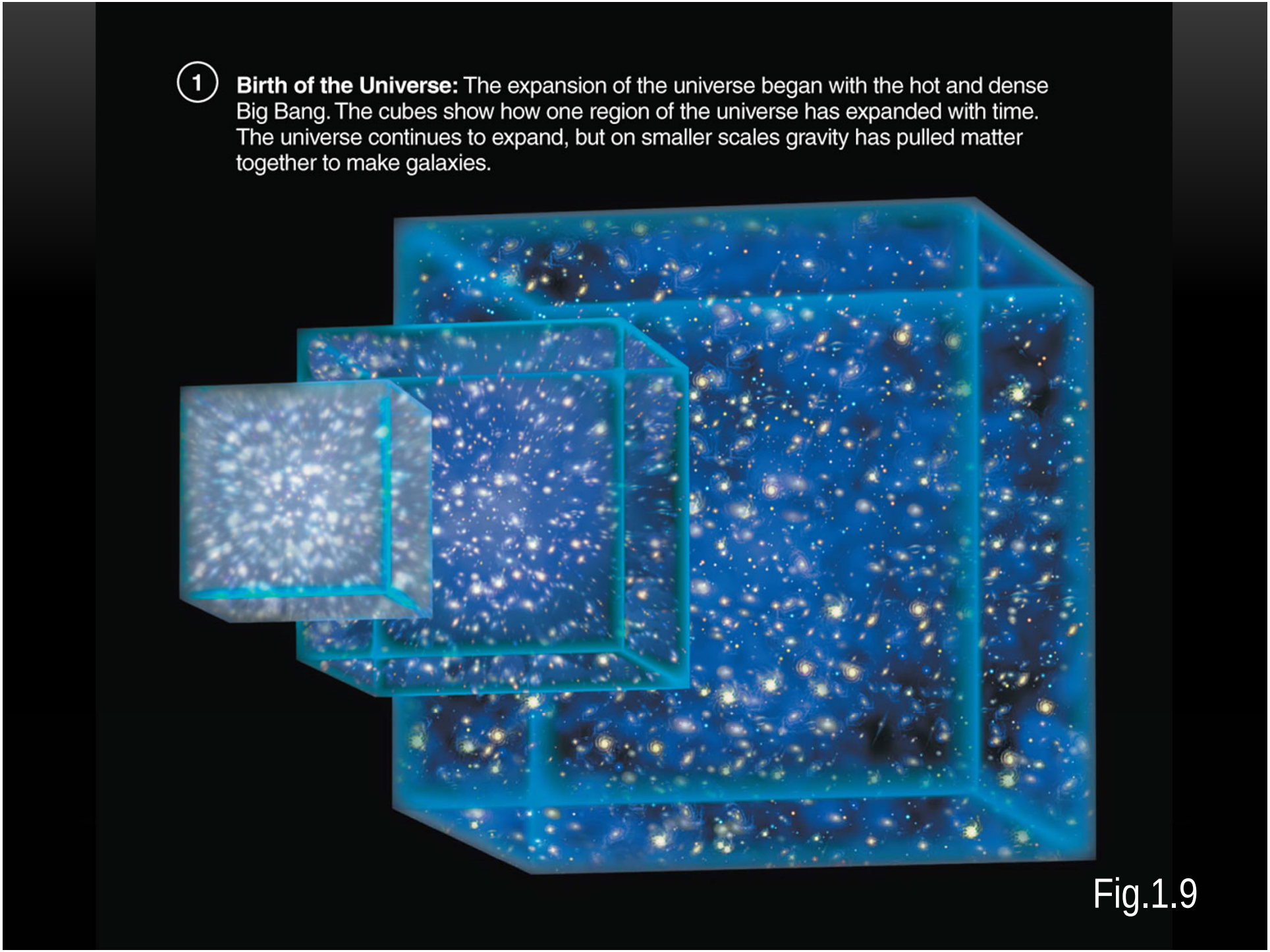
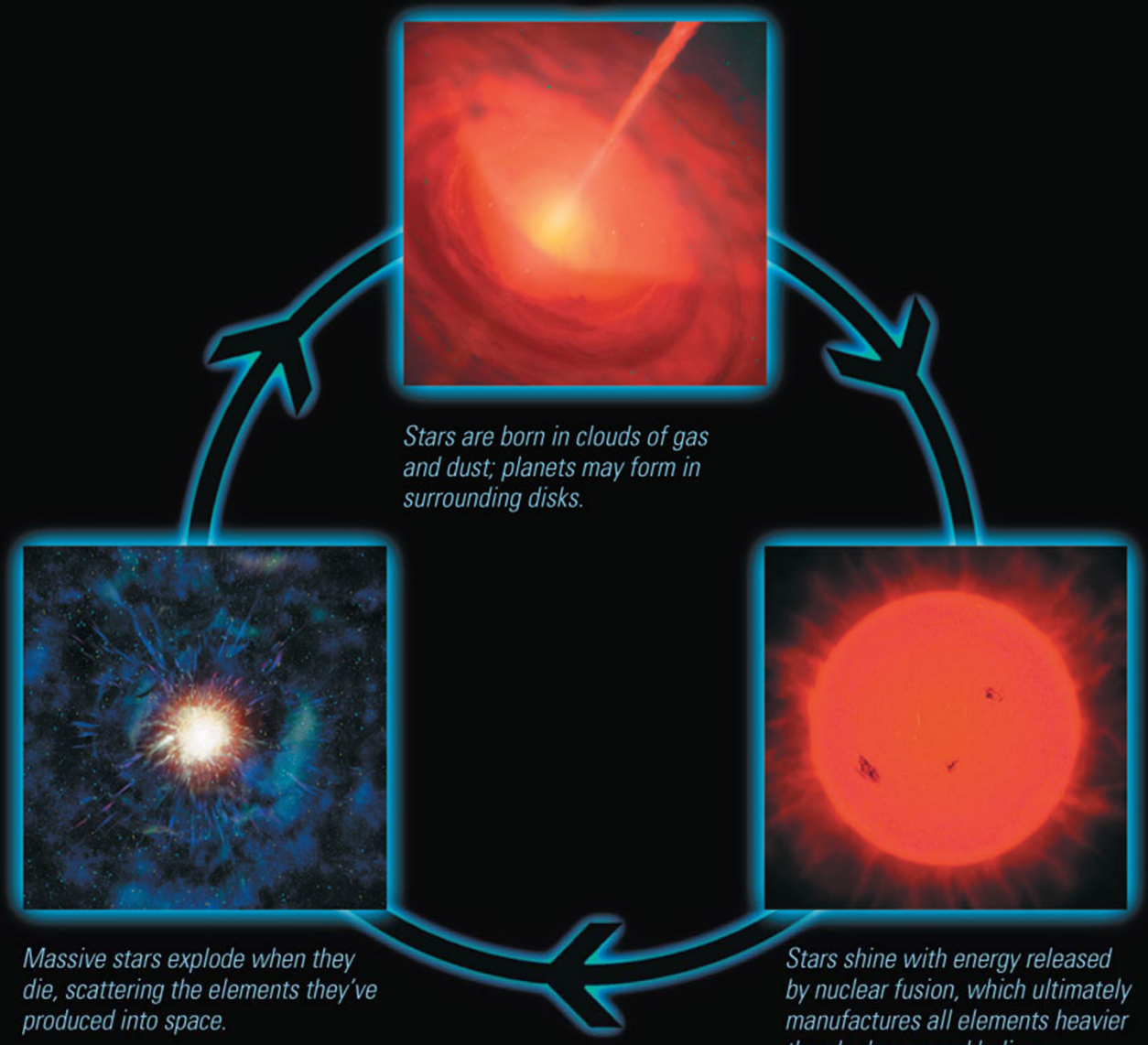

1
Birth of the Universe: The expansion of the universe began with the hot and dense Big Bang. The cubes show how one region of the universe has expanded with time. The universe continues to expand, but on smaller scales gravity has pulled matter together to make galaxies.

Fig.1.9


2
Galaxies as Cosmic Recycling Plants: The early universe contained only two chemical elements: hydrogen and helium. All other elements were made by stars and recycled from one stellar generation to the next within galaxies like our Milky Way.

Fig.1.9



3 **Life Cycles of Stars:** Many generations of stars have lived and died in the Milky Way.

Fig.1.9

④ **Earth and Life:** By the time our solar system was born, 4½ billion years ago, about 2% of the original hydrogen and helium had been converted into heavier elements. We are therefore "star stuff," because we and our planet are made from elements manufactured in stars that lived and died long ago.

Fig.1.9

CHANNEL SETTING INSTRUCTIONS FOR *RESPONSECARD RF*

1. PRESS AND RELEASE THE "GO" OR "CHANNEL" BUTTON.

2. WHILE THE LIGHT IS FLASHING RED AND GREEN, ENTER THE 2 DIGIT CHANNEL CODE:

   CHANNEL IS 41

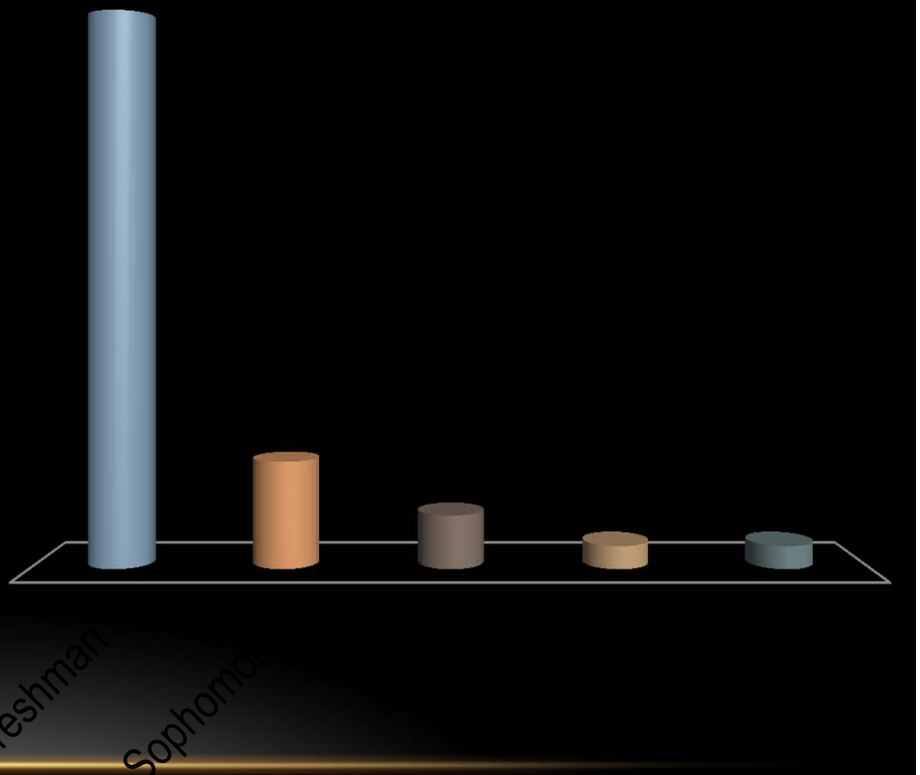
3. AFTER THE SECOND DIGIT IS ENTERED, PRESS AND RELEASE THE "GO" OR "CHANNEL" BUTTON. THE LIGHT SHOULD FLASH GREEN TO CONFIRM.

4. PRESS AND RELEASE THE "1/A" BUTTON. THE LIGHT SHOULD FLASH AMBER TO CONFIRM.

Once this is set up, the thing remembers its settings: you only need to do this setup ONCE

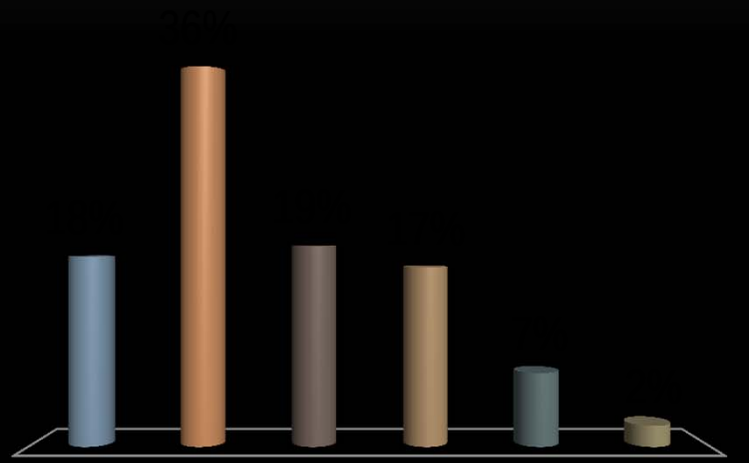
WHAT YEAR ARE YOU IN?

1. Freshman
2. Sophomore
3. Junior
4. Senior
5. Other



WHICH COLLEGE ARE YOU IN?

1. Science & Engineering
2. Liberal Arts
3. Business and Economics
4. Education & Human Service Professions
5. Fine Arts
6. Other



SPACESHIP EARTH

- Earth “rotates” about its axis (*once per day*)

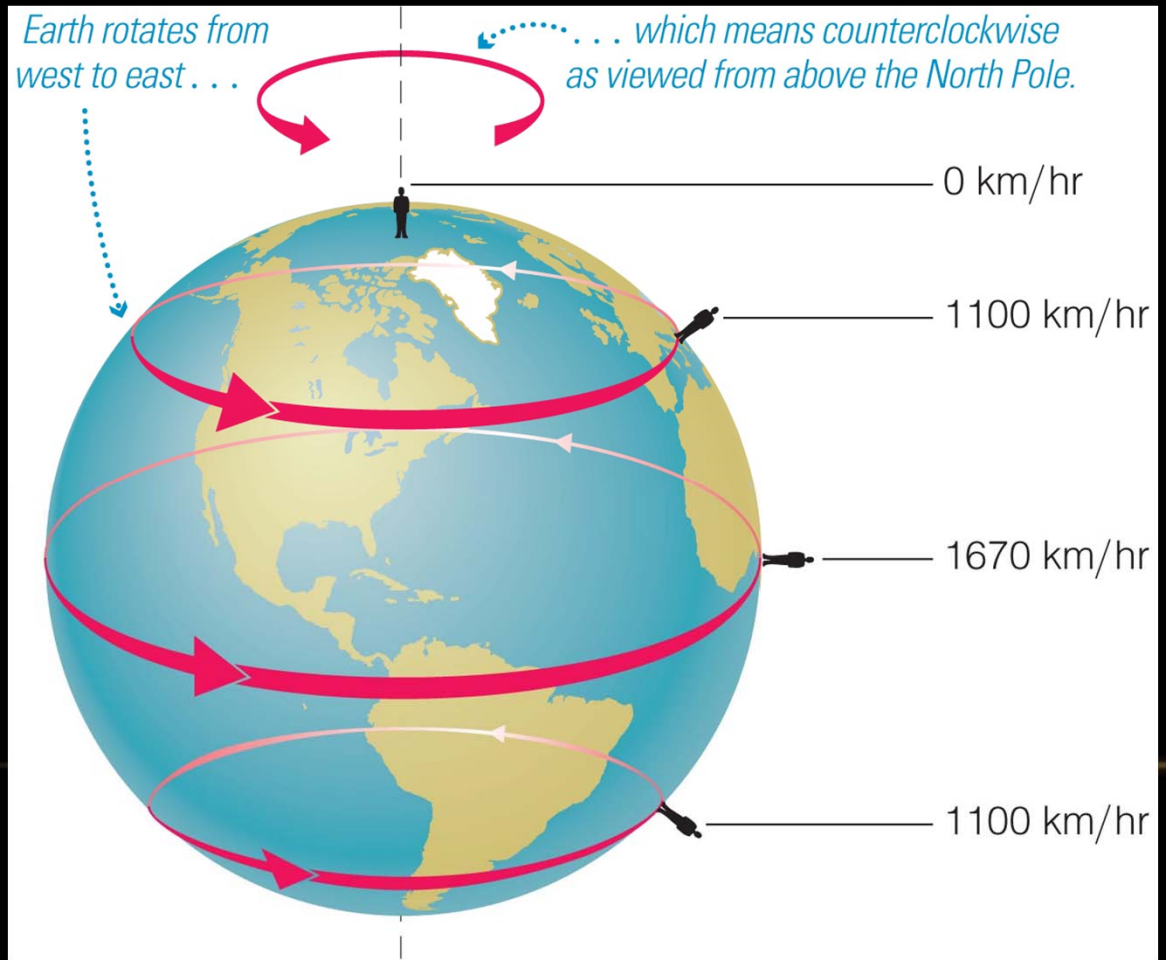


Fig.1.11

SPACESHIP EARTH

- While “revolving” about the sun (*once per year*)

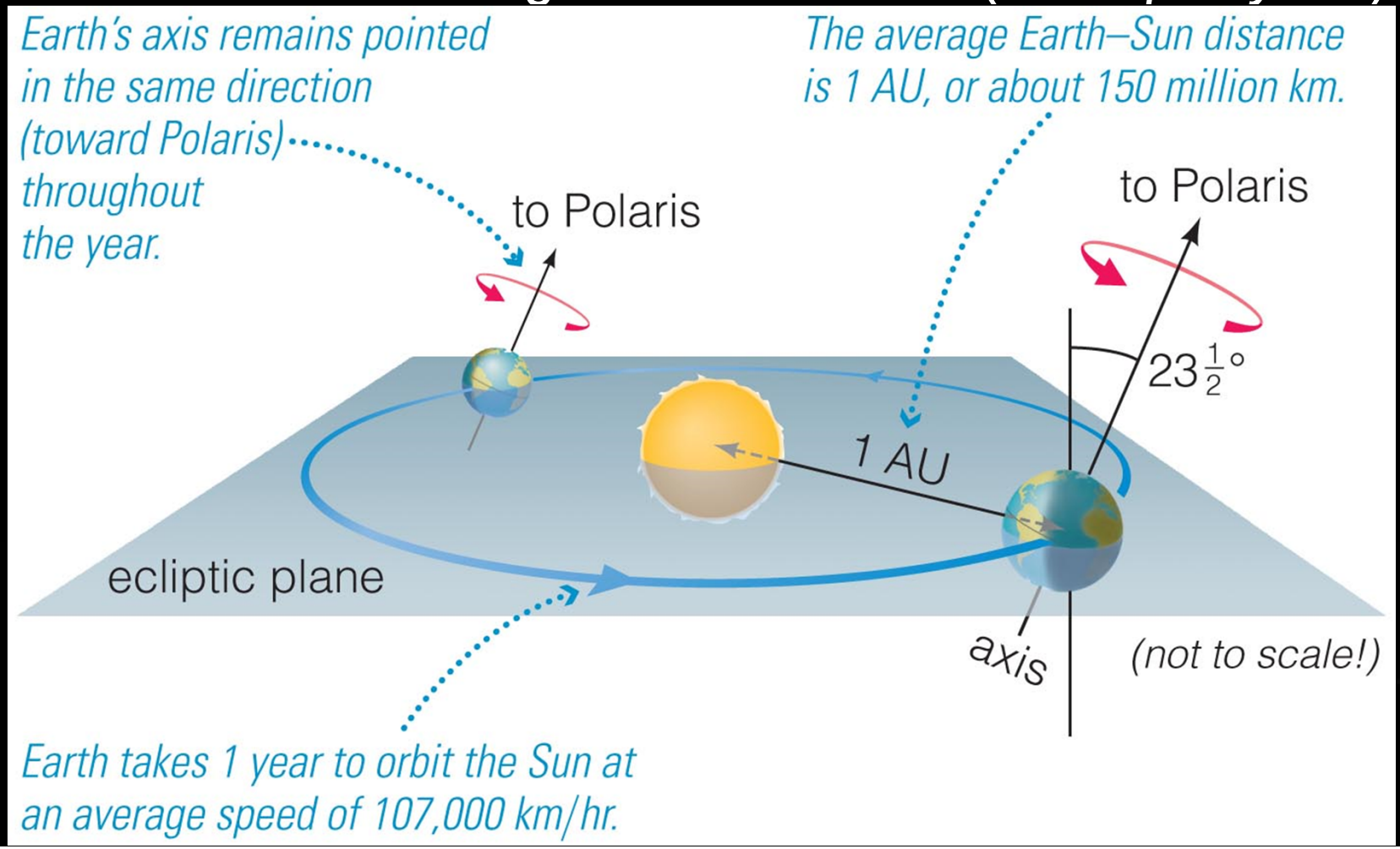


Fig.1.12

SPACESHIP EARTH

- … while the sun orbits the galaxy

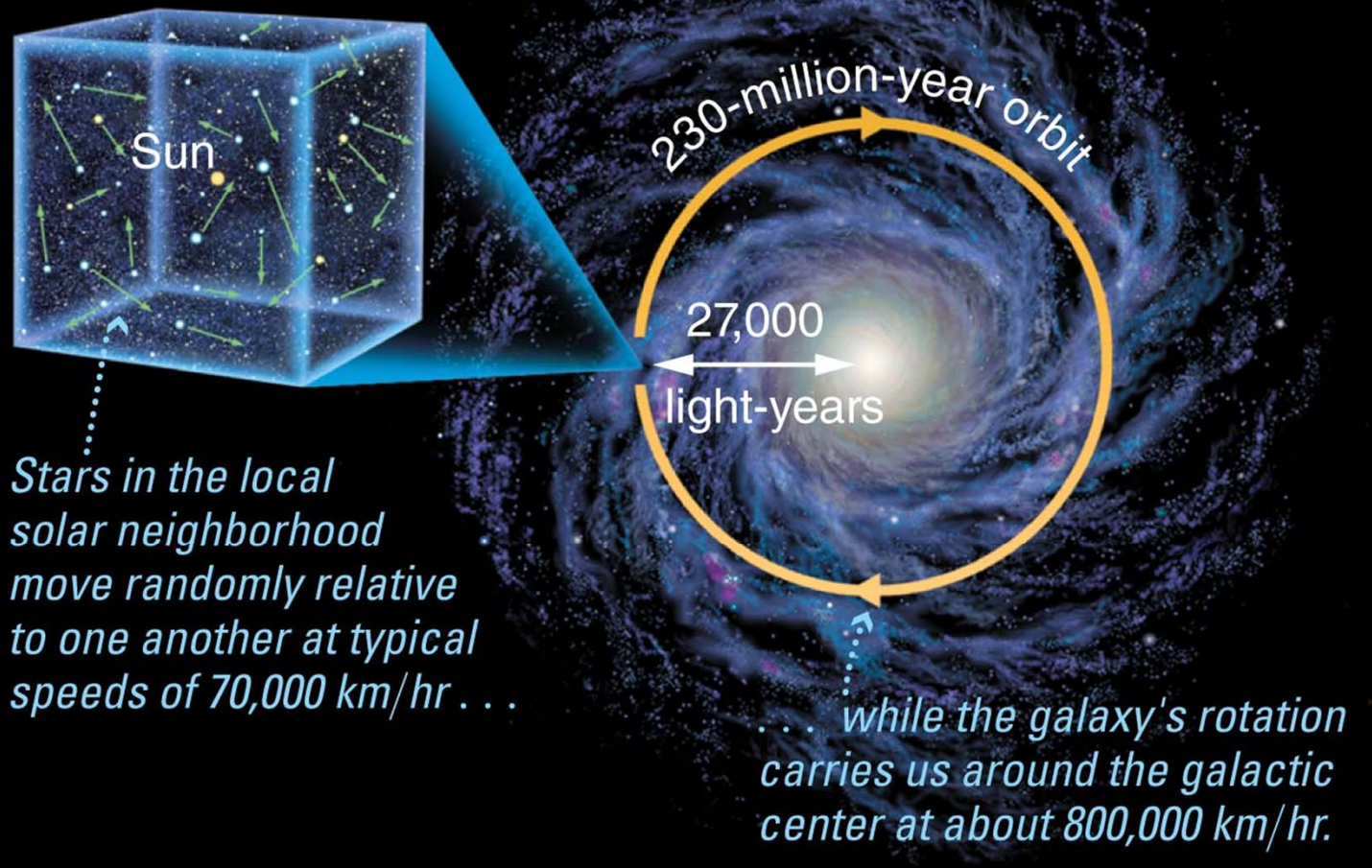


Fig.1.13

SPACESHIP EARTH

- … while the galaxy zooms towards Andromeda at about 300,000 km/hr

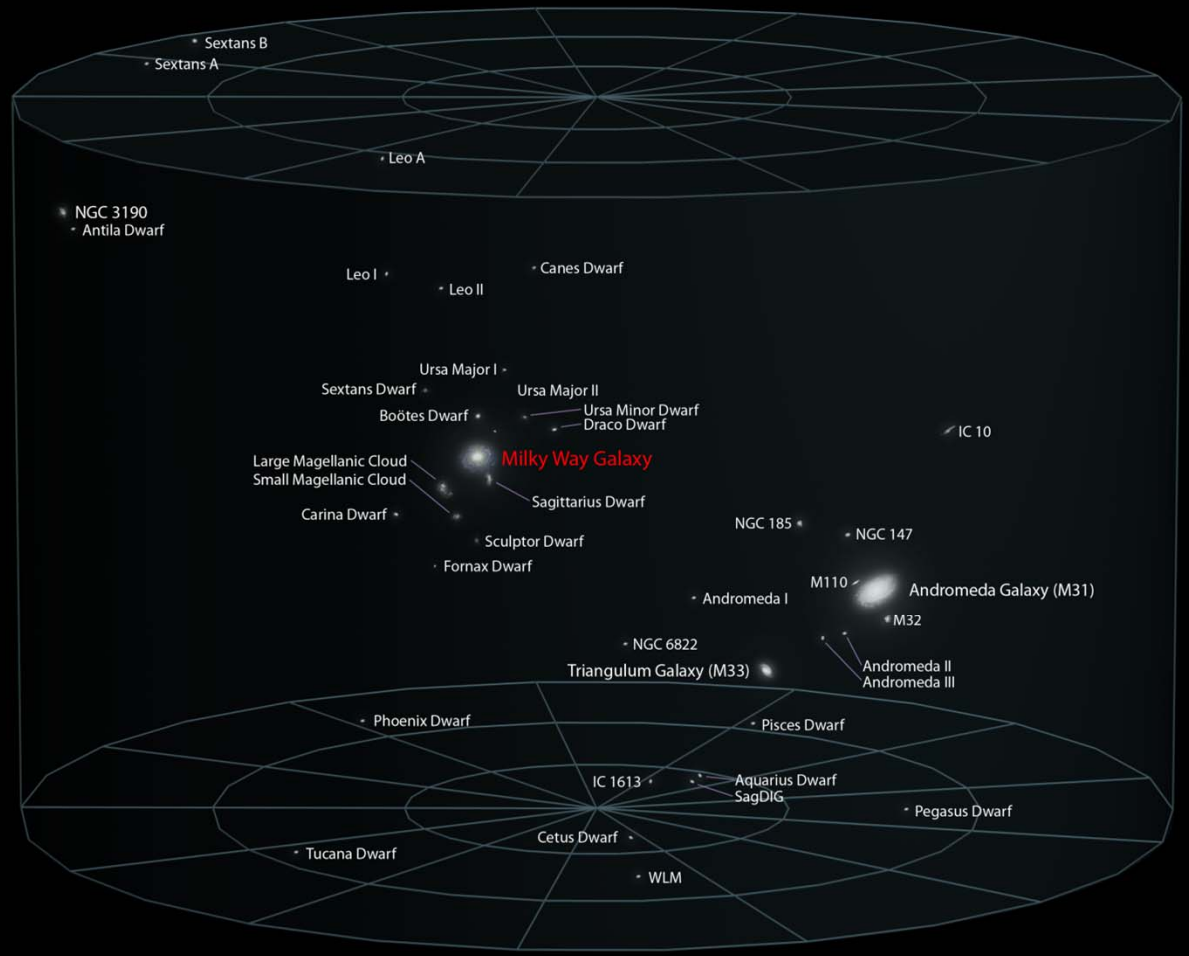


Image from Wikipedia's Local Group article

SPACESHIP EARTH

- … and galaxy groups all fly away from each other as the universe expands
- We see galaxies moving away faster the further away they are
- Much more about this in Ch.16

PLAY

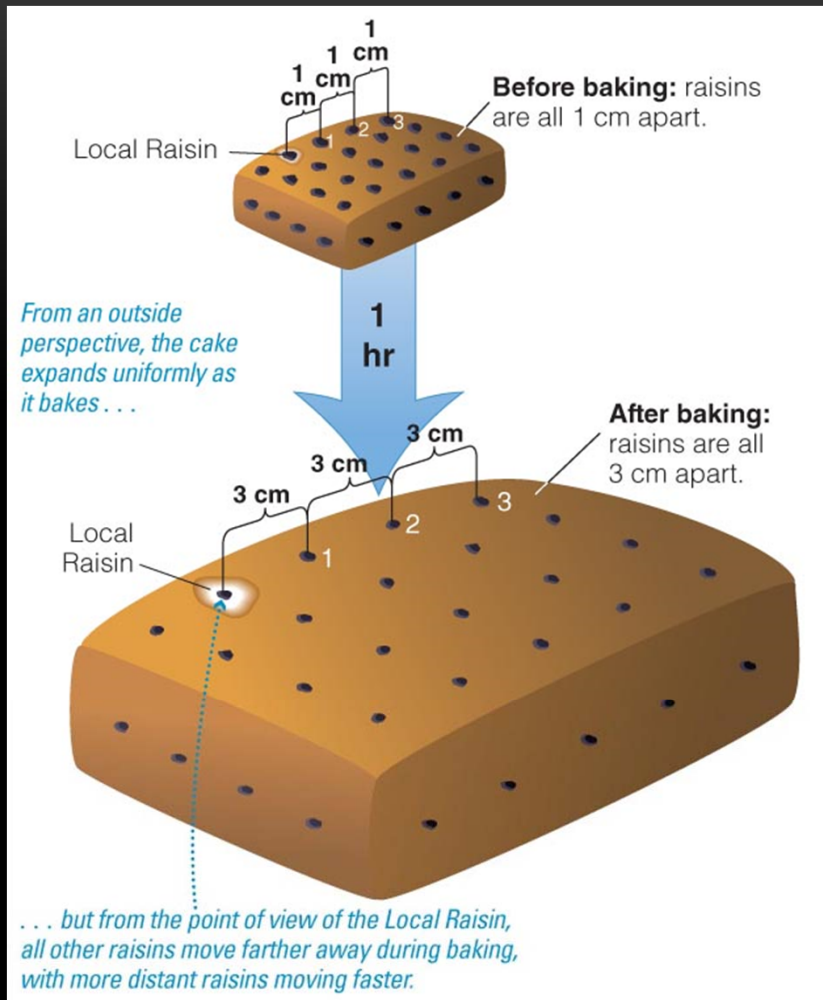


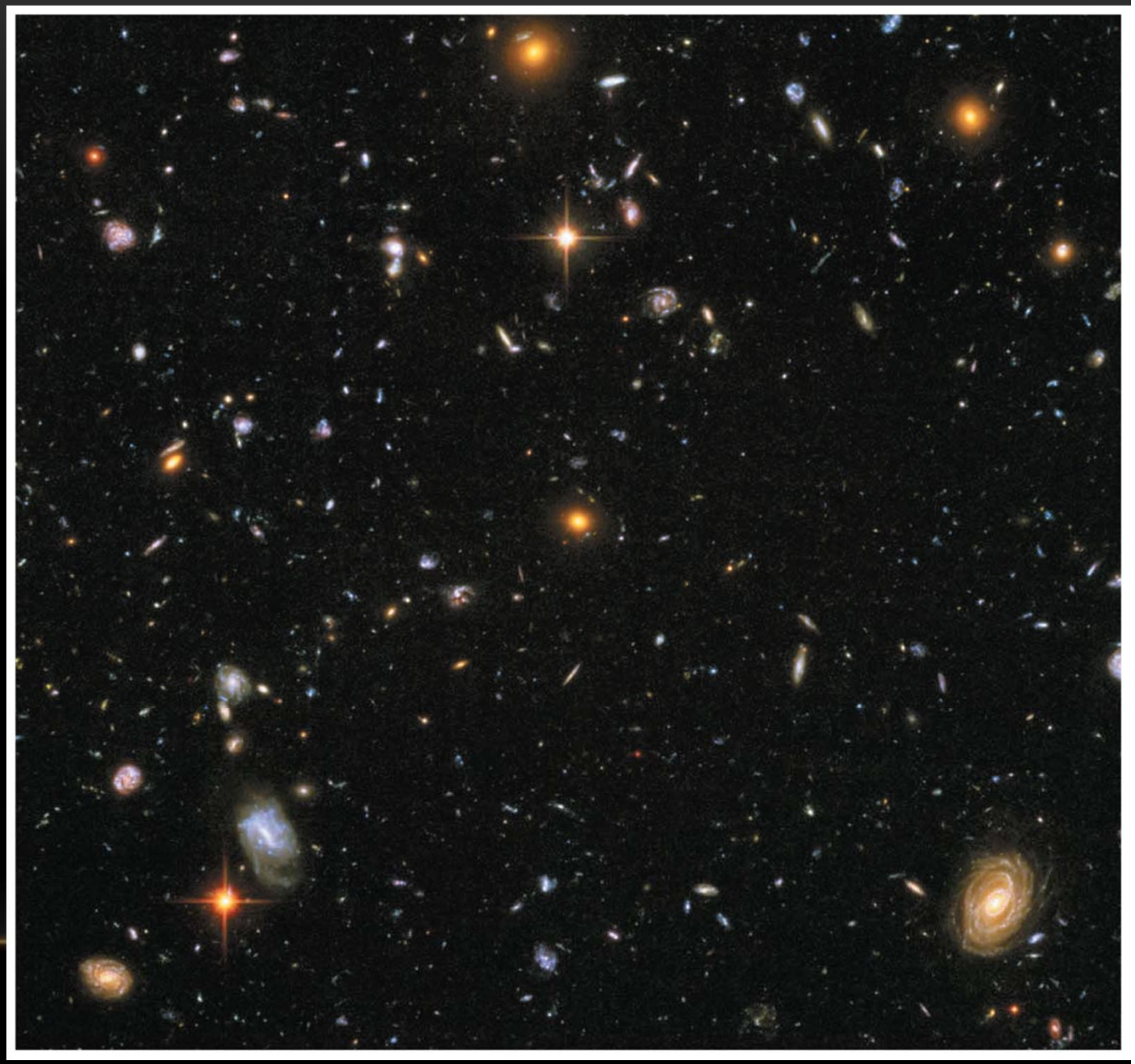
Fig.1.15

Distances and Speeds as Seen from the Local Raisin

Raisin Number	Distance Before Baking	Distance After Baking (1 hour later)	Speed
1	1 cm	3 cm	2 cm/hr
2	2 cm	6 cm	4 cm/hr
3	3 cm	9 cm	6 cm/hr
⋮	⋮	⋮	⋮

LOTS OF GALAXIES

… and all headed away from us, faster if further



First picture in this chapter: from Hubble Deep Field

WHAT HAPPENS TO THE RAISINS IN THE BAKING UNIVERSE ANALOGY?

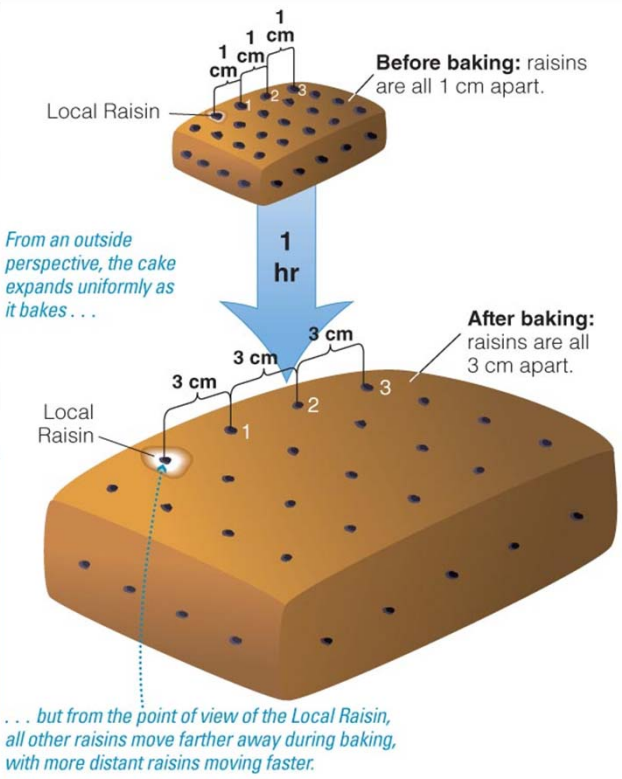
A. They move apart and get bigger.

✓ B. They move apart and stay the same size.

C. They do not move, but they get bigger.

D. They get closer together and get smaller.

E. They get closer together and get bigger.



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3	3 cm	9 cm	6 cm/hr
⋮	⋮	⋮	⋮

FROM THE PERSPECTIVE OF RAISIN 2, WHICH RAISINS ARE MOVING AWAY?

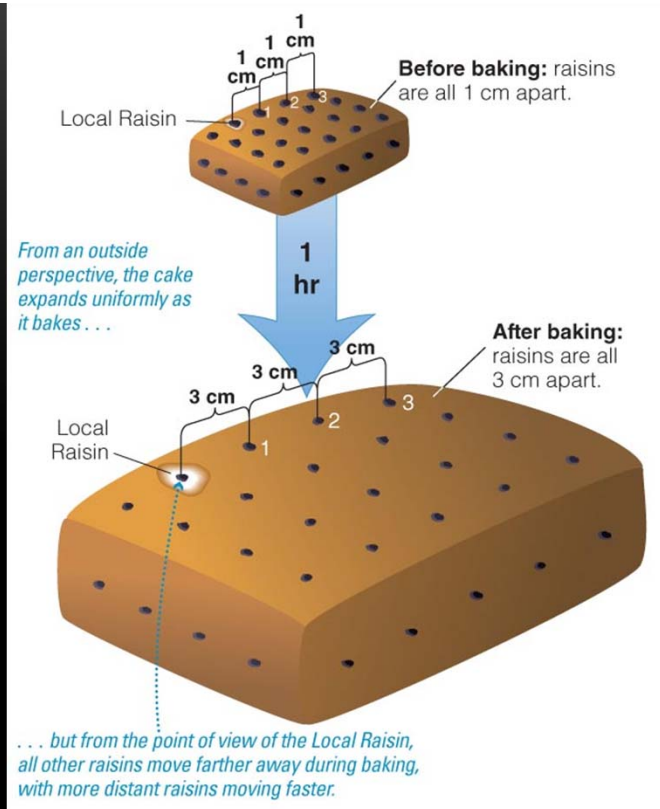
A. Raisin 1 and Raisin 3

B. Raisin 1 and the local raisin

C. Raisin 3 and the local raisin

D. Raisin 1, Raisin 2 and Raisin 3

✓ E. Raisin 1, the local raisin, and Raisin 3



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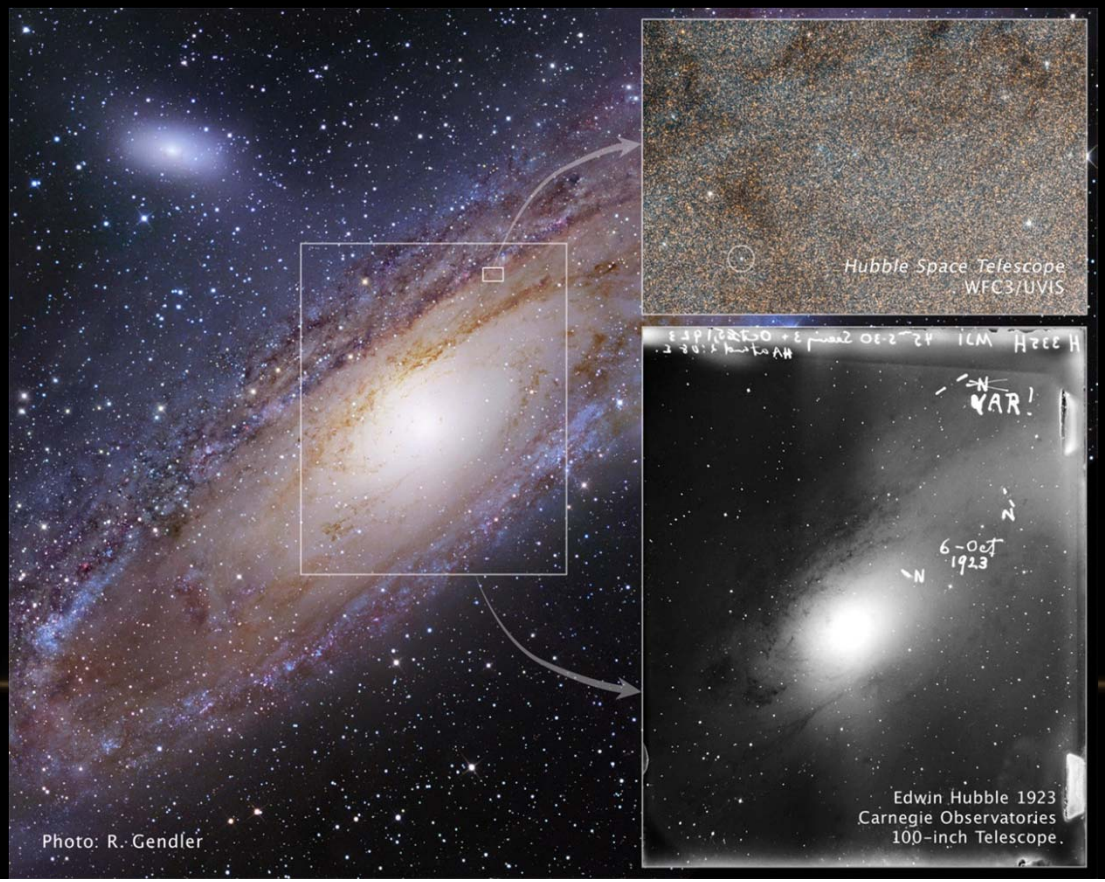
⋮	⋮	⋮	⋮

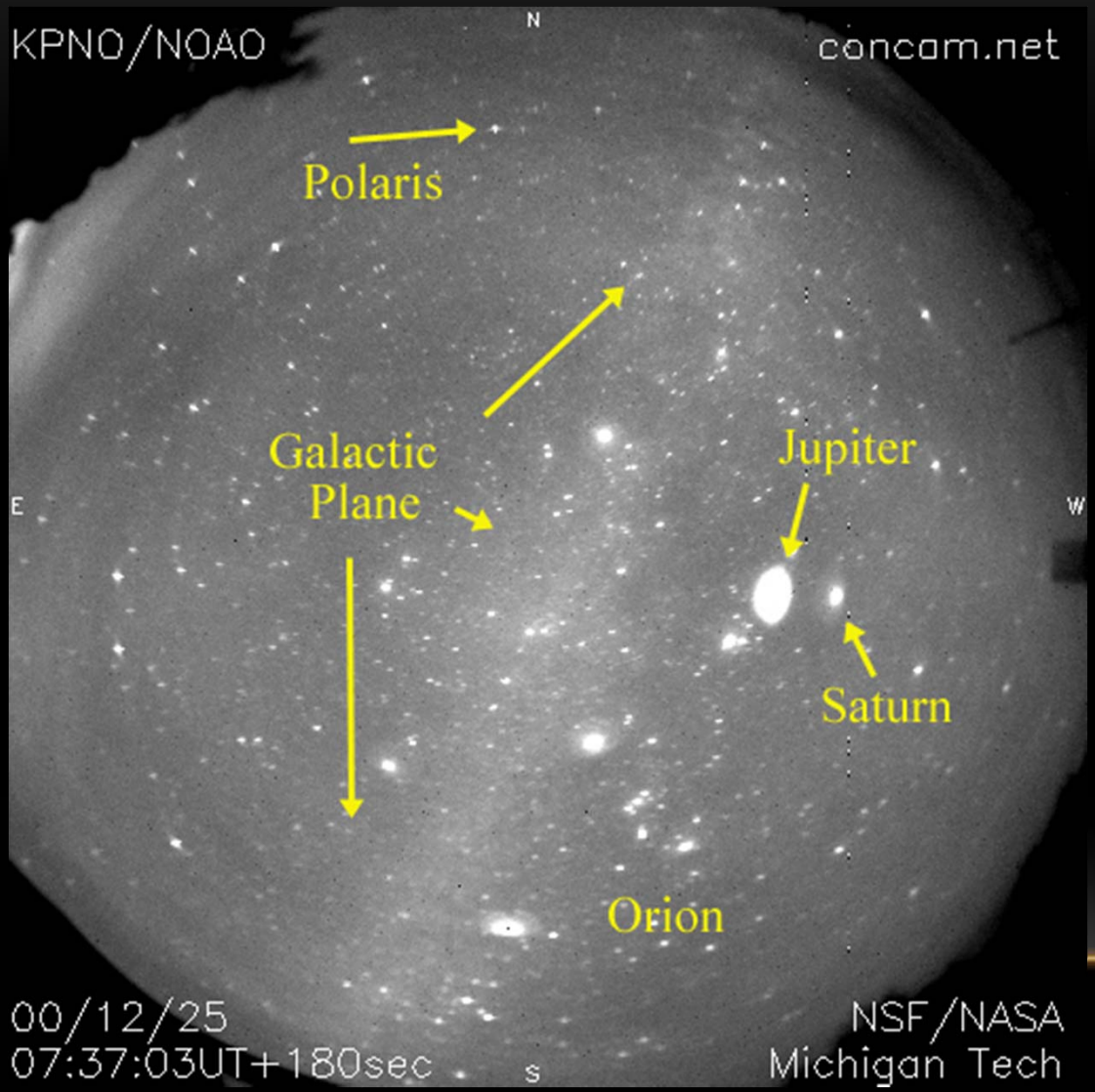
Raisin 3 local raisin

EXPANDING UNIVERSE

- Much more about how this works and was figured out later in the semester



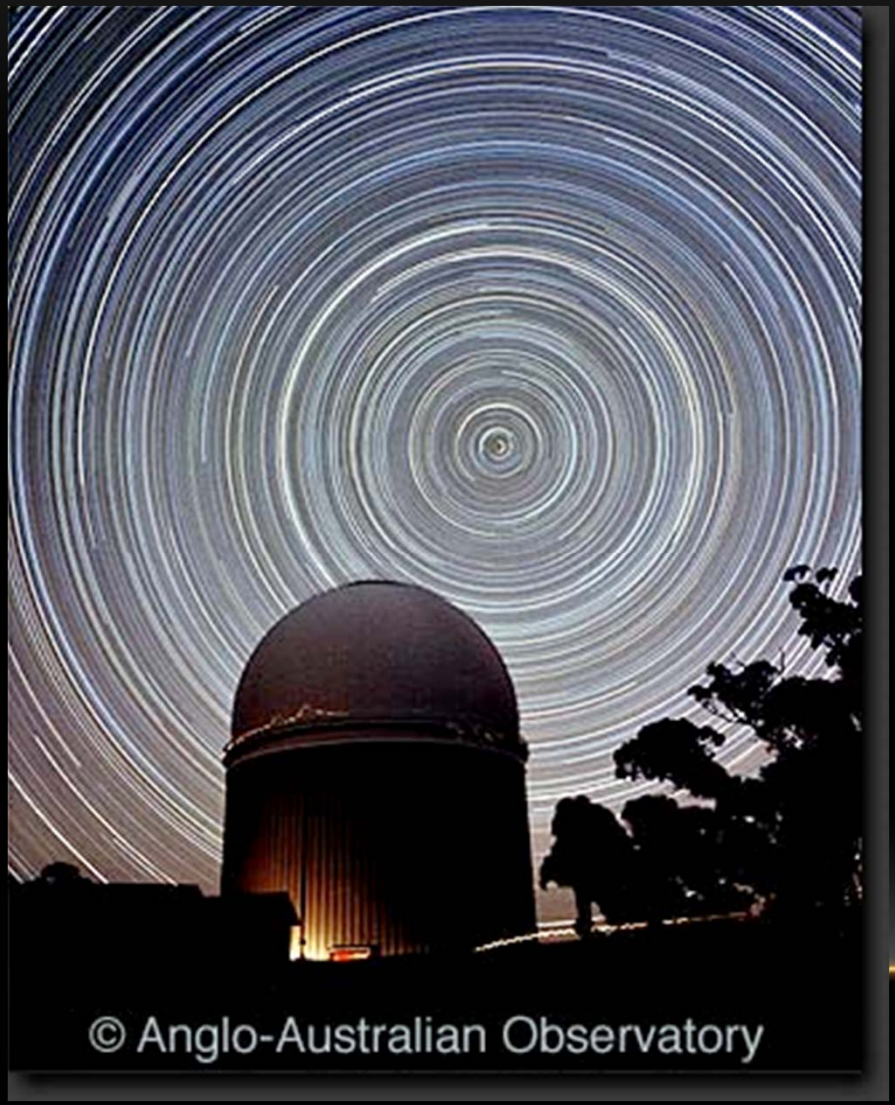
VIEW FROM EARTH



- A composite of the night sky for a whole night
- Like looking up into a bowl painted with stars
  - "Celestial Sphere", more later on this

CONCAM project, KPNO, 12/25/00

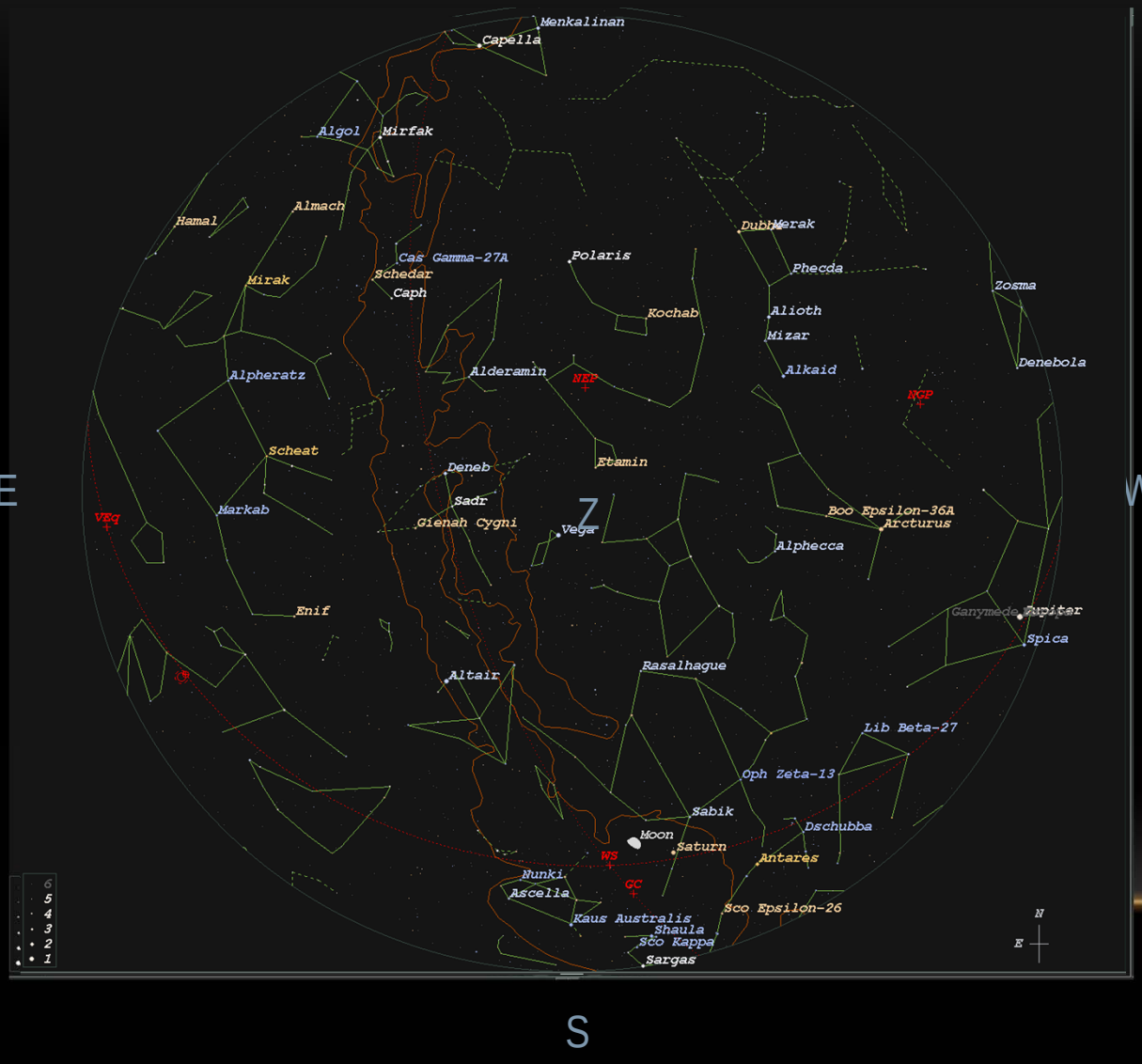
OVER A WHOLE NIGHT…



- We see the stars spin around the pole
  - This is the south celestial pole, seen from Australia
  - We see the same thing around the North Celestial Pole (near the star “Polaris”)

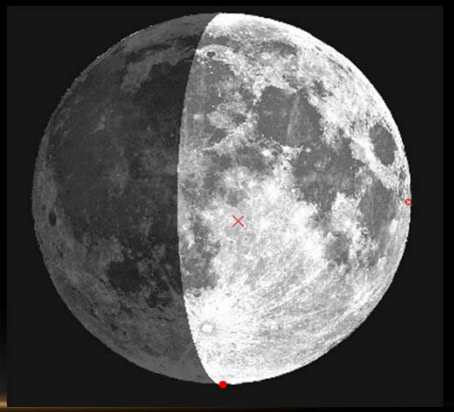
Photo by David Malin, AAO

TONIGHT



- 20:00 Aug 30
- Whole Sky

Moon tonight looks like:



Only 61% illuminated,

Full Moon is a week away

WHAT DO YOU SEE?

- Early evenings are pretty nice this time of year.
  - Go look at what's being talked about in class!
  - Grab a pair of binoculars, you will be pleasantly surprised (but don't expect colorful close-ups like in the book)
  - Look at Moon!!
- Note the light pollution
  - What can be done?

WHAT DO YOU SEE?

- Standing outside looking up, sky looks like a hemisphere
  - Zenith straight up, Meridian is line from N-S

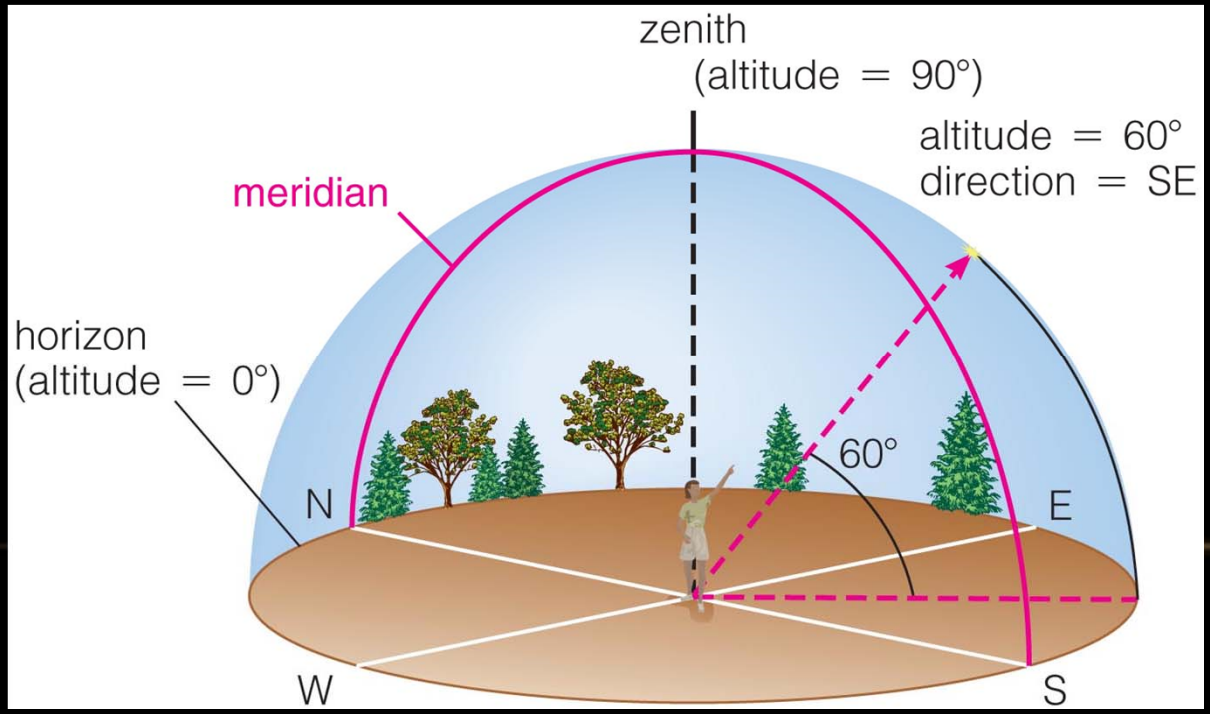


Fig.2.6

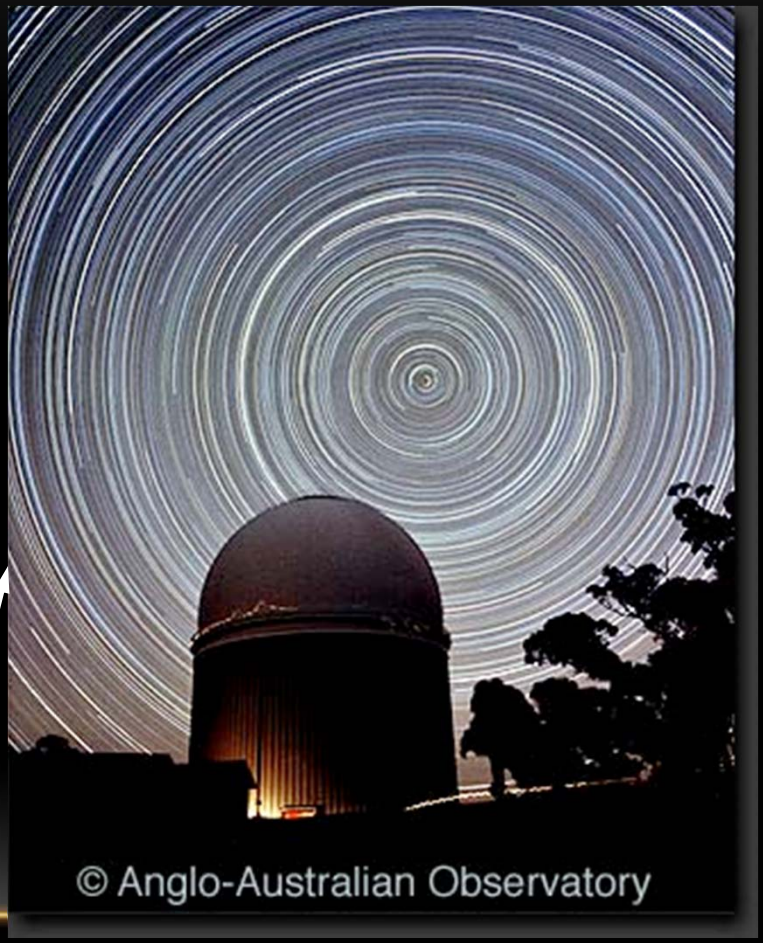
THE CELESTIAL SPHERE

- is the Sky – as if it were a glass ball and we were at the center
- Stars appear fixed on this sphere
- It rotates as if it were on a rod run through the Celestial Poles (North & South)
- Stars are fixed points of light on this sphere. Patterns form Constellations
  - These also divide the sky up into areas

THE CELESTIAL SPHERE

- Silly? But that's what it looks like.
  - Sit around outside for a few hours and see
  - Or, try this java applet:
  - http://physics.weber.edu/schroeder/sky/skymotionapplet.html

PLAY



Circumpolar stars never rise or set