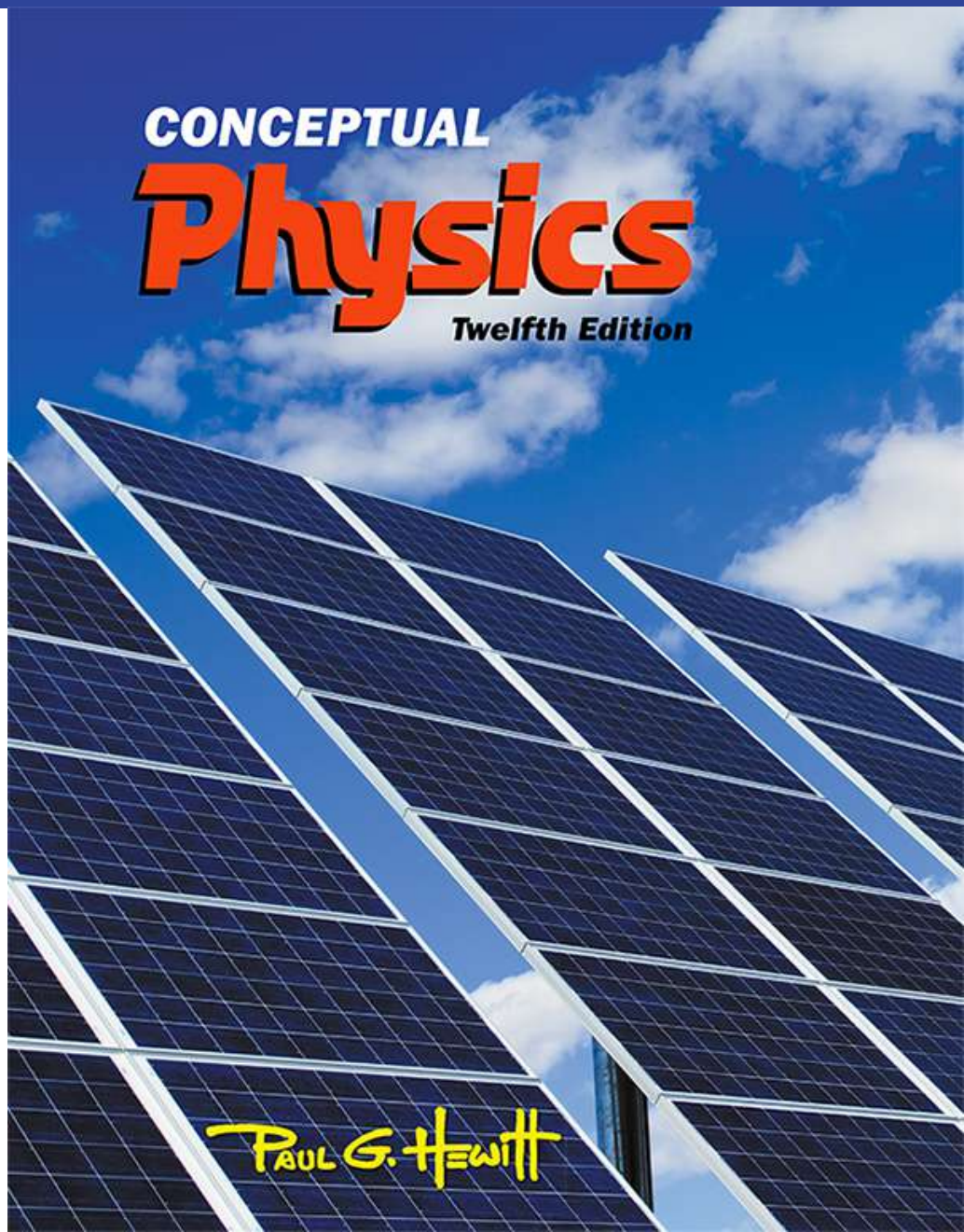
Lecture Outline

Chapter 24: Magnetism

24.8 *Earth's Magnetic Field*

24.9 *Biomagnetism*

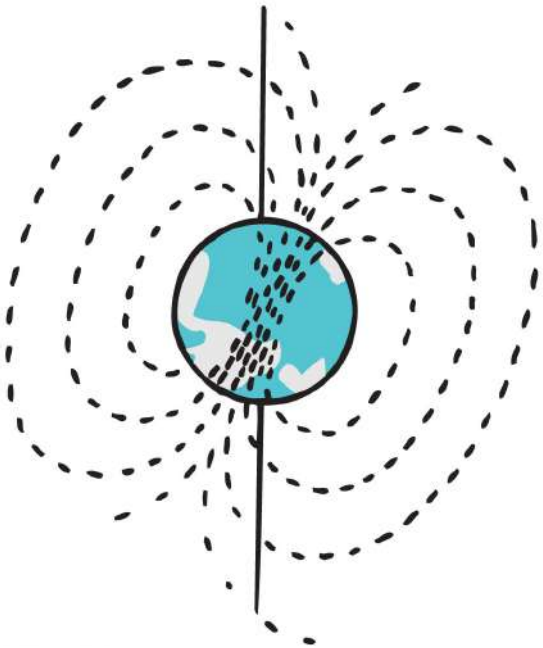


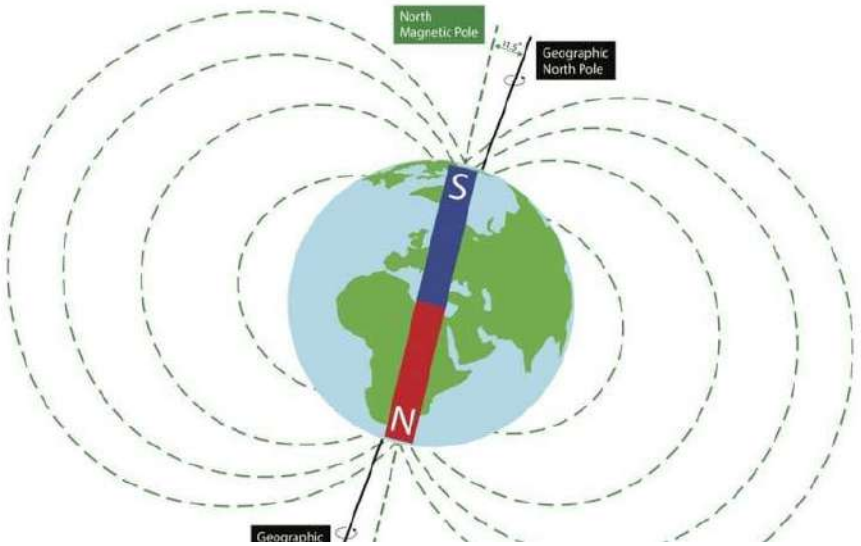
Test Tomorrow:
Chapter 24 only.
No equations needed.

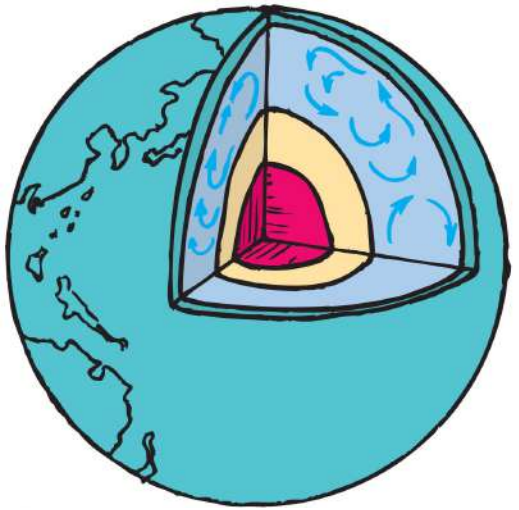
First, some demonstrations…

24.8 Earth's Magnetic Field

- Earth is itself a huge magnet.
- The magnetic poles of Earth are widely separated from the geographic poles.
- And, it's actually a magnetic south S pole close to the geographic N pole.



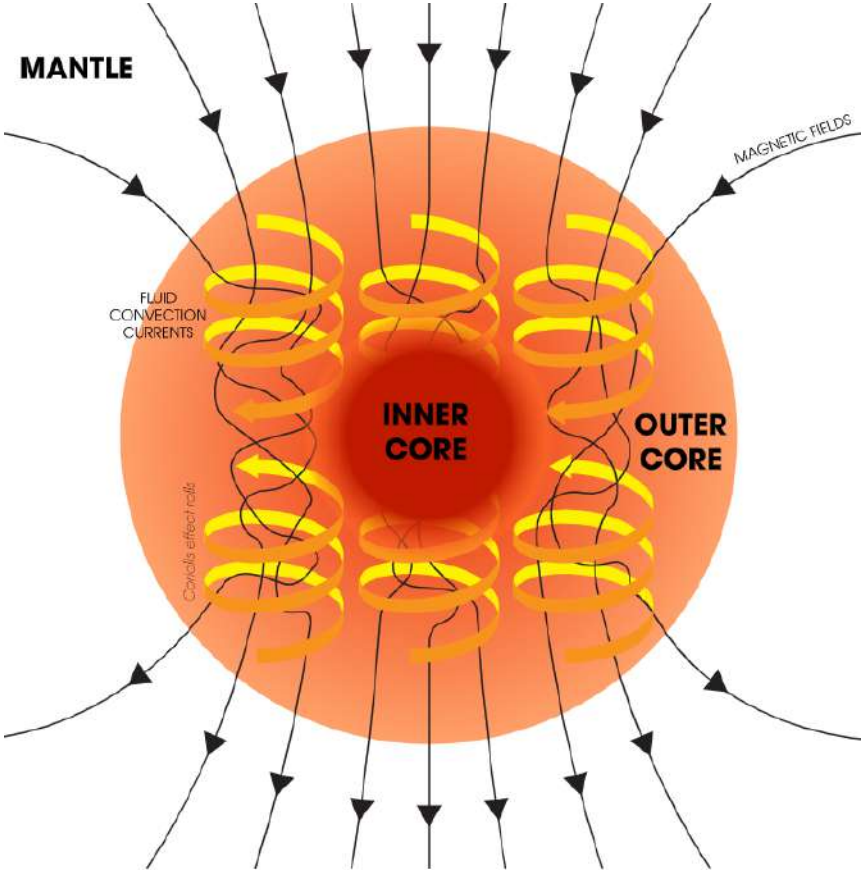




- The magnetic field of Earth is *not* due to a giant magnet in its interior—it is due to electric currents.

→ It is **too hot** for a permanent magnet.

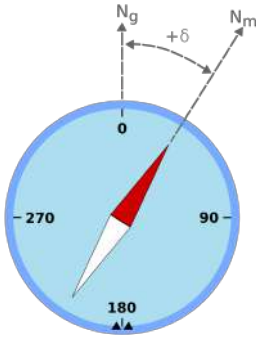
- Most Earth scientists think that moving charges looping around within the molten part of Earth create the magnetic field.

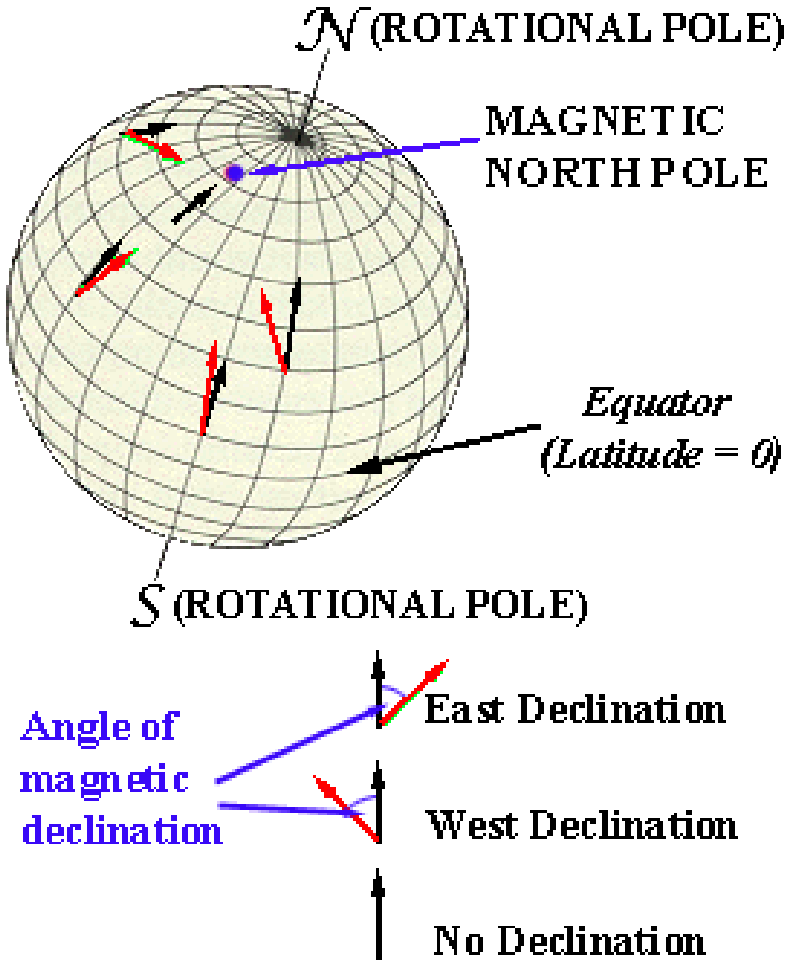


Magnetic Declination

Magnetic *declination* δ is the difference between where a compass points and true north.

In Minnesota, the declination angle is about 5°east.



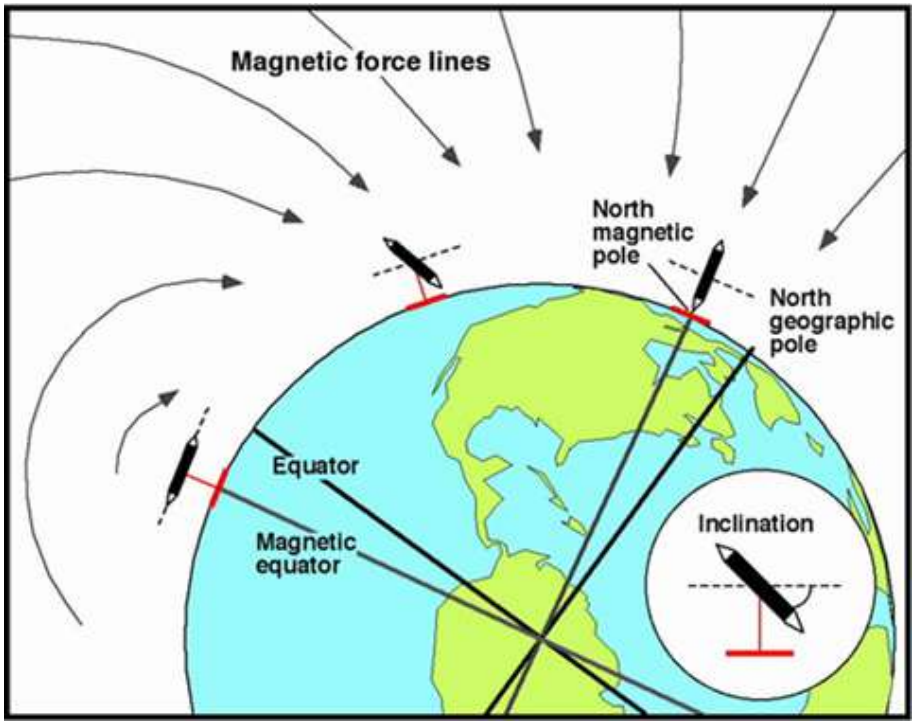


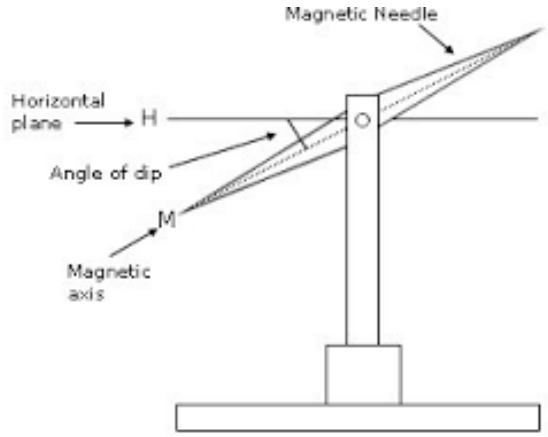
Magnetic dip

The magnetic field only points parallel to the surface at the magnetic equator.

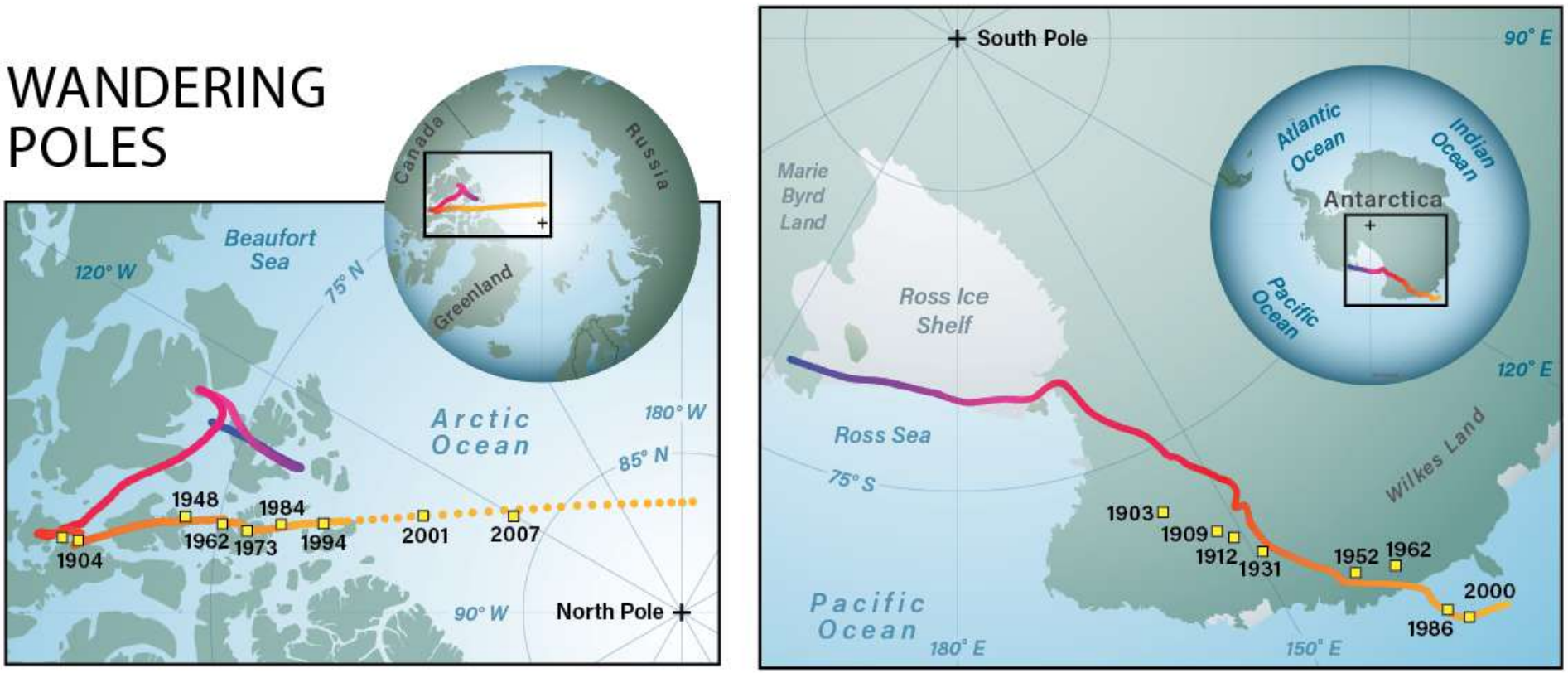
The *dip* angle is the angle that the field dips (or points) downward.

A special compass is needed to measure the dip angle →

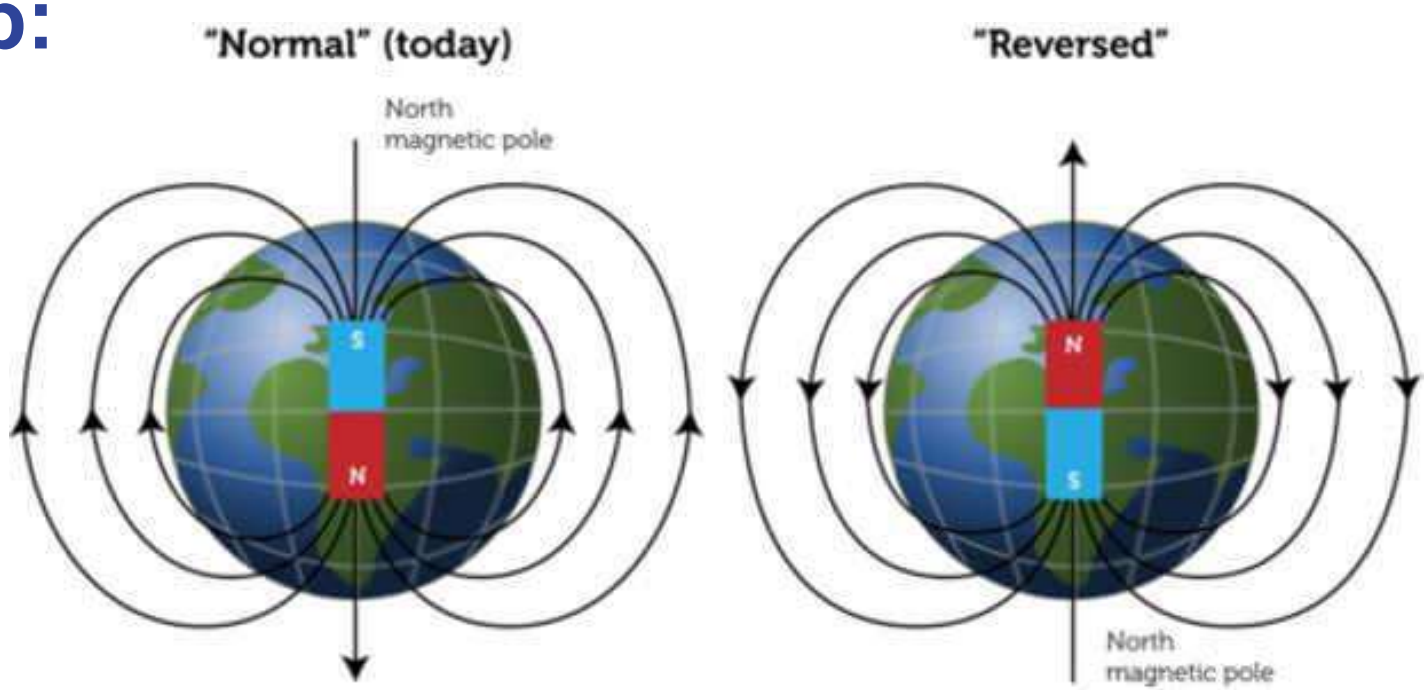




Earth's magnetic poles wander…



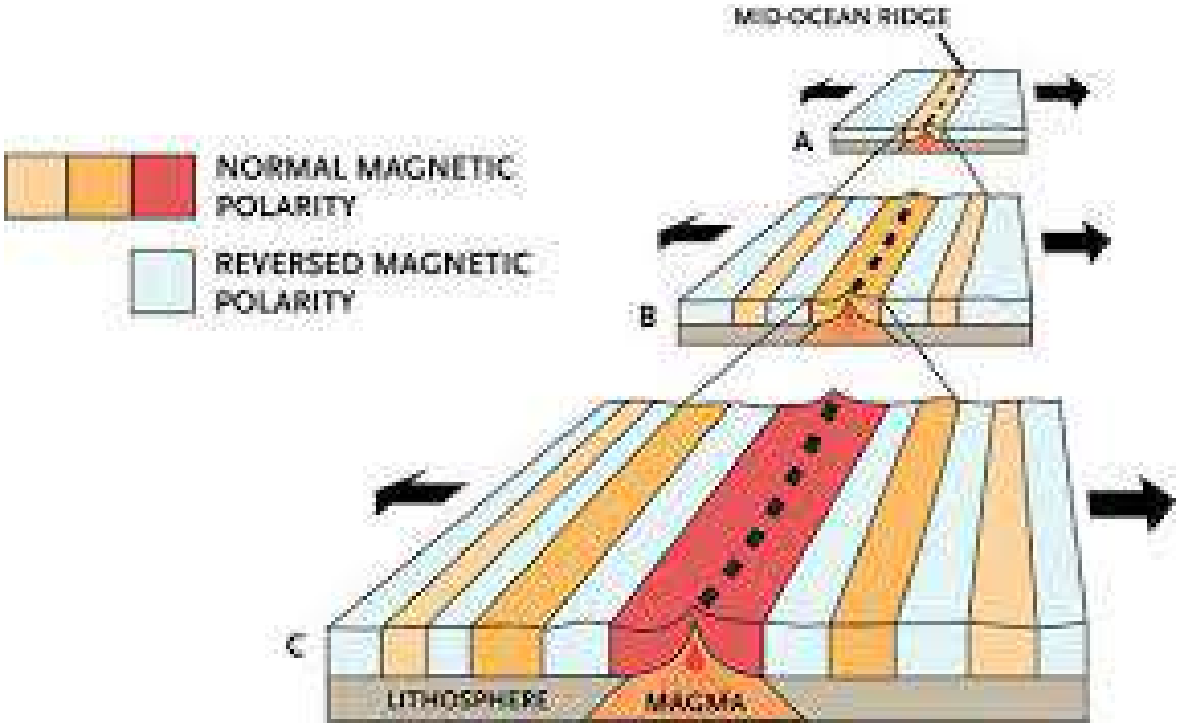
…and flip:



Earth's magnetic field reverses direction:
→20 reversals in last 5 million years.
→ Recent weakening of the field strength may lead to a reversal soon!

Sea floor spreading:

- Evidence for magnetic reversals are recorded in the iron-containing rocks that emerge as lava on the ocean floor, then cool:



long ago

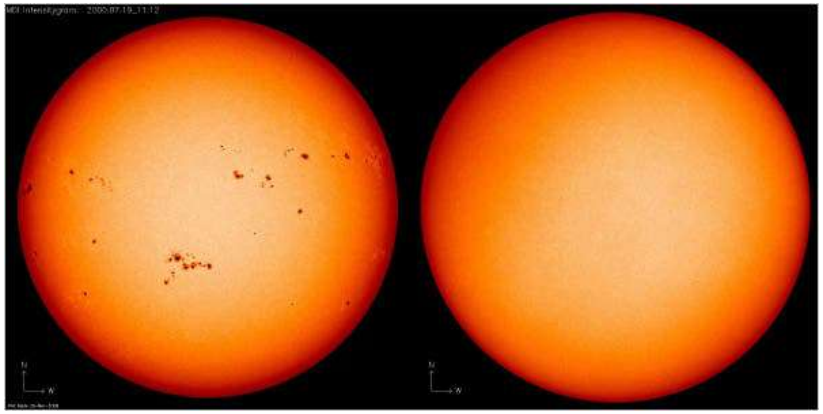
not as long ago

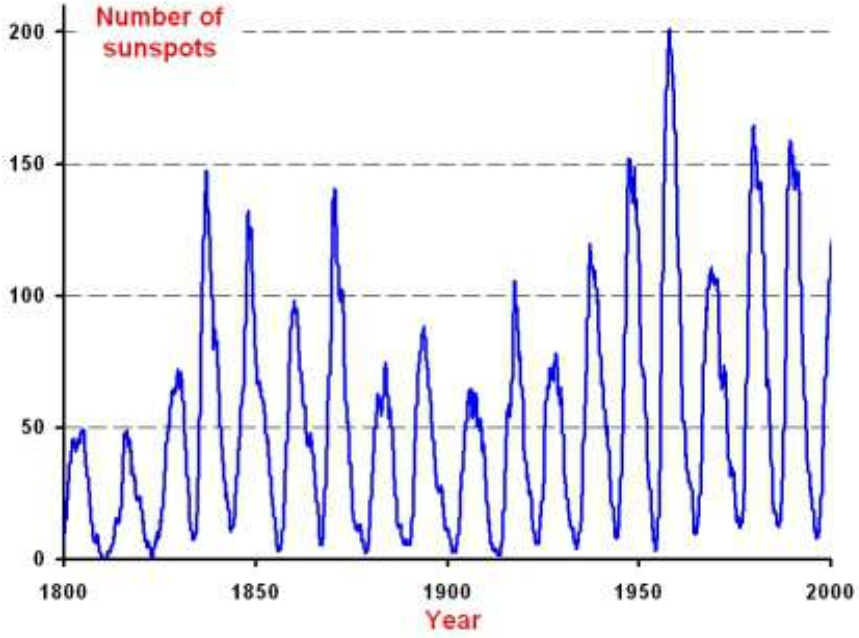
now…

The Sun's magnetic field also reverses:

sunspot maximum

sunspot minimum



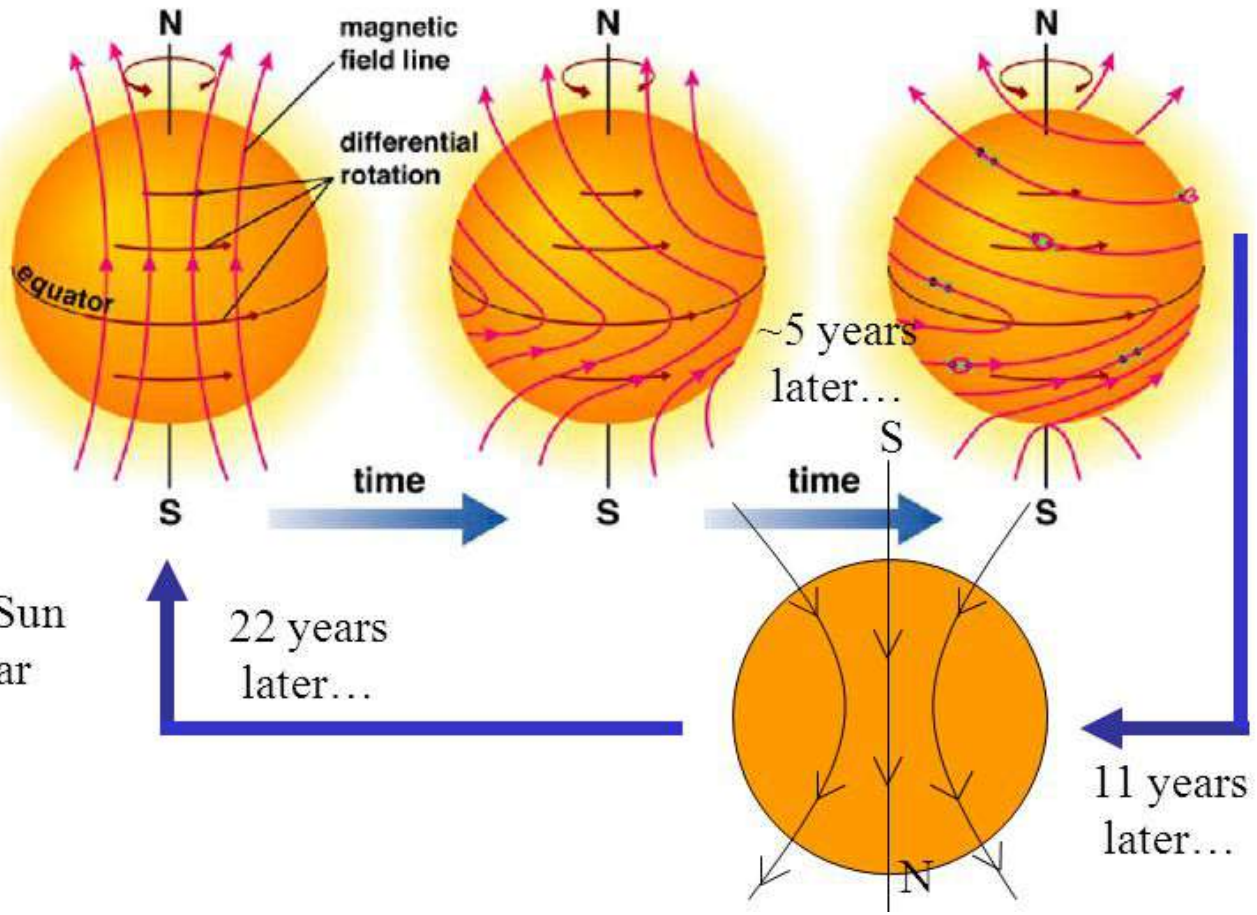


Sunspots are cooler areas are caused by magnetism.
It takes 11 years to go from sunspot maximum to maximum.
And then the sun's poles reverse, and the cycle repeats.
The total cycle takes 2 x 11 years = 22 years.

Magnetic Field Configuration of the Sun During Different Phase of the Solar Cycle

Solar Minimum
- Dipole Magnetic Field
- No Sunspot

Solar Maximum
- ***Toroidal*** Magnetic Field
- Many Sunspots

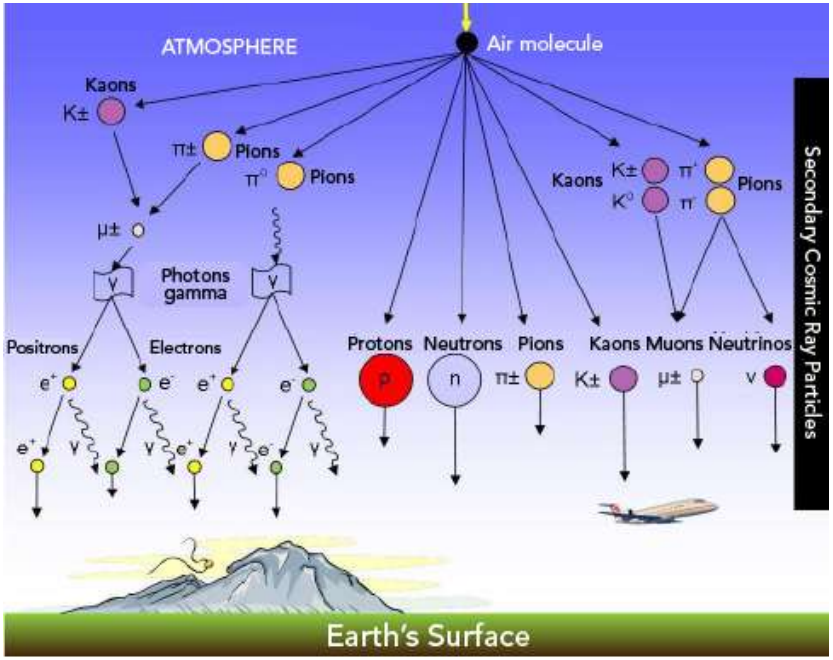


But, this is only half of the story!

The magnetic field configuration of the Sun evolves with a 22 year cycle.

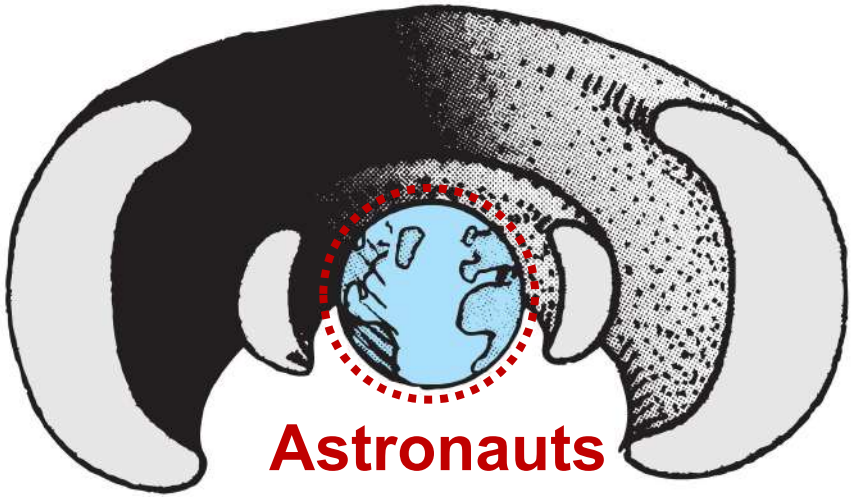
Earth's Magnetic Field Protects Us:

- Universe is a shooting gallery of charged particles called **cosmic rays.**
- They come from the Big Bang, exploding stars and the sun.
- Cosmic radiation is hazardous to electronic equipment and to astronauts.
- Most are absorbed by Earth's atmosphere.



Earth's Magnetic Field, Continued

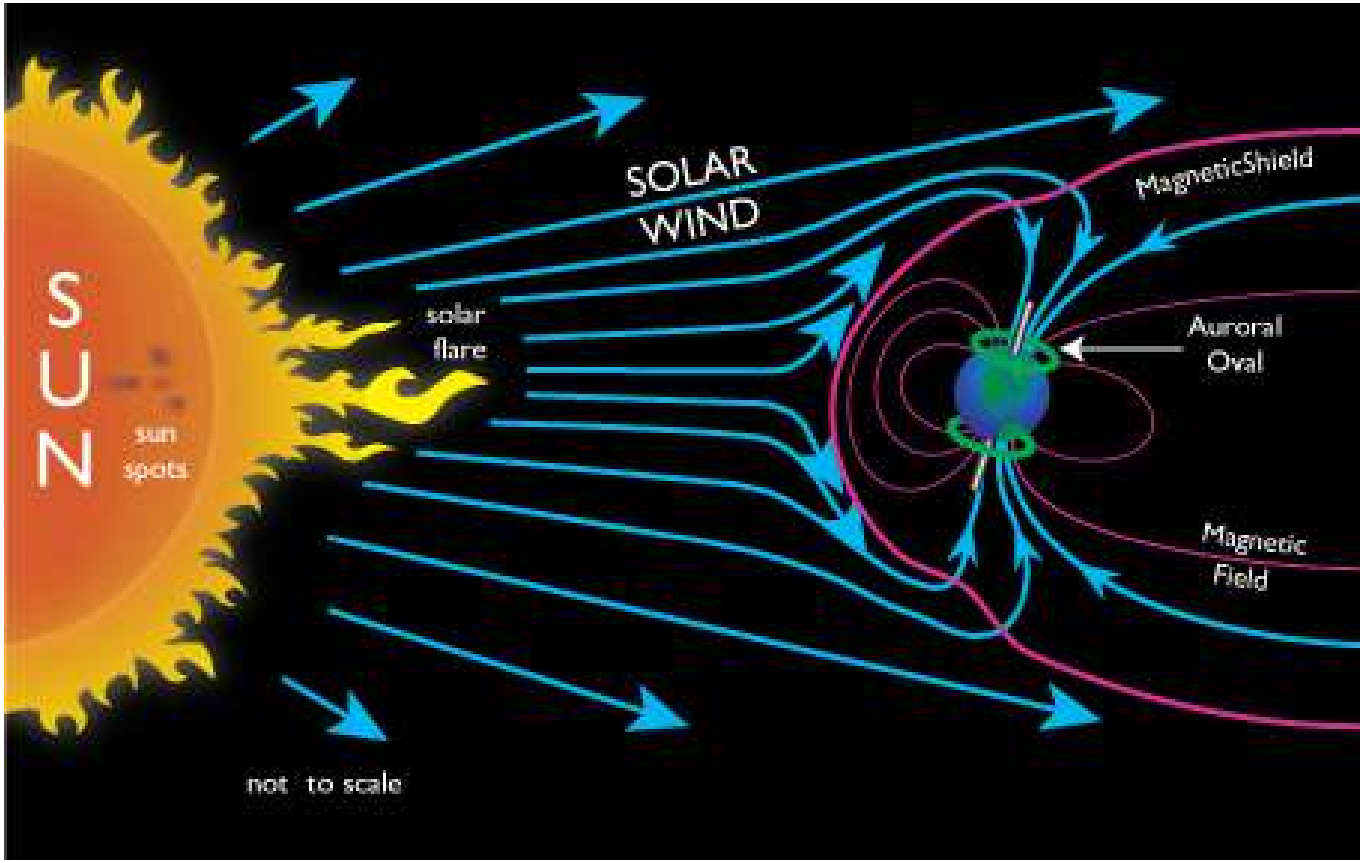
- Cosmic rays are deflected away from Earth by Earth's magnetic field.
- Some of them are trapped in the outer reaches of Earth's magnetic field and make up the Van Allen radiation belts



Astronauts orbit well within these belts

Earth's Magnetic Field funnels them…

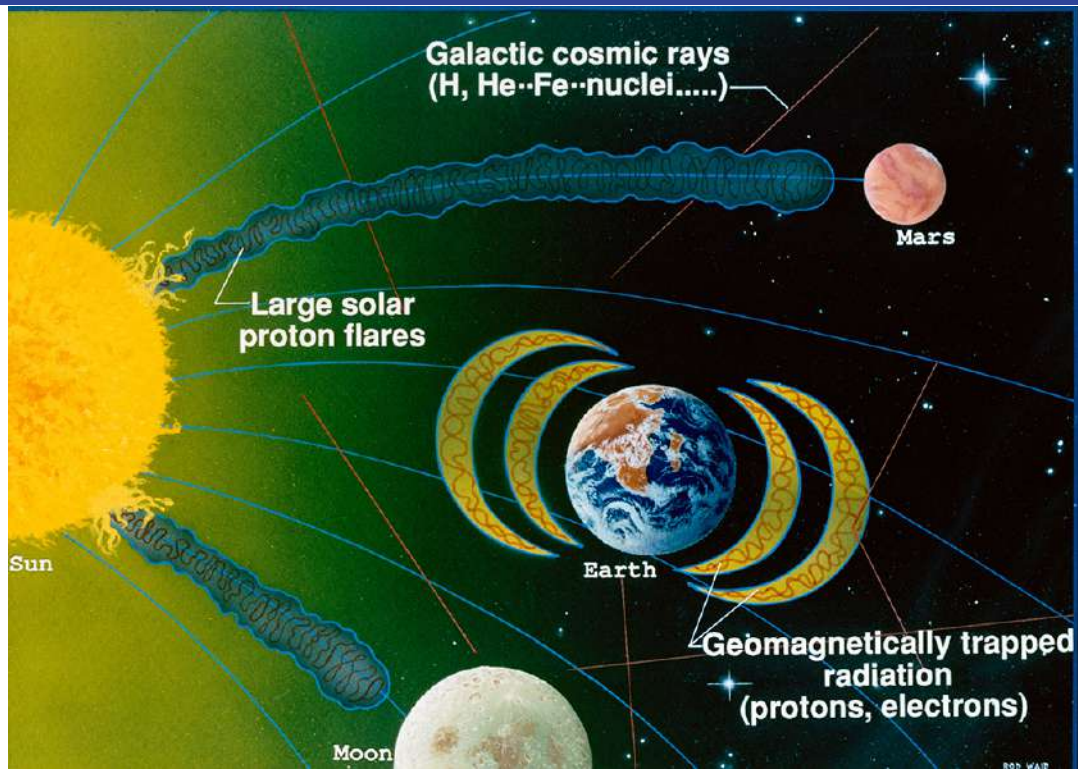
- The trapped particles follow corkscrew paths around the magnetic field lines of Earth. They are deflected from lower latitudes up into the polar areas:



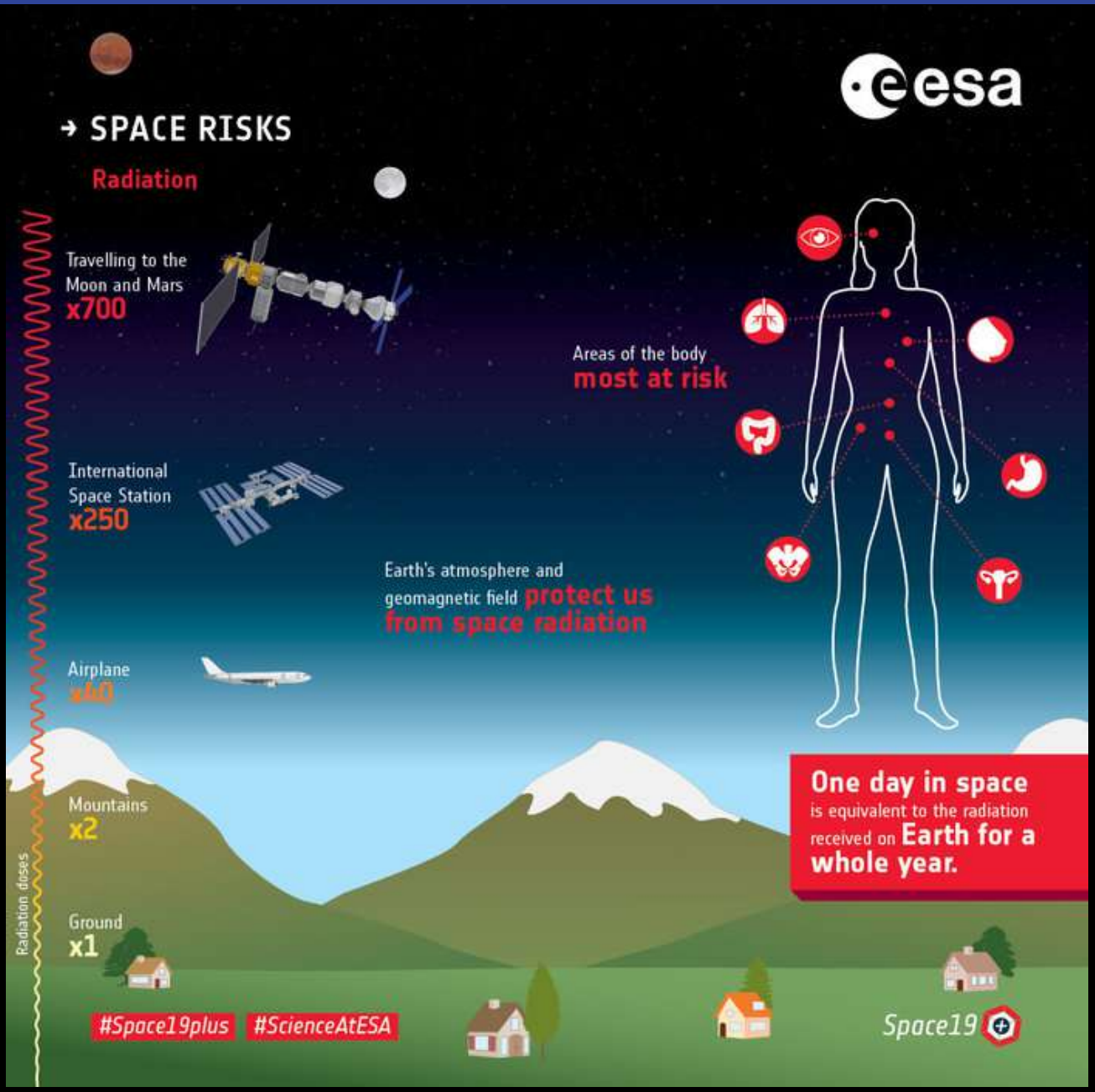
Earth's Magnetic Field

- Disturbances in Earth's field often allow the ions to dip into the atmosphere, where they collide with nitrogen and oxygen gas.
- This causes it to glow like a fluorescent lamp around the poles.
- *aurora borealis = northern lights*
  aurora australis = southern lights

- In space you have little protection
- → US astronauts saw flashes of light
- → A trip to Mars could be deadly during a solar storm



- Even with the atmosphere and magnetic field to protect you, in Minnesota about 5 particles hit each square cm (tip of your pinky) every minute.
- → This increases as you near the poles.


esa
→ SPACE RISKS
Radiation
Travelling to the Moon and Mars
x700
International Space Station
x250
Airplane
x40
Mountains
x2
Ground
x1
Radiation doses
Areas of the body most at risk
Earth's atmosphere and geomagnetic field protect us from space radiation
One day in space is equivalent to the radiation received on Earth for a whole year.
#Space19plus
#ScienceAtESA
Space19

Classwork: page 466

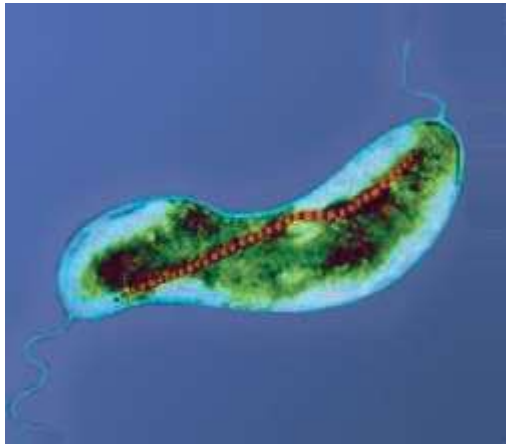
26. Why are there probably no permanently aligned magnetic domains in Earth's core?

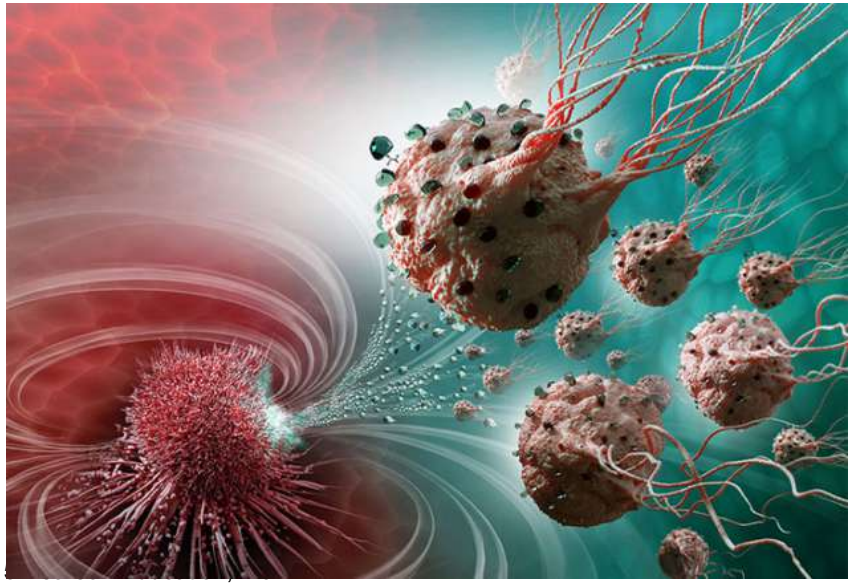
27. What are magnetic pole reversals?

28. What is the cause of the aurora borealis (northern lights)?

Biomagnetism

- Certain bacteria biologically produce single-domain grains of magnetite (a compound equivalent to iron ore) that they string together to form internal compasses.
  - They then use these compasses to detect the dip of Earth's magnetic field.
  - Equipped with a sense of direction, the organisms are able to locate food supplies.

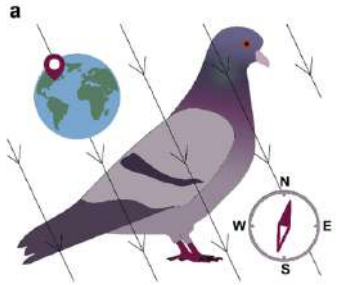


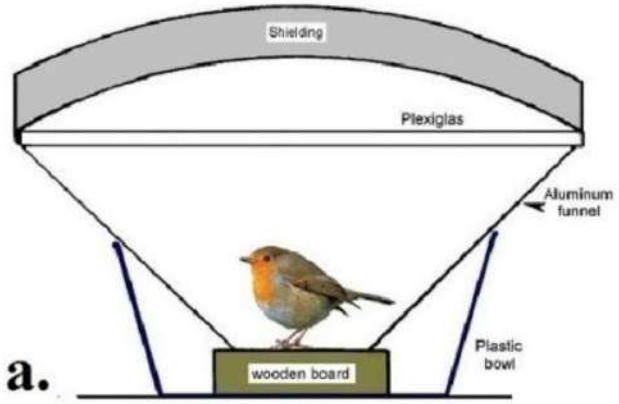


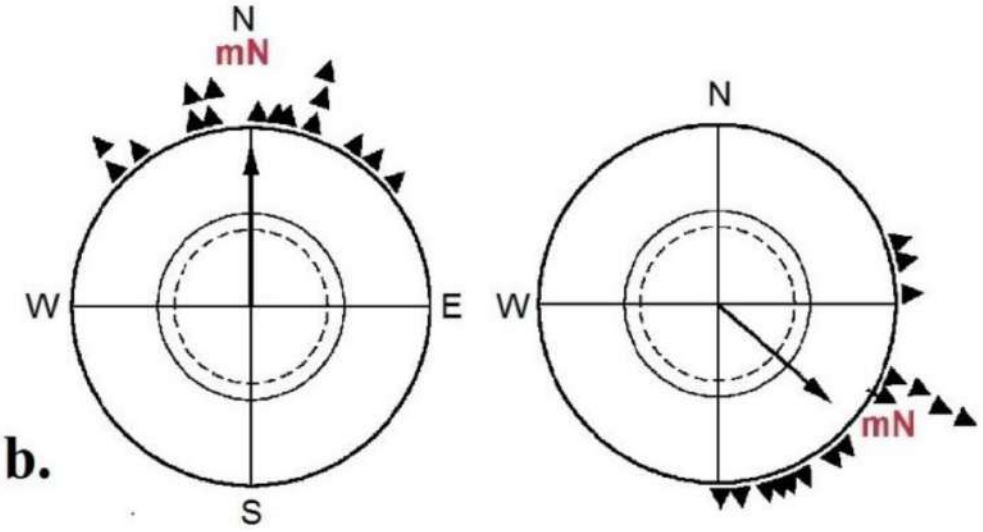
- Biologists are using magnetic fields to guide drug-loaded bacteria to cancer cells to kill them.

Biomagnetism

- Pigeons have multiple domain magnetite magnets within their skulls
- Pigeons have a magnetic sense:
- They can tell longitude by magnetic declination and latitude by the dip angle!

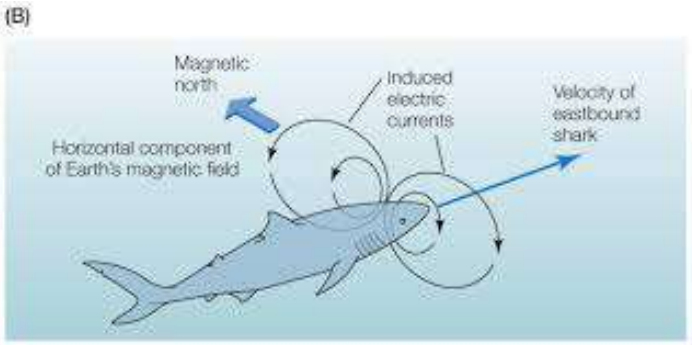






Other creatures use magnetism to...

…navigate. Butterflies, sea turtles, fish and bees (although bees mostly use the Sun's position).



→ See the video posted in Teams.

…and, apparently, to defecate in line with Earth's field.

Classwork continued

29. Name at least six creatures that are known to harbor tiny magnets within their bodies.

30. When do cosmic rays penetrate your body?