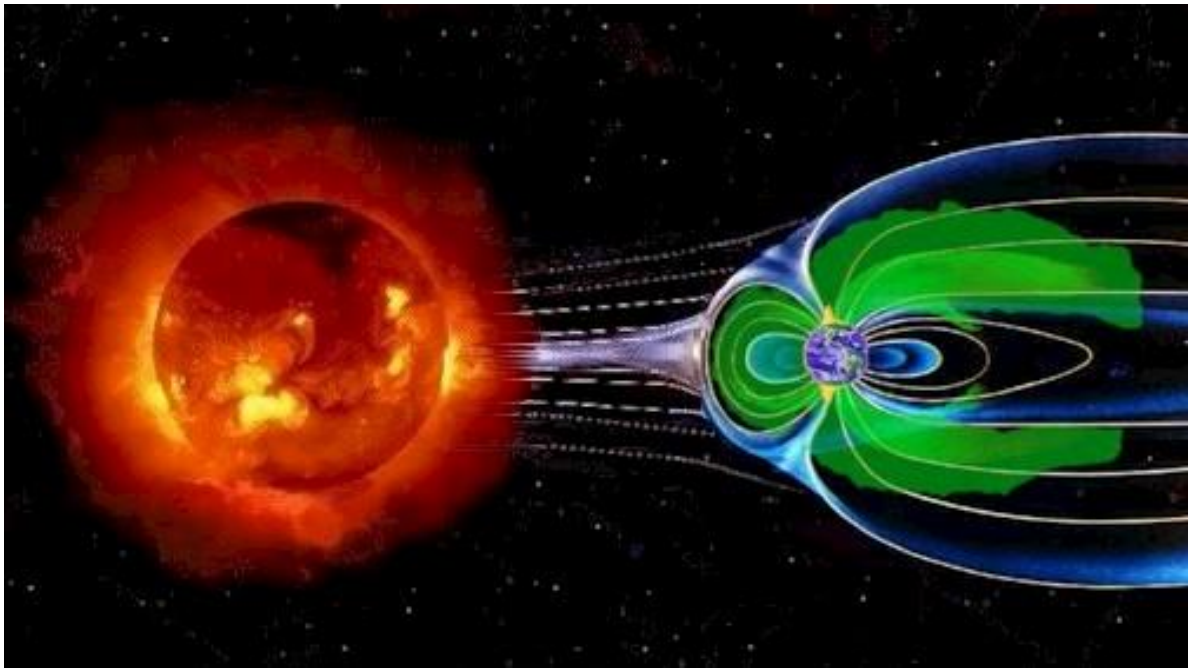
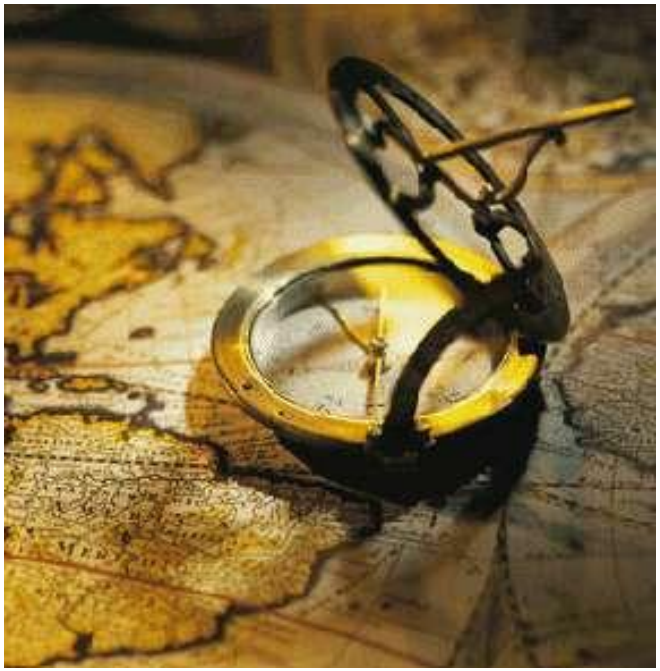
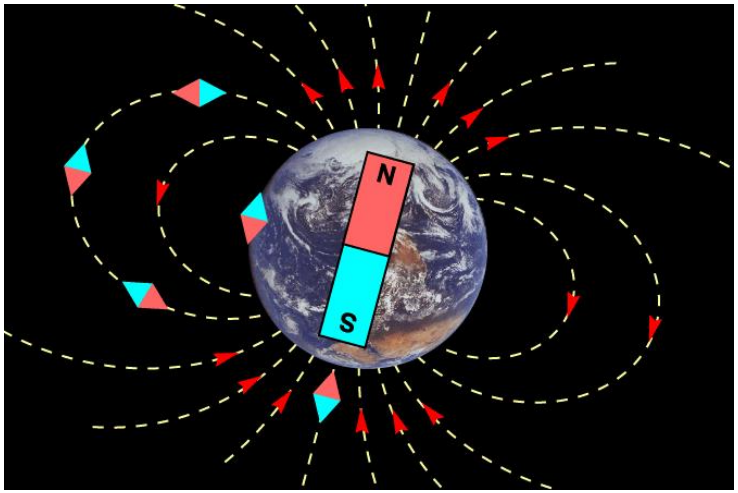


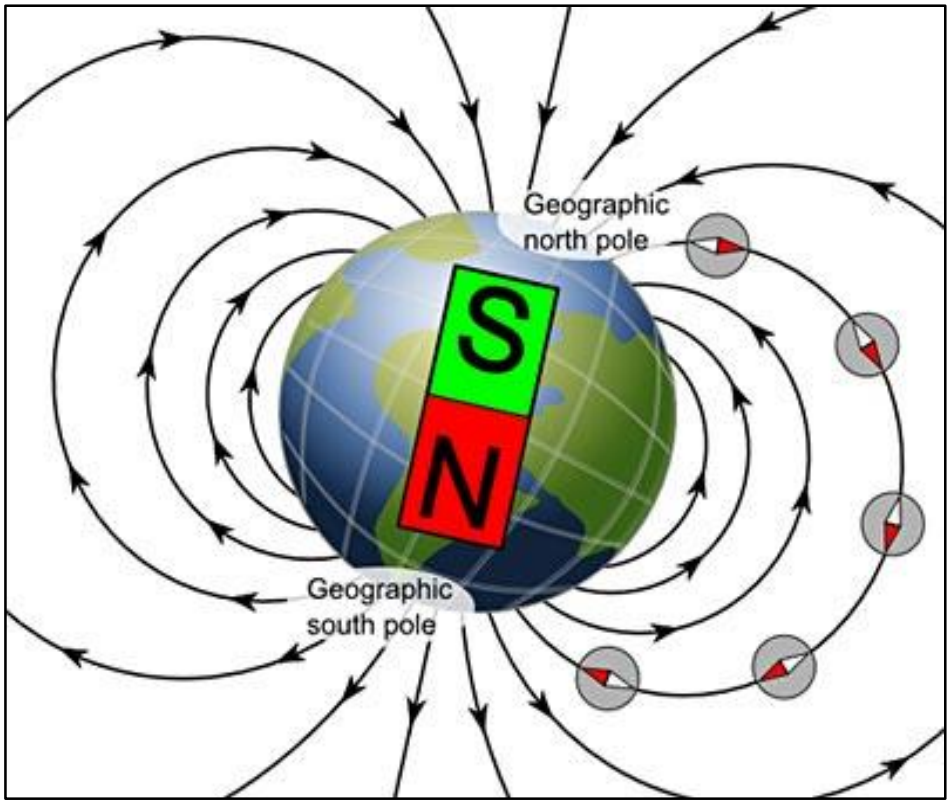


Magnetosphere



Earth is a Magnet!

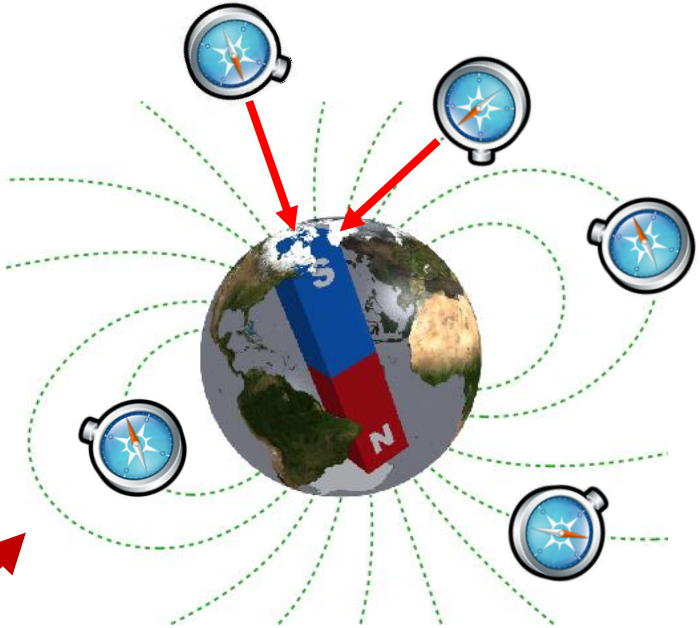
The Earth acts much like a bar magnet: its magnetic field deflects compasses on the Earth's surface to point northwards.



- **We represent the magnetic field at any point on or above the Earth's surface by a line pointing in the direction a compass would point.**
- **Close to the Earth's surface, the magnetic field has a "donut" shape.**

The North Pole of the Earth has "south" polarity.

Understanding a Compass



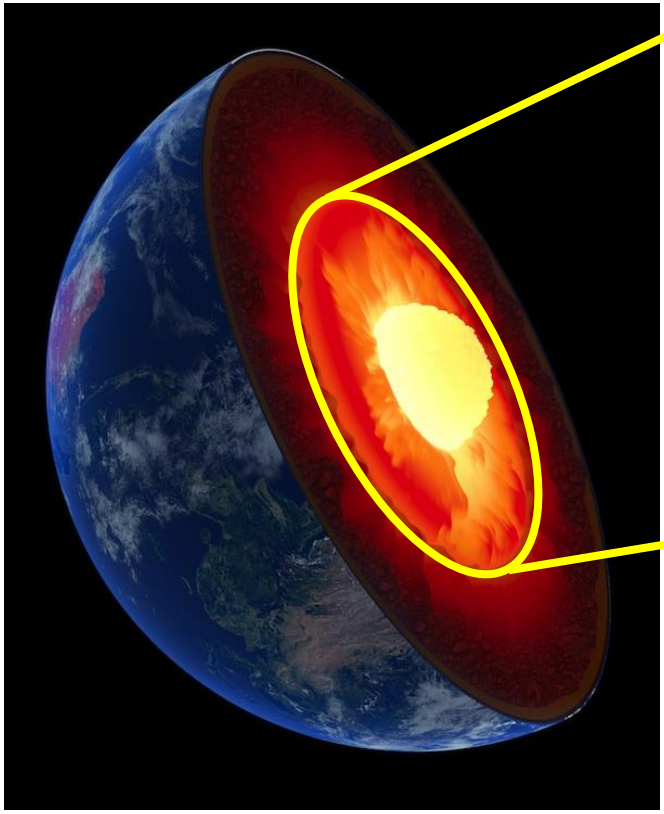
Question 1: what direction is North?

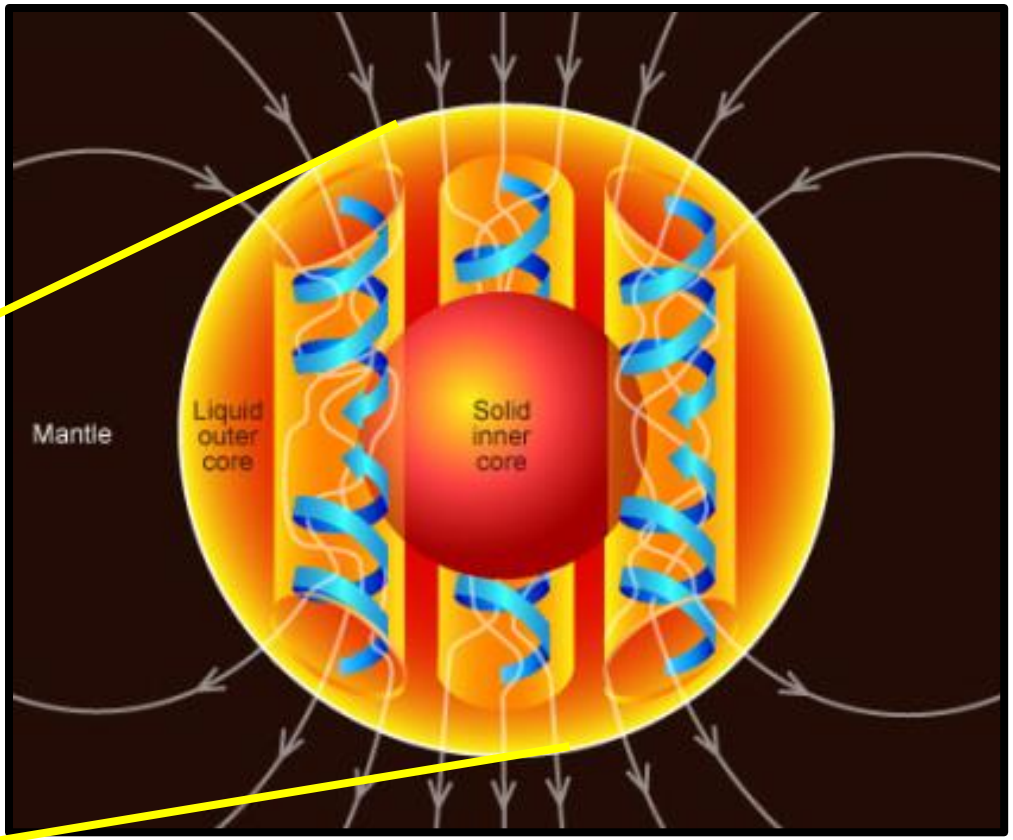
Question 2: where does a compass point at the <u>magnetic North Pole</u>?

Answer: straight down!

What creates Earth's Magnetic Field?

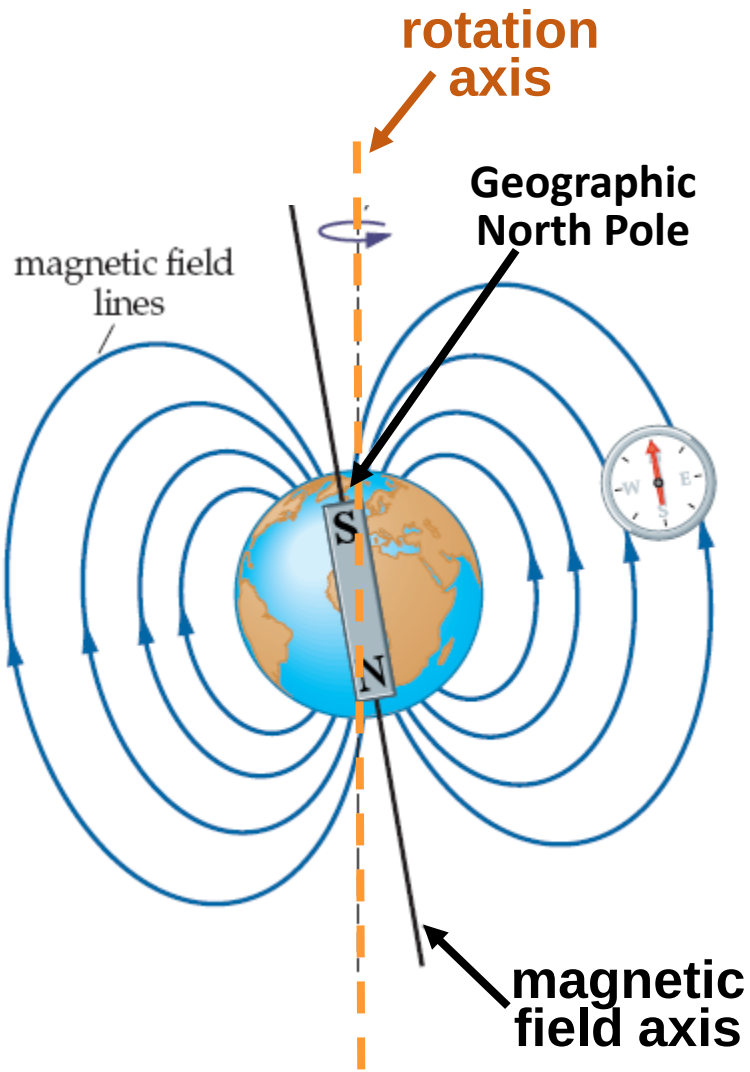
Geodynamo Theory





Rotating, convecting, and electrically conducting liquid outer core acts to induce and constantly maintain Earth's magnetic field.

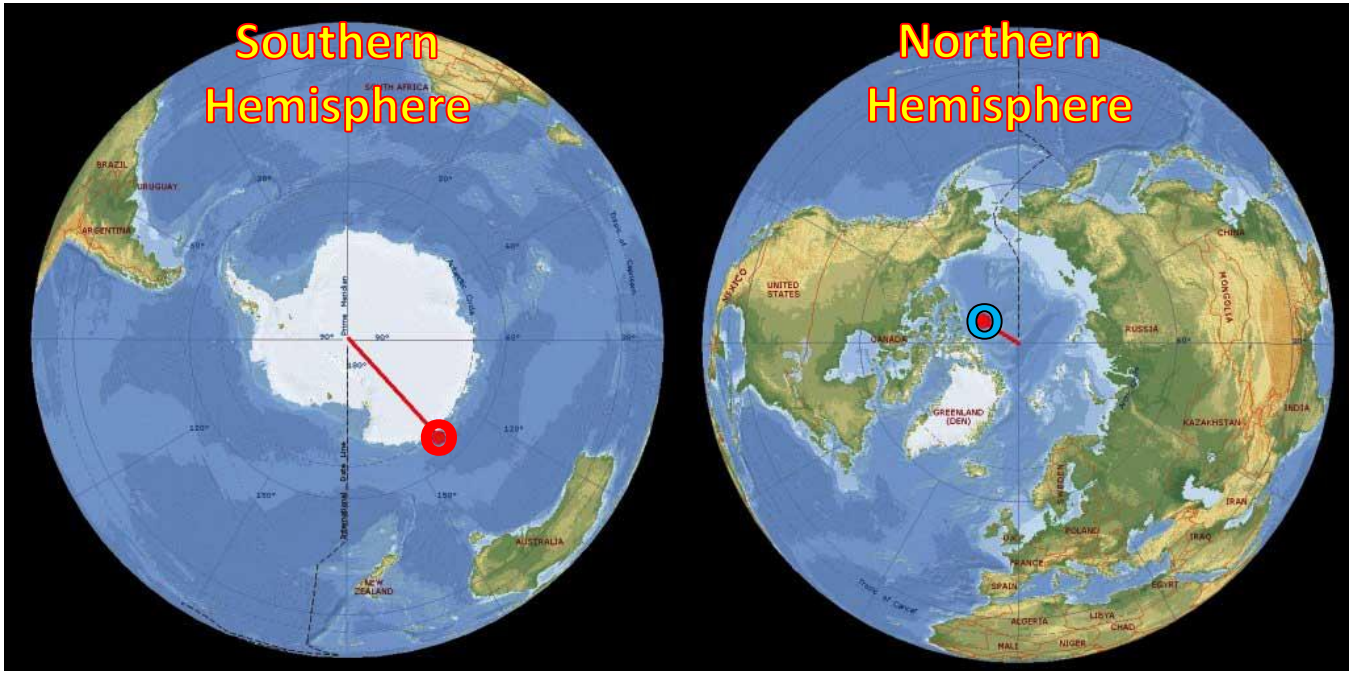
Magnetic Field Axis



- The <u>axis of Earth's magnet</u> and the <u>geographical (rotation) axis</u> ***do not coincide***.
- The <u>magnetic field axis</u> is **tilted at 11.5°** to the axis of rotation of the Earth.
- The <u>magnetic field axis</u> ***does not pass through the center of the Earth***.
- The <u>magnetic poles</u> and <u>geographic poles</u> are **not the same**.

Magnetic Poles

- **The Earth's North and South Magnetic Poles** are also known as **Magnetic Dip Poles**, with reference to the vertical **"dip" of the magnetic field lines** at those points.



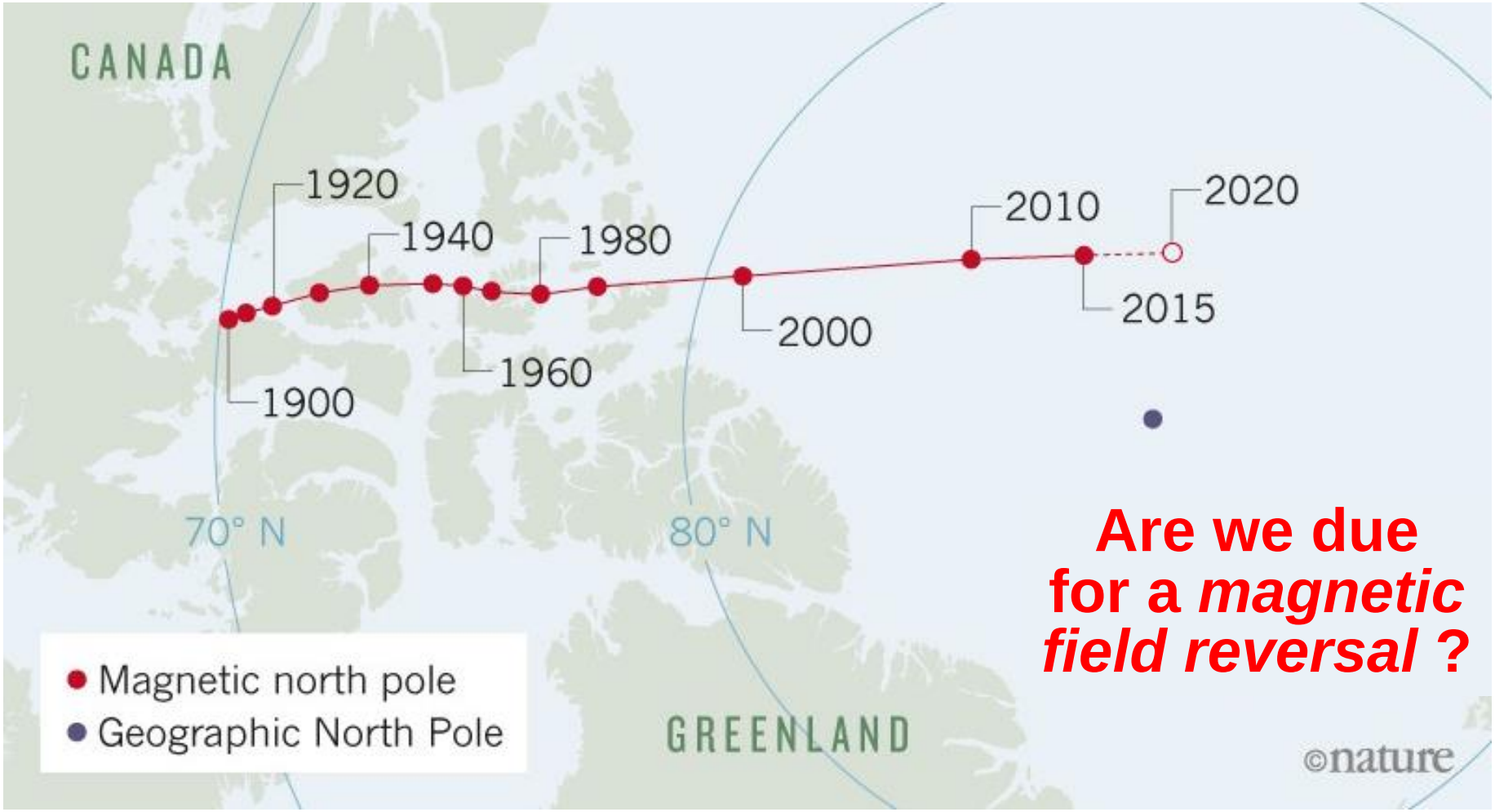
Magnetic Dip Poles Location (2010)

1800 mi from True South **380 mi from True North**

- **The positions of the Earth's magnetic poles are not very well defined: they are spread over an area, wandering ~50 km (~30 mi) back and forth every day.**

Magnetic Poles Are Constantly Moving

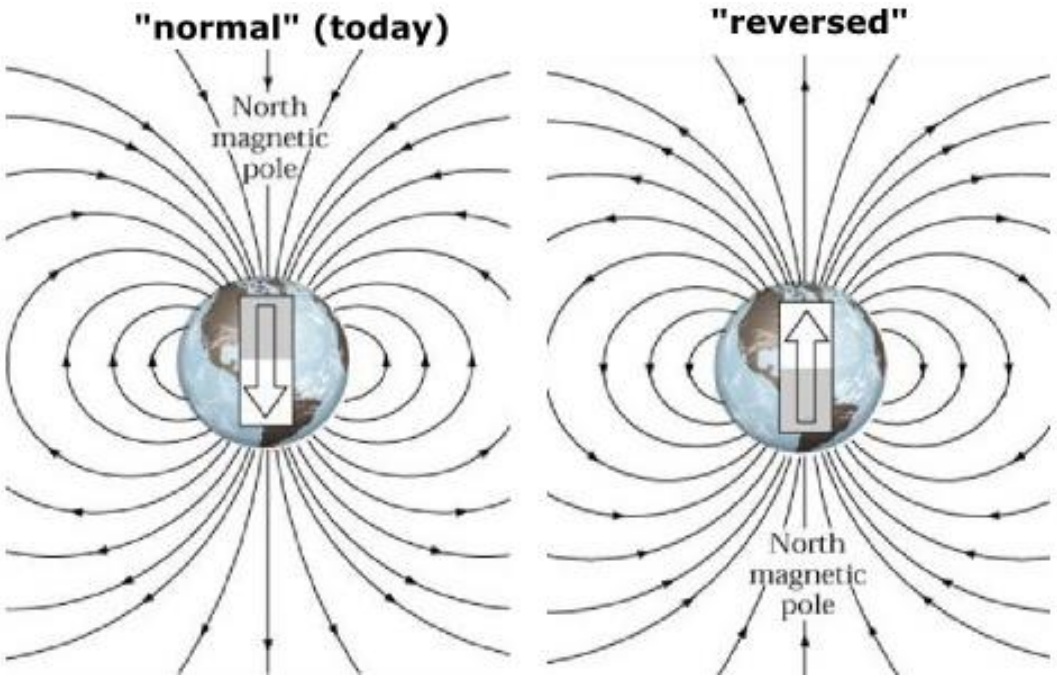
The magnetic north pole has been steadily moving towards Siberia, Russia by an average 10 km per year in the 19th century, lately accelerating to 40-50 km per year.



Are we due for a *magnetic field reversal* ?

Magnetic Field Reversal

- **Careful study of the magnetic structure of ancient rocks suggests that the Earth's magnetic field has reversed its direction many times (*evidence of at least 171 found!*) over the Earth's history.**

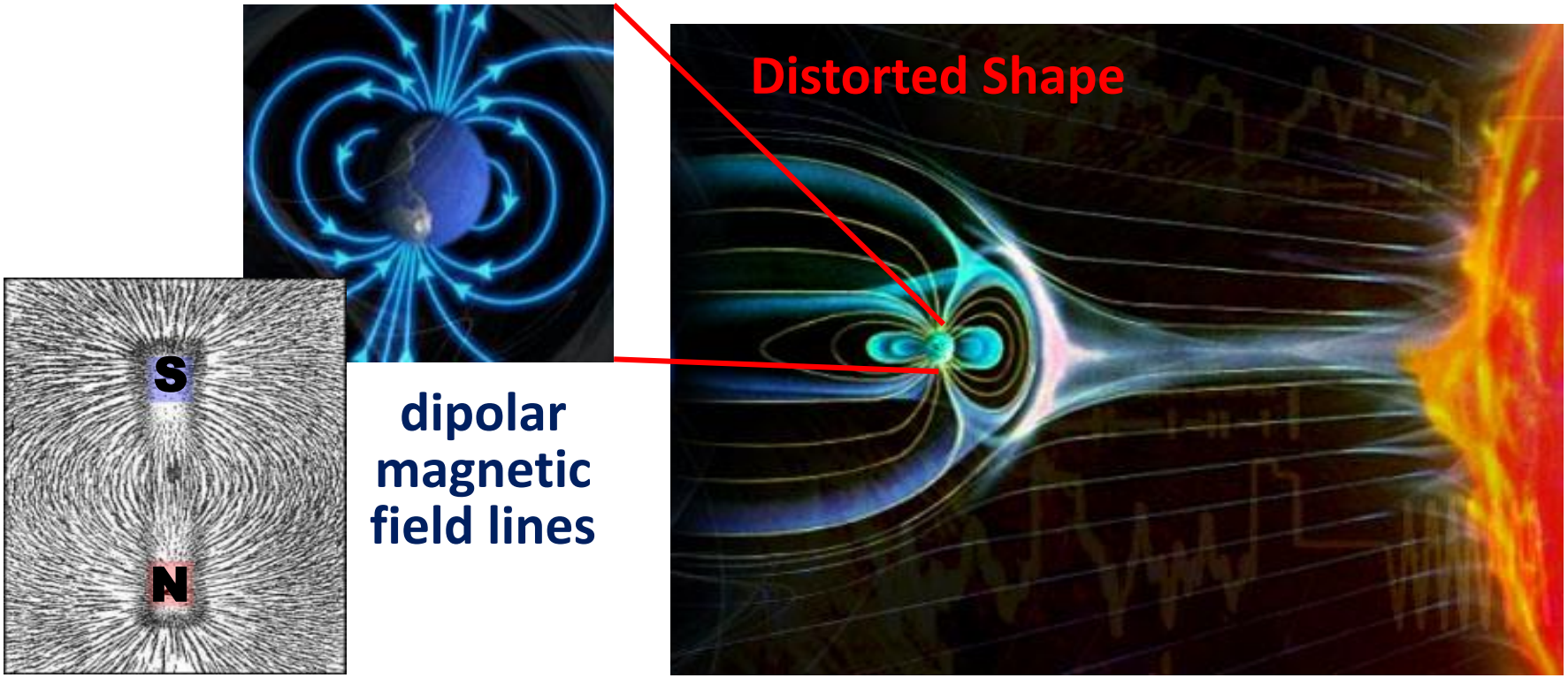


How exactly this reversal mechanism works is still not completely understood…

- **Field reverses once every 400,000 years on average.**
  - **Reversal takes about 10,000 years to happen.**
    - **Last reversal was ~780,000 years ago.**

Earth's Magnetic Field Shape

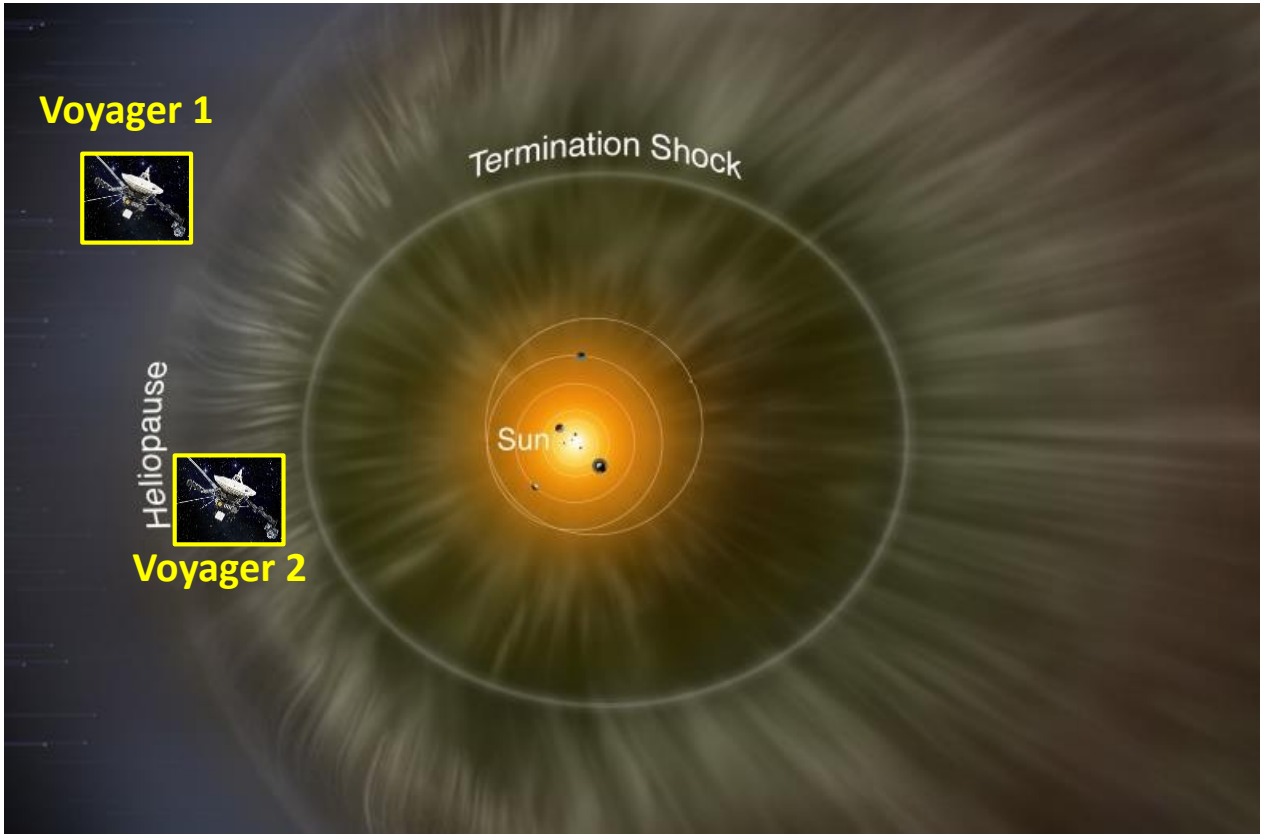
- **At the Earth's surface, the magnetic field is dipolar - similar to that of a *bar magnet*. Further out, it is distorted by Solar Wind.**



- **Magnetosphere is asymmetric: the *sunward side* is about 10 Earth radii out but the other side stretches out in a *magnetotail* that extends beyond 200 Earth radii.**

Solar Wind

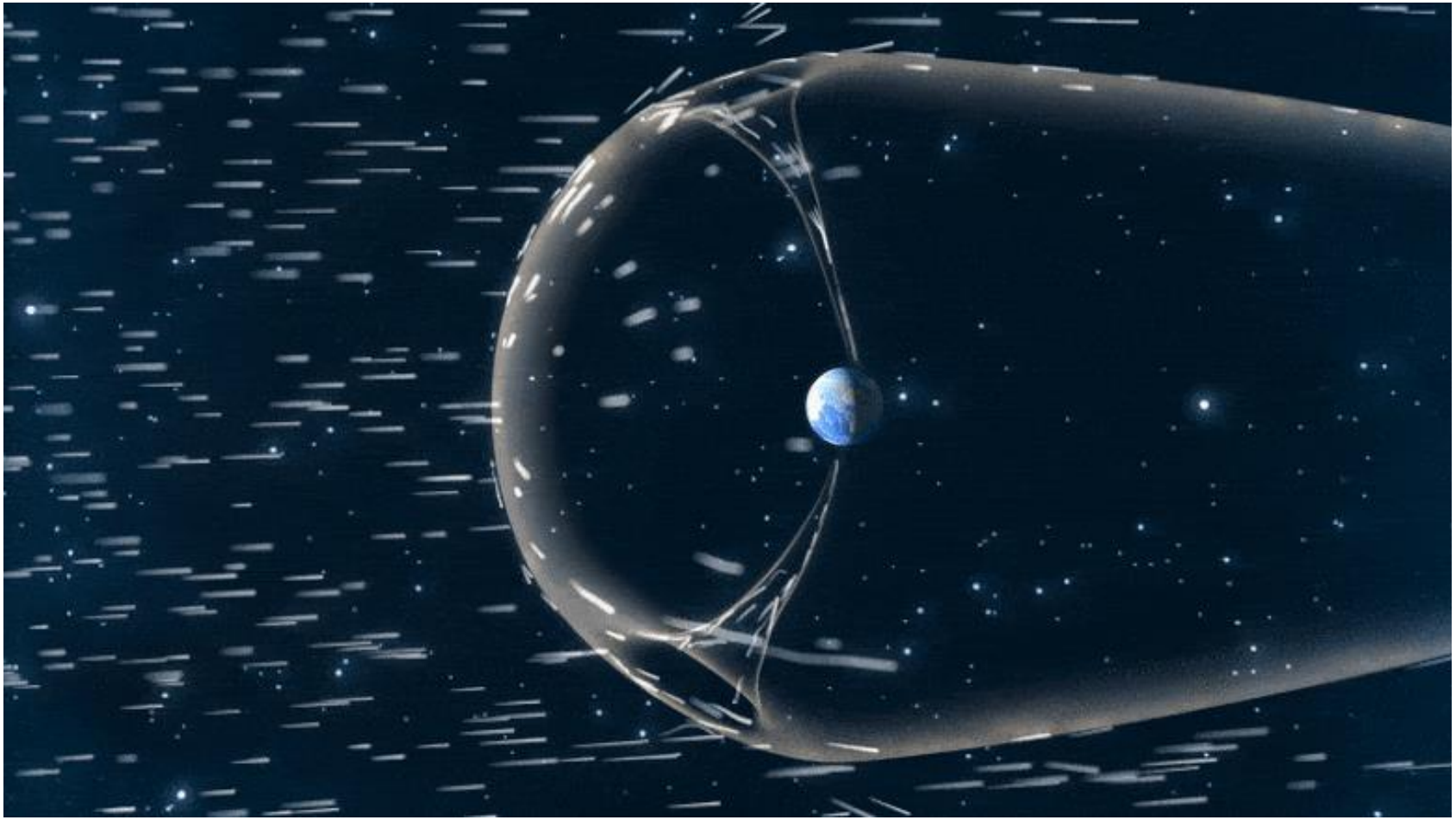
- **The Solar Wind is a stream of *plasma* released from the upper atmosphere of the Sun (photosphere and corona).**



- **Solar Wind consists of mostly electrons and protons.**
- **The stream of particles varies over time and averages 1.3×10^{36} particles per second!**

- **Planets with a weak or non-existent magnetosphere (Venus, Mars) are getting their atmosphere stripped off by the Solar Wind.**

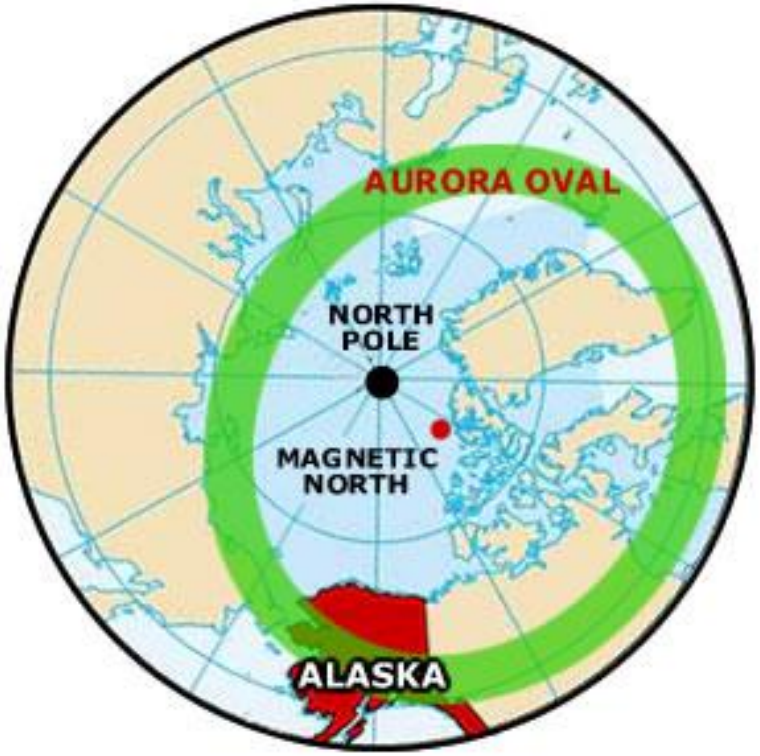
Magnetic Shield

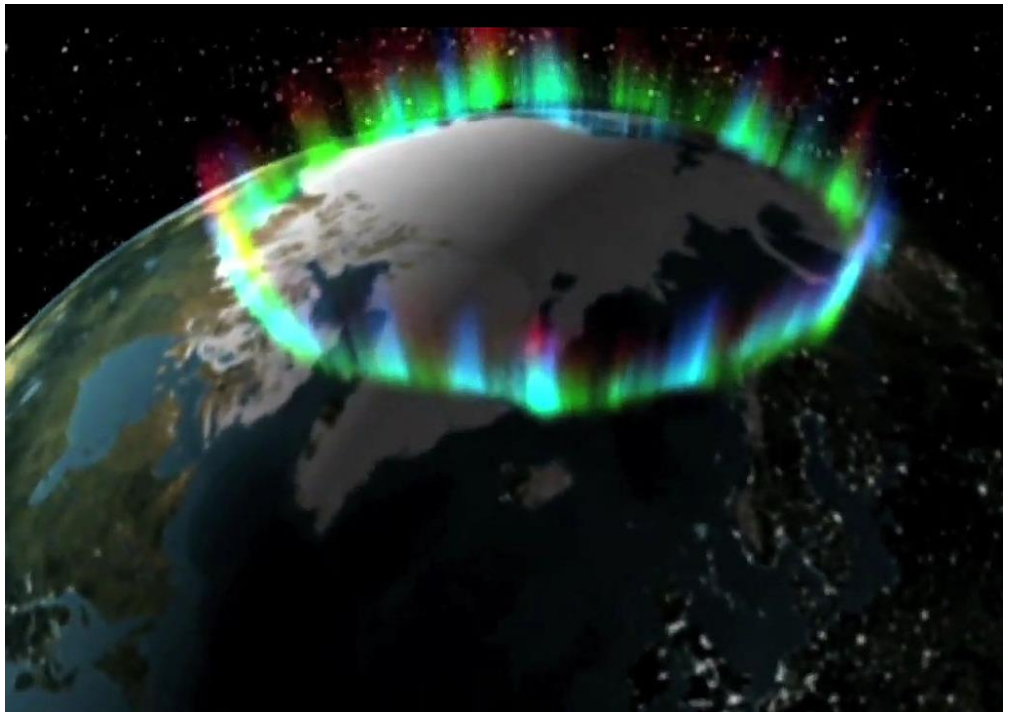


The Earth's magnetic field deflects most of the particles away and acts to protect life on Earth from Solar Wind as well as from cosmic ray particles coming from deep space.

Aurora Borealis or Northern Lights

(Galileo!)





- ***Generally*** **can be <u>observed</u> at night <u>in the polar regions</u> between 60 and 72 degrees north and south latitudes, within the Arctic and Antarctic polar circles (south: *Aurora Australis*).**
- **Periods of particularly <u>intense Solar activity</u>, called *geomagnetic storms*, cause a lot of disturbance to the Earth's magnetic field, including <u>auroras as far south as Hawaii</u> (just 20°N latitude)!**

Aurora Borealis or Northern Lights

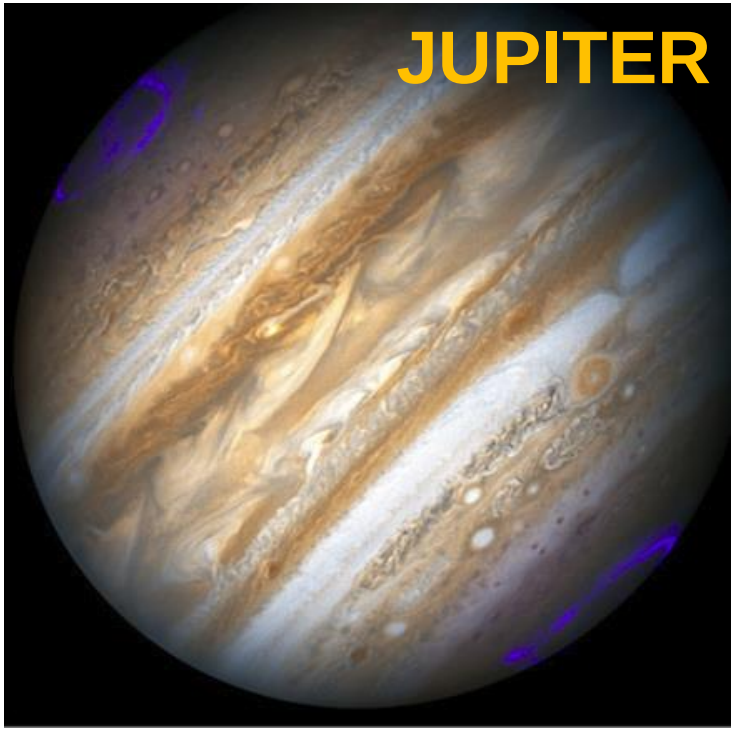
(Galileo!)

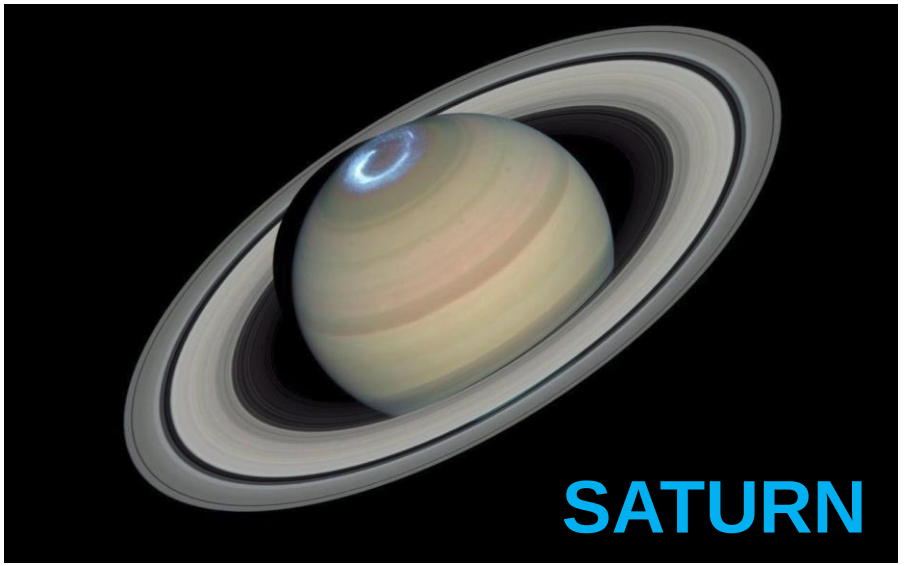
"Dance of the Spirits"

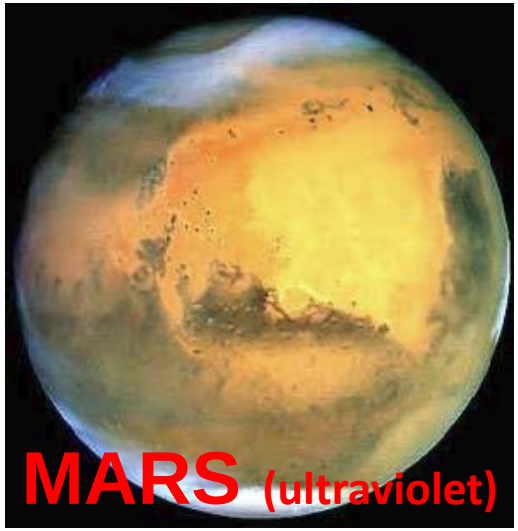
Aurora colors:

- **Red – oxygen atoms at ~200 mi high**
- **Blue – ionized nitrogen molecules**
- **Green-Yellow – oxygen atoms at ~60 mi high – most common!**
- **Pink/crimson/purple – mix of the above**

Aurora on other planets







Aurora Borealis Video

“Fantastic Aurora” explained:
https://www.youtube.com/watch?v=N5utQxtma2U

“Night of the Northern Lights”:
https://www.youtube.com/watch?v=fVsONlc3OUY