# Magnetic Fields and Forces

**Learning goals**: *Students will be able to*

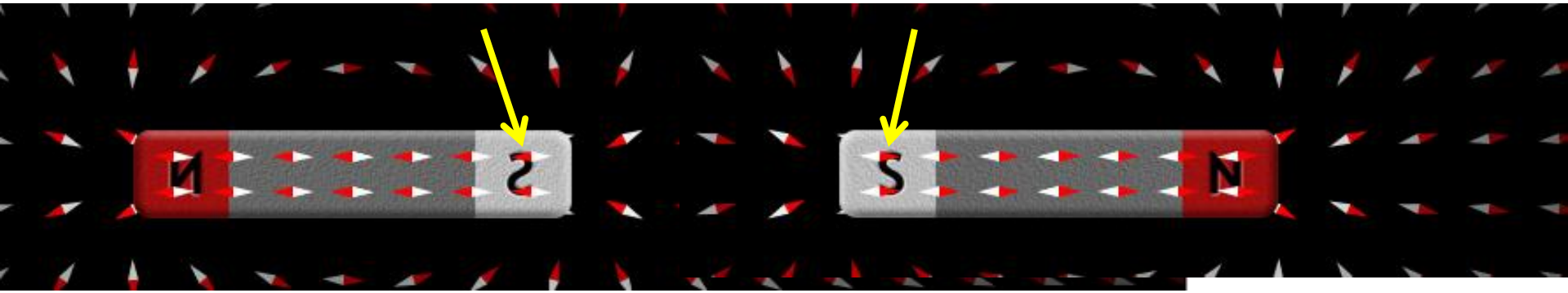
- Predict the direction of the magnet field for different locations around a bar magnet and an electromagnet.
- Relate magnetic field strength to distance quantitatively and qualitatively
- Predict the direction of the magnetic field created by moving charges and the force between two magnetic fields.
- Compare and contrast bar magnets and electromagnets
- Identify the characteristics of electromagnets that are variable and what effects each variable has on the magnetic field's strength and direction.

Two bar magnets are brought near each other as shown. The magnets...

A) attract

B) repel

C) exert no net force on each other.

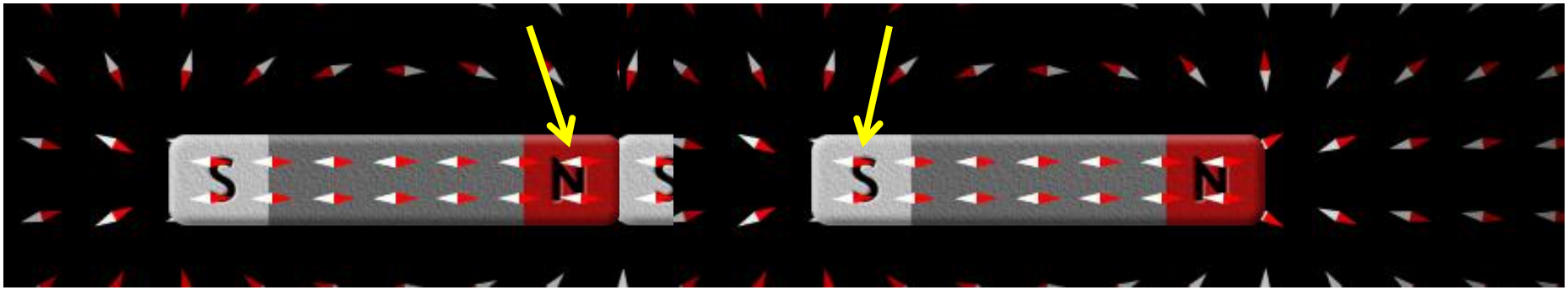


Two bar magnets are brought near each other as shown. The magnets...

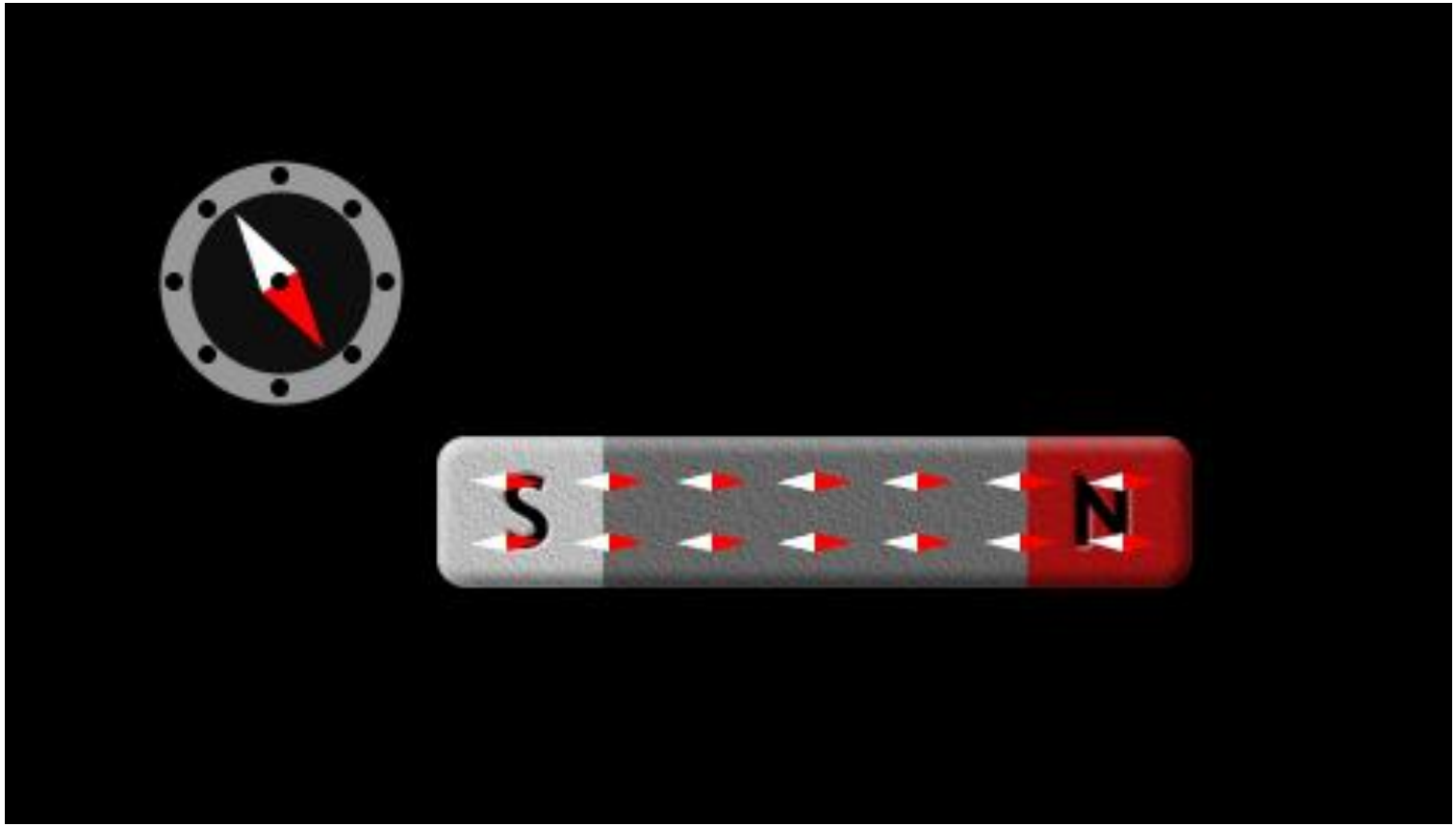
A) attract

B) repel

C) exert no net force on each other.

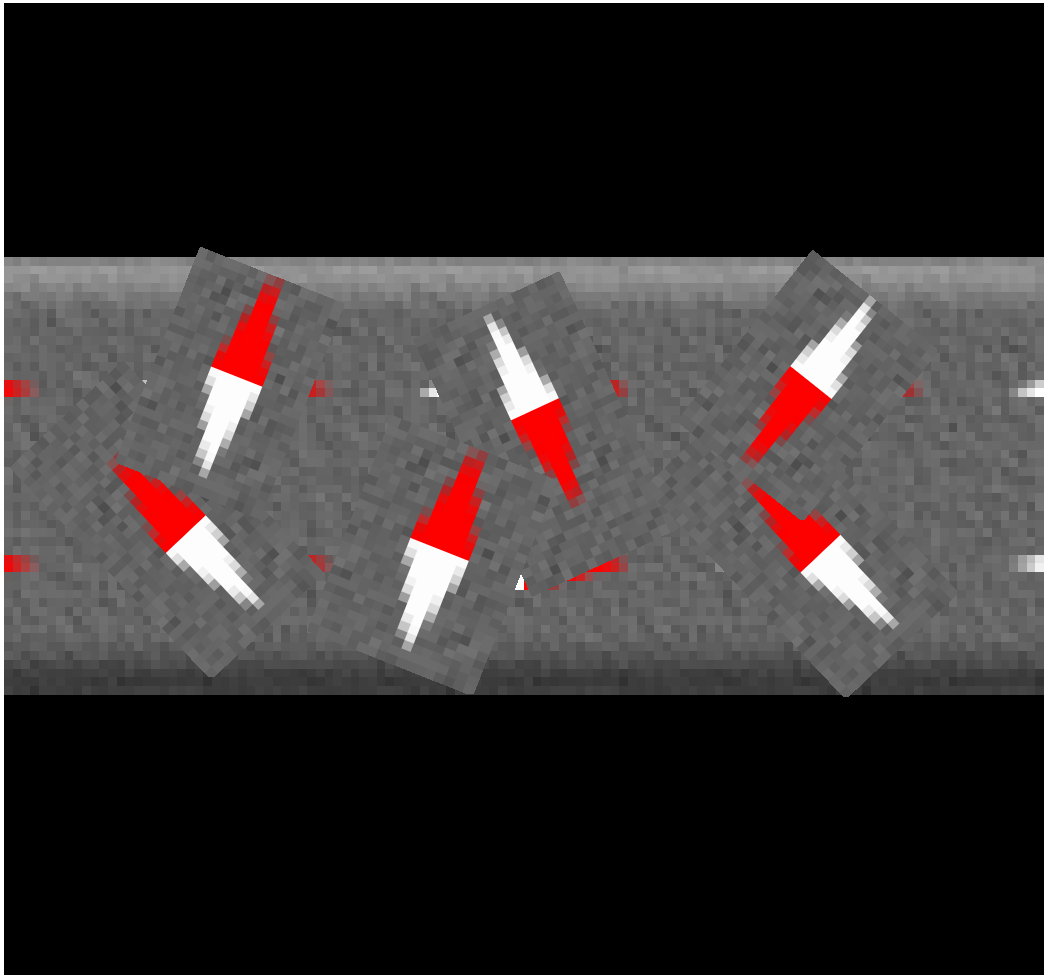


**Magnetic domains** – sections of the material where all atoms are aligned with the magnetic moments pointing the same direction.



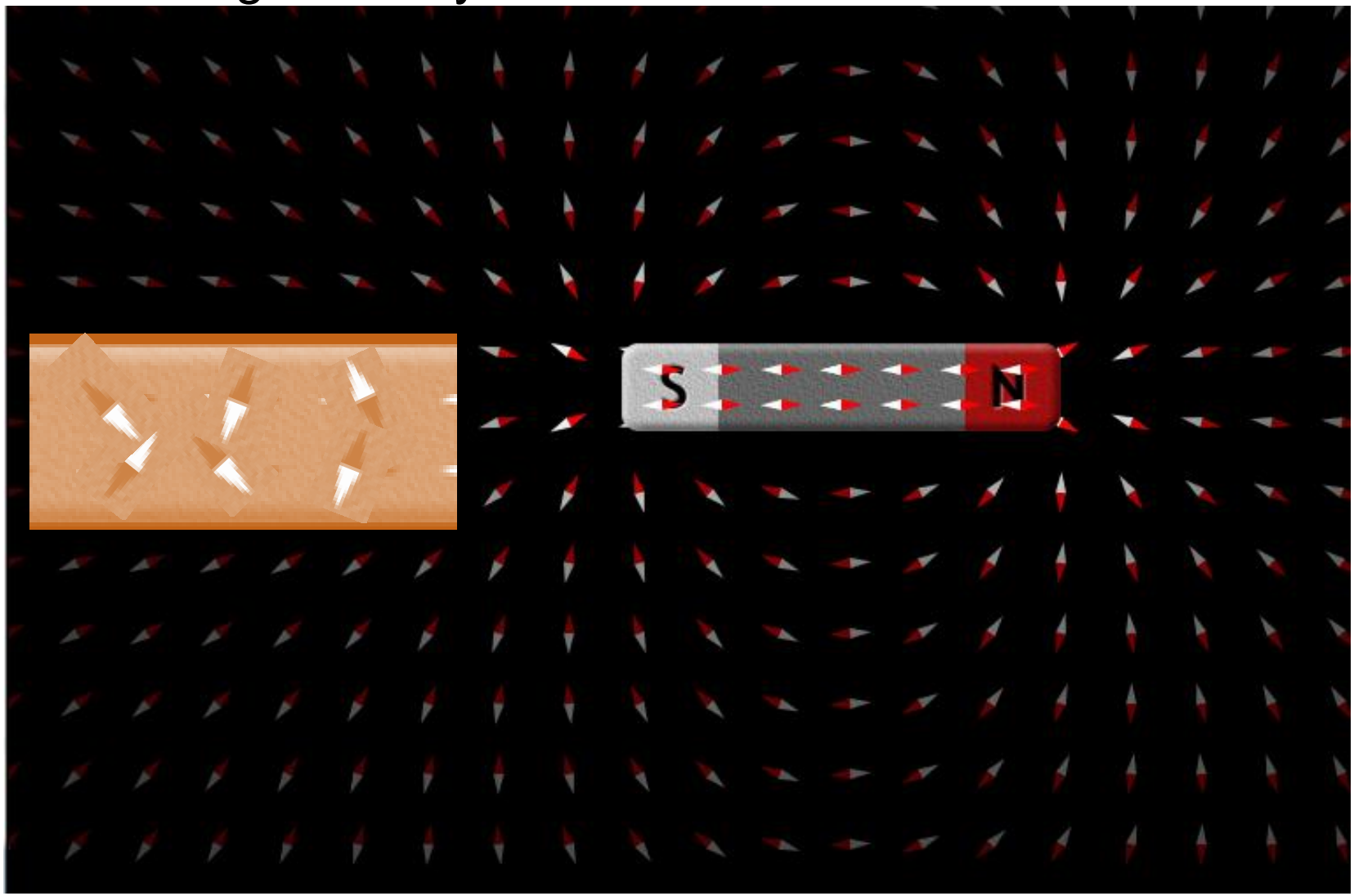
Non-magnetized material

domains are randomly aligned – no net magnetic field



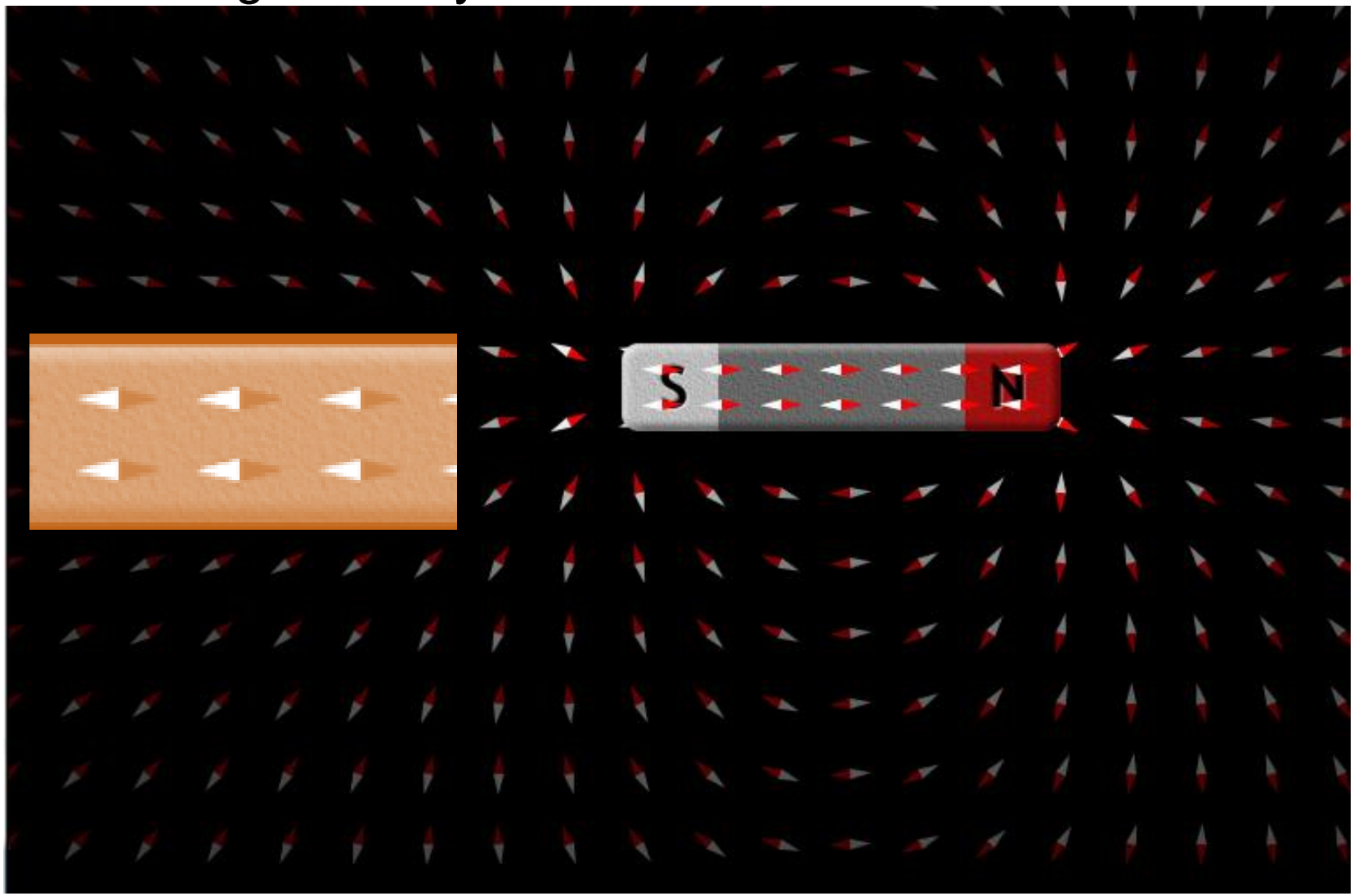
**When hot – above curie point**

magma or if you heat the metal…

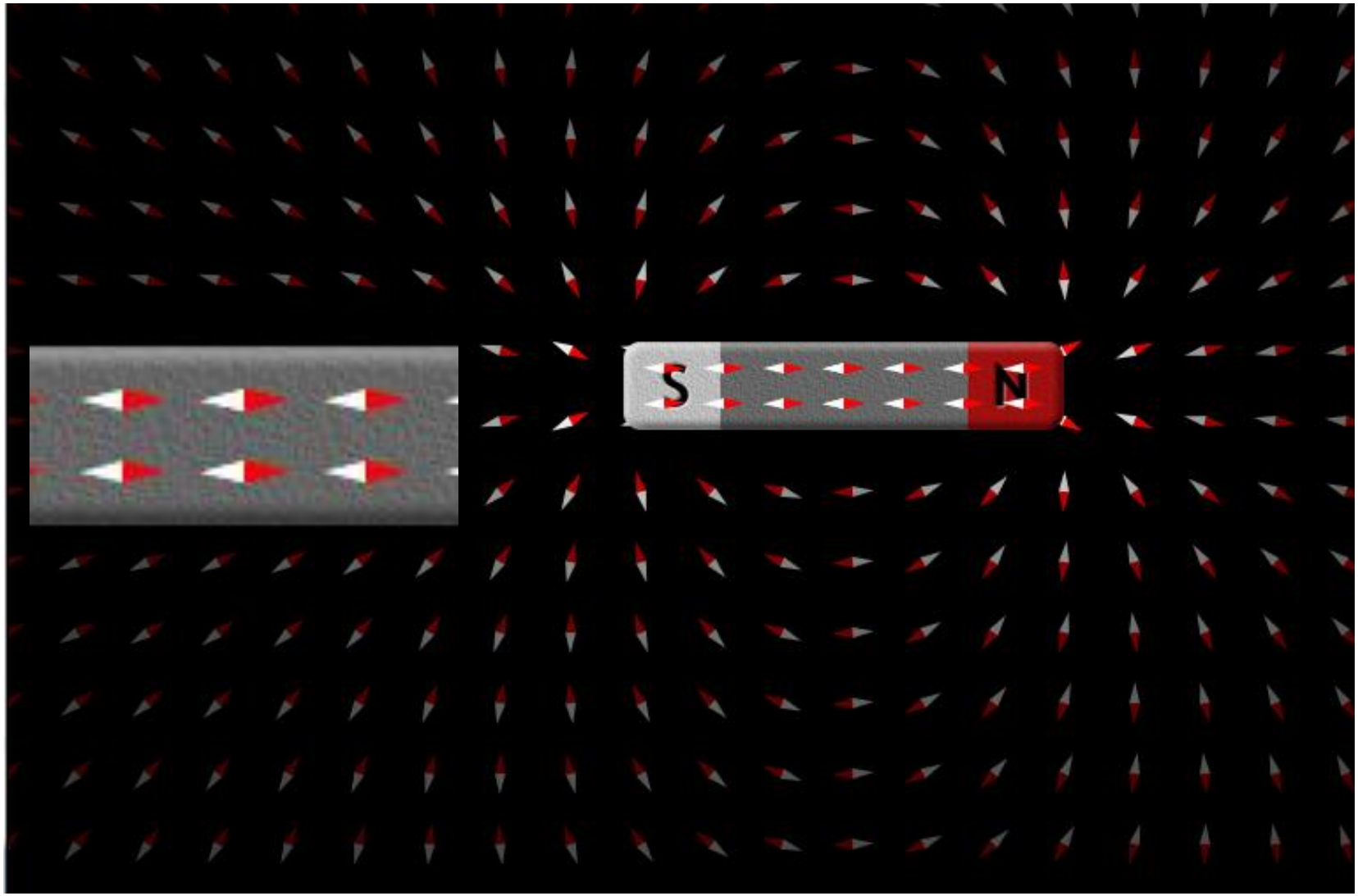


**When hot – above curie point**

magma or if you heat the metal…



**Cools – now have a magnet** (domains are aligned)

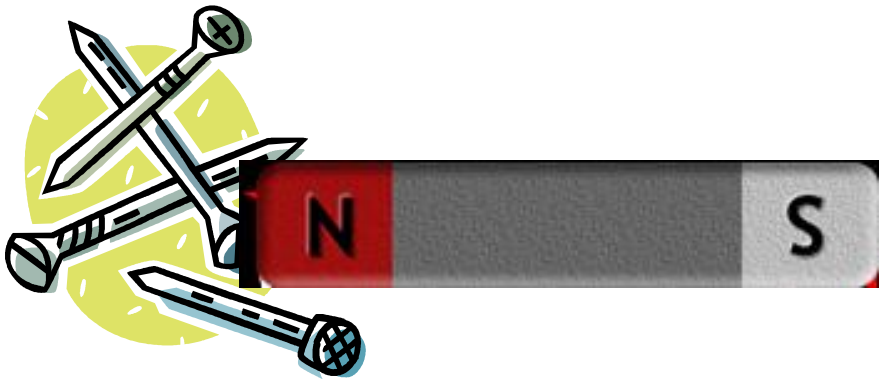


# Other ways to make a magnet

Major blow or steady vibrations while in a magnetic field

Rub on a magnet (if it's a soft magnetic material)

Store with a magnet for an extended time.



## Magnetic Materials

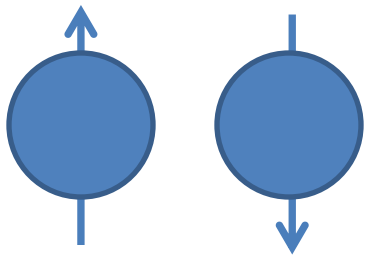
- Measured in Gauss or Tesla (1 T = 10,000 G)
  - Earth's field is 0.5 G or 5 x $10^{-5}$ T
- Ferromagnetic materials: Iron , Magnetite, Loadstone, neodymium (1 – 1.4 T) rare earth – except not really rare

- Paramagnetic: Aluminum, Platinum, Oxygen (weak$10^{-5}$)

- **Soft magnetic materials** (easy to mag or un-mag)
- **Hard magnetic materials** (difficult to mag or un-mag)

# Never have a N w/out a S!

- Electrons have an intrinsic magnetic field

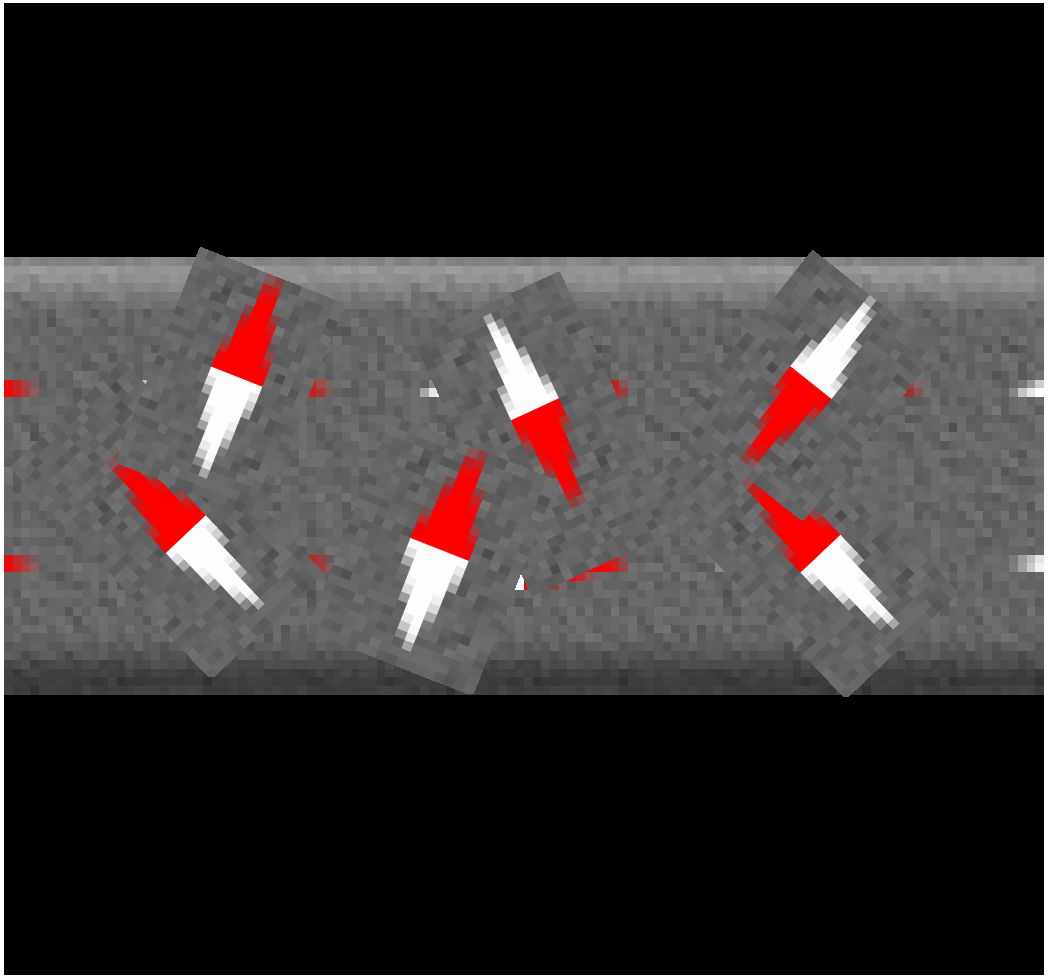


- Most pair up and cancel their fields but not ferromagnetic materials.

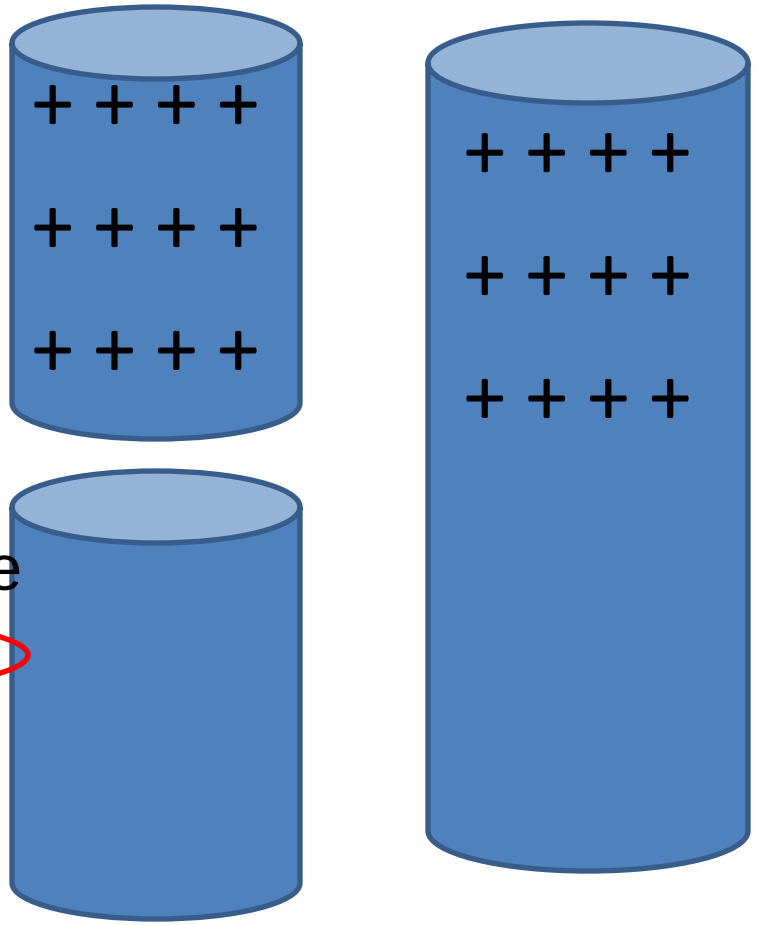
Non-magnetized material

domains are randomly aligned – no net magnetic field

Ferromagnetic materials: atoms align so their fields align in sections called ***domains***.



If you cut this charged plastic rod in half, would the two halves



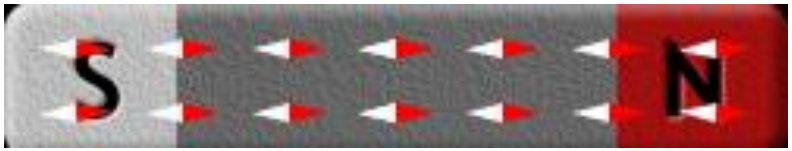
A: both have positive charge

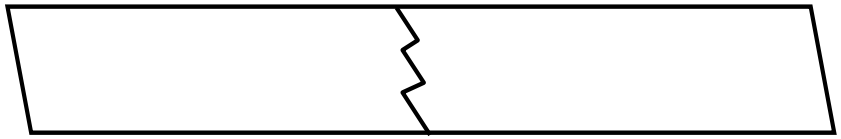
B: top positive and bottom negative

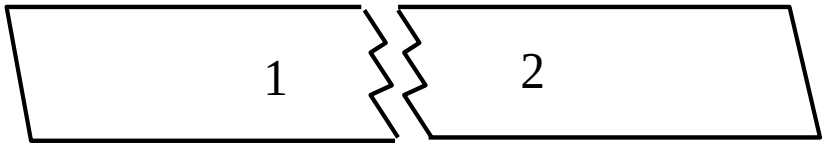
C: top positive and bottom neutral

A permanent bar magnet is broken in half.

Do the pieces attract or repel?



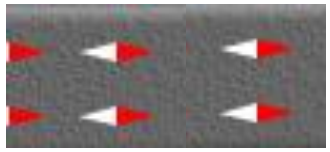



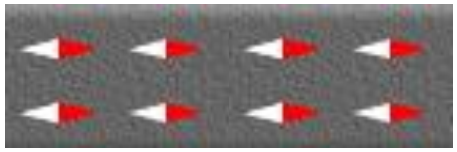



A: Attract

B: Repel

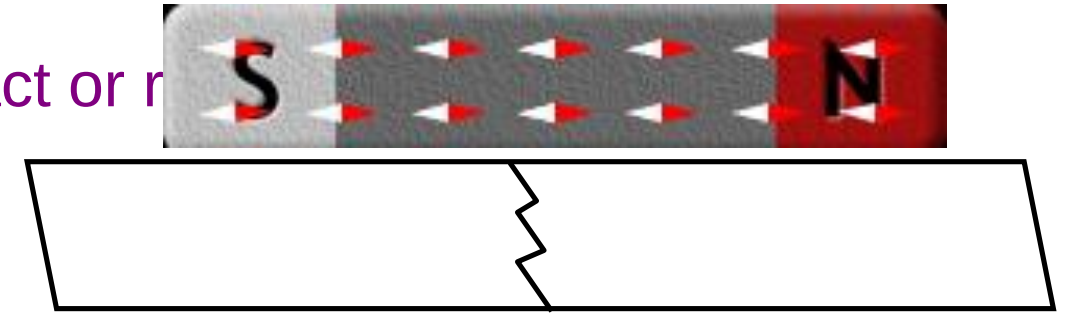
C: Neither





A permanent bar magnet is broken in half. The two pieces are interchanged, keeping their orientations fixed, as shown below.

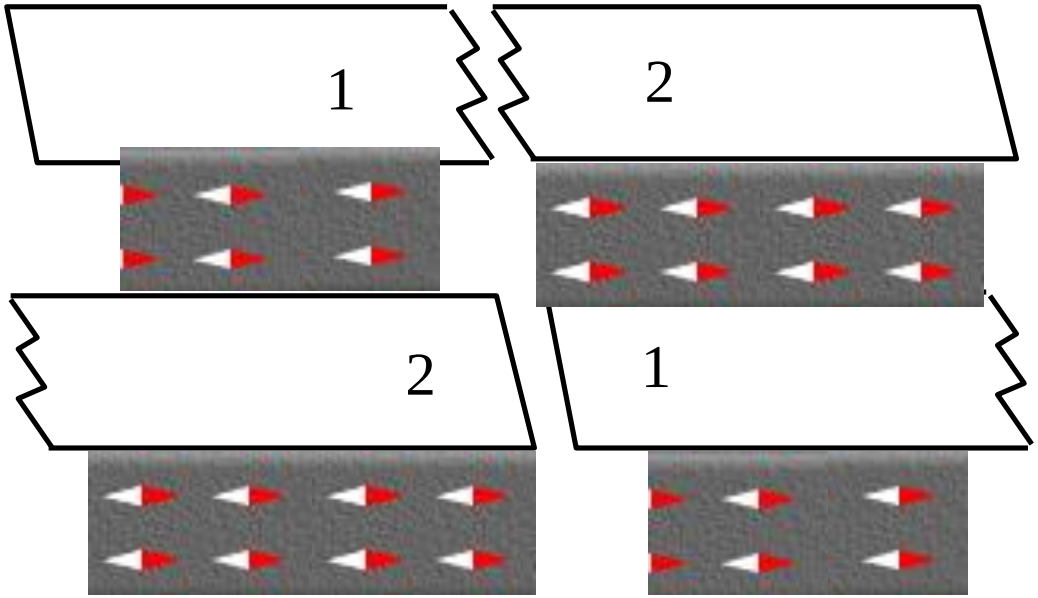
Do the pieces attract or r



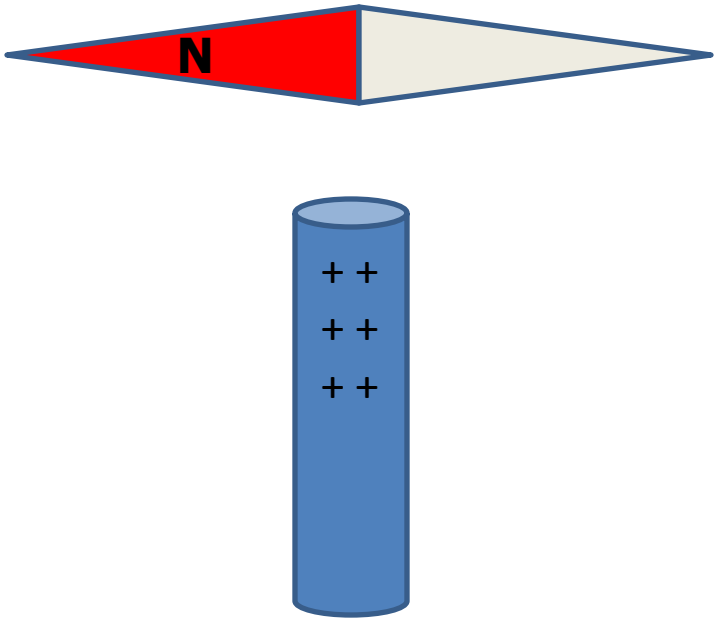

A: Attract

B: Repel

C: Neither



- The diagram shows a compass needle, viewed from above, which can pivot freely about its center. A stationary positively charged plastic rod is placed as shown.




The compass needle will:

A) Rotate clockwise in the plane of the screen

B) Rotate counterclockwise in the plane of the screen.

C) Rotate so the N pole goes out of this slide .

D) Rotate so the S pole goes out of this slide.

E) Will not rotate.

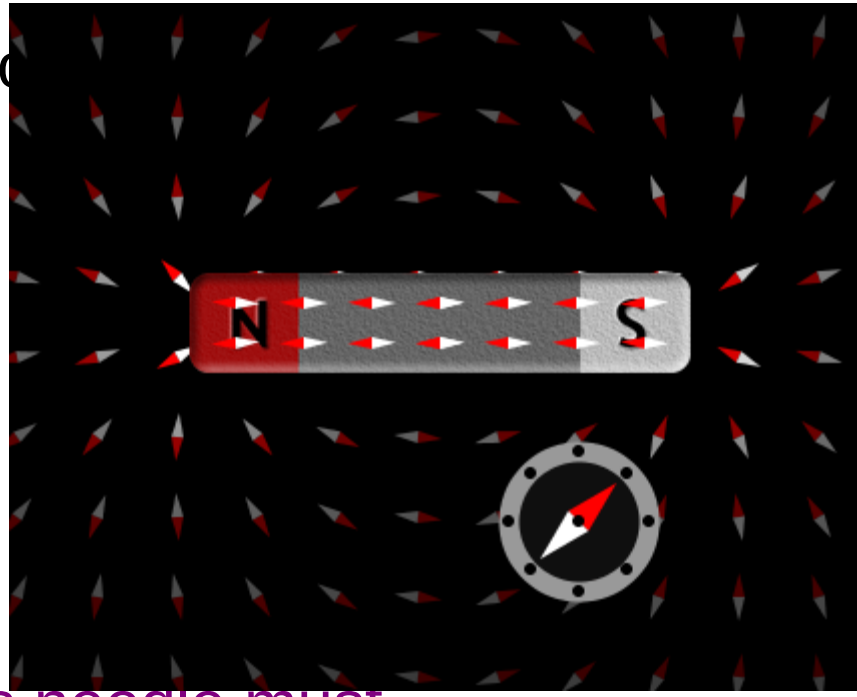
## Facts about bar magnets:

1) North poles attract to South poles (opposites attract)

2) Magnetic field lines point fr

3) Compass needles are little magnets.

(They point in the *same* direction as B-field)




The arrow (tip) of the compass needle must be… A: North B: South

## Which compass shows the correct direction of the magnetic field at point P?

A. 

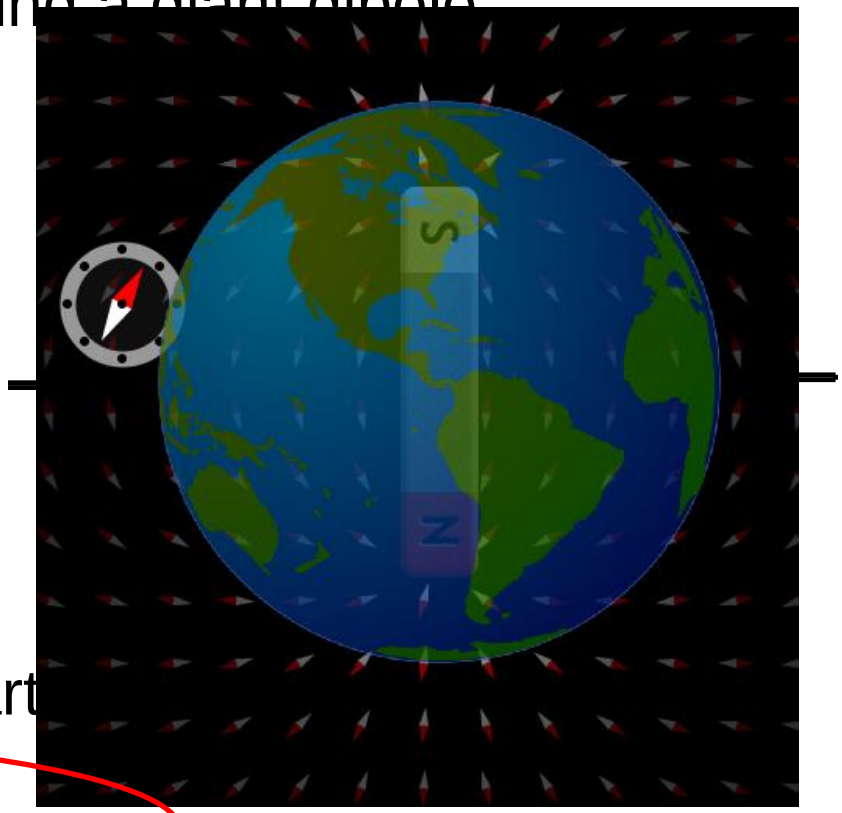
B. 

C. 

D. 

P

Compass needles point roughly towards the earth's geographic North Pole.
Earth can be viewed as having a giant dipole magnet embedded in it.




From this, which can you conclude?…

A: Geographic North = magnetic North Pole of eart

B: Geographic North = magnetic South Pole of earth

## Earth's Magnetic Field

- Not caused by the core being magnetized (too hot)
- Earth's core is rotating charged particles
- Jupiter spins much faster & has much larger B-field
- Dip Angle – tells what angel the field points at your current location
  - 0 degrees at Equator
  - 90 at magnetic North ~1300 miles from geographic North
  - Flips every few million years
- Birds and many bacteria have a chain of magnets as part of their structure

# Electromagnets

What is happening?

What is similar and different between the bar magnet and an electro-magnet?