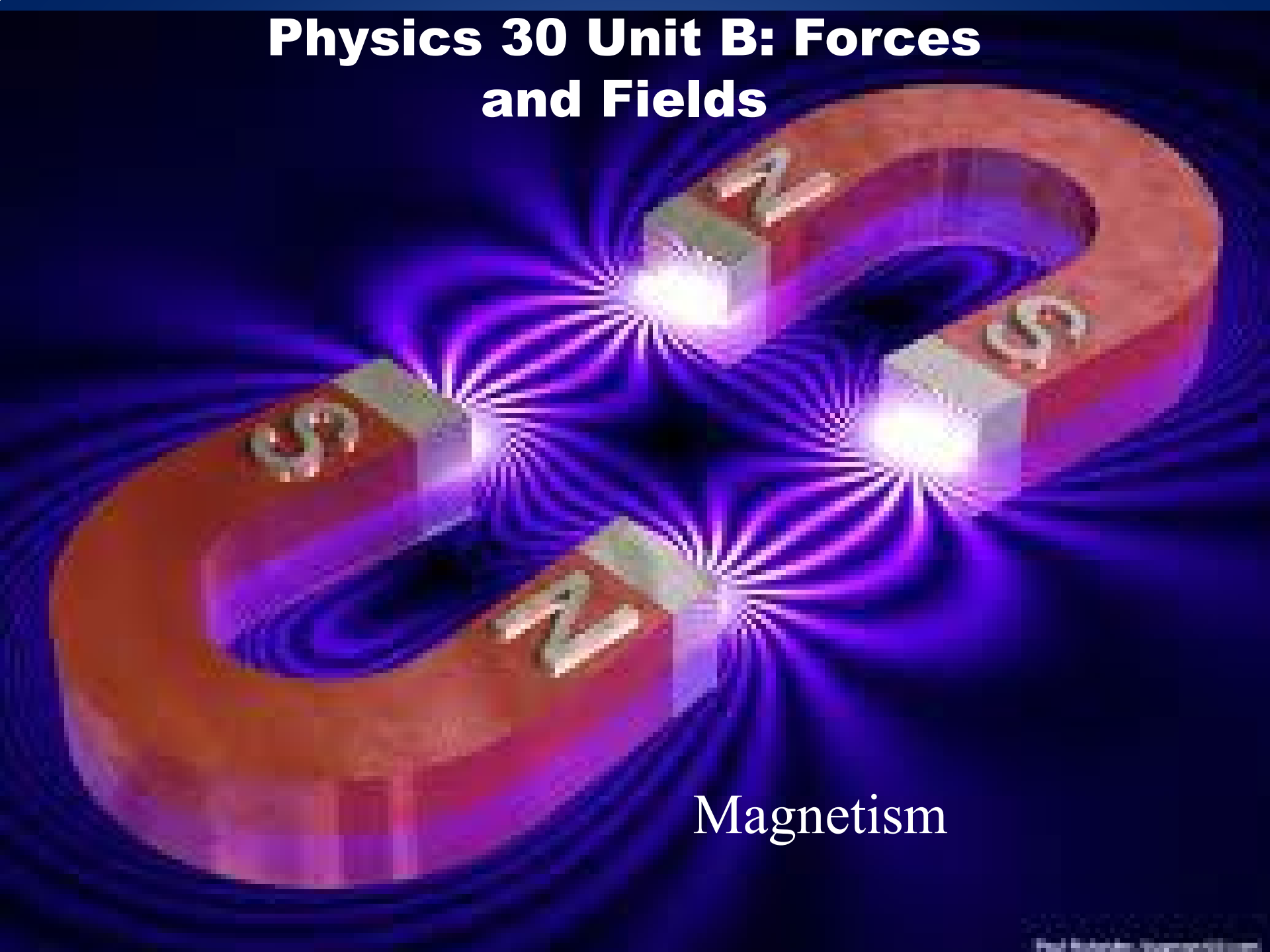
# Physics 30 Unit B: Forces and Fields

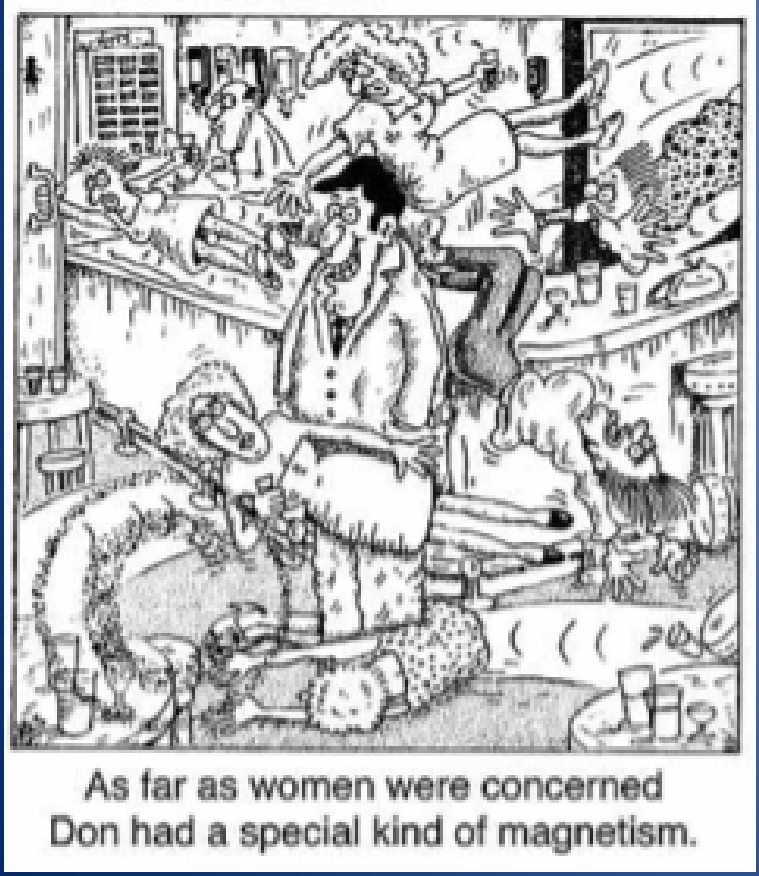


Magnetism

# Objectives

- describe magnetic interactions in terms of forces and fields.
- compare gravitational, electric and magnetic fields ⟨caused by permanent magnets and moving charges⟩ in terms of their sources and directions

# What do we already know about magnetism?



As far as women were concerned
Don had a special kind of magnetism.


"I can't work with computers, on account of my animal magnetism."

# Early Discoveries

- The Greeks knew magnets produce a force on some metals, called ferromagnetic materials.
- The force was exerted without contact: they called it 'action at a distance' force.
- But they couldn't explain why this force worked.

# Enter: Faraday

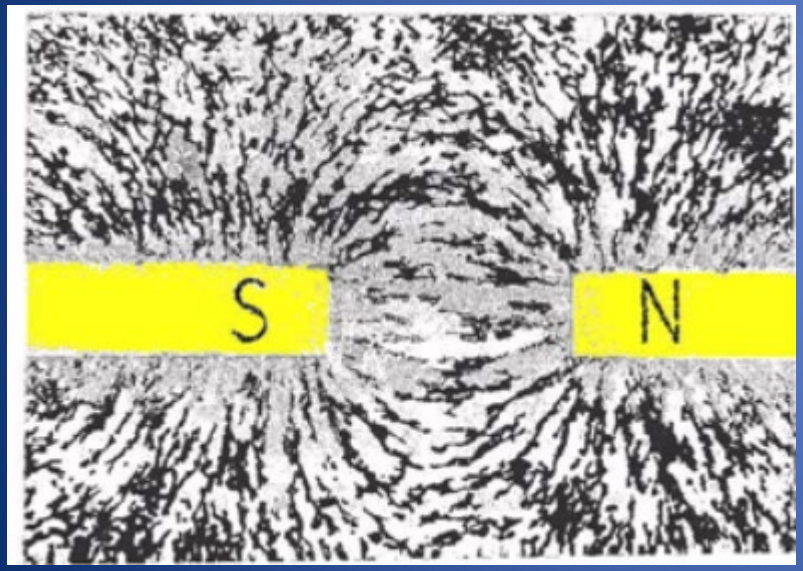
- 19th Century Chemist and Physicist
- Pioneer of Chemistry:
  - oxidation numbers
  - anode, cathode
  - electrolysis
  - discovered benzene
  - bunsen burner
- Pioneer of Physics:
  - MAGNETIC FIELDS
  - Electromagnetism
  - Electromagnetic Induction

# Magnetic Fields

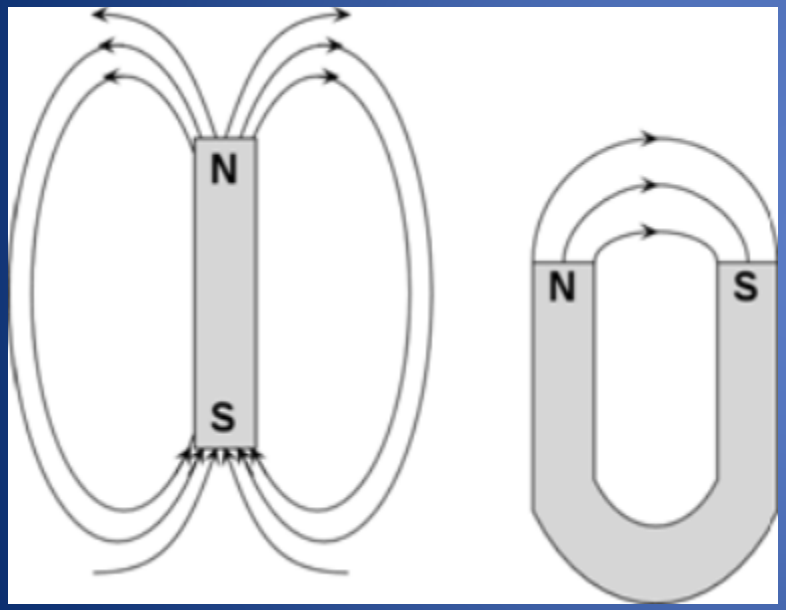
- The direction of the force can be explained through field theory.

- All magnets produce a magnetic field (symbol, B)
- The direction of the field is the direction a test compass would point.

- B-fields can be represented by field lines.
- The closer together the field lines, the stronger the field.
- B-fields are vectors.

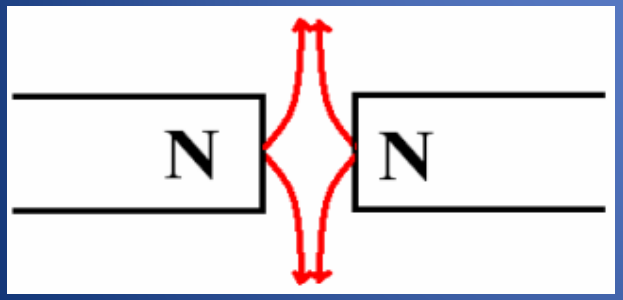


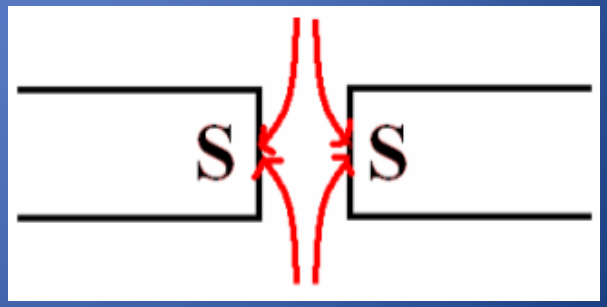

- **Iron filings indicate the field lines between two bar magnets.**

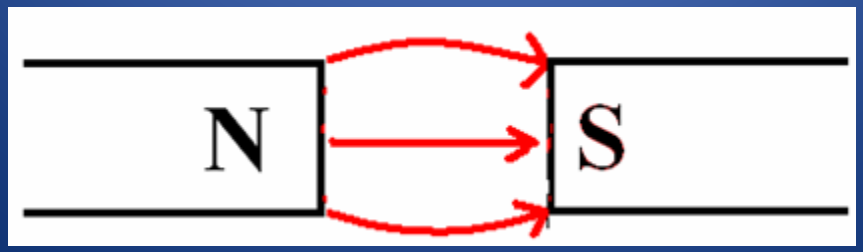



- As B-fields move in the same direction a test compass would point, lines move from north to south poles.

- **Field Lines move out from North Poles into South Poles**
- **Like Poles Repel…**
- **Unlike Poles Attract…**

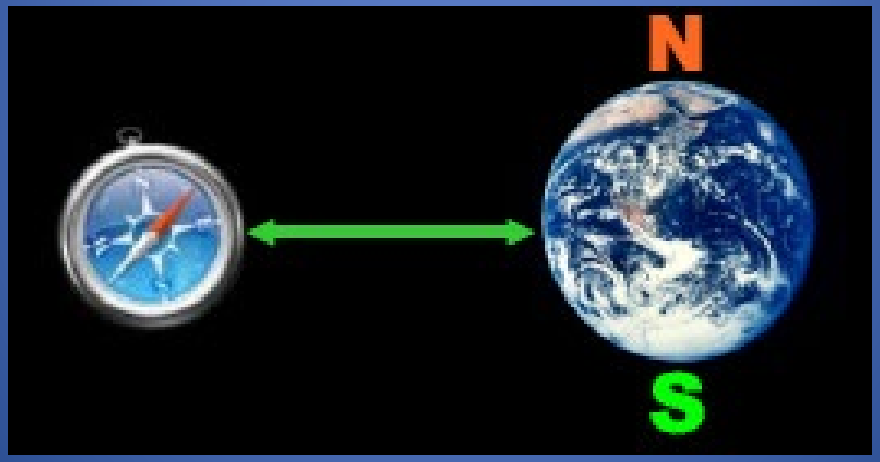


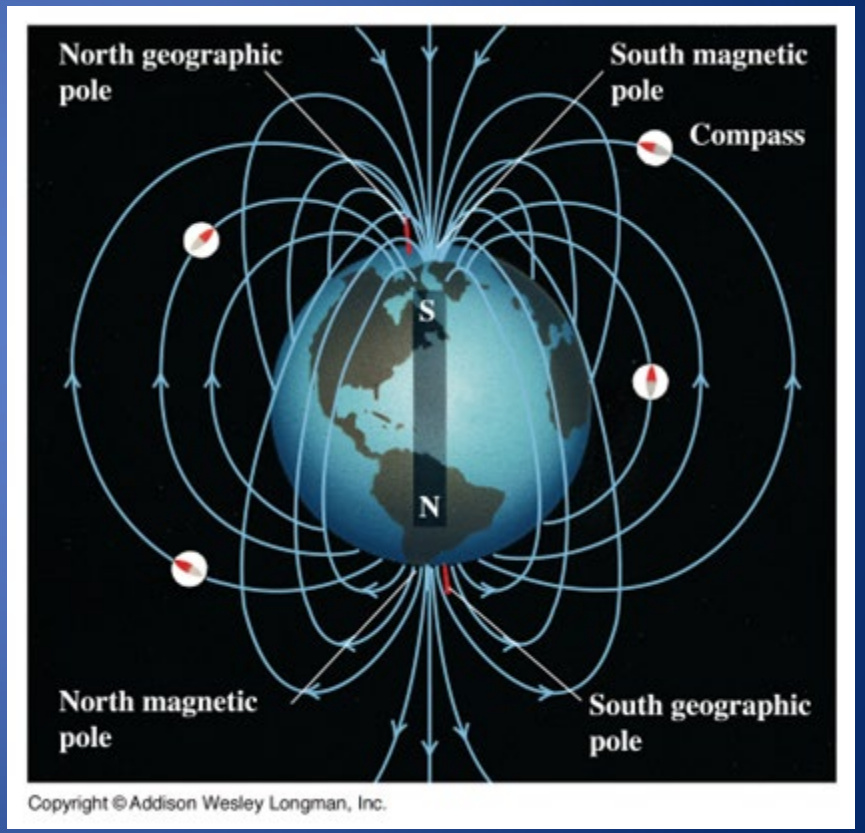
# Hey, wait a second!!!

- Don't compasses point towards the north pole?



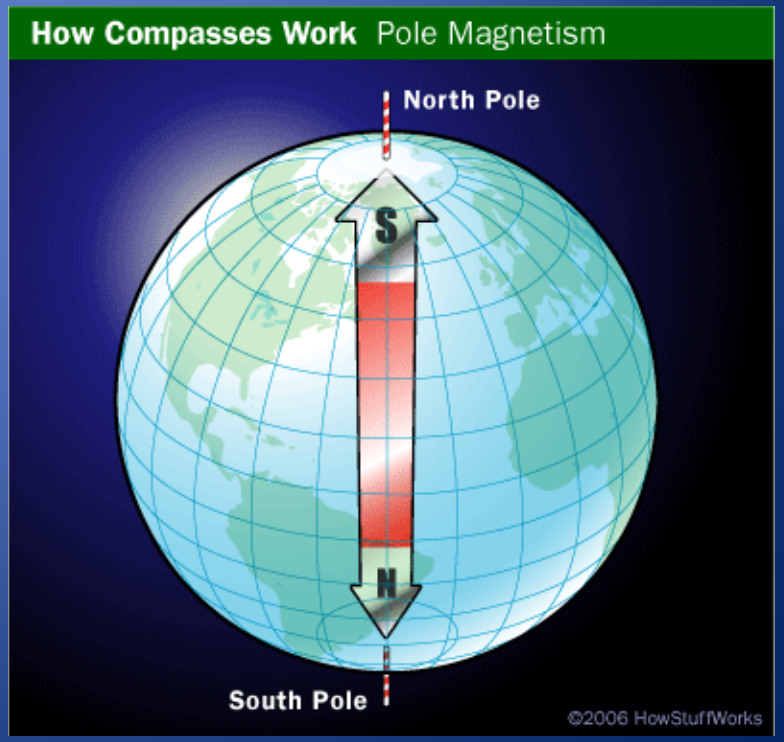
# Explanation

- Actually… The Earth affects compasses because it acts like a large bar magnet, producing a B-field.
- However, the magnet has a south magnetic pole where we have a north geographic pole.

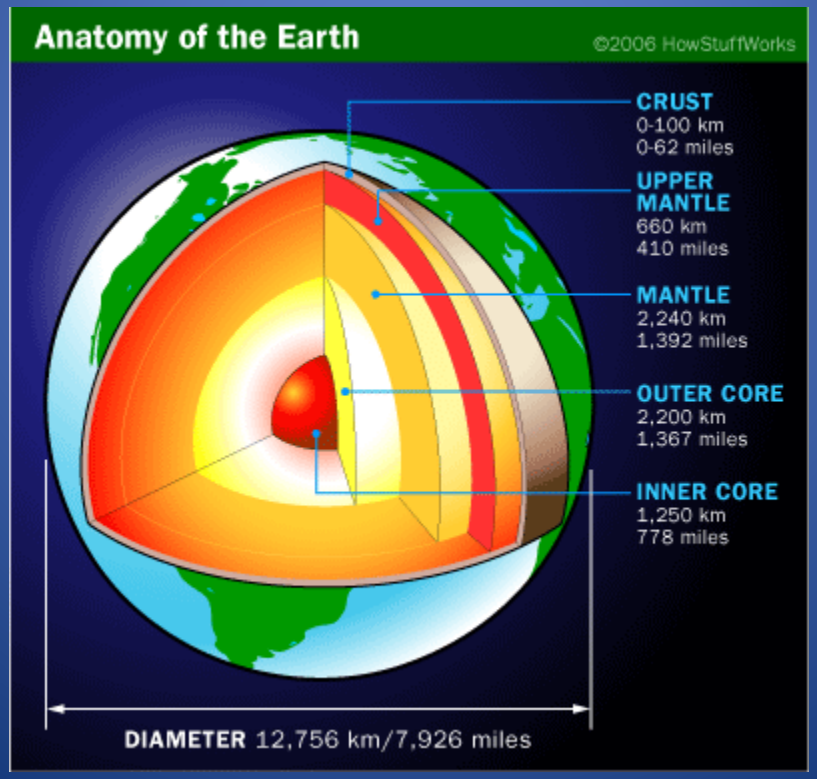


- **As the north poles of magnets point towards geographic north, it only makes sense that geographic north is actually magnetic south.**

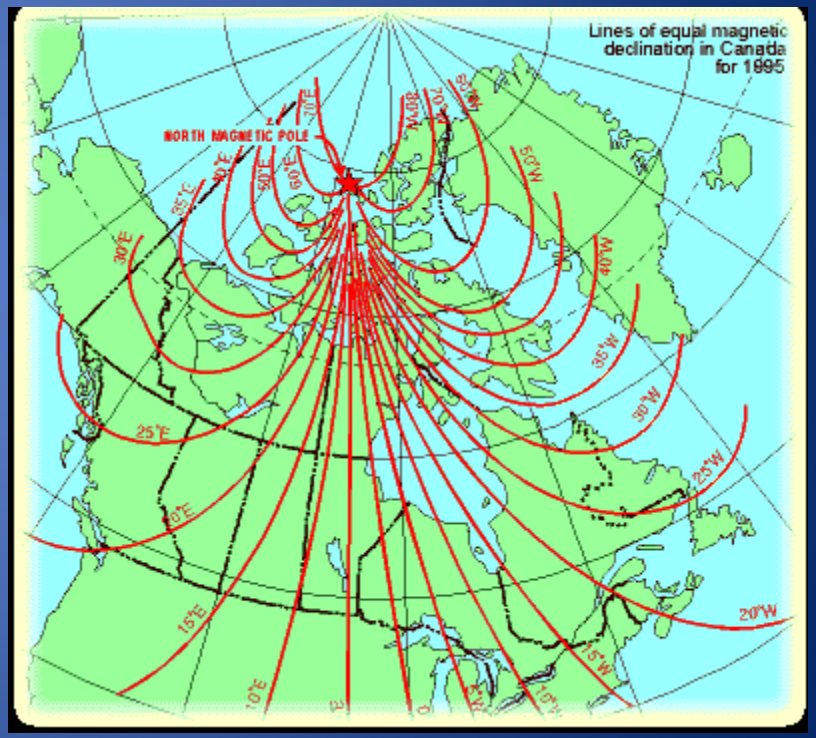
**So, why is the Earth a magnet anyways?**



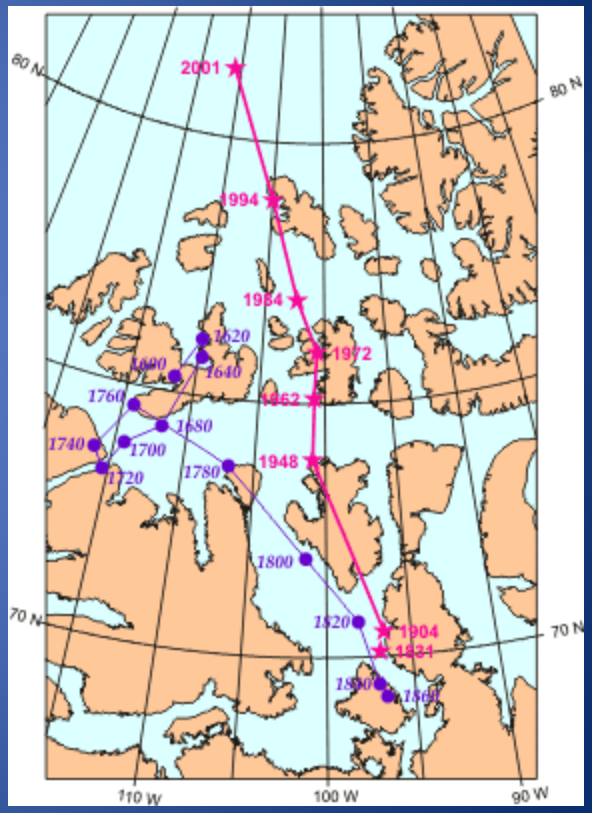
- No one is certain...but it could be because of
- rotating molten iron in the Earth's core.



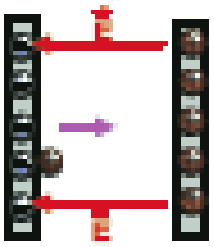
- To make matters worse...
- The south magnetic pole doesn't even line up with the north geographic pole.
- The south magnetic pole is actually located about 1500 km S of the north geographic pole, in the Baffin Islands.
- To make up for this, cartographers use angles of declination (about 12˚ W for NYC, the amount GN is from MS.)

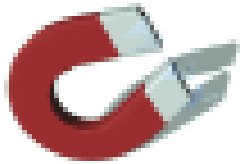


- And to make things even worse...
- The poles are not even fixed! They are constantly moving and flip every 10 000 years or so.
- Interesting!



# Comparing Fields

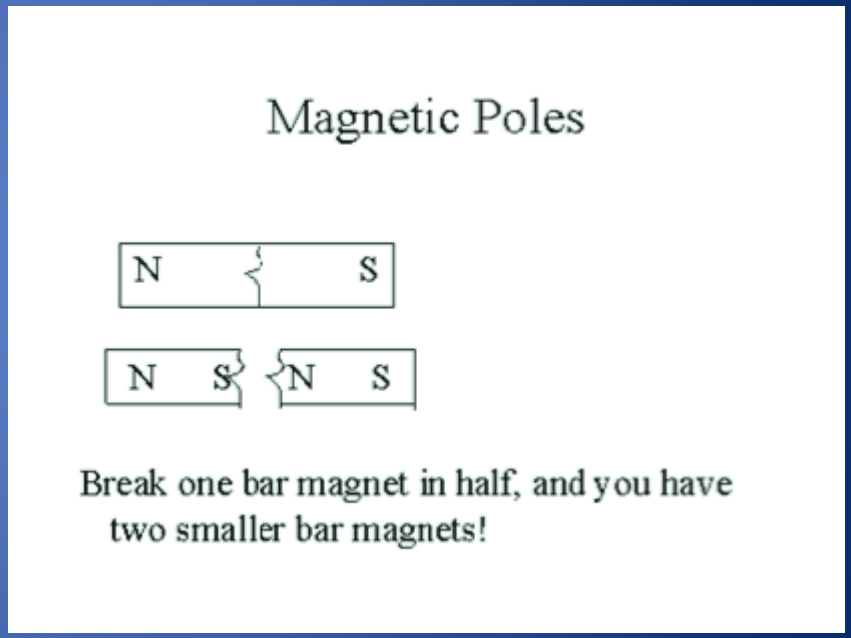




- **Gravitational Fields:**
  - Move towards the centre of objects (often the earth)
- **Electric Fields:**
  - Move in the direction a +ive test charge would go from + to - charge
- **Magnetic Fields:**
  - Move in the direction a test compass would point go from N to S poles

# Magnetic Monopoles

- Unlike electric charges (positive and negative), magnetic poles can't be separated (into a monopole).
- Breaking a bar magnet in two results in two similar magnets.
- Both north and south poles attract common magnetic metals.



- **European Centre for Nuclear Research (CERN) in Switzerland becomes operational in May 2008**
- **MOEDAL (monopole and exotic object detector)**
- **“The discovery of a monopole would be a revolution which wouldn't only affect high level physics, but would even affect basic physics and our good old Physics 101 textbooks.”**

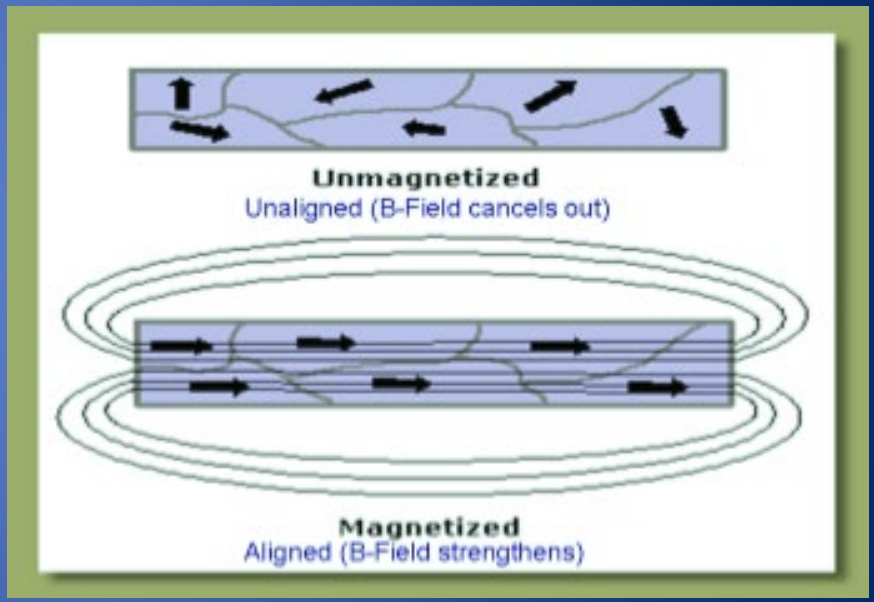
**Dr. James Pinfold**

# So, what causes magnetism anyways?


- On the subatomic level, it has to do with the way electrons spin.
- Paired electrons spin, creating magnetic domains.

# Magnetic Domains

- In most materials, the domains are out of alignment.
- In magnets, the domains are aligned. This causes a magnetic field to be produced.
- Hmm...moving electrons produce a B-field?



- This effect is very noticeable in ferromagnetic materials such as iron, nickel or cobalt.
- If another element is added to this material, the effect can be made permanent, producing a permanent magnet.
- ex) ALNICO magnets.