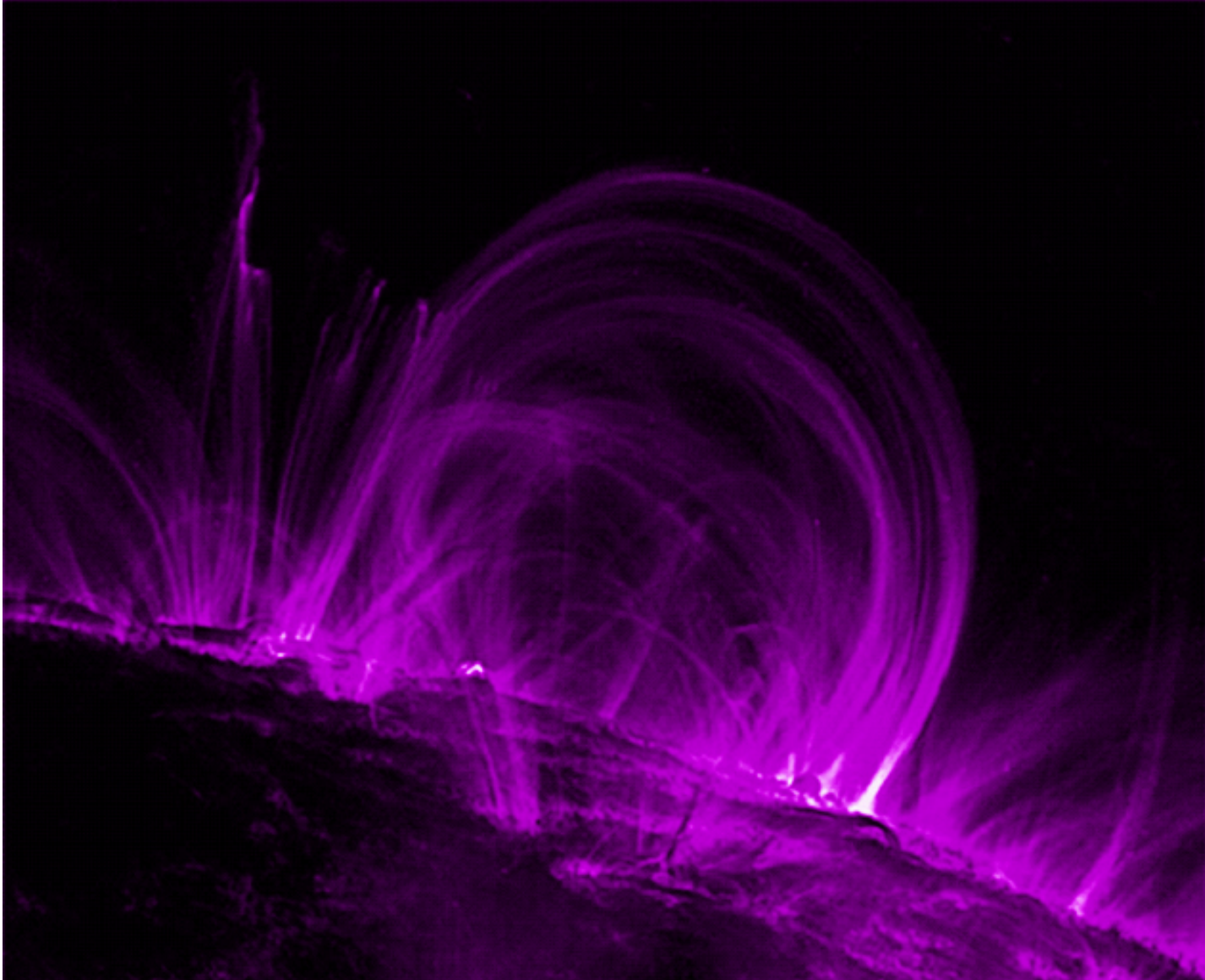
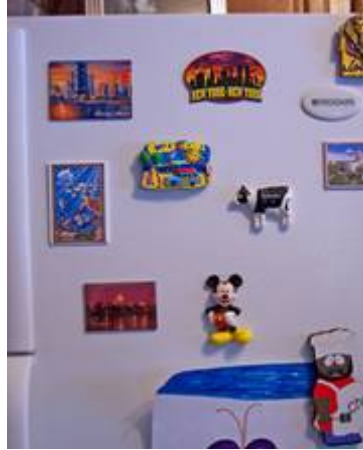


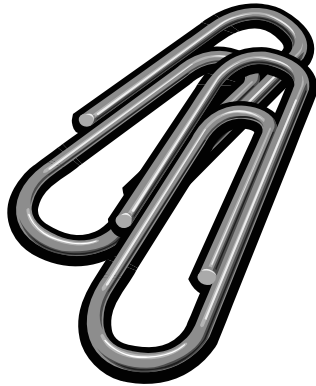
EXPLORING MAGNETISM



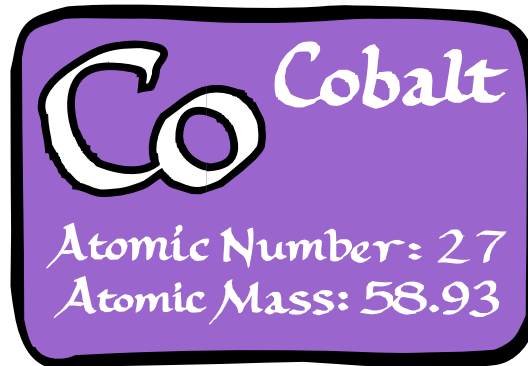
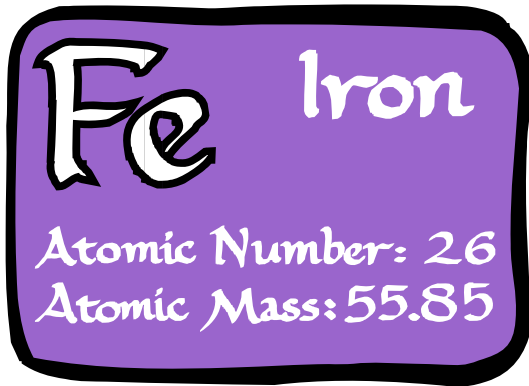
What is a Magnet?



What Materials are Magnetic?

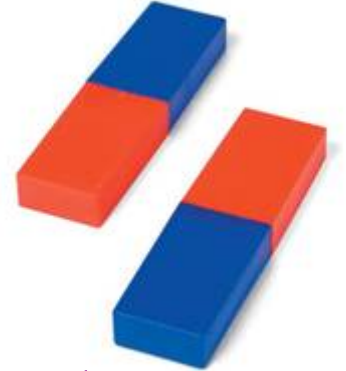


What Materials are Magnetic?



What Do Magnets Do?

- ✓ Attract or repel other magnets (exert a force)
- ✓ Attract other magnetic metals
- ✓ Have at least 2 distinct ends (poles) each



Like poles repel, opposite poles attract

Notes:

- Do not need to touch to exert force (can exert force through empty space)
- Can turn other magnetic metal objects into temporary magnets

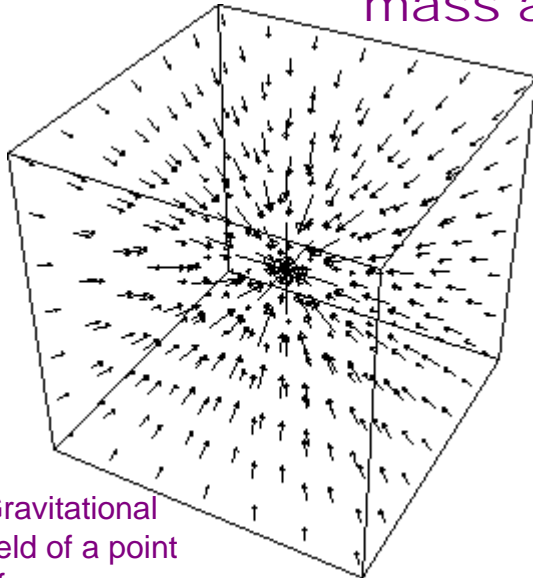
What is a Force?

Force is a push or pull that causes a change in motion.

A Force Field is the pattern in space of how that force is felt by other objects.

Fundamental Forces arise from fundamental properties of matter:

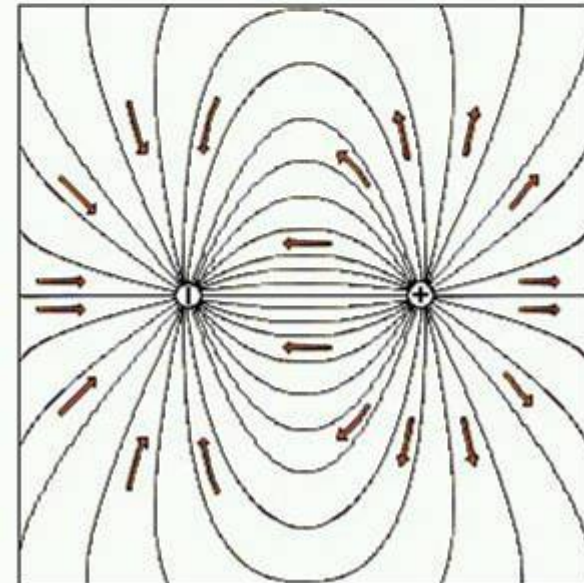
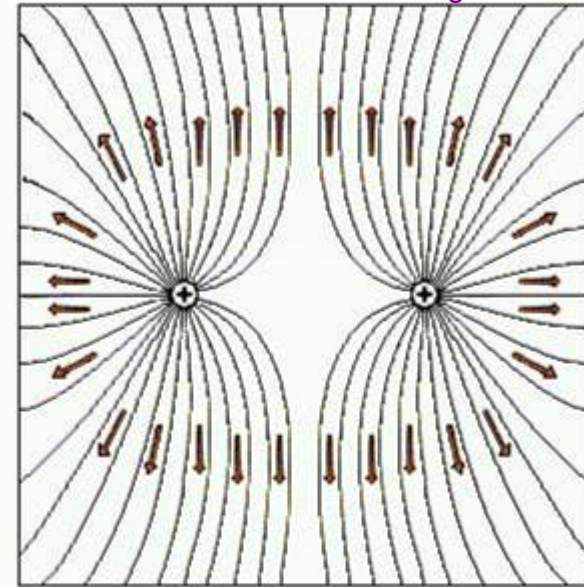
Gravity arise from Mass:
mass attracts mass



Gravitational field of a point of mass

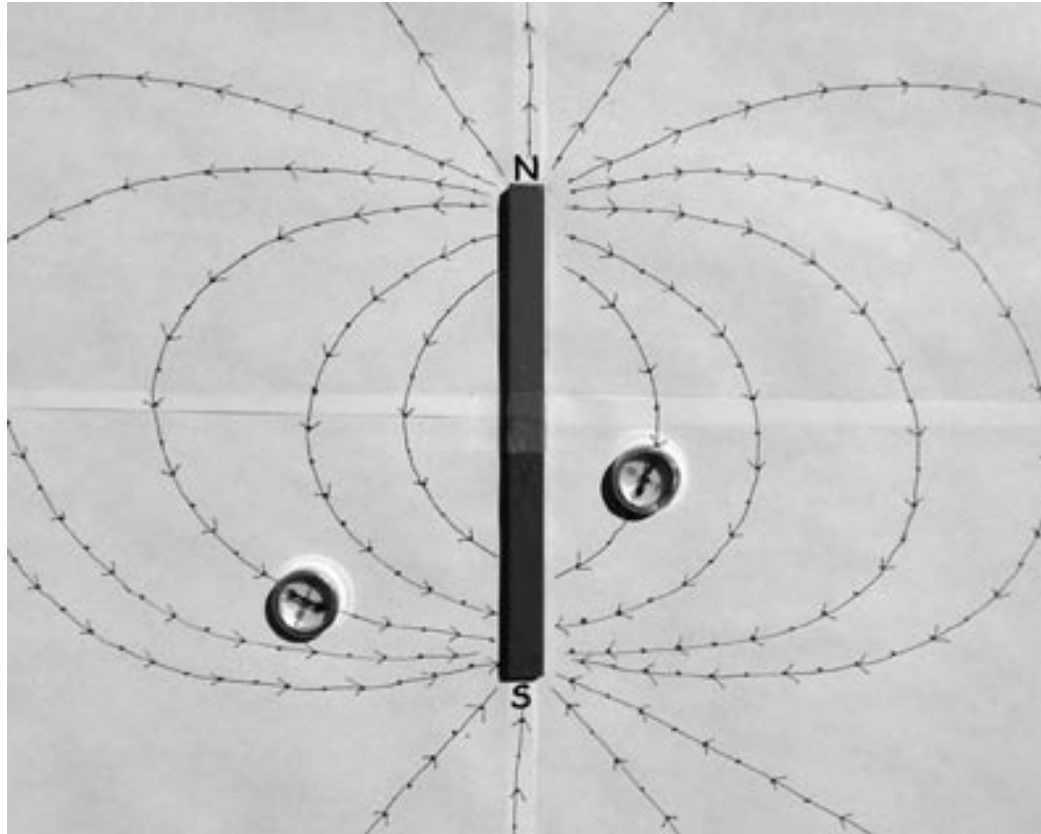
Electric force arises from Charge: two kinds of charge (positive and negative), like charges repel and opposite charges attract

Electric field of 2 like charges



Electric field of 2 opposite charges

Magnetic Field



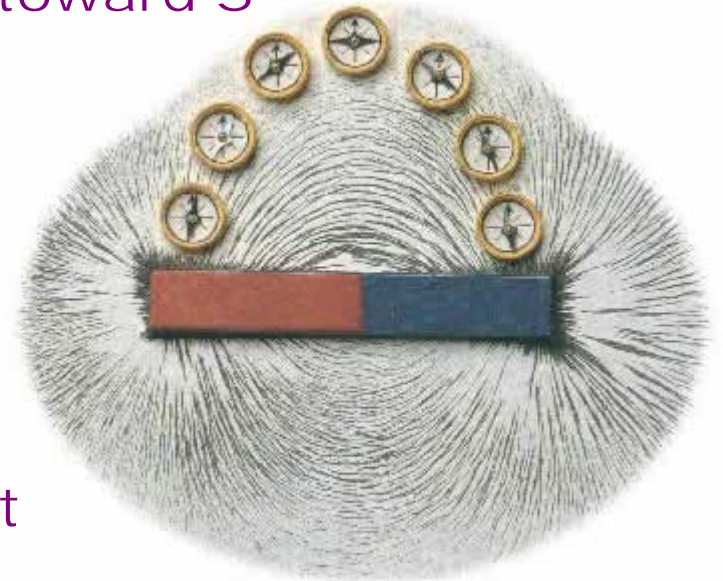
Magnetic field of a Bar Magnet: 2 poles, called North and South

Dipole field

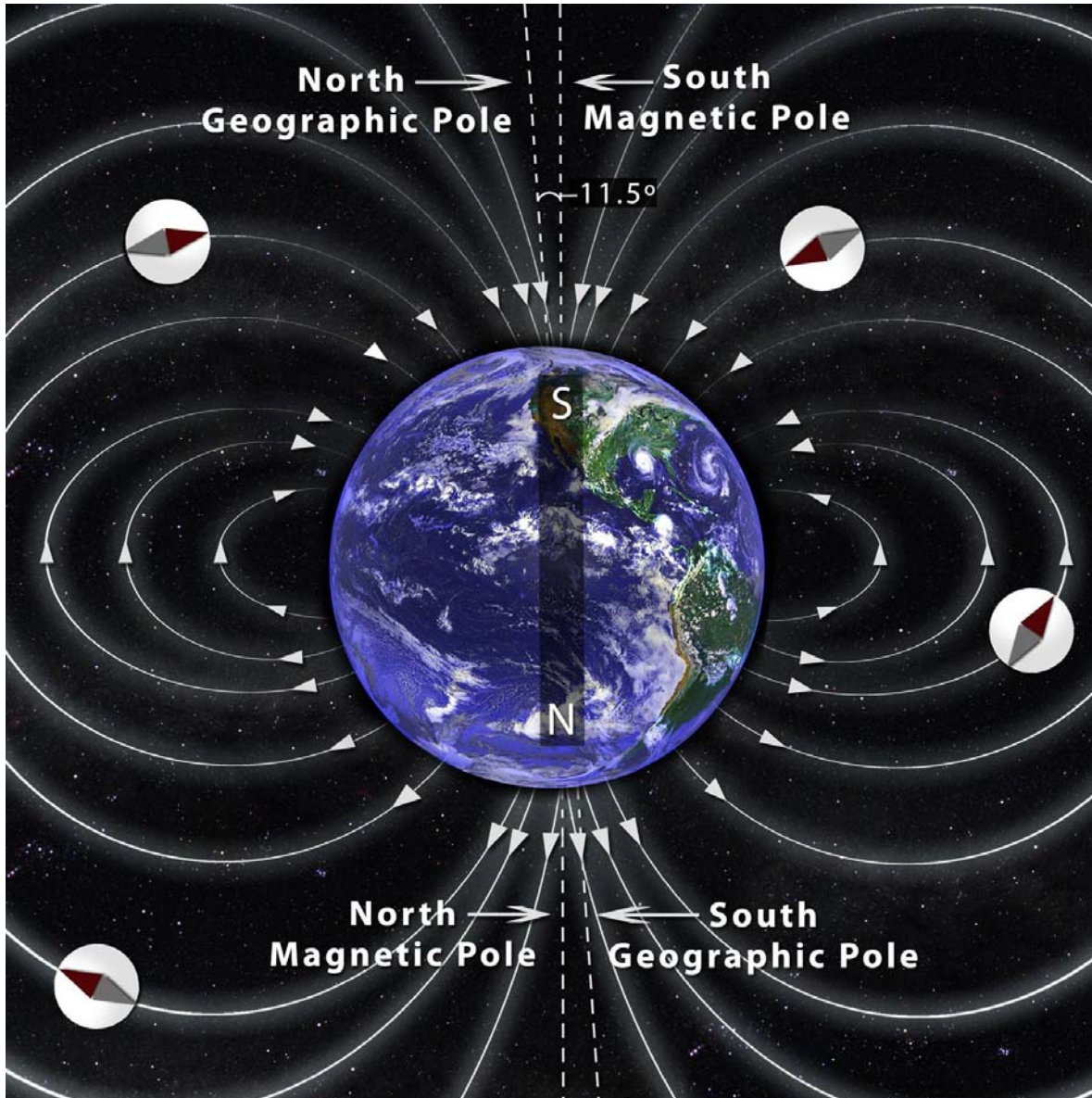
Field has direction: lines point away from N and toward S

Definition of a Pole: Where lines meet (converge)

e.g.: lines of longitude on a globe meet at poles



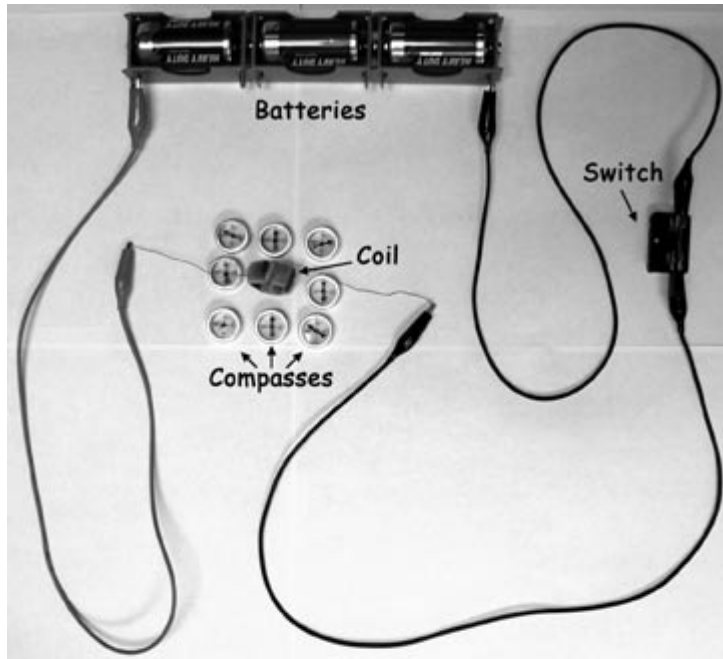
Earth: A Huge Bar Magnet



Moving molten iron in Earth's outer core causes most of Earth's magnetic field.

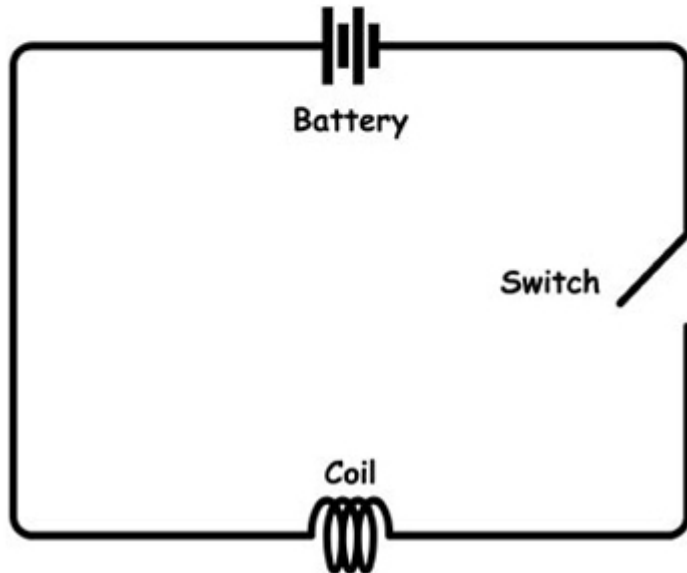
Magnetic field poles are NOT aligned with geographic poles. They also wander and flip (500,000 yrs between flips, 10,000 yrs to complete flip).

Electricity and Magnetism



Electric Current (Electricity) is moving charge.

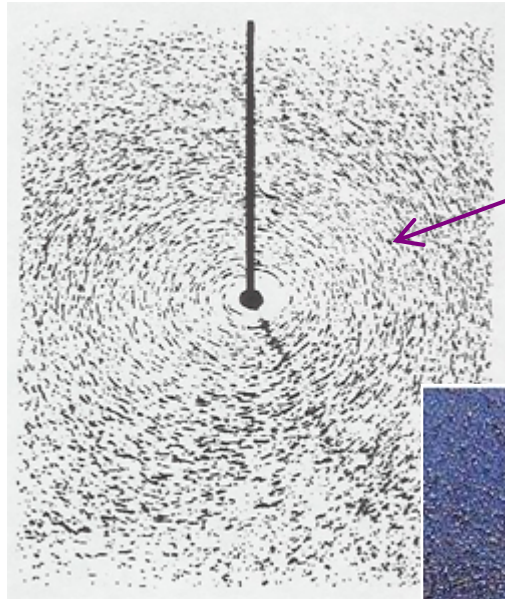
In an electric circuit, batteries provide an electric field to push charges through a wire, which provides a path for them to flow. Unless there is a complete circuit the charges cannot flow.



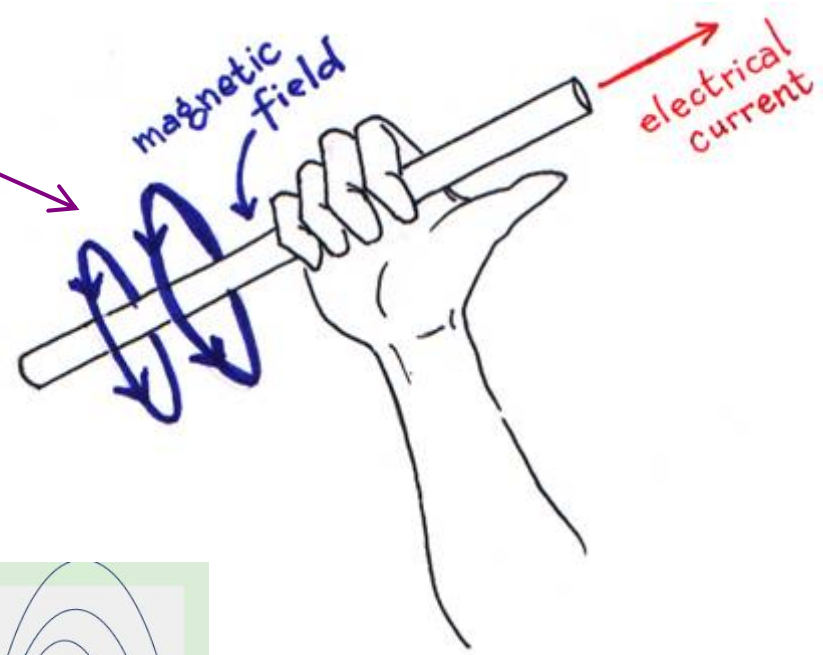
Compasses around a circuit with flowing electric current detect a magnetic field.

Magnets can push or pull on a wire with current flowing through it.

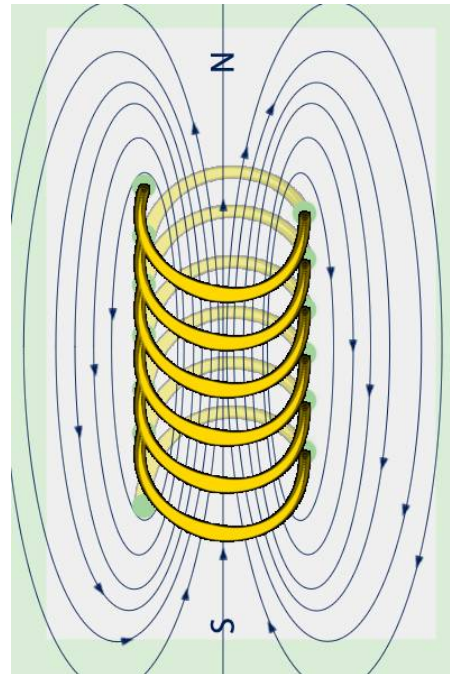
Electricity and Magnetism



The shape of the magnetic field around a long, straight wire carrying electric current

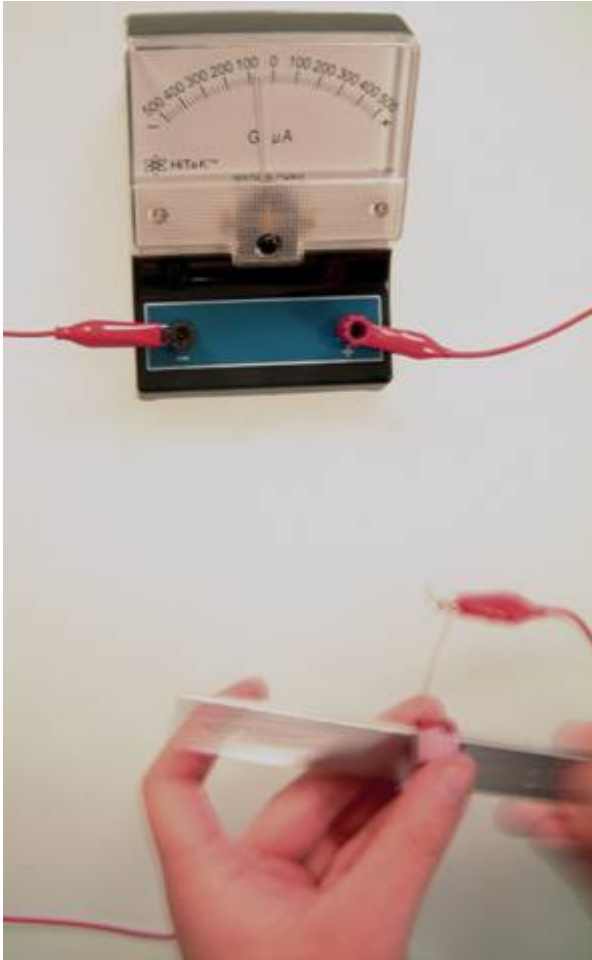


Looping the wire turns the magnetic field into a toroidal (donut) shape.



Many loops in a solenoid shape creates a dipole-shaped magnetic field, similar to that of a bar magnet

Electricity and Magnetism



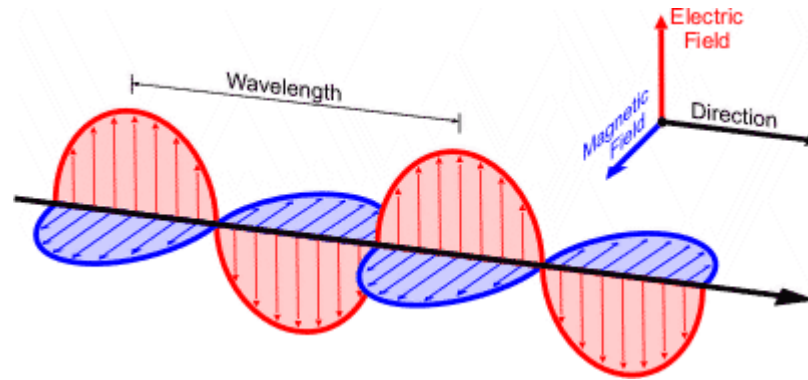
A dynamic electric field creates a magnetic field.

A dynamic magnetic field creates an electric field.

The basic principle behind electric generators is creating relative motion between a magnet and a wire to create an electric field that will push current through a circuit.

Converts kinetic energy into electric energy.

Electromagnetic Radiation



A dynamic electric field creates a magnetic field.

A dynamic magnetic field creates an electric field.

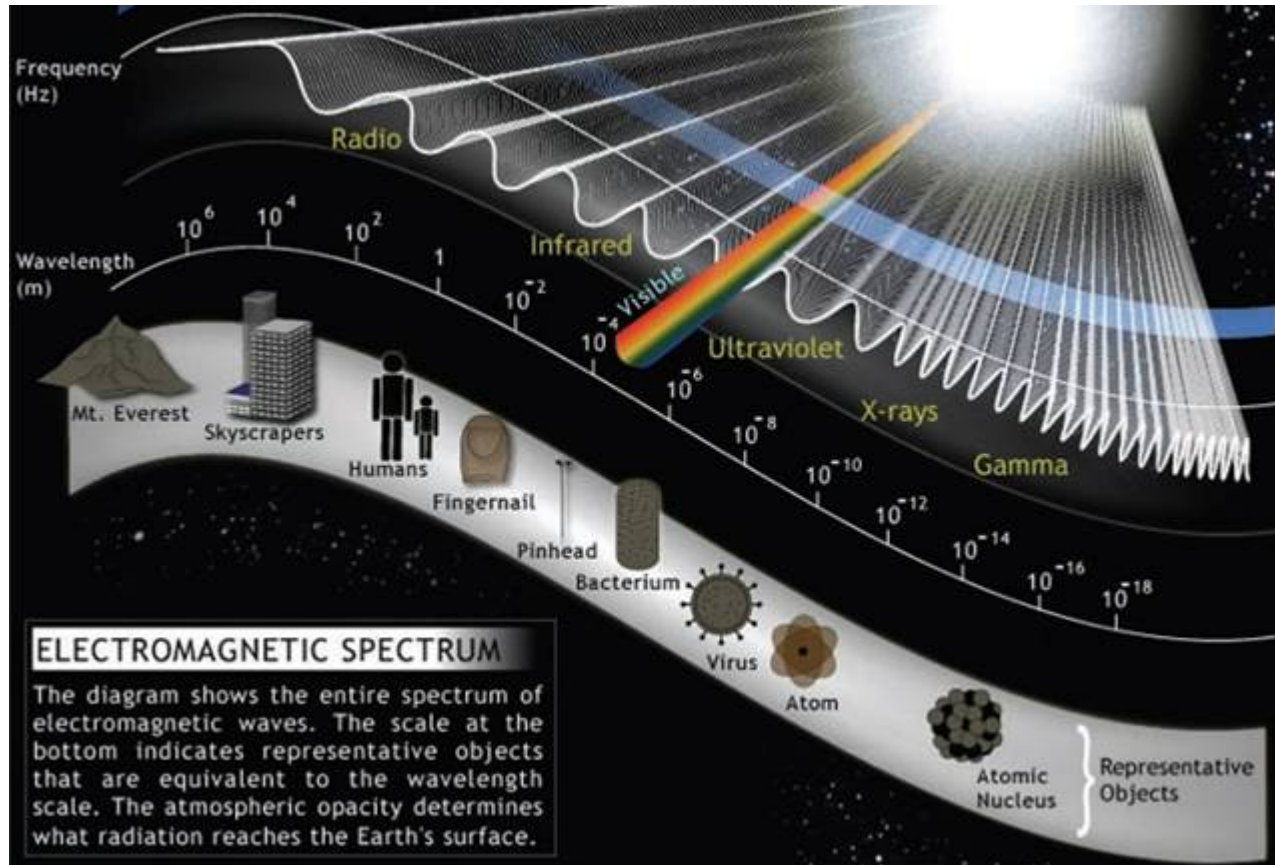
Wiggle a charge and it will create waves in the electric field around it. Those electric field waves will create magnetic field waves, which in turn create more electric field waves, ...

Wiggle a magnet and the same thing happens, just the first waves are in the magnetic field.

Electromagnetic Radiation

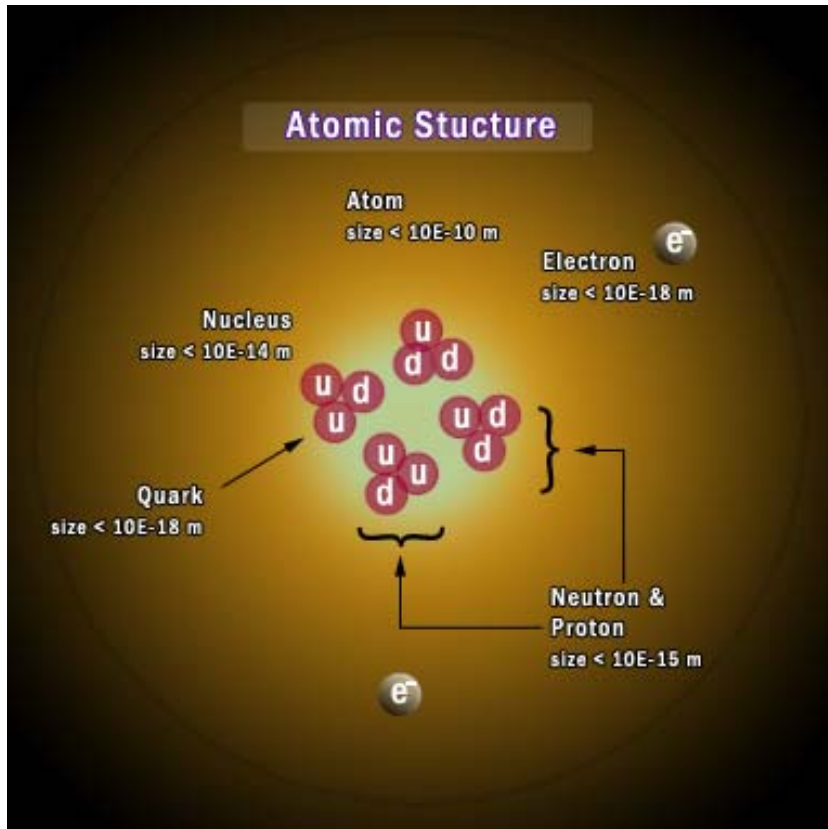
Electromagnetic waves travel through empty space at a speed of 300,000 km/s (186,000 miles/sec).

EM waves with wavelengths 400-700 nm are seen by the human eye as **Visible Light**.



Current in a Magnet?

What causes magnetism in a magnet?



Atoms are the basic building blocks of the Elements. They are neutrally charged, but composed of smaller charged particles:

Quarks - combine to form neutrally charged **neutrons** and positively charged **protons** in the *nucleus*
Electrons – negatively charged particles that orbit the nucleus in variously shaped “shells” or energy levels.

Electrons' orbital motion as well as quantum mechanical spin produce an electric current and hence a magnetic field in the atom.

Current in a Magnet?

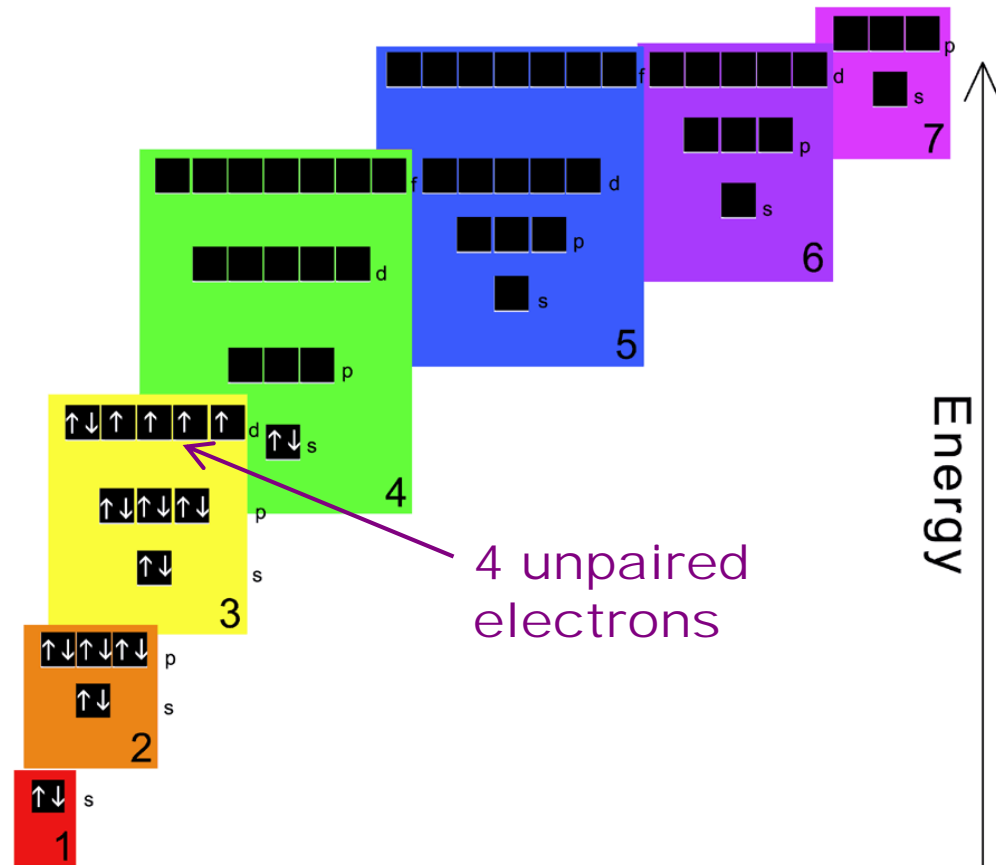
What causes magnetism in a magnet?

In most atoms, the magnetic fields generated by each electron cancel each other out.

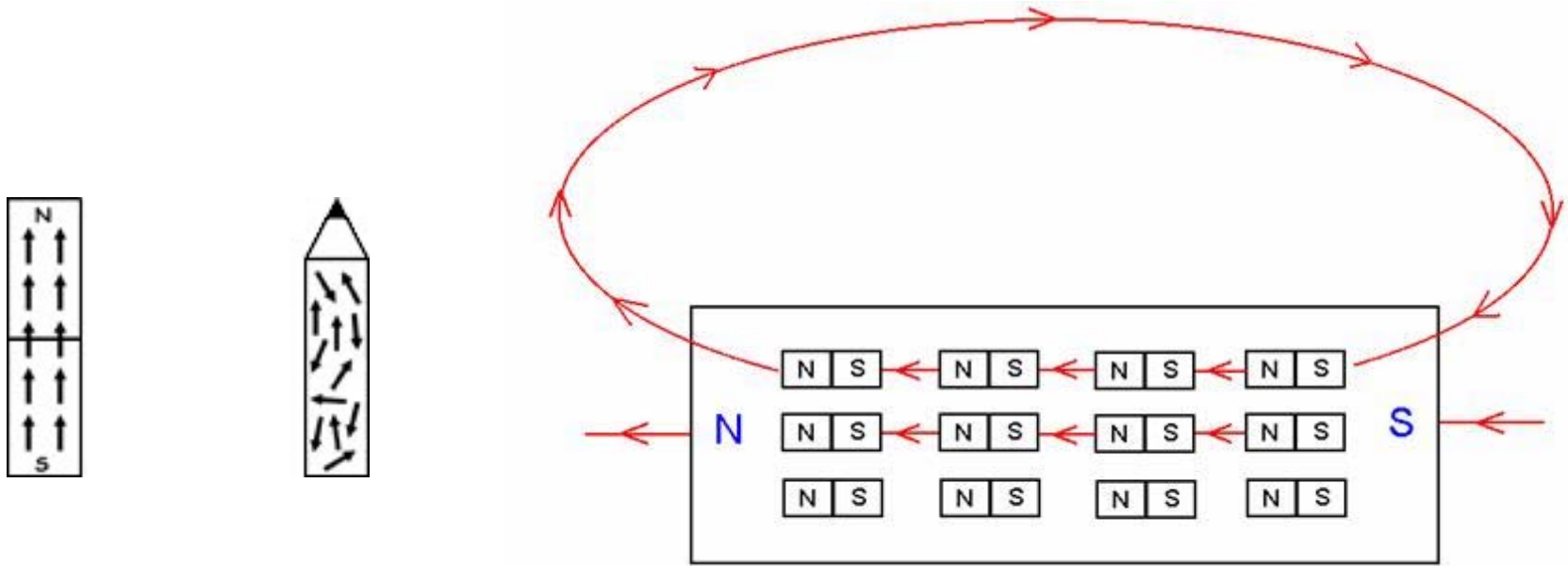
In an atom two electrons can pair up and occupy an energy level, but their spins are opposite of each other, canceling their magnetic field.

But in a few atoms (like Fe, Co, and Ni) there are unpaired electrons in different energy levels whose spins can align and give the atoms an overall magnetic field.

Electron Structure of Iron



Magnetism in a Magnet



When elements like Fe form solids, they form crystalline structures with little domains of many, many atoms all aligned. Each domain is like a mini-bar magnet. When all the domains are allowed to align, the whole object takes on a large-scale magnetic field.