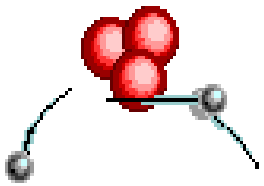
Electricity and Magnetism

Electricity

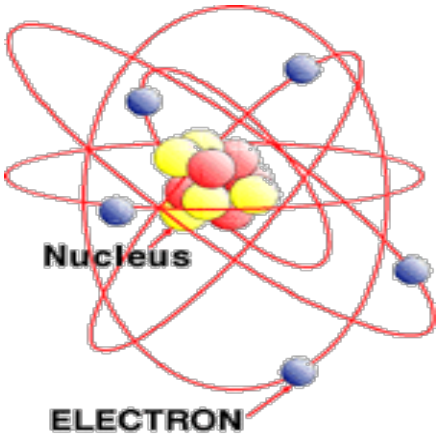
Calendar from 1938 with "Reddy Kilowatt" - the electric industry's mascot. Picture credit: corbis.com

"Electricity" came from the Greek words "elektor," for "beaming sun" and "elektron," both words describing amber. Amber is fossilized tree sap millions of years old and has hardened as hard as a stone.



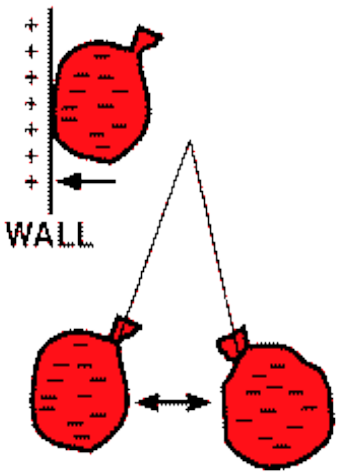
All matter is made up of atoms.
Atoms are made up of three smaller particles --the proton, the neutron and the electron.

Electrons spin around the center, or nucleus.



The nucleus is made up of neutrons and protons.

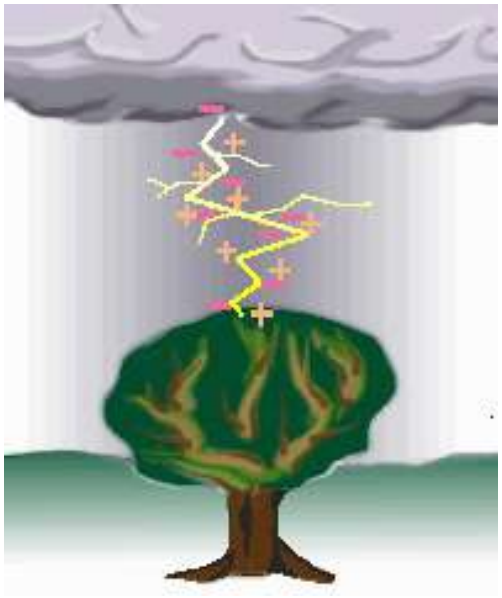
Electrons (-) contain a negative charge.
Protons (+) contain a positive charge.
Neutrons are neutral. They have neither a positive nor a negative charge.



<u>Static electricity</u> is the imbalance of positive and negative charges.

Like charges repel and unlike charges attract.

When you take off a wool hat, it rubs against your hair. Electrons move from your hair to the hat. Now each hair has the same positive charge. The hairs try to get as far from each other as possible. The farthest they can get is by standing up and away from the others.



Lightning is a big

spark...static electricity

on a **giant** scale.

Clouds get their charges as water and ice particles move and interact. Smaller, positively charged particles rise to the top of the cloud and larger, negatively charged particles gather at the bottom. When the buildup of charge is great enough, the oppositely charged particles attract and discharge their energy as a bolt of lightning.

When we charge something with static electricity, no electrons are made or destroyed. No new protons appear or disappear. Electrons are just moved from one place to another. The net, or total, electric charge stays the same. This is called the **principle of conservation of charge**.

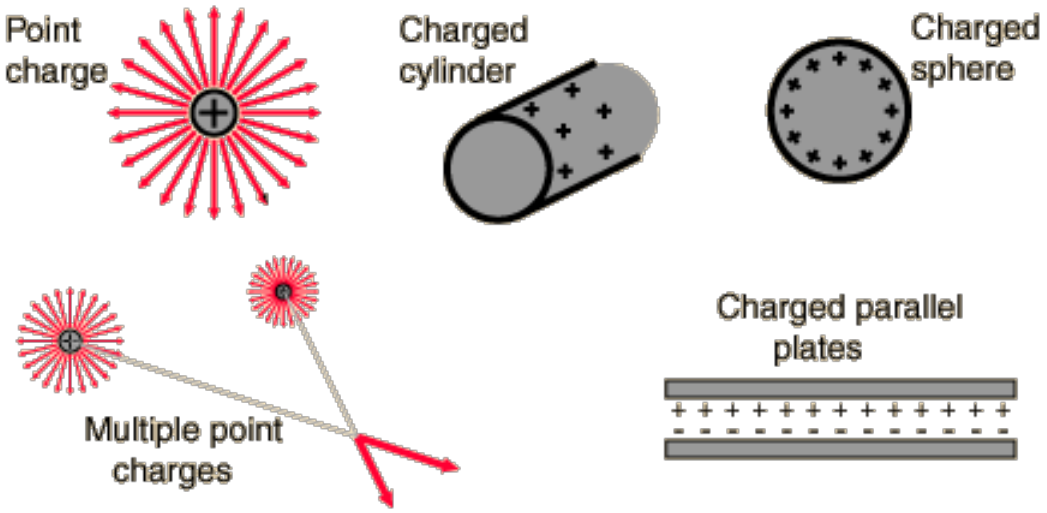
Two atoms were walking down the street one day, when one of them exclaimed, "Oh, no I've lost an electron!"

"Are you sure?" the other one asked.

"Yes," replied the first one, ***"I'm positive."***

Electric Field

Electric field is defined as the electric force per unit charge. The direction of the field is taken to be the direction of the force it would exert on a positive test charge. The electric field is radiating outward from a positive charge and radiating in toward a negative point charge.



What is near the Geographic North Pole, a Magnetic North or a Magnetic South?

Allow a bar magnet to swing freely on a string. The end that points towards the geographic north pole is called the north seeking pole of the magnet. It is labeled "N" since it is the North magnetic pole of the magnet. Its opposite end is labeled "S" for South magnetic pole. This is the convention used to determine the "N" or North end of a magnet.

Like poles repel each other and unlike poles attract each other.

Thus, the magnetic field created by the molten core of the earth must have a magnetic South pole near the geographic north pole in order to attract the "N" end of our bar magnet and compass needles. This pole near the geographic north pole is sometimes called the geomagnetic north pole.

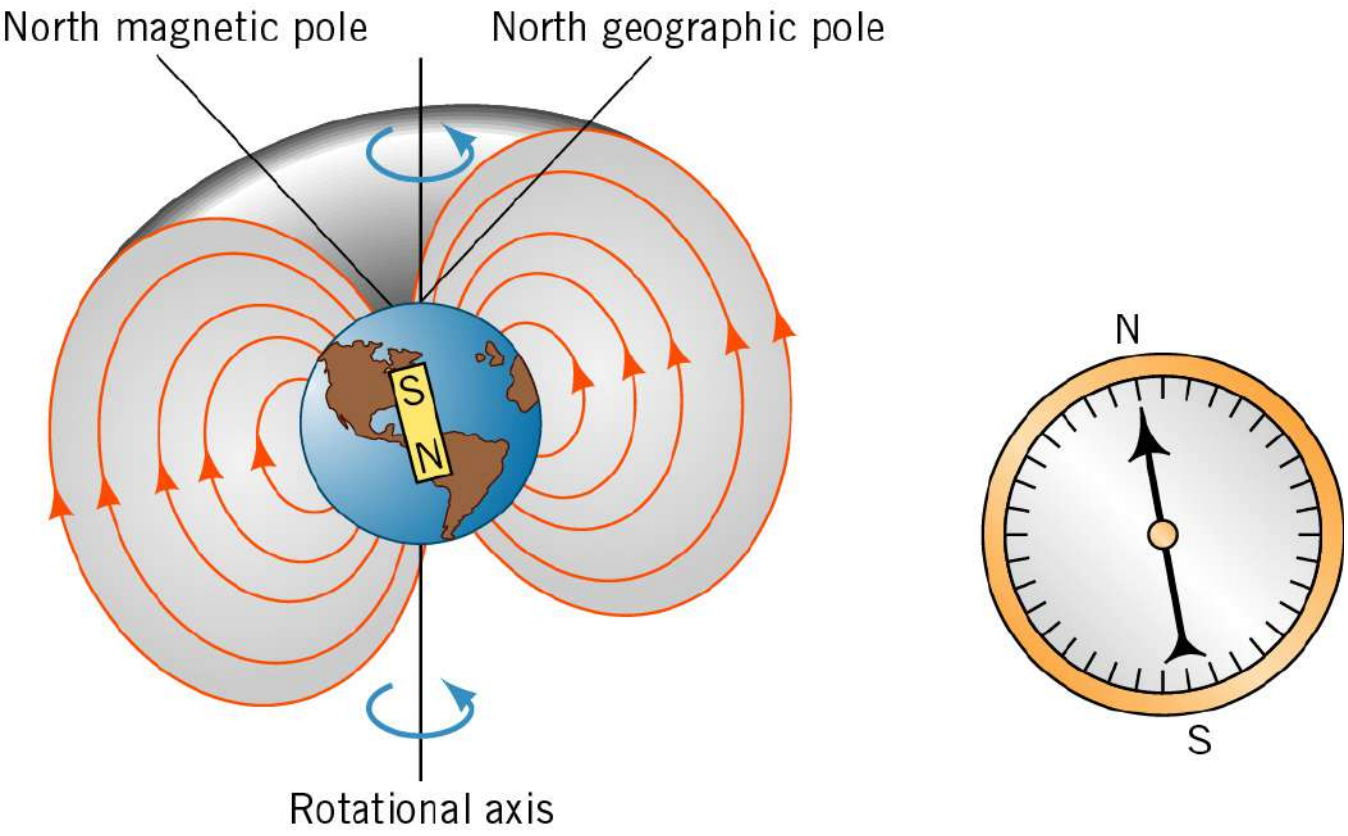
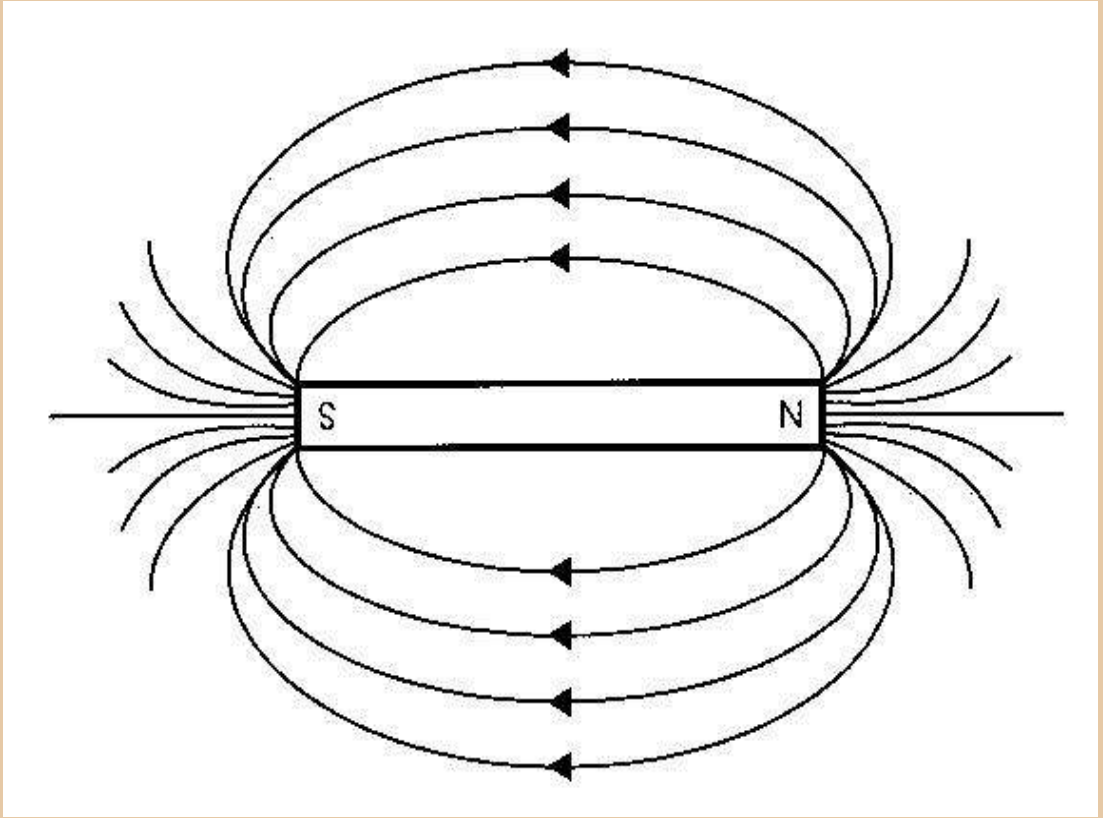


Figure 5-3

A compass needle and the Earth. Any magnet will twist because of the forces between its poles and and those of the Earth. Every magnet has at least two poles.

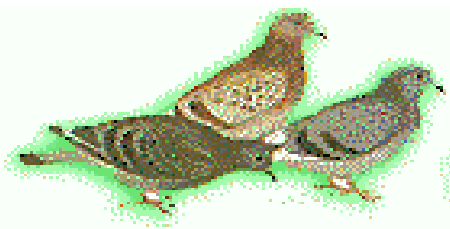
Magnetic Field

Collection of lines that map the directions that compass needles would point.

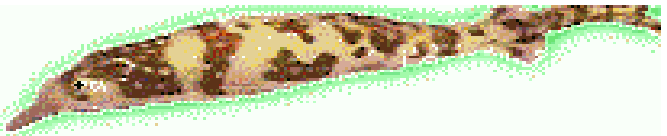


Dipole Field

There are no isolated magnetic poles in nature.



animal magnetism



Crystals of magnetite have been found in magnetic-sensitive bacteria and in the brains of some animals, including homing pigeons.

Magnetite is a form of iron oxide which, under the name lodestone, was used for primitive compasses by mariners as early as the twelfth century.

Courtesy Jerry Ohlinger's Movie Material Store

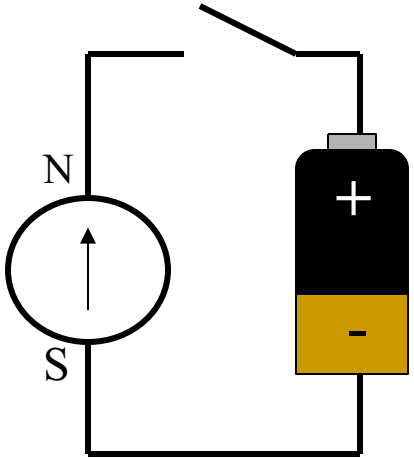
Luigi Galvani induced convulsive twitching in amputated frog legs with an electric spark. Alessandro Volta said they were from chemical reactions.

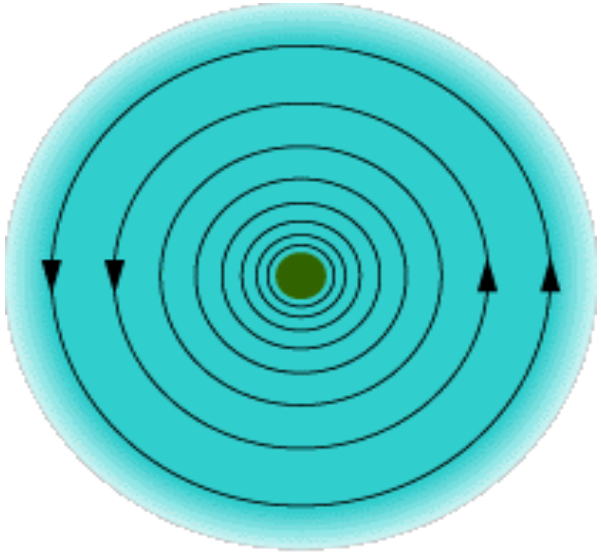
Electric Current

Electric current is the flow of charged particles.

Magnetic fields can be created by motions of electrical charges.

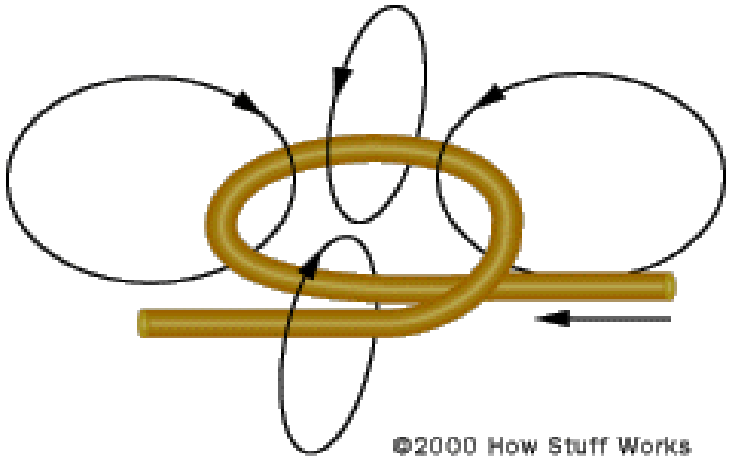
Volta's work on chemical reactions led to the development of the battery.





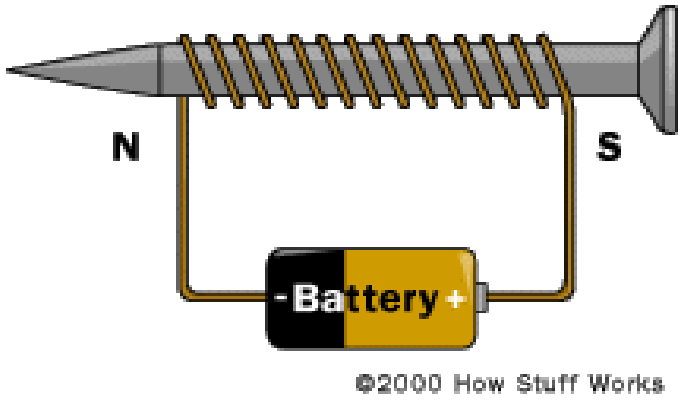
The green circle in the figure is the cross-section of the wire itself. A **circular magnetic field** develops around the wire, as shown by the circular lines. The field weakens as you move away from the wire.

An easy way to amplify the wire's magnetic field is to **coil** the wire.



A Simple Electromagnet

If you wrap wire around a nail 10 times, connect the wire to the battery and bring one end of the nail near the compass, you will find that it has a much larger effect on the compass.



The nail behaves just like a bar magnet.

An Electric Motor

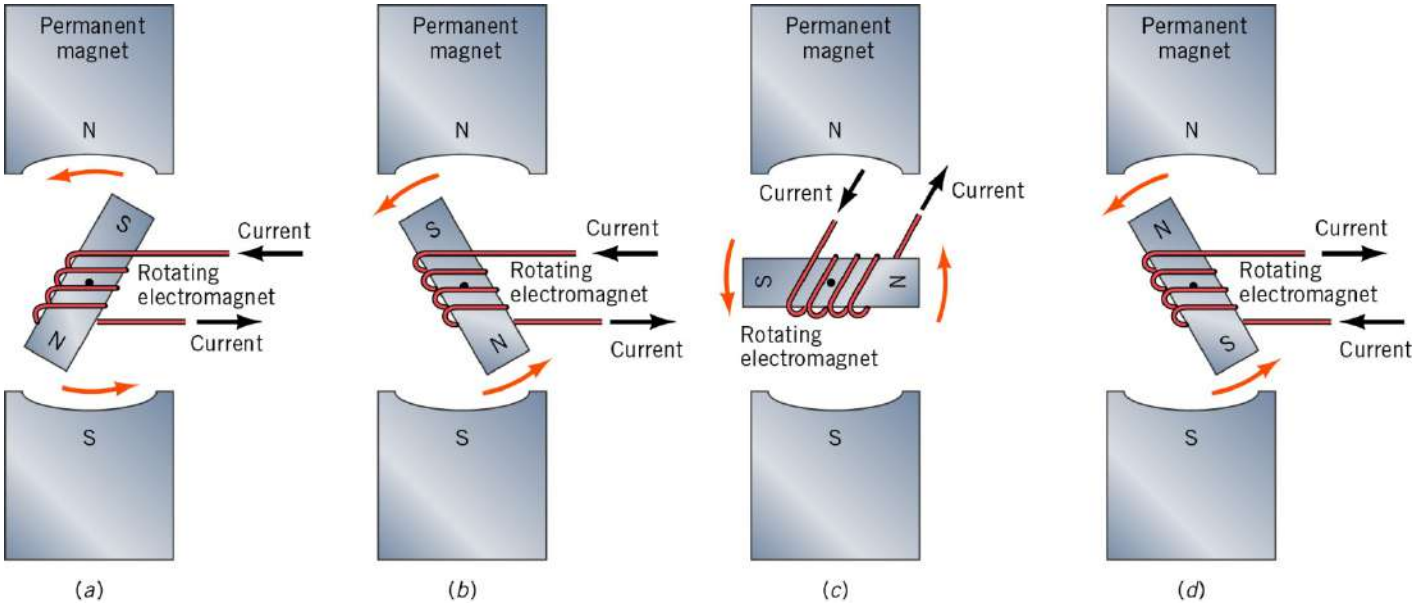
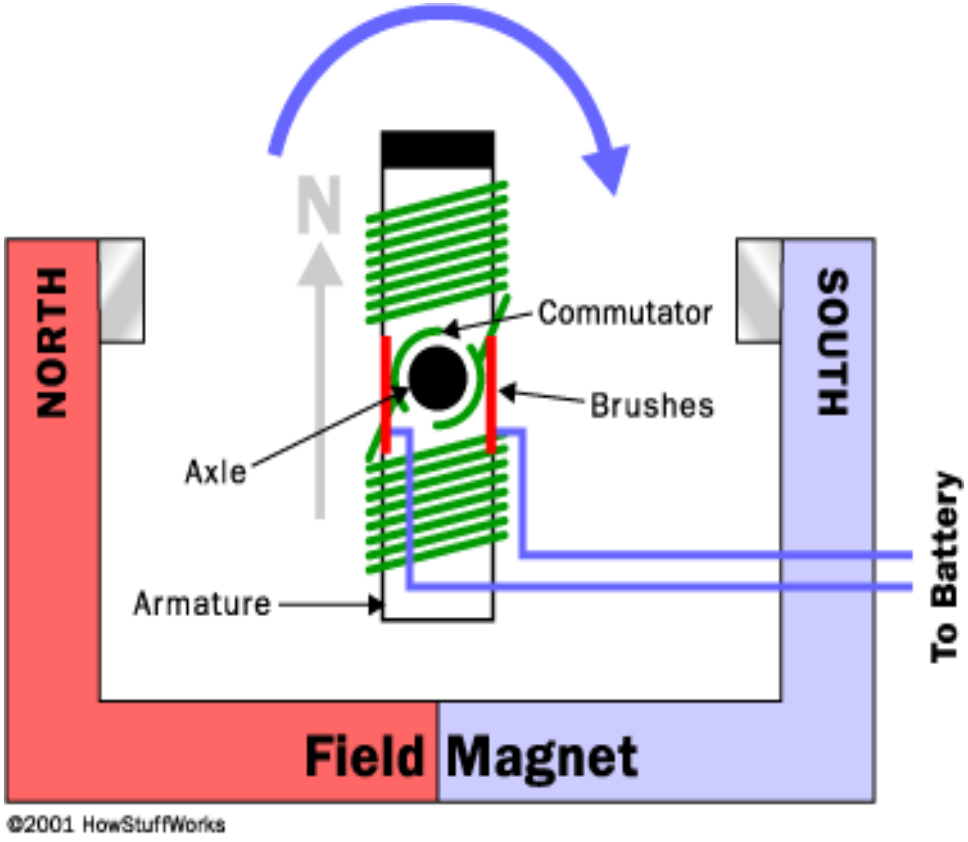


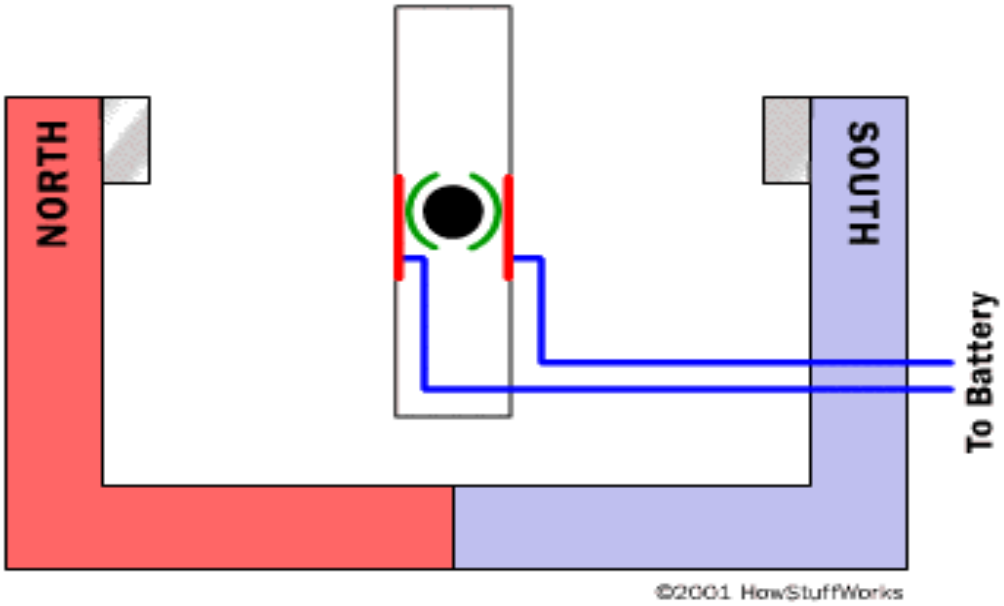
Figure 5-8
The simplest motors work by placing an electromagnet that can rotate between two permanent magnets.
(*a*) When the current is turned on, the north and south poles of the electromagnet are attracted to the south and north poles of the permanent magnets. (*b*)–(*d*) As the electromagnet rotates, the current direction is switched, causing the electromagnet to continue rotating.

Electric Motor

- **Armature or rotor**
  - - Electromagnet
- **Commutator**
  - - These plates provide the two connections for the coil of the electromagnet.
- **Brushes**
  - -These are two pieces of springy metal or carbon that make contact with the contacts of the commutator.
- **Axle**
- **Field magnet**
- **DC power supply**

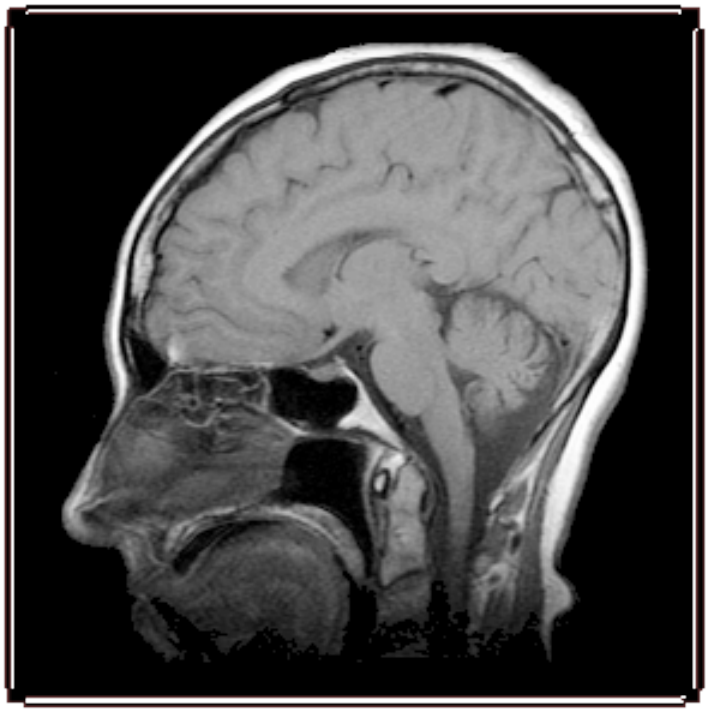


Motor in Action



As the armature (electromagnet) passes through the horizontal position, the poles of the electromagnet flip. Because of the flip, the north pole of the electromagnet is always above the axle so it can repel the field magnet's north pole and attract the field magnet's south pole.

Magnetic Resonance Imaging



The nucleus of most atoms can be pictured as microscopic dipole magnets. Magnetic resonance imaging (MRI) is an imaging technique used primarily in medical settings to produce high quality images of the inside of the human body. Magnetic resonance imaging is based on the absorption and emission of energy in the radio frequency range of the electromagnetic spectrum.