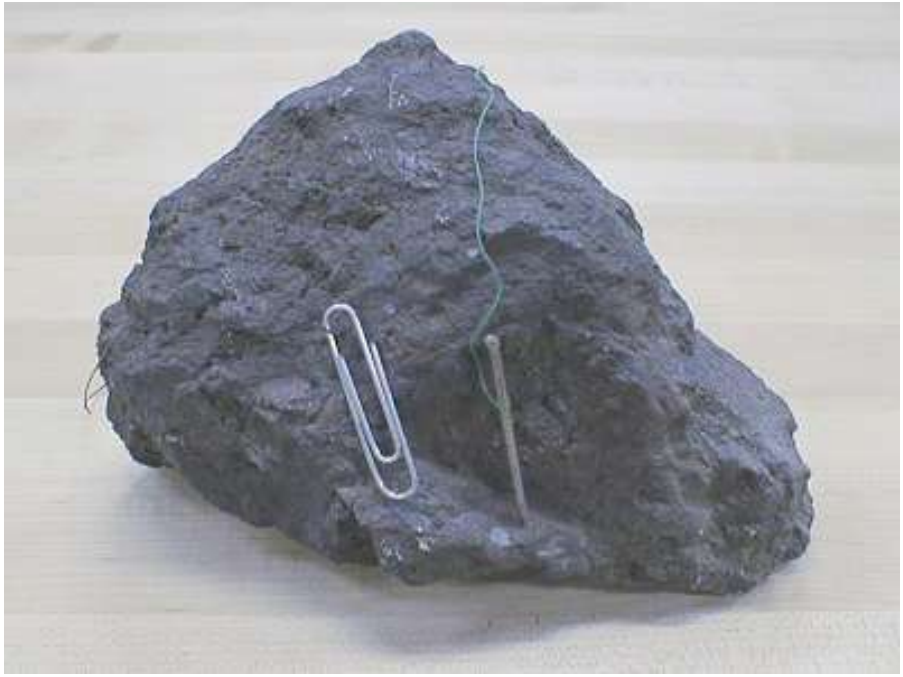
Permanent Magnets

12th C, Magnets first used in navigational compass, Chinese

magnetism

- Magnesia, province of Greece
- Unusual property of lodestone noted over 2000 years ago



16th C, William Gilbert

- “Every magnet has two poles, a north and a south.”
- “Like magnetic poles repel, unlike poles attract.”

Magnetic Poles

- The North pole of a magnet will point toward the earth's north pole
- south pole of a magnet will always point toward the Earth's south pole

MAGNETS

- **properties**

1. Polarized

   - North-seeking pole

   - South-seeking pole

2. Magnetic pole characteristics

   - two north poles or two south poles will repel

   Like poles repel

   - north pole and south pole will attract

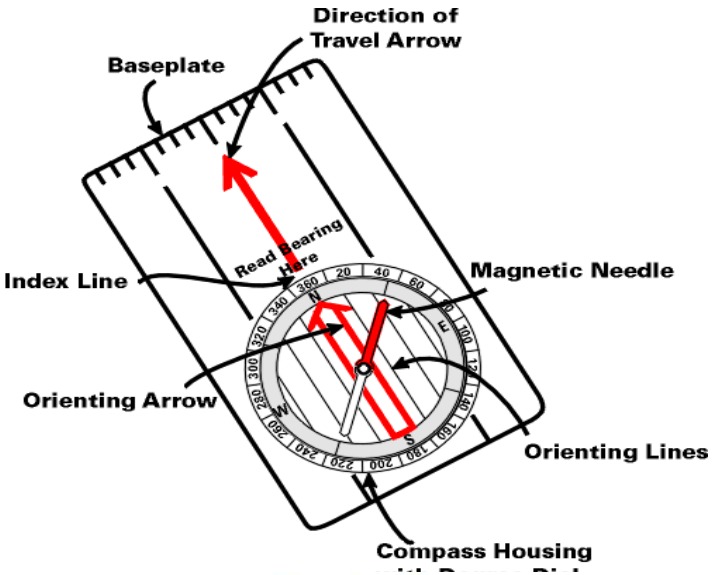
   Opposite poles attract

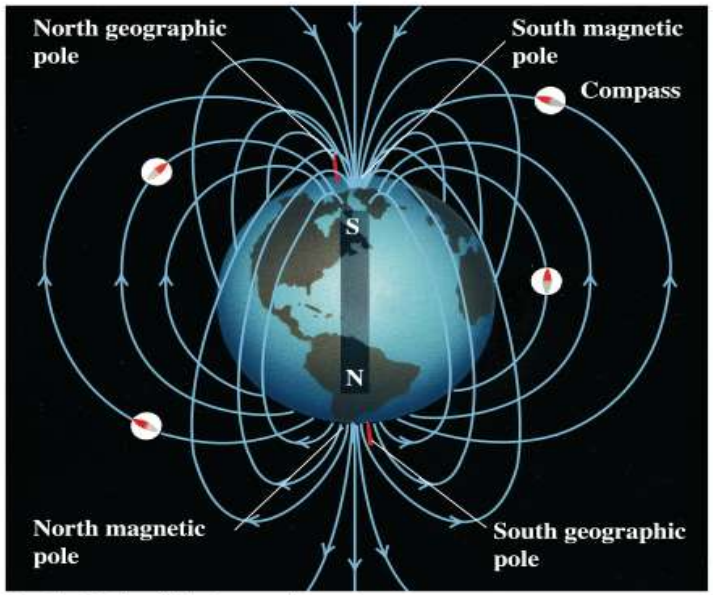
   *** magnetic poles cannot be isolated***

- **examples**

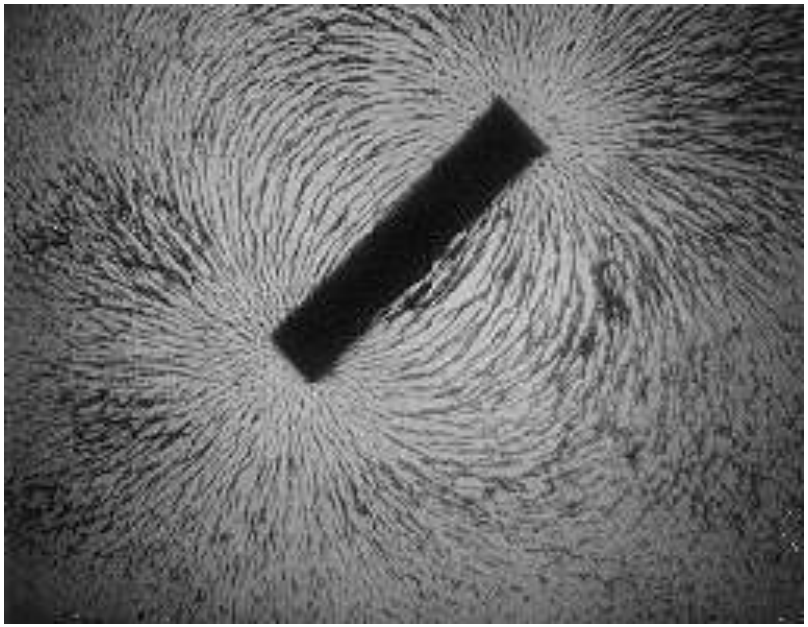
  - compass

  - Earth





“Opposites attract. Likes repel.”



The above describes both magnetic and electric force, but

electric charges can be isolated,

magnetic poles cannot.

Elements of Magnets

- Five elements that can be made into magnets.
  1. iron
  2. cobalt
  3. nickel
  4. gadolinium
  5. dysprosium

Permanent magnets

- Permanent magnets are made from an alloy
  - Alloys are combinations of two or more elements in a solid solution
  - Permanent magnet alloy
    - Steel - Iron and Carbon
    - Alnico - Iron, aluminum, nickel, cobalt and copper
    - Magnequench - iron, neodymium and boron
    - Ceramic magnet - iron and other oxides
    - Rubber – magnet powdered magnet material embedded in rubber
    - Alnico magnet - poles of a very strong magnet face each other creating a strong magnetic field

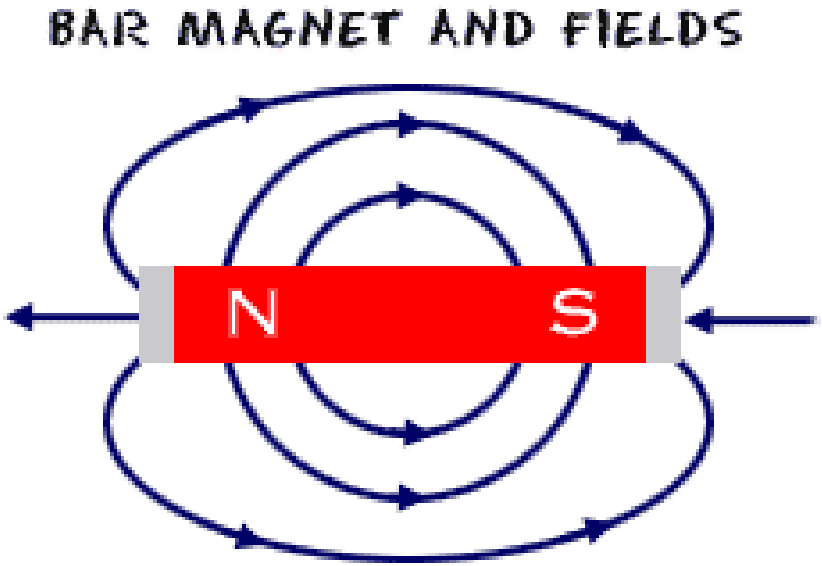
MAGNETIC FIELDS

An area around a magnet or any current-carrying wire where a magnetic force exists

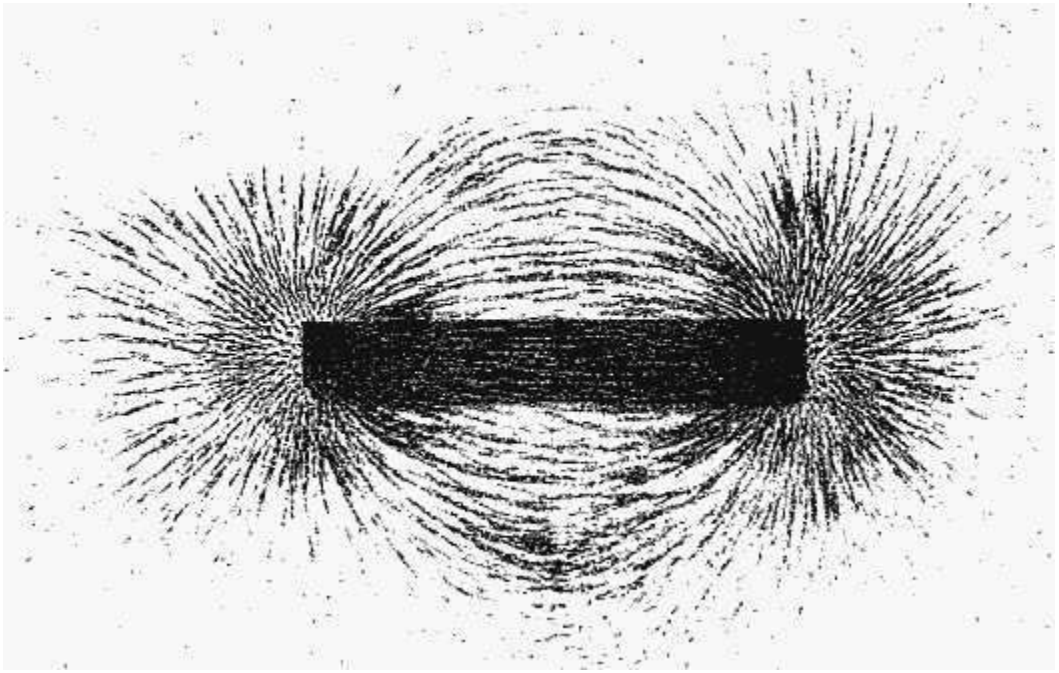
- **Magnetic field lines**

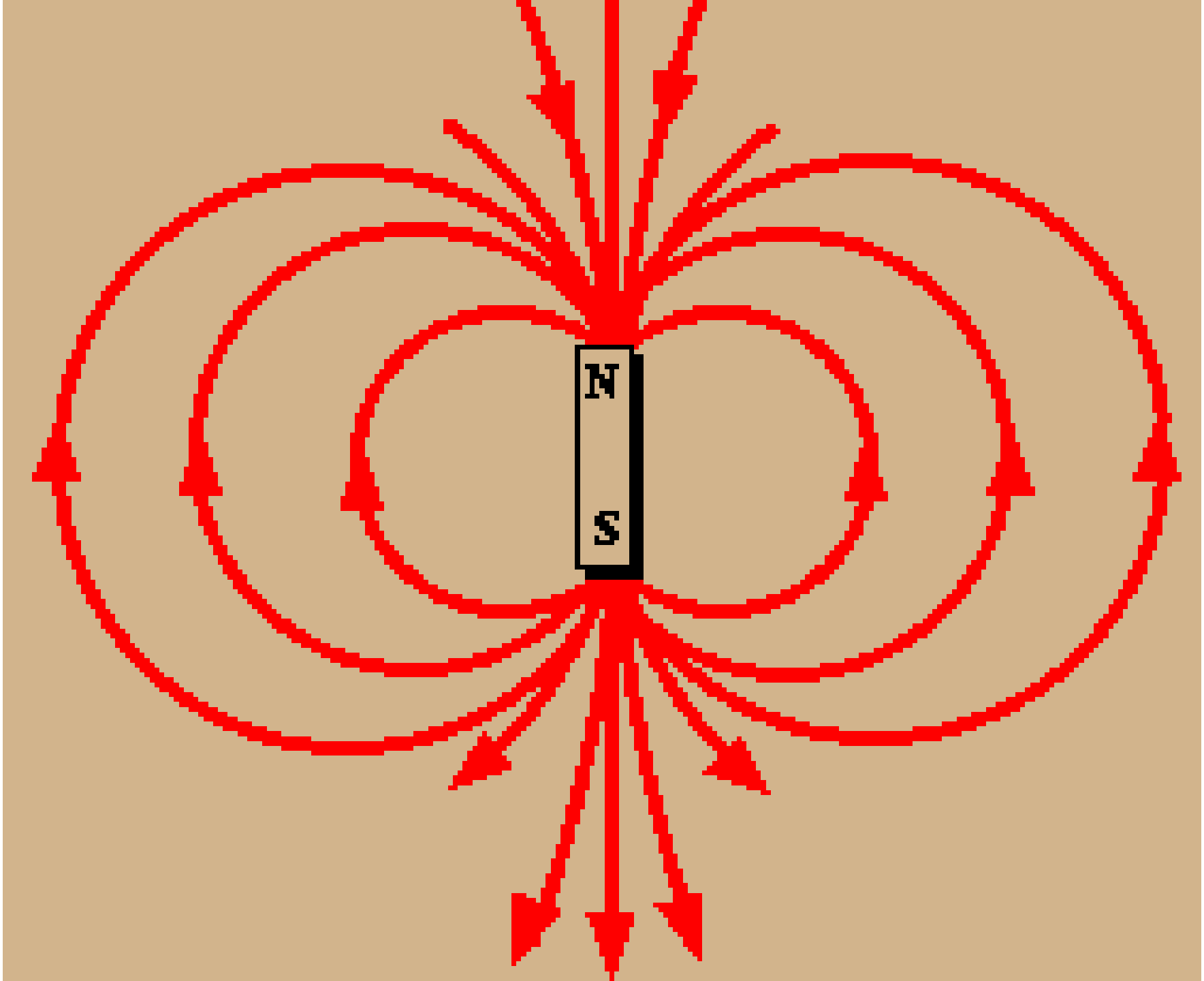
1. Spread from one pole, curve around the magnet, and return to the other pole
2. Direction of field →leaves north pole & enters south pole
3. Lines closer together = stronger field

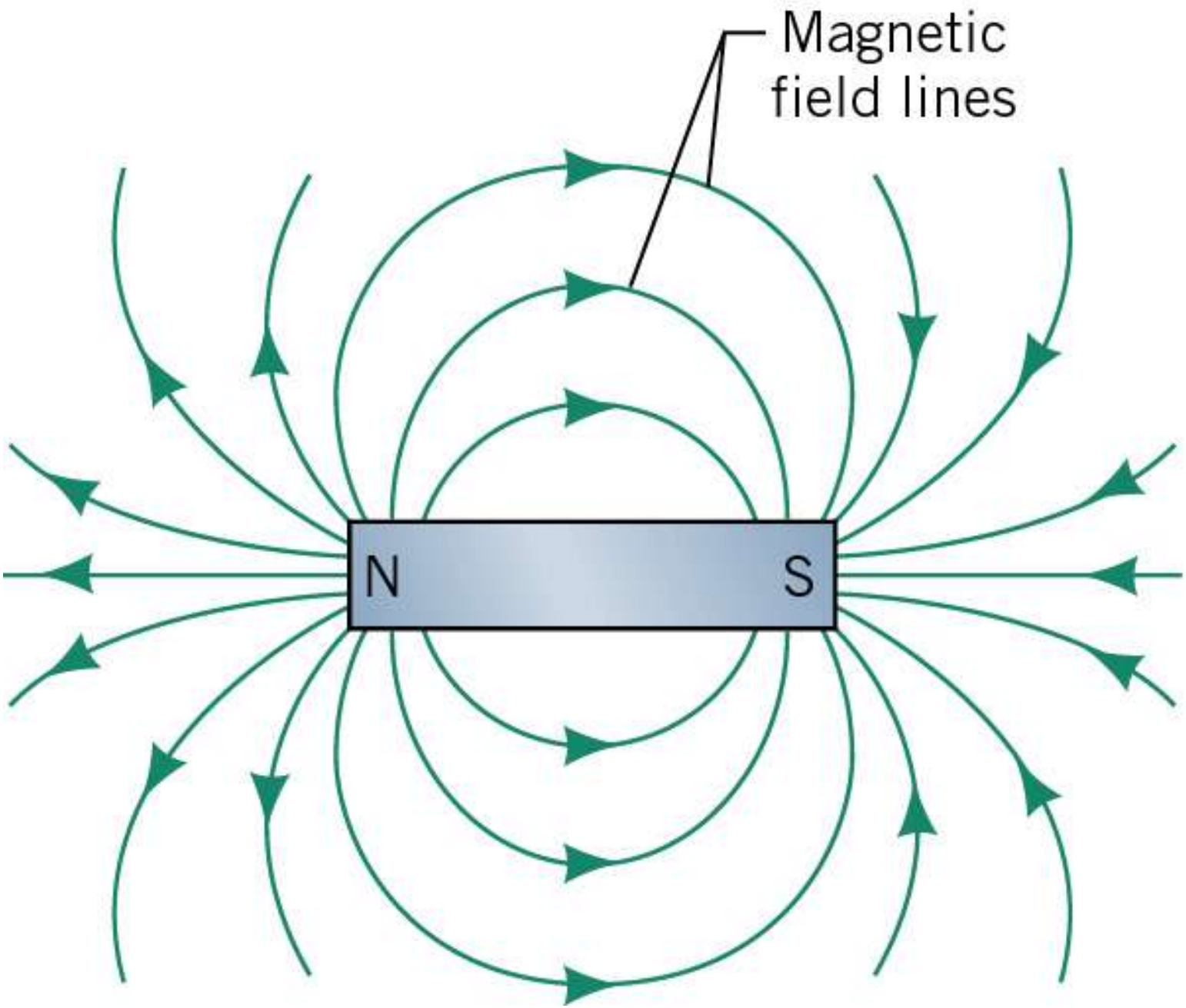
   - strongest at the poles

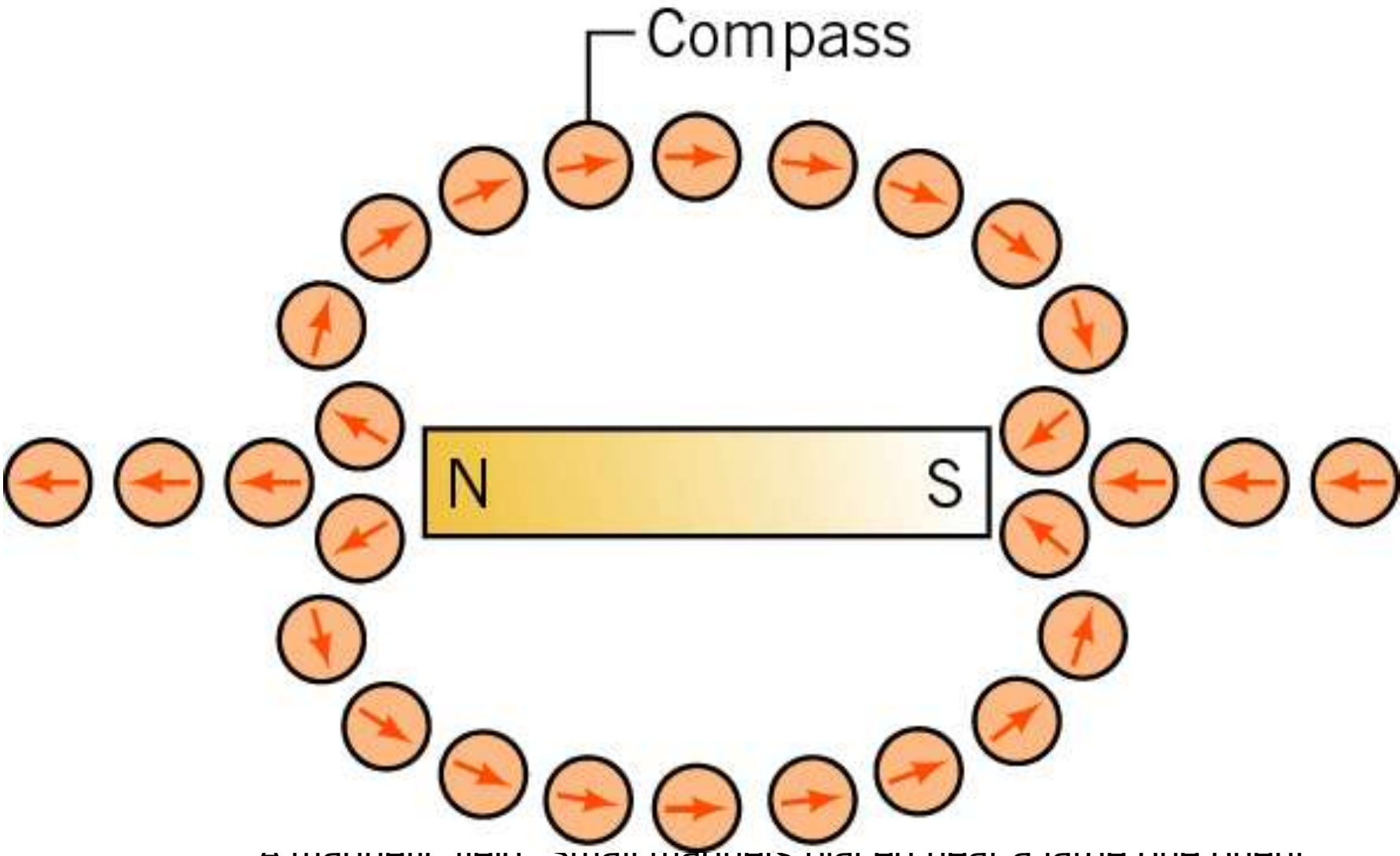


MAGNETIC FIELDS

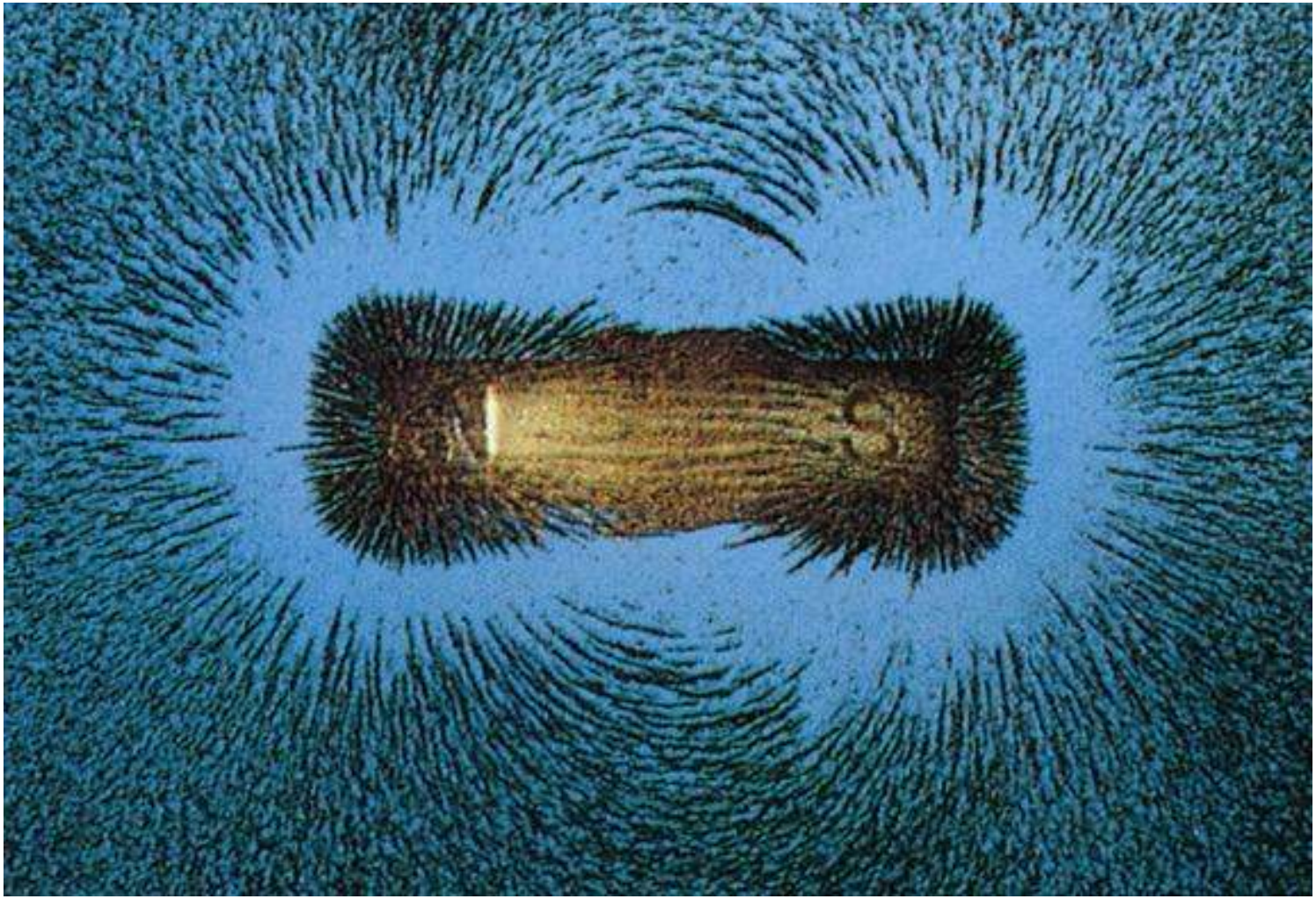



N
S


Magnetic
field lines
N
S



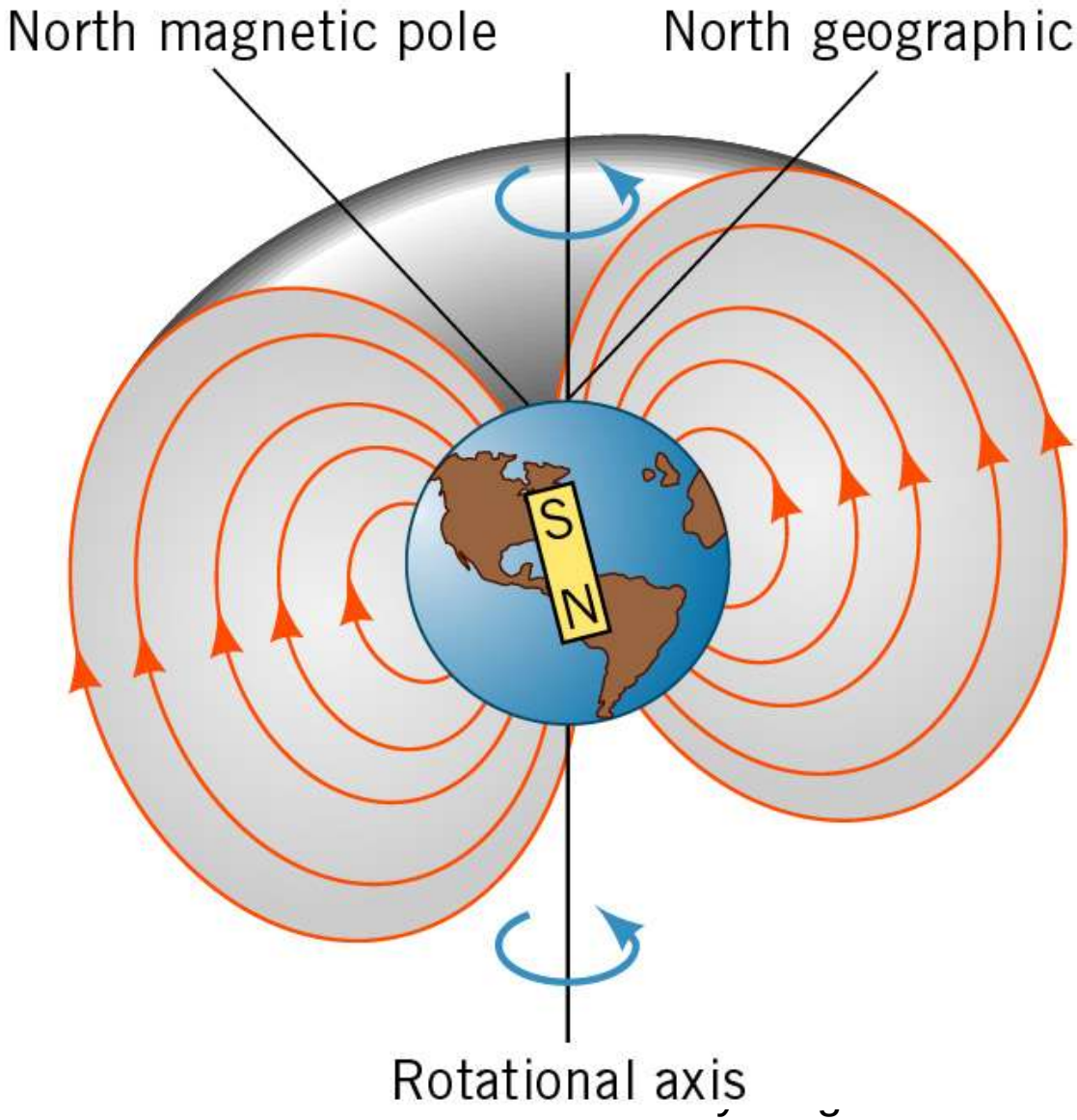
A magnetic field. Small magnets placed near a large one orient themselves along the lines of the magnetic field, as shown.

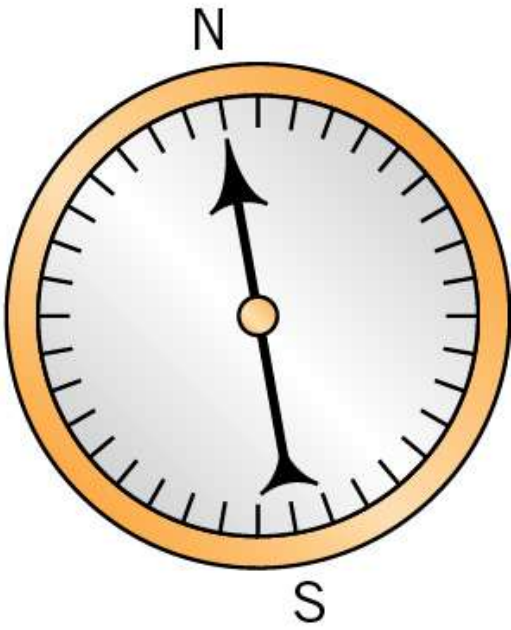


Courtesy Andy Washnik

Figure 5-5(b)

Iron filings placed near a bar magnet align themselves along the field.


North magnetic pole
North geographic pole
S
N
Rotational axis


N
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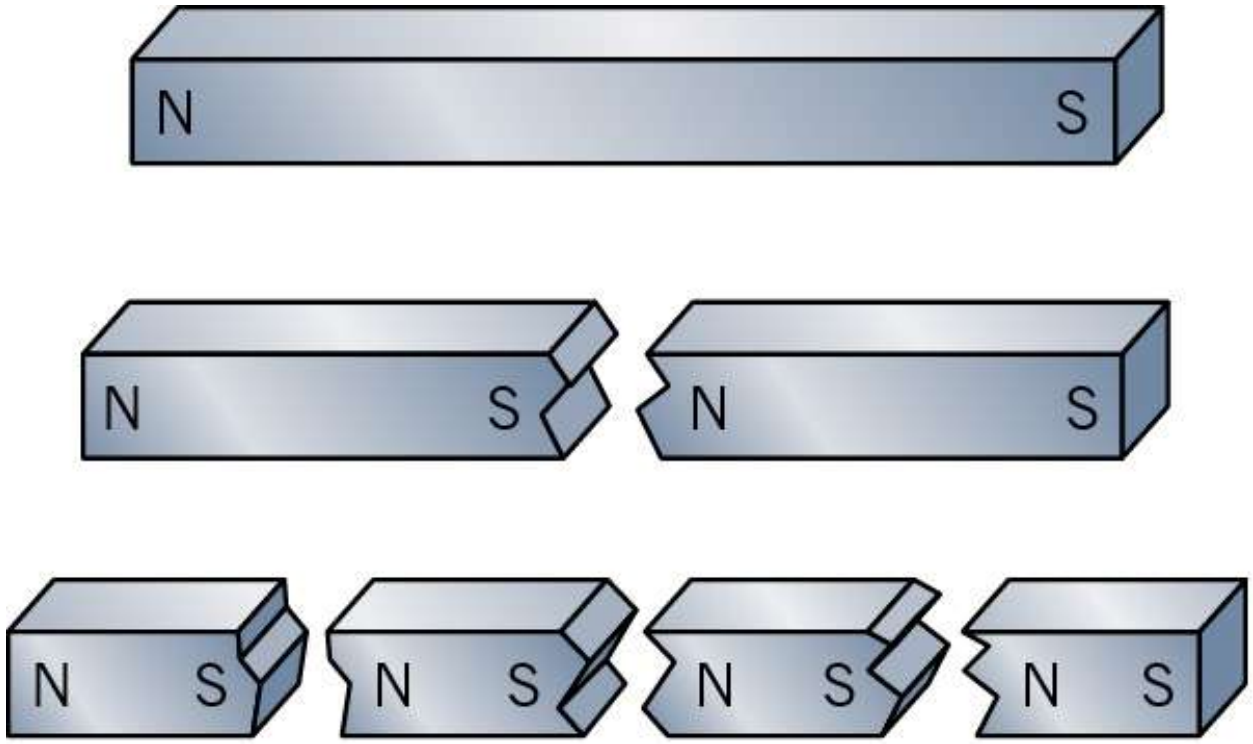


Figure 5-6

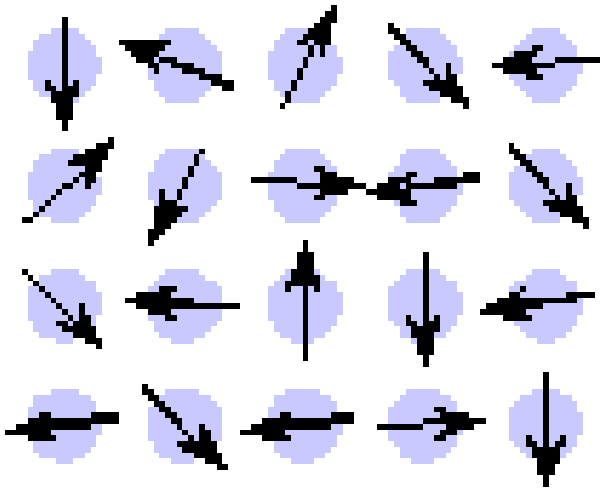
Cut magnets. If you break a dipole magnet in two, you get two smaller dipole magnets, not an isolated north or south pole.

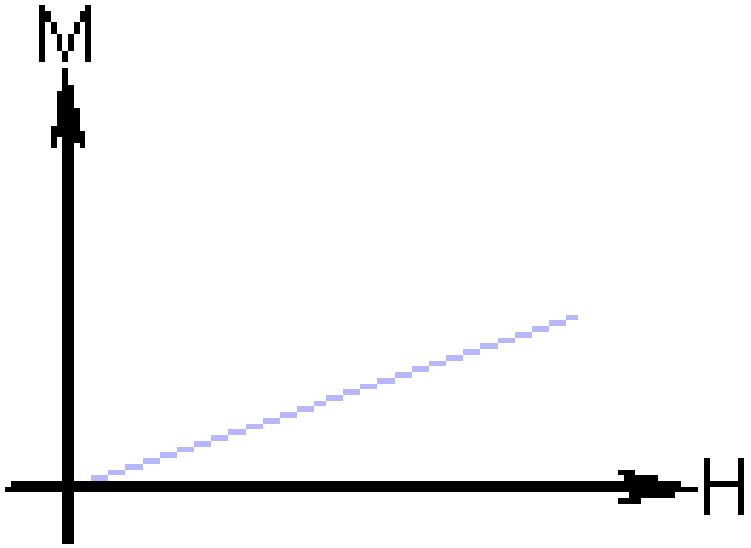
Magnets use

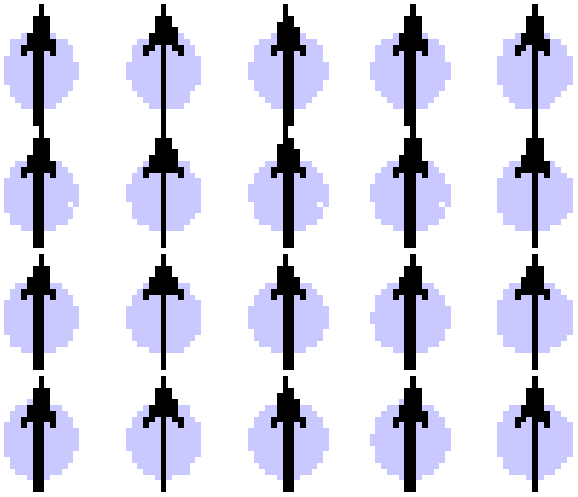
- Used in: microwaves, speakers, electric motors clocks, watches, etc., ...

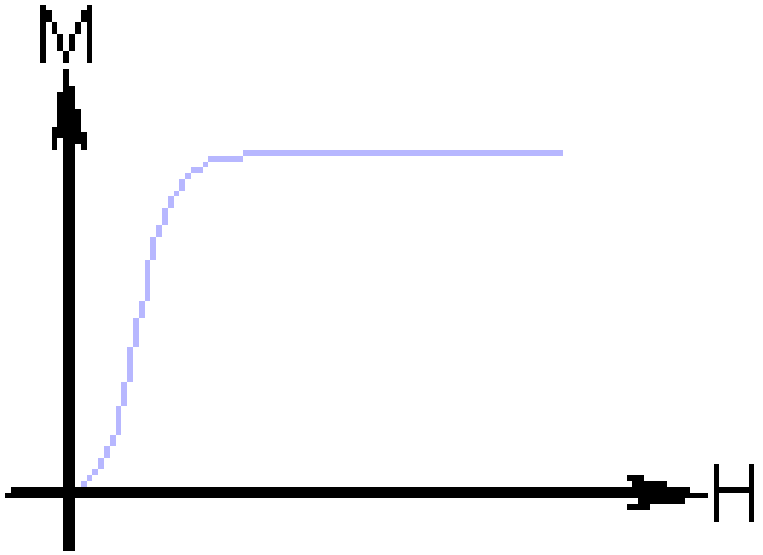
Inside magnets

- Atomic magnetic model
  - Each atom has a north south pole and when aligned they create a magnet
    - In a permanent magnet all of the poles are aligned
    - A group of atoms with aligned magnetic poles are called magnetic domains.
  - Heat can destroy a magnet because it causes the atoms to randomly align themselves
  - Most atoms do not have south and north poles because the electrons cancel out
    - One electron spins one way and one electron spins the other
    - Magnetic fields
    - Earth




M
H




M
H

Earth's magnetic poles

- North magnetic pole – is really a south pole
- Earth magnetic field results from the molten rock within the earth
- Magnetic field lines are lines that identify the position and strength of the magnetic field around an object
  - These lines are imaginary

The earth's Magnetic Field Protects us from Solar Wind

Magnetic forces

- All magnetic forces are produced by the action of magnetic fields on electric currents

Magnetism and Electricity

- Electricity makes magnetism
  - Every wire with electrons flowing through them create an magnetic field
  - A solenoid is a coiled wire that can create a strong magnetic field
  - If an iron core is placed in the solenoid it becomes an electromagnet

1820, Hans Oersted

- …connected a battery to let electric current flow, and noticed a compass needle twitch and move.

Electricity from Magnetism

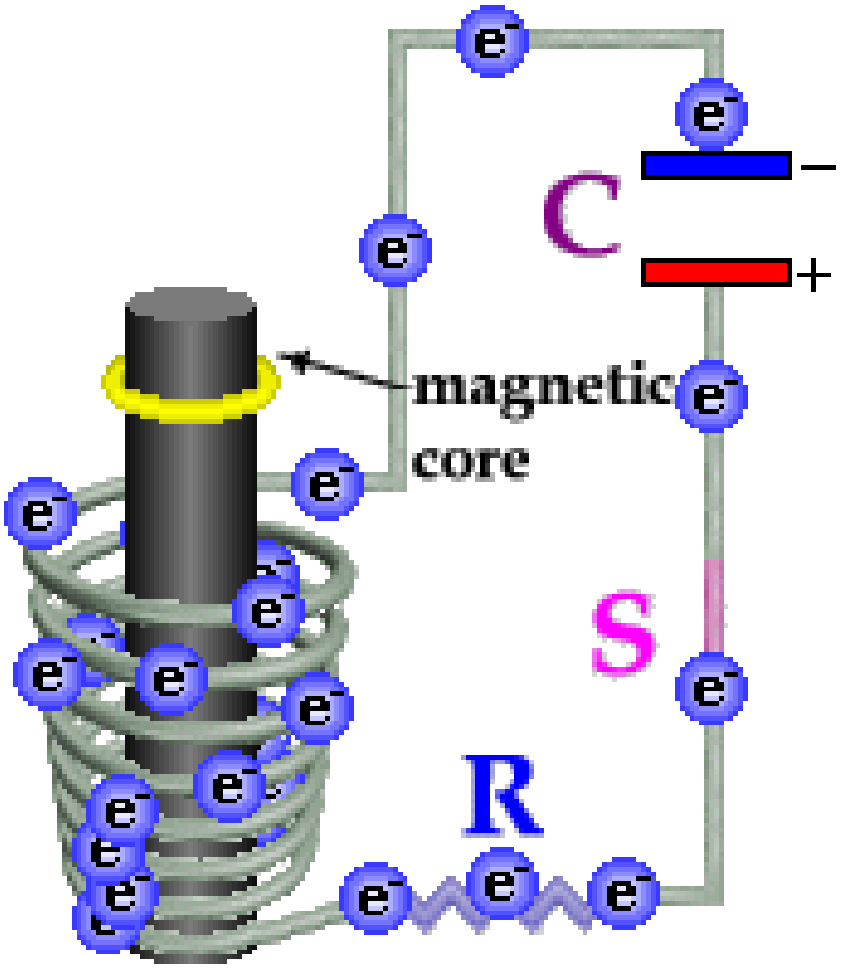
- Moving electrons cause magnetic fields
- Moving magnetic fields cause electrons to move
- Magnetism can be used to make electricity
  - The process by which a magnetic field produces an electric current is electromagnetic induction
  - When a magnetic field is moved in a solenoid and electric current is produced

Maxwell's Laws:

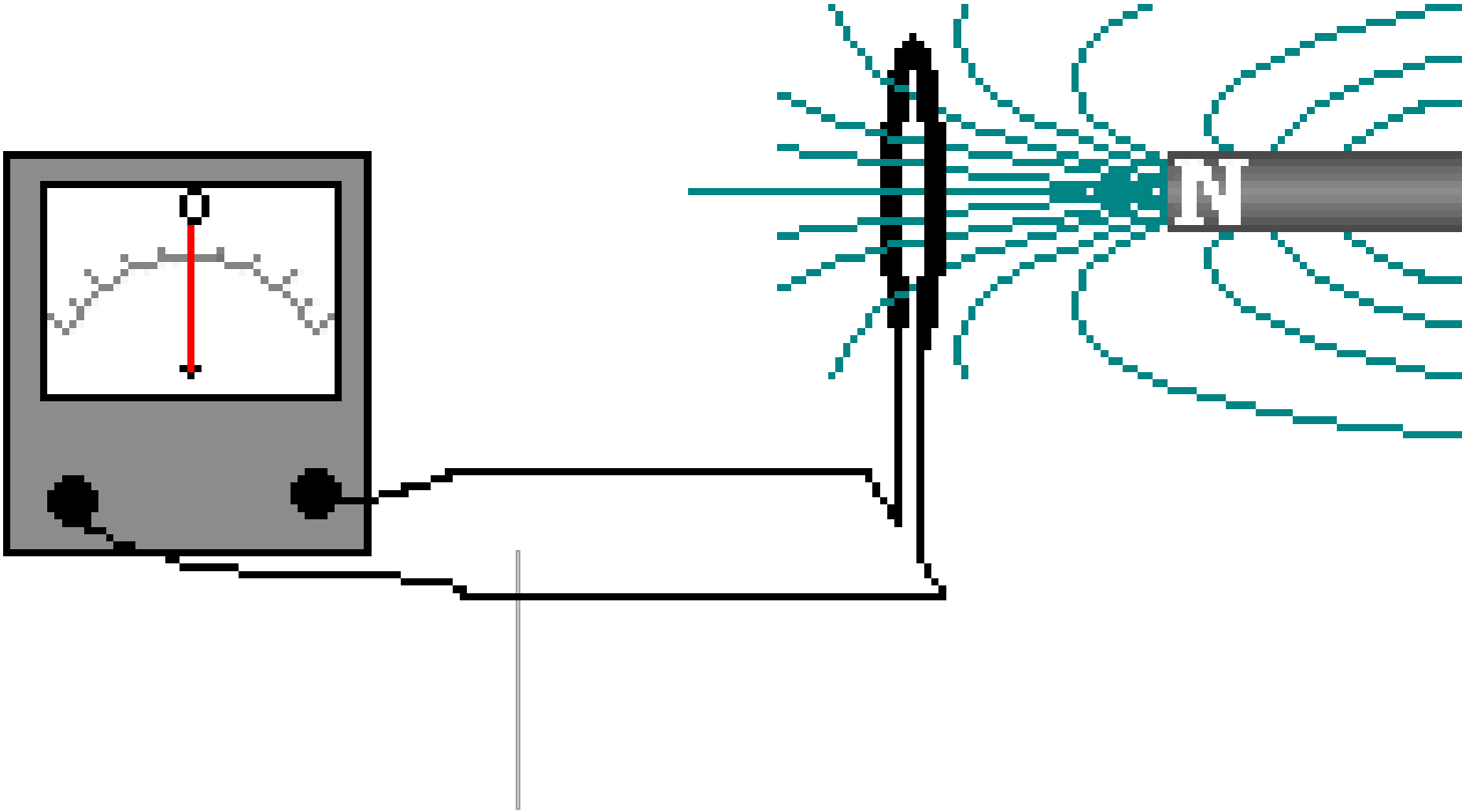
1. Like charges repel, unlike attract
2. There are no magnetic monopoles in nature
3. Magnetic phenomena can be produced by electrical effects
4. Electrical phenomena can be produced by magnetic effects

Electricity & Magnetism:
“ two sides of the same coin “

- Every time an electric charge moves, a magnetic field is created.
- (electromagnet)
- Every time a magnetic field varies, an electric field is created.
- (hydroelectic dams)


e-
C
−
+
magnetic
core
S
R

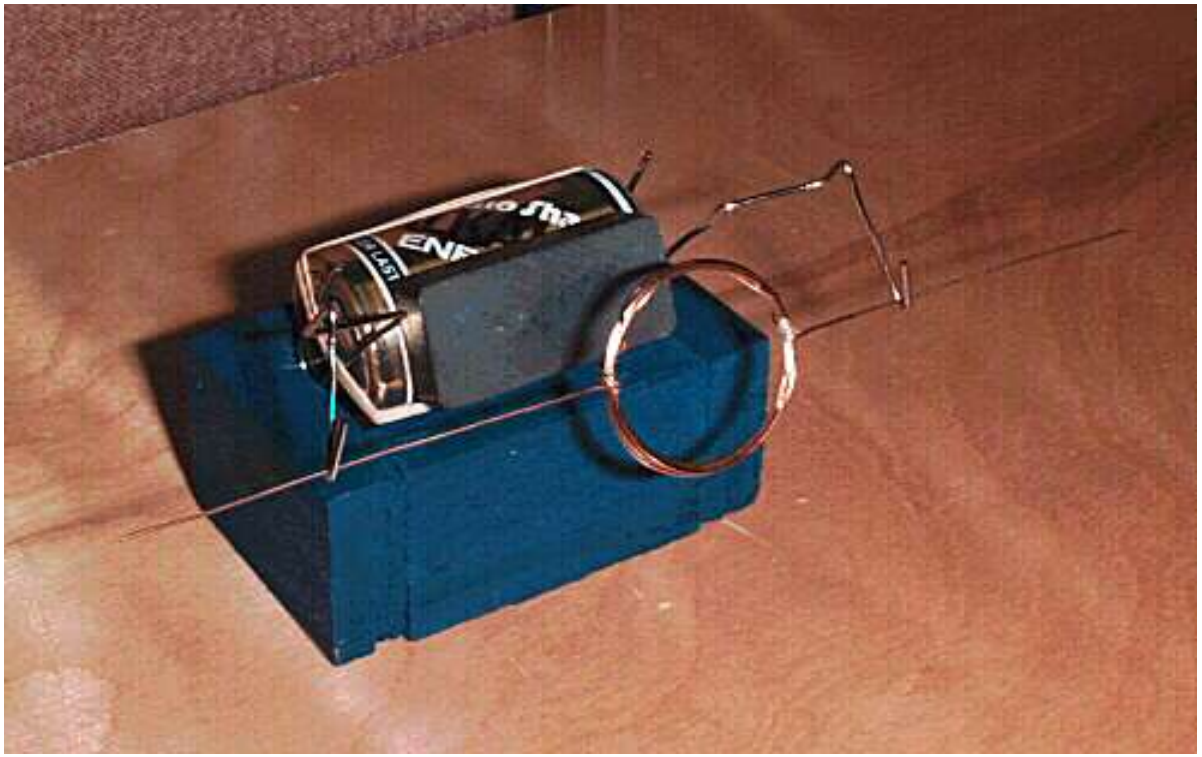
Electromagnetic Induction



Transformers

- Consist of a primary coil placed in a secondary coil.
  - When there is any change in current in the primary coil there will be current in the secondary coil
- The coil on a gasoline engine works like this to increase voltage

Electric motors convert electricity into magnetic fields, for useful rotary motion



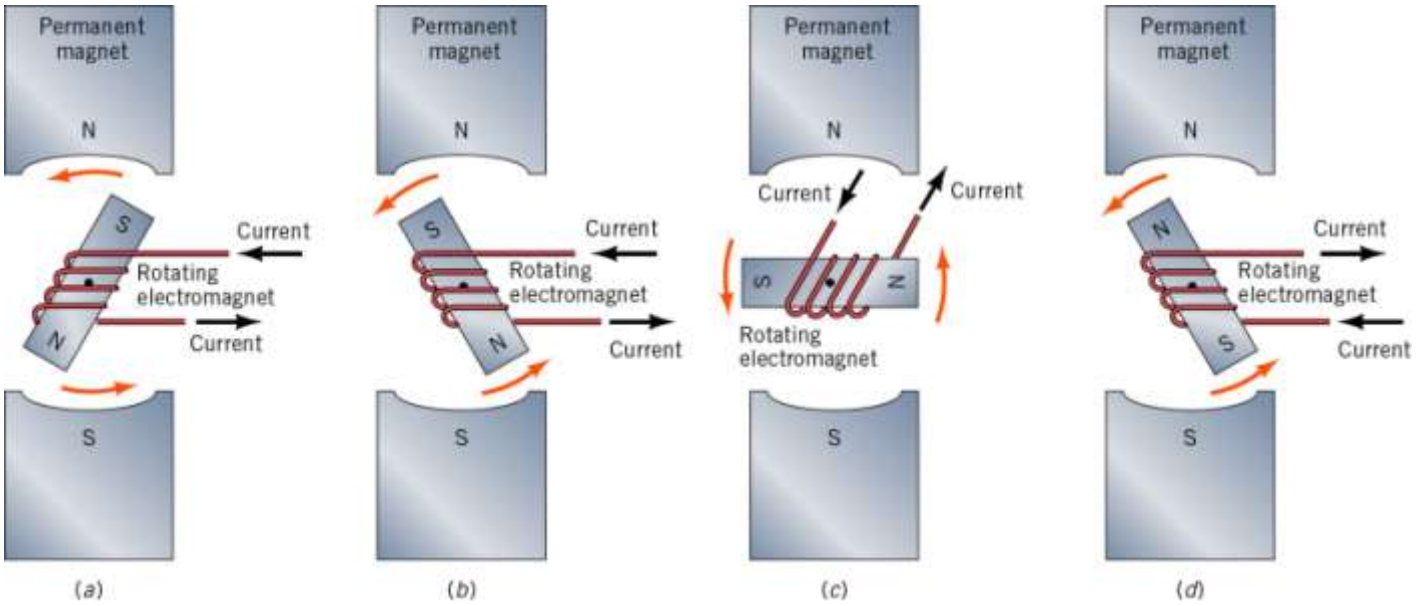


Figure 5-8

An electric motor. 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.

Electrical Generators

- …are the exact opposite of electric motors: they convert rotary motion into electrical energy.

link

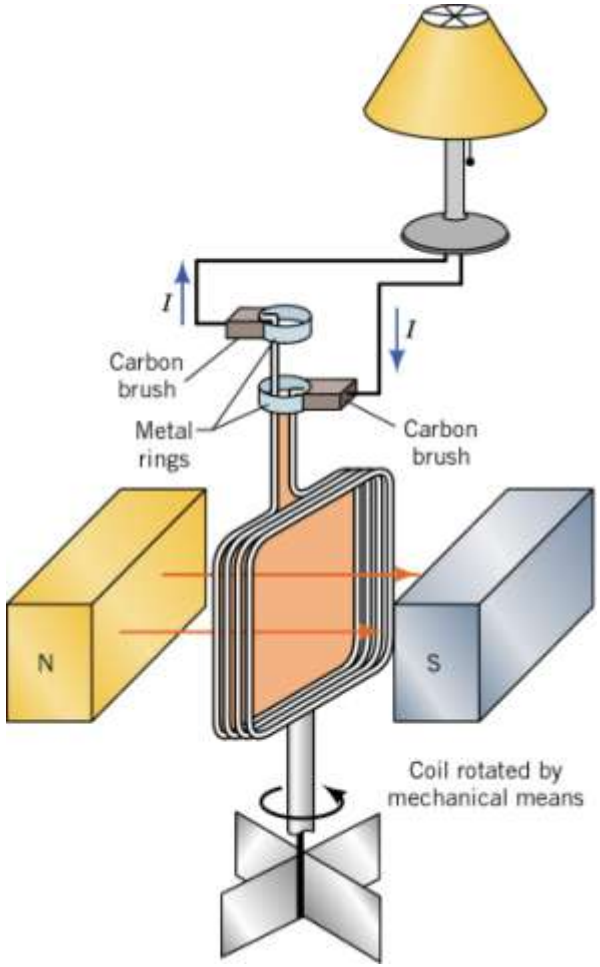


Figure 5-10

An electric generator. As long as the loop of wire rotates, there is a changing magnetic field near the loop and a current flows in the wire.

Anything that can turn an axle can power a generator.

- Flowing water, pressurized steam, wind, or a gasoline engine can drive a rotating turbine that houses coils of copper wire.

James Maxwell in the 1860s

- was first to see that the four laws formed a coherent system
- realized that the four laws predicted the existence of a new kind of energy wave—electromagnetic radiation

Maxwell, in 1867, proposed that light is an electromagnetic wave.

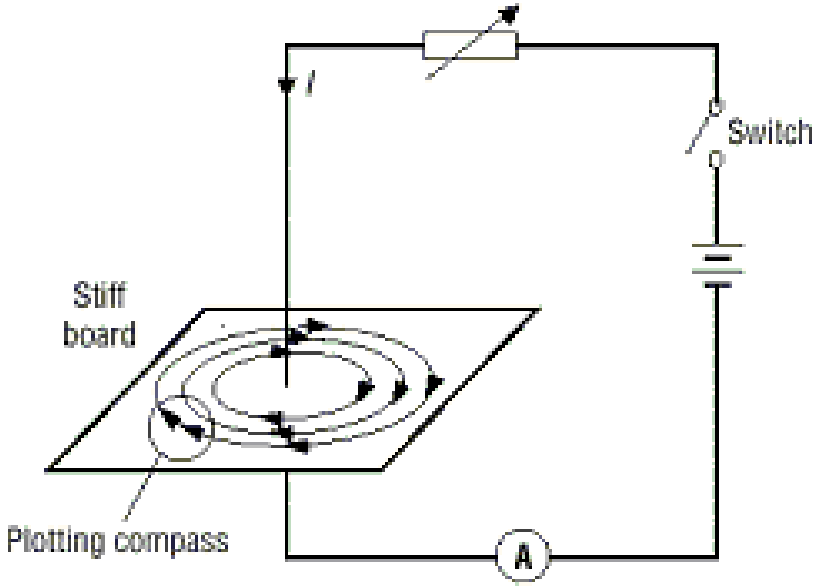
"The spectrum of visible light, from red to violet, is only an octave or so in the range of invisible radiations. There is a whole keyboard of information all the way from the longest wavelengths of radiowaves (the low notes) to the shortest wavelengths of X-rays and beyond (the highest notes)" (**Bronowski**, p. 353).

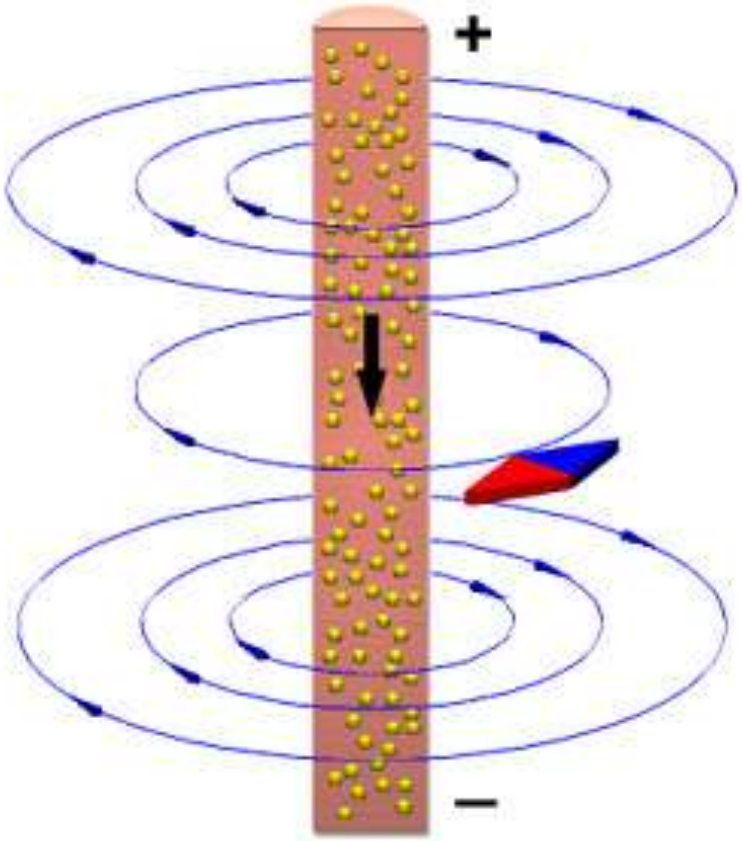
ELECTRICITY → MAGNETISM (**Maxwell & Oersted**)

- **Electric currents cause magnetism**

How can you tell?

- An electrical current will travel through a wire creating an magnetic field





ELECTROMAGNET

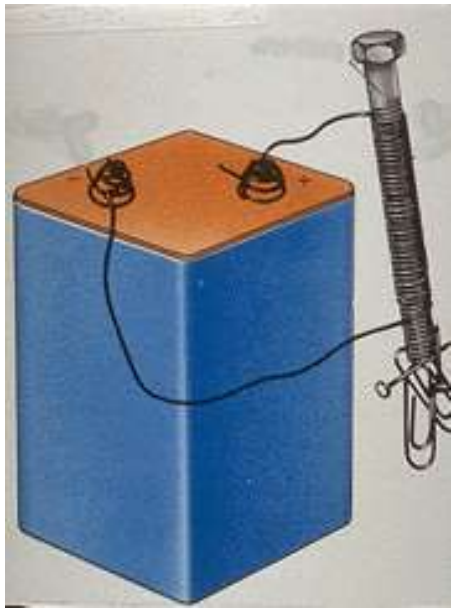
A magnet with a field produced by an electric current

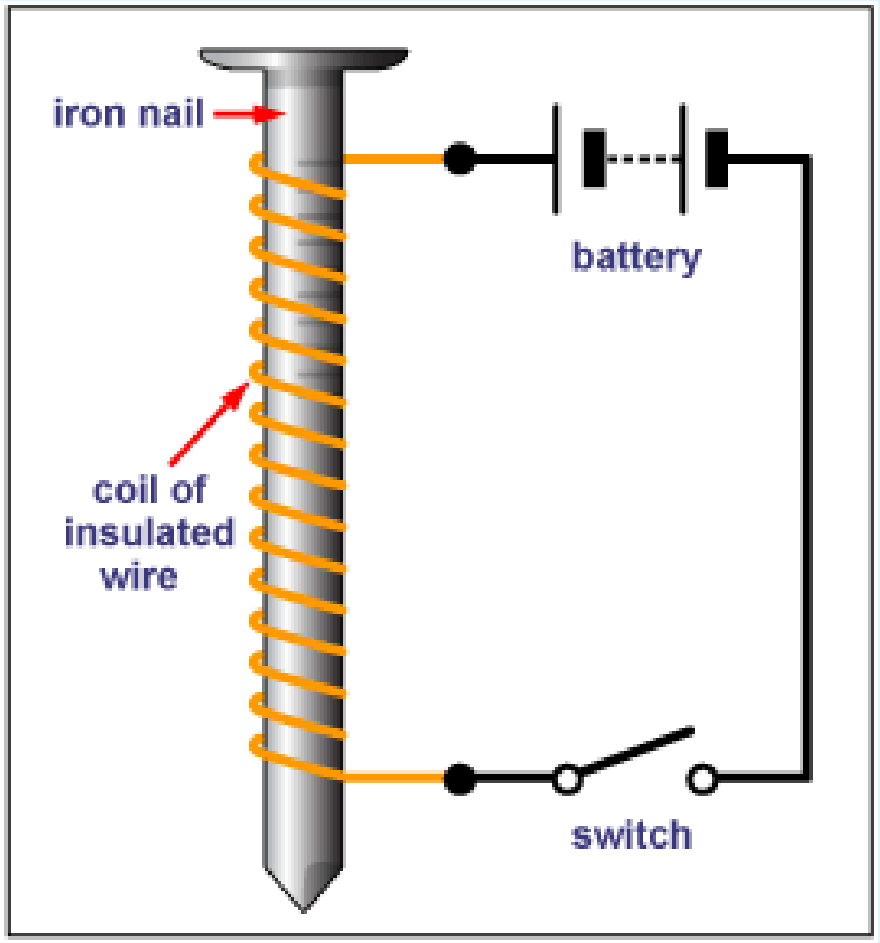
Is a temporary magnet

- **Electromagnetism**

- a moving charge produces a magnetic field

- more coils of wire= more current= stronger magnet





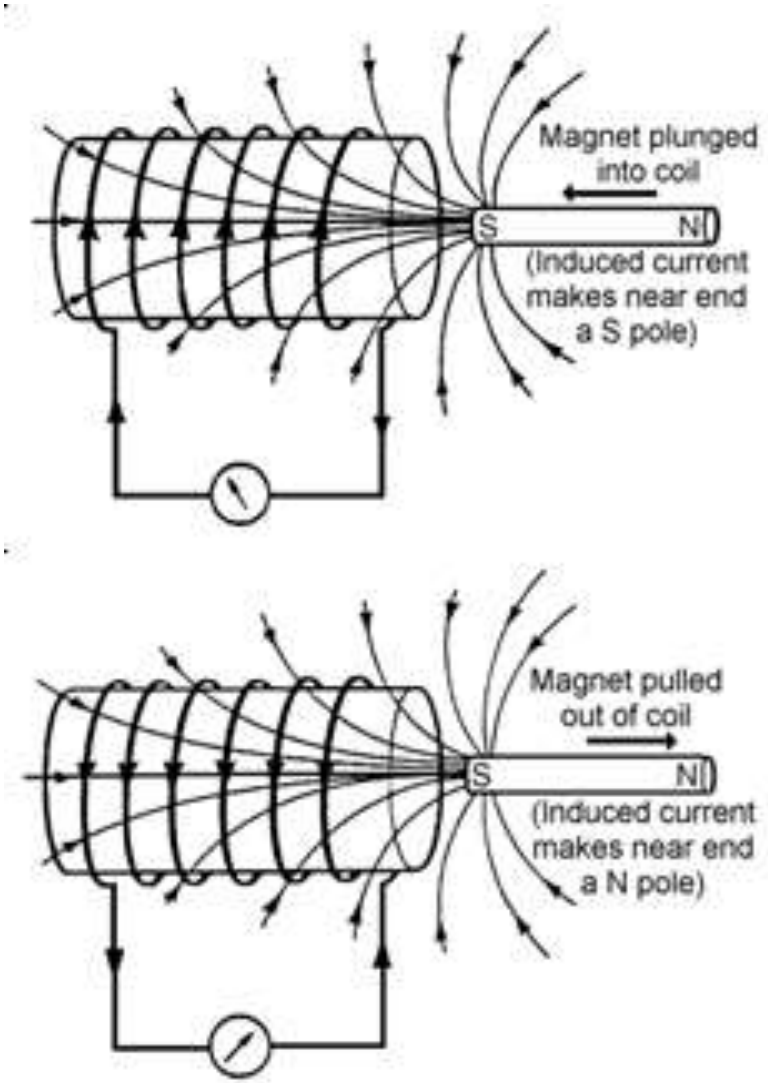
MAGNETISM → ELECTRICITY (**Faraday**)

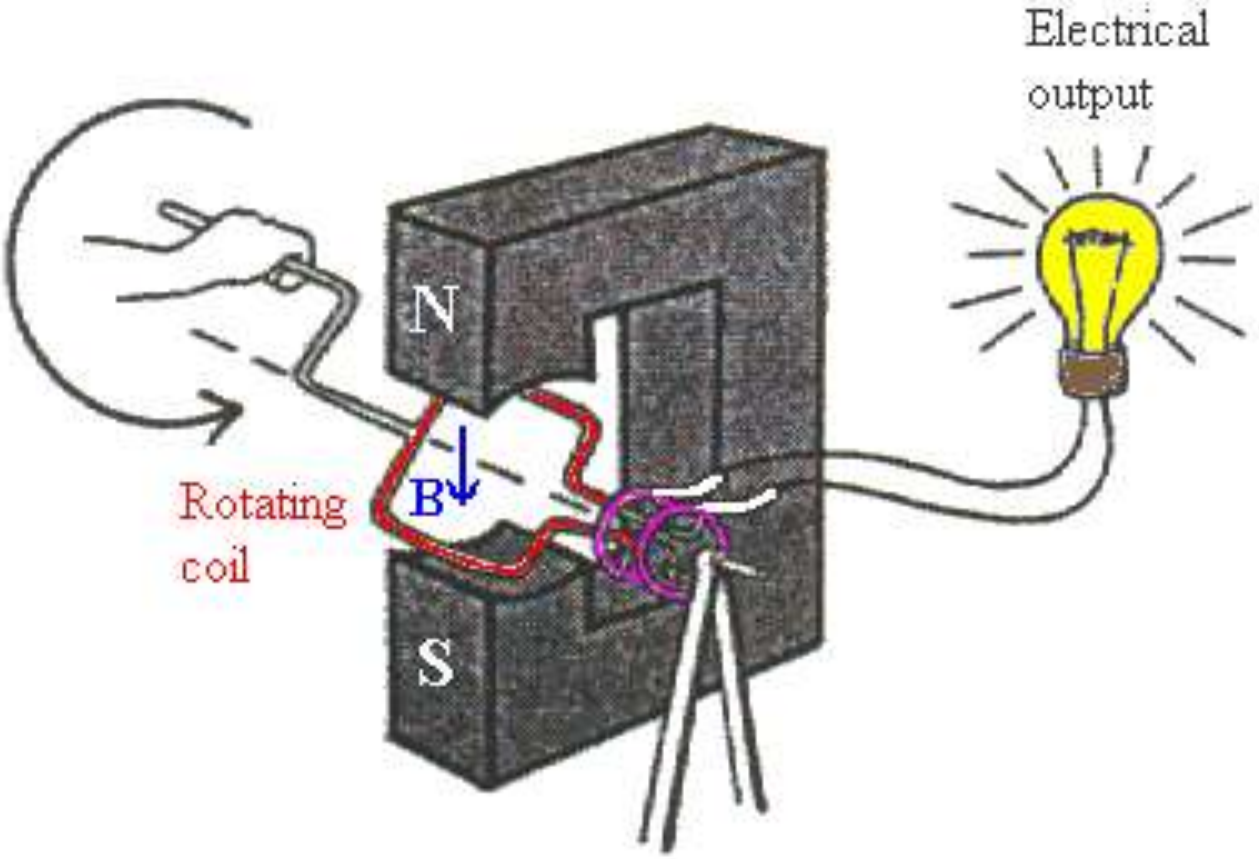
- **Moving magnets can generate electricity**

How can you tell?

- **Electromagnetic induction**

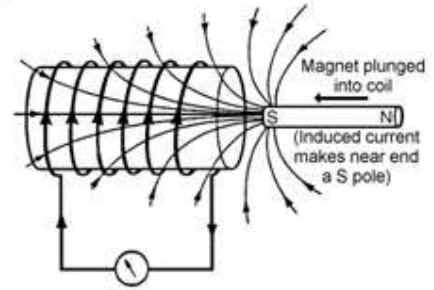
  moving a magnet in and out of a coiled wire created an electrical current without a battery

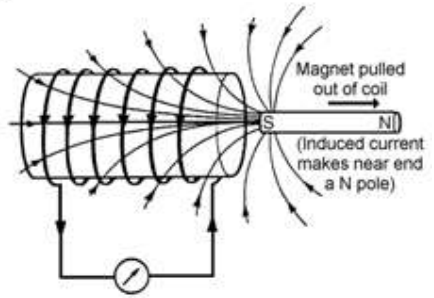



Electrical
output
N
B
Rotating
coil
S

Moving magnets --> electricity

1. Electromagnetic “induction”

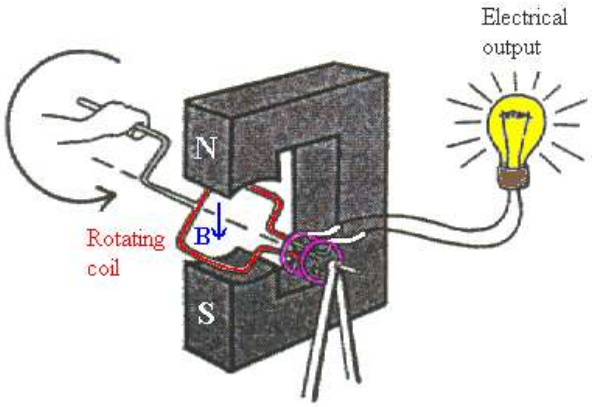




   – EM Induction = to force current to flow

2. Generator

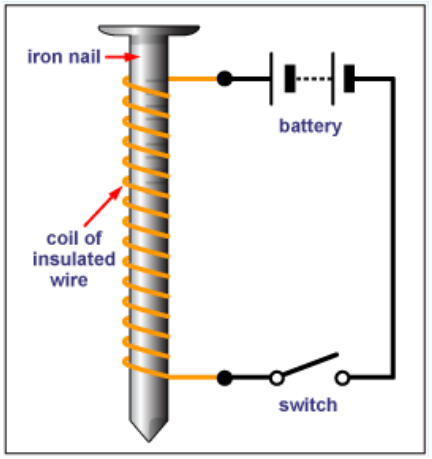
   – The direction of current (electron flow) is dependent on:
      - Direction the magnet (or coil) moves
      - Poles of magnet



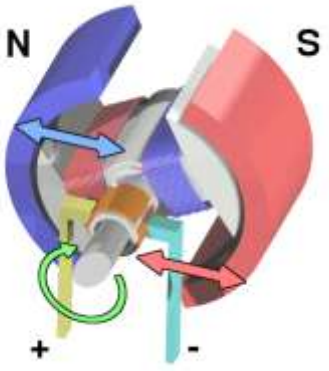
Moving electrons (electricity) --> magnetism

1. Electromagnet
   - More coils,
   - or more current (more power source)

   = stronger magnet



2. Motor
   - Permanent magnet interacts with temporary magnet to produce motion



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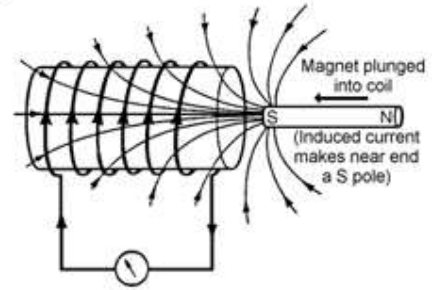

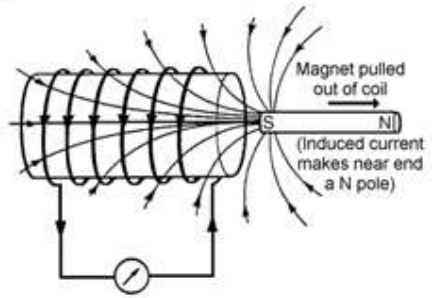

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