

Heat Flow



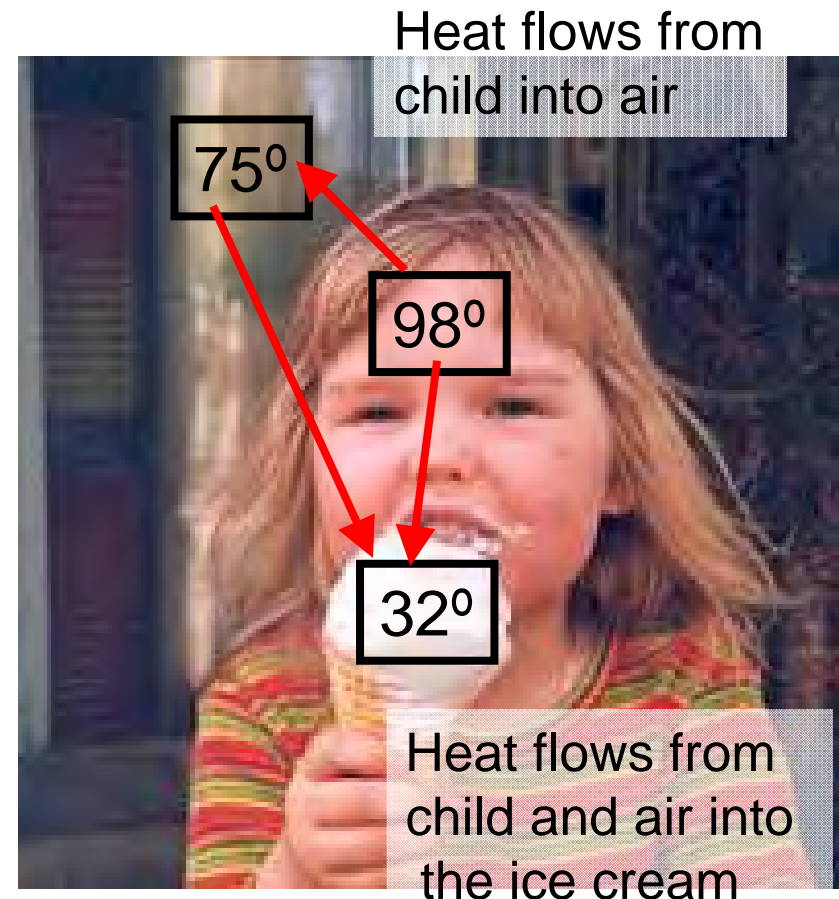
National Science Foundation
WHERE DISCOVERIES BEGIN

Heat Flow

Transferring energy from high temperature to low temperature objects is called *heat flow*.

Heat flow stops when temperatures equal.

Various ways by which heat flow may occur.

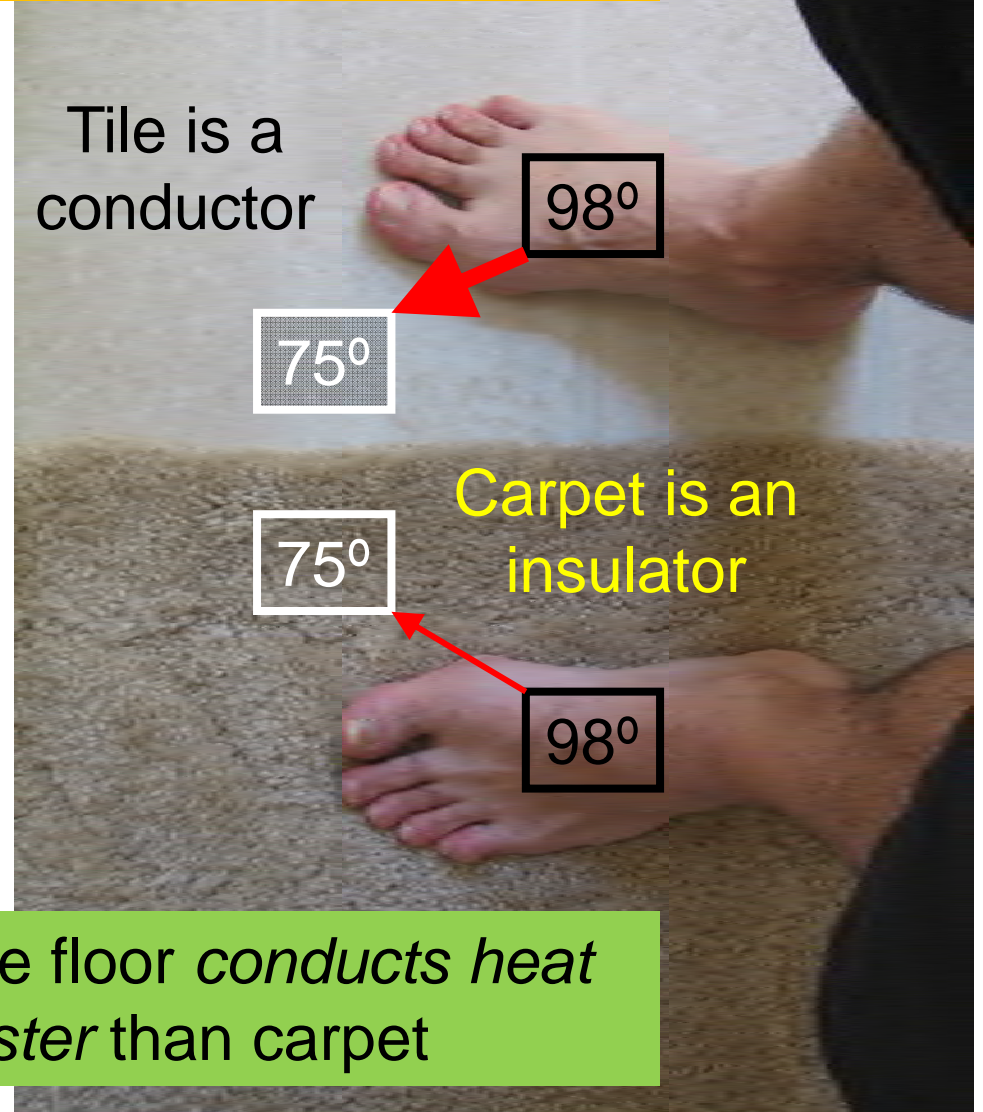


Conduction

Conduction is heat flow by direct physical contact.

Some materials are good thermal conductors (heat flows quickly) others are insulators (heat flows slowly).

Tile floor *feels* colder than carpet



Tile floor *conducts heat faster* than carpet

Torching Money

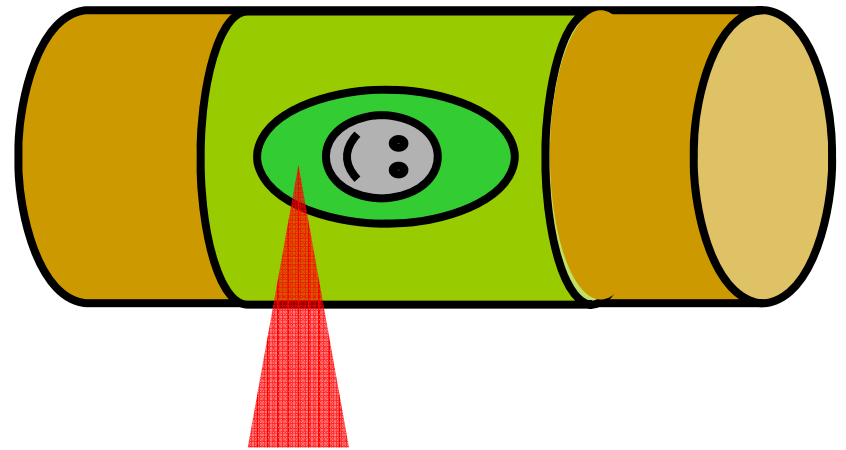
Wrap a dollar bill tightly around a copper pipe.
Put it into a flame.
Paper doesn't get hot enough to burn.



Torching Money

Copper metal is a very good heat conductor.

Heat from the flame quickly passes into the copper so the paper never reaches ignition temperature (451 °F).



Paper is a heat insulator (just like wood) but in this case it's such a thin layer the heat doesn't have far to travel.

Conduction in Cooking

Heat flow by conduction is important in cooking.

Air is an insulator so you can safely reach into an hot oven.

Metals are good conductors so you need protection to touch a metal pan.

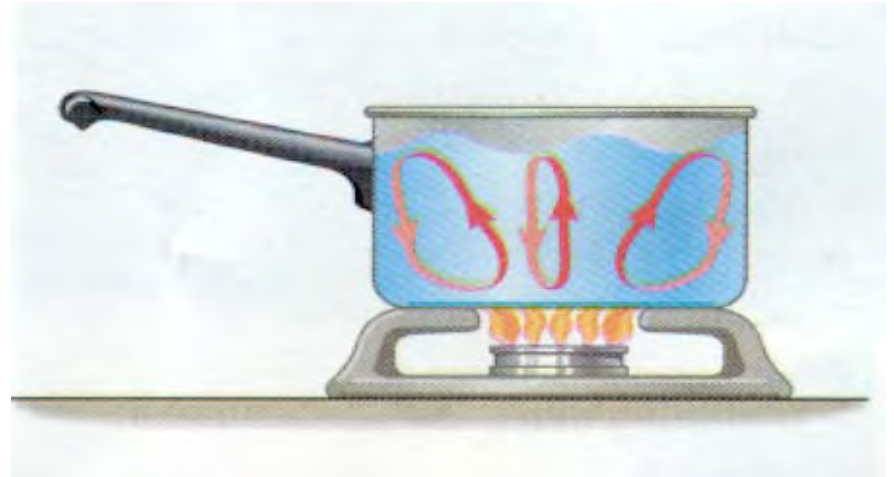
Cloth is a good insulator so you use oven mitts.



Convection

Heat flow in a fluid often occurs by **convection**.

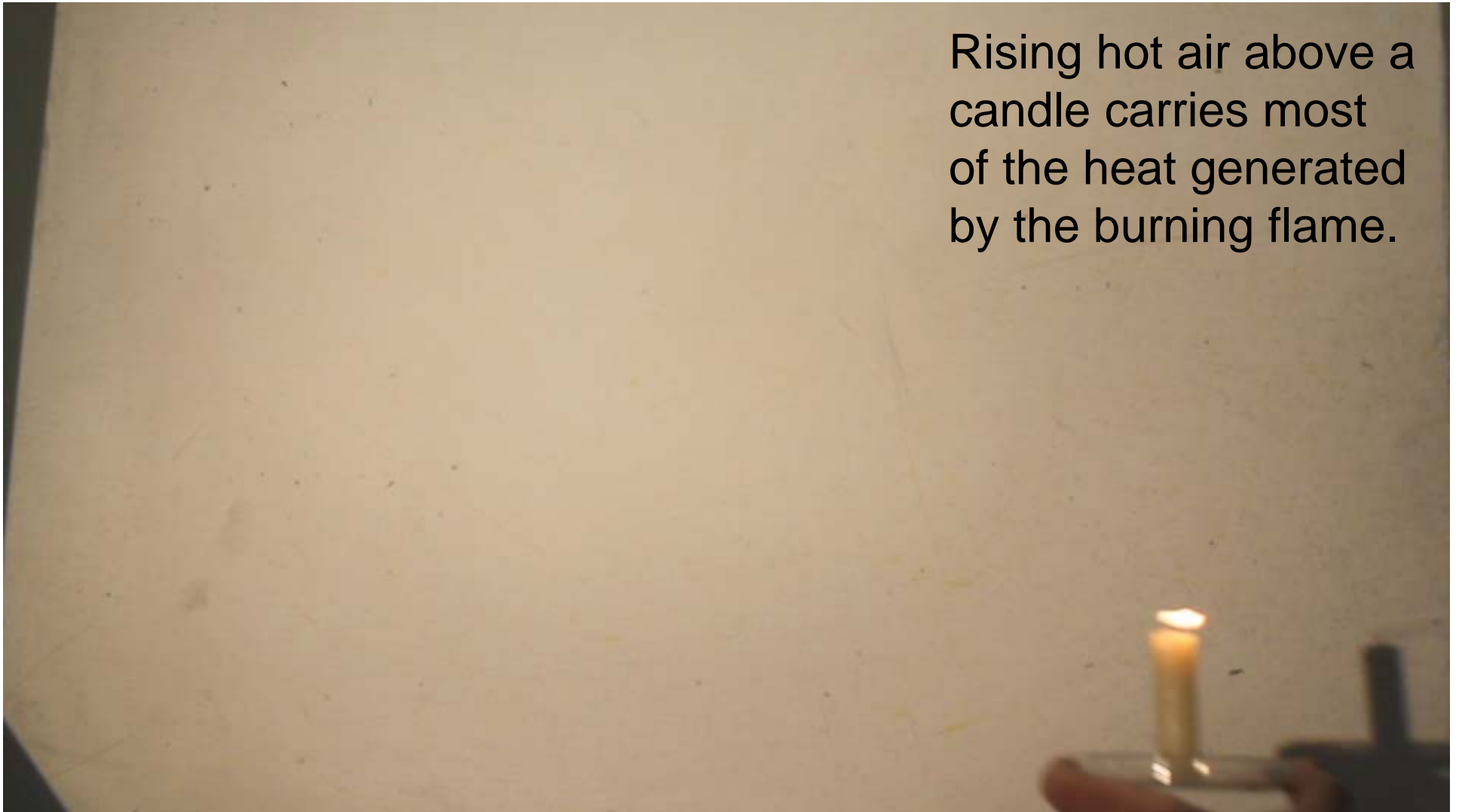
Buoyancy causes warm fluid to rise, which carries energy with the flow.



Shadows reveal rising air currents of hot air.

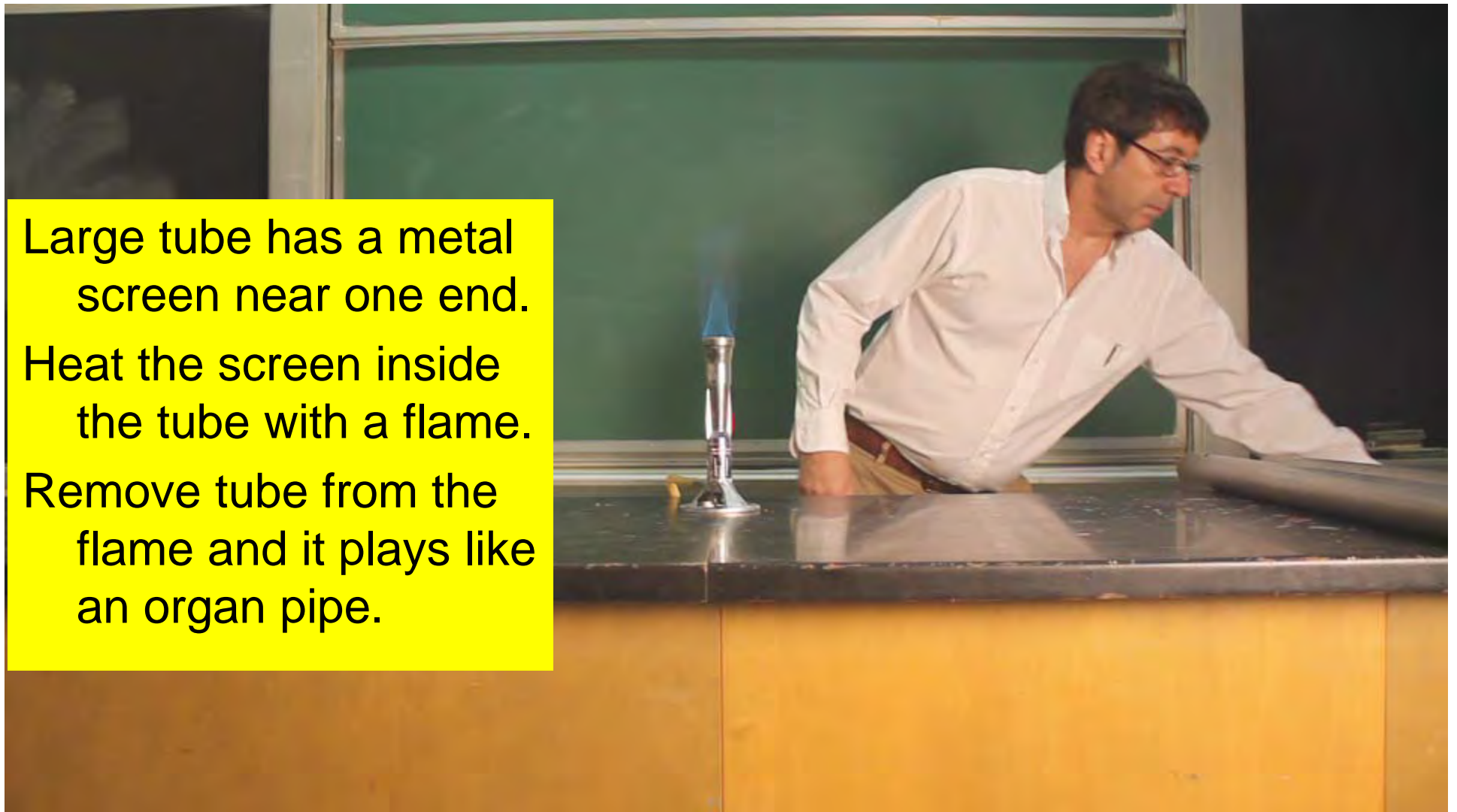
Convection from a Candle

Rising hot air above a candle carries most of the heat generated by the burning flame.



Hoot Tube

Large tube has a metal screen near one end. Heat the screen inside the tube with a flame. Remove tube from the flame and it plays like an organ pipe.

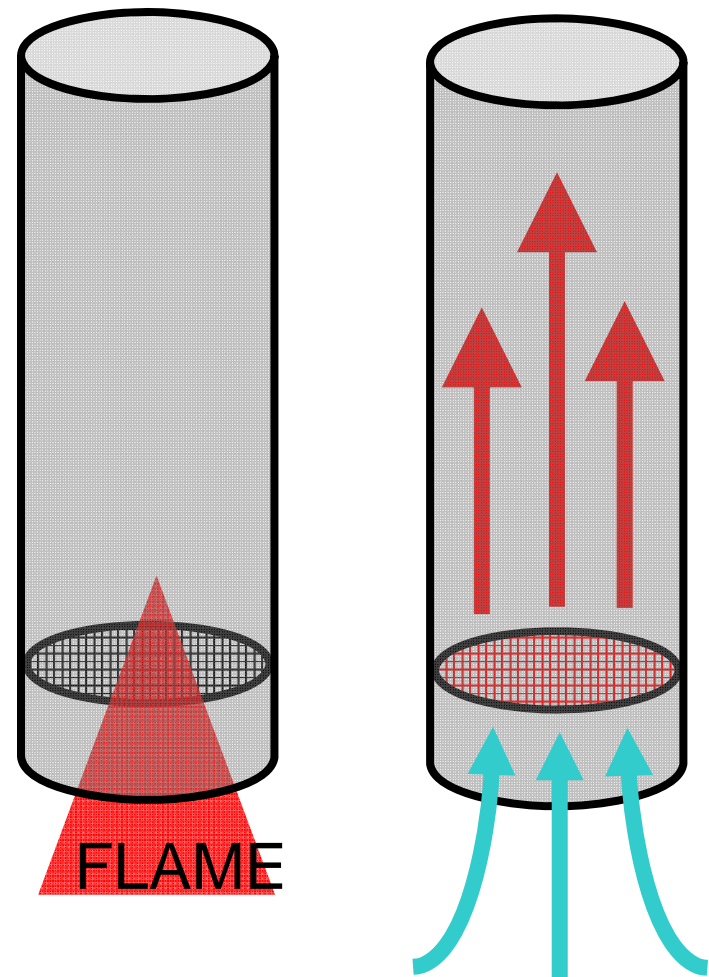


Hoot Tube, Analyzed

Remove the flame and hot air rises from the screen, drawing in cold air.

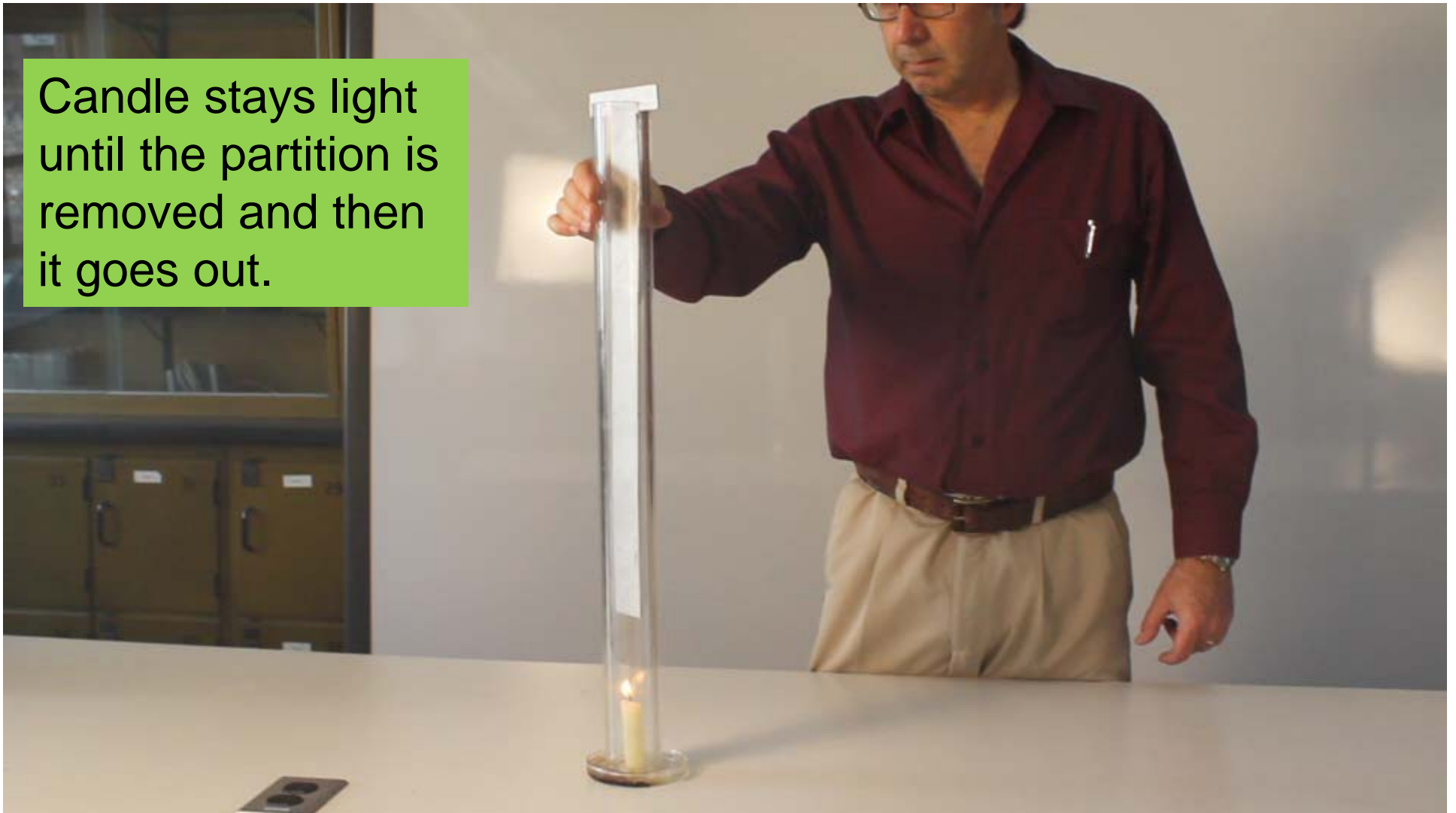
Hot air rising through pipe causes vibration at natural frequency, which depends on the length of the pipe.

Amplitude depends on the diameter of the pipe.



Candle in a Tube

Candle stays light until the partition is removed and then it goes out.

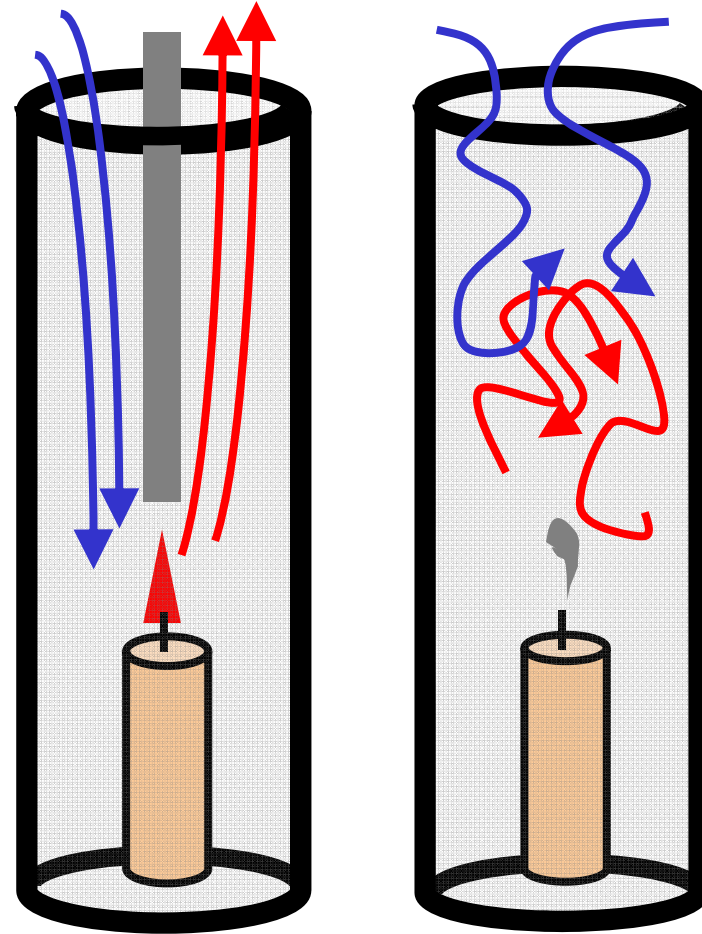


Candle in a Tube

Partition allows hot air to rise, drawing in cold air (with fresh oxygen) to fuel the candle flame.

Without the partition, turbulence impedes the inflow and outflow.

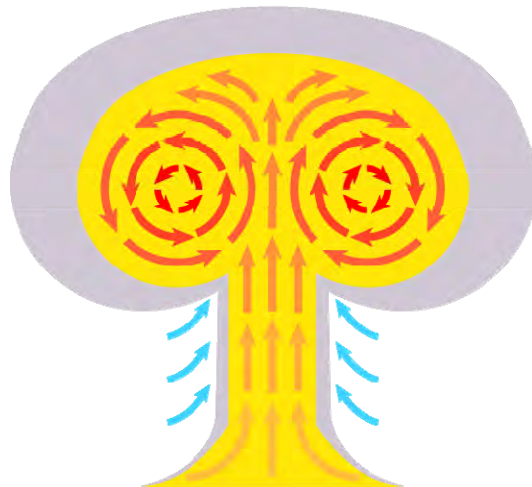
Convection is disrupted because tube is narrow.



Mushroom Cloud

When a large mass of hot air, such as from an explosion, quickly rises by convection the flow may form a vortex (mushroom cloud).

Fresh air is drawn into the stem as the turning vortex of hot gases rises by buoyant convection. The outside cools and looks like a normal cloud.



Radiation

All light carries energy, so it transfers energy.

This type of heat flow is called **radiation**.



Heat Lamp

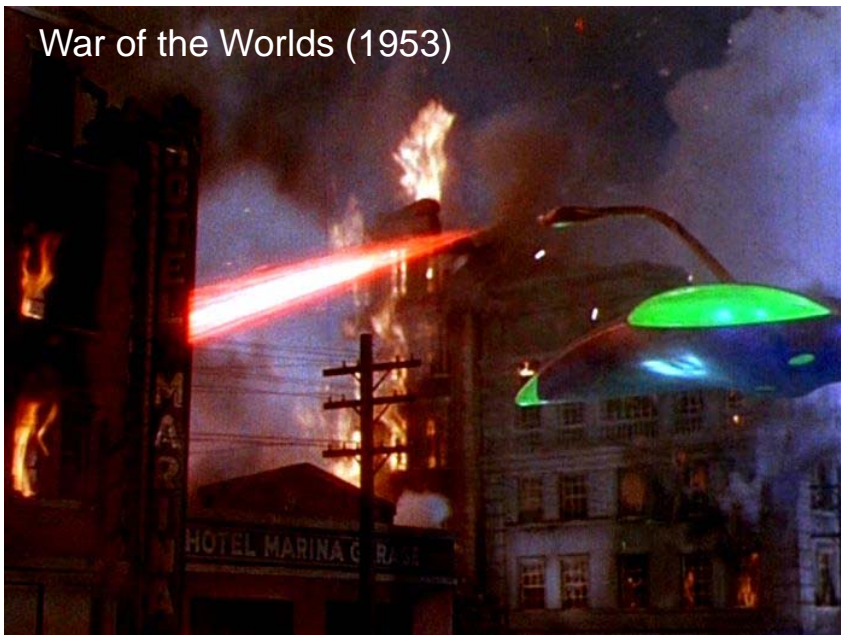


Highly reflective fire proximity suits

Heat-Ray

“Heat-ray” weapons first appeared in science fiction in H.G. Wells’ War of the Worlds (1898).

War of the Worlds (1953)



Mars Attacks! (1997)



High powered lasers are similar to H.G. Wells’ heat-ray.

Freeze-Ray

There's no current technology to create a ray that *removes* energy from an object.



Mr. Freeze in *Batman and Robin* (1997)

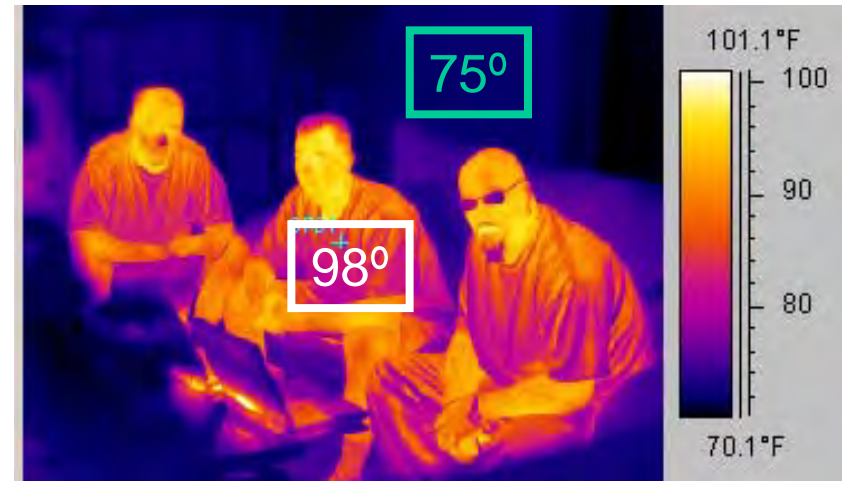


Emission of Radiant Energy

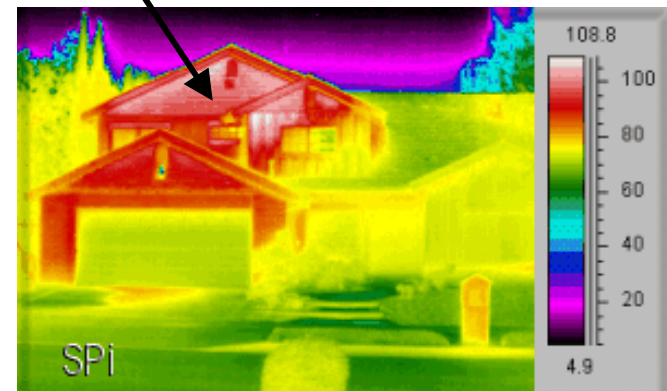
All objects radiate light;
higher the temperature
the higher the light's
frequency.

At room temperature the
radiated light is at
frequencies too low for
our eyes to see.

Special cameras are
sensitive to this infrared
radiation.

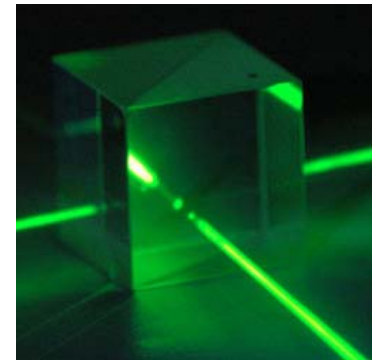


Attics in this house were kept
warm for growing marijuana.



Predator (1987)

Normal view and heat vision filmed at the same time.



Beam splitter was used so that the two cameras are get the same view.

Cameras & Infrared Light

Digital cameras are sensitive to infrared light, such as from a TV remote control, which is invisible to the human eye.

As seen by
human eye



As seen by digital camera



Summary

- Transferring energy from high to low temperature objects is called heat flow.
- Conduction is heat flow by direct physical contact of hot and cold objects.
- Convection is heat flow in a fluid caused by warm fluid rising due to buoyancy.
- Radiation is heat flow due to light, such as from a heat lamp or a fireplace.