Skittles, Jell-O and Diffusion

The Experiment

http://commons.wikimedia.org/wiki/File:Skittles-Louisiana-2003.jpg

Demonstrate diffusion in Skittles and Jell-O

The Principle

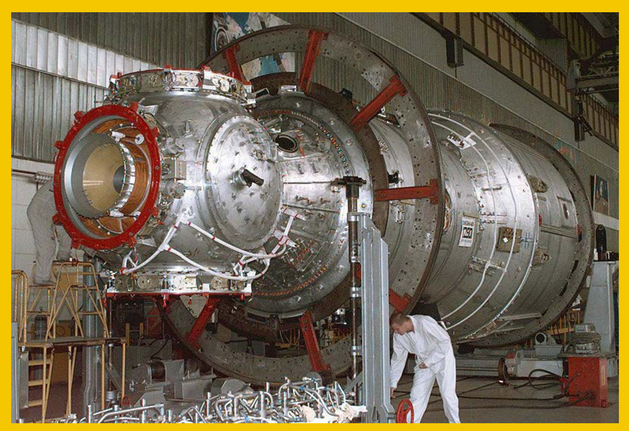
Measure diffusion by Fick's Law:

$$J = -D \cdot \frac{\delta \phi}{\delta x}$$

Difference in concentration drives diffusion

The Application

In industry we apply these principles in research and production



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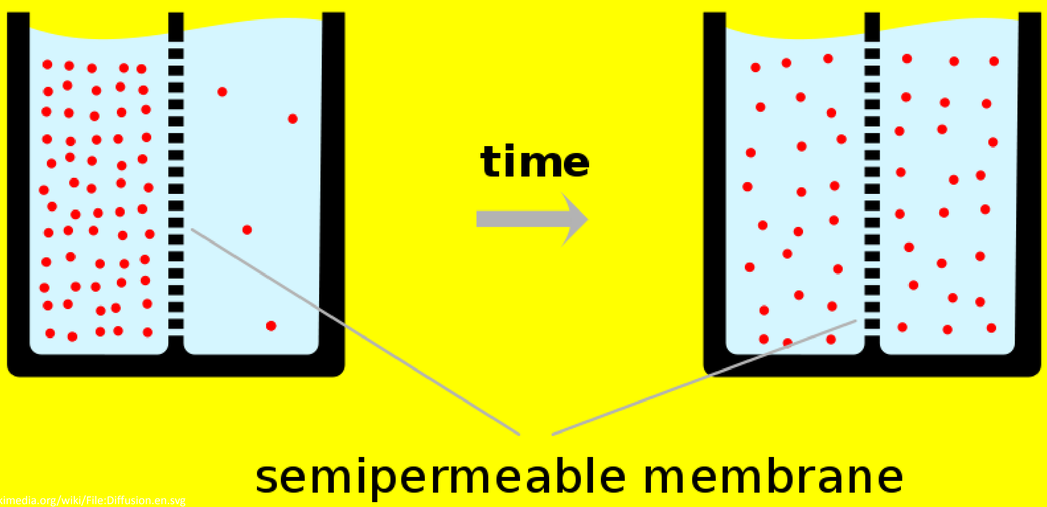


http://commons.wikimedia.org/wiki/File:Diffusion.en.svg

Can you think of other examples of diffusion happening around you?

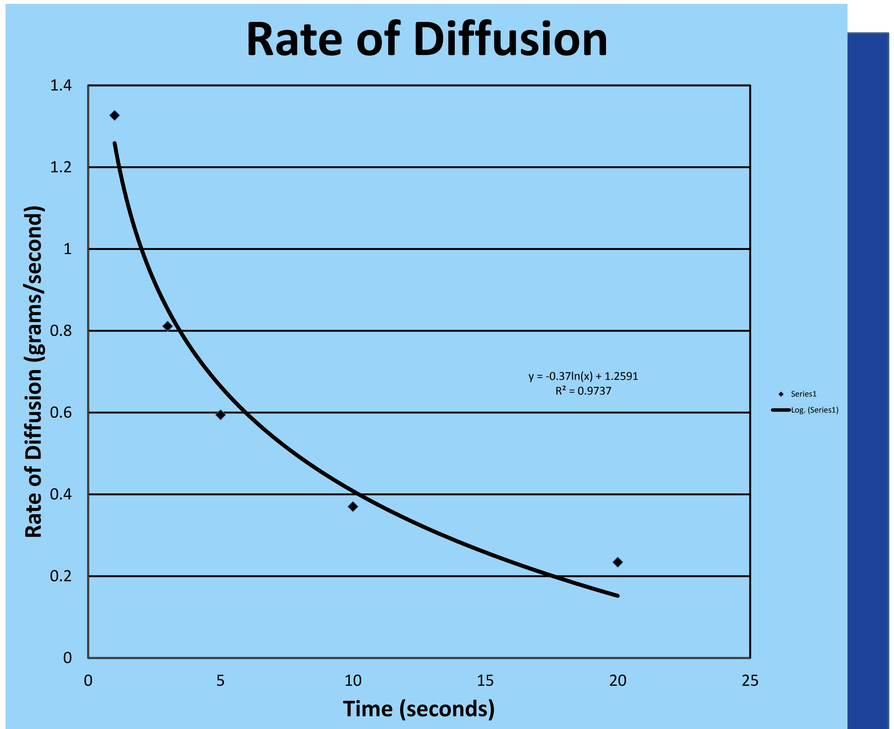
Milk Diffusion in Cookies

How does milk get into your cookie?

Diffusion

When you first put a cookie into a glass of milk, there is a lot of milk around the cookie but no milk in the cookie itself. The milk wants to go from where there is a lot of milk to where there is no milk. This process is called *diffusion*.

http://commons.wikimedia.org/wiki/File:Super_Slow_Motion_Oreo_Dunk_in_Milk.jpg



$$J_{.A} = -D_{.AB} \cdot \frac{\Delta C_{.A}}{\Delta x}$$

Mass diffusion equation

http://commons.wikimedia.org/wiki/File:Oreo_Dump_Action.jpg

Why does milk drip out of the cookie when you take it out of the milk? If you take the cookie out of the milk, it drips off the cookie because there is now more milk in the cookie than on the outside of the cookie.

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Cameron Quist, Brad Wallo, Matt Burnham, Jonathon Horton, Ken Alford

What's Cooking, Mom?

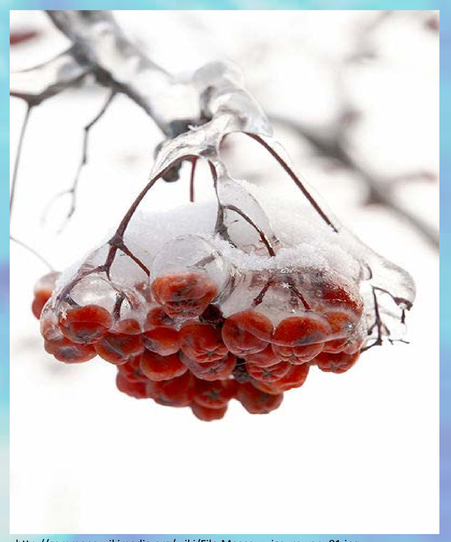
How diffusion and advection affect smell

Mass diffusivity and concentration

$$D_{AB} = \frac{T^{3/2}}{P}$$

$$J_A = -D_{AB} C \nabla x_A$$

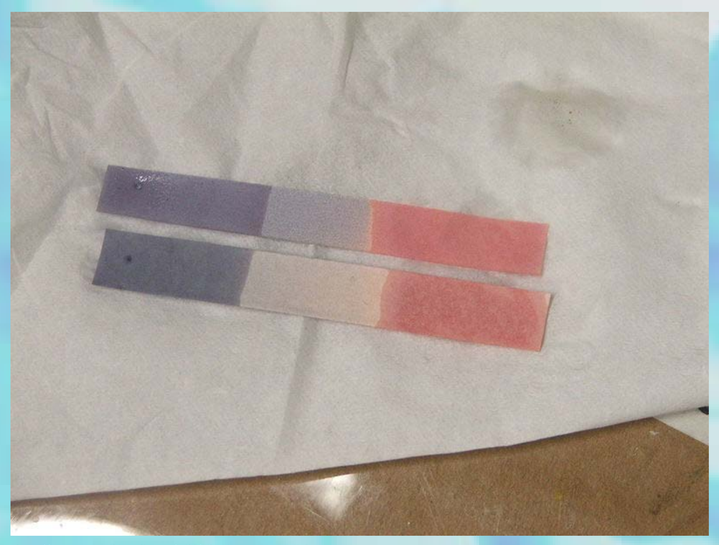
Cold vs. Hot



http://commons.wikimedia.org/wiki/File:Moscow,_ice_rowan_01.jpg

http://commons.wikimedia.org/wiki/File:Yay_for_Cherry_Pie!.jpg

Litmus paper test



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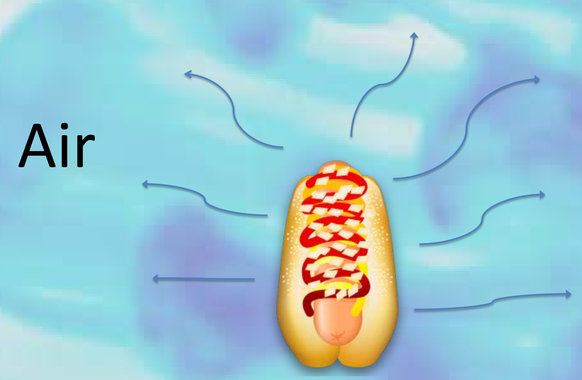
Diffusion vs. Advection



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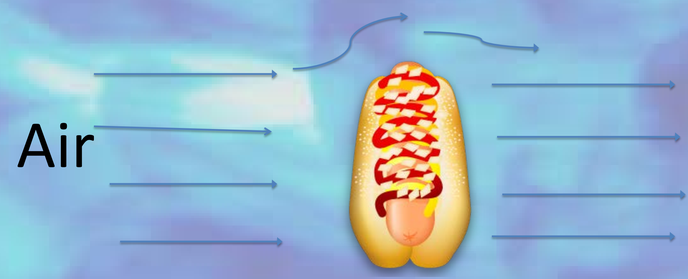

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$$N''_A = J_A + x_A(N''_A + N''_B)$$

Diffusion **Advection**

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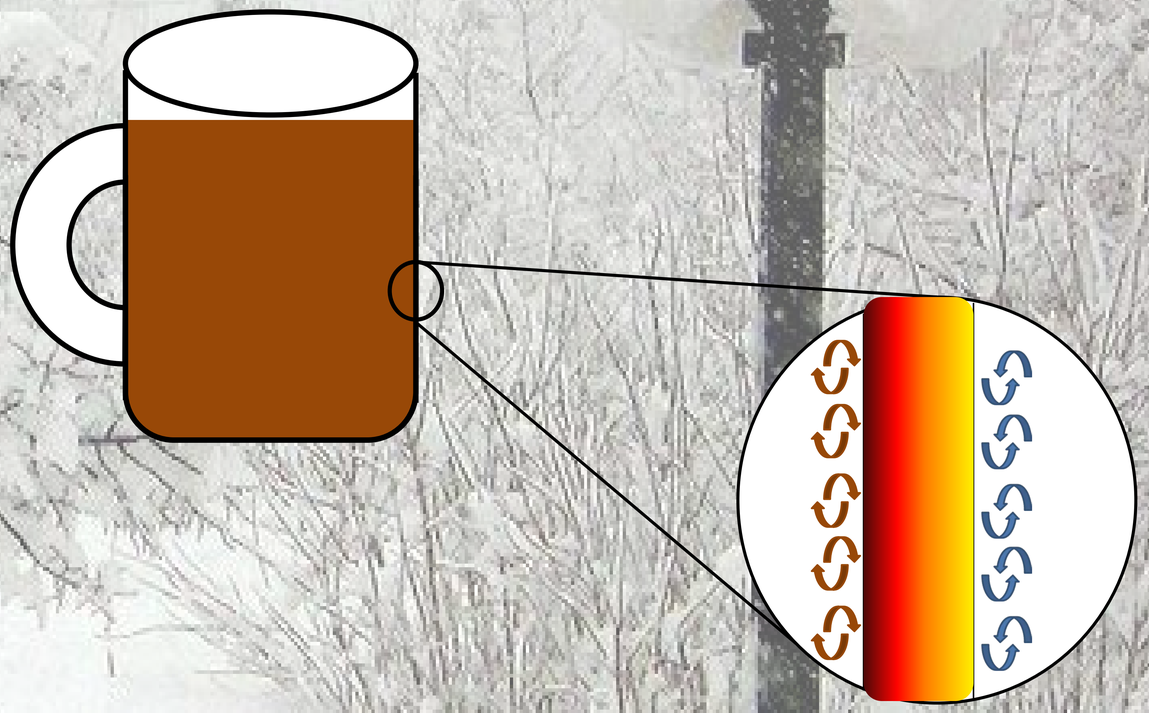
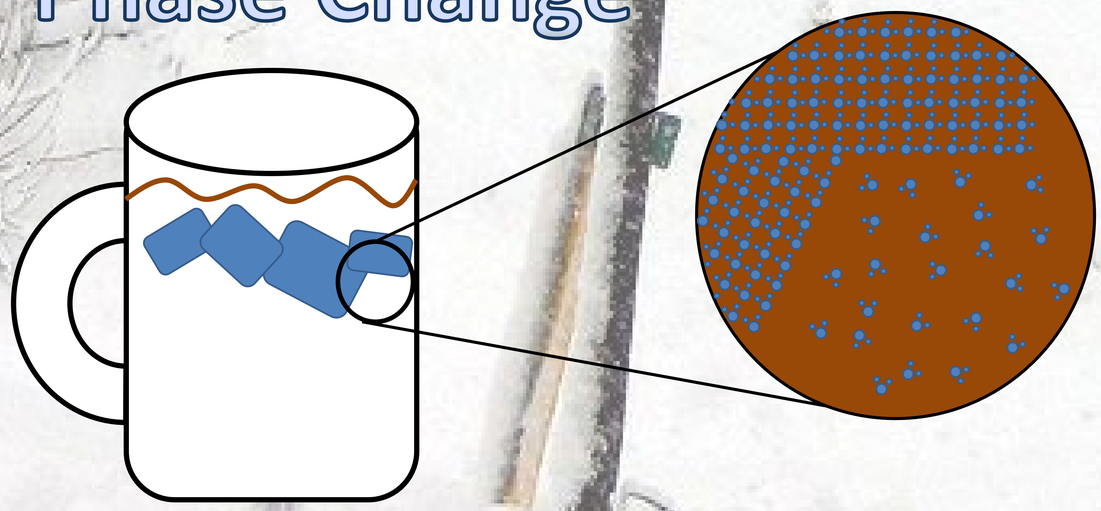
FREE Hot, Hot, Hot Cocoa!!!

Convection

Conduction



Latent Heat Phase Change



Question: Which method cools a cup of hot chocolate the fastest?

Applications: Cooling towers

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How to Save a Popsicle

http://commons.wikimedia.org/wiki/File:LoranPop.gif

Are you telling me
that holding my popsicle in the fan
will melt it faster than it will on its own?

http://commons.wikimedia.org/wiki/File:Hw-newton.jpg

Newton's Law of Cooling States that the rate at which heat is transferred, depends on the temperature difference between surroundings and the object. If there are no external factors affecting temperature, eventually the two temperatures will equalize and heat flow will stop.

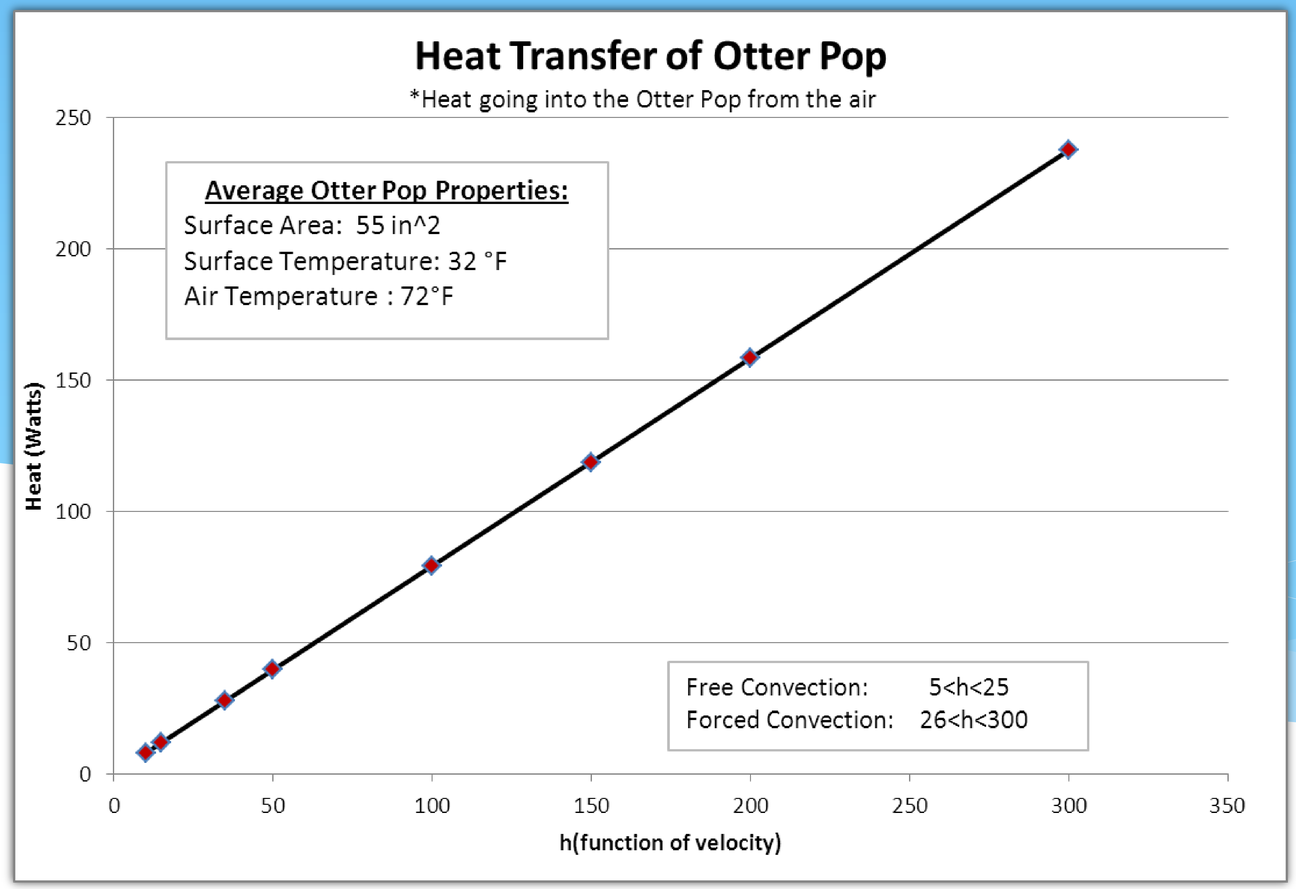
Convection Occurs as a gas or liquid moves across a surface, transferring heat with it . The faster air sweeps by your body, the more heat it is able to take with it. The faster that same air moves past the popsicle, the more heat flows INTO the cold surface.

http://commons.wikimedia.org/wiki/File:Kawasaki-Electric_Fan.jpg

The Direction of Heat Flow

Is determined by which temperature is greater than the other. This means that the same cool breeze that cools you off after a game of basketball on a hot day will HEAT UP something cold—like a popsicle

$$-Heat_{transfer} = (h)\cdot(Area_{surface})\cdot(Temp_{surface} - Temp_{surround})$$



Free Convection: Boiling Water

http://commons.wikimedia.org/wiki/File:Boiling_water.jpg

Forced Convection

http://commons.wikimedia.org/wiki/File:Hairdryer_20101109.jpg

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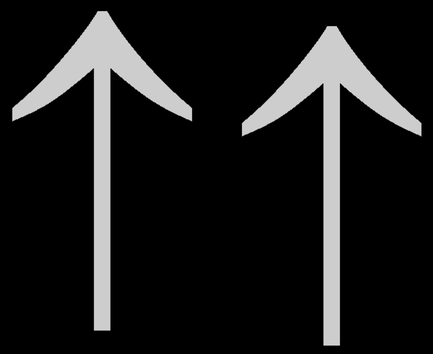
Invisible Ink

Convection- Energy transfer due to random molecular motion, as well as bulk movement



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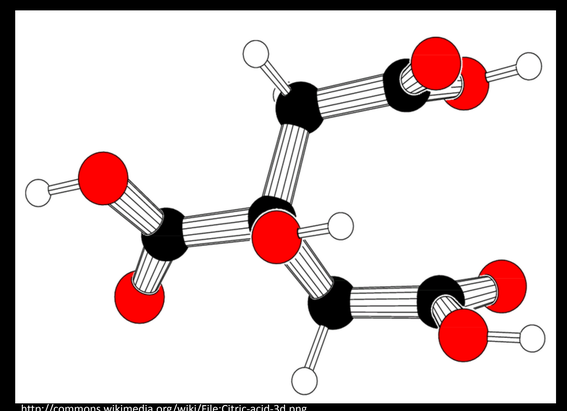
Citric Acid



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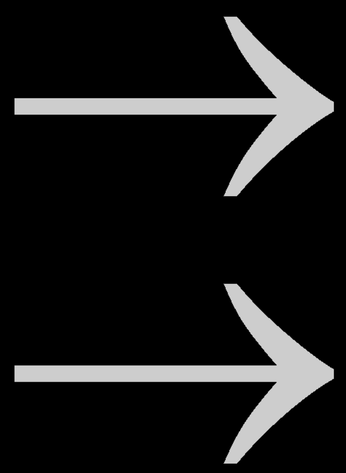
Why this Works:
Citric acid on paper burns quicker than the paper does

Why is convection faster?



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Radiation- Energy transfer due to electromagnetic waves (photons)

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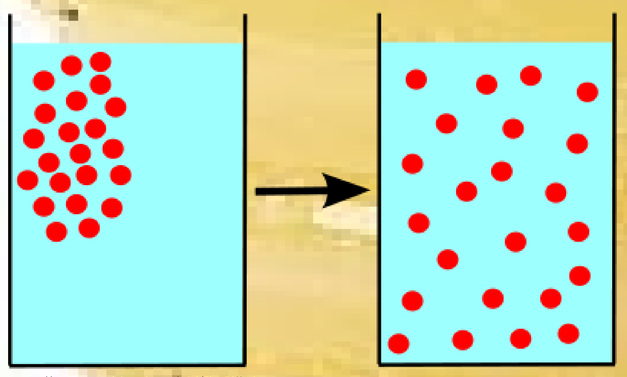
Stir Before you Drink

What is diffusion?



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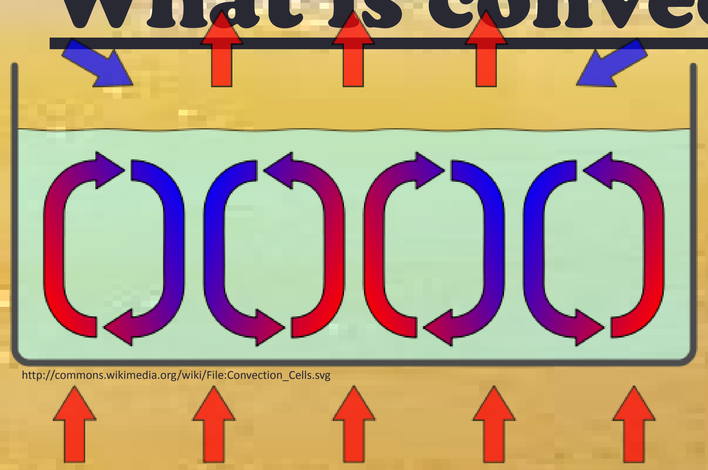
SLOWLY

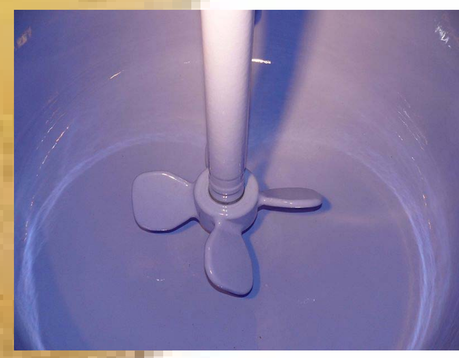
What is convection?



http://commons.wikimedia.org/wiki/File:Convection_Cells.svg

QUICKLY

BECAUSE OF



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STIRRING

Why does it diffuse?

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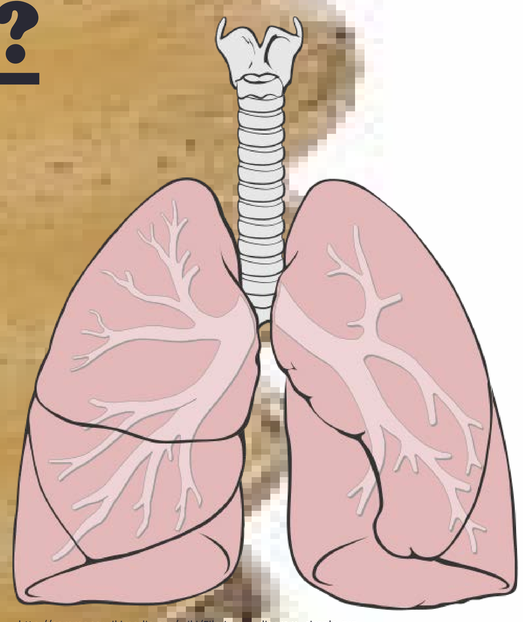
DISORDER IS NATURAL

Why is this kool?

http://commons.wikimedia.org/wiki/File:Chocolate_Sour-Cream_Icing_before_adding_icing_sugar.JPG

ITS DELICIOUS



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BREATHING

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http://commons.wikimedia.org/wiki/File:RoastingMarshmallow.jpg

FREE S'MORES!

brought to you by

radiation heat transfer

and by DOW®

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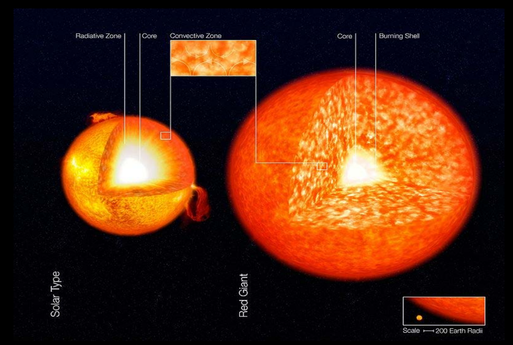
From the sun, to car engines, to the person next to you, radiation occurs everywhere. It keeps our planet warm and helps our bodies regulate our temperature.

Thermal radiation is the transfer of energy from one body to another without contact of any kind. Anything with a temperature above absolute zero emits some thermal radiation.



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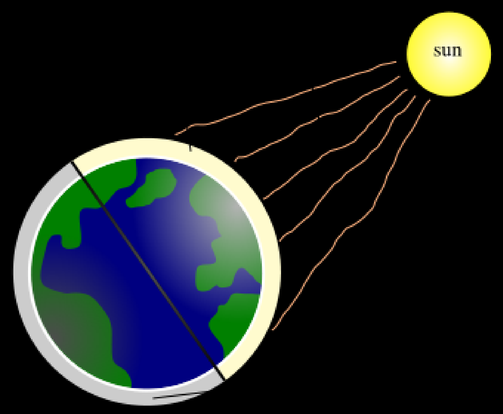
fire (n): a chemical reaction that releases heat and light (A.K.A. radiation!)

$$q_{rad} = \varepsilon\sigma(T_s^4 - T_{surr}^4)$$

$$\sigma = 5.67 * 10^{-8} \frac{W}{m^2 * K^4}$$

$$\varepsilon_{marshmallow} \approx .95$$



http://commons.wikimedia.org/wiki/File:Ionospheric_absorption_(en).svg

We can mimic the radiation of fire by providing heat and light with an alternate source… thus cooking the marshmallow.

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Fire: http://commons.wikimedia.org/wiki/File:FireIcon.svg

FREE ICE CREAM!!!!

Microsoft Clip Art

TOO COOL FOR SCHOOL

Cool Beans Team: John Chan, Brad Hancock, Jay Liu, Ryan Marelli, Brandon Martin

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What is Conduction?

Conduction is the transfer of energy from the more energetic to the less energetic particles of a substance due to interactions between the particles.

Fun Fact

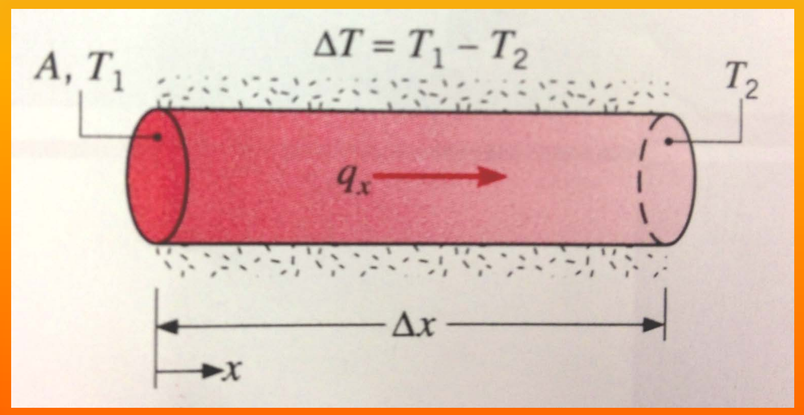
Ever noticed that metals tend to feel cold? Believe it or not, they're not colder! They only feel colder because they conduct heat away from your hand. You perceive the heat that is leaving your hand as cold.

http://commons.wikimedia.org/wiki/File:White_mocha_ice_cream.jpg

The Conduction Rate Equation

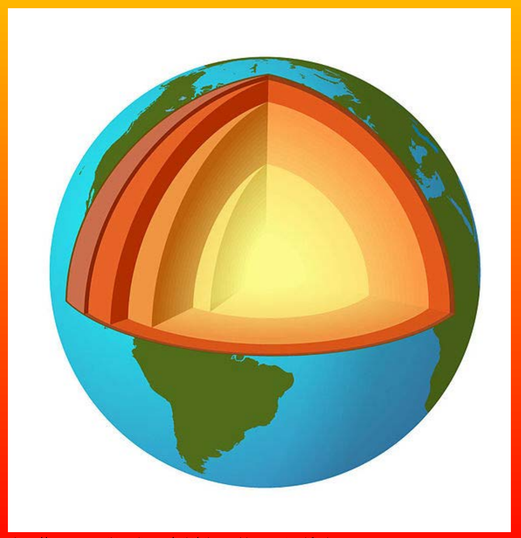
$$q_x = -k * A_c * \left(\frac{T_h - T_c}{\Delta X}\right)$$

- q_x: heat transfer rate
- k: thermal conductivity
- A_c: Cross-sectional area of medium
- T_h/T_c: temperatures of two surfaces
- ΔX: distance between two surfaces



Examples of Conduction

- A metal spoon in your hand melts ice cream
- Metal handrails feel colder than plastic or painted handrails
- Mood rings change color based on hand temperature and conduction heat transfer
- Heat conducts through your frying pan to cook food.
- Heat conducts from the center of the earth to keep the surface of the earth warm



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GOOSE-BUSTERS

Do goose bumps help you stay warm?

Why?

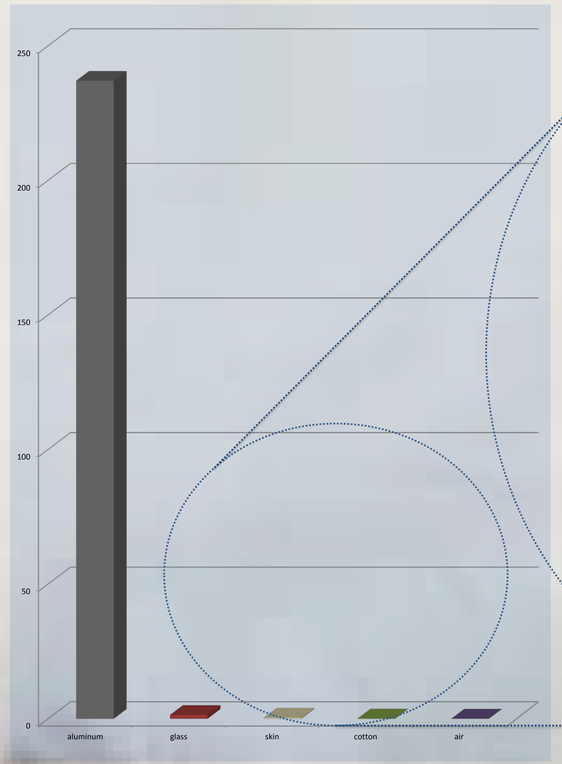
Thick hair traps air making insulation

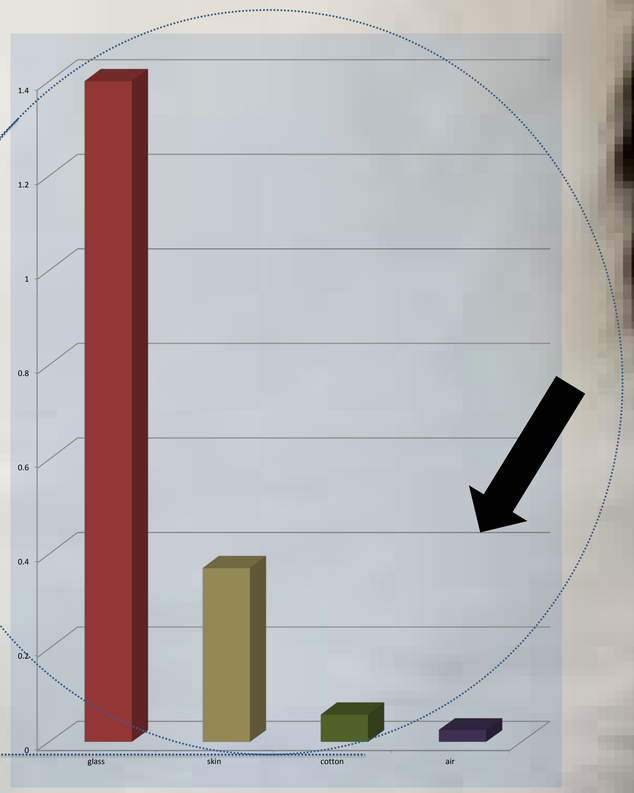
Heat must travel through the trapped air before it is lost

Air doesn't conduct heat very well

Only if you're really hairy!

How Well Materials Conduct



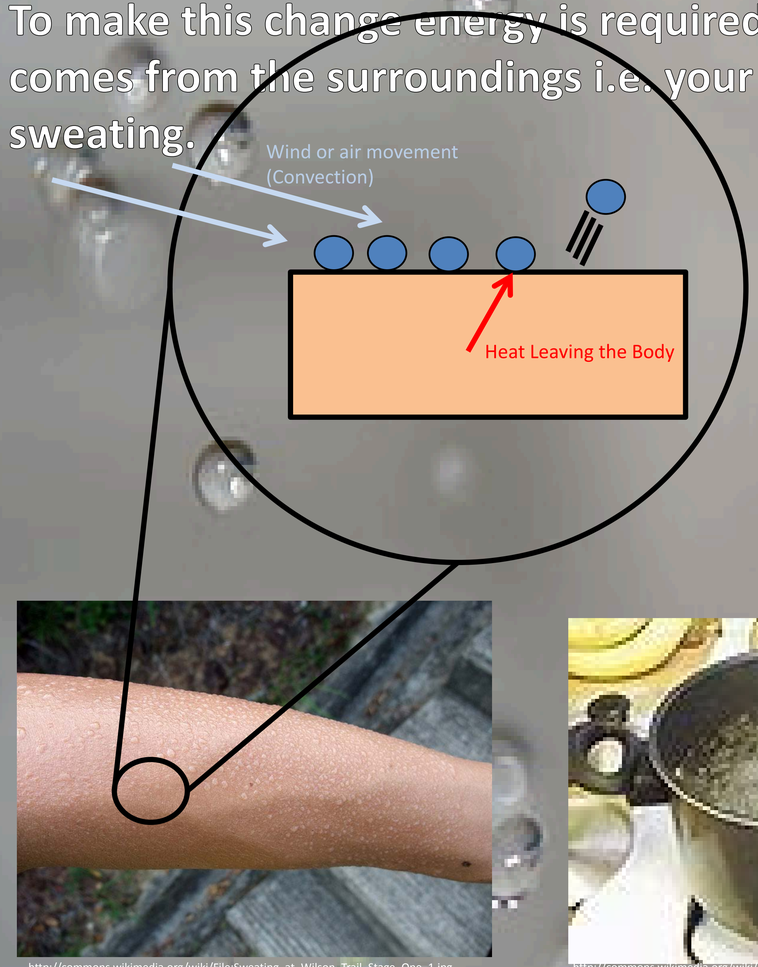


Latent Heat Transfer!

Michael Albretsen, Shawn Carlson, Greg Hyatt, Eric Manwill, Devin Moss

How does Evaporation cool stuff?

Evaporation is water changing from a liquid to a gas. To make this change energy is required. This energy comes from the surroundings i.e. your body when sweating.



Common Examples

Sweating, Boiling water, Condensation

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http://commons.wikimedia.org/wiki/File:Boiling_water.jpg

http://commons.wikimedia.org/wiki/File:Condensation_on_water_bottle.jpg

Fun Facts!

- Benjamin Franklin first discovered how to freeze water in the summer using the power of evaporation
- Ancient Persians used the cooling power of water evaporation to air condition their homes
- People have died in the summer due to hypothermia caused by water evaporating off their wet skin
- Nuclear power plants use evaporative cooling to prevent meltdowns

Persian Qanat

http://commons.wikimedia.org/wiki/File:Mud_houses,_Syria.jpg

http://commons.wikimedia.org/wiki/File:Nuclear_Power_Plant_Cattenom.jpg

Our Experiment

Water bottles wrapped in paper towels are placed in a pan of water. The water is evaporated using a fan to blow air across them. Heat flows from the hot soda to the evaporating water and cools the soda

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Cold Soda!

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