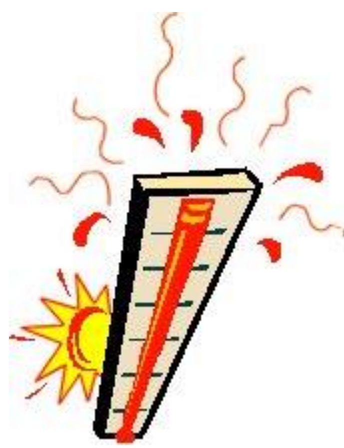
**Grade 7 Science**
**Unit C**
**HEAT AND TEMPERATURE**
**Study Guide**



## UNIT C: HEAT AND TEMPERATURE

**Topic A**: Illustrate and explain how human needs have led to technologies for obtaining and controlling thermal energy and to increased use of energy resources.

- Investigate and interpret examples of heat-related technologies and energy use in the past (e.g. domestic and industrial purposes)
- Trace linkages between human needs and development of heat-related materials and technologies (hair and clothes dryers, oven mitts, ski wear)
- Identify and explain uses of devices and systems to generate, transfer, control and remove thermal energy (use of furnace and thermostat to keep temperature constant)
- Identify examples of personal and societal choices in using energy resources and technology (how much hot water we use and how we heat it)

**Topic B**: Describe the nature of thermal energy and its effects on different forms of matter, using informal observations, experimental evidence and models.

- Describe the effect of heat on the motion of particles, and explain changes of state using the particle model of matter.
- Distinguish between heat and temperature, and explain temperature using the concept of kinetic energy and the particle model of matter.
- Compare heat transmission in different materials (e.g., conduction of heat in different solids, absorption of radiant heat by different surfaces)
- Explain how heat is transmitted by conduction, convection and radiation in matter.
- Investigate and describe the effects of heating and cooling on the volume of different materials, and identify applications of these effects (expansion joints on bridges).

**Topic C**: Apply an understanding of heat and temperature in interpreting natural phenomena and technological devices.

- Describe ways in which thermal energy is produced naturally (e.g., solar radiation, combustion of fuel, living things, geothermal sources and composting)
- Describe examples of passive and active solar heating and explain the principles that underlie them (e.g., design of homes to maximize use of winter sunshine)
- Compare and evaluate materials and designs that maximize or minimize heat energy transfer (e.g., insulated containers, different window coatings)
- Explain the operation of technological devices and systems that respond to temperature change (thermometers, bimetallic strips, thermostatically-controlled heating systems)
- Describe the function of household devices for generating, transferring and controlling thermal energy (operation of heaters, furnaces, refrigerators and air conditioners)

**Topic D**: Analyze issues related to the selection and use of thermal technologies, and explain decisions in terms of advantages and disadvantages for sustainability.

- Identify and evaluate different sources of heat and the environmental impacts of their use (fossil fuel, renewable and nonrenewable sources of energy)
- Compare the energy consumption of alternative technologies for heat production and use, and identify related questions and issues (compare electric, gas, microwave and solar ovens; identify issues regarding safety of fuels, hot surfaces and combustion)
- Identify positive and negative consequences of energy use, and describe examples of energy conservation in your home and community.

**Topic A: Illustrate and explain how human needs have led to technologies for obtaining and controlling thermal energy and to increased use of energy resources.**

**1. Investigate and interpret examples of heat-related technologies and energy use in the past** (Pg. 180-184)

<u>Steam engines</u> were the first engine type to see widespread use. That is because they have the ability to convert raw heat into mechanical work. A fire heats water which turns to steam and the steam then has the ability to move things. They were first invented by Thomas Newcomen in 1705, and James Watt (a Scottish inventor) made big improvements to steam engines in 1769. Steam engines powered all early locomotives, steam boats and factories, and therefore acted as the foundation of the Industrial Revolution.

Coal stoves were used for both heating and cooking before homes had electricity. Although not a clean heating source, it was relatively efficient and would produce heat long after the fire went out. This picture shows the old coal bucket used to carry coal from outside, into the house.

**2. Trace linkages between human needs and development of heat-related materials and technologies.** (Pg. 185-186)

Probably the greatest human need that drove heat technology was to keep from freezing. The greatest want may have been a desire for more free time. As our lives became busier, we were always looking for ways to save time so that we could have more leisure hours to enjoy.

EXAMPLES:

**Hair Dryers** —The hair dryer dries your hair by speeding up the evaporation of water from the hair's surface. The hot air emitted from a hair dryer increases the temperature of the air surrounding each strand of hair. Since warm air can contain more moisture than air at room temperature, more water can move from your hair into the air. The increase in temperature also makes it easier for the individual molecules in a water droplet to overcome their attraction to one another and move from a liquid to a gas state.

**Oven Mitts** — these allow people to remove hot items from the stove without have to wait for them to cool. They are made of an insulating material such as cotton or Insul-Bright which consists of hollow, polyester fibers needle punched through Mylar. The hollow fibers resist conduction, while the reflective mylar resists radiant energy. The energy, hot or cold, is reflected back to its source.

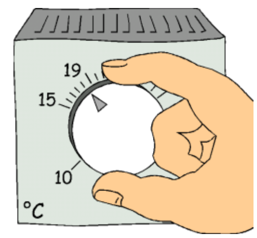
**Ski Suits** — Many modern garments are constructed with a lightweight micro fiber Polyester Lycra composite that, when worn against the skin, traps body heat between its fibers and recycles that heat throughout the garment. In addition, the fabric wicks moisture quickly through the garment enabling you to remain dry and warm.

**3. Identify and explain uses of devices and systems to generate, transfer, control and remove thermal energy.**

We know that thermal energy is a good and useful thing. The question is, how do we control it so that it does what we want?

A good example of this is the heating system in your home.

Thermostats control nearly all types of heating and cooling equipment, keeping room temperatures, cooking devices, hair dryers, etc. within a set range. By doing so, they ensure comfort, cut energy waste, and offer considerable convenience.




A thermostat has a temperature sensor and an activating switch. Some are mechanical, others electronic. Thermostats are either manual or digital.

**4. Identify examples of personal and societal choices in using energy resources and technology.** (Pg. 187)

We have an amazing energy source called the "Sun". Since heat is energy, this is the original source of all the heat we use. The Law of Conservation of Energy states that "Energy cannot be created or destroyed. It can only be converted from one form to another". The most efficient use of the Sun's energy is to use sunlight itself for heating purposes and this is what solar heaters do (we will be talking more about them later). Heat energy is a form of energy that transfers from matter at higher temperatures to matter at lower temperatures. However, we often want heat when it is not available to we produce it by converting other forms of energy back into heat. For example, plants that grew hundreds of millions of years ago used the sun's energy to photosynthesize and create food (chemical energy). When the plants died and were buried, they turned into fossil fuels (oil, gas, coal). We now take that chemical energy and burn it to create heat energy. The problem is that fossil fuels not only pollute the environment, but they will also run out one day. It is important that we find other sources of heat energy since our very lives depend on staying warm in temperatures below 0°C. Finding other resources will ensure sustainability of heat resources – in other words, we will have resources that will allow future generations to not freeze in the cold.

**TOPIC B: Describe the nature of thermal energy and its effects on different forms of matter, using informal observations, experimental evidence and models.**

**1. Describe the effect of heat on the motion of particles, and explain changes of state using the particle model of matter.** (Pg. 191-196)

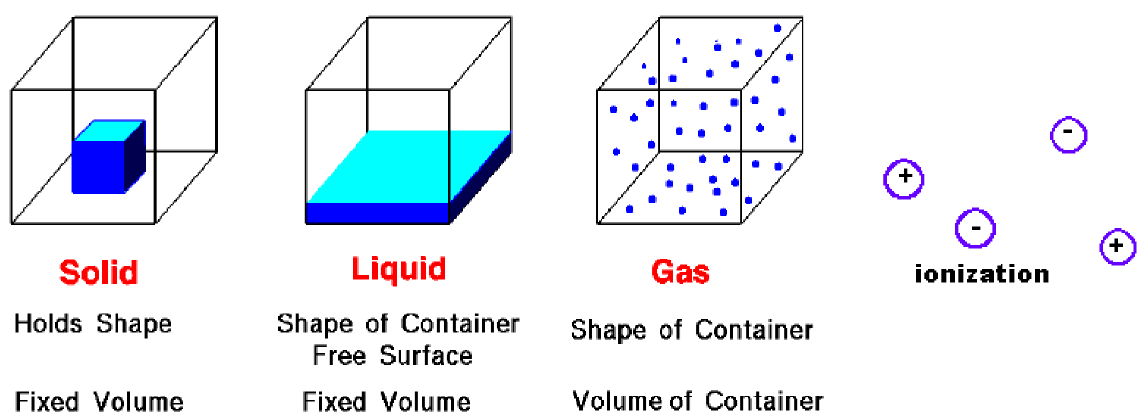
Everything in the universe is made of matter. Here is another law for you.

The Law of Conservation of Matter states the "Matter cannot be created or destroyed. It can only change from one form to another". Sounds a lot like the Law of Conservation of Energy, doesn't it.

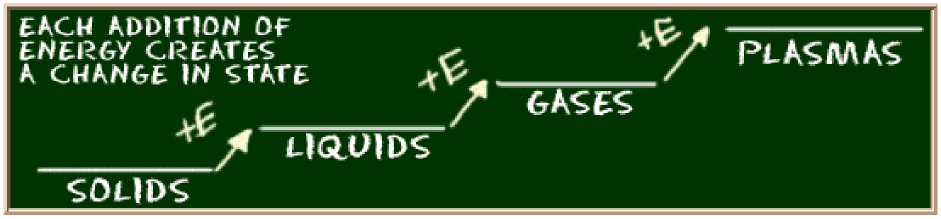
Matter is anything that has mass and takes up space. All matter is made up of tiny particles called atoms.

STATES OF MATTER

There are five main states of matter: solids, liquids, gases, plasmas, and Bose-Einstein condensates. Your textbook talks about three of these —solids, liquids and gasses — but ignores the plasmas (extremely high energy pieces of atoms) and Bose-Einstein condensates (extremely low energy atoms) because they are not well understood. Humans tend to ignore things they don't understand but that doesn't mean they don't exist. However, we will focus on the middle three states. Each of these states is also known as a phase. Matter can change from one phase or state to another when special physical forces are present. One example of those forces is temperature. The phase or state of matter can change when the temperature changes. Generally, as the temperature rises, matter moves to a more active state.



Phase describes a physical state of matter. The key word to notice is physical. Things only move from one phase to another by physical means. If energy is added (like increasing the temperature or increasing pressure) or if energy is taken away (like freezing something or decreasing pressure) you have created a physical change.

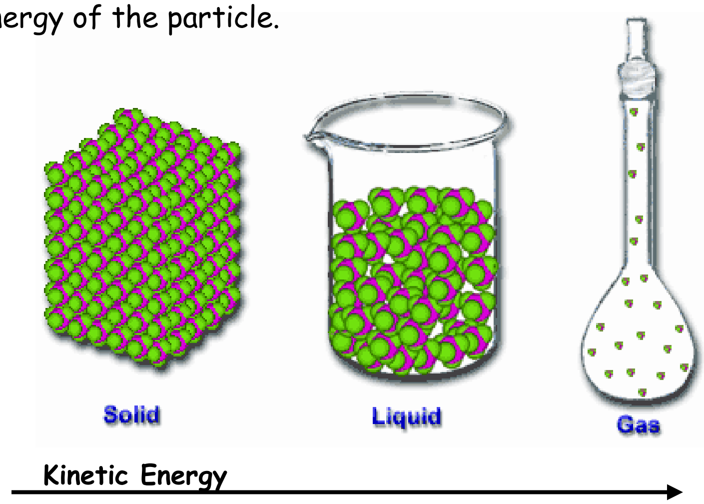



Matter can move from phase to phase, but still be the same substance. You can see water vapor over a boiling pot of water. That vapor (or gas) can condense and become a drop of water. If you put that drop in the freezer, it would become a solid. No matter what phase it was in, it was always water. It always had the same chemical properties.

PARTICLE MODEL OF MATTER

This is a theory that helps explain how matter changes from one state or phase to another. There are four basic components:

1. All matter is made up of tiny particles called atoms. These can only be seen with electron microscopes.
2. The atoms are always moving – they all have kinetic energy.
3. The particles have space between them. Different states of matter have different amounts of space.
4. Adding heat (energy) to matter makes the particles move more quickly. Since faster moving things have more kinetic energy, adding heat increases the energy of the particle.



Weird Water – Generally, materials contract or compress when they become solids since the particles (atoms) are more tightly packed together. If that were the case for water, when it freezes it would become smaller but it you have ever put a glass of water in the freezer you know that it not the case. Water actually expands and becomes less dense (it floats) when it goes from a liquid to a solid state – weird! At normal atmospheric pressure, molecules usually behave in predictable ways as their temperature changes.

Water starts out behaving normally. As its temperature drops, water obediently shrinks together--until it reaches 4 degrees Celsius. Then, amazingly, water reverses course, its volume slowly increasing as it chills. When water finally freezes, at 0°C, it expands dramatically.

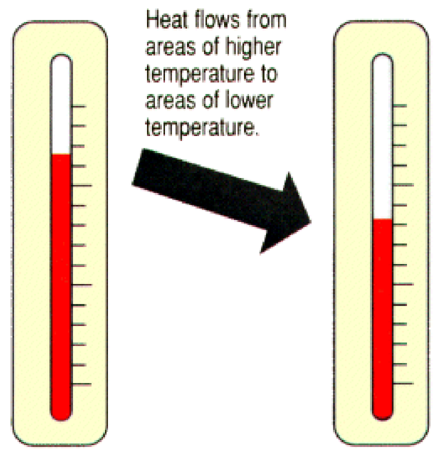
Water's quirky behavior is caused by the shape of its molecule and by how its molecules bond to one another. If frozen water weren't less dense than liquid, there would be no floating icebergs to sight off the bow of a ship. There would be no skating on ice-covered ponds, while fish and other life shelter in insulated, 4°C water below. If water froze from the bottom up, much of Earth's water would solidify in winter, and life might be impossible. This is just another reason to appreciate water as life-support for all living things.

**2. Distinguish between heat and temperature, and explain temperature using the concept of kinetic energy and the particle model of matter.** (Pg. 198-202)

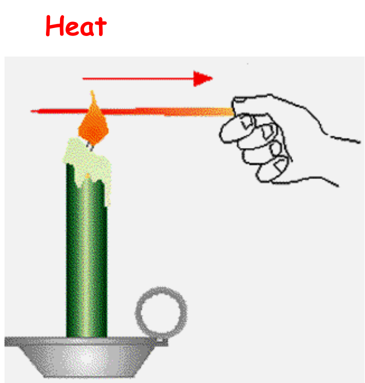
Common Misconception: Often the concepts of heat and temperature are thought to be the same, but they are not. Perhaps the reason the two are usually and incorrectly thought to be the same is because as human beings on Earth everyday experience leads us to notice that when you heat something up, say like putting a pot of water on the stove, then the temperature of that something goes up. More heat, more temperature - they must be the same, right? Turns out, though, this is not true.

<u>Heat</u> energy is the collective random motion of molecules. Heat energy spontaneously flows "down the temperature scale" from a warmer region to a cooler one. If there is no temperature difference, there is no heat flow. Like all energy, it is measured in <u>Joules (J)</u>.

Temperature: the average kinetic energy of individual atoms and molecules. The distinction between heat and temperature may be made by the following example: A cup of water at 80°C (176°F) is much hotter than a bathtub of water at 30°C (86°F) meaning average kinetic energy of individual water molecules at 80°C is greater than at 30°C. If you were to float the cup in the bathtub, heat would flow through the cup and into the cooler water of the tub.




Sweat is an excellent example of how our bodies regulate our temperature through heat. When we sweat, it is warmer than the surrounding air so heat moves from the sweat to the air. This process actually decreases the temperature of the skin and helps us to feel cooler.

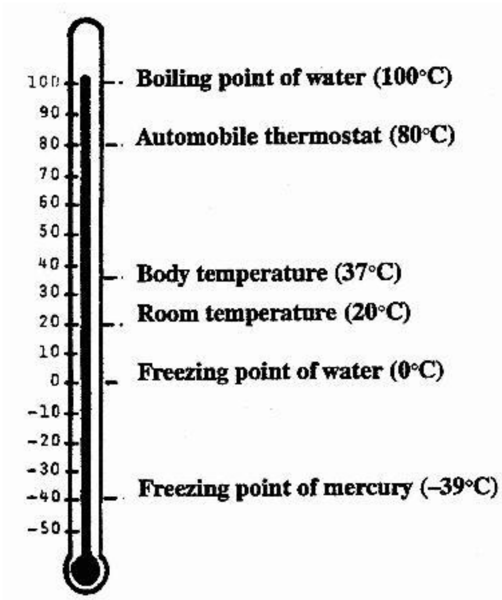



Once the candle begins to warm the left side of the metal bar, a temperature difference is created along the bar and heat energy is transferred throughout the bar from hot to cold. The transfer occurs as molecules in the bar transfer their kinetic energy to those in direct contact with them.

Thermal Energy is the total kinetic energy of all the particles the substance contains. Since energy is defined as the ability to do work, the more energy you have, the more work gets done. Think about two cups of hot cocoa. One is a "grande" and the other a "small". They each have the same temperature, they would each transfer heat if put next to a cooler object. However, the larger cup would transfer more heat because there are more particles with energy. If you had just finished skiing and were cold, the larger hot chocolate would warm you up more. That is what thermal energy is all about.

MEASURING TEMPERATURE

In Canada, we use the Celsius scale to measure temperature which is the metric scale.

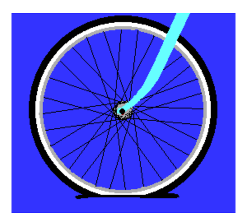



## 3. **Compare heat transmission in different materials.** (Pg. 203-204)

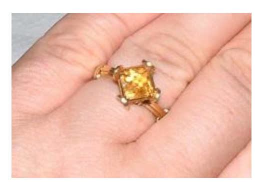
We know from the particle model of matter that substances expand as they get warmer and contract as they get cooler – with the exception of water which contracts until it reaches 4°C and then it expands. The important thing is that things change their volume when they either heat or cool. This is important to know for many reasons.

EXAMPLES

This is a picture of a sidewalk that has been cracked because water got in between the blocks, expanded and cracked the concrete when the water froze.



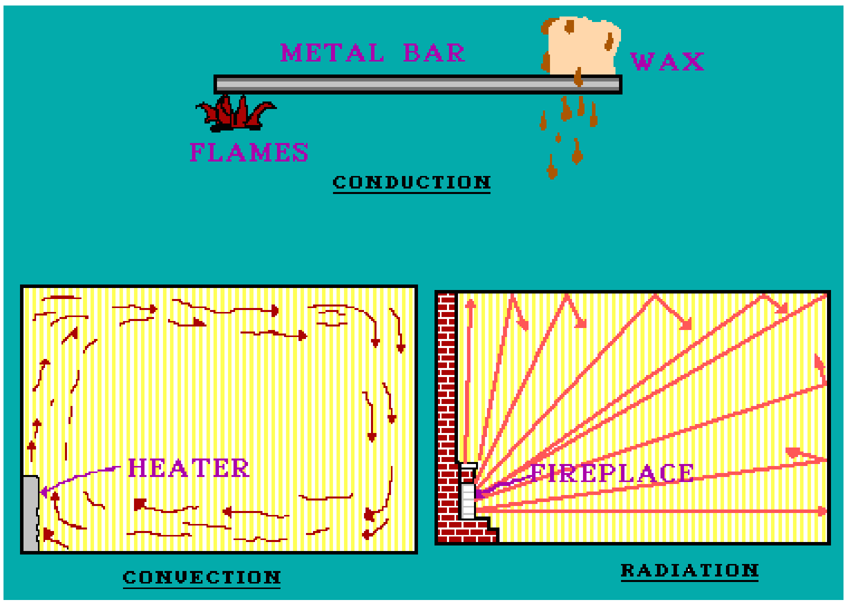
You get ready to ride your bike in the winter but notice that the tires are flat. Although your tires were okay in the summer, the gas inside of them contracts in the very cold weather and shrinks, making the tires flat.



Metals expand more than any other solid material and this can help solve or create problems. For example, if you cannot easily remove a ring, all you have to do is run it under very warm water and it will expand, allowing it to easily slip off.

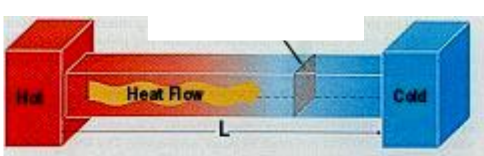
**4. Explain how heat is transmitted by conduction, convection and radiation in matter.** (Pg. 209 – 221)

Since all phases of matter are different, different methods are required to transfer heat from one place to another. The important thing is that thermal energy can be transferred from particle to particle. The three methods are conduction, convection and radiation.




CONDUCTION

Conduction is the only way that heat can pass through opaque solids. If one end is heated, the heat will pass through to the other end. Molecules moving causes conduction. The faster molecules, which are hotter, vibrate against slower moving cool molecules causing them to heat up. Energy is transferred from the faster molecules to the slower ones. Heat always passes from hotter to cooler objects. Have you ever noticed that metals tend to feel cold? Believe it or not, they are 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.

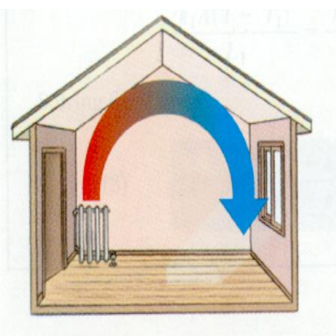


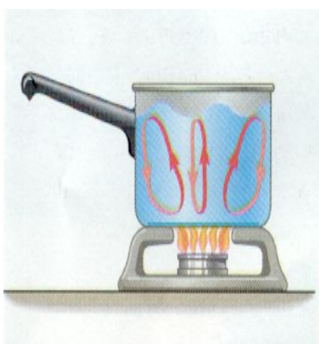
Some materials are better conductors than others. This table shows the thermal conductivity of good insulators which have low thermal conductivity and good conductors which have high <u>thermal conductivity</u>.

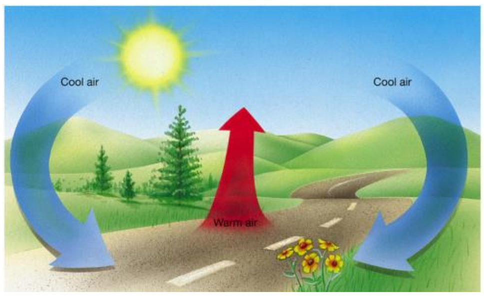
| Substance *(insulators)* | Thermal Conductivity | Substance *(conductors)* | Thermal Conductivity |
| --- | --- | --- | --- |
| Styrofoam | 0.010 | Lead | 0.353 |
| Air | 0.026 | Iron | 79 |
| Wool | 0.040 | Aluminum | 240 |
| Body fat | 0.20 | Silver | 420 |

<u>CONVECTION</u>

Convection is heat transfer by mass motion of a fluid such as air or water when the heated fluid is caused to move away from the source of heat, carrying energy with it. Convection above a hot surface occurs because hot air expands, becomes less dense, and rises. Hot water is likewise less dense than cold water and rises, causing convection currents which transport energy. Convection can also lead to circulation in a liquid, as in the heating of a pot of water over a flame. Heated water expands and becomes more buoyant. Cooler, more dense water near the surface descends and patterns of circulation can be formed, though they will not be as regular as suggested in the drawing. Convection is thought to play a major role in transporting energy from the center of the Sun to the surface, and in movements of the hot magma beneath the surface of the earth.



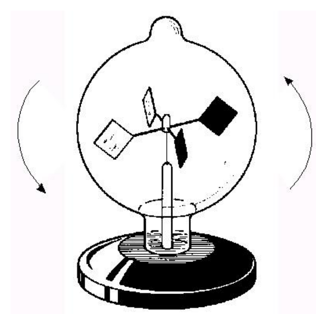




RADIATION

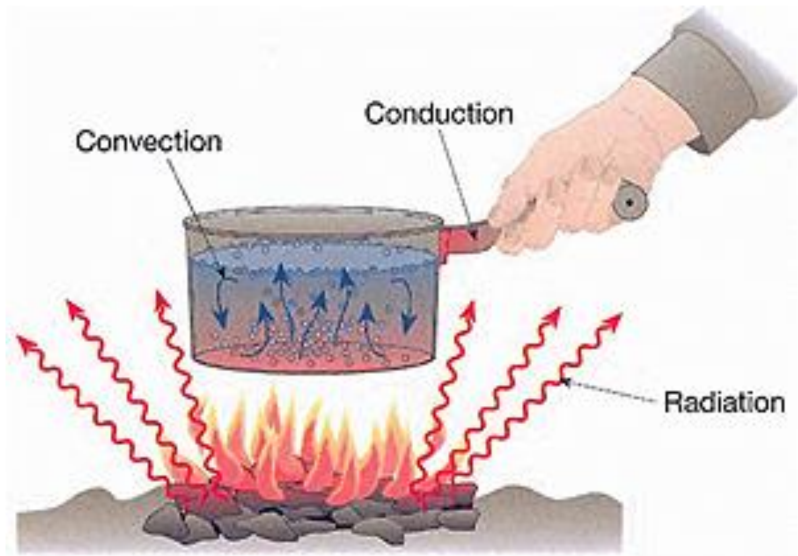
Radiant heat transfer is the transfer of heat from a heated surface. It does not require the movement of particles as conduction and convection does. Instead, the energy is part of the electromagnetic spectrum which also includes light, radio waves and x-rays. Radiant heat is also called infra-red radiation. The most common form of radiant heat transfer is the transfer of heat from the sun to the earth. This is what keeps us warm. We can also see radiant heat transfer while baking a potato in the oven. The oven is heated up and then the heat is transferred radiantly from the walls of the oven to the potato in the oven. Pets understand radiation very well. They will lie near a window knowing the heat will radiate through the glass and warm them up during their nap.

A Crookes' radiometer (or light mill) is a good example of how radiant energy works. It has four vanes suspended inside a glass bulb. Inside the bulb, there is a good vacuum. When you shine a light on the vanes in the radiometer, they spin -- in bright sunlight, they can spin at several thousand rotations per minute! This movement is caused by the black surface absorbing photon (light) energy and heating the gas near it. Hot gas molecules move faster than cold ones and, by bumping onto the dark surface, they make it move toward the light surface.



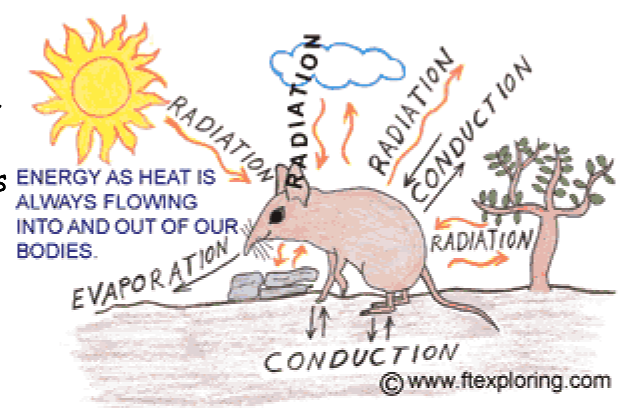
Radiant heat can be partially controlled using colour. Dark colours absorb radiant heat while light colours repel the energy. Knowing this, designers of cars, clothes, homes – you name it – use colour to help control heat transfer.

Many technologies use two or all three types of heat transfer.  Cooling is a good example.  The pan is made of a good conductor (metal) and the handle is made of an insulator (plastic).  The shape of the pan allows a liquid to develop convection currents which help evenly heat what is being cooked.  The stove burner (or the fire in this case) transfers heat by radiation from a high energy source to a low energy source.



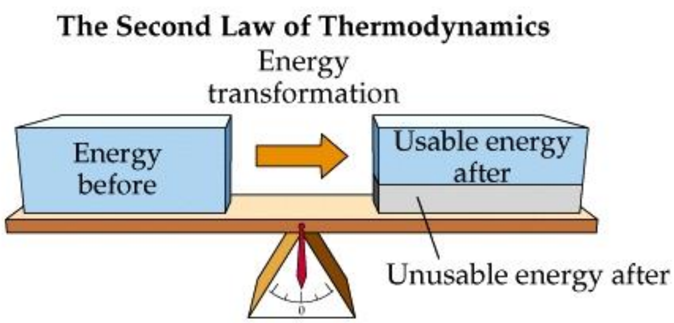

For animals (like us) heat flow is a really big deal. The way that each animal is made and behaves and where they can live, has a lot to do with heat flow.

Because of heat flow, cold-blooded reptiles and insects that live in cold climates only come out in the summer. Heat flow is why there are a lot more reptiles and insects in equatorial climates than arctic climates.  Warm-blooded mammals and birds with their high metabolisms and hotter bodies can live and move in some pretty cold places. But, because of heat flow, they have to have good dry fur or feathers, or a good layer of blubber, and plenty of high energy food to keep that body heat coming.




When you put on a jacket in the winter, or wear shorts on a hot day, you are adjusting your heat flow, trying to help your body keep its temperature very close to 38 degrees C. It's a never ending struggle. Energy as heat is always flowing out of, and into, your body.

**Evaporative Cooling:** Evaporation acts as a coolant. This fact is used for refrigerators, air conditioners and even our body. As humidity decreases and/or temperature increases, water goes from a liquid state to a gas state (evaporation). Liquid is a lower energy state and the energy required to convert liquid water to water vapour is sizable. The particles that make the leap from low to high energy will be the highest energy (warmest) particles in the liquid. Therefore, when these particles leave as a gas, they take thermal energy (heat) away from the surface of the object. In the case of refrigerators, the liquid is called a coolant which evaporates at a very low temperature and draws heat away from the interior of the fridge. For our bodies, the cooling comes when we perspire. As the sweat evaporates, it draws the required energy from the nearest source (our skin) and we cool down.




In order to transform matter from one form (liquid) to another (gas) it requires energy. In the case of evaporative cooling, this energy is in the form of heat. As water evaporates, the heat energy comes from the warmest thing in contact with the water. With people, this is the skin. With refrigerators, a liquid called "coolant" is circulated around and the heat comes from the food inside of the fridge.

Cooling bandana uses evaporation to draw heat away from the body.

**5. Investigate and describe the effects of heating and cooling on the volume of different materials, and identify applications of these effects.**
(Pg. 205-206)

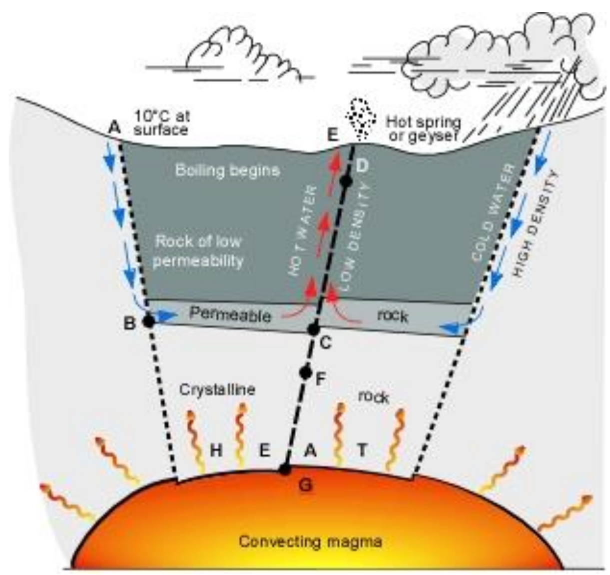
Expansion joints help solve the problems of bridges and railroad tracks expanding and contracting at different temperatures. These joint are placed between non-flexible solids (such as metal or concrete) so that when they expand, they don't bend or crack. When they contract, the expansion joint fills in so there is not a large gap.

Hot air balloons take advantage of the expansion of gases on heating so because the gas inside the balloon is warmed with a flame, it is less dense or more buoyant than the air outside of the balloon. This allows the balloon to float up and the height can be controlled by changing the temperature of the enclosed air.

**TOPIC C: Apply an understanding of heat and temperature in interpreting natural phenomena and technological devices.**

**1. Describe ways in which thermal energy is produced naturally.** (Pg. 223)

Solar Energy: The Sun is the source of all of Earth's energy. Because energy is not created or destroyed, the sun's radiant, solar energy is used not only for heat, but for literally every other energy source that we have. This sun has been shining for billions of years and there is no reason why it should not continue. In this sense it comes closer to being an inexhaustible heat source than any other practical possibility.




Geothermal Energy: Energy that is generated by converting hot water or steam from deep beneath the Earth's surface. Heat is a form of energy and geothermal energy is, literally, the heat contained within the Earth that generates geological phenomena on a planetary scale. This includes volcanoes, geysers and hot springs. 'Geothermal energy' is often used nowadays, however, to indicate that part of the Earth's heat that can, or could, be recovered and exploited by man.

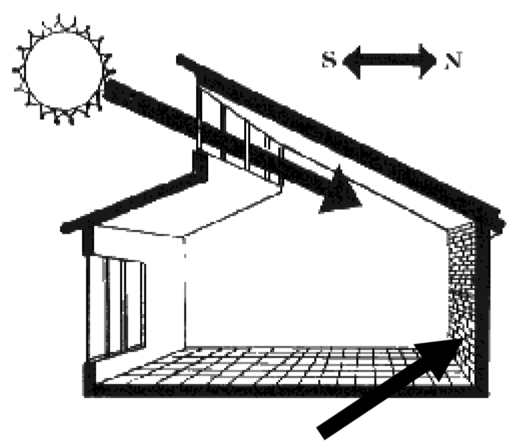
Fire is able to convert stored chemical energy into heat and light (plus sound) energy. Fire naturally occurs due to lightning strikes, volcanic action or extreme drought. Fire has been the predominant heat source for technological advancement, starting with the human's ability to control this energy.

Decomposition or decay is a natural source of heat. If you have ever been around a composter, you will notice that it is warmer than the surrounding air. During the decay process, energy from the breakdown of organic material is converted to heat.

**2. Describe examples of passive and active solar heating and explain the principles that underlie them.** (Pg. 224 – 228)

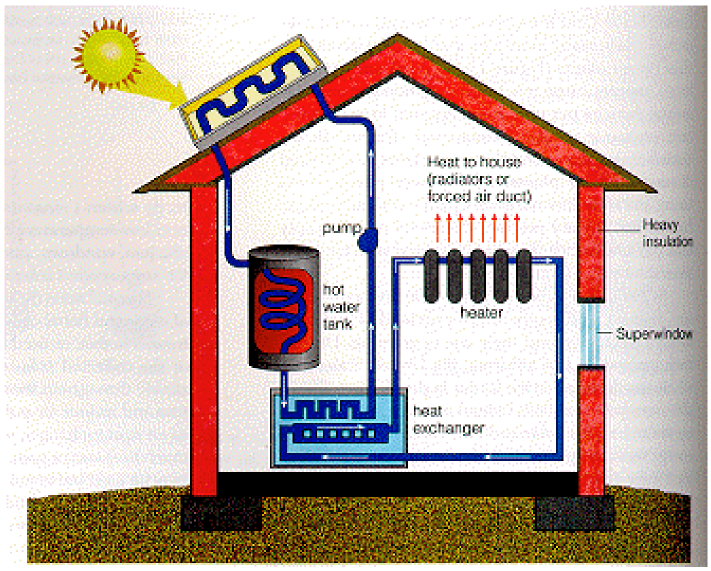
PASSIVE SOLAR HEATING

Solar energy is a radiant heat source that causes natural processes upon which all life depends. Some of the natural processes can be managed through building design in a manner that helps heat and cool the building. The basic natural processes that are used in passive solar energy are the thermal energy flows associated with radiation, conduction, and natural convection. When sunlight strikes a building, the building materials can reflect, transmit, or absorb the solar radiation. Additionally, the heat produced by the sun causes air movement that can be predictable in designed spaces. These basic responses to solar heat lead to design elements, material choices and placements that can provide heating and cooling effects in a home. Most passive solar heating homes have large, south-facing windows and some sort of thermal mass to absorb, store and distribute heat (often a rock wall). The goal of all passive solar heating systems is to capture the Sun's heat within the building's elements and release that heat during periods when the sun is not shining. At the same time that the building's elements (or materials) is absorbing heat for later use, solar heat is available for keeping the space comfortable (not overheated).



ACTIVE SOLAR HEATING

Active solar systems use solar collectors and additional electricity to power pumps or fans to distribute the sun's energy. The heart of a solar collector is a black absorber which converts the sun's energy into heat. This absorber is in contact with copper pipes and the heat is conducted through the metal into the water in the pipes. Using a pump, the heated water is then transferred to another location for immediate heating or for storage for use later.

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|---|
| **3. Compare and evaluate materials and designs that maximize or minimize heat energy transfer.** (Pg. 233-236) |

We know that energy wants to move from higher to lower levels. Therefore, the tendency for energy loss will be in the direction of hot to cold. Technology is advancing that will allow us to keep heat where we want it and keep it out of where it is undesirable.

HEAT LOSS IN HOMES

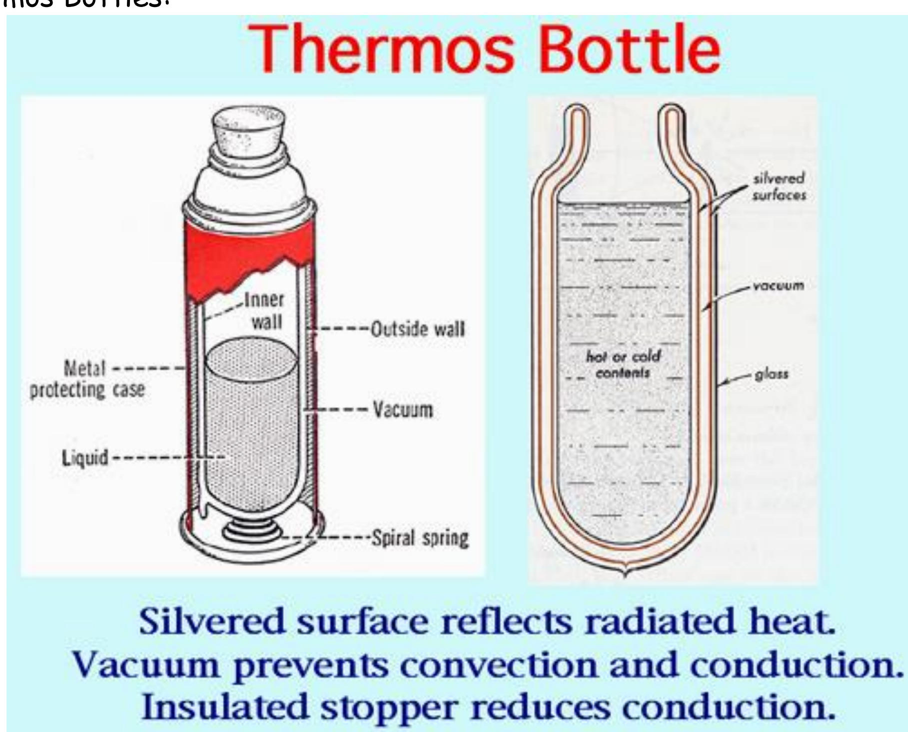
Heat is always trying to move from inside your warm home to the cold air outside. The majority of this heat loss is through conduction as heat moves through the walls and the roof. Heat may also transfer by radiation through windows and by convection through gaps where doors and windows are poorly sealed.

Insulation: Almost all homes in Canada have insulation in the hollow walls. This may be Styrofoam or fiberglass. Both are good insulating materials because of their low thermal conductivity value and because of the air space they contain (since air is another good insulator). The one place where people don't usually have enough insulation is in their attic even though that is a major area of heat loss.

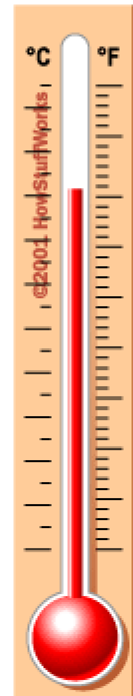
Windows:

- Loss through conduction – since conduction requires a solid, multiple glazed windows slow heat loss by placing a gas (either air or argon) between the glass panes. They may be double or triple-paned.
- Loss through convection - heated indoor air rubs against the interior surface of the window glass. The air is cooled, becomes more dense, and drops to the floor. As this stream of air drops to the floor, more warm air rushes to take its place at the glass surface. The cold glass surface strips heat from the indoor air. Sitting on a sofa, you recognize this convective movement as a cold draft and raise the thermostat. Air also moves outside through convection currents.
- Loss through radiation - Clear glass absorbs heat and dumps it outdoors. This can be lessoned by coating the glass with materials than inhibit the transfer of heat energy.

Thermos Bottles:



**4. Explain the operation of technological devices and systems that respond to temperature change.** (Pg. 229-232)




Thermostats, bimetallic strips, thermometers, heat controls

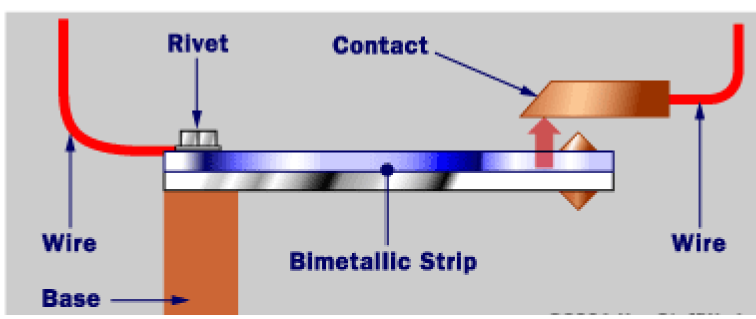
THERMOMETERS

If you look around your house, you will find lots of different devices whose goal in life is to either detect or measure changes in temperature:

- The thermometer in the backyard tells you how hot or cold it is outside.
- The meat and candy thermometers in the kitchen measure food temperatures.
- The thermometer in the furnace tells it when to turn on and off.
- The thermometer in the oven lets it keep a set temperature (hot).
- The thermometer in the refrigerator lets it keep a set temperature (cold).
- The fever thermometer in the medicine cabinet measures temperature accurately.

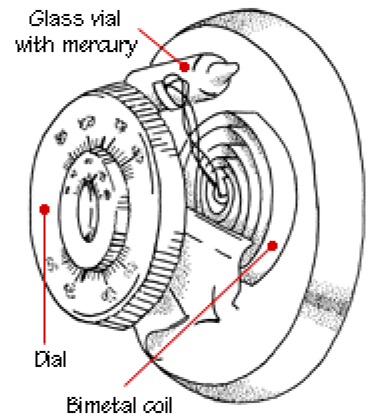
Bulb thermometer: the common glass thermometer that contains some type of fluid, generally mercury or red alcohol. Bulb thermometers rely on the simple principle that a liquid changes its volume relative to its temperature. Liquids take up less space when they are cold and more space when they are warm so as temperatures rise, the liquid alcohol or mercury is forced up through a very small opening called a bore.

Bimetallic strip: the bimetallic strip thermometer, because it is made of metal, is good at controlling temperature. The principle behind a bimetallic strip thermometer relies on the fact that different metals expand at different rates as they warm up. By bonding two different metals together, you can make a simple electric controller. This sort of controller is often found in ovens. Here is the general layout:




Two different metals make up the bimetallic strip. In this diagram, the top metal would be chosen to expand faster than the bottom metal if the device were being used in an oven. When the oven gets hot enough, the strips bend down and the rising temperature stops.

THERMOSTAT MERCURY SWITCH

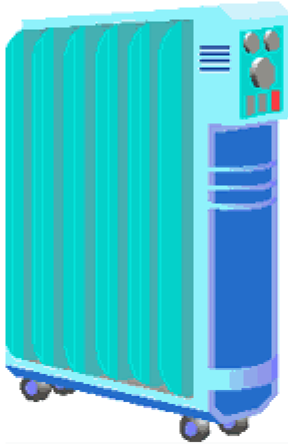



Thermostats control the flow of electricity to a device. The amount of electrical flow will make electrical appliances either hotter or colder so it is important to make sure just the right amount of current gets to a device. A house thermostat controls the furnace so that it gives out just the right amount of heat. It has two thermometers – one for room temperature and one for the furnace temperature. It also has a bimetallic strip, on top of which sits a tube of liquid mercury which is a mercury switch. When the temperature starts to rise, the strip will bend up, tipping the attached mercury tube. When the metal mercury makes contact with circuit wires, electricity will flow, the furnace comes on and the heat will be forced into the home using fans within the furnace unit. When the temperature starts to rise, the bimetallic strip will bend back down and the mercury will no longer be in contact with the circuit so the furnace shuts off.

**5. Describe the function of household devices for generating, transferring and controlling thermal energy.** (Pg. 230-231)

LOCAL HEATING SYSTEMS

These are small heaters which provide heat for a small area such as a room. Fireplaces, wood-burning stoves and space heaters are examples of local heating systems. They are becoming more popular because they allow homeowners to heat the area where people are without heating the whole home which wastes energy.

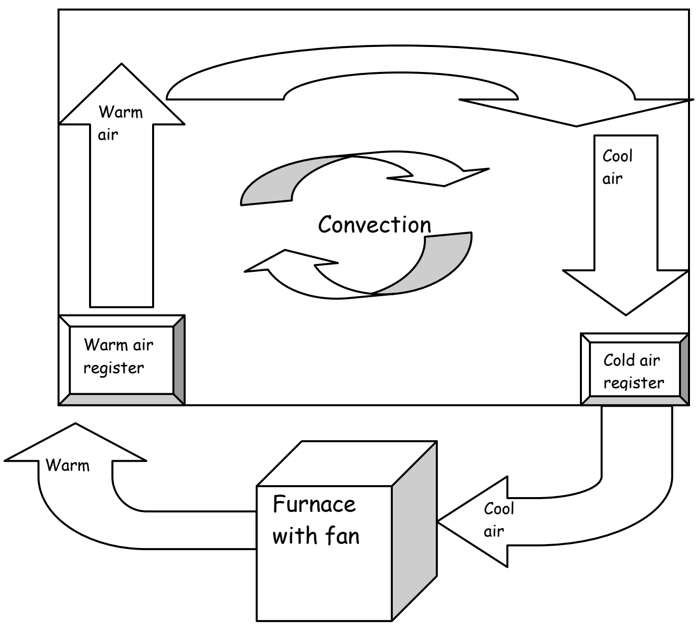


CENTRAL HEATING SYSTEM

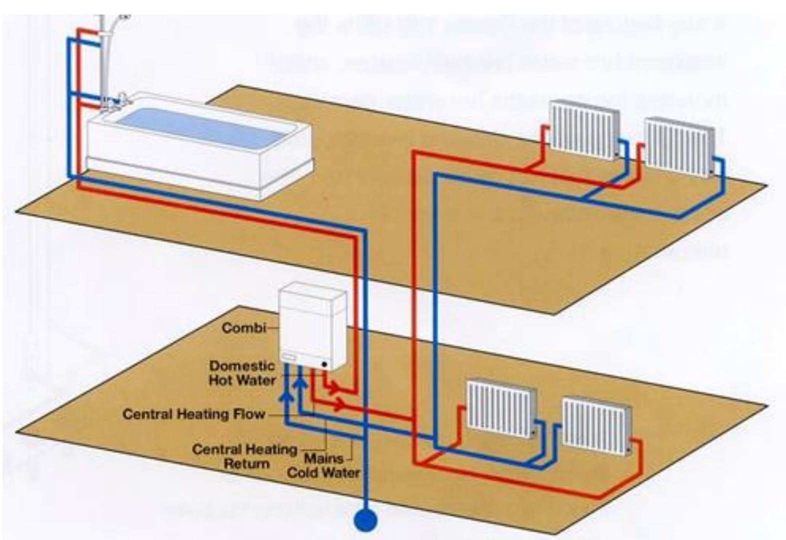
These provide heat from a single, central source (furnace).

Forced Air: This is the most common type of central heating system. Fuel is burned in the furnace. The heat travels up through metal ducts (pipes) to all parts of the house. A blower then pulls air back into the where it will be re-circulated after being re-heated. You will notice that the heater vents in your home are on the floor. That is because you want to use convection to ensure even distribution of heat in the room. If vents were on the ceiling, the warm air would simply stay up there since warm air rises, anyway.

Hot-Water: A furnace or boiler is the heat source, burning fuel such as natural gas. The fire heats water which is then pumped throughout the house to metal radiators. The hot water heats the radiator through conduction and warm air then radiates out into the room. The water is returned to the furnace or boiler to be re-heated.




Forced Air Heating System




Hot Water Heating System

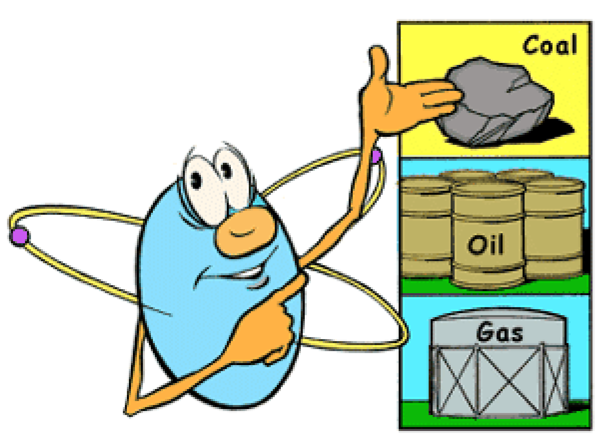
**TOPIC D: Analyze issues related to the selection and use of thermal technologies, and explain decisions in terms of advantages and disadvantages for sustainability.**

1. **Identify and evaluate different sources of heat and the environmental impacts of their use.** (Pg. 239-240)

We live in a province that has a vast supply of coal. Therefore, it is not surprising that we use this fossil fuel as our primary energy source. But, what are fossil fuels?

These are fuels formed in the ground from the remains of dead plants and animals. It takes millions of years to form fossil fuels. Millions of years ago the earth was covered with lush plants. As the trees and plants died, they sank to the bottom of the swamps of oceans. They formed layers of a spongy material call peat. Over many hundreds of years, the peat was covered by sand and clay and other minerals, which turned into a type of rock called sedimentary. More and more rock piled on top of more rock, and it weighed more and more. It began to press down on the peat. The peat was squeezed and squeezed until the water came out of it and it eventually, over millions of years, it turned into coal, oil or petroleum, and natural gas.

We burn coal to produce electricity which, in turn, produces heat and light. The problem is that fossil fuels are not sustainable (they will eventually run out). Fossil fuels take millions of years to make. We are using up the fuels that were made more than 300 million years ago before the time of the dinosaurs. Once they are gone they are gone. They are also very bad for the environment, being the major contributor to both acid raid (from sulfur dioxide which creates sulfuric acid) and global warming (from excess carbon dioxide which is a by-product of burning).

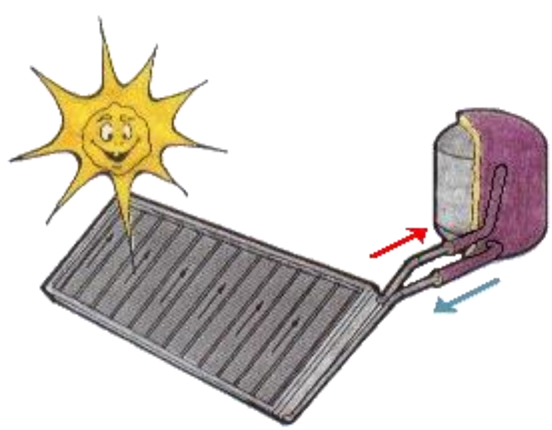


**2. Compare the energy consumption of alternative technologies for heat production and use, and identify related questions and issues.**
(Pg. 241-244)

| Source | Advantages | Disadvantages |
| --- | --- | --- |
| ***Coal*** | • Inexpensive<br>• Easy to recover (in U.S. and Russia) | • Requires expensive air pollution controls (e.g. mercury, sulfur dioxide)<br>• Significant contributor to acid rain and global warming<br>• Requires extensive transportation system<br>• Non-renewable |
| ***Nuclear*** | • Fuel is inexpensive<br>• Energy generation is the most concentrated source<br>• Waste is more compact than any source<br>• Extensive scientific basis for the cycle<br>• Easy to transport as new fuel<br>• No greenhouse or acid rain effects | • Requires larger capital cost because of emergency, containment, radioactive waste and storage systems<br>• Requires resolution of the long-term high level waste storage issue in most countries<br>• Potential nuclear proliferation issue<br>• Non-renewable |
| ***Hydroelectric*** | • Very inexpensive once dam is built<br>• Government has invested heavily in building dams, particularly in the Western U.S.<br>• Renewable<br>• Clean | • Very limited source since depends on water elevation<br>• Many dams available are currently exist (not much of a future source[depends on country])<br>• Dam collapse usually leads to loss of life<br>• Dams have affected fish (e.g. salmon runs)<br>• Environmental damage for areas flooded (backed up) and downstream |
| ***Gas / Oil*** | • Good distribution system for current use levels<br>• Easy to obtain<br>• Better as space heating energy source | • Very limited availability as shown by shortages during winters several years ago<br>• Could be major contributor to global warming<br>• Expensive for energy generation<br>• Large price swings with supply and demand<br>• Non-renewable |

| Source | Advantages | Disadvantages |
|---|---|---|
| ***Wind*** | • Wind is free if available<br>• Good source for periodic water pumping demands of farms as used earlier in 1900's<br>• Renewable<br>• Clean | • Need 3x the amount of installed generation to meet demand<br>• Limited to windy areas<br>• Equipment is expensive to maintain<br>• Need expensive energy storage (e.g. batteries)<br>• Highly variable - wind can be damaging during windstorms or not turn during still summer days.<br>• Endangers bats and birds. |
| ***Solar*** | • Sunlight is free when available<br>• Renewable<br>• Clean | • Limited to sunny areas throughout the world<br>• Demanded the most when least available, e.g solar heating)<br>• Does require special materials for mirrors/panels that can affect environment<br>• Current technology requires large amounts of land for small amounts of energy generation |
| ***Biomass – living or recently living material*** | • Used by specific industries<br>• Could create jobs because smaller plants would be used<br>• Renewable | • Inefficient in small plants<br>• low heat content in fuel will increase greenhouse gases that impact global warming |

Energy sources are considered <u>non-renewable</u> if they cannot be replaced in a normal lifespan.



**3. Identify positive and negative consequences of energy use, and describe examples of energy conservation in your home and community.**
(Pg. 245 – 250)

**1** - Heating is the single biggest energy use in homes. A well-maintained heating system will hold down fuel costs and provide reliable comfort. Check the filters in your warm air heating system monthly and replace or clean them when they become dirty. Have your heating system checked periodically by a licensed professional.

**2** - Proper insulation in walls, ceilings and floors also significantly reduces the loss of heat to the outdoors. Insulation will pay for itself in fuel cost savings and home comfort.

**3** - Storm windows and doors are big energy and money savers. They can reduce heating costs by as much as 15% by preventing warm air from escaping to the outside. Double glazed and thermopane windows or even clear plastic across windows can minimize heat escape.

**4** - The many small openings in a home can add up to big heat losses. Caulking and weather stripping cracks in walls and floors, windows and doors will save fuel and money. Keeping the fireplace damper closed tightly when not in use will also result in heating cost savings.

**5** - Letting sunlight in by opening curtains, blinds and shades over windows facing the sun helps keep your home warm and reduces heating needs. At night or when the sky is overcast, keeping drapes and curtains closed will help keep the warmth indoors.

**6** - Dry air makes you feel colder than moist air at the same temperature. Maintaining home humidity will produce personal comfort at a lower thermostat setting and save money. Shallow pans of water near radiator tops or near warm air vents, or a room humidifier, will help raise humidity levels.

**7** - Keeping your heating thermostat at the lowest temperature comfortable for you will save on heating costs.

**8** - Insulate heating hot air ducts and hot water pipes that provide heat to the rooms in your home. This will reduce heat loss in areas that are not insulated and will help your heating system work more efficiently.