Appendix A

STSE

Important Notes

1. These STSE modules are intended for teacher reference. Each is designed to target specific outcomes within Grade 9 Science. It should be notes that the activities associated with each module are NOT mandatory. They are suggested activities to be used at the discretion of the teacher.

2. There STSE modules and the associated supplements can be found at www.gov.nl.ca/edu/sp/sci_gr9curguide.htm

Celestial Navigation

Outcomes:

1. Describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems. (111-5)
2. Relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary study areas. (109-11)

Introduction

In May, 1497 an Italian captain, John Cabot set sail from Bristol, England with a crew of English sailors on a voyage of exploration and discovery. He first sighted a "new-found-land" on June 24th (Prowse, 1895). Cabot returned to Bristol with news of his discovery in August of the same year. How was Cabot able to navigate over 3000 kilometres across the ocean from Europe to the island of Newfoundland and then successfully return to Bristol?

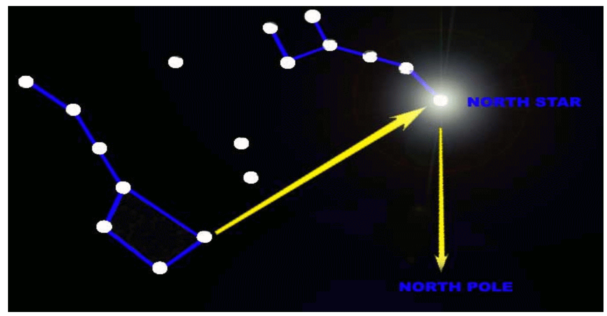


Figure 1: Using the Big Dipper to find the Little Dipper is easy using this method. Photo courtesy of http://www.m4040.com/Survival/Skills/Navigation/Navigation.htm.

Figure 2: This time lapse photo shows Polaris at the center; note that while the other stars show movement, Polaris is stationary. Photo courtesy of http://zimmer.csufresno.edu/~fringwal/courtright.html.

Celestial Navigation

On a clear night in the northern hemisphere we can see thousands of stars. Ursa Major is a constellation that includes seven stars that make up the Big Dipper. Once you have found the Big Dipper it is easy to locate the Little Dipper. Simply connect the last star at the bottom of the big dipper to the adjacent star at the brim and extend it as shown in the diagram below. The extended line points directly towards the Little Dipper. The last star on the handle of the Little Dipper is known as the North Star, the Pole Star or Polaris.

Polaris is positioned directly over our north pole, the axis of rotation of Earth. Therefore, as Earth spins, Polaris never changes its position in our night sky. If Polaris is directly overhead at the north pole it must disappear into the horizon as we move toward the equator. As you move from zero degrees latitude at the equator and move north, Polaris begins to rise so that when you move to 10 degrees north latitude Polaris now appears 10 degrees above the horizon. Early naval explorers realized this and used this information as they navigated vast distances across oceans. Celestial navigation, or using a celestial object such as the moon, planets or stars to navigate, has been used by people for thousands of years. But why was knowing latitude so important?

For ancient explorers like Cabot it would be valuable information to know the latitude at their home port. To do this they would measure the angle that Polaris made with the horizon. If they knew that their destination was a similar latitude they would try to keep Polaris at the same altitude in the sky as they sailed. Cabot left Bristol which is 51°N latitude and supposedly landed in Bonavista which is 48°N latitude. A possible explanation to the question as to how he was able to successfully return to Bristol in such a short time could be that he kept the North Star at the same altitude in the sky as he sailed all the way back across the Atlantic Ocean.

Knowing your position on our planet enables you to draw a map. Navigators of the fifteenth century quickly produced maps that depicted our modern view of the Americas.

Celestial Navigation Technology

Many ingenious inventions were created to measure the altitude of the North Star. Early Arabian explorers used a kamal to measure latitude. A kamal consists of a small rectangular wooden block measuring approximately 2.5 cm by 5 cm (Wikipedia). The navigator would thread a line through the center of this block and hold the line between their front teeth. The line would

Figure 3: The notched rope ensured that the latitude measurements provided by users of this kamal were consistent.

then be pulled through the kamal until the navigator aligned the horizon with the bottom short edge and the North Star with the top edge. When this was accomplished a knot would be tied in the line to record the position of the North Pole relative to the navigator’s home port. This would essentially be a record of their home port latitude. When returning to their home ports, navigators would attempt to realign their kamal by steering their ships north or south to find their original latitude.

Figure 4: Astrolabe dating back to the 11th century.

A shipwreck at Red Bay Labrador dating back to the 1600's contained an astrolabe used by early Basque whalers to determine their latitude. The Astrolabe allowed the mariner to sight celestial bodies including the moon, the sun and stars. Noting the time of the year, the time of day and measuring the altitude of the body using the astrolabe enabled them to find their latitude.

Other navigational devices soon followed. Quadrants, sextants and other devices that relied on celestial bodies to make navigation at sea possible have been salvaged from shipwrecks all around our province. Many shipwrecks occurred because although sailors could easily calculate their latitude from celestial bodies, determination of longitude, or their east to west position, was more difficult to find. It wasn’t until the use of an accurate chronometer, in the 1772 voyage of HMS Resolution, that longitude could be accurately measured. Before this early navigators had difficulty judging their distance from shore resulting in many marine disasters.

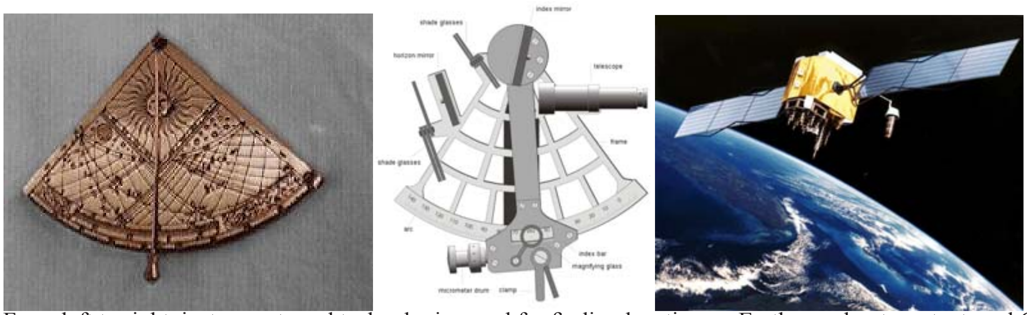


Figure 5: From left to right, instruments and technologies used for finding location on Earth: quadrant, sextant, and GPS using satellite technology.

Conclusion

Today we rely on Global Positioning Systems (GPS), LORAN and Radar to accurately find our position while navigating at sea. These advanced technologies rely on our ability to send and receive signals. But what happens if these signals are interfered with or the devices malfunction? For thousands of years sailors have been sailing by the stars without any advanced electronic equipment. Current technology allows for much more accurate determination of where you are on Earth, the older technologies discussed in this module could still be used for more general approximations. In fact, many outdoor's people prefer to navigate by the stars.

Questions

1. Explain why a sailor would be unable to use celestial navigation all the time.
2. What alternatives do we have to celestial navigation today?
3. Why is it important to know how to use a variety of navigation techniques?
4. Are there any other uses for celestial navigation than just navigation at sea?

References

Ifland, P. (2000). *The history of the sextant*. Available: http://www.mat.uc.pt/~helios/Mestre/Novemb00/H61iflan.htm

Kamal. Available: http://en.wikipedia.org/wiki/Kamal

Prowse, D.W. A History of Newfoundland. London: Macmillian, 1895.

Tyson, P. (2000). Secrets of ancient navigation. Available: http://www.pbs.org/wgbh/nova/longitude/secrets.html

Activity

Constructing and Using a Kamal

Purpose: To construct and use a Kamal.

Materials: 1 technical eraser - typically 2 cm by 6 cm

1 metre of twine/thread

1 heavy duty threading needle

1 metre stick

1 sticky star (0.5 cm diameter)

Background:

Although the kamal was generally used in equatorial regions it can be used in the classroom to demonstrate a celestial positioning technique.

Teacher note:

To prepare for this activity a horizontal line should be placed on the chalkboard approximately at eye level with seated students. Place the sticky star 0.5m above this line approximately in the middle of the board

Procedure:

1. Prepare your kamal by threading your needle and inserting it and drawing the thread through the centre of your eraser.
2. Remove and return your needle.
3. Tie a knot in the end of your thread and place it between your front teeth so that you are able to adjust the length of thread between your teeth and the eraser
4. Record the distance between the knot in your line and the eraser when you have adjusted your kamal so that the horizon appears at the bottom of your eraser and the star appears just over the top of your eraser.

Data:

Construct a table similar to your classroom seating plan and place all student data on the board.

Analysis:

1. Would your distance from the board along one of your classroom rows represent your latitude or longitude?
2. You are sailing on the ocean and the knot in your Kamal that you measured at your home port was 0.5 m. The distance that you measure now is 0.4 m. In which direction should you travel to get to your destination, north or south? Why?

   Use your kamal to help you answer this question.
3. Do you think your kamal would be an accurate device? How far could you be north or south of your destination if your measurements were off by 1 degree?

   You can research about latitude measuring devices such as the quadrant and the sextant to help you with this question.

Plastics and Modern Life

Outcomes:

- Provide examples of scientific knowledge that have resulted in the development of technologies. (111-1)
- Explain how society's needs can lead to developments in science and technology. (112-3)
- Analyse the design of a technology and the way it functions on the basis of its impact on their daily lives. (113-4)
- Make informed decisions about applications of science and technology, taking into account environmental and social advantages and disadvantages. (113-9)

Introduction

Are plastics important to you? If you are uncertain about your answer to this question, simply take a moment and look around your classroom or home and identify items that are made from plastics. You will quickly realize that plastics come in various shapes, sizes, and colours, and have various uses.

Figure 1: Many items on a teacher's desk are made from plastics.

The word "plastic" comes from the Greek word "plastikos", which means "to form". In more technical terms, plastic is a material that can be heated and molded into different shapes, which remain after it cools.

Did You Know?

Plastics are the most used materials in the world.

Before the invention of plastics, clay and glass were the only two materials that could be molded. Both were used to make containers; however, the containers were very heavy and easily breakable. Plastics were quickly admired because they were very light and strong. A person was finally able to easily transport such items as milk, juice, and shampoo in containers that if dropped, would not break.

Figure 2: Dropping a plastic container of shampoo in the bathtub will not result in it breaking.

Snowmobile companies are currently competing to build machines with hoods that are both light and strong. Light translates into faster machines that can be easily lifted out of snow or lifted onto transportation vehicles (e.g. trailers). Strong translates into machines that are not easily damaged by such things as tree limbs, tree stumps, and rocks.

Figure 3: This snowmobile is mostly made from plastics, which results in it being both light and strong.

Natural Plastics

While most of the plastics we would recognize are synthetic, some plastics occur naturally:

1. Collagen is a protein in animals that is responsible for holding together ligaments, cartilage, and tendons. It was used by Native Americans for making tools. The twisted, spiral shape (helix) is what gives collagen its flexibility.

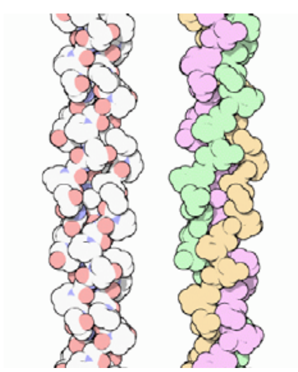


Figure 4: Two representations of what is called a collagen helix

2. Henry Ford, the famous inventor and original owner of the Ford Motor Company, experimented with soy-based plastics for making automotive parts.

Figure 5: One of the first Ford vehicles ever made. There are automotive parts on this vehicle that are made from soy-based plastics

3. Cellophane, which is still sold and used today, is a thin transparent film made from wood pulp.

Figure 6: It is wise to wrap cold meats like salami in cellophane before storing it in the refrigerator.

Synthetic Plastics

Most plastics are human-made from oil, which is extracted from beneath Earth's surface. Oil contains molecules made up of short chains of carbon atoms which chemists refer to as monomers. Ethene (which has the chemical formula C2H4) is an example of a monomer (the prefix "mono" means "one").

Monomers can be joined together to form much larger molecules which chemists refer to as polymers (the prefix "poly" means "many"). For example, a polymer formed from the combining of ethene monomers could contain up to 300 or 400 carbon atoms depending on the type of plastic being created.

The almost endless variety of plastics that we have today is a result of the many different combinations or arrangements of monomers that are possible. Each combination of monomers creates a polymer that is used to form a plastic, which has its own unique set of physical and chemical properties. These properties enable scientists and technologists to use each type of plastic for specific purposes.

Plastic is chemically inert (i.e., will not react with other substances). As a result, it is a great material for making containers. Substances such as water, gasoline, soap, alcohol, and acid can be stored in plastic containers because the plastic and the substances will not react with each other.

Figure 7: Liquid hand soap does not react with the plastic container.

Because of their ability to be moulded into a variety of shapes, plastics can be used to make such varied things as toys, bottles, planes, clothes, computers, and bubble gum.

Did You Know?

Recent research has suggested that not all plastics are safe for storing water. Depending on the type of plastic, water may leach out (dissolve) a dangerous chemical from the plastic. To learn more about this topic, conduct research on the chemical "bisphenol a".

How Are Plastics Made?

Plastics are formed in two different chemical reactions: (1) condensation reaction and (2) addition reaction.

1. ***Condensation Reaction:*** Two monomers react with each other to form a larger molecule called a polymer. When the monomers react, two hydrogen atoms and one oxygen atom are released. These atoms recombine to form a molecule of water (H2O). It is the formation water that gives the reaction its name: condensation. The polymer that is formed can then react with another polymer to form an even larger molecule. This process can be continued until a polymer with the desired properties is attained.

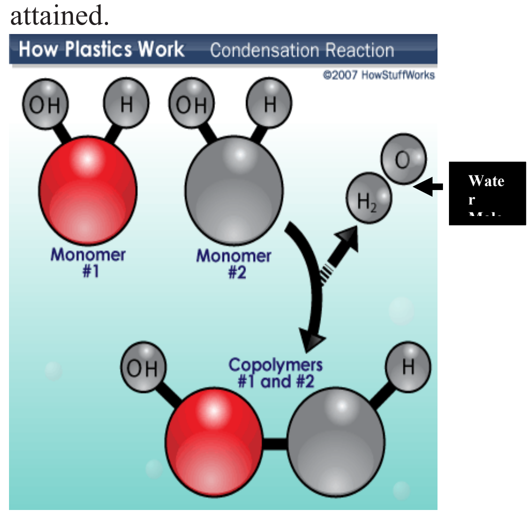


Figure 8: An illustration of a condensation reaction. Notice the formation of a polymer and a water molecule from two monomers. Illustration courtesy of HowStuffWorks, 2007.

2. ***Addition Reaction:*** Certain types of monomers react with each other to form a polymer. In this type of reaction the smaller monomers are "added" or joined together to form a long chain of monomers. The chain of monomers (i.e., polymer) can be made to specific lengths. Each of the different lengths will possess certain properties and characteristics which will allow it to be used to form different types of plastics.

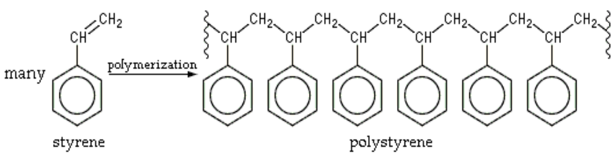


Figure 9: An illustration showing how the addition of many styrene molecules (i.e. monomers) can make a polystyrene molecule (i.e. polymer).

Types of Plastics

Plastics can be categorized into two main groups: (1) thermoset and (2) thermoplastics.

1. *Thermoset plastics* are hard and durable, and keep their shape once they have been cooled and hardened. In fact, it is impossible for them to be returned to their original forms. Examples of thermoset plastics include: polyurethane foam (e.g. sponge in chairs); polyesters (e.g. used in making clothing); and epoxy resins (e.g. a form of super strong glue).
2. *Thermoplastics* are softer than thermoset plastics. They can be softened when heated and even returned to their original forms. When heated, they are easy to mould into packaging, fibres, and films. Examples of thermoplastics include: polyethylene (e.g. plastic comprising food storage bags) and polypropylene (e.g. plastic comprising car trim and battery cases).

Figure 9: Freezer bags are made from polyethylene (i.e. thermoplastic).

Did You Know?

A toothbrush is composed of 11 cubic centimetres of plastic (not counting the brush). If 27 million people across Canada throw away three toothbrushes this year, this would create the equivalent of a plastic rope the thickness of your little finger that stretched all the way from Toronto to Tokyo. If we used toothbrushes with replaceable heads, we would significantly reduce the amount of plastic that will end up in the environment each year.

Cameron Smith "Let growth cater to need, not want" February 02, 2008 - Toronto Star

Some Common Synthetic Plastics

1. *Polystyrene* is made from styrene monomers. It can form hard, impact-resistant plastic, which can be used for developing such things as framing for glasses and framing for televisions. When this plastic is heated and air is blown through it, what we commonly refer to as Styrofoam® is created. Styrofoam® is the material that is often used for producing white poly bead insulation as well as disposal drinking cups and plates.

Figure 10: Disposable plates made from Styrofoam® (i.e. polystyrene).

2. *Polyvinyl Chloride* (PVC) is a thermoplastic that is formed when vinyl chloride (C2H3Cl) monomers join together. PVC is normally very hard and brittle. To make such items as the water pipes that are installed in many houses today, a chemical is added to this substance to make it soft and mouldable.

Figure 11: PVC water pipes in a recently built house.

3. *Polytetrafluoroethane* (Teflon®) is made from the combining of tetrafluoroethylene monomers (C_2F_4 ; "tetrafluoro" refers to the four fluorine atoms in each monomer). This type of plastic is strong, smooth, chemically resistant, and heat resistant. Teflon® is used in the production of such things as films and frying pans.

Figure 12: The surfaces of these two frying pans are made from Teflon.

4. *Polyvinylidene Chloride* is made from the combining of vinylidene chloride (C2H2Cl2) monomers. This type of plastic is made into films and wraps, which will not allow food odours to escape or enter.

Figure 13: Some plastic wraps will prevent food odours from escaping.

Conclusion

Plastics have truly revolutionized the world by improving many aspects of our daily lives. However, as with any progress, there are often some negative points or impacts to consider. Plastics do not react chemically with most things and therefore, will not decay or easily break down to environmentally-friendly compounds. As a result, throwing away plastics (e.g. shopping bags, water bottles, etc) has become a very serious environmental issue.

While recycling is often seen as a way to solve this environmental problem, the reality is that only a very small amount of plastic is recycled each year. Research is currently being done on creating "bio-degradable" plastics. For example, using corn oil instead of crude oil could produce plastics that are friendlier to the environment.

So, stop and take a moment to reconsider the question posed in the opening paragraph, "are plastics important to you"?

Questions

1. List and describe the two major types of plastics.
2. Differentiate between the four common plastics.
3. What is wrong with society using plastics? What can be done to solve (or reduce) the negative points or impacts associated with using plastics?
4. Compare the advantages and disadvantages of plastics.
5. Using examples, discuss how important plastics are to humans.
6. It has been estimated that, worldwide, there are between 500 billion and 1 trillion plastic shopping bags discarded each year. That's about 1 million bags per minute! Many businesses encourage people to use reusable shopping bags to help reduce the amount of plastic in the environment. Should we put a ban on the use plastic shopping bags? Why or why not? Defend your position by considering both sides of the argument.

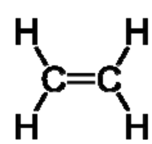
Sources of Information

The following websites relate to the topic of plastics and can be accessed for additional information:

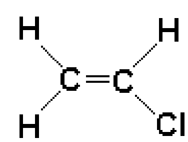
- http://www.plastics.ca/
- http://www.epa.gov/
- http://en.wikipedia.org/wiki/Plastics
- http://www.sdplastics.com/plastics.html
- http://www.sciencehowstuffworks.com/plastics

Optional Information

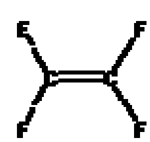
Chemists usually write the chemical formulas of substances such as ethene (C2H4). However, sometimes they draw the shape of the molecule to show how the atoms are bonded together. These are called structural formulas. The following are structural formulas of some of the chemical formulas presented above:



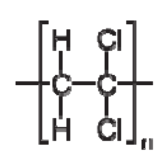
Ethene (C_2H_4). The lines between the letters represent chemical bonds between the atoms.



Polyvinyl Chloride (PVC)



A monomer of Tetrafluoroethylene.



A monomer of vinylidene chloride. This is sometimes written CH_2CCl_2. The "n" represents many monomers that would form the polymer.

Electricity Conservation: The New Trend

Outcomes:
- Identify different approaches taken to answer questions, solve problems, and make decisions (109-7);
- Compare examples of past and current technologies developed to meet a similar need (110-9);
- Analyse the design of a technology and the way it functions on the basis of identified criteria such as cost and impact on daily life and the community (113-5);
- Make informed decisions about applications of science and technology, taking into account environmental and social advantages and disadvantages (113-9)

Introduction

Inflation and the resulting high cost of living have made saving money a daily concern. People are constantly looking for ways to "stretch out" their money and to "make it go further".

Figure 1: Try it and you'll quickly discover that it is impossible to actually "stretch out" money to make it "go further"!

When it comes to household electricity use, conservation is the primary means of saving money. Saving money on an electricity bill has obvious financial rewards. However, there is an equally important savings, which is a reduction in the demand for fossil fuels.

Oil, coal, and natural gas are the fuel fossils that are used to generate much of the world's electricity. While Newfoundland and Labrador produces relatively little electricity from fossil fuels, in Canada, approximately 25% of all electricity is generated using fossil fuels. Burning fossil fuels contribute to the production of greenhouse gases such as carbon dioxide (CO2 (g)), which are the main contributors to the global warming effect (i.e. climate change). Burning fossil fuels also produces other harmful gases that cause acid precipitation and which lower air quality. Thus, electricity conservation results in both saving money and helping the environment.

Figure 2: A plant that generates electricity by burning fossil fuels. The actual greenhouse gases are not visible but steam and unburned by-products such as soot are. Photo courtesy of Wikipedia Commons.

One of the issues associated with attempting to conserve electricity is that the results of peoples' actions are not immediately visible. As an example, how much electricity would be conserved if a person decided to take a shorter shower on a given morning? Or, how much would be conserved if a person decided to turn off the second light in their bedroom on a given evening? While we "know" we would reduce the amount of electricity being used in these cases, how much would we actually save? Would it be worth the effort?

Figure 3: Unless you need additional light for reading or other activity, there is no need to turn on this lamp if the other lamp is already turned on in the same bedroom.

To address this problem a Newfoundland and Labrador company (Blue Line Innovations) have developed a device called the PowerCost Monitor. This device is placed in a person's home and takes information from that person's electricity meter, which is located on an outside wall (i.e. outside of house). The PowerCost Monitor displays the "real time" electrical usage on a small monitor, which is located on an inside wall (i.e. inside of house). The benefit of a device such as this is that the monitoring is done in real-time, thereby allowing the results of the person's conservation actions to be immediately visible. A person can obtain a measurement of the electricity conserved by such things as "turning down" a heater, taking a shorter shower, turning off lights, etc. Such a device can motivate a person to continue trying to conserve electricity because they can visualize the immediate results of their actions.

Figure 4: This device allows for real-time monitoring of electricity usage.

This assumption was shown to be correct by a study undertaken in the years 2007 and 2008. In this study, customers of Newfoundland Power participated in a program that allowed them to monitor the amount of power that they were using in their homes. The program revealed that these families decreased their electricity consumption by an average of 18%. In dollars, this would equate to a savings of approximately \$54.00 on a \$300.00 electricity bill or more than \$600 per year.

It is important to understand that it was not the PowerCost Monitor that was responsible for saving electricity. The device simply provided people with measurements of real-time electricity usage, which provided them with immediate feedback on their actions to conserve electricity and motivated them to make small changes in behaviour which had big impacts in their electrical usage.

Options for Saving Electricity, Money, and Protecting the Environment

Our "savings options" can be grouped into two categories: (1) spending money and modification, or (2) changing attitudes and habits.

1. **Spending Money and Modification**. This category would include such savings options as: buying energy-wise appliances, doors, windows, and electronics; insulating basements and attics with more insulation; and using programmable thermostats.

Figure 5: A well insulated basement will help reduce the amount of electricity needed to keep the rest of the house warm.

Sometimes this savings option is not always practical. For example, why replace an old refrigerator, which is working perfectly, with a new refrigerator that uses less electricity? The money savings would never pay for the new refrigerator! Why tear up a finished basement to add more insulation? The money savings would never pay for the materials that would be destroyed or ruined in the renovations.

2. **Changing Attitudes and Habits**. This category represents a cheap, effective and easy way of conserving electricity and saving money.

Many people would be surprised to discover how changing their habits in relation to how they use their home appliances dramatically influences (i.e. lowers) their electricity bills.

Figure 6: Whether the dishwasher is a new, energy efficient model or an older model, waiting until the dishwasher is fully loaded before starting the wash cycle results in less hot water being used. This means less electricity is used.

Ways to Conserve Electricity

1. ***Hot Water Tanks:*** Heating water accounts for approximately 20% of the energy use in the home. Usually hot water tanks come from the manufacturer with the thermostat preset to keep the water at a temperature of 60 ºC. As a result, the heating elements will try to maintain this temperature at all times, which is hotter then is needed for normal family use (e.g., washing hands, washing dishes, showering, etc). Lowering this setting to 50 ºC will cause the heaters to “cut in” less. It is estimated that every 10 degree reduction results in a savings of about 4% on the cost (and energy used) to heat water each year.

Figure 7: Hot water tanks often come preset at 60 °C. To keep the water at this temperature, the tank uses more electricity than it would if the temperature was set a five or ten degrees lower. While the savings would be huge, the amount of hot water available to the household would not be reduced.

To further reduce the amount of energy used to keep the water in a hot water tank hot, you can insulate the hot water tank and any exposed hot water pipes. Finally, using low-flow shower heads will greatly reduce the amount of hot water used for each shower, thereby reducing the amount of electricity used.

2. ***Dishwashers and Clothes Washers:*** Dishwashers are most efficient when they are loaded to capacity. If you run the dishwasher when it is only half full, it will use the same amount of hot water as it would if it was full of dirty dishes. Not waiting until the dishwasher is full means you will use more energy cleaning dishes.

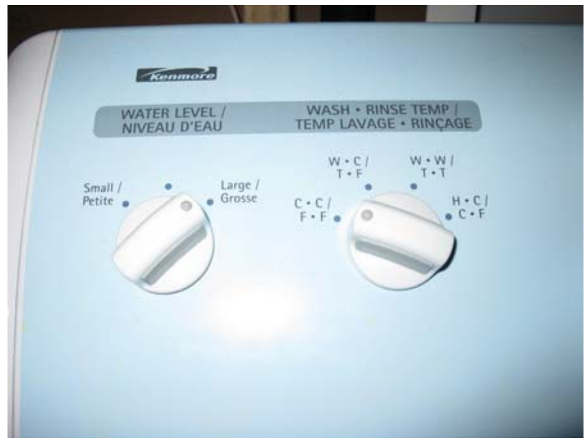


Figure 8: The cold-wash and cold-rinse setting (C-C) means less hot water is used during the wash cycle. The hot-wash, cold-rinse setting (H-C) requires more hot water. If you make sure you wash only large loads (high water setting) the energy savings will be even greater.

Energy savings are even greater when the dishwasher has a high energy efficiency rating. Since all appliances sold in Canada must have an EnerGuide label, it is easy for consumers to choose appliances that are energy efficient. Consumers can compare both the immediate purchase cost as well as the long term operating (energy usage) costs of similar appliances. Choosing the most energy efficient model, within the purchaser’s budget, will provide the greatest savings.

Another symbol, the Energy Star label, is also helpful when purchasing appliances. When included as part of the EnerGuide label, the Energy Star indicates that the appliance meets a premium level of energy efficiency. It also indicates that this appliance is among the most energy-efficient products available.

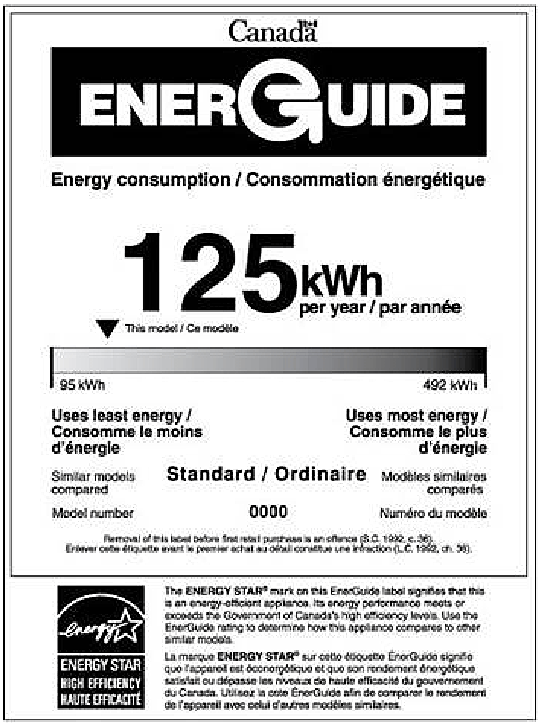


Figure 9: This EnerGuide label shows that the appliance uses very little energy as compared to other models/brands of the same type. The Energy Star symbol reinforces that this product is among the most energy-efficient in its class.

Clothes washers function similarly to dishwashers and as a result, the same conservation tactics apply. Clothes can be effectively washed in large loads and using cold water, particularly if a good detergent is purchased and used.

3. ***Clothes Dryers:*** These are simply large heating units. Air drying, whether on an inside line or an outside line, is a more environmentally-friendly method of drying clothes. If air drying is not possible, it is important to remember that full loads in clothes dryers are more efficient than half loads. Also, if a person has more than one load of clothes to dry, then he or she should do them one after the other in as short of a time span as possible. This will take advantage of an already heated dryer and as a result, less electricity (or energy) will be consumed.

When purchasing a new clothes dryer, one should reference the EnerGuide label. In addition, look for one that has a moisture sensing feature. This feature allows the clothes dryer to sense when the clothes are dry and immediately shut off, thereby using less electricity. For older models, the best way to conserve electricity is to use the timers to shorten cycle times, thereby reducing the amounts of electricity used. Remember that over drying clothes will cause them to shrink, which sometimes makes them wrinkly, charged with static electricity, and no longer wearable.

Figure 10: An outside line, which does not use electricity to dry clothes, is more environmentally friendly than even the most energy efficient clothes dryer. Photo courtesy of wikipedia commons.

4. ***Refrigerators and Freezers:*** These appliances work best when there is a lot of space all around them. This space allows for the warm air that is generated by the devices to escape. Allowing the warm air to escape prevents the appliance from working harder (i.e., uses less electricity). Refrigerators and freezers should be placed far away from heat sources such as ovens, hot air ducts, and windows. Such heat sources will cause the devices to use more electricity (or energy) to keep its contents cold. A temperature between 5 ºC and 10 ºC for a refrigerator and -5 ºC for a freezer will not only maintain food, but will provide the best electricity savings.

Cleaning the dust from the condenser coils at the back or bottom of both devices will help to also maximize their efficiency. A vacuum or brush can be used to do this, but first make sure that both devices are unplugged. Switching to manual defrost mode will save about 33% of a refrigerator's electricity use. Finally, limit the number of times and the length of times that the doors on both devices are open. This prevents warm air from entering and also reduces the number of times that the devices "cut in".

5. ***Ovens and Stove Tops:*** To reduce the amount of electricity used in preparing food, use a microwave oven to warm/cook the food. Microwave ovens use much less electricity than a conventional electric oven. Also, glass dishes can be used to cook food in ovens because the food can be cooked at lower temperatures and preheating the ovens is not necessary.

   When cooking on a stove top, using covered pans will prevent a large portion of the heat from escaping and will allow the food to cook faster. Also, use the burners that matches the pot size. Bigger pots will require the smaller elements to be turned on for longer and smaller pots will result in the bigger elements giving excess heat off to the surroundings.

Figure 11: Electric ovens use large amounts of energy to cook food.

6. ***Lighting:*** Lighting a house is responsible for about 15% of the household electricity bill. Advances in lighting technology have resulted in opportunities for savings of both electricity and money. Compact fluorescent light bulbs conserve electricity and they give much more light than incandescent light bulbs. For example, a 20 to 25 watt fluorescent light bulb (i.e. an energy-saving light bulb) is equal to a 100 watt incandescent light bulb. (It is important to realize that fluorescent light bulbs operate differently from incandescent light bulbs. Fluorescent light bulbs pass electricity through a gas, which causes it to give off light, whereas incandescent light bulbs pass electricity through a high resistance wire (e.g. tungsten), which causes it to glow white hot.) For example, over a seven hour period while producing the same amount of light, an 8 watt fluorescent light bulb will conserve about 280 watts of electricity in comparison to an incandescent light bulb. The fluorescent bulb also lasts up to nine times longer.

Figure 12: A compact fluorescent light bulb.

Figure 13: An incadencent light bulb.

Turning off incandescent light bulbs whenever a person leaves a room saves energy. However, for fluorescent light bulbs, a person would need to be gone for more than 15 minutes in order to accumulate any savings. The amount of electricity needed to start a fluorescent light bulb is roughly about equal to the amount it burns in 15 minutes. Finally, keeping the fixtures and light bulbs clean can result in fewer light bulbs required and therefore, less electricity being used

Did You Know?

As much as 20% of the light produced can be lost due to dust that has collected on the light bulb and/or fixture.

Conclusion

The ways to help the environment, conserve electricity (or energy), and ultimately save money are not limited to the things discussed here. Turning off such things as lights, televisions, DVD players, computers, when not being used or not being needed are good first steps that lead in the direction of electricity conservation. Also, reducing the thermostat settings in rooms, when they are not occupied, will conserve a great deal of energy.

Figure 14: Why not substitute warmer clothes instead of increasing the thermostat setting when it is possible (e.g., late spring/early fall)? Would you be willing to sacrifice a little comfort in order to reduce the energy consumed in your house?

Everyone can play a part in electricity conservation and no part is too small. People need to challenge themselves, their families, and their friends to conserve as much electricity as possible. It not only makes sense, it frees up money that could be spent in other enjoyable ways.

Questions

1. Why do you think the PowerCost Monitor and the associated program proved to be so successful?
2. Describe five occurrences in your house that wastes electricity.
3. List and describe five actions that you could take to conserve electricity in your home.
4. Describe two electricity conserving ideas that have not been discussed.
5. Research the concept of "vampire energy". How much energy and money is being consumed by energy vampires in your home?

Potential Group Activities

1. Describe ways in which others in your school and community can be involved in electricity conservation.
2. Create a poster that promotes electricity conservation.
3. How can your school conserve electricity? Your group could present their ideas and/or plan to the school administration.

Potential Individual and Group Activity

1. Record the following in relation to your family for a period of one month:
- number of showers;
- dishwasher use in hours;
- clothes washer use in hours; and
- dryer use in hours.
2. Record the same things for the subsequent month, but have your family members make attempts to "cut back".
3. Compare the electricity bills for the two months. Compare your results with your classmates. Create a bar graph to present the comparison. Discuss the results with your classmates. Discuss the scientific accuracy of the activity. How could it be improved?

Sources

Below are some websites that relate to the topic of electricity that can be accessed and explored for additional information:

http://www.howtoconserveelectricity.com/

http://www.takechargenl.ca/

http://www.vuelectronics.com/

http://www.ceati.com/

http://www.ecomall.com/biz/lighting.htm

http://www.ecomall.com/biz/conserv.htm

Heredity, Genetics and Genetic Engineering

Outcomes:
- Provide examples of Canadian contributions to science and technology related to heredity and genetic engineering (112-12)
- Evaluate information and evidence gathered on the topic of genetics and genetic engineering (209-5, 210-8)
- Identify major shifts in scientific understanding of genetics. (110-3)
- Provide examples of how the knowledge of cellular functions has resulted in the development of technologies (111-1)

Introduction

There is a great deal of debate concerning genetic engineering. Some people believe that genetic engineering offers the greatest potential for providing increased food supply and for curing many diseases. Others people feel we do not know enough about the potential negative effects of genetic engineering and as a result they believe it is greatest threat to our world and society. Which side of the debate do you agree with? How did you make your decision? Was it based on careful consideration of the information that is available or is it based on opinions and misinformation?

When it comes to issues related to science and technology, it is important that we ensure we make informed decisions. Thus, when it comes to decisions related to genetic engineering technologies we must first become knowledgeable about the subject.

In this STSE you will review the history of heredity and genetics leading to the modern science of genetic engineering. The contributions of genetic engineering technologies to food production and medicine will also be explored.

Heredity

Somewhere in your home is an old photo album or shoe box. It may contain pictures of your parents and grandparents in their “younger days”. As you view the photographs one thing is obvious; you resemble some of the people in the photos. Do you have your Mom’s eyes, your Dad’s nose? Are you the “spitting image” of one parent, a “chip off the old block”?

Traits, such as eye and hair color, height, etc. are inherited from our parents. This process is called **heredity**. The concept of heredity has been common knowledge for thousands of years. However, how these traits pass from parent to offspring was a mystery for most of this time.

A number of theories were suggested to explain heredity but it was Gregor Mendel, a little know Austrian monk and botanist, who was the first person to get it, more or less, right.

Figure 1: Gregor Mendel (1822-1884) an Austrian monk, who taught natural science to high school students, was the first person to trace the inheritance of characteristics through successive generations. He is often called the “father of modern genetics”.

Early Theories of Heredity

Before Mendel's time several different theories had been put forth to explain heredity.

Aristotle (384-322 BC) believed that heredity was caused by tiny particles that came together from all the different parts of the body. He called these particles pangenes. He suggested that both the egg and sperm contained these pangenes. The coming together of the egg and sperm was ultimately responsible for the inheritance of traits. Aristotle's theory was still widely accepted in the 19th century and was adopted by famous scientists such as Jean Baptiste de Lamark and Charles Darwin.

> Jean Baptiste de Lamark (1744-1829) was born in northern France. He studied to be a Jesuit before joining the army. After leaving the army, he worked as a bank clerk in Paris. Later he studied medicine and botany (at which he became an expert). Later he became professor at the National Museum of Natural History where he was responsible for insects and worms (of which he knew little). He took on this enormous challenge of learning about, and developing, this new field of biology. He coined the term "invertebrate".

Other early theories of heredity included Antony von Leeuwenhoek's idea that all traits were inherited from the father and a competing idea that the mother's egg contained all the inherited traits.

> Antony van Leeuwenhoek (pronounced Lay wen hook) (1632-1723) was born in Holland. He worked as a fabric merchant, a wine assayer, city official, and surveyor. Even though he was not highly educated, he was interested in microscopes. He experimented with different types of lenses and improved the magnifying power of his microscopes. He was one of the first to observe microorganisms. He described different types of bacteria and calculated their size.

In the 19th century the **blending theory** of heredity became prominent. This theory suggested that offspring were an average of their parent's traits. For example, if one parent was tall and the other was short the resulting offspring would be of medium height.

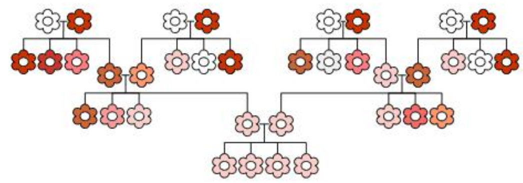


Figure 2: The example above shows how the color of a species of flower blend into one color for the species if the theory of blending was correct. Courtesy of Wikipedia commons.

The one thing these scientists had in common was that each was trying to explain something that most people were aware of; it was obvious that "something" or "some mechanism" was controlling the way traits were passed along from parents to the next. For example, black cows usually gave birth to black calves; plants that grew from seeds that produced red flowers generally produced seeds that resulted in new plants that produced red flowers and so on. In other words, there seemed to be a "law of heredity". The evidence and observations each scientist made was analyzed and discussed. The theories that resulted, to explain this "law" were based on the data that they had available to them.

As you will see, while some of these theories did contain some correct ideas, eventually each of these theories was replaced. And while it is often easy for us to look back at early theories and think "they must have been foolish to believe that", we should really use this as an opportunity to reflect on how science progresses over time. Generally, younger scientists later build on the work and ideas of those who came before them. In most cases relatively minor changes are made to the older theory to make it align with new observations. However, in some cases the entire theory is thrown out when new and "ground breaking" research is conducted. This, we will see, is what happened to the early theories to explain heredity.

Mendel's Theory of Heredity

Many of the early theories were based upon observations gathered in a haphazard fashion and did not follow what we would describe as acceptable scientific methodology.

In 1856, Gregor Mendel began experimenting on pea plants (Pisum sativum). Mendel was meticulous in his note taking and record keeping of both the procedures he followed as well as the results he observed. The data he collected came from the results of crossing large numbers of pea plants. Using today's standards, most would agree that the methodology Mendel used was "scientific".

During his work with pea plants, Mendel observed that a number of traits always existed in only two forms. For example, the pea flower colour was either purple or white. No intermediate colours were ever observed. This observation was significant as it contradicted the blending theory of heredity accepted by many leading scientists of Mendel's time.

Figure 3: Pea plant with purple flowers.

In his experiments, Mendel crossed pea plants with different forms of traits and observed how frequently these forms occurred in their offspring over several generations.

In one series of experiments he fertilized purple-flowering pea plants with white-flowering plants. Mendel collected the seeds of this cross and planted them. When the resulting offspring matured and flowered they were all purple-flowering plants. Mendel referred to the purple color in pea flowers as the **dominant trait**. He then crossed these first generation offspring together (i.e., purple with purple). When the second generation flowered he observed that 75% had the dominant purple-flowering trait but surprisingly 25% had white flowers, a 3 to 1 ratio. The white-flowering trait that seemed to disappear in the first generation reappeared to a lesser extent in the second generation. Mendel referred to the white-flowering trait as the **recessive trait**.

Mendel conducted numerous experiments on pea plants using a variety of different traits. He often observed the same 3:1 ratio of dominant to recessive traits. Mendel realized this ratio was the key to solving the mystery of heredity.

Mendel first published his ideas in 1866. He concluded:

- traits are tiny units of inheritance that are passed to offspring unchanged
- offspring receive these units in pairs – one from each parent
- traits may not show up in an individual but can still be passed on to the next generation.

Despite the significance of Mendel's work, his ideas were largely ignored by the scientific community for almost 40 years.

Genetics

Since the rediscovery of Mendel's theory in the early 1900's, there has been an explosion of knowledge regarding genetics, the study of heredity, and the gene, Mendel's unit of inheritance.

Scientists soon recognized the importance of the chromosomes within the nucleus of the cell. Most human cells have 46 chromosomes arranged in 23 pairs. During mitotic cell division these chromosomes are copied to ensure that each new cell receives the same number of chromosomes. However, in the production of sex cells (eggs and sperm) the number of chromosomes is cut in half. Each egg or sperm receives only one chromosome from each pair.

Chromosomes are long strands of deoxyribonucleic acid (DNA). In 1944, it was a Canadian scientist, Oswald Avery who identified the DNA strand as the hereditary material of the cell.

Avery's discovery led to the identification of the structure of DNA by American James Watson and Englishman Francis Crick. Their DNA model was shaped like a twisted ladder, which they referred to as a double helix.

Figure 4: The DNA molecule looks like a twisted ladder. Photo courtesy of the Biotech Learning Hub, www.biotechlearn.org.nz.

Genes are segments of the DNA strand. They are the body's blueprint. Each gene tells the body how to make a particular protein. Some proteins build and repair the body while others are responsible for controlling body processes.

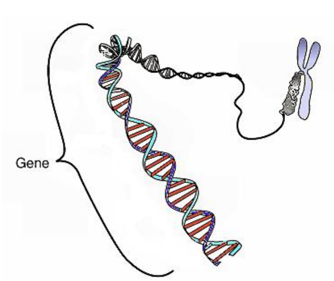


Figure 5: Chromosomes are made up of long strands of DNA; genes are made up of segments of DNA.

During sexual reproduction egg and sperm cells unite to form an offspring. The chromosomes in the nucleus of each sex cell contain the parents' DNA (genes). Through the process of reproduction offspring receive pairs of genes for each trait – one gene from each parent. With this knowledge, the mystery of heredity was solved.

Mutations

When cells are dividing and copying their genetic information, random changes can occur. These changes are called **mutations**. Mutations result when a segment of DNA is added to or deleted from a chromosome or when a segment is placed in the wrong place.

Mutations occur naturally, but they can also be caused by environmental factors such as toxic chemicals, X-rays, and ultraviolet light. These factors are called **mutagens**.

Most mutations have no effect on an organism. However, some mutations cause disease. Cystic fibrosis is an example. In 1989, Canadian scientists discovered the defective gene responsible for cystic fibrosis. It is estimated that 1 out of every 25 Canadians carries this defective gene as part of their DNA.

Genome

All the genetic information in DNA is referred to as the **genome**. In 1990, the United States government launched the Human Genome Project to identify all the genes in the human DNA. Completed in 2003, over 20 000 genes were identified and their location on specific chromosomes was mapped. This detailed genetic map made targeted manipulation of the genome possible.

Figure 6: The human genome project logo represents the various branches of science that were involved in this huge undertaking.

Genetic Engineering

The genetics knowledge explosion led to the modern science of genetic engineering. **Genetic engineering** is biotechnology that deals with manipulation of the genome.

Scientists have figured out how to cut a gene out of one DNA strand and place it into another. The ability to recombine DNA (recombinant DNA technology) has made significant contributions in the areas of food production and medicine.

Food Production

Use of recombinant DNA technology has the potential to improve the quality, shelf life, chemical resistance and disease resistance of various foods. Specific genes from fish, scorpions, viruses and bacteria can be inserted into the DNA of plants and animals that we use as food. The inserted genes can change the observed features of the modified organism. For example, an antifreeze gene from the DNA of a fish may be inserted into the DNA of a tomato plant. The modified tomato plant will manufacture antifreeze proteins. This protein may improve the yield and quality of tomatoes in colder climates. Plants and animals improved through recombinant DNA technology are called **genetically modified organisms** or GMOs.

Genome Atlantic is a not-for-profit corporation promoting genome research in Atlantic Canada. In 2004, they began a project to identify specific genes in the potato genome. Potatoes are an important food crop that is susceptible to insect pests and diseases. The project inserted a promoter gene into different locations on the potato genome. The promoter gene activates the gene beside it allowing scientists to determine what the gene does. More than 20 000 different mutant plants were produced during this project. These plants were then observed to identify the effect of the specific gene on traits such as tuber quality, disease and chemical resistance. This information was then used to guide traditional plant breeding. Plants with specific genes were bred together to develop new and improved potato varieties.

AquaBounty Technologies is a company that brings together genetic engineering and aquaculture. Using a process developed at the University of Toronto and Memorial University, AquaBounty Technologies produce genetically modified salmon. By inserting a gene in the genome of these species, the fish grow and mature faster than traditional fish.

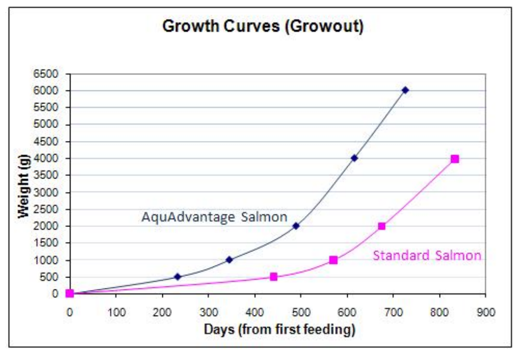


Figure 7: Data from AquaBounty Technologies shows the genetically engineered salmon grow larger and faster than the non-modified salmon. Photo courtesy of AquaBounty, www.aquabounty.com

Because the genetically modified salmon are ready for market sooner, the company can provide a cost effective, environmentally friendly solution through their land-based aquaculture facilities.

Medicine

Genetic engineering is also making significant contributions to the area of medicine. Scientists use recombinant DNA technology to produce drugs and to provide human gene therapy.

For example, diabetes mellitus is a genetic disease. People with diabetes mellitus do not produce enough of a protein called insulin. These individuals may lack a gene that tells their body how to produce the insulin protein. As a result of the disease they need to take regular injections of insulin. To produce insulin, scientists insert the correct form of the human gene into the genome of bacteria. The bacteria then produce the human insulin protein which used as a medicine. Other pharmaceuticals, like human growth hormone and interferon are produced using this recombinant DNA technology.

Recombinant DNA technology is also being used as human gene therapy. Humans who lack a specific gene or have a defective gene can have a healthy gene inserted into their DNA. White blood cells are removed from the body and loaded with modified viruses. These viruses have been altered to contain the healthy human gene. When the white blood cells are injected back into the body, the virus inserts the healthy gene into a non-specific location on the human DNA.

Conclusion

The study of heredity and genetics provides a good example how science and society are interconnected. The rapid increase in our knowledge of the mechanisms of heredity, and the development genetic engineering, has resulted in many benefits but also raises many moral and ethical questions. The decisions we make about whether to support or reject the technologies and products related to genetic engineering should be based on a sound understanding of the issues. As citizens we are obligated to be knowledgeable about topics such as genetic engineering and to be aware of the potential benefits, as well as the possible dangers that may also arise, so that we can make appropriate decisions that will direct policy makers.

Questions

1. Scientific theories change over time as new experimental evidence or observations are obtained. Find an example of this from the article.
2. What is a scientist? Does Gregor Mendel fit with your view of a scientist? Explain your reasoning.
3. Gregor Mendel's work went unrecognized for almost 40 years. Suggest two possible reasons why this occurred.
4. Gregor Mendel was the first scientist to more or less solve the mystery of how traits are inherited. Suggest possible reasons why Mendel was successful.
5. What are two examples of Canadian contributions to genetics and genetic engineering?
6. Female patients are routinely asked if they are pregnant before certain X-rays are taken. Why is it important for the doctor/radiologist to have this information? Explain.
7. Ultra-violet light from the sun or tanning beds is a known mutagen causing skin cancer. Design an information device (poster, multimedia, etc) to inform teenagers of the risks associated with "the perfect tan".
8. AquaBounty technologies public relations officer has accepted your request for an interview. What are 3 questions regarding their technology or food products you would like answered?
9. Should foods that have been genetically modified be labelled? Would you eat genetically modified foods? Explain why or why not.
10. Cloning is another form of genetic engineering. Using this biotechnology, scientists transfer genetic material from the nucleus of an adult donor cell to the nucleus of egg that has had its DNA removed. This produces a new organism with the same DNA as another previously existing animal, a clone. Should human cloning be allowed? Give reasons for your answer.

11. Artic expeditions are underway to find frozen woolly mammoth remains. It is hoped that the DNA from a quick frozen mammoth cell could be inserted into a donor elephant egg that has had its DNA removed. It is thought that this process could reproduce offspring of an extinct organism. Should scientists continue to explore this technology? Why/why not? What are some of the potential problems of bringing extinct organisms "back to life"?

References and Sources of Further Information

AquaBounty Technologie

http://www.aquabounty.com

Genetics

http://cogweb.ucla.edu/ep/DNA_history.html

http://en.wikipedia.org/wiki/Introduction_to_genetics

http://www.accessexcellence.org/AE/ATG/data/released/0349-JoanCarlson/index.php

http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1SEC916560

Nicolson, C. P. (2001) Baa! : the most interesting book you'll ever read about genetics and cloning. Kids Can Press Ltd. (Toronto)

Gregor Mendel

http://anthro.palomar.edu/mendel/mendel_1.htm

http://classweb.gmu.edu/mgabel/unit2-math-web/mendel.pdf

http://www.accessexcellence.org/RC/AB/BC/Gregor_Mendel.php

Human Genome Project

http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml

Potato Genome Project

http://www.genomeatlantic.ca/popupApproved.php?approved_id=11&source=1

Extension Activity 1

With so much information available regarding genetic engineering it is important to critically examine and evaluate the source of information.

Conduct an internet search of the phrase "genetic engineering". Locate and choose 3 different websites regarding genetic engineering. Record the following information for each website:

- Record the web address (URL).
- What is the publication date (if given)?
- What is the author(s) name and/or organization?
- Who is the intended audience?
- What is the author's/group's intent?
- Is the material biased/unbiased?
- Is the information objective or emotional in nature?
- Do you think the website provides a good source of information upon with to make decisions? Why or why not?

Extension Activity 2

Genetic engineering raises moral and ethical questions. Different individuals, scientists, groups, and organizations hold different positions regarding these questions.

Choose one of the following topics:

- Cloning
- Genetically modified foods

Research the topic and locate sources of information that represent different positions.

Identify the key moral or ethical question and write a short paragraph to describe it. List the positive and negative consequences of using the technology. Why may some people not agree with the use of this technology?