PART A: Electronics are Made from Resources

Objectives:

- Students learn about the resources consumed and conserved in the design, manufacturing, distribution, use and end-of-use stages in the life cycle of electronic products.
- Students develop skills related to reading non-fiction.

Materials:

- The article "Electronics are Made from Resources" – one copy for each student
- Overhead of the above article
- Blank overhead and markers for creating graphic organizer while thinking aloud
- Large pieces of scrap paper, sticky tack, markers for the "Word Wall"
- Bulletin board space with the title: "The Life Cycle of Electronics…". Consider at least two sections: 1. What Do People Think About When They Design Electronics? 2. Questions We Have About Designing Electronics.

Activities:

1. Ask students to find a partner and a piece of paper. (We suggest using paper that has already been used on one side – you may want to put a box in your classroom to collect this type of paper instead of putting it into the recycling bin.) Ask pairs of students to brainstorm answers to this question: "What do people who make computers think about when they design a computer?" Provide some examples (e.g. making computers more affordable, easier to use, better than other computers, able to work more quickly, etc.) and solicit a few examples before giving the pairs approximately five minutes to generate their own list.

2. After the pairs have created their lists, solicit their answers to create a master list that can be posted in the classroom throughout the unit. You may wish to record their answers on the back of a poster or piece of bristol board that has been used on one side.

3. Tell students the overall purpose of the unit: to examine the life cycle of electronic products in order to identify what is being done well and what can be improved. Students should be asked to consider the impacts of the life cycle on all living things. With this in mind, tell students that you are going to "read" an article about electronic products and that you are going to model at least two strategies for reading non-fiction articles (the students will practice these strategies again in Lesson 5). For additional reading strategies, go to: www.edu.gov.on.ca/eng/studentsuccess/thinkliteracy/files/Reading.pdf

4. Reading strategy one: previewing vocabulary. Tell students that you are going to skim the article to search for words/phrases with which you are not familiar. Define "skim". Do this aloud so that the students hear your thought process. For each word:
   a. Write the word in big letters on a scrap piece of paper;
   b. Ask volunteers what it means. Use a dictionary or encyclopedia where necessary. Write the definition on the paper;
   c. Ask a student to sketch a picture of the object beside the definition;
   d. Post the words around the room for use throughout the unit.

5. Reading strategy two: discuss the purpose for reading the article. Why are you reading it? What do you want to know? Remind them of the purpose of the unit. Ask students to anticipate what the article is about by scanning the article. Think aloud as you model how to create a graphic organizer to organize your notes while reading the article. Your graphic organizer may look something like this:

What Do I Want To Know About?	Main Points
Circuit boards and hard drives	
Plastic housings	
Monitors	
How does this relate to the purpose of the unit: the pluses and minuses of how electronics are designed, made, used and dealt with at the end-of-use stage?	

6. Ask students to create and complete their own graphic organizer using yours as a model.

7. After the students have completed their own graphic organizers, ask students for issues/questions/big ideas related to designing electronics. For example, one issue found in the article is that additives and different types of plastics that are mixed together make recycling difficult. Another example is that some companies are looking for alternative materials that lessen the impact on the environment, such as plant-based resources like corn which is used in bioplastics.

PART B: The Life Cycles of Resources Have Benefits and Drawbacks for All of Us

Objective:

Students learn about aspects of various resources involved in the life cycle of electronic products. "Life cycle" refers to the entire life of a product, from design and manufacture to distribution, use and end-of-use stage. The focus of the activity is to examine the advantages and disadvantages of each stage of the life cycle using a global perspective that considers humans and the rest of the natural world.

Materials:

- Copies of puzzles found on page 9. One copy of each puzzle for each group of two to three students. **Cut the puzzles into pieces before you give them to the students so that they do not know the correct order.**
- Used envelopes
- One copy of each puzzle copied on an overhead transparency and then cut into pieces
- Overhead projector
- One copy of "Puzzle Analysis" sheet on page 12 for each student

Activities:

1. Ask students to get into groups of two to three people – for tips on helping students develop their group work skills, go to www.resources4rethinking.ca/en/toolbox. Provide each group with six envelopes – one puzzle per envelope. Tell students to put the pieces into the order of occurrence of the facts based on logic and clues within the puzzle pieces.
2. Once the group is finished, ask them to discuss the following questions:
   - Were there any surprises for you?
   - Did any of the facts worry you?
   - What are the benefits and drawbacks of each resource?
   - What are some of the stages in the life cycle of a product in which resources are used?
3. Once everyone has finished completing the puzzles, ask volunteers to put the sequence they chose for each puzzle on the overhead projector using the copy made on overhead transparencies. Ask the group to explain the logic they used to create the order. Ask the class for meaningful (not simply polite!) feedback on this logic. The point of the puzzles is to carefully read and reflect on the facts in the puzzles and to begin to think about the life cycle of products and the resources we use to make them – there may be more than one logical order to each puzzle.

Give students the "Puzzle Analysis" sheet found on page 12. Ask students to complete the table and read the article about the 4R Hierarchy on page 13, and review the puzzles in preparation for the quiz during the next lesson.

WHAT ELECTRONICS ARE MADE FROM

When electronics are manufactured, resources from the earth are gathered and processed into basic materials used in the manufacturing process. These basic materials are used to make the various components that are put together to make the computer products that you buy.

A desktop computer includes: a video card, a hard drive, a main circuit board commonly called a “motherboard”, and other components in a large case. The microprocessor, or “central processing unit” (CPU), works with the operating system to control the computer. It essentially acts as the computer’s brain. The CPU produces a lot of heat, so a desktop computer uses circulating air, a fan and a “heat sink” to draw heat away from the processor, to help keep it cool.

Circuit Boards and Hard Drives

Circuit boards are used to connect different parts and components together inside the computer. Components such as resistors, connectors and the microprocessor are attached to the circuit board. Copper is used to create pathways on the circuit board that conduct electricity from part to part. Circuit boards and hard drives also contain metals such as iron and gold. Until recently, metals such as lead have also been used to make circuit boards. These can be harmful to the environment if disposed of improperly. While older products may still contain lead, newer products have eliminated it from circuit boards and electronic components.

A hard drive stores digitally encoded data on rapidly rotating platters with magnetic surfaces.

Plastic Housings

Plastic is commonly used in many electronic products. While most plastics are manufactured from petroleum oil, some companies are using plant-based resources such as corn to create bioplastics. Bioplastics are not typically used in computers because they cannot tolerate heat very well and will deform at the temperatures at which most desktop and notebook computers operate. Many different types of plastics may be used in a single electronic product. If the plastics are not manually separated at the beginning of the recycling process, they can get mixed together during later steps. Once plastics are ground up and mixed together, they are difficult to separate and become hard to recycle. Some plastics contain additives such as flame retardants that also complicate recycling.

Monitors

There are two basic types of monitors. The cathode-ray tube (CRT) found inside some monitors is a funnel-shaped, leaded glass tube with a metal frame inside. The lead in the glass provides shielding from electromagnetic rays produced inside the cathode-ray tube, which produces the picture on the screen. Much of the glass can be sold for reuse in new CRT glass or can be sent to metal smelters to recover the lead. Liquid crystal display monitors (LCDs) use small fluorescent lights, which contain very small amounts of mercury in order to make them work. When LCDs are properly recycled, their materials can be used in other products.

RESOURCE PUZZLES

Note to teacher: these puzzles contain facts that may be concerning to students. Be sure to use the other lessons in this guide to assure students that some people are working to maximize the opportunities involved with using resources and to reduce the negative social and environmental impacts of using resources. In addition, use the lessons in this guide to provide students with an opportunity to react positively to the concerns presented in the puzzles by working on a change in their own community. **Please note:** footnotes in the text below refer to sources listed on pg. 35.

COPPER

Copper is used to build integrated circuits and chips, among many other computer parts. It is quickly replacing aluminum as the main chip material. Studies show copper not only makes computers more affordable, but also helps improve speed. This boosts performance and makes copper the more energy-efficient choice. Saving electricity helps us to avoid putting pollutants into the air that we all breathe.[1] ❒

On average, one kg of ore taken from an open pit mine yields 90g of copper. That means that in order to build an average desktop computer, about 135kg of rock must be moved to uncover the ore. As well, an average of 130kg of ore needs to be processed to build one computer. Many plants and animals live in places where people want to mine metals. Mining disturbs and sometimes destroys the habitat of many living things.[2] ❒

When companies develop large metal mines, the local area's economy and environment can be affected. For example, farmers may have to move off their land when a large mine is built. New mining developments can also bring job opportunities. Toxins created during the mining process can enter the water, making it undrinkable. This may mean that local people may not be able to use the water again, even once all of the metal has been taken out of the mine, because toxins last a long time.[3] ❒

Refining copper produces sulfur dioxide. Sulfur dioxide (SO_2) is one of the two gases responsible for "acid rain", a serious environmental problem in Canada which pollutes rivers, coastal waters, forests and soils.[4] Some companies are working to reduce SO_2 emissions. For example, the BHP Copper Metals smelter – the largest copper smelter in North America – uses a system that traps as much as 99 percent of the SO_2 produced during copper smelting. Even so, one third of the sulfur dioxide emissions in Canada come from mining operations.[5] ❒

During shipping, high heat and humidity can cause many metals to rust. Copper doesn't rust easily, that's why it's an ideal metal for shipping long distances.[6] ❒

Copper's recycling rate is so high that nearly all of the copper that humans have ever mined is still in circulation.[7] Recycling copper reduces the demand for newly mined copper. This reduces the habitat destruction and air pollution that copper mining and refining can cause and saves money too![8] ❒

BIOPLASTICS

Bioplastics are made from renewable materials like soy beans and corn. At some stages in their life cycle bioplastics are more environmentally responsible than conventional plastics. The production of bioplastics results in the emission of less carbon dioxide, a gas which accelerates climate change. ■

Bioplastics are not as heat resistant and tough as conventional petroleum-based plastics. Some manufacturers blend bioplastics with petroleum-based plastics to make them stronger while still keeping some of the environmental benefits of bioplastics. ■

Bioplastics are biodegradable and can be composted in composting factories. This is much better than sending them to landfills. Bioplastics are new, so there is a risk that many people won't yet know they can be composted and will send them to the landfill or recycling factory instead. At the recycling factory, bioplastics would spoil the conventional plastics, perhaps making them unusable. ■

Bioplastics are often made from genetically modified soy and corn. Unlike conventional plastics which come from oil, which is a non-renewable source, soy and corn are a renewable resource. There are concerns about using genetically modified crops because we still don't understand their long-term effects or the impact on small farms.[10] ■

A few leading electronics companies have developed products made with bioplastics. In 2002 HP developed a prototype printer that was made with a bioplastic shell, and in 2007 Fujitsu introduced a notebook with a chassis made from cornstarch. ■

Over-cultivating crops for bioplastics can cause soil erosion, biodiversity loss, water pollution, and a reduction in land available for growing food. It can also increase the use of fertilizers and pesticides.[9] ■

CARDBOARD

Paper and cardboard are made from trees. It is important to protect our forests because forests help clean the air and are home to many animals. Canada's boreal forest is home to caribou, foxes, wolves and bears. A million acres of boreal forests are logged annually in Canada, which has put several species of plants and animals at risk.[11] Trees can be cut down (harvested) responsibly – maintaining biodiversity, soil, water and air quality, and preserving endangered and old-growth forests. A number of organizations have developed processes to help consumers identify wood and paper products that have been harvested responsibly. ❍

Canada is the world's leading exporter of forest products. The forestry industry contributed $40.4 billion to Canada's trade surplus in 2000. It provides employment, directly or indirectly, to approximately one million Canadians.[12] ❍

In Canada, forestry was first practiced by First Nations people who used the forest for food, clothing, medicine, boat-building and shelter. Today, many First Nations communities still rely on forests for their livelihood, their health and their well-being. Their access to healthy forests is sometimes compromised by industrial logging operations.[13] Recently, more than 50 new business partnerships, worth hundreds of millions of dollars, were established between Aboriginal Canadians and forest companies.[14] ❍

As with many forms of manufacturing, pulp and paper mills create air pollution. The chemicals in the pollution are thought to be related to a number of health consequences including asthma, lung cancer and heart failure.[15] Converting mill waste into renewable energy now provides almost 57% of the paper industry's total electricity.[16] ❍

Corrugated cardboard is used in virtually every shipping box. It often eliminates the need for additional packaging and overwrap, while protecting the product.[17] Corrugated cardboard is much lighter than traditional wooden crates and requires smaller amounts of fuel to transport. This reduces the amount of climate-changing gases produced. Climate change worsens extreme weather events like floods, droughts, and hurricanes.[18] ❍

Paper and cardboard made with recycled fibre (from used paper and cardboard) is more environmentally responsible. It takes less electricity, water and greenhouse gases to make paper from used paper than from new tree fibre. Using previously used paper to make new paper also protects forests (and the other plants and animals in the forest).[19] Printing the English editions of "Harry Potter and the Deathly Hallows" on recycled, bleach-free paper saved 197,685 trees and 7.9 million kilograms of greenhouse gases.[20] ❍

CONVENTIONAL PLASTICS

Conventional plastics can achieve a level of performance that no other material can match. Computer designers choose plastics for their toughness, durability, flexibility and their electrical insulation properties. Plastics have made it possible to reduce the weight of many electronic products and make them much smaller, which means less material is used in production.[21] ●

Plastics take up valuable room in landfills because they don't degrade naturally. Once the plastic reaches the landfill, it may leak chemicals into the local ground water which then circulates throughout the water system. This can impact the health of living things. ●

Many people are concerned about the health risks associated with certain types of plastics. PVC, labeled with a number three in the recycling symbol found on the bottom of many plastic objects, has been linked to cancer, liver problems and fertility problems.[23] A number of companies in the high-tech industry have taken steps to eliminate PVC from products and packaging. ●

Recycling programs recover lots of plastic that can then be used to manufacture new products. Using recycled plastic instead of new plastic saves electricity, water and waste. ●

Plastics help to make electronics products smaller and lighter in weight. This means that less fuel is required to transport them. This avoids the production of climate-changing gases. Climate change has many consequences including more severe weather events like hurricanes, droughts, floods and ice storms. ●

Conventional plastics are made from oil. In the Athabasca Oil Sands in Northern Alberta the production of one barrel of oil requires two to five barrels of water. Using this much water is lowering the water levels in streams, lakes, ponds and wetlands.[22] Many living things rely on this water. ●

FOSSIL FUELS AND OTHER FORMS OF ENERGY

Fossil fuels include oil, natural gas and coal. When burned, they release energy which can power vehicles, machines, and generate electricity. Burning fossil fuels emits carbon dioxide, a greenhouse gas that speeds up climate change. Climate change has many consequences including the damage of coral reefs. Over a million different species of fascinating plants and animals live in coral reefs.[24] Also, climate change increases the spread of pests and diseases like West Nile Virus and malaria, which compromise the health of many people around the world.[25] ▲

Fossil fuels are one of many forms of energy, some of which are renewable. Renewable energy resources can be replenished in a short period of time and have less impact on the environment than extracting and using fossil fuels. The five renewable energy sources used most often include hydro power (water), solar (sun), wind, geo-thermal (heat from within the earth), and biomass (organic material made from plants and animals).[26] ▲

In the area around the Athabasca Oil Sands of Northern Alberta, there is concern that water pollution resulting from oil production is negatively impacting human health. Abnormally high rates of cancers and other serious illnesses have been documented in the First Nations community of Fort Chipewyan. ▲

A benefit of the Athabasca Oil Sands project is that many jobs have been created in the area which has resulted in the strongest period of economic growth ever recorded by a Canadian province. Alberta's 2006 unemployment rate is the lowest level ever recorded.[27] ▲

Fossil fuels are burned in the transportation of products. Some forms of transportation use more fuel than others. For example, every ton of freight transported by air for one kilometer results in 0.6 kilograms of carbon dioxide emissions, compared to 0.003 kilograms for ocean transport.[28] ▲

Coal, oil and natural gas are often mined in remote areas and must be transported long distances to the places where people want to use them. There have been media reports that the construction of oil and natural gas pipelines in Canada threatens fragile Arctic and boreal forest plants and animals. For example, caribou need to migrate longer distances each year in order to find enough food to survive. Their travel is often restricted by oil and gas pipelines. Caribou are important to the well-being of many First Nations people.[29] ▲

FLAME RETARDANTS

Many companies are investigating replacements for brominated flame retardants. In February 2003, the European Union adopted the Restriction of Hazardous Substances (RoHS) Directive, which restricts the use of six chemicals in the manufacture of various electronic and electrical equipment, including two flame retardants used in some plastics. In response to this directive, some companies that sell products internationally are restricting and eliminating the use of these chemicals in all their products – not just the ones they sell in Europe. ▼

Most electronic components, circuits and cables have flame retardants, as do many of the outer plastic covers of electronic products, especially TVs. Flame retardants save lives. In 2005 an Air France jet crashed on landing at Toronto International Airport and caught on fire. All three hundred passengers and crew members survived. Safety officials have credited flame resistant materials in the plane as a key factor in preventing loss of life.[31] ▼

Adding flame retardants to plastics can complicate recycling by altering the chemistry of the materials. Two pieces of plastic of the same type might have two different flame retardants, so when they are ground up and melted, it is difficult to make pure plastic. Recycling companies are working to overcome this problem. ▼

One class of flame retardants (brominated) has been found to accumulate in the bodies of animals and humans and has been found in human breast milk.[30] ▼

When plastics are not recycled properly and are burned improperly, some types of flame retardants release toxic chemicals, such as dioxins, which may be linked to serious health concerns including cancer and birth defects.[32] ▼

Flame retardants are chemicals used to help ensure that products do not catch on fire. They also allow people more time to safely exit a building if there is a fire because they can slow down or even completely prevent a fire. ▼

RESOURCE PUZZLES ANALYSIS SHEET

PART A: Resource puzzle

COPPER

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4. Plastics help to make electronics products smaller and lighter in weight. This means that less fuel is required to transport them. This avoids the production of climate-changing gases. Climate change has many consequences including more severe weather events like hurricanes, droughts, floods and ice storms.
5. Recycling programs recover lots of plastic that can then be used to manufacture new products. Using recycled plastic instead of new plastic saves electricity, water and waste.
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FLAME RETARDANTS

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3. Many companies are investigating replacements for brominated flame retardants. In February 2003, the European Union adopted the Restriction of Hazardous Substances (RoHS) Directive, which restricts the use of six chemicals in the manufacture of various electronic and electrical equipment, including two flame retardants used in some plastics. In response to this directive, some companies that sell products internationally are restricting and eliminating the use of these chemicals in all their products – not just the ones they sell in Europe.
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6. When plastics are not recycled properly and are burned improperly, some types of flame retardants release toxic chemicals, such as dioxins, which may be linked to serious health concerns including cancer and birth defects.[31]

PART B: Analysis of Advantages/Drawbacks of Resources

On a scrap piece of paper, create a chart like the one below to list some of the advantages and drawbacks of each resource (e.g. bioplastic – more environmentally responsible at end-of-use stage, higher financial cost).

Resource	Advantages	Drawbacks

PART C: 4R Hierarchy

Many of us are familiar with the 4Rs –"rethink, reduce, reuse, recycle". What many people are less familiar with is that the 4Rs are said in the order in which they have the most benefit to Earth and all of us. For example, rethinking the way we design things can have huge benefits. For example, compact fluorescent light bulbs use 75% less energy than traditional light bulbs.

Reducing is more advantageous to Earth and all of us than recycling. For example, when you recycle an aluminum can, you use approximately five percent of the resources that would have been used if you had purchased a new can. This is much better than using a new can! However, you do use additional resources when you have someone come to your house or school to pick up the can to bring it to the recycling plant. Every time you do not use an aluminum can at all, you effectively use zero percent of the resources you would have consumed if you had used a new can!

Rethink. If that doesn't work, reduce. If that doesn't work, reuse; and only if all of that doesn't work, recycle.

SOURCES

1. Source: http://www.copper.org/innovations/2000/01/speeding_up.html
2. Source: “Stuff: The Secret Lives of Everyday Things”, John Ryan, pg. 49
3. Source: http://www.decoin.org/history.html
4. Source: http://www.pollutionprobe.org/Reports/ARP06.pdf, pg. 11
5. Source: http://www.copper.org/innovations/how/howdo4.htm
6. Source: http://adaptation.nrcan.gc.ca/posters/curriculum/science2/ontario_e.php
7. Source: http://www.copper.org
8. Source: http://resources.schoolscience.co.uk
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