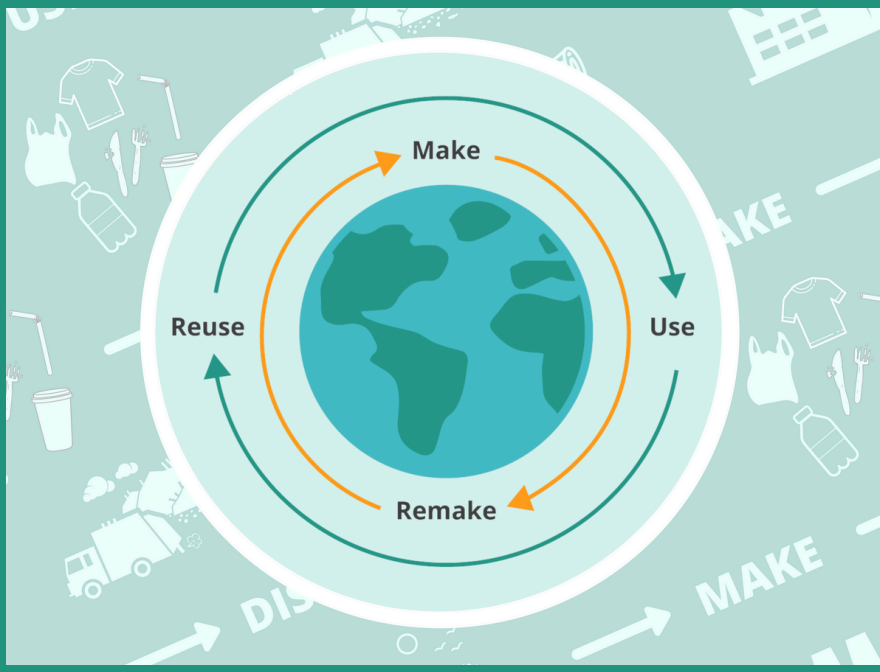
A Guide to

Eco 360:

Activity 2: What are Plastics?



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Land Acknowledgement

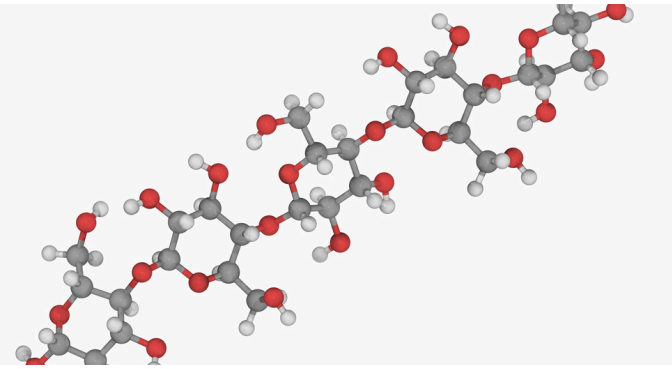
In the spirit of respect, reciprocity and truth, we acknowledge and honour Moh'kinsstis, and the Treaty 7 region of Southern Alberta where this pilot project was conducted. This land is the traditional Treaty 7 territory of the Blackfoot Confederacy; Siksika, Kainai, Piikani, as well as the Tsuut'ina and the Îyâxe Nakoda Nations. This territory is home to the Métis Nation of Alberta, Region 3 within the historical Northwest Métis homeland.

With gratitude, we acknowledge the land and the Indigenous people that have taken care of it since time immemorial, and continue to honour and celebrate this territory.

Backgrounder: What are Plastics?

What are Plastics?

Synthetic or man-made plastics are light-weight, tough, flexible and durable materials created from fossil fuels. Most plastics are made from synthetic polymers – long chains of molecules made by bonding a series of smaller units called monomers, where monomers can be one, two or three atoms (Perkins, 2017).



Example of a polymer composed of the repeating smaller units (monomers)

Polymers occur in nature, such as cellulose which makes up the cell walls of plants or our DNA structure. Plastics today are mostly man-made, created from carbon atoms in fossil fuels. Using carbon atoms from fossil fuels allows for long chains of polymerization which makes plastics very durable as a product (Brown, 2021).

Plastics are designed to be tough and are hard to break down. Another strength of plastic is that it does not react chemically with most substances, therefore it doesn't decay when used for different applications. For this reason, it is important to keep plastics out of the environment (Freudenrich, 2021).

History of Plastics

The first synthetic polymer was invented in 1869 by John Wesley Hyatt in New York, by treating cellulose derived from cotton fiber to create a plastic that could be crafted into a variety of shapes. Hyatt was inspired by an offer of $10,000 put forward by a firm in New York asking for anyone to provide a substitute for ivory, as its over consumption had put a strain on the natural supply. Hyatt's synthetic polymer from cotton could be shaped into natural substances such as tortoiseshell, horn, linen and ivory (Science History Institute, 2021).

In 1907 Leo Baekeland invented Bakelite, which is the first fully synthetic plastics as it contained no molecules found in nature. The need for inventing Bakelite came from the rapidly growing electricity industry as the United States was going through electrification. The industry was looking for a substitute for shellac (purified lac, which is a natural resin secreted by the lac insect (Britannica, 2013)) which was used as a natural electrical insulator. Bakelite served to be an excellent insulator, was durable, heat resistant and unlike celluloid, was feasible for mass production (Science History Institute, 2021). "Hyatt's and Baekeland's successes led major chemical companies to invest in the research and development of new polymers, and new plastics soon joined celluloid and Bakelite. While Hyatt and Baekeland had been searching for materials with specific properties, the new research programs sought new plastics for their own sake and worried about finding uses for them later" (Science History Institute, 2021).

Did you know?

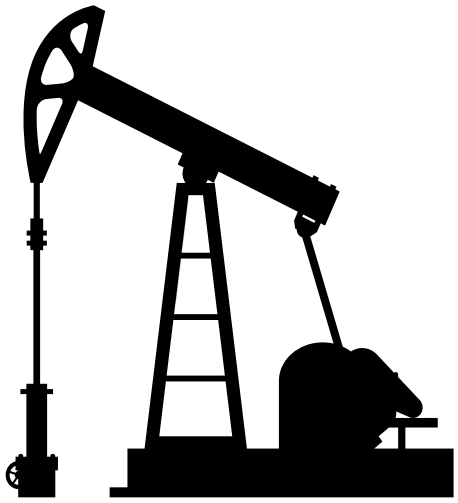
Bakelite was used as a synthetic plastic for early home phones like this one!

Life Cycle of Plastics

The life cycle of plastic can be categorized into three main stages – the extraction of raw materials, the production of plastic products from raw materials, the consumption of plastic products and end of life post-use.

Extraction of Raw Materials

As plastics are made from synthetic polymers derived from fossil fuels, the life cycle of plastics starts at the extraction of fossil fuels. Therefore, the production of plastics is directly linked to the fossil fuel industry and as such, the life cycle assessment of plastic should consider the environmental impacts associated with the extraction of fossil fuels. About 99% of the feedstock to produce plastic comes from fossil fuels, and this accounts for roughly 8-9% of global oil and gas consumption (D. Nielsen, Hasselbalch, Holmberg, & Stripple, 2019).



Production of Plastic

From the raw fossil fuels extracted, such as natural gas and oil, they are then refined into ethane and propane to prepare for creating plastic. Ethane and propane are then treated with high heat to be converted into monomers such as ethylene and propylene. These monomers are then combined with catalysts to create polymers. The polymers then go through further processes to create plastic tubes, which are then cut into small plastic pellets. Plastic pellets are then shipped to various plastic factories to be melted and molded into various products, such as water bottles, food packaging, and so on. (Plastics Industry Association, 2021).

Example of blue plastic pellets being molded into an ice pack.

Watch this video for additional information on the life cycle of plastics:

https://www.youtube.com/watch?v=_6xlNyWPpB8 (4:06 minutes)

Consumption and End of Life

Once the plastic products are created and distributed for various end-use, they enter the consumer markets. According to Our World in Data, the production of plastic increased nearly 230-fold (figure below) in 2019 compared to 1907, when the first synthetic plastic – Bakelite – was produced (Ritchie & Roser, 2018).

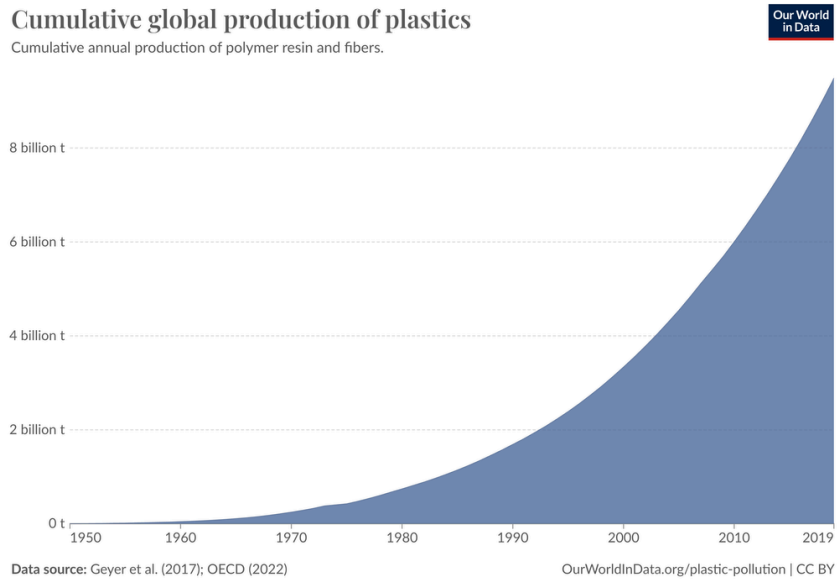


Figure 1. Cumulative global plastic production. Source: (Ritchie & Roser, 2024).

It is estimated that the annual global production of plastic is approximately 380 million tons, out of which about 40% - 50% is single-use plastic. Single-use plastics are utilized for one-time use after which they are discarded (Plastic Oceans, 2021).

In contrast to the enormous amount of plastic consumption, **less than 9% of all plastic gets recycled globally** (Plastic Oceans, 2021; National Geographic Society, 2019). The rest of the plastic either ends up in landfills or unfortunately, mismanaged and left in the environment, causing harm at unprecedented rates.

Here are some additional resources on circular economy:

- https://debrisfreeoceans.org/the-life-cycle-of-plastics
- https://science.howstuffworks.com/plastic.htm
- https://angelwater.com/blog/life-cycle-plastic-water-bottle/
- https://plasticpollutionblogsite.wordpress.com/2016/09/21/the-life-cycle-of-a-plastic-product-part-2-reworking-the-cycle/
- https://www.nationalgeographic.org/article/whopping-91-percent-plastic-isnt-recycled/
- https://plasticactioncentre.ca/directory/plastic-by-the-numbers/

References

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Brown, N. (2021). The Life Cycle of Plastics. Retrieved from Debris Free Oceans: https://debrisfreeoceans.org/the-life-cycle-of-plastics

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Freudenrich, C. (2021). How Plastics Work. Retrieved from How Stuff Works: https://science.howstuffworks.com/plastic.htm

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Perkins, S. (2017). Explainer: What are polymers? Retrieved from Science News for Students: https://www.sciencenewsforstudents.org/article/explainer-what-are-polymers

Plastic Oceans. (2021). Plastic Pollution Facts. Retrieved from Plastic Oceans: https://plasticoceans.org/the-facts/

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Ritchie, H., & Roser, M. (2024). Plastic Pollution. Retrieved from Our World in Data: https://ourworldindata.org/plastic-pollution

Science History Institute. (2021). History and Future of Plastics . Retrieved from https://www.sciencehistory.org/the-history-and-future-of-plastics

Curriculum Connections

Activity 2: What are Plastics?

Alberta

- Grade 7 Unit A: Interactions and Eosystems
  - 1 - Investigate and describe relationships between humans and their environments, and identify related issues and scientific questions
- Grade 9: Social Studies
  - 9.2.5 - How does individual consumer behaviour impact quality of life (e.g., environmental issues)?

Ontario

- Grade 9 Geography
  - E1. The Sustainability of Human Systems: analyze issues relating to the sustainability of human systems in Canada (FOCUS ON: Interrelationships; Geographic Perspective)

Activity 2: What are Plastics?

Overall Objective

The objective of this activity is to learn about plastics, their history and application in our daily life. Learners will conduct research to understand the life cycle of plastics and share their findings with class.

Materials

- Internet-enabled device
- Topic backgrounder
- Eco 360 notebook (we recommend asking learners to maintain a notebook for this program to write down reflections as they go through the program)
- Life Cycle of Plastics Worksheet
- Life Cycle of Plastics Infographic

Time Required

60 minutes - 95 minutes

Learning Outcomes

By the end of this activity, learners will:

- Understand plastics, their history and application in life
- Describe the life cycle of plastics
- Apply research skills to investigate a question
- Understand how much plastic waste ends up in the environment

Grade Level

Suitable for Grades 7 to 12

Activities Outline

Step One

Begin by exploring what are plastics and how they are made, their history, and uses by watching the videos below:

- Plastics 101:

  https://www.youtube.com/watch?v=ggh0Ptk3VGE (6 minutes)

- A Brief History of Plastics:

  https://www.youtube.com/watch?v=9GMbRG9CZJ (5:41 minutes)

- 7 Different Types of Plastics and their Uses:

  https://www.youtube.com/watch?v=PbuiIhr0LVA (4 minutes)

Step Two

- Divide your class into 3 - 5-person Jigsaw groups - you can find more information here:

  https://www.jigsaw.org/

- In their Jigsaw groups, learners will research the question, 'What is the life cycle of plastics?'
- Distribute the Life Cycle of Plastics Worksheet to learners
- Distribute the Life Cycle of Plastics Infographic to learners
- As instructed on the Worksheet, assign one stage of the life cycle to each learner in a Jigsaw group for research. There are 5 stages identified in the life cycle, therefore forming Jigsaw groups of 5 learners is recommended.
- Have learners research the life cycle stage assigned to them, looking at what happens during that life cycle stage, the co-benefits and challenges in that stage. Learners can use any resources of their choice. For ease we have curated several resources and provided them on the Worksheet on this topic.
- Learners can record their findings on the Worksheet under the life cycle stage assigned to them.

Step Three

Allow one learner from each Jigsaw group to join other learners that are assigned the same cycle stage. In this step, learners will discuss their findings and take notes on the Worksheet.

Step Four

- Ask the learners to re-join their original Jigsaw group and have each learner in the group share their findings with their group. Learners can complete their worksheets by learning about other life cycle stages from their peers in the group as they come together.

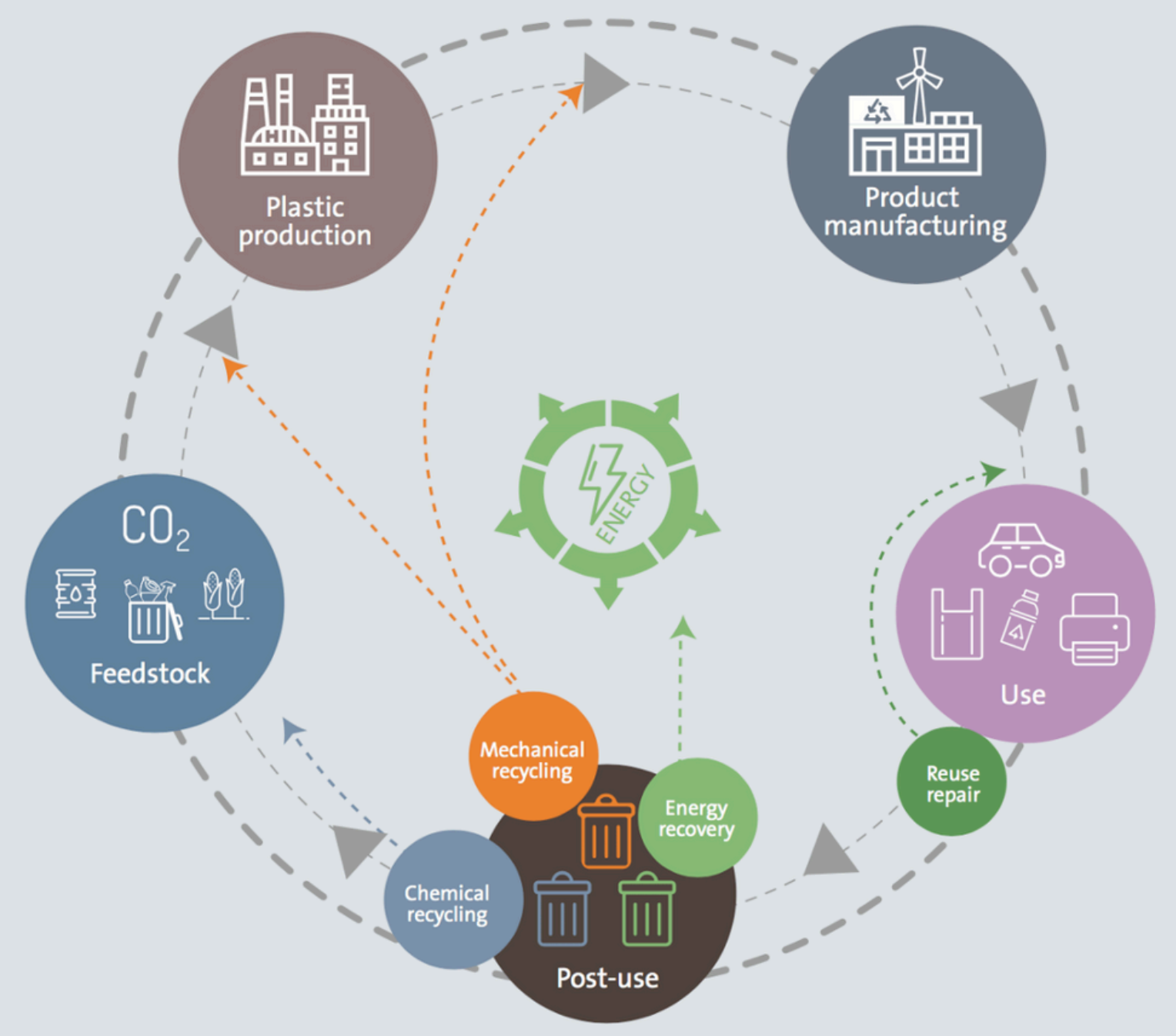
Learner Assessment

Consolidation: Have learners reflect on the activity, recording in their notebooks the main stages of the plastic life cycle that they explored in their Jigsaw groups and how the life cycle could be adapted to a circular economy.

Associated Worksheets

Eco 360

Life Cycle of Plastics



Source: Plastics Europe

Instructions for Jigsaw Group Research:

1. Distribute the Life Cycle of Plastics Infographic to learners provided on the activity webpage, linked here.
2. After forming Jigsaw groups, assign one life cycle stage out of the five provided to each learner in a Jigsaw group for research. Following instructions on the activity, have learners complete the research.
3. Have learners record their research in this worksheet under the life cycle stage assigned:
    a. Feedstock
    b. Plastic Production
    c. Product Manufacturing
    d. Use
    e. Post Use

Recommended Resources for Research:

Learners can research the life cycle stage on their own. Here are a few recommended resources to get them started on research:

1. Lifecycle of a Plastic Product - article
   https://plastics.americanchemistry.com/Lifecycle-of-a-Plastic-Product/
2. What Really Happens to the Plastic You Throw Away - a Ted Talk video
   https://www.youtube.com/watch?v=_6xlNyWPpB8&feature=emb_title
3. Plastic Packaging Resources
   https://www.plasticsoupfoundation.org/en/plastic-facts-and-figures/#productie
4. Plastic in the Environment - a library of articles
   https://www.plasticsoupfoundation.org/en/plastic-problem/plastic-environment/
5. The Life Cycle of Plastic - article
   https://www.generalkinematics.com/blog/the-life-cycle-of-plastic/

Life Cycle Stage 1: Feedstock

Life Cycle Stage 2: Plastic Production

Life Cycle Stage 3: Product Manufacturing

Life Cycle Stage 4: Use

Life Cycle Stage 5: Post Use