Introduction

MANY STUDENTS are unfamiliar with the idea that common, everyday activities place a demand on nature. From buying convenience foods at restaurants, to throwing plastic packaging in the trash, to purchasing fast fashion clothing. To raise awareness, *The Anthropocene Project* and The Royal Canadian Geographical Society (RCGS) have partnered to create a resource which explores the complex and irreversible impact humans are having on the planet in the time of the Anthropocene.

The Anthropocene is the proposed current geological epoch in which humans are the primary cause of permanent planetary change. An epoch is a division of time that is a subdivision of the geologic time scale used by all Earth scientists. The use of the term "Anthropocene", which has yet to be formally adopted into the official geologic time scale, is supported by an international collective of scientists who believe that the Holocene, our current geological epoch, characterized by stable climates and minimal human impacts, has ended. Instead, they suggest a new epoch, the Anthropocene, has emerged in its place due to unprecedented human land use, resource consumption and waste production.

The following resource, which integrates and expands upon the multidisciplinary body of work developed by *The Anthropocene Project*, was created to engage students in the ongoing discussion about the genesis of the term and the usefulness of distinctly identifying the Anthropocene as an epoch within the geologic time scale. It is primarily intended for Canadian educators teaching grades 4-12 who are interested in opening a dialogue with students through the use of photography, film, and augmented and virtual reality. All associated educational materials have been written by qualified educators and are linked to the Canadian Geography Learning Framework for K-12 classrooms.

This resource is truly one-of-a-kind, incorporating a floor gigapixel, augmented reality experiences, virtual reality, and awe-inspiring video clips from around the world. We encourage you to use the information and multimedia provided to give your students an immersive learning experience that allows for a deep and emotional understanding of human-environment interactions. The fourteen activities included in this guide can be applied in any order to give students the opportunity to see the Earth and their role as responsible global citizens from an entirely new perspective. Please see the official program website for more information (canadiangeographic.ca/anthropocene).

The RCGS and its partners are proud to make this innovative educational resource available to teachers and students in Canada. Comments on your experience with this resource, or questions about the included materials, are welcome at info@cangeoeducation.ca.

Contributors

THE DEVELOPMENT of the following learning resource would not have been possible without the dedicated efforts of our partners and contributors, who helped with research and content creation, and provided guidance, media and invaluable perspectives.

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The Anthropocene Education Program was undertaken with the financial support of the Government of Canada through the federal Department of Environment and Climate Change and RBC Foundation and produced with the participation of TELUS Fund.

Canadian Geographic EDUCATION

The Royal Canadian Geographical Society / La Société géographique royale du Canada

THE ANTHROPOCENE PROJECT

Ce projet a été réalisé avec l'appui financier de :
This project was undertaken with the financial support of:

Environnement et Changement climatique Canada
Environment and Climate Change Canada

RBC Foundation

TELUS Fund

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Materials

THIS TEACHER'S GUIDE is accompanied by several pieces of technological equipment, cards and materials that will help you and your students complete the activities in each section.

Included in the kit:

- Floor gigapixel (1)
- Wall-hanging print: *Sudan the rhino* (1)
- Wall-hanging print: *Ivory tusk pile* (1)
- Wall-hanging print: *Plastic bales* (1)
- Blocks (100)
- Book: *The Adventures of a Plastic Bottle: A Story About Recycling* (1)
- Book: *Le Grand Voyage de Monsieur Papier* (1)
- Oculus headsets (10) and charging cables (10)
- Oculus remotes (10)
- Oculus cases (10)
- iPads (10)
- iPads charging cables (10) and adapters (10)
- Headphones (10)
- Painters tape
- AA batteries

Not included in the kit:

- String
- Paper and writing utensils
- Assorted household plastic items
- Small paper bags
- Dry-erase markers
- Tracing paper
- Measuring tapes or rulers
- Weigh scales
- Calculators

Materials

Introduction:

- There are no cards for this section.

Instructions for teachers:

- There are no cards for this section.

1. Bioaccumulation:

- There are no cards for this section.

2. Not all plastic waste is recyclable:

- Decomposition Rates (2)
- Plastic Items (1)
- Plastic Sorting (5)
- Types of Plastic (1)

3. The life cycle of plastics:

- Storyboard Template (1)

4. The history of plastic:

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5. Plastics in the solid waste stream:

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7. Importing and exporting plastic:

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Materials

8. Golden spikes:

- Choosing a Golden Spike (5)
- Proposed Anthropocene Markers (9)
- Anthropocene Markers on the Gigapixel (1)

9. Technofossils:

- Technofossil Facts (5)

10. Terraforming:

- Ecological footprint : plastic consumption (1)
- Big Lonely Doug (1)

11. Anthroturbation:

- There are no cards for this section.

12. Climate change:

- There are no cards for this section.

13. Extinction:

- Logic Model (1)

14. Urbanization:

- The Four Rs of Recycling (1)

Instructions to teachers

Before you use the Anthropocene education kit with students, we recommend that you read through the following to familiarize yourself with the contents of the kit and to introduce the big ideas associated with the Anthropocene to the class.

GENERAL

At the time that this teacher's guide was written, the term "Anthropocene" was not yet formally adopted as part of the official geologic time scale. Further, not all scientists believe that the formal adoption is necessary or even useful. Officially, we still live within the Meghalayan Age of the Holocene Epoch, the latter having begun approximately 11,700 years before present. The formalization of the Anthropocene is being considered by the International Commission on Stratigraphy as a potential formal addition to the geologic time scale, however, until an official decision is made, the term remains informal. As a result, the term "Anthropocene" has been defined in many different ways by various academic and non-academic groups. In this teacher's guide, we use the term to discuss a potential geological time unit characterized by measurable and abrupt changes in many of the Earth's natural cycles caused by humans. As such, the definition of the Anthropocene that this teacher's guide supports is as follows:

An•thro•po•cene:
(n.) From the Greek anthropos, meaning "human being," and kainos, meaning "new" or "recent." The proposed current geological epoch in which humans are the primary cause of permanent planetary change.

The information and multimedia associated with the education kit are largely focused on events or practices happening in Canada and around the world to demonstrate that human impacts in the Anthropocene are a global phenomenon. The changes commonly associated with the Anthropocene, such as increased urbanization, large-scale agriculture, rapid global warming, ongoing ocean acidification and elevated extinction rates, affect the planet and its inhabitants as a whole, as all systems are interconnected through the lithosphere, hydrosphere, atmosphere, biosphere and "technosphere".

Before, during and after the time when you have the education kit at your school, we encourage you to spend some time outdoors, specifically at locations where the human and natural worlds intersect, to contemplate various interactions between humans and the environment and to note how your observations change after working through the activities in this guide.

Instructions to teachers

To stay up-to-date on the discussions and decisions related to the Anthropocene within the scientific community, visit:

- The Anthropocene Working Group: quaternary.stratigraphy.org/working-groups/anthropocene/
- The International Union of Geological Sciences: iugs.org/
- The Geological Society of America: geosociety.org/gsa
- The Geological Society of London: geolsoc.org.uk/

Education kit contents

The education kit will have been at another school prior to arriving at your school. Upon receiving the kit, please go through the materials list to ensure all components have arrived, and alert us at info@cangeoeducation.ca if anything is missing or damaged as soon as possible.

Begin charging the Oculus headsets and iPads immediately to avoid interruptions in activities or lessons. If the AA batteries in the Oculus remotes need replacing, please use the provided batteries.

All of the content included in the education kits is available online, via the program website at canadiangeographic.ca/anthropocene, however virtual reality headsets will be required to view the virtual reality (VR) films and devices equipped with the AVARA app will be required to view the augmented reality (AR) sculptures.

Age-appropriate content

The educators responsible for this teacher's guide have done their best to ensure that the content is appropriate for students in grades 4 to 12. However, no one knows the level of student comfort as it pertains to certain topics better than their teacher. We recommend that all educators review the activities and watch the recommended videos ahead of time to determine if they are indeed appropriate for the age and comprehension levels of students.

Copyright

Instructions to teachers

Addressing climate anxiety or feelings of worry or confusion

The information provided in the teacher's guide addresses serious topics such as climate change, extinction and ecosystem degradation. Educators should be prepared for the possibility that students may experience overwhelming feelings of worry, fear, confusion or sadness. Concern about climate change is affecting more and more people as the associated impacts become more apparent around the world.

Assure students that this is a reasonable and healthy response to a perceived threat. Tell students that they have the ability to process the information about how the world is changing and learn from it without being hindered by their emotions.

Your first step is to acknowledge the validity of their feelings and then work with your students to see how you can provide support so that they feel they can handle their feelings in a positive and healthy way. Many psychologists are now recommending that educators encourage students to overcome these feelings by taking action, or by joining an activist, discussion, or support group (sometimes called climate cafes). A change in habits can often offer positive emotional engagement.

The Eco-anxiety video was created and included with this resource to help educators and students understand and acknowledge the possibility that they may have an emotional response to learning about the negative environmental aspects of the Anthropocene. Please see the program website to access this video at canadiangeographic.ca/anthropocene.

Supervised use of technology

The education kit contains several pieces of technological equipment that are costly and easily damaged. Students should not be allowed to use the devices without supervision and should be given proper instruction prior to using them. Schools are responsible for covering any costs associated with the replacement of devices should they be lost, damaged or otherwise compromised as a result of use by staff or students as agreed upon in the terms and conditions on the education kit booking website (canadiangeographic.ca/anthropocene).

Watching the full length film *ANTHROPOCENE: The Human Epoch*

Copies of *ANTHROPOCENE: The Human Epoch* have not been provided in the education kit, but the film can be viewed via the following provider:

- Criterion On Demand

Instructions to teachers

VIRTUAL REALITY

Motion sickness with VR headsets

It is possible that some viewers may experience the following symptoms associated with motion sickness when using the virtual reality headsets:

- Nausea
- Dizziness
- Fatigue
- Headaches
- General discomfort
- Disorientation
- Vertigo
- Drowsiness
- Pallor
- Sweating
- Vomiting

The following actions are recommended to help prevent or reduce these symptoms:

- Removing the headset
- Using the headsets while sitting down
- Using a fan or opening a window
- Closing your eyes during transitions or high-movement scenes
- Watching one video at a time followed by a break

Use and troubleshooting

The 14 activities included in this teacher's guide each contain a list of virtual reality films that complement the information provided. The virtual reality headsets come equipped with five films (*Denman Island, Recycled Life Cycle, Ivory Burn, Dandora and Carrara*), each of which are available in English and French. The headsets do not need to be connected to the Internet as the films have all been saved to the internal memory. Note: If the headsets are connected to the Internet, students will have the ability to open the Oculus Store and download games and applications. Please take measures to ensure they do not unnecessarily connect to the internet or download anything onto the headsets.

Instructions to teachers

Each of the headsets is labelled with a sticker that matches the sticker on its remote. It is important to keep the paired items together, as a paired remote will only work with the correct headset.

To charge the Oculus Go:

- Use the provided USB 2.0 Micro-B grey cables and the 10 port Anker chargers. When the light on the Oculus Go is solid green, the battery is above 95%. When the light on the Oculus Go is solid orange, the battery is below 95%.

To watch the virtual reality films:

1. Charge the headsets prior to use using the Anker charger.
2. Optional: connect the headphones to the headset.
3. Put on the headset and the headphones, and hold the remote in your hand.
4. Press and hold the power button on the top of the headset for three seconds.
5. Follow the instructions that appear on the screen to connect the remote to the headset.
6. Optional: once the main menu appears, look to the bottom right corner to verify the remaining battery power of the remote (left) and the headset (right).
7. Using your index finger and the trigger at the front of the remote, select the *Navigate* tab.
8. Select *Gallery* (alternatively, select *Library* > *Apps* > *Oculus Gallery*).
9. Select *Internal Storage*.
10. Select the list view (icon with three stacked horizontal lines) to see the film titles. Use the scroll bar to see the films lower down in the list.
11. Select the desired film.
12. Adjust the volume using the + and – buttons on the top of the headset.
13. To return to the *Gallery* when a film is playing, press the trigger and select *Back*.
14. To shut off the headset, press and hold the power button on the top of the headset, and select *Power off*.

Note: it is not possible to control all headsets such that a single video plays simultaneously for all students. Videos

Instructions to teachers

To put your headset on:

- Loosen the side straps and then the top strap, put your headset on, then tighten the side tabs and the top strap.
- If you're wearing glasses, put the headset on from the front first.
- The headset should fit comfortably and shouldn't apply too much pressure on your face and head, nor should it be falling down.
- With your hands holding both sides of your headset, slowly move your Oculus Go up and down until the picture is clear and the headset feels comfortable.

If the remote needs to be paired to a device:

- Hold the Oculus and Back buttons on the remote until the remote LED blinks and then lights up.
- In the Oculus app, tap Left or Right to choose which hand you'd like to use and then tap Continue to finalize the pairing.
- You can change which hand you'd like to use by selecting Handedness from the controller settings menu in the Oculus app.

To replace the battery in the remote:

- Remove the battery cover of your controller by lightly pulling at the bottom half of the controller until it comes loose.
- Lightly pull on the battery from the bottom end of the controller until it comes loose and can be removed.

To turn the Oculus Go off:

- With your headset off, press and hold the power button for 10 seconds.
- Or, with your headset on, press and hold the power button until you see a shut down menu in VR. On the shut down menu, select Power off using the remote.

The following website has additional instructions and information: support.oculus.com/183135912238400/

If you experience any difficulties using the Oculus Go headsets, please contact us at info@cangeoeducation.ca.

Instructions to teachers

AUGMENTED REALITY

Use and troubleshooting

The 14 activities included in this teacher's guide each contain a list of augmented reality experiences that complement the information provided. The wall-hanging prints are meant to be used in conjunction with the AVARA app already installed on the iPads. Turn on the iPads and open the AVARA app and follow the on-screen instructions to view the models in 3D.

The prints should be hung on the wall using the grommets or the provided painters tape. Do not use materials such as duct tape that will leave a residue on the prints or the walls. They should be hung at the following heights to ensure a proper experience:

- **Sudan the rhino**
  To be hung so that the bottom of the print is 66 cm above the ground
- **Ivory tusk pile**
  To be hung so that the bottom of the print touches the ground
- **Plastics**
  To be hung so that the bottom of the print touches the ground and the arrow on the back of the print is pointing upwards

Note: students have the option of downloading the AVARA app from the Google Play Store or the iStore onto their personal devices.

ONLINE VIDEO CLIPS

The 14 activities included in this teacher's guide each contain a list of online video clips that complement the information provided. This clips can be accessed on the program website at canadiangeographic.ca/anthropocene. In most cases the films are in English with French subtitles, although there are a few exceptions. These clips can be watched by students via the provided iPads or on classroom screens or computers.

ONLINE GIGAPIXELS

A gigapixel image is a mosaic of extremely high-resolution digital photographs, which combined, contain one billion pixels of information. The floor gigapixel is an example of this, however there are four interactive gigapixels created by world-renowned photographer Edward Burtynsky that showcase the application of detailed digital photography to the understanding of the changes created by humankind to the geology and ecology of the planet. Students can interact with the images by finding the embedded triggers that, when selected, play short film extensions.

Instructions to teachers

Cathedral Grove on Vancouver Island

- gigapixel-theanthropocene.org/Forest/

Carrara Marble Quarries in Italy

- gigapixel-theanthropocene.org/Carrara/

Lagos, Nigeria

- gigapixel-theanthropocene.org/Lagos/

Scarborough Transfer Station

- gigapixel-theanthropocene.org/Recycle/

Note: teachers who are unable to use the floor gigapixel have the option of completing the activities using this online version.

1 BIOACCUMULATION

Grade Level

7–9 (can be modified for younger and older grades)

Learning Goal

- Explore how plastics enter the environment and move through a food web, threatening ecosystems and living organisms in the process.

Learning outcomes

By the end of the lesson, students will be able to:

- Understand that the natural world is not a separate entity from humans, but that both are interconnected aspects of a whole.
- Describe a food web and the critical roles of each organism in keeping an ecosystem healthy.
- Describe the process of bioaccumulation in terrestrial and aquatic organisms.
- List ways that plastic pollution threatens the health of animals and humans.
- Make informed decisions about avoiding or reducing microplastics in ways that benefit the living world and are respectful of the natural life cycles of the animals they share the Earth with.

Materials

Included:

- 60 coloured blocks (10 red, 10 white, 10 green, 10 blue, 10 yellow, 10 black)
- Gigapixel
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Background information

Bioaccumulation is the buildup of substances, such as plastics, chemicals and other toxins, in the bodies of animals living in terrestrial and aquatic habitats. The term bioaccumulation is a combination of the words "biological" and "accumulation" and is most often used to describe the buildup of toxins or foreign substances in the bodies of living animals over time. These substances tend to build up when they are ingested more quickly than they are broken down or expelled. All biological organisms that get their food from their surrounding environment — from microscopic phytoplankton that live in the oceans, to birds, to humans — are capable of ingesting toxins or foreign substances.

Bioaccumulation can have an impact on an entire food web within an ecosystem. For example, consider the following: a single phytoplankton in the ocean ingests a small amount of a certain toxin. A small fish feeds on several phytoplankton, and the toxin begins to accumulate in the body of the fish. A large fish then feeds on several smaller fish, accumulating even more of the toxin in its body. Finally, a bear catches several large fish, and as a result, the bear's body ends up containing the largest concentration of the toxin out of all the organisms in the ecosystem. This ever-increasing buildup of large concentrations of a toxin is referred to as biomagnification.

Humans are now producing more than 300 million tonnes of plastic. Bioaccumulation is therefore a major concern in the Anthropocene epoch, not only because the ongoing ingestion of toxins by wildlife is problematic, but because humans that consume organisms that are higher up in the food web are at risk of experiencing health-related issues as a result.

To ensure the health and safety of Earth's organisms, including humans, we must prevent toxic substances from entering the food chain. To do this, we must first understand the origins of these substances, how they end up in different ecosystems, and which substances are the most dangerous and why. Use the following questions, activities and resources to explore the topic of plastic bioaccumulation in the food web, as well as potential solutions currently being studied in Canada.

Introduction

Ask students to think about plastic and its relative importance in their everyday lives. Discuss with students their understanding of the advantages and disadvantages of plastics, and how plastics end up in recycling or disposal facilities versus in the natural environment. Consider doing a thumbs-up activity where, by show of thumbs, students show how well they think they understand the advantages and disadvantages of plastics. Students place their thumbs up if they think they can name three or more advantages and/or disadvantages, down if they can only name one of each, or sideways if they can name two of each. If needed, discuss what a food chain is, the components of an ecosystem, and how animals might ingest plastics unintentionally, and what the consequences might be. Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below as part of this warm-up:

1 BIOACCUMULATION

Not included:

- Writing tools
- 14 paper bags labelled with "plankton"
- 9 paper bags labelled with "shrimp"
- 5 paper bags labelled with "fish"
- 2 paper bags labelled with "shark"

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- Spatial significance
- Interrelationships

Geographic Inquiry Process

- Ask geographic questions
- Evaluate and draw conclusions
- Reflect and respond

Geospatial Skills

- Foundational elements

Burtynsky photographs

Cape Coral #1
Lee County, Florida, USA, 2012

- Why is plastic useful or important? Answer: *Plastic is versatile and can be physically and chemically altered to serve many purposes. It is durable, lightweight, sanitary and cost-effective to produce.*
- When does plastic become pollution? Answer: *When plastic starts to accumulate in an area, causing harm to plants, wildlife, humans and the environment, it is considered pollution.*
- How does plastic get into the environment? Answer: *A few of the many examples include when plastic is improperly discarded, is picked up by wind or water, ends up near drains or rivers, is ingested by an animal, or falls off our clothing or cars.*
- What are microplastics? Answer: *Microplastics are small fragments of any kind of plastic that are 5 millimetres or smaller, such as clothing strands, microbeads and broken pieces of larger objects.*
- How can microplastics hurt land and water animals? Answer: *Plastic is generally safe in its original form, but when it is broken down and ingested by animals, over time it can slowly release chemical toxins that are harmful or poisonous.*
- How can microplastics affect humans? Answer: *Fish and wildlife that contained toxins after ingesting large amounts of plastic can then be eaten by humans, threatening human health. Humans can also breath in microscopic plastic particles or drink water that contains microplastics, both of which increase the concentration of toxins in the human body. These toxins can sometimes interfere with human hormonal function or disrupt the functioning of certain organs or bodily systems.*
- Are some communities affected differently when it comes to plastic pollution? Answer: *Indigenous people, as well as people from low-income and rural communities who depend on wild seafood and animals for their diet, face greater risks from plastics.*

Gigapixel activity

As students explore the gigapixel image, explain that many of the items they are looking at can be a source of microplastics in the environment. Explain that there are in fact two types of microplastics. Primary microplastics are small plastic particles that are intentionally manufactured in this size for use in cosmetic products or as abrasives. Secondary microplastics result when larger plastic products — such as plastic bags, bottles or fishing nets — break down into smaller plastic pieces. Ask students to identify any sources of primary or secondary microplastics they see on the gigapixel.

Tell students they are going to act out how microplastics bioaccumulate in the bodies of animals that together form a food web and how microplastics biomagnify in that food web. The setting will be an ocean because microplastics tend to be more abundant in aquatic environments.

1 BIOACCUMULATION

Dandora Landfill #1
Nairobi, Kenya, 2016

Saw Mills #2
Lagos, Nigeria, 2016

Manikarnika Ghat
Varanasi, India, 2013

Give each student a paper bag, a pencil and some coloured blocks. Tell each student that the label on their paper bag represents their position in the food web. Ask them to place their blocks on different plastic objects on the gigapixel image (colours do not matter at this point; blocks of all colours can be placed anywhere on the gigapixel). Explain that the edges of the gigapixel represent an ocean and the blocks represent food particles that the lowest level members of the food web, the plankton, will consume.

Tell all the plankton that it's feeding time, and ask them to pick up all the blocks and place them in their paper bags. Once feeding is over, ask them to count how many blocks of each colour they collected and write it down on their paper bag.

Now announce that it is feeding time for shrimp, which prey on plankton. Ask the shrimp to feed on the plankton by taking the coloured blocks in the planktons' paper bags and placing them in their own. Once a plankton has been eaten, they must step off the gigapixel to symbolize that they have been removed from the food web. The shrimp then tally the coloured blocks in their bags and note the totals in pencil on the bags.

Next is feeding time for the fish, which prey on shrimp. Ask the fish to feed on the shrimp by taking the coloured blocks in the shrimps' paper bags and placing them in their own. Once a shrimp has been eaten, they must step off the gigapixel to symbolize that they have been removed from the food web. The fish then tally the coloured blocks in their bags and note the totals in pencil on the bags.

Last is feeding time for the sharks, which prey on the fish. Repeat the same process as before until all the fish have been eaten and the sharks have tallied their coloured blocks.

Now explain that the red and white blocks represent microplastics that were suspended in the water column after having entered the ocean from a river or beach. Tell the class that bioaccumulation began when the plankton started feeding. Have the plankton, shrimp, fish and sharks compare how many red and white blocks (or pieces of microplastic) they "ate" and discuss which of the four members of the food web consumed the highest concentration of plastic. Explain that the sharks ate the most plastic because as you move up the food chain, the same amount of plastic is transferred to a decreasing number of animals, thus increasing the concentration in each animal's gut. This is known as biomagnification.

Optional: Have students use the AVARA app on the provided tablets to locate trigger 1 embedded in the gigapixel image and then watch the short film that appears on their devices.

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

1 BIOACCUMULATION

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Coles Bay and University of Victoria* video, which shows graduate students sampling for fish in Coles Bay and categorizing the contents found in their stomachs
- the *University of Toronto* video, which shows graduate students studying the plastic content collected from the stomachs of fish and an interview with Chelsea Rochman on sources of and solutions to plastic pollution
- the *Denman Island and University of British Columbia* video to learn about the Guardian Watchmen for the K'ómoks First Nation and the water sampling techniques used by graduate students at the University of British Columbia

Virtual reality

Using the provided headsets, have students experience:

- the *Denman Island* video, which immerses students in the scientific research being done by the Guardian Watchmen for the K'ómoks First Nation and the University of British Columbia

Conclusion

Discuss with students their understanding of the process of bioaccumulation and how microplastics form and proceed to enter different environments. The following questions may help spark conversations:

- How is it possible that some animals cannot differentiate between food and plastic, much like the plankton did not know that the red and white blocks were microplastics?
- Where would humans be placed in the food web acted out on the gigapixel, and would they be susceptible to the ingestion of plastic?
- What can happen to an animal or a human if they consume too much plastic?
- How is it possible that an issue, in this case plastic pollution, can affect different people in different ways?
- How does the proliferation of plastic in the environment harm our relationship with the Earth?
- What role can humans play in solving this issue?

1 BIOACCUMULATION

Evaluation of student learning

Assess students based on their understanding of the roles of the different animals in the activity, how microplastics move through the food chain, the impact of microplastics on the environment and life, the purpose of the different coloured blocks, and the overall results of the feeding activity. Use the questions in the conclusion to evaluate the knowledge gained after performing the gigapixel activity or watching the film extensions.

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to avoiding or reducing microplastics.

For younger students:

- Have students create their own animated movie describing the relationship between an animal and its environment using the Creative Movie Maker for Kids app. They can pick a natural environment, such as a lake, forest or mountain, or an urban setting such as a city. They can select different animals that live in that environment, add dialogue and movement to tell a story about the impacts of plastics on the animals in their movies, and share their stories with their online community.
- Remind students that collective action goes a long way in terms of reducing pollution in the environment. Organize a student-led riverbank, schoolyard or park cleanup to empower students to take action in their community. Alternatively, take part in an organized cleanup like the Clayoquot CleanUp in British Columbia.
- Consider following the people and groups listed below on social media to draw inspiration from how they are dealing with the plastic pollution crisis:
  - ▷ Hannah Testa (greenpeace.org/usa/stories/fifteen-year-old-turning-tide-plastic-pollution/)
  - ▷ Boyan Slat (.mnn.com/earth-matters/wilderness-resources/blogs/remember-kid-who-invented-way-clean-ocean-plastic-hes-back-and-its-happening)

1 BIOACCUMULATION

For older students:

- Have students organize a STOP (Students Take On Plastic) event in their school or community following the guidelines set out by the Green Schools Alliance.
- Have students take selfies with one of the items on the gigapixel image, print out the photographs and keep them in a visible place for the entire school year (e.g., locker, bedroom wall, fridge door, notebook cover). Have students create a personal pledge aimed at reducing their use of that item or that type of plastic in their everyday lives. Check in with students on their progress throughout the year and encourage them to research alternative products or materials to ensure their pledge is respected.
- Join a related worldwide initiative, such as:
  - ▷ Ocean Cleanup (theoceancleanup.com/)
  - ▷ 10,000 Changes (10000changes.ca/en/)
  - ▷ Ocean Conservancy (oceanconservancy.org/)
  - ▷ Students for Zero Waste (sanctuaries.noaa.gov/news/jul18/students-for-zero-waste-week-2018.html)
  - ▷ Beat the Microbead (beatthemicrobead.org/)

2 NOT ALL PLASTIC WASTE IS RECYCLABLE

Grade Level

7–9 (can be modified for younger and older grades)

Learning Goal

- Differentiate between the seven different types of plastic and reflect on how long plastic pollution remains in the environment once discarded.

Learning outcomes

By the end of the lesson, students will be able to:

- Describe the purpose of having recycling codes on plastic products and the seven different types of plastics that are commonly found in household recycling.
- Understand how the chemical composition of the seven types of plastics affects whether or not they can be recycled in a traditional curbside recycling program.
- Think critically about their personal consumption of plastic products and their recycling habits, and develop new recycling strategies.
- Explain the difference between organic materials, organic waste, and recyclable and non-recyclable materials.

Materials

Included:

- Gigapixel
- Decomposition Rates card (1)
- Plastic Items card (1)
- Plastic Sorting card (5)
- Types of Plastic card (1)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Background information

In Canada, different plastics are distinguished from one another based on their chemical makeup and their resin identification code, which is the triangular recycling symbol commonly found on the bottom of plastic products. In total, there are seven different types of plastics, but not all communities in Canada recycle all seven types of plastic since it is not always economical or mechanically possible to do so.

Plastics are derivatives of polymers, complex chains of organic molecules containing carbon, hydrogen, oxygen and other naturally occurring elements. These polymers come from natural materials such as crude oil, coal, natural gas, cellulose and salt. Polymers can be heated, pressed and chemically modified to produce synthetic compounds, such as plastics, which can be shaped, coloured and made rigid or flexible depending on their eventual use. Thus, plastics are organic materials that have been reshaped and repurposed for human use and must be recycled or incinerated once they are no longer useful. However, they should not be confused with organic waste such as leaves, vegetable peels and bones, which are biodegradable and capable of returning nutrients back into the earth once they decompose.

Different types of plastic exist based on their chemical and structural composition. To make recycling and disposal easier for the public, waste management companies have adopted a system that labels the different types of plastic using the numbers 1 to 7. These numbers are known as resin identification codes (resin ID codes) and each number symbolizes the specific plastic resin out of which different products are made:

- Number 1 is for polyethylene terephthalate (PET) (e.g., water bottles)
- Number 2 is for high-density polyethylene (HDPE) (e.g., milk jugs)
- Number 3 is for polyvinyl chloride (PVC) (e.g., pipes)
- Number 4 is for low-density polyethylene (LDPE) (e.g., plastic bags)
- Number 5 is for polypropylene (PP) (e.g., food containers)
- Number 6 is for polystyrene (PS) (e.g., styrofoam)
- Number 7 is for "all other types" including polylactic acid (PLA) (e.g., nylon)

Not all communities in Canada recycle the same types of plastic; many recycle only types 1 and 2 based on the regulations of the municipal government and the demand for these types of plastics from the recycling companies that will pay for post-consumer recyclables. Further, if the items are too dirty, they may get sent to the landfill, where it can leach toxic chemicals into the soil and groundwater. Plastic takes an extremely long time to decompose; some scientists estimate it can take hundreds if not thousands of years to decompose, while others argue it never fully decomposes.

2 NOT ALL PLASTIC WASTE IS RECYCLABLE

Not included:

- A mix of clean, empty plastic containers collected at school or at home (optional)
- Opaque tape (optional)
- Dry-erase markers (optional)

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- Spatial significance
- Geographic perspective

Geographic Inquiry Process

- Ask geographic questions
- Interpret and analyze
- Evaluate and draw conclusions
- Reflect and respond

Geospatial Skills

- Foundational elements
- Technologies

Burtynsky photographs

Dandora Landfill #3
Plastics Recycling, Nairobi, Kenya, 2016

Because plastic has become a household staple for most people around the world and has since started to accumulate in the environment, humanity must take action to reduce the prominence of single-use plastics and the amount of non-recycled plastic pollution, beginning with learning the differences between the seven types of plastic.

Introduction

Discuss with students their understanding of the widespread use of plastic and how plastic has replaced, in many cases, metal, glass and wood. Have students pair up and think of two items that are now made of plastic but were previously made of other materials. Write everyone's ideas on the board. Ask students to reflect on the advantages and disadvantages of producing these objects out of plastic. Have they ever seen these objects in recycling bins or waste bins? What are their impressions of the quantity of these items that get recycled versus those that get sent to landfill? Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below as part of this warm-up:

- What are some advantages associated with plastics? Answer: *Plastics are light, versatile, strong and inexpensive. They keep things clean and organized. They are used to build objects that increase our quality of life (e.g., smartphones, cars).*
- What are some examples of industrial sectors that produce plastic waste? Answer: *Building and construction, mobility and transport, electronics, agriculture, health care, sports and leisure, energy.*
- What is plastic made of? Answer: *Plastics come from naturally occuring materials such as crude oil, natural gas, salt, and coal. By combining these materials in different ways and subjecting them to heat and pressure, different polymers or plastics can be created.*
- Can plastics be harmful to humans? Answer: *Certain types of plastic, namely types 3, 6 and 7, are known to contain substances that are toxic to humans.*
- What are the connections between plastics and the global economy? Answer: *Post-consumer plastics (plastics that have been used by consumers and then collected through residential or commercial recycling programs) are a relatively high-valued item, and their value fluctuates much like the price of gas, depending on the availability of source materials, the number of processing facilities, consumer demand and social acceptance.*
- Are there any communities that do not have curbside recycling or recycling facilities nearby? Answer: *Many households in isolated or rural communities have limited recycling opportunities when compared with households in urban areas.*
- Why are some communities and countries opting to ban a few or all single-use plastic items from their economy? Answer: *Banning single-use plastics will cut down on plastic pollution and microplastics and will force individuals and industries to use sustainable alternatives.*

2 NOT ALL PLASTIC WASTE IS RECYCLABLE

Benidorm #1
Spain, 2010

Breezewood
Pennsylvania, USA, 2008

PS10 Solar Power Plant
Seville, Spain, 2013

Gigapixel activity

Before the activity, collect an assortment of empty plastic containers and discarded plastic materials from your home or school recycling. Make sure the items are clean and safe for handling. Refer to the Plastic Items card for ideas on what to bring in. Be sure to put a removable piece of tape or a sticker over the triangular recycling logos with the resin ID codes.

Start the activity with a matching game. Place all the plastic items in a pile in the centre of the gigapixel image and ask students to match the items to those pictured on the gigapixel. Consider having one item per student, or divide the students into groups. Students can place the items on top of a matching item on the gigapixel once they have located one.

Explain to students that, although each of the items is unique, they share characteristics that enable them to be grouped into categories or types of plastic. These categories are largely based on things like colour, texture, density, source material and overall purpose (e.g., for storing food or cleaning products). In Canada, there are seven different official categories recognized by the recycling industry. These categories have existed since 1988 when the Society of the Plastics Industry introduced a coding system (known as resin ID codes) to make sorting and recycling plastics easier for recyclers.

Divide students into groups of two or three, and give each group a copy of the Types of Plastic card. Have students read over the card and familiarize themselves with the different types of plastic.

Give each group a copy of the Plastic Sorting card and task them with guessing the resin ID code of ten of the items placed on the gigapixel. Allow enough time for students to think critically about the different types of plastics, and encourage students to feel the items and look at them closely to get a better sense of their rigidity, transparency and weight.

Have students sit in a circle around the edges of the gigapixel. As a group, create seven piles of items that represent the seven types of plastic. Pick up an item and ask students for the resin ID code based on their answers on the Plastic Sorting card. Peel off the tape covering the ID code to see if they are right. Place the item in the appropropriate pile and repeat this procedure with all remaining items. Discuss which items were the hardest to identify or were frequently incorrectly identified. What is it about these items that makes them hard to identify? Is it possible that this could contribute to confusion when it comes to placing these items in the recycling or trash?

Divide the class in two. Invite the first half of the class to work together to create two new piles using the Types of Plastic cards: items that can easily be recycled, and items that cannot. Double check their work and consider checking your local municipality's website for further details about which items are easily recycled in your community. Discuss with students if they have been correctly disposing plastic items according to these two piles.

2 NOT ALL PLASTIC WASTE IS RECYCLABLE

Using the pile of recyclable items, ask the remaining half of the class to lineup the items based on how long they think they will persist in the environment if improperly recycled or sent to landfill. Which items will likely decompose relatively quickly? Which ones will persist for hundreds of years? Once the students have finished sorting the items, go through the Decomposition Rates card with them and discuss how their sorting results compare to the estimations. Discuss if they feel differently about using certain items knowing they can persist for hundreds of years in the environment if improperly recycled. Consider tying in the items that ended up in the non-recyclable pile. Explain to students that some non-recyclable items can be repurposed into new items (e.g., plastic bags can be recycled into plastic lumber for decks and fences) and that many municipalities and organizations are trying to come up with innovative and cost-effective ways of doing so.

Optional: Have students use the AVARA app on the provided tablets to locate triggers 3, 4, 6 and 7 embedded in the gigapixel image and then watch the short films that appear on their devices.

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Canada Fibers* video that shows how a materials recovery facility works
- the *EFS Plastics* video that shows the procedures used by recycling and compounding facilities
- the *SARCAN* video that provides an example of plastic repurposing procedures in Canada

Virtual reality

Using the provided headsets, have students experience:

- the *Recycled Life Cycle* video that shows the sequence of events when recycled materials move from a transfer station to a repurposing facility.

Augmented reality

Using the provided tablets and the wall-mounted vinyl triggers, have students explore:

- the *plastic bales* sculpture using the AVARA app

2 NOT ALL PLASTIC WASTE IS RECYCLABLE

Conclusion

Discuss with students their new understanding of plastics in general and the need for plastics in our everyday lives. The following questions may help spark conversations:

- What comes to mind when you hear the word plastic?
- How do different people have different relationships with or impressions of plastic?
- What are the current alternatives to plastic?
- Should humanity be working towards a more sustainable alternative to plastic?
- Should individuals be responsible for reducing their consumption of plastic or should corporations be responsible for reducing their production of plastic?
- What would the world look like if plastics had never been invented?
- If we were able to collect all the plastic pollution currently on land and in the oceans, what would be the next step?
- Do you think communities, provinces, territories and countries should ban single-use plastics, like bags and utensils? Explain.
- What can you as an individual do to take action against the overconsumption of plastic?
- How can we convince individuals and corporations that are unwilling to change their behaviour to take action?

Evaluation of student learning

Assess students based on their understanding of the different types of plastics, why some plastics are recyclable in certain communities while others are not, and the limitations of plastic recycling in Canada. Monitor student abilities to differentiate between different types of plastic, and evaluate critical thinking skills when it comes to categorizing plastics. Use the questions in the conclusion to evaluate the knowledge gained and student thinking performed in this activity.

2 NOT ALL PLASTIC WASTE IS RECYCLABLE

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to recycling plastics.

For younger students

- Lead an activity that allows students to invent ways of repurposing existing plastic items. For example, a laundry detergent container could be repurposed into a watering can or a bird feeder. Take this one step further by having students design, build and decorate their inventions.
- To raise awareness, put together a play that takes the audience through plastic recycling practices in different parts of the country highlighting the limitations experienced by certain communities.
- Consider following these people and groups on social media to keep up with their innovative strategies for repurposing plastic items:
  - ▷ Recycle Coach (recyclecoach.com/)
  - ▷ The Last Plastic Straw (thelastplasticstraw.org/)

For older students

- Have students research the recycling rules and regulations in their community to identify which items and which types of plastic can and cannot be recycled in their curbside recycling bins. Have them create digital pamphlets or an e-blast that can be shared with schoolmates, teachers, parents and community members to raise awareness and encourage efficient recycling habits.
- Have students compose a letter to a local recycling facility or member of parliament to see what steps are being taken to improve recycling standards in the community and in what ways their class or school can become involved.
- Join a related worldwide initiative, such as:
  - ▷ My Little Plastic Footprint (mylittleplasticfootprint.org/)
  - ▷ 10,000 Changes (10000changes.ca/en/)
  - ▷ Precious Plastic (preciousplastic.com/)
  - ▷ Plastics for Change (plasticsforchange.org/)

3 THE LIFE CYCLE OF PLASTICS

Grade Level

4–12

Learning Goal

- Consider the journey of a plastic product from creation to degradation, and understand that while some of the plastic we use is recycled, essentially extending its lifespan, much of it is sent to landfill.

Learning outcomes

By the end of the lesson, students will be able to:

- Tell the story of what goes into making a plastic water bottle and what happens to it at the end of its life cycle.
- Describe the products that make up the bulk of curbside recycling collections in urban areas and discuss the reasons for sending a plastic object to landfill.
- Explain how recycling can be a solution to pollution, but also how recycling should be used more as a last resort than a primary option.
- See beyond the negative stigmas that are often associated with waste management careers and explain why these types of jobs are important.

Materials

Included:

- Gigapixel
- Storyboard template card (1)
- Book: *The Adventures of a Plastic Bottle* (1)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Background information

Plastic is versatile, malleable, strong, light and cost-effective to produce. It is an important invention that has simplified and improved the lives of countless people worldwide, as it can be used for storing, transporting, protecting and preserving food and medication. Plastic is also ubiquitous and extremely long-lasting, and its production requires inordinate amounts of natural resources, such as water, natural gas and crude oil. As a result, plastic — more specifically, our plastic production, consumption and disposal habits — has become an environmental and economic problem that needs to be addressed if we are to protect our future and the future of the planet.

As concern for the environment grows, more and more people are asking questions about the necessity of certain single-use plastic objects, like water bottles, razors and yogurt containers. What resources — and how much of them — go into the production of these items? How long do these items take to break down if sent to landfill? Is it possible for chemicals to be released into the environment as these items degrade over time? How difficult is it to recycle plastic items into new objects? How can we use less single-use plastic?

To answer these questions, we need to consider the individual life cycles of these items. For example, the general life cycle of a plastic water bottle is as follows (see the educational videos at 10000changes.ca and the TEDx explanatory videos on *What really happens to the plastic you throw away* for even more info):

1. Crude oil and natural gas are physically extracted from sources in the earth at a very large scale.
2. The oil and gas are shipped to refinery plants, often by rail or via heavy-duty transport trucks that burn large amounts of fossil fuels.
3. The oil and gas are separated from one another and distilled into simpler components that are ready for plastic factories.
4. The distilled forms of oil and gas are shipped to plastic factories, again via transport trucks or by rail.
5. The plastic factories create useable mixtures of oil and gas that are made up of long chains of molecules called polymers. This is a chemically based process that requires energy.
6. The polymers are compressed into hard pellets that are then melted down in molds that create the shape of a bottle.
7. The empty bottles are shipped to a bottling plant, where they are filled with water that has been filtered and purified.
8. A lid and packaging are added to the exterior of the bottle.

3 THE LIFE CYCLE OF PLASTICS

Not included:

- Tracing paper (optional)
- Art supplies (optional)
- Blank paper (optional)
- Computers or other devices with internet access (optional)

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- Geographic perspective
- Patterns and trends

Geographic Inquiry Process

- Ask geographic questions
- Acquire geographic resources
- Communicate

Geospatial Skills

- Foundational elements

Burtynsky photographs

Alberta Oil Sands #9
Fort McMurray, Alberta, Canada, 2007

9. The bottles are shipped to retailers.
10. The bottles are purchased by consumers and transported back home (or to another destination). The water is consumed, and the bottle is either recycled or, more often, thrown in the trash and sent to a landfill.
11. Some of the bottles sent for recycling never get recycled, because they're dirty or it's not financially viable to recycle them. The bottles that do get recycled are melted back down into pellets at recycling facilities and remade into new products. Eventually, those products will also end up in the trash, because each time an existing plastic bottle is melted down and recycled into something new, it loses a fraction of its quality and durability.

Thus, the production of a water bottle involves the use of various forms of energy and fuel and the creation of a large amount of pollution in the form of greenhouse gas. Specifically, it takes roughly three times the amount of water to produce a plastic water bottle than to fill one. Use the following questions, activities and resources to find out what your students think about the life cycle of plastic products.

Introduction

Ask students to think about the last time they purchased or used a single-use plastic water bottle. Discuss with students their understanding of the advantages and disadvantages of single-use plastics and their impressions of whether or not something as simple as a plastic water bottle is a necessity of life.

Consider doing a tactile introductory activity where students are asked to assemble a timeline of the life cycle of a plastic water bottle based on the steps above. Print off photographs that represent each step and ask students to put them in order of start to finish. Have students compare their timelines and discuss the correct order of events. Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below as part of this warm-up:

- What are single-use plastics? Answer: *Items intended to only be used once before disposal, such as plastic forks and knives, plastic shopping bags, plastic coffee cup lids and plastic straws.*
- Why do manufacturers put so much time, effort and money into producing a plastic water bottle if it requires three times more water to make one than to fill one? Answer: *They benefit from the revenue, and consumers benefit from the convenience, many of whom prefer bottled water for its taste, high quality and safety.*
- Would it be possible to live in a world without certain plastic items, including water bottles? Answer: *The environmental cost of the massive consumption of bottled water has led governments worldwide to consider a ban its sale.*

3 THE LIFE CYCLE OF PLASTICS

Oil Fields #22
Cold Lake, Alberta, Canada, 2001

Oxford Tire Pile #5
Westley, California, USA, 1999

Dandora Landfill #3
Plastics Recycling, Nairobi, Kenya, 2016

- Could there ever be such a thing as a plastic-free community? Answer: *Yes and no. The Blue Communities Project has designated several communities across Canada and around the world as Blue Communities for banning the sale of bottled water in public facilities and at municipal events (as well as recognizing water as a human right and promoting public water services). But private citizens can still buy all the plastic they want.*
- Is it possible to produce a water bottle with a shorter lifespan than the estimated 500 years? Answer: *Landfills are slowly beginning to incorporate microbes and enzymes adapted to break down trash, and research is being done on how to develop new materials that are more environmentally friendly.*
- What other items containing plastic have complex life cycles and long life spans? Answer: *The majority of manufactured items contain some form of plastic, and many of these take between 50 and several hundred years to degrade, including cell phones, car tires, clothing and chewing gum.*
- As a piece of plastic degrades in a landfill, where does the plastic go? Is it ever really gone? Answer: *Every plastic that has ever been created still exists today in some shape or form. Plastic will break down into smaller and smaller pieces called microplastics that never fully degrade in the ocean or on land. Instead, they exist indefinitely and just get smaller and smaller over time.*

Gigapixel activity

Have students walk around the gigapixel in pairs, pointing out and discussing with each other objects or patterns that stand out against the rest. Have students put their left foot on an item they have used or seen in the store before. Keeping their left foot where it is, ask students to place their right foot on an item they have used in the past week. How many students were successful at this activity?

Have a brief conversation with students that revolves around the objects they saw that were the most and the least common. Make sure students understand that they are observing a pile of recyclables at the Scarborough transfer station in the Greater Toronto Area. This is a drop-off depot used to collect, sort and transfer all the city's recyclables collected at the curb. Residents can also use this depot to dispose of their unwanted items for a fee. Here, the waste is sorted, and large trucks will eventually transport the sorted items to landfills, hazardous waste facilities or recycling facilities.

Sit with students in a large circle on the gigapixel, making sure every student can see you clearly. As a group, read the story by Alison Inches called *The Adventures of a Plastic Bottle: A Story About Recycling* (French classes can use *Le Grand voyage de monsieur Papier* by Angèle Delaunois). Take a few moments at the end of the reading to discuss the events that occurred in the story and the major themes addressed throughout, such as recycling, repurposing and sustainability.

3 THE LIFE CYCLE OF PLASTICS

Inform students that they will create their own illustrated story based on the format used in *The Adventures of a Plastic Bottle*. First, ask them to scour the gigapixel for an object that they think would make a compelling character in a story about the life cycle of a common plastic item. Next, ask them to develop a story written from the perspective of that object/character. This story should should cover the life cycle of that object/character and should conclude with it/them becoming something new (much like in *The Adventures of a Plastic Bottle*). Students will most likely require some research time to uncover information about the actual manufacturing, transportation, consumption and disposal of their object.

To develop an outline for their story, students should use the *Storyboard Template* card. This will help them picture scenes in the story while writing accompanying text. Explain that one scene must incorporate what they saw in the gigapixel — that is, their object/character in a heap of recycling at a transfer station. They will need to decide on the events that led to their object/character ending up at the transfer station, as well as what takes place afterwards. Optional: for their final submission, or for practice, students can use tracing paper and trace their object from the gigapixel image. Alternatively, they can draw their own interpretation by hand.

Students should submit a hand-drawn storybook after a few days of work. If time allows, have students take turns standing on the gigapixel image near their object of inspiration and read their story to their classmates. Optional: have students focus only on the illustrations at first, and then have them use the ChatterPix Kids and the Flipgrid apps to bring the stories and the characters to life. Share the resulting digital stories using the QR codes obtained from the apps.

Optional: Have students use the AVARA app on the provided tablets to locate triggers 4, 6 and 7 embedded in the gigapixel image and then watch the short films that appear on their devices.

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Full Cycle Part One* video, which shows how a piece of recycling collected by waste management services at the curbside ends up as part of a compacted plastic bale ready for processing
- the *Full Cycle Part Two* video, which shows how a bale of plastic becomes pelletized so that it can be used to make something new

3 THE LIFE CYCLE OF PLASTICS

- the *Canada Fibers* video that shows how a materials recovery facility works
- the *EFS Plastics* video that shows the procedures used by recycling and compounding facilities
- the *SARCAN* video that provides an example of plastic repurposing procedures in Canada.
- the *GPR Plastics* video that shows how the process of plastic injection moulding can be used to create plastic bins

Virtual reality

Using the provided headsets, have students experience:

- the *Recycled Life Cycle* video that shows the sequence of events when recycled materials move from a transfer station to a repurposing facility.

Augmented reality

Using the provided tablets and the wall-mounted vinyl triggers, have students explore:

- the *Plastic bales* sculpture using the AVARA app

Conclusion

Discuss with students their understanding of the life cycle of a plastic object such as a water bottle and how the durability and longevity of this material that once made it revolutionary and highly sought-after has now also made it an environmental hazard. The following questions may help spark conversations:

- What factors dictate whether a plastic bottle ends up being recycled or sent to a landfill?
- What steps can humans take to make sure more plastics are being recycled?
- The widespread use of plastics has generated a number of benefits for society and for the environment. What are some examples of these benefits?
- The widespread use of plastics has generated a number of negative issues for society and for the environment. What are some examples of these issues?
- Describe the link between plastic use and climate change.

3 THE LIFE CYCLE OF PLASTICS

Evaluation of student learning

Assess students based on their understanding of the book *The Adventures of a Plastic Bottle* and their ability to express their own scientific and creative ideas in their personal stories. If research is involved, observe their ability to differentiate between pertinent information and superfluous facts. Use the questions in the conclusion to evaluate the knowledge gained after performing the gigapixel activity or watching the film extensions.

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to reducing our collective carbon footprint.

For younger students:

- Read more about this issue. *Why Should I Recycle* (Jen Green), *I Can Save the Earth! One Little Monster Learns to Reduce, Reuse, and Recycle* (Alison Inches), and *Michael Recycle* (Ellie Bethel) are great options that weave in suggestions for action that younger students can incorporate in their daily lives. French options include *La poubelle et le recyclage : A petits pas* (Gérard Bertolini and Claire Delalande), *Je trie les déchets* (Jean-René Gombert) and *Pourquoi je dois recycler les déchets* (Jen Green and Mike Gordon).
- Show students that they can connect with nature while making a commitment to reducing and reusing plastic. For example, have students create bird nests and frog homes out of plastic containers, or build a vertical wall garden using two-litre pop bottles that are cut open and filled with soil and seeds.
- Consider following these people/groups on social media to draw inspiration from how they are taking action against the overconsumption of plastic:
  - ▷ Team Marine (teammarine.org/)
  - ▷ Jordan Howard (jordaninspires.com/bio-1)
  - ▷ Plastic Pollution Coalition (plasticpollutioncoalition.org/)

3 THE LIFE CYCLE OF PLASTICS

For older students:

- Have students take part in a debate that focuses on the challenge of becoming a plastic-free school or community. Half the class will research and present supporting information on the benefits and practicality of banning single-use plastics, while the other half will educate the jury on the need for and benefits of single-use plastics and the alternatives to sending them to a landfill. Perform this debate in front of an audience of peers, teachers and parents to raise awareness about this issue and start a grassroots movement to reuse existing plastic and reduce plastic consumption overall.
- Hold a recycling challenge that gets students excited about cleaning up their school. Spend some time indoors and outdoors picking up litter. Then, challenge classes to sort the collected waste, dividing paper, plastic, metal, organics and trash. See which class can collect and properly sort the most waste according to your municipal recycling program.
- Join a related worldwide initiative, such as:
  - ▷ RecycleMania (recyclemania.org/)
  - ▷ Global Recycling Day (globalrecyclingday.com/)
  - ▷ #RecyclingGoals Challenge (globalrecyclingday.com/take-part-in-the-recyclinggoals-challenge/)

3 THE LIFE CYCLE OF PLASTICS

4 THE HISTORY OF PLASTIC

Grade Level

10–12 (can be modified for younger grades)

Learning Goals

- Learn about when and how plastics were invented, when and why they became popular, and what led to the plastic crisis we are facing today.

Learning outcomes

By the end of the lesson, students will be able to:

- Construct a general timeline outlining the history of plastic.
- Think critically about the prevalence and necessity of plastic in their personal lives.
- Put their emotions related to the impacts of plastic on the environment into words, especially about the plight of certain living organisms in the face of the plastic crisis.
- Take small steps in their everyday lives towards living more sustainably with their families.

Materials

Included:

- Plastics and nature cards (5)
- Thoughts on Plastic card (1)
- Gigapixel
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included:

- Writing tools and notebooks or journals

Background information

Synthetic or human-made plastic is a relatively new invention in human history. Despite this, few people are familiar with the timeline and the story behind its creation. The following provides a brief summary of some of the major scientific and societal advances linked to the plastics industry (see *History of Plastics* and *History and Future of Plastics* for more details about each important event):

1850s: Parkesine, the first semi-synthetic plastic was made from cellulose (a molecular component of plant cell walls) to replace expensive and rare materials used for decoration such as ivory and ebony.

1860s: Celluloid was made by combining cellulose and alcoholized camphor (a substance found in the wood of the camphor laurel, a large evergreen tree found in Asia) to feed the growing demand in the Americas and the United Kingdom for less expensive but durable household items.

1900s: Bakelite, the first entirely synthetic human-made plastic was invented, revolutionizing the electricity industry because it could safely insulate wiring and could be manufactured in large volumes. Bakelite is the product of a chemical reaction between phenol and formaldehyde.

1908-1912: Cellophane, a thin, cellulose-based, transparent material was invented and primarily used for food packaging due to its moisture-proof and flexible qualities.

1920s-1930s: Polyvinyl chloride (PVC) was commercially produced due to a shortage of natural rubber and was made from a combination of salt, oil and chlorine.

1930s: Polyethylene, made from a chemical reaction involving heat and ethylene, was invented and mass-produced due to its military application and versatility.

1940s: Nylon, a new alternative to silk, was invented and popularized in the form of women's stockings.

1950s: Polyester, made from a combination of alcohol and carboxylic acid, was invented and gained notoriety as the no-wrinkle fabric of choice for people who valued low-cost, convenient fabrics.

1950s: At the same time that polyester was increasingly being used, polypropylene also became popular. It was made through a process that involved "cracking petroleum" and was used in a large number of applications (e.g., food packaging, upholstery, storage bins) due to its extreme durability.

4 THE HISTORY OF PLASTIC

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- Patterns and trends
- Interrelationships

Geographic Inquiry Process

- Ask geographic questions
- Evaluate and draw conclusions
- Communicate
- Reflect and respond

Geospatial Skills

- Foundational elements
- Technologies

Burtynsky photographs

Industrial Park
North Las Vegas, Nevada, USA, 2007

Fisher body plant #1
Detroit, Michigan, USA, 2008

1950s: A combination of styrene and butadiene is developed, leading to the invention of polystyrene — a lightweight, transparent plastic that can be tinted to any colour.

1960s: The word "plastic" began to be commonly used in everyday conversation, and plastics were found in most households, stores and businesses. Plastics allowed for the mass production of products and packaging. Plastic bags were beginning to be found at every major retailer.

1970s-1980s: As more and more plastic was produced and discarded, and researchers began to question the potential downsides of this ubiquitous material, environmentalists began leading campaigns to educate the public and industry leaders on the dangers of the overconsumption of single-use plastic and improper waste disposal. Recycling programs started to be introduced.

1980s: In the United States, the resin identification code system was introduced.

1990s: The use of plastic around the world continued to increase. In response, some scientists began developing bioplastics — a safer and more sustainable alternative made from plants instead of fossil fuels — permitting them to be classified as biodegradable.

2000s: The Great Pacific Garbage Patch became the world's largest floating conglomerate of plastic and garbage, containing an estimated 79,000 tonnes of plastic and covering as estimated surface area of 1.6 million square kilometres — larger than the size of the entire province of Quebec.

2010s: A study found that it's possible that humans are ingesting around 5 grams of plastic every week, which is the equivalent weight of a credit card. Pictures began to emerge on social media and through news outlets of beached whales and dead birds whose stomachs contain unbelievable amounts of plastic, sparking a second wave of education and activism to promote a more sustainable approach to using plastic. Growing bodies of research indicated plastics can be found in the atmosphere (the air surrounding the Earth) and cryosphere (where water is in solid form, such as glaciers and permafrost), even in remote areas.

4 THE HISTORY OF PLASTIC

Burning tire pile #1
Near Stockton, California, USA, 1999

China recycling #8
Plastic toy parts, Guiyu, Guangdong Province, China, 2004

Introduction

Ask students to think about an answer to the following question: What are plastics and where do they come from? Discuss with students their impressions of how the invention of plastic revolutionized modern society and everyday life. Consider doing an introductory activity where students are asked to research and elaborate on the timeline of the history of plastic based on the important events listed above. Have students research people, places and events connected to the history of the invention and proliferation of plastic. Include a discussion of the lesser-known impacts of the plastic crisis on youth mental health and increasing use of terms like eco-anxiety and climate anxiety. Explain to students that there are many positive outlets for these types of worries, and that this activity will help them explore their own personal feelings about plastics and the environment. Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below as part of this warm-up:

- How long have humans been using synthetic plastic? Answer: *Since around 1907, when Belgian-American chemist Leo Baekeland invented Bakelite, the first entirely synthetic plastic.*
- What are some implications of the mass production of plastic? Answer: *The durability and resistance to degradation that plastic offers has meant that since the mid-20th century, the increase in the use of plastics has substantially outpaced any other manufactured material. Only about 9% of all plastic waste created since then has been recycled.*
- How do researchers and companies track how much plastic is recycled? Answer: *Researchers and government agencies collect data from organizations directly involved in the generation, recycling, composting and combustion of plastic materials in municipal solid waste. They also work with landfills to measure how much waste is discarded in different municipalities.*
- What is eco-anxiety? Answer: *Eco-anxiety is an ongoing and unshakable concern over environmental and climate-related issues, involving a fear of not knowing what to do to address these issues. An increasing number of youth are experiencing exo-anxiety and feel they have been left to solve the problems their parent's generation created.*
- In what ways are humans and animals similarly affected by plastic waste? Answer: *Small plastic particles called microplastics can enter our digestive system through the food and water we consume. Certain hazardous chemicals in plastic — such bisphenol A (BPA), which can interfere with our hormones — can be absorbed through our skin through the clothing we wear or can enter our respiratory system through the air we breathe.*

4 THE HISTORY OF PLASTIC

Gigapixel activity

Explain to students that this activity will be a private reflection on society's increased use of plastics and the potential impacts on humans, animals and the environment. Have students walk around the gigapixel image, quietly reflecting on the different items they see. As students search for items they are familiar with, explain that this picture was taken at the Scarborough Transfer Station near Toronto, Ont., in 2019 and that the City of Toronto currently has seven of these transfer stations in operation, where waste is collected, sorted and then sent to an incinerator, a landfill or a recycling facility. Municipal waste trucks collect waste at the curb and deliver it to these stations, and residents can drop off their waste for a fee. These stations opened as a direct result of the increase in plastic waste produced by residents and local industries over the last century. Although this gigapixel image displays recycling waste from the Toronto area, similar facilities can be found in urban areas across Canada.

Next, explain that the City of Toronto has taken action to reduce plastic pollution within the city limits by opening these stations and actively collecting plastic waste. The streets and recreational spaces in Toronto are relatively pollution-free thanks to waste management operations paid for by the city and its taxpayers. However, the unfortunate truth is that only a fraction of this waste is actually recycled — the majority is sent to landfills — and many residents are simply unaware of the amount of waste they produce because they cannot see it. According to Charles Wilkins, an author featured in the May/June 2017 issue of Canadian Geographic, "Beyond the city's annual processing of 200,000 tonnes of recyclables, its residents produce household garbage (the stuff we put in green bags) at a rate of 10,000 tonnes a week, or half a million tonnes a year. For maximum efficiency, tractor trailers, each bearing nearly 40 tonnes of compacted garbage, are meticulously clocked out of Toronto so as to arrive at the city's Green Lane landfill near London, Ont., at a rate of one every 10 minutes, hour by hour, weekday after weekday."

The result is that despite the efforts of residents and city workers to contain plastic waste, much of it ends up in the environment. Explain to students that for this to change, people need to be made aware, and that they themselves can play a role in raising societal awareness.

Use the Thoughts on Plastic card for the rest of the activity. Begin with the first question: ask each student to open their notebooks or journals, and to walk around the gigapixel image writing down any adjectives, thoughts or feelings that come to mind. They can write about a specific item or the feeling they get from the gigapixel image as a whole.

Next, give small groups of students a Plastics and Nature card. Ask students to match a plastic item they see on their card to a similar item on the gigapixel image and to take a seat on there. Next, ask students to think critically about the pictures on their card and to answer a selection of questions from your teacher card in their notebooks or journals.

4 THE HISTORY OF PLASTIC

Once students are done, have them gather in a circle on the gigapixel image. Explain that a lot of research is indicating that youth are carrying a burden commonly referred to as eco-anxiety, which stems from worrying about the future of the planet and the impacts of climate change and human population growth. Inform students that in talking about their feelings, they will be better equipped to deal with any future emotions or concerns they have about environmental issues and climate change and that they are in a safe space to do so. Invite students who are comfortable sharing their emotions to talk about their answers with the rest of the class. Task the class with supporting one another as they continue their learning journey about the history, present and future of plastics and pollution. Consider reviewing tips about how to deal with any worries they have, such as talking to friends, getting involved in projects, getting creative about their consumption habits, considering alternative methods of transportation, and cultivating a stronger relationship with nature. Taking action is the best prescription for eco-anxiety!

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video Clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Eco-Anxiety* video about how to deal with feelings of anxiety related to climate change
- the *Full Cycle Part One* video, which shows how a piece of recycling collected by waste management services at the curbside ends up as part of a compacted plastic bale ready for processing
- the *Full Cycle Part Two* video, which shows how a bale of plastic becomes pelletized so it can be used to make something new

Virtual reality

Using the provided headsets, have students experience:

- the *Recycled Life Cycle* video that shows the sequence of events when recycled materials move from a transfer station to a repurposing facility.

Augmented reality

Using the provided tablets and the wall-mounted vinyl triggers, have students explore:

- the *Plastic bales* sculpture using the AVARA app

4 THE HISTORY OF PLASTIC

Conclusion

Discuss with students their understanding of the invention of synthetic plastic, the ways it revolutionized everyday life, the issue of single-use plastic waste, and the mental and physical health effects that can manifest in humans and animals. Consider introducing students to inspirational and effective projects that are underway that focus on sustainability and conservation. Ask students what type of future they would like to help build and how they would like to get involved. The following questions may help spark conversations:

- What role can humans play in solving climate and environmental issues?
- How can we support one another in our efforts to live more sustainably?
- What products offer increased benefits compared with plastic?
- How can plastic be used in a more sustainable way?
- What would happen if society were to reject different forms of plastic in favour of more sustainable options?

Evaluation of student learning

Assess students based on their understanding of the invention of synthetic plastic, the relationship between natural materials and human-made plastics, how plastics have affected society, and the many ways humans can work towards living more sustainably. Assess student responses to the Thoughts on Plastic questions and their participation in group discussions.

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to educating others about the plastic crisis.

For younger students:

- Have students take an online quiz testing their knowledge of the relationship between plastics and the environment. The following organizations have created quizzes that cater to different age levels:
  - ▷ Earth Day Network (earthday.org/oceans-and-plastic-pollution-quiz/)
  - ▷ GVI (gvicanada.ca/blog/plastic-pollution-quiz/)

4 THE HISTORY OF PLASTIC

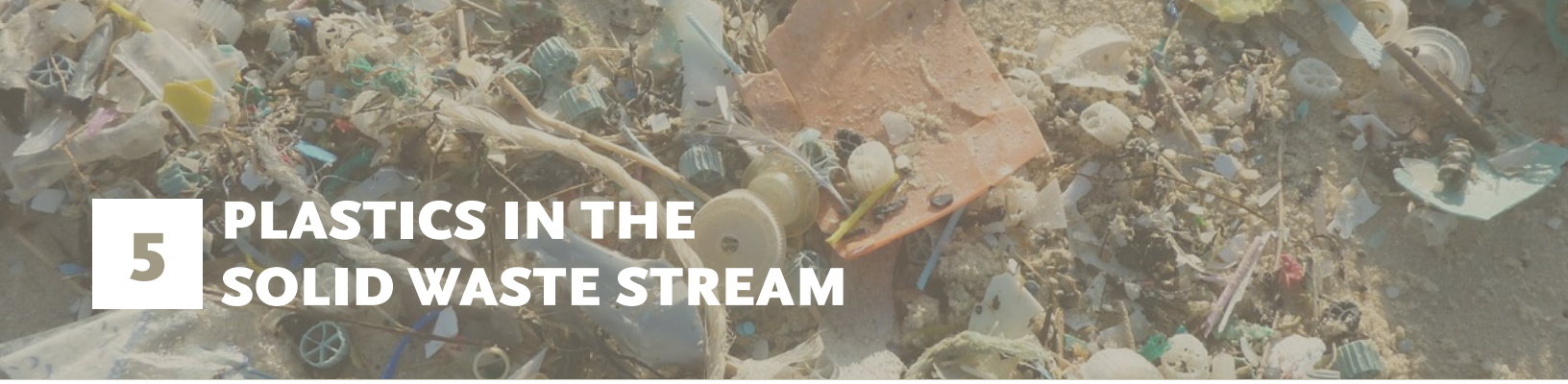
- ▷ Plastic Pollution Coalition (plasticpollutioncoalition.org/blog/2016/4/21/quiz-test-your-knowledge-about-plastic-pollution)
- ▷ Plastic Bag Grab Challenge (plasticbaggrab.com/resources/educational)

- Have students develop their own quiz for friends and family to help raise awareness about plastic-related issues.
- After their time on the gigapixel image, encourage students to explore their own community's recycling habits. Have them research the different recycling options, facilities and collection habits in their community. Take it one step further, and plan a field trip!
- Consider following these people/groups to learn about different ways to connect with nature specifically designed for elementary and intermediate students:
  - ▷ Kids for a Clean Environment (kidsface.org/)
  - ▷ Children and Nature Network (childrenandnature.org/)
  - ▷ EcoKids (ecokids.ca/)

For older students:

- Have students develop interview questions for local recycling and waste management organizations to learn more about the history of waste management in their community. Have students profile willing participants and share their stories with schoolmates, friends and family. Consider having students design an award or plant a tree in celebration of individual and team efforts they feel are worthy of recognition.
- Have students lead peer group discussions with other students about their feelings relating to climate change and eco-anxiety. If the school has an environment club, consider inviting the club to do a presentation in your class, or work with the club to help students who may be feeling confused or stressed because of their feelings about climate change and plastic pollution.
- Join a related worldwide initiative, such as:
  - ▷ YES! (yesworld.org/)
  - ▷ Ecology Global Network (ecology.com/)
  - ▷ Earth Force (earthforce.org/)

4 THE HISTORY OF PLASTIC



5 PLASTICS IN THE SOLID WASTE STREAM

Grade Level

7–9 (can be modified for younger and older grades)

Learning Goal

- To understand the operation of a transfer station and understand the relative amounts of recyclables versus household and school waste that collect in these facilities, using an example from the city of Toronto.

Learning outcomes

By the end of the lesson, students will be able to:

- Describe what happens to items that do and do not contain plastic once they are collected at the curb by waste management services in urban settings.
- Examine the role of product packaging and resource waste in relation to landfills.
- Understand the usefulness of doing waste audits.
- Highlight any areas for improvement by educating others about what should and should not be considered a recyclable material.

Materials

Included:

- Gigapixel
- Quadrat Survey cards (3)
- Audit Questions card (5)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

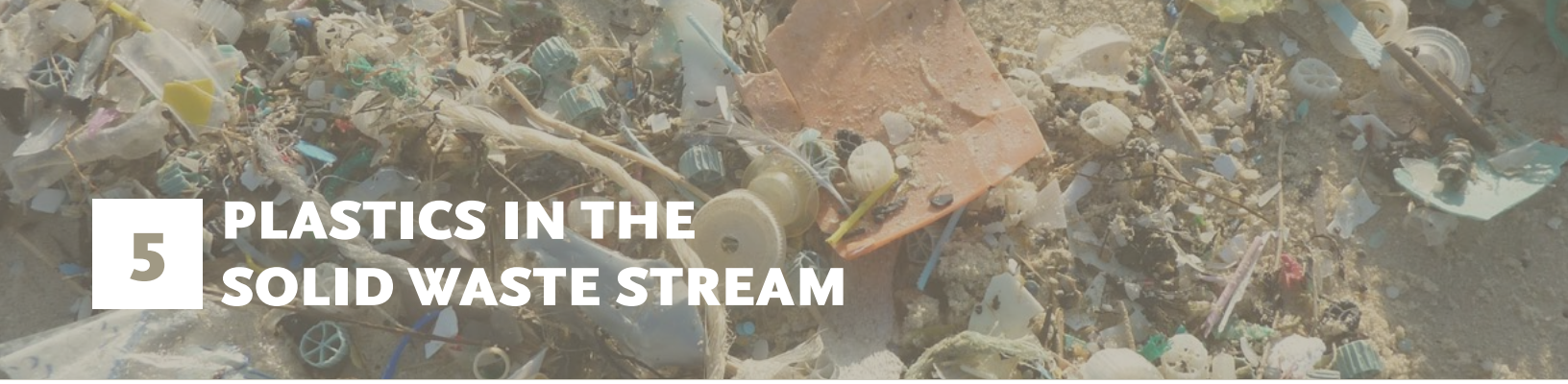
Not included

- Writing utensils (optional)
- Notebook or paper (optional)
- Masking tape, painters tape or rope
- Measuring tapes or rulers

Background information

The more waste Canadians produce, the more money taxpayers and local governments need to spend on waste management. To offset the amount of unnecessary waste that ends up in recycling bins, garbage cans and landfills, Canadian can be more mindful of what they are throwing away. To do so, however, requires that all citizens know the rules of recycling in their community and are equipped with alternative solutions when making decisions about waste disposal. People must also know the true amount of waste they produce in a year and what impact this has on their carbon footprint and the biosphere as a whole. Below are some interesting facts about waste production and plastic use in Canada:

- Despite the efforts of many Canadians to recycle properly, most of the garbage collected from households and commercial enterprises ends up in landfills; a small amount is sent to incinerators.
- Canadians are among the top producers of garbage per person in the world.
- About 31 million tonnes of garbage are produced by Canadians each year, and of that amount, only 30 per cent is recycled.
- Each Canadian is responsible for producing about 2.7 kilograms of garbage each day — that's almost 1,000 kg a year.
- In 2016, paper products and organics made up 67 per cent of the total amount of solid waste collected and diverted from landfills, while plastics made up only 5 per cent.
- Canada has over 10,000 landfill sites across the country.
- Studies have shown that about 7.5 billion tonnes of plastic has been produced around the world since 1950 but only 9 per cent of that has been recycled.
- Canadians throw away about 3.3 million tonnes of plastic waste every year, of which about 2.8 million tonnes get sent to landfills. That means about 85 per cent of Canada's plastic waste ends up in landfills.
- Roughly 12 per cent of Canada's plastic waste is sent to other countries to reduce the amount of space and processing required on Canadian soil. However, this has a negative outcome since many of the countries that receive the waste do not have the capacity or the infrastructure to deal with it — this results in the plastic either being incinerated or polluting the environment.
- When waste in a landfill decomposes, it releases methane gas, a greenhouse gas that is 21 times more harmful than carbon dioxide.



5 PLASTICS IN THE SOLID WASTE STREAM

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Patterns and trends
- ▷ Geographic perspective
- ▷ Spatial significance

Geographic Inquiry Process

- ▷ Ask geographic questions
- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions
- ▷ Reflect and respond

Geospatial Skills

- ▷ Foundational elements
- ▷ Spatial representations

Burtynsky photographs

Kumbh Mela #2
Allahabad, India, 2013

- It is estimated that common plastic items, such as plastic bags, straws, cups and plastic toothbrushes can take anywhere from 20 to 500 years to decompose. But the plastic never fully disappears; it just breaks down into smaller and smaller particles that disperse in the environment.

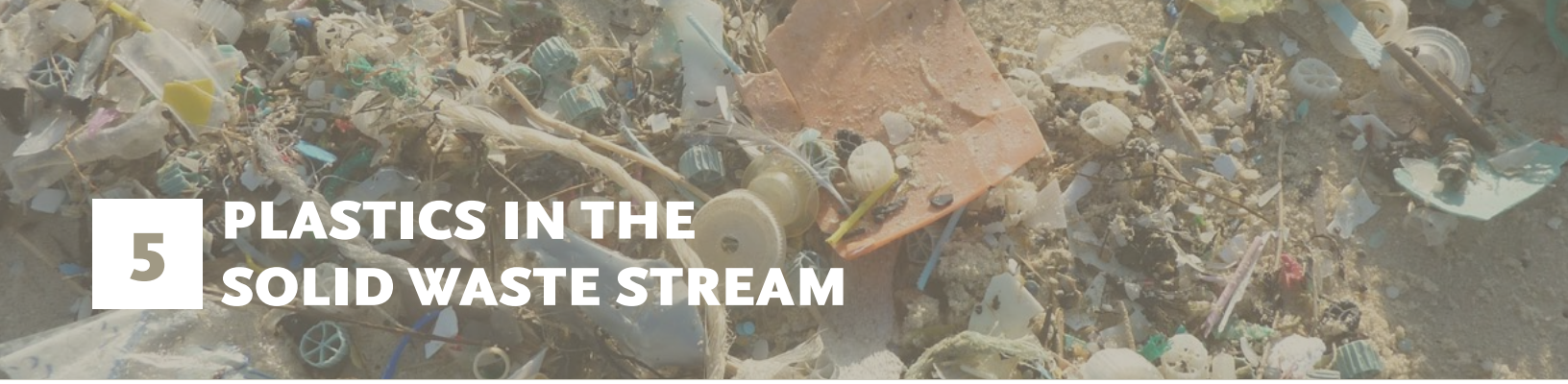
Introduction

Ask students the following question: What items do I use on a daily basis that contain plastic? Discuss the daily activities your students engage in that depend on plastic in one way or another. How much of the plastic they use gets thrown away at the end of the day, week or month? What are the implications of all Canadians using the same amount of plastic, on average, every day or year?

Consider doing an introductory activity where students compare the implications of one person throwing away plastic on a regular basis to millions of people doing the same thing, perhaps by asking students to discuss the facts listed above. Try a method that will motivate your students to think quickly and critically. For example, organize speed conversations. Have your class arrange their chairs in small groups so each person is sitting across from another. Give your students two minutes to talk about a fact listed above. Students must then move to a different group and sit facing a new partner. These two will talk for the next two minutes at which point the students will shift places again. Continue until each person ends up in the group of seats in which they started.

Next, use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below as part of this warm-up:

- What are some common household items that contain plastic? Answer: *Bottles, containers, garden hoses, toys, foam cushions, buckets, food wrap, plumbing.*
- What are some household items that contain hidden plastics? Answer: *Chewing gum, disposable coffee cups, tea bags, aluminum food cans, pop cans, paper milk cartons, sunscreen, wipes.*
- Are all items that contain plastic collected by local waste management services? Answer: *No. Items like pop cans, potato chip tubes, pails, flower pots, egg cartons and milk cartons are often accepted in curbside recycling. However, items like incandescent light bulbs, styrofoam containers, hard plastic dishes, makeup containers and plastic bags are not often collected.*
- Are programs the same across Canada? Answer: *No. There are differences in access to and use of recycling programs across all provinces and territories.*
- Why are there restrictions on what can be placed in a recycling bin? Answer: *Recycling services cannot always find an end buyer for the large and continuous truckloads of used plastics. Shipping these undesired materials overseas to other markets is not a good option.*



5 PLASTICS IN THE SOLID WASTE STREAM

China Recycling #9
Circuit boards, Guiyu, Guangdong Province, China, 2004

Homesteads #27
Coleman, Crowsnest Pass, Alberta, 1985

Dandora Landfill #1
Nairobi, Kenya, 2016

- What are some of the biggest deterrents to recycling for citizens? Answer: *It is considered an inconvenient chore, people don't always have space to keep recycling bins, there's a perception that recycling doesn't make a difference, there is no tangible reward for recycling, containers must be washed completely (depending on where you live), and items must be sorted and disassembled.*
- In general, if Canadians have the means to recycle, do they? Answer: Yes. *According to Statistics Canada, "Income and education have little impact on recycling behaviour; households with access to recycling programs tend to use them equally". However, their living situation may affect their ability to recycle. Isolated and mobile homes and apartments tend to see less recycling success than single-detached homes.*

Gigapixel activity

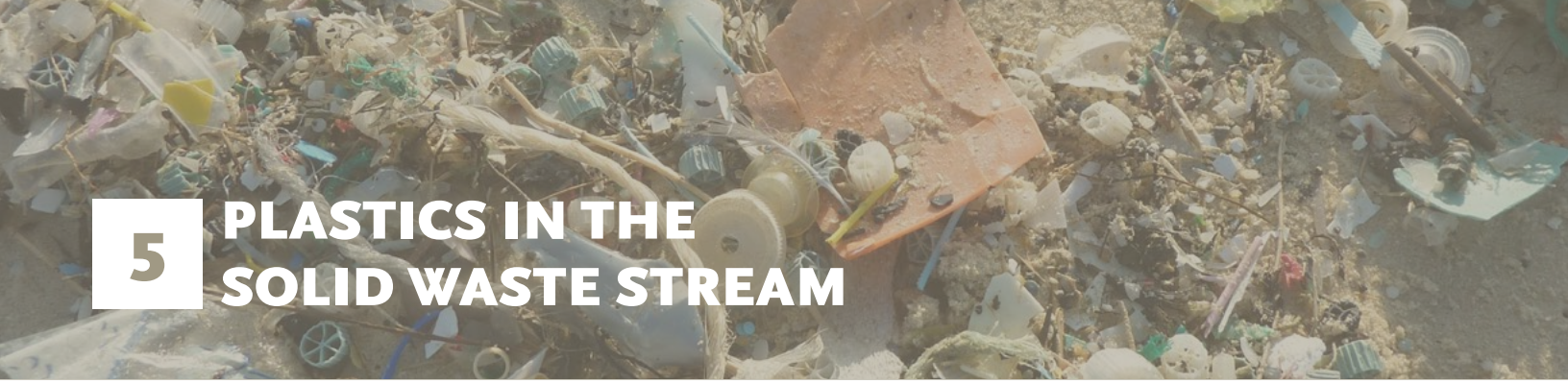
Explain to students that they will be testing two commonly used techniques for sampling and tracking plastics in the environment and in the solid waste stream.

Explain to students that we have all seen garbage cans, recycling boxes and landfills. However, if we want to be serious about changing our habits to increase recycling success and decrease solid waste, we need to know exactly what we are putting into our different waste receptacles and into the environment. When researchers need to estimate the overall quantity of pollutants in a specific environment, for example microplastics on a beach, they use a quadrat sampling method. This method divides the research area into survey areas, and the number of pollutants is surveyed in a random selection of these smaller survey areas. The resulting information is then used to determine the average per survey site and then the average of all the survey sites.

Optional: Have students use the AVARA app on the provided tablets to locate trigger 1 embedded in the gigapixel image and then watch the short film that appears on their devices.

Divide students into teams of four and have them select a spot on the gigapixel. Have them outline a quadrat using removable tape or rope (note: each quadrat must be the same size). Next have them complete their quadrat survey using the provided set of Quadrat survey cards as a model, counting the number of items in each category and adding in any items that are not listed (students can write in notebooks or on recycled paper for this). Encourage students to be as detailed as possible in their identification of items (e.g., distinguishing a milk carton from a cardboard box). Calculate the total number of items in each of the survey categories.

Once students are done counting, pass out the Audit Questions cards and have students do the math to answer the listed questions. Wrap up the activity by discussing everyone's answers. This discussion can include an estimation of the total percentages of plastics, trash and other materials featured in the gigapixel image by tallying the counts from each of the groups. You can then extrapolate from this to discuss how many loads of waste like the



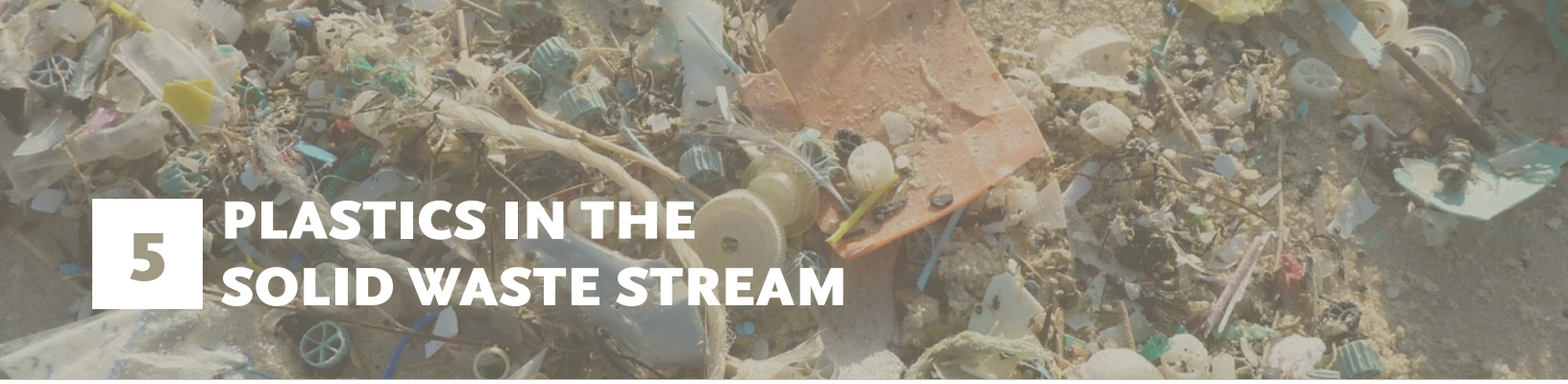
5 PLASTICS IN THE SOLID WASTE STREAM

one in the gigapixel image are brought to the Scarborough transfer station on a daily, monthly and yearly basis, and where most of this waste ends up (i.e., being recycled, being sent to the landfill or being sent to incinerators).

To tie in a geographical discussion or to have students research which of the items they counted would be considered recyclables based on provincial and territorial waste management laws, visit the following links (or research your municipality's recycling guidelines):

- Recycle BC (recyclebc.ca/)
- Alberta Recycling (alberta.ca/recycling.aspx)
- Saskatchewan Waste Reduction (saskwastereduction.ca/)
- Manitoba Simply Recycle (simplyrecycle.ca/)
- Recycling Council of Ontario (rco.on.ca/)
- Recycling Is Remaking Quebec (recreer.recyc-quebec.gouv.qc.ca/en/)
- P.E.I.'s Island Waste Management Council (iwmc.pe.ca/wastewatchguidelines.php)
- Recycle - Government of New Brunswick (gnb.ca/content/gnb/en/departments/elg/environment/content/land_waste/content/recycling/recycle.html)
- Nova Scotia Municipal Collection Information (www.novascotia.ca/nse/waste/muncollection.asp)
- Central Newfoundland Waste Management (cnwmc.com/services/sort-it-households/)
- Government of Yukon (yukon.ca/en/waste-and-recycling/recycling/what-can-i-recycle-and-where)
- Government of Northwest Territories (enr.gov.nt.ca/en/services?combine=&field_service_category_tid=129&field_program_type_tid=All)
- Government of Nunavut (gov.nu.ca/environment/information/environmental-protection)

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).



5 PLASTICS IN THE SOLID WASTE STREAM

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Dandora* video that showcases one of the world's largest landfill sites
- the *Full Cycle Part One* video, which shows how a piece of recycling collected by waste management services at the curbside ends up as part of a compacted plastic bale ready for processing
- the *Full Cycle Part Two* video, which shows how a bale of plastic becomes pelletized so that it can be used to make something new
- the *Canada Fibers* video that shows how a materials recovery facility works
- the *EFS Plastics* video that shows the procedures used by recycling and compounding facilities
- the *SARCAN* video that provides an example of plastic repurposing procedures in Canada

Virtual reality

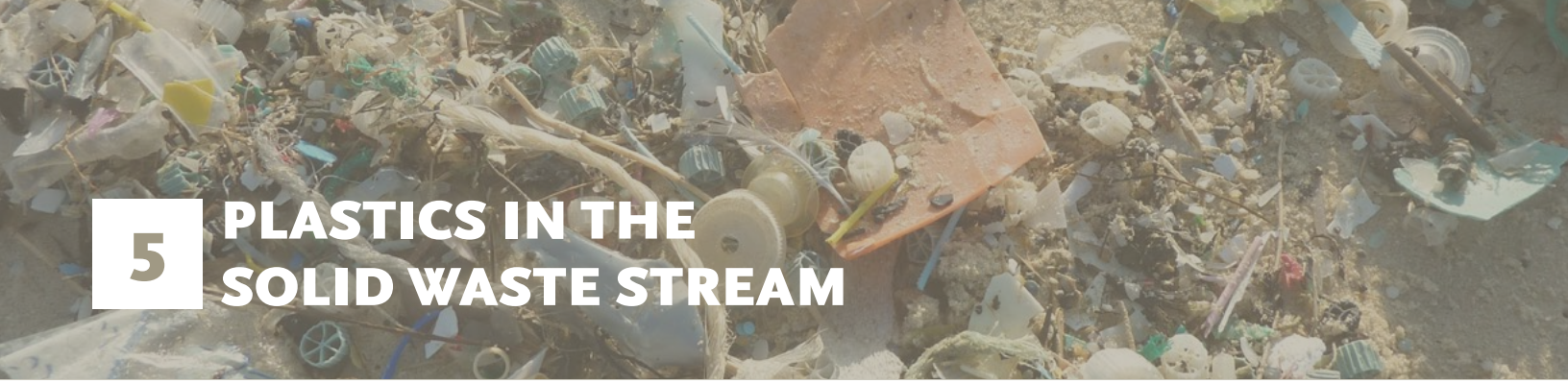
Using the provided headsets, have students experience:

- the *Recycled Life Cycle* video that shows the sequence of events when recycled materials move from a transfer station to a repurposing facility.
- the *Dandora* video that provides a journey through one of the world's largest landfill sites

Augmented reality

Using the provided tablets and the wall-mounted vinyl triggers, have students explore:

- the *plastic bales* sculpture using the AVARA app



5 PLASTICS IN THE SOLID WASTE STREAM

Conclusion

Discuss with students their understanding of the state of recycling in Canada and the relative proportions of recyclables, compostables and trash that often wind up in landfills. The following questions may help spark conversations:

- What brands were most often recorded during the gigapixel activity?
- What types of plastics, metal and trash were most often recorded during the gigapixel activity?
- What are the advantages and disadvantages of a collection system that groups all plastics, metals, paper and trash together prior to sorting — as is the case in Toronto?
- How can you take small steps to ensure you are not being wasteful (e.g., using both sides of a piece of paper, submitting work electronically, buying local produce that does not come with packaging, taking a bicycle instead of the bus).
- How do you think students and staff at your school could recycle more?
- Does recycling really make a difference in terms of protecting the planet?

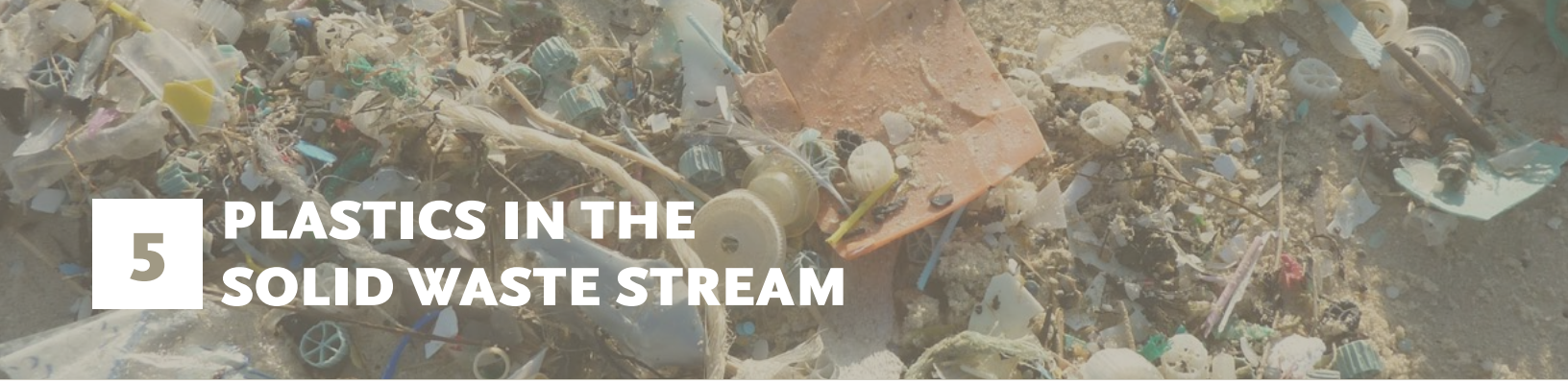
Evaluation of student learning

Assess students based on their understanding of the facts presented in the introduction and the survey and calculations done during the gigapixel activity. If students are asked to do additional research about municipal waste management programs, observe their ability to uncover the most useful facts and information and their understanding of geographical variations in recycling laws and initiatives. Use the questions in the conclusion to evaluate the knowledge gained after performing the gigapixel activity or watching the film extensions.

Learning to action

For younger students

- Have students run a reward system where each student in the school who makes an effort to clean and recycle different items that they throw away throughout a given time period gets a ticket — the student or class with the most tickets at the end gets to choose a reward for them and their friends!

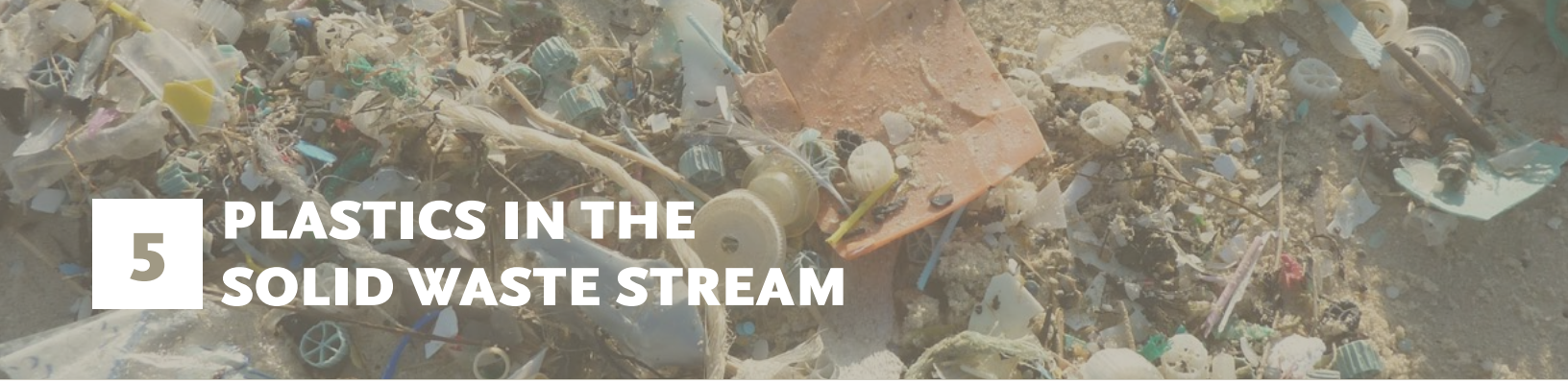


5 PLASTICS IN THE SOLID WASTE STREAM

- Set up a mini transfer station like the one featured in the gigapixel image: have other classes follow the rules and regulations of most transfer stations, and drop off their items in clear bags that your class can then sort, tally and weigh. The class that dropped off the most items is the class that owes the "transfer station" the most money! We suggest starting with a clear, empty bag in each classroom and running the exercise for a week.
- Have students pick one of the facts presented in the background section above, and write a response. For example, there are over 10,000 landfills in Canada — let's make sure we stop before we get to 15,000!
- Consider following these people/groups on social media to draw inspiration from how they are limiting their carbon footprint:
  - ▷ UK Student Climate Network (ukscn.org/)
  - ▷ Australia's carbon neutral kindergarten (sustainableportphillip.com/articles/2019/9/9/australias-first-carbon-neutral-preschool)
  - ▷ Autumn Pelletier (theglobeandmail.com/canada/article-autumn-peltier-14-to-address-united-nations-about-water-climate/)

For older students

- Many citizens, even the ones with the best of intentions, often do not fully know how to dispose of hazardous materials or objects in safe and proper ways because they have difficulty finding the information on how to do so. Have students do research online and prepare an infographic that explains how to dispose of batteries, refrigerators, telephones, paint cans and other hazardous materials. Share these infographics with the community so everyone can learn!
- Research sustainability consultants like Great Forest and Badger Balm to see what they are doing to make a difference. List how you can mimic their approaches and implement them.
- Research or join a related worldwide initiative, such as:
  - ▷ UCLA students who reduced their carbon footprints (newsroom.ucla.edu/releases/education-food-choices-reduce-greenhouse-gases)
  - ▷ 101 companies reducing their carbon footprints (forbes.com/sites/blakemorgan/2019/08/26/101-companies-committed-to-reducing-their-carbon-footprint/#2d47536d260b)
  - ▷ Great Forest (hgreatforest.com/)
  - ▷ Global Footprint Network (footprintnetwork.org/about-us/)



5 PLASTICS IN THE SOLID WASTE STREAM

6 PLASTICS AND SOCIETY

Grade Level

7–12 (can be adapted for younger grades)

Learning Goal

- To think about humanity's complicated relationship with plastics and how that relationship needs to be redefined now that the environmental and health risks of plastics and microplastics have become all too well known.

Learning outcomes

By the end of the lesson, students will be able to:

- Form an educated opinion about the complex relationship that humans have with plastics.
- Understand that the properties that make plastic a highly valued commodity are the same ones that make it a hazard to the environment and animals on Earth.
- Provide an argument for why single-use plastics are problematic and why individuals and corporations must take measures to reduce the overuse of plastic.

Materials

Included:

- Gigapixel
- Exploration card (5)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included

- Writing utensils (optional)
- Notebook or paper (optional)

Background information

A global plastic waste crisis is upon us due to overconsumption and limited recycling of single-use plastics once consumers no longer want them. This crisis has major implications for human and animal health and for the environment. Piles of plastic waste are building up in landfills, ports and recycling facilities in different parts of the world, with no end in sight.

The word about this crisis is spreading, and consumers and corporations are starting to support a change in our past habits relating to the use of plastic. Some cities are banning or restricting certain single-use plastics, such as straws and grocery bags. Some organizations are opting to use sustainable, eco-friendly source materials for their products. Homeowners are choosing to build homes out of plastic-free materials. Stores are beginning to look for plastic-free materials to create their clothing. Schools are planning river cleanups, plastic-free lunch days and climate marches.

So it seems that, in the midst of the plastic crisis, a revolution has slowly begun brewing. Public awareness and frustration is starting to get the attention of leaders and decision-makers, and it's starting to seem that the elimination of single-use plastics from our daily lives might actually be possible.

Students are an integral part of this fight for the future of our planet, and it is up to educators to arm them with the facts, language and confidence to become global change agents. So as to not overwhelm them, begin a discussion about how their actions can truly make a difference using the activity suggestions below.

Introduction

Begin with an overview of the state of the global plastic crisis by analyzing the most up-to-date data as a group. The website Our World In Data (ourworldindata.org/plastic-pollution) has produced a series of tables, graphs and infographics depicting trends in plastic pollution across the globe that are great for the classroom. Its detailed FAQs and slide decks are a great starting point for group discussions.

Write the following questions on the board and have students reflect on their answers in their class notebook: Why do humans use so much plastic? Why is plastic problematic? What is being done to address the current plastic crisis? What can we as individuals or as a community do to help?

Next, have students get into pairs and interview one another about their answers. This might prove controversial, as different students may have competing opinions about the subject matter — but this is OK! Remind your students to listen to their partner and respect their opinion even if it opposes their own. Give students ample time to get into the details of their conversation, and let the discussions happen.

6 PLASTICS AND SOCIETY

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Patterns and trends
- ▷ Geographic perspective
- ▷ Spatial significance
- ▷ Interrelationships

Geographic Inquiry Process

- ▷ Ask geographic questions
- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions
- ▷ Reflect and respond

Geospatial Skills

- ▷ Foundational elements
- ▷ Spatial representations

Burtynsky photographs

Alberta Oil Sands #9
Fort McMurray, Alberta, Canada, 2007

Manufacturing #10ab
Cankun Factory, Xiamen City, China, 2005

Next, have students build on their initial opinions using a different method. Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below to increase the geographic scale at which students think about the plastic crisis and to help them understand the connection between natural resources, single-use plastics and waste disposal. This can be done by showing all four images to all students in sequence or by giving each student or pair of students two images to compare.

- What do you see?
- What do these images make you think about?
- Are there any problems that you can identify from these images?
- Which raw materials or natural resources are associated with these images?
- How are some of these products made, packaged and distributed throughout their life cycle?
- What questions do the images raise for you?
- Does recycling keep the products that we use out of landfills?
- What title or headline would you give these images?
- Why did the photographer choose these scenes to photograph?

Invite students to share their answers with a partner or with the group. Ask students how they would share these images with society to inspire change and what story or message they would like to share.

Gigapixel activity

Explain to students that they will be using the gigapixel image to build on their previous study of Edward Burtynsky's photographs and their opinions of the plastic crisis. Tell students that at different points during their life, they will no doubt come across a photograph that will pull them in and be so compelling that it will evoke different emotions, including that of motivation.

Divide the students into groups of two or three and hand each group a tablet loaded with the AVARA app. Share the questions on the Exploration card with students and have them focus on using creative and emotional language in their answers. Students should quietly walk around the gigapixel image in their groups to interpret the subject matter. Allow sufficient time for students to answer all questions and explore the film extensions. Explain to students that they will be using their notes to complete a second part of the activity, which is a short article about the image. Have them do their best to recount the feelings, emotions, questions and thoughts that came to mind while looking at the image and the film extensions.

6 PLASTICS AND SOCIETY

China Recycling #8
Plastic Toy Parts, Guiyu, Guangdong Province, China, 2004

Dandora Landfill #3
Plastics Recycling, Nairobi, Kenya, 2016

To conclude, give students time to test out their photojournalist skills. Have each student use the headline they came up with while exploring the gigapixel image to write a short fictional story for a newspaper or magazine related to the gigapixel image. The story should summarize the following:

- The reason the photograph was taken
- What transpired as the photograph was being taken
- Any significant events associated with the image
- Any actions that transpired after the event, such as a rally or a political action
- The impact of the photograph on society, perhaps both local and global

Encourage students to be creative and to tell the story they want to tell, whether it is a story about inspiring action, a story about a failed opportunity or initiative, or a story about a landfill that reached its capacity. Have students consider whether they are a part of their story, a bystander or a third-party journalist.

Optional: Have students use the AVARA app on the provided tablets to locate triggers 2, 3 and 5 embedded in the gigapixel image and then watch the short films that appear on their devices.

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Dandora* video that showcases one of the world's largest landfill sites
- the *Eco-Anxiety* video about how to deal with feelings of anxiety related to climate change
- the *Epicerie LOCO* video where three store owners talk about the success of their waste-free grocery store
- the T*om Szaky and Loop* video where Tom Szaky, CEO and founder of TerraCycle, shares his personal experience with changes in the plastics industry

6 PLASTICS AND SOCIETY

Virtual reality

Using the provided headsets, have students experience:

- the *Recycled Life Cycle* video that shows the sequence of events when recycled materials move from a transfer station to a repurposing facility
- Watch the *Dandora* video that takes viewers on a tour of the grounds at the landfill and showcases how workers sort through the heaps of materials for recyclables

Augmented reality

Using the provided tablets and the wall-mounted vinyl triggers, have students explore:

- the *plastic bales* sculpture using the AVARA app

Conclusion

Discuss with students their feelings about how they can help tackle the plastics crisis and how art, photography and film can be used in the fight to educate society and inspire action. Have them share their thoughts about the scale of the plastic crisis and how that can move people to act or make them feel overwhelmed. The following questions may help spark conversations:

- Is plastic an isolated problem?
- What are the biggest obstacles to solving the plastic crisis?
- Do you think anti-plastic feelings are growing?
- Despite the ever-growing problem, why do you think people still want to continue to use plastic?
- In just a few short years, our knowledge and understanding of the impacts of plastics on the environment and the food chain has increased significantly. Do you think we are at a point where we have enough knowledge to bring about serious changes to the functioning of our society?
- What is a step you can take to reduce plastic in the solid waste stream?

Evaluation of student learning

Assess students based on their ability to make connections between photography, film, art, and societal and environmental issues. Assess their responses to the questions on the Exploration card and their journalism assignments. Use the questions in the conclusion to evaluate the knowledge gained after performing the gigapixel activity or watching the film extensions.

6 PLASTICS AND SOCIETY

Learning to action

For younger students

- Have students role play to encourage them to think about the plastic crisis. Write several jobs or the names of well-known people, such as celebrities and politicians, on Popsicle sticks, and have students must pick one. Have students research their character's stance on the plastic crisis and ways to deal with increasing amounts of plastic waste. Have them perform brief skits in front of schoolmates to inform others about the many different opinions about plastic.
- Have students act out an interview in which one person asks the other about their ideas on using sustainable alternatives to plastics. Have pairs of students sit back to back as they pretend to talk over the phone. The interviewer can even be given a goal or a certain answer they have to reach during the conversation. This type of practice will prepare students for times when they are asked to share their opinions on the spot.
- Consider following these people/groups on social media to draw inspiration from how they are sharing the story about plastic and motivating people around the world to take action:
  - ▷ Kids Against Plastic (kidsagainstplastic.co.uk/)
  - ▷ Earth Day Network (earthday.org/act-on-plastic-pollution/)
  - ▷ Steppup Puppets (changemakers.com/empathy/entries/steppup-puppets)

For older students

- Have students organize a photo competition for their school with the goal of motivating viewers to take action against plastics. Have students plan, execute and judge the competition and put together a gallery to display all the submissions.
- Research or join a related worldwide initiative, such as:
  - ▷ Afroz Shah (cnn.com/2019/10/17/world/cnnheroes-afroz-shah-afroz-shah-foundation/index.html)
  - ▷ Lewis Pugh (lewispugh.com/)
  - ▷ Young People's Trust for the Environment (ypte.org.uk/)
  - ▷ Brita's #NoFilterNoFuture social media campaign, referring to Brita's filtering water bottles and the reality about the future of plastic (marketingdive.com/news/campaign-trail-why-brita-used-photoshop-to-trash-idyllic-locations/560721/)

6 PLASTICS AND SOCIETY

7 IMPORTING AND EXPORTING PLASTIC

Grade Level

10–12 (can be adapted for younger grades)

Learning Goal

- To realize that plastic waste is increasingly being sent to landfills and polluting natural spaces as a result of the demand for single-use plastic products and the rising costs to export both recyclable and non-recyclable materials.

Learning outcomes

By the end of the lesson, students will be able to:

- Explain Canada's plastic waste export trends.
- List where Canada has historically been diverting its plastic waste and what recent changes have happened globally.
- Examine the policies of countries that received plastic recyclables in the past but are now banning the import of these materials.
- Describe how a circular economy works.
- Think critically about the information being shared around the world about global recycling and waste production trends.

Materials

Included:

- Gigapixel
- Trash Tracking card (1)
- Coloured blocks (100)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Background information

Interest and concern is growing nationally and globally about the export of plastic recyclables and waste from developed countries to developing ones. In recent years, many of the world's poorest countries have spoken out about how they have reached capacity for handling and processing waste from other richer, and oftentimes more wasteful, countries. Top plastic importers like China, Malaysia and Thailand are dealing with massive amounts of plastic waste from other countries that lack the processing capacity and funding to manage the waste themselves.

There are a number of reasons why so much waste is produced in developed countries like Canada:

- misconceptions that 100 per cent of recyclables placed into the appropriate bins end up being recycled into new products
- a false understanding of how waste management services actually work
- a lack of education on what is and is not considered recyclable in different parts of the country
- the incorrect assumption that most waste is diverted to recycling or composting facilities rather than ending up in landfills.
- poor attitudes or approaches to recycling and waste, such as "out of sight out of mind," throwing things away when in fact there is no true "away" and that it's entirely acceptable to treat poorer developing countries as the world's dumping grounds

The right approach to consumerism and recycling can make a real difference in the grand scheme of things. For global citizens to be able to make the right choices, they must be able to separate fact from fiction and feel empowered to find more information if need be. This is where your students can take the first step towards increasing their personal recycling rates and ensuring their per capita production of waste falls well below the national daily average of 2.7 kilograms.

Introduction

Critical thinking is a 21st-century skill required by all global citizens. It occurs when people try to make reasoned and informed decisions and judgements about the information they receive. Someone who has developed their critical thinking skills can deliberate with others in a respectful way about the subject matter in question and can better understand the world around them.

The day before you plan to use the gigapixel image, explain to students that they will be testing and expanding their critical thinking skills pertaining to the subject of importing and exporting plastic recyclables and waste — a topical subject considering the changes in this industry in the last few years.

7 IMPORTING AND EXPORTING PLASTIC

Not included

- ▷ Writing utensils (optional)
- ▷ Notebook or paper (optional)
- ▷ Weigh scales (optional)

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Patterns and trends
- ▷ Spatial significance
- ▷ Interrelationships

Geographic Inquiry Process

- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions
- ▷ Reflect and respond

Geospatial Skills

- ▷ Foundational elements
- ▷ Spatial representations

Burtynsky photographs

Dandora Landfill #1
Nairobi, Kenya, 2016

Assign one of the following articles to each student to read as preparation for the gigapixel activity. Ask students to take short-form notes and to make a glossary of any terms they found difficult to understand. Optional: use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) as part of this discussion.

- Why Canada's recycling industry is in crisis mode (theglobeandmail.com/canada/article-wish-cycling-canadas-recycling-industry-in-crisis-mode/)
- Where does your plastic go? (theguardian.com/us-news/2019/jun/17/recycled-plastic-america-global-crisis)
- We asked 3 companies to recycle Canadian plastic and secretly tracked it. Only 1 company recycled the material (cbc.ca/news/technology/marketplace-recycling-trackers-b-c-blue-box-1.5299176)
- Media Briefing: Canada's Plastic Waste Export Trends Following China's Import Ban (greenpeace.org/canada/en/qa/6971/media-briefing-canadas-plastic-waste-export-trends-following-chinas-import-ban/)
- 111 million tonnes of plastic waste will have nowhere to go by 2030 due to Chinese import ban: study (cbc.ca/news/technology/china-plastics-import-ban-1.4712764)
- Canada to ban single-use plastics by 2021 (canadiangeographic.ca/article/canada-ban-single-use-plastics-2021)
- Why we need to totally rethink plastic waste (canadiangeographic.ca/article/why-we-need-totally-rethink-plastic-waste)
- Plastic recycling is broken. Here's how to fix it (nationalgeographic.com/news/2018/06/china-plastic-recycling-ban-solutions-science-environment/)

After students have read their articles, ask them to briefly summarize the stories so that all students have a bit of information about the general topics. Pose the following questions to the entire group. While they are speaking, encourage students to offer sound reasons or to explain their thinking.

- What was the main message in the article?
- Is what is being said fact or opinion? Who is speaking? Are they an expert in the subject? Is the publication trustworthy or science based?
- Do you agree or disagree with the headline? Why?
- Would this article benefit the cause to reduce plastic pollution?
- What background information was missing? What questions were you left with?

7 IMPORTING AND EXPORTING PLASTIC

Oil Fields #2
Belridge, California, USA, 2003

Oxford Tire Pile #8
Westley, California, USA, 1999

Oil Fields #22
Cold Lake Alberta, Canada, 2001

- What do you stand to gain or lose if the content in the article is true? What do you stand to gain or lose if the content is false?
- What was your emotional reaction to the story?
- What is the most memorable point that was made in the article?

Before working through the following gigapixel activity, explain to students that one of the easiest ways for individuals to become aware of just how much waste they are contributing to the global solid waste stream is to do a tracking exercise. Task students with tracking their household's waste production for one week using the Trash Tracking card as a guideline (or print out enough copies for each student). Students must, to the best of their ability, track each individual item that their household places in the garbage, recycling or compost throughout the week (modify the card to match your municipality's garbage sorting system if need be). They must tally the entire number of items that are "thrown away" throughout the week, and should try their best to weigh all of the items (e.g., by placing them in a bag or box and measuring the weight with a scale). Make sure students are honest and thorough, tracking every single egg shell, granola bar wrapper, plastic bag and cotton swab.

Gigapixel activity

Using their Trash Tracking cards, have students use the gigapixel image to "map" the items that match what they used throughout the week, using a unique identifier. For example, one student can lay clothespins over the items they used throughout the week. A second student can use post-it notes, and a third student can use tokens. If there are enough coloured blocks supplied in the kits, they can also be used. Once each student has taken the time to identify as many items as possible on the gigapixel image that match what they used throughout the week with their unique identifiers, ask the students to stand around the border of the gigapixel and reflect on what they see.

Ask students if some households produced more waste than others. What was the average amount of items? How many households were below the national daily average of 2.7 kg? Which items were consistently used the most by all households? What other patterns and trends stood out in the data? Optional: have students practise recording the data and visualizing the trends using graphing software.

Optional: Have students use the AVARA app on the provided tablets to locate trigger 1 embedded in the gigapixel image and then watch the short film that appears on their devices.

After the students discuss the results and collect their identifiers, consider challenging them to discover what will happen next to the items they threw away throughout the week. Task students with tracking these items beyond their homes. Are they collected at the curb and sent to sorting facilities? Do these facilities keep all the materials or do they ship them elsewhere?

7 IMPORTING AND EXPORTING PLASTIC

Which countries would most likely accept these items? Which items would most likely be shipped overseas? Could any of these items end up back in Canada in their original form or in a new form?

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Dandora* video that showcases one of the world's largest landfill sites

Virtual reality

Using the provided headsets, have students experience:

- the *Recycled Life Cycle* video that shows the sequence of events when recycled materials move from a transfer station to a repurposing facility
- the *Dandora* video that takes viewers on a tour of the grounds at the landfill and showcases how workers sort through the heaps of materials for recyclables

Augmented reality

Using the provided tablets and the wall-mounted vinyl triggers, have students explore:

- the *plastic bales* sculpture using the AVARA app

Conclusion

Canadian Geographic has produced a map on promising global plastic reduction initiatives (canadiangeographic.ca/article/mapping-world-plastics). Have students summarize the information on this map using the knowledge they gained from the gigapixel activity.

National Geographic maintains a running list of actions against plastic pollution (nationalgeographic.com/environment/2018/07/ocean-plastic-pollution-solutions/). Have students scan the list for an entry that piques their interest, based on the knowledge they gained from reading the articles and doing their own household trash tracking. Have the class briefly share their thoughts on the initiatives they read about and vote on which initiatives would make the biggest difference in terms of solving the plastic pollution crisis.

7 IMPORTING AND EXPORTING PLASTIC

Evaluation of student learning

Assess students based on their ability to think critically and objectively about the material they read in the provided articles and the lengths to which they go to truly understand the messaging. Evaluate their ability to separate fact from fiction from opinion and to apply theoretical knowledge to real world solutions. Take note of students' abilities to scan articles rather than read them and to target the most important points.

Learning to action

For younger students

- Have students use pieces of scrap paper and pens to consider what they can do to help solve plastic pollution and the apparent need to export waste from developed countries. Hand some paper and a pen to each student and ask them to write the words "I can," followed by two changes they can make in their daily lives to reduce their personal plastic pollution. Next, have them write the words "I need" and fill in the rest of the space with what they will need to accomplish their previous objectives. Students can share their ideas orally, or hang them up for the rest of the school to see.
- Look up some of the many instructions online for how to make reusable bags out of old T-shirts. Have students create some, and then organize a craft sale where the proceeds go to a charitable environmental or wildlife foundation.
- Take an eye-opening field trip similar to the one Ms. Whittick's class took to the Cranbrook landfill in British Columbia. Students will no doubt return home with a new perspective on whether or not their personal choices make a difference.
- Consider following these initiatives or groups:
  - ▷ Classroom Energy Diet Challenge (energydiet.canadiangeographic.ca)
  - ▷ #ZeroPlasticLunchDay (cnn.com/specials/world/zero-plastic-lunch-day)

For older students

- Rise Above Plastics has put together an instructive, free and downloadable toolkit for anyone interested in taking a stand against plastic pollution. Review this with your students and challenge them to make their own customized toolkit for their school or community. Enlist the help of the local government or environment groups to share the toolkit on their websites or social media.
- Challenge students to go an hour without touching any plastic —- can they do it? What were the biggest obstacles? Could they go longer than an hour if they tried? Start a campaign such as #OneHourNoPlastic and have students compete to raise awareness about the ubiquity of plastics in our lives.

7 IMPORTING AND EXPORTING PLASTIC

- Research or join a related worldwide initiative, such as:
  - ▷ Love Letters to the Sea (143figureit.com/love-letters-to-the-sea)
  - ▷ Plastic-free July (plasticfreejuly.org/)
  - ▷ World Oceans Youth Advisory Council (worldoceansday.org/youth-advisory-council)
  - ▷ Environmental Youth Alliance (eya.ca/)
  - ▷ Civic Laboratory for Environmental Action Research citizen science projects and prototype instructions (civiclaboratory.nl/citizen-science/)
  - ▷ Pollution Tracker (pollutiontracker.org/)
  - ▷ the researchers behind the Trash Track program (www.senseable.mit.edu/trashtrack/)

8 GOLDEN SPIKES

Grade Level

7–12 (can be adapted for younger grades)

Learning Goal

- To understand that to help scientists date fossils and use ancient sediments to understand major events that happened in the Earth's history, there are a set of internationally approved guidelines for how to identify different times in Earth's history. This is called the geological time scale of the Earth.

Learning outcomes

By the end of the lesson, students will be able to:

- Understand what a geological epoch is.
- Explain the historical and scientific meanings behind the term "golden spike" in the context of the Anthropocene.
- Describe why golden spikes are useful in the Earth sciences.
- List and explain the potential golden spikes for the beginning of the Anthropocene epoch.
- Understand the debate process that takes place when a new time period is added to the geological time scale.

Materials

Included:

- Gigapixel
- Choosing a Golden Spike card (5)
- Proposed Anthropocene markers cards (9)
- Anthropocene markers on the gigapixel card (1)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Background information

The geological time scale is the official timeline of the Earth's 4.6 billion years of history. It is used by all Earth scientists, along with fossil evidence, to describe the most important events that have occurred on Earth, and the times at which they took place, relative to the formation of the planet. Currently, we are still officially living in the Holocene, an epoch that started about 11,700 years ago and is defined by warmer climates and the presence of humans on all major continents.

The time that passes between each of the significant events described in the geological time scale is not equal because these events occurred in most cases irregularly, and in some cases randomly. For example, the extinction of the dinosaurs, which happened 66 million years ago, is a well-known marker in the geological time scale, identified by the high number of dinosaur fossils from before the extinction event and the lack of fossils afterwards.

To define a specific event on the geological time scale requires the use of a physical signal that occurs globally and will persist indefinitely in the fossil record. For example, the extinction of the dinosaurs was marked by a sudden increase in the metal iridium in soils around the world at the time of a collision between a meteorite and Earth. The common name for this type of signal is "golden spike" (named after the gold rail spike that was used to complete the First Transcontinental Railroad in the United States in 1869).

All time periods in the geological time scale remain informal until a committee of academic experts ratifies their official adoption. This type of decision typically involves only a single, dominant signal that scientists can easily agree upon to use as the associated golden spike.

Now, however, there are multiple potential golden spikes marking the beginning of a new epoch, the Anthropocene, and this is causing significant debate among leading experts in the Earth sciences.

Introduction

Use the information in the background to introduce the idea of a golden spike in the context of geology to the class. Divide the students into groups of three to five and hand out the Choosing a Golden Spike card to the different groups. Let the students discuss the information presented. If questions arise, allow time for some preliminary research.

Explain to students that scientists have not yet universally agreed upon a golden spike to mark the beginning of the Anthropocene on the geological time scale. Some scientists believe it is too soon to decide on a marker and advocate doing more research on the matter. Other scientists believe the Anthropocene ought to have begun thousands of years ago, when humans could be found on all major continents. Still others argue that humans have had a measurable impact on the natural systems of the Earth only since industrial times.

8 GOLDEN SPIKES

Not included

- ▷ Writing utensils (optional)
- ▷ Notebook or paper (optional)
- ▷ Tracing paper (optional)

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Patterns and trends
- ▷ Spatial significance
- ▷ Geographic perspective

Geographic Inquiry Process

- ▷ Ask geographic questions
- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions
- ▷ Reflect and respond
- ▷ Communicate

Geospatial Skills

- ▷ Foundational elements
- ▷ Spatial representations

Burtynsky photographs

Tetrapods #1
Dongying, China, 2016

Hand each group a Proposed Anthropocene Marker card (telling them to keep the cards picture side up) and explain that these images represent some of the most-often discussed proposed markers for the beginning of the Anthropocene. Ask them to discuss among themselves what markers could be represented by the images on the cards (e.g., the picture of the chicken represents the proposal that chicken bones ought to be considered a potential marker for the Anthropocene, since an increase in the number of domesticated chicken bones in the fossil record coincides with an increase in the human population and thus the magnitude of human-induced changes on Earth).

Once the students think they know what marker their pictures represent, have them flip over their cards and see if they guessed correctly. Lead a discussion that explores the pros and cons (from a geological and archaeological perspective) for each proposed marker. For example, chicken bones can easily be identified by archaeologists and remain in the fossil record, but chickens are not equally distributed across the world and thus wouldn't necessarily be considered a global signal (as seen in this Vox article, which includes a map showing the world's 19.6 billion chickens: vox.com/2014/6/20/5825826/these-maps-show-where-all-the-worlds-cattle-chickens-and-pigs-live).

Use the following discussions to get students thinking about Anthropocene markers before using the gigapixel image:

- Why do scientists require a marker for the Anthropocene that provides a globally synchronous signal?
- Why do scientists wish to mark the Anthropocene at all?
- What difference would it make if the Anthropocene was formally adopted into the geological time scale (as opposed to using the term informally as has been done so far)?
- Will it matter to society if we are living in the Anthropocene as opposed to the Holocene, our actual current epoch?
- What benefit do humans get from dividing the past into specific time periods?

Gigapixel activity

Ask the students to walk around the gigapixel image, taking in the volume and variety of products shown. Ask them to consider what they see and decide on another potential marker for the Anthropocene that is different from the ones discussed in the introduction. Examples could include items they see directly (e.g., plastic, paper) or associated markers (e.g., extinction of animals because of plastic pollution, climate change).

8 GOLDEN SPIKES

Clearcut #2
Palm Oil Plantation, Borneo, Malaysia, 2016

Building Ivory Tusk Mound
Nairobi, Kenya, April 25th 2016

Industrial Park
North Las Vegas, Nevada, USA, 2007

Task students with creating their own card describing a potential marker for the Anthropocene based on their decision in the previous step. Using the Anthropocene markers on the gigapixel image card as a template, have students draw their chosen material/marker and fill in the details (i.e., event, timing, marker, geographical extent and start date). Students will need to research this information and acquire it from reputable and scientific sources.

Once everyone has had a chance to complete their card, repeat the exercise from the introduction, but this time use the cards created by the students. Students should attempt to guess different markers as they are passed around within the group. Once everyone has had a chance to make a number of guesses, flip over the cards and reveal the true markers chosen by the students.

Conclude with a discussion about how students would vote on which marker to use, what start date to propose, what type of sedimentological or physical evidence would be used and where the samples would be collected around the world. In essence, pretend you are the voting committee of the International Commission on Stratigraphy deciding on whether or not to formally adopt the Anthropocene as part of the geological time scale.

Optional: use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) as additional images as part of this decision-making activity.

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Crawford Lake* video that explains how scientists collect sediment samples and analyze them to understand past land use
- the *Crawford Lake and Catherine Tammaro* video, which explains the research being done at Crawford Lake in more detail
- the *Stan Finney Golden Spike* video, in which Stan Finney explains the use of golden spikes to understand geological history

Conclusion

Discuss with students their new understanding of golden spikes and Anthropocene markers and the need within the scientific community to resolve the issue of formalizing the Anthropocene epoch. Consider watching *ANTHROPOCENE: The Human Epoch* as a class to learn about additional markers that were not discussed in this activity. Viewing the film will help students appreciate the significant and irreversible ways in which humans have altered the geology of the planet through daily activity.

8 GOLDEN SPIKES

Evaluation of student learning

Evaluate students' abilities to understand new scientific terms and fields of study based on the information provided. Assess their ability to make connections between everyday human activities and global-scale environmental and geological impacts. Examine their cards reflecting their chosen Anthropocene markers and the level of study involved in completing the required information.

Learning to action

For younger students

- Run an "Art in the Anthropocene" exercise where students are asked to pick apart the word Anthropocene using art (Anthropocene is a combination of the Greek anthropo meaning "human" and "cene" from kainos, meaning "new" or "recent." Have students explain to one another their answer to the question "What is the Anthropocene?"
- Consider following these groups to learn more about the Anthropocene:
  - ▷ Fun Kids Live (funkidslive.com/learn/geology-rocks/geology-rocks-anthropocene-period/#)
  - ▷ Archaeology: Clues from the past (amnh.org/explore/ology/archaeology)

For older students

- Have students create art posters or infographics explaining what they understand the Anthropocene to be. Make it a group exercise where pairs of students each get a letter in the word Anthropocene and must decorate that letter pulling from the knowledge they gained in the above activity. Use this collage to explain the Anthropocene to anyone who wants to learn more about this interesting time period.
- Research more about the Anthropocene using the following:
  - ▷ Natural History Museum (nhm.ac.uk/discover/what-is-the-anthropocene.html?utm_source=tw-link-post-20191127-kp&utm_medium=social&utm_campaign=general)
  - ▷ Population Matters (populationmatters.org/campaigns/anthropocene?gclid=EAIaIQobChMIjqLUheSd5gIVkp-fCh3BHwIxEAAYASAAEgIrwfD_BwE)

9 TECHNOFOSSILS

Grade Level

7–12 (can be modified for younger grades)

Learning Goal

- To understand what makes a technofossil different from a prehistoric fossil and the risks technofossils pose to the future of planet Earth, as well as its current state.

Learning outcomes

By the end of the lesson, students will be able to:

- Define what a technofossil is and what its properties are.
- List different types of technofossils and threats they pose.
- Make connections between plastics and the growing layer of technofossils on planet Earth.

Materials

Included:

- Gigapixel image
- Technofossils fact cards (5)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included

- Notebook or paper (optional)
- Pens or pencils (optional)

Background information

Technofossils are human-generated objects that, if preserved in the strata, will serve as future geological markers through which the Anthropocene epoch can be considered.

Concrete is one of the most significant technofossils that humanity will leave behind. Since its invention, enough concrete has been poured to coat the Earth in a two-millimetre thick layer of the material. From 1995 to 2015, rapid urbanization and population growth saw the production of more than half of the planet's total volume of concrete. A similar story is true for many other technofossils.

Aluminum, the most abundant metallic element in the Earth's crust, cannot be found in nature in its purest form. First synthesized in the early 1800s, the metal was not successfully mass-produced until the mid-20th century. From then until the early 21st century, the total production of aluminum metal has been at least 500 million tonnes. Considering its light weight and ubiquitous use in daily life, as a technofossil, aluminum will become a significant indicator of human activity on Earth.

The mounds of plastics in landfills around the world are also fall into this category. By 1950, less than two million tonnes of plastics were manufactured globally per year. By the early 21st century, this amount had reached 300 million tonnes per year. The total cumulative amount of plastics produced by 2015 was calculated to be well over five billion tonnes, enough to cover the entire Earth in plastic wrap, making plastic a key technofossil for consideration as an indicator of the Anthropocene.

Technofossils like plastics, concrete and aluminum, along with other human-made materials, can essentially serve as trace fossils through which the proposed Anthropocene epoch can be dated and characterized. Rapidly changing as advancements in technology take place, and largely resistant to decay, they make up physical components of the technosphere, which is the aggregate of all human systems and technologies (industrial, agricultural, etc.), including human-generated objects (plastics, concrete, etc.), that is regarded by some as a new "sphere" on Earth originating from (and currently largely parasitic on) the biosphere. The technosphere is estimated to weigh upwards of 27 trillion tonnes, that's almost 57,000 times the weight of all the humans on Earth.

9 TECHNOFOSSILS

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Spatial significance
- ▷ Patterns and trends
- ▷ Geographic perspective

Geographic Inquiry Process

- ▷ Ask geographic questions
- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions

Geospatial Skills

- ▷ Foundational elements

Burtynsky photographs

PS10 Solar Power Plant
Seville, Spain, 2013

Dandora Landfill #3
Plastics Recycling, Nairobi, Kenya, 2016

Introduction

Begin by showing students the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene). Give students a few minutes to consider each image. Review the key information presented in the background with students, and ask the questions below as a sort of warm-up:

- What makes something a technofossil?
- Do you think people frequently used the term technofossil 5, 20 or 50 years ago?
- What would an archaeologist digging through the Earth's layers 100,000 years from now think about humans if they came across the layer for the year 2019?
- The fossils of early organisms accumulated over hundreds of thousands of years, but the technofossils being left behind by humans are accumulated in a much shorter time period. What do you think this means for our species? What do you think this means for others species? What about the planet as a whole?
- What would it take to stop the layer of technofossils from growing? If stopping completely isn't possible, how can students slow the rate of growth?

Gigapixel activity

Explain to students that they will be taking a closer look at plastics as a technofossil using the gigapixel image. Tell students that the gigapixel image represents a small fraction of the total technosphere, as the volume of plastics pictured is miniscule compared with all the plastic that has ever been produced by humans since its invention. Take a few minutes to discuss the scale of the gigapixel image in relation to the scale of the layer of plastic technofossils that is gradually growing around the world, in both terrestrial and aquatic habitats.

Divide the group into teams and hand each a Technofossils fact card. Have the groups read their cards among themselves, paying close attention to the photo and the details in the explanatory text, and then record their answers.

Have each group take their turn reading their card and answers to the class. Ask the class to assess whether answers were similar or unique. Have the students examine each other's answers through discussion, and contribute any ideas they might be missing.

Hand each group a tablet so they can use the AVARA app to locate the seven different triggers embedded in the gigapixel image and then watch the short films that appear on their devices. After viewing the short films, revisit the questions from the introduction and the previous exercise. Does seeing footage of an issue make them want to modify their previous answers? Did new ideas come to mind?

9 TECHNOFOSSILS

Makoko #1
Lagos, Nigeria, 2016

Fuels and Chemical Storage
Houston, Texas, USA, 2017

Optional: Instead of the giant floor mural, students can also use the online interactive gigapixel image, which offers a few different films (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Texas Oil* video, which includes footage of some of the world's largest oil refineries
- the *Seawall* video, which dives deeper into the story behind the construction of seawalls in China
- the *Dandora* video, which takes viewers on a walk through the Dandora landfill
- the *Alex Bilbao* video, in which Alex Bilbao talks about the origin of technofossils

Virtual reality

Using the provided headsets, have students experience:

- the *Dandora* video, which takes viewers on a journey through the Dandora landfill and into the lives of the workers who salvage recyclables from the mounds of plastic waste

Conclusion

Discuss with students their new understanding of the term technofossil and how their perception of things like plastic, concrete and metal may have changed following the lesson. The following questions may help spark conversations:

- Why have technofossils become an issue in the recent past?
- How do you feel you are contributing to the layer of technofossils around the world?
- How can humans use their technology to stop any future growth of technofossil layers on Earth?
- What footprint do you personally want to leave behind?
- Who should be responsible for dealing with the environmental implications of the appearance of technofossils? Which do you think are the most pressing implications?

9 TECHNOFOSSILS

Evaluation of student learning

Allow students to evaluate each other's responses during the gigapixel activity as well as their abilities to select a leader, share ideas, be respectful and think creatively and critically. Encourage any ideas for self or group improvement. While they are performing the gigapixel activity, assess their answers to the discussion questions and their focus on the task.

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to recycling plastics.

For younger students

- Lead an activity that flips the lesson on its head. Ask students about the ways in which our environment has shaped humanity. Have students reflect on their daily environment (classroom, bedroom, backyard, etc.) and pick out the ways in which their interactions in these spaces are shaped by nature. To take action to protect the world we live in, we must first understand the ways we connect to it.
- Have students collect newspaper and magazine articles to share with their classmates. Then, make posters about the different issues contributing to a growing technosphere, using the articles and making their own illustrations and lettering.
- Consider following these young people on social media to keep up with their work related to stopping the growth of the technosphere:
  - ▷ Xiye Bastida (twitter.com/xiyebastida?lang=en)
  - ▷ Holly Gillibrand (twitter.com/hollywildchild?lang=en)
  - ▷ Mari Kopeny (twitter.com/LittleMissFlint)

For older students

- Have students organize a clothing and games swap to raise awareness about the importance of reusing and recycling items that are in perfectly good condition. Part of the reason behind the increasing growth of the technosphere is the frequent habit of discarding items after they no longer interest us. Why not swap them for something new from a friend?

9 TECHNOFOSSILS

- Take students on a water walk (motherearthwaterwalk.com/). Building on the concept of aquatic environments in danger due to human land-use practices, students can take a field trip to a local body of water (a stream at a local park, or a nearby beach, for example) to conduct a detailed assessment of the water and surrounding land and then document their findings by mapping and profiling the water and the neighbouring area. Have them plan their own field trip next time to assess a different habitat!
- Join or follow a related worldwide initiative, such as:
  - ▷ Jane's walk (janeswalk.org/)
  - ▷ We don't have time (wedonthavetime.org/)
  - ▷ Surfers against sewage (sas.org.uk/about-us/)

9 TECHNOFOSSILS

10 TERRAFORMING

Grade Level

4–9 (can be modified for older grades)

Learning Goal

- To learn what terraforming is and what the main types of human-caused terraforming are, and to use inventive thinking techniques to brainstorm ways humans can actively reverse the effects of climate change that result from this type of land use.

Learning outcomes

By the end of the lesson, students will be able to:

- Define the term "terraforming" and list examples of how humans bring about great changes to the geology and geography of the planet.
- Understand the reasons why terraforming may be problematic for the future of the planet and its species.
- Provide creative suggestions to reverse the impacts of terraforming.

Materials

Included:

- Gigapixel
- Ecological Footprint card (1)
- Big Lonely Doug card (1)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included:

- Calculators (optional)

Background information

The scientists researching the characteristics of the Anthropocene are charting the progression of human influence on the Earth's natural systems through a variety of markers, one of which is called "terraforming": the reshaping of land for agriculture, industrialization and urbanization and for the extraction of resources. Many different lines of evidence overwhelmingly point to the conclusion that humans are now changing the Earth more than all other natural processes combined (e.g., volcanoes, earthquakes, energy and water transport, weather). Many different examples of terraforming can be used to explain this conclusion in greater detail. Here are a few that touch on the scale and importance of human-induced environmental change:

Tree cutting: British Columbia makes up about 10 per cent of the land in Canada and is home to more than half of Canada's species of large plants like trees and shrubs, as well as three-quarters of its bird and mammal species. The old forests of British Columbia take up an important amount of carbon dioxide, a greenhouse case that is contributing to climate change. Despite this fact, old forests in the region are being logged at a very fast rate. Less than 10 per cent of old forests remain on Vancouver Island.

Destroying nature to accommodate more people: Nigeria is the most populous country in Africa, with a rapidly growing population that, as of July 2018, was an estimated 203 million people. Nigeria's population will surpass that of the United States sometime before 2050, which would make it the world's third largest country by population. Its largest city, Lagos, is one of the world's largest cities. Since the 1960s, it has grown from fewer than 200,000 inhabitants to about 20 million people in just two generations.

Creating toxic garbage: The Dandora landfill, in Kenya, is among the largest of its kind in the world. The area receives industrial, agricultural, commercial and medical waste, amounting to about 2,000 tonnes per day. A 2007 study by the United Nations Environment Programme found fatally high levels of lead in soil samples around the landfill. Half of the 328 local children tested suffered from respiratory problems and exhibited lead concentrations in their blood that exceeded internationally accepted levels.

Leaving scars on the land: Hambach, the largest open-pit mine in Germany, produces a type of soft brown coal. The mine's Bagger 291 and 293, among the largest land vehicles ever built in human history, remove the sand covering the underlying coal. Each winter, the mining company clears about 70 hectares of forest to access new layers of brown coal (that's like 70 high school running tracks). Almost all of Hambach's old forests are gone, and villages have been evicted because of the mine's expansion.

10 TERRAFORMING

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Spatial significance
- ▷ Geographic perspective

Geographic Inquiry Process

- ▷ Ask geographic questions
- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions
- ▷ Reflect and respond

Geospatial Skills

- ▷ Foundational elements
- ▷ Technologies

Burtynsky photographs

Super Pit #4
Kalgoorlie, Western Australia, 2007

Greenhouses #2
El Ejido, Southern Spain, 2010

Introduction

The simplest definition of the word "terraforming" is the act of transforming the Earth's surface to meet human needs. Explore this definition with your students. Have them write down a list of five human needs that can be met with the resources that the Earth provides. Then have them write a list of five pros and five cons associated with those needs and resources. Next, consider as a group the number of people living on planet Earth (about 7.7 billion) and how their collective needs are met. Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below to prepare students for the activity:

- If someone gave you a huge piece of land that you could do whatever you wanted with, what would you do with it?
- Would you keep the land in its natural form, or would you change it to suit your needs?
- What types of land use are there? Are they all important? (e.g., agricultural, residential, commercial, recreational)
- What is a natural resource? How do you use natural resources in your everyday life?
- Does everyone use the same amount of natural resources on a daily basis?
- Why do commercial projects use so much land and so many resources to make "stuff" for people to buy?

Optional: if discussing deforestation specifically, have students use the AVARA app on the provided tablets with the Big Lonely Doug card to get a visualization of the one of the world's oldest and most endangered Douglas fir trees. Big Lonely Doug is the second largest douglas fir in Canada. Over 1,000 years old, it stands alone in the middle of a British Columbia clear-cut, having been spared by a veteran logger who recognized its significance.

Gigapixel activity

Inform students that, every day, the average Canadian produces 2.7 kilograms of garbage (paper, plastic, metal, etc.) and uses 329 litres of water (by drinking, running the faucet, showering, etc.). The average lifetime ecological footprint, which takes into account all the resources a person uses, of someone living in Canada is 7.5 hectares — roughly the same size as eight football fields. With about 7.7 billion people now living on Earth, that's a lot of land being used for human activities instead of being kept pristine and in its natural form.

10 TERRAFORMING

Clearcut #4
Vancouver Island, British Columbia, Canada, 2016

Saw Mills #2
Lagos, Nigeria, 2016

Give students time to explore the gigapixel image independently. Ask them to take stock of the items they see that they have used in the past day, week and month. Ask them if they are familiar with the term "ecological footprint." Explain that this is a measure of the impact a person has on the environment. It is most often expressed as the amount of land required to sustain their lifestyle and use of natural resources. Someone's ecological footprint is often used as a score of how sustainably they are living and can give them an idea if there are any small changes to reduce their consumption of resources they can incorporate into their lives.

Many types of calculators exist to measure an ecological footprint; this activity will use simple mathematics to take students through a calculation of their ecological footprint based on the items shown on the gigapixel image.

Distribute an Ecological Footprint card to each student. Ask students to walk around the gigapixel image entering the following information on their cards (point out the example on the card for clarification):

- the names of 10 items on the gigapixel image that they have used at least once in the last year (column A)
- the number of times they used each of the 10 items per week in the last week (column B)
- the total number of each item used in the past year (column C)
- the totals for all columns B and C

Lead a brief discussion about the numbers on the students' cards. Are they surprised by the results? Were they interested to find out that, for example, finishing a 100 gram container of yogurt every day for a year amounts to 365 pieces of plastic a year? What are their feelings about their numbers? Do some students have much higher/lower numbers than others? Why might that be?

Now have students think about making a commitment to reduce their consumption of the items on their list. Ask them to consider an average week and the real amounts of each item they would be willing to give up each week. Have a discussion about easily implementing alternatives, such as using a metal reusable water bottle instead of disposable plastic ones.

- Have students write the number of possible yearly reductions they would be willing to make for each product (column D).
- Have students finish by calculating their future plastic commitments (column E).

Wrap up the activity by challenging students to stick to their commitments for the following week, and revisit the activity based on their new consumption habits to have them visualize the very real differences that they could be making!

Optional: Have students use the AVARA app on the provided tablets to locate triggers 3, 4 and 5 embedded in the gigapixel image and then watch the short films that appear on their devices.

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (www.gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Have students watch:

- the *Port Renfrew* video, which talks in depth about Big Lonely Doug and deforestation happening on Vancouver Island
- the *Tom Szaky and Loop* video where Tom Szaky, CEO and founder of TerraCycle, shares his personal experience with changes in the plastics industry

Virtual reality

Using the provided headsets, have students experience:

- the *Carrara* video, which shows a prime example of terraforming, in the shape of a massive marble quarry being excavated

Augmented reality

Using the provided tablets and the wall-mounted vinyl triggers, have students explore:

- the *plastic bales* sculpture using the AVARA app

Conclusion

Consider playing the Tom Szaky and Loop video, where Tom Szaky, CEO and founder of TerraCycle, shares his personal experience with changes in the plastics industry. Students will no doubt find his words informative and inspiring. After watching the video, take up the following questions:

- What are some goals you would like to set after watching Tom Szaky's interview?
- How do you plan to accomplish your goals?
- Why is there such a big push to reduce, reuse, recycle and report (as opposed to repurpose)? What will this lead to?

10 TERRAFORMING

- How are big changes like terraforming related to the items you listed on your ecological footprint card?
- When someone uses the phrase "I threw it away," what do they mean whey they say "away"? Where is away? Is away really a thing?

Discuss with students their understanding of the fact that every small change matters when it comes to ensuring a positive future for ourselves and our planet. If every person committed to a series of small changes, the world would be a very different place and the global market would have to respond by adapting products to match the desires of consumers. Remind students of the three common Rs, and add "report" to make it four Rs:

- REDUCE: If at all possible, do not buy any new single-use items.
- REUSE: Safely reuse existing products as many times as possible before getting rid of them for good.
- RECYCLE: Recycle whatever materials cannot be reused. Recycling should be viewed as more of a last resort and not the first option.
- REPORT: Report on your successes regularly (consider using 10,000 changes as a way to start: 10000changes.ca) and take stock of your failures to keep yourself motivated.

Evaluation of student learning

Assess students based on their mathematical understanding of the gigapixel activity and their ability to make connections between the image and their everyday lives. Assess their comprehension of new scientific terms like "terraforming" and "ecological footprint."

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to reducing their ecological footprint.

For younger students

- Sometimes people are not motivated to get into a recycling program simply because of a lack of recycling bins or roadblocks to sorting different kinds of recycling and waste. Have your students do some research in their school or community to see if this is the case and, if so, what is preventing people from recycling. Have students organize a fundraiser to raise money for more recycling bins or any other necessary resources to improve participation.

10 TERRAFORMING

- Get students to organize a composting program with the school's cafeteria. Every day, different teams of students can be responsible for collecting compostable items and placing them in an outdoor composter or garden.
- Consider following these people and groups on social media to keep up with their innovative strategies for repurposing plastic items:
  - ▷ 10,000 Changes (10000changes.ca/en/)
  - ▷ I want to be (berecycled.org/)
  - ▷ Trees For Cities (treesforcities.org/)
  - ▷ Project Giving Kids (projectgivingkids.org/save-the-planet/)

For older students

- Have students organize a project that focuses on drawing comparisons between an ongoing environmental issue in their neighbourhood and the same issue taking place elsewhere in the world. This will help them understand the interconnectedness of different regions, people and issues around the world. Have them submit their project idea to the Our Canada Project (ourcanadaproject.ca/).
- Join or follow a related worldwide initiative, such as:
  - ▷ Seabin Project (seabinproject.com/)
  - ▷ Clean the world (cleantheworld.org/)
  - ▷ EcoDom (en.ecodom.mx/)

11 ANTHROTURBATION

Grade Level

4–12

Learning Goal

- To understand that anthroturbation — the digging, drilling, mining, and blasting that humans do beneath the Earth's surface — is one of the defining markers of the Anthropocene and will leave a lasting impression for millions of years to come.

Learning outcomes

By the end of the lesson, students will be able to:

- Define the term "anthroturbation" and give examples of different kinds of rock and soil disturbances that fall under this category of land use.
- Understand the scale at which human activities like mining and underground tunnelling operate.
- Better describe the complex relationship between humans and the environment.

Materials

Included:

- Gigapixel
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included:

- Several pieces of string, cut into 1 to 1.5 metre lengths
- Painters tape
- Notebooks or paper
- Pens or pencils

Background information

Anthroturbation, large-scale tunnelling under the Earth by humans, will leave behind one of the most definitive records of our presence. Described as "the scarring of our planet" and the "transformation of the underworld," drilling, extensive mining and deep quarrying are proof of just how much humans can transform the Earth both above and below the surface. Consider the following examples:

Berezniki: Five mines operate in the town of Berezniki, Russia, collectively composing an underground web of an estimated 10,000 km of tunnels. As a result, the town of Berezniki has experienced giant sinkholes that swallowed roads and buildings and shut the local railway station. Many residents have moved, despite the jobs available at the mines, and there are calls to move the entire town. The potash mined here is ultimately destined to fertilize large industrial farms, like those in the Imperial Valley in California. Completely enveloped in darkness, the tunnels stretch for an estimated 3,000 kilometres.

Europe: Gotthard Base Tunnel in the Alps is now the world's longest railway tunnel, some 57 kilometres long, for both passenger and freight trains. To connect Switzerland's German- and Italian-speaking regions, the tunnellers had to bore through a wide range of rock strata, ranging from solid granite to sedimentary rock. About 28.3 million tonnes of material were excavated during construction. With the rock overhead measuring up to 2,300 metres deep, the Gotthard Base Tunnel is also the deepest railway tunnel in the world.

United Kingdom: Growing Underground is a farm 33 metres below Clapham, south London, in a disused Second World War bunker. The plants are grown on vertically stacked trays using hydroponics, presenting an alternative to the harmful terraforming of traditional agriculture practices. Presently, Growing Underground is using a 550-square-metre area that will produce about 20,000 kg of greens every year. Its hydroponics system uses 70 per cent less water than traditional open-field farming, and all nutrients are kept within the closed-loop system, removing any risk of agricultural run-off.

Florida: Phosphate ore is one of the world's most critical mineral resources. Phosphates are a crucial component of industrial agriculture. Like fossils fuels, phosphate ore is not renewable: the deposits mined in Florida are formed through the deposition of phosphate-rich materials in ancient marine environments. To access the ore, phosphate surface-mining operations must clear natural vegetation and topsoil. Run-off, from both the industrial mining of phosphates and their use in agriculture operations, is a key factor in the creation of harmful algal blooms, loss of fish species and pollution of vital water sources.

11 ANTHROTURBATION

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Spatial significance
- ▷ Geographic perspective

Geographic Inquiry Process

- ▷ Ask geographic questions
- ▷ Interpret and analyze
- ▷ Communicate
- ▷ Reflect and respond

Geospatial Skills

- ▷ Foundational elements

Burtynsky photographs

Mines #19 - Westar Open Pit Coal Mine. Sparwood, British Columbia, Canada, 1985

Super Pit #4
Kalgoorlie, Western Australia, 2007

Introduction

Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) and the questions below to introduce the term "anthroturbation" and its associated concepts of underground drilling, mining and tunnelling:

- What do you see in these images?
- Who or what is responsible for these landforms?
- How are these landforms made?
- What has been displaced or affected because of the appearance of these landforms?
- How long do you think it took for these landforms to get as big as they are?
- What is the term *anthro* normally used for? (humans)
- What does the word *disturbance* mean?
- What do you think the word *anthroturbation* means?
- Why do you think these landforms made the list of top ways in which humans are transforming the planet both above and below ground?
- How does an underground disturbance like a tunnel affect the people, wildlife and places on the surface of the Earth?

Next, explain to students that the difference in scale between some of these mines, tunnels and quarries and us is similar to that between an ant and its surroundings (think trees, bushes, bicycles, dogs, young children, etc.). Tell them that they will be using the gigapixel to explore this idea and the concept of scale further.

Gigapixel activity

Have students walk around and study the objects in the gigapixel image. Next, have students continue their exploration from a seated or crawling position, searching for minor details they may have missed while standing. Explain that they will be going on a micro hike and that they will be relying on their observation and imagination skills to complete the activity.

Divide students into small groups, and give each group a piece of string roughly 1.5 metres in length (and some small pieces of painter's tape, if necessary). Ask them to find an intriguing spot on the gigapixel for an ant to explore, and have them "map" their hike by placing the string along a route between, over and under different items pictured on the gigapixel image.

11 ANTHROTURBATION

Silver Lake Operations #2
Lake Lefroy, Western Australia, 2007

Iberia Quarries #2
Marmorose EFA Co., Bencatel,
Portugal, 2006

Have students record their journey through the trash entirely from an ant's perspective by writing in their journal or on a scrap piece of paper. Encourage them to be creative and consider what they might smell, feel or hear along the way. Is there wind that makes it hard to cross certain items? What obstacles do they encounter along the way? Is the size of the trash pile overwhelming? How long did their journey take the in "ant time"? Make sure that scale factors into their story and that they are constantly thinking about the difference in size between them, the objects they are walking on and the size of the entire trash pile.

Have them look for different kinds of materials, surfaces and textures, including Styrofoam, cardboard and glass. Look for dirt, plants and anything else that makes them stop and consider what is in front of them.

Make sure they move slowly down the string, searching for every individual thing they can find. When they are done, have groups compare their observations with those of other groups who hiked across different spots. What interesting things did one group see that another missed?

Optional: have students record their journey in as much detail as possible and then challenge other groups to find the items mentioned and figure out the path they took on their hike!

Optional: Have students use the AVARA app on the provided tablets to locate triggers 2, 4 and 5 embedded in the gigapixel image and then watch the short films that appear on their devices. These will also provide a frame of reference for scale.

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Gotthard Tunnel* video that takes viewers on a journey through the world's largest underground tunnel
- the *Berezniki* video, which shows footage from a potash mine in Berezniki, Russia, that is 400 metres below ground
- the *Seawall* video, which gives viewers an idea of the amount of sediment that needs to be excavated and moved to construct giant structures such as seawalls
- the *Iskut* video, which provides a detailed account of how mineral exploration and drilling in Canada is harming Indigenous communities
- the *Klabona Keepers* video, which shows how a group of Indigenous land protectors in northern B.C. are navigating a complex relationship with local mining companies

11 ANTHROTURBATION

Virtual reality

Using the provided headsets, have students experience:

- the *Carrara* video, which shows stunning up-close footage of the ongoing quarrying activities in Italy

Conclusion

Discuss with students why they think they were asked to go on a micro hike during a lesson about anthroturbation and giant mines, tunnels and quarries. How does looking at the world from different perspectives or scales help us understand just how big or small something really is? Explore the locations and examples of anthroturbation in greater detail using Google Earth by having students search for other locations around their country or the world that could be classified as examples of this scale of disturbance.

Consider watching one of more of the online video clips listed above to really give students a sense of the size of these human-made landforms. Ask students how they would describe traversing a mine or walking through a tunnel if they were an ant!

Evaluation of student learning

Assess students based on their creative thinking skills and their ability to use terms and descriptors that match well with the subject matter. Assess their attention to detail and if they sped through the exercise or really took the time to follow direction and observe even the most minute details. If students attempt to locate the hikes taken by other groups, assess their ability to match descriptors to visuals.

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to reducing their ecological footprint.

For younger students

- Take a micro hike outdoors! It's one thing to attempt this exercise with a 2D image, but quite another to describe what it is like to hike through blades of grass and up the sides of sidewalks. Having students observe the world around them while diligently recording notes and observations will help them form a stronger connection with their environment. This is crucial if they are to become invested in protecting the planet for themselves and for future generations.

11 ANTHROTURBATION

For older students

- Have students research possible forms of anthroturbation in or around their community, or perhaps smaller but sizable human-made landforms such as landfills, dams, shopping complexes, septic fields and parking lots. Have them complete a follow-up activity related to scale by measuring the relative sizes of these landforms using Google Earth or by creating hand-drawn maps that display everything in relative terms. Have students reflect on how much land is dedicated to human land use relative to how much land remains natural or untouched. Alternatively, have them measure the scale of human-made landforms in and around their community and compare them to natural geological landforms such as volcanoes, tectonic plates or mountains. Seeing the scale of human pressures on the planet relative to naturally formed landforms will help them understand just how powerful a force human land use has become, which will help empower them in discussions about sustainability and conservation.
- It is well known that large projects such as mines and oil sands are changing the Canadian landscape. Many First Nations communities are affected either directly or indirectly by their construction and operation. Land, in Canada, has an important Indigenous significance, and mining projects degrade the health and functioning of these ecosystems. Have students research this in greater detail to learn more about ongoing human-related issues with respect to anthroturbation.
- Join or follow a related Canadian or worldwide initiative, such as:
  - ▷ Climate chance (climate-chance.org/en/best-pratices/green-ambassadors-project/)
  - ▷ Klabona Keepers (firstnations.de/mining/tahltan-klabona.htm)
  - ▷ Mining matters (miningmatters.ca/)

11 ANTHROTURBATION

12 CLIMATE CHANGE

Grade Level

7–12 (can be modified for younger grades)

Learning Goals

- To understand that climate change already affects human lives every day and will affect the lives of future generations.
- To come to the conclusion that it is not too late to reverse some of the negative impacts of climate change, but to do so, a shift in consciousness must take place immediately.

Learning outcomes

By the end of the lesson, students will be able to:

- Describe some of the most pressing issues related to climate change.
- Provide examples of how climate change affects humans, animals, plants and ecosystems.
- Discuss what makes a climate change advertisement or campaign impactful.
- Provide an argument for whether the ad industry has a responsibility to educate consumers on the threats of climate change to inspire action or not.

Materials

Included:

- Gigapixel image
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included:

- Notebooks or paper and pens (optional)

Background information

Since the Industrial Revolution, over 390 billion tonnes of anthropogenic carbon emissions have been released into the air through cement production and the burning of fossil fuels. For much of the Earth's history, CO_2 levels ranged between 200 parts per million (ppm) and 280 ppm. In 2013, CO_2 levels reached 400 ppm for the first time on record. At the current rate, it is estimated that the Earth's climate will warm from 3.2 to 5.4°C above pre-industrial levels by 2100. The discovery and exploitation of new methods of oil extraction will ensure that until a more efficient form of energy is found, global sustainability will take a back seat to the status quo.

Climate change is not limited to the release of greenhouse gases in the atmosphere. Indeed, there are issues taking place underwater as well. Coral bleaching may be more likely to occur should sea water temperatures continue to rise. In 2016, the Great Barrier Reef in northeastern Australia, the world's largest reef system, suffered a devastating mass bleaching event. In all, around 22 per cent of the entire reef's corals were lost. Bleaching is not limited to Australia, and is seen on other coasts with increasing frequency as ocean temperatures rise and acidity increases. Australia is the world's largest coal exporter, and many of the mines and ports are centred around Queensland, where reefs experienced the greatest damage. The tension here between conservation and industry has been lengthy and ongoing. While there is hope that the coral reefs will recover, the increased frequency of bleaching events will only put more stress on those that survive.

Climate change is also affecting cities across the world. In the last decade, Lagos, Nigeria, has emerged as one of the economic capitals of western Africa. As the city is composed of a series of islands and peninsulas on the Gulf of Guinea, natural processes of coastal erosion are exacerbated by climate change, putting much of Lagos at a high risk of flooding. The wealth disparity here is stark, and a significant number of residents live in dense informal settlements close to or on the water. With the peninsula highly vulnerable to storm surges, adaptation projects include the construction of a seawall known as the "Great Wall of Lagos." About 100,000 five-ton concrete blocks are being arranged to form the wall, which will extend over eight kilometres. However, what might protect the wealthy districts of Eko Atlantic and Victoria Island may end up directing damage from a storm to unprotected informal communities.

What do these stories have in common? Major fossil fuel companies have known for decades that their products — oil, natural gas and coal — cause global warming. Companies that operate along coastlines are aware that physical damage, dredging, quarrying, poor fishing practices and boat anchoring present a danger to coral reefs. Reducing our greenhouse gases emissions would help slow the rate of sea-level rise, but it seems unlikely that mega-corporations would be prepared to demand industry-wide changes that could potentially stop further rises altogether. These three examples seems like incentive enough to put pressure on citizens and industries to change the status quo. And students have a right, and perhaps even a responsibility, to take part in the fight for the future of their planet.

12 CLIMATE CHANGE

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Spatial significance
- ▷ Geographic perspective

Geographic Inquiry Process

- ▷ Ask geographic questions
- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions
- ▷ Reflect and respond

Geospatial Skills

- ▷ Foundational elements

Burtynsky photographs

Petrochemical Plants
Baytown, Texas, USA, 2017

Saw Mills #2
Lagos, Nigeria, 2016

Introduction

Share the background information with students. Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) as part of this exercise. Apply the concepts presented in Bloom's taxonomy to guide students through a reflection exercise to help them digest the information they heard and the pictures they have seen. Have students use a notebook, and begin a warm-up exercise by asking them to:

- Write down a fact they remember from the stories.
- Show they understand that fact by writing down why they think it is important.
- Think about how they can use this knowledge in the future by writing down one way that they see themselves doing so.
- Ask themselves if this information is part of a larger pattern or trend, and write down their answer.
- Evaluate the information by looking at it from different perspectives (e.g., homeowner, business owner, child, adult). Have them write down some ideas.
- Extend their learning by thinking about all of their previous answers and writing down an action item for themselves to make sure they retain what they have learned.

Ask students what they have discovered about their own impression of climate change after doing this exercise. Tell them to use their feelings and opinions in the following activity.

Gigapixel activity

Ask students to describe what they know about word clouds. Show them examples by searching for some online; the website wordart.com has many great examples. Tell them that word clouds are a powerful communication tool because they have the ability to present different kinds of information simultaneously. They can combine art and language, they can provide information about the frequency of words used, and they can get a complicated message across by breaking up an idea into basic words.

Ask students to consider how they would make a word cloud that symbolizes how time is running out to act on the current climate emergency and urges politicians and industries to take larger steps when it comes to making real, meaningful change. Have them consider this as they walk around the gigapixel image taking note of a few key ideas that stand out to them initially.

12 CLIMATE CHANGE

Pengah Wall #1
Komodo National Park, Indonesia, 2017

Salton Sea #1
Eastern Shore, California, USA, 2009

Now have students create word clouds using the following instructions:

- They can only use words that they find on the gigapixel image.
- They must take the shape of something they see on the gigapixel image.
- The size of each word must represent how many times they saw that object on the gigapixel image.
- Words can be written in any direction.
- Colours can be used to make certain words stand out.
- Their word cloud must convey a message.

Assist students as they work on their word clouds — this might include helping them count words or design a draft version — and give students the time they need to sit on the gigapixel image to really take in the words and materials.

Optional: Have students use the AVARA app on the provided tablets to locate the seven triggers embedded in the gigapixel image and then watch the short films that appear on their devices. Information provided in the videos can be considered fair game for their word clouds if you so choose.

Optional: Students can also use the online interactive gigapixel instead of the floor gigapixel (gigapixel-theanthropocene.org/Recycle/). This will come in handy for work done in extra hours.

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Port Renfrew* video, which touches on the impacts of deforestation related to climate change
- the *Eco-Anxiety* video, which explains some of the feelings people associate with climate change and the overwhelming changes taking place across the planet
- the *Coral Reef* video, which portrays stunning coral reefs that are undergoing bleaching due to climate change
- the *Denman Island and University of British Columbia* video, which explains direct impacts on coastal communities related to climate change

12 CLIMATE CHANGE

Virtual reality

Using the provided headsets, have students experience:

- the *Denman Island* video, which takes viewers through the impacts of climate change on coastal communities

Conclusion

Ask students what they learned by studying the gigapixel image and creating their word clouds. Ask them if it is a reasonable goal for students, their families and businesses to try to light a fire and raise awareness. Have students think about sustainability and climate change in their future careers. What kinds of careers do students think would line up with the goals of this exercise?

Share student's word clouds around school as part of an awareness campaign. They can post questions like these underneath their word clouds to get their schoolmates thinking about the content:

- Do you trust the way different media outlets portray climate change?
- Can you help protect the rights of our environment?
- Does climate change affect the rich and the poor in the same ways?
- How is climate change affecting your health?
- How are climate change and gender connected?
- How are human rights affected by climate change?
- Are climate change, war and poverty connected?
- Does climate change matter? Why or why not?

Evaluation of student learning

Assess students based on the creativity and detail applied to their word clouds. Have students complete a self-assessment where they pair up and ask each other questions about the lesson and their word clouds. The questions students ask each other should reflect on themselves, the steps they took to complete their word clouds, and if there was anything they would add or do differently the next time.

12 CLIMATE CHANGE

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference and have their voice heard.

For younger students

- Lead an activity where students review the latest news about the climate strikes and marches now regularly occurring in many countries around the world. Have them track the story of how these marches transpired and how students were at the heart of many of them, including Fridays for Future (fridaysforfuture.org/). Show the class that student-led action is real and can have a lasting impact.
- Consider following these people and groups on social media to keep up with their innovative strategies for getting their voices heard:
  - ▷ Luisa Neubauer (youtube.com/watch?v=WsfacjPOBIw)
  - ▷ Earth Uprising (earthuprising.org/)
- Or share these games and activities with students:
  - ▷ NASA Climate Kids (climatekids.nasa.gov/menu/play/)
  - ▷ Kids against climate change (kidsagainstclimatechange.co/start-learning/)
  - ▷ Climate change live (climatechangelive.org/index.php?pid=185)

For older students

- Sometimes there is worry that climate change is too scary to talk about with younger students. Have your older students create a graphic novel or cartoon based on a series of climate change events linked in a logical sequence that incorporates mitigating and adapting to the impacts of climate. Have them pair up with younger students and explain how humans have the power to stop climate change and the good that can come of it.
- Join a related worldwide initiative, such as:
  - ▷ Indigenous Climate Action (indigenousclimateaction.com/)
  - ▷ Global Climate Strike (globalclimatestrike.net/)
  - ▷ Y on Earth (yonearth.org/xiye-bastida-global-youth-activist-thought-leader-strike-with-us/)

12 CLIMATE CHANGE

13 EXTINCTION

Grade Level

7–12 (can be modified for younger grades)

Learning Goal

- To understand that plastic affects both humans and animals, and that a growing number of animal species are in danger of going extinct as a result of their inability to cope with the encroachment of plastics in their habitats.

Learning outcomes

By the end of the lesson, students will be able to:

- List ways plastics appear in and affect animal habitats.
- Describe different ways in which plastics affect ecosystems and wildlife.
- Make connections between the plastic products humans use on a daily basis and the loss or endangerment of different species in both aquatic and terrestrial habitats.

Materials

Included:

- Gigapixel image
- Logic Model card (1)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included:

- Notebooks or paper (optional)
- Pens or pencils (optional)
- Multiple copies of the Logic Model card

Background information

Mass extinction is a marker of the Anthropocene, with many scientists agreeing we are currently in the midst of a sixth mass extinction — one resulting from human activity and pollution. Previous epochs have been separated by abrupt changes in fossil records, such as the transition from the Cretaceous period to the Paleogene, when the dinosaurs went extinct. Yet although these mass extinctions took place over periods of millennia that might seem relatively brief (as most things are, when measured against the entire geological time scale), the rapidity of the extinctions occurring by human hand is, by any measure, extraordinary. A 2016 World Wildlife Fund report found that a staggering half of all animal species had seen a significant decline in population since 1970, with freshwater species most severely affected.

The current proposed extinction event is marked by the decline in the population size of some of the world's largest animals, including elephants and rhinoceroses. In recent years, illegal ivory poachers — heavily armed and using military tactics — have killed tens of thousands of elephants across Africa. Their tusks are then smuggled through corrupt networks (often with the assistance of unscrupulous government officials) and sold to eager markets for use in upscale items: statuettes, jewellery, furnishings and various trinkets.

On March 20, 2018, the world learned that Sudan, the last remaining male northern white rhinoceros, died. His death leaves only two remaining rhinos of his subspecies, Najin (his daughter) and Fatu (his granddaughter), and drives home the fact that all five of the world's diverse species of rhinoceros have been brought to the edge of extinction because of human appetite for their distinctive horns.

Stories like Sudan's tend to make their way into the news most frequently because humans are more attached to large majestic mammals than to organisms such as insects, fish and birds. But ecosystem loss and species declines are also happening to many smaller species, due to habitat fragmentation and degradation, disturbance of natural spaces for oil extraction and urban expansion, increasing amounts of toxic chemicals and solid waste pollution in waterways and habitats, and the ingestion of plastics by animals.

The following activity explores the relationship between the growing amount of plastic waste that is ending up in natural habitats and the extinction of different species of terrestrial and aquatic animals.

13 EXTINCTION

Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- ▷ Spatial significance
- ▷ Geographic perspective

Geographic Inquiry Process

- ▷ Interpret and analyze
- ▷ Evaluate and draw conclusions
- ▷ Reflect and respond

Geospatial Skills

- ▷ Foundational elements

Burtynsky photographs

Clearcut #1
Palm Oil Plantation, Borneo, Malaysia, 2016

Building Ivory Tusk Mound
Nairobi, Kenya, April 25th, 2016

Introduction

Start the lesson by viewing one or more videos from the following list with students. Each video covers, in a unique way, the pressures that human resource extraction and land use impose on animals and ecosystems across the world.

- the *Coles Bay and University of Victoria* video
- the *Coral* video
- the *Dandora* video
- the *Denman Island and University of British Columbia* video
- the *Nigeria* video
- the *Port Renfrew* video

If you watch more than one video, have students select the one they found the most interesting, and give them time to answer the following questions:

- Where in the world was the video filmed?
- What do you understand to be the main message?
- Was there a protagonist or an antagonist?
- What emotions did you feel after watching the video?
- How does the video relate to what we are studying in class?
- Did you see a direct connection between animal extinction and solid waste produced by people?

If images are a preferred resource, use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) instead.

Lead a discussion that gets students thinking about the ways in which the plastic that is a part of their daily lives could potentially hurt or pose a threat to animals in their country, but also elsewhere in the world. This discussion may go in the direction of images students have seen of animals being caught in plastic nets or having stomachs full of plastic debris. Students may also talk about ocean currents that transport plastic and garbage to different parts of the world. Allow the discussion to evolve organically, giving little hints or suggestions along the way. Explain that the ideas discussed will help them with the next activity, which is designed to extend their understanding of animal extinctions using the gigapixel image.

13 EXTINCTION

Pivot Irrigation #11
High Plains, Texas Panhandle, USA, 2011

Oil Spill #4
Oil Skimming Boat, Near Ground Zero, Gulf of Mexico, June 24, 2010

Gigapixel activity

Explain to students that logic models are visual descriptions of a series of causes and effects that eventually lead to an outcome or result. People working in the field of economics, mathematics, urban planning, waste management and medicine all use logic models as a means of better understanding the different components of their work. Some logic models are highly detailed, with several steps and explanations, while others are simple, linking only a few pieces of a larger puzzle.

Make copies of the Logic Model card so that each student has their own copy (or divide the class into small groups and give one copy of the Logic Model card to each group). Explain the direction of flow presented in the model and the different components:

- Box 1 represents human activities that are necessary for the creation of plastic materials that either directly or indirectly pose a threat to one or more animal species
  - ▷ e.g., the expansion of oil sands; crude oil is needed to produce plastic, and oil sands destroy the habitats of terrestrial and aquatic animals where they feed, breed and seek shelter
- Box 2 represents individual plastic items seen in the gigapixel image
  - ▷ e.g., water bottle, six-pack rings, Ziploc bags
- Box 3 represents the ways the plastic items in box 2 can end up in natural habitats.
  - ▷ e.g., a water bottle can be blown by the wind off a truck and into a river, eventually making its way into the ocean and then a bay where various aquatic species live
- Box 4 represents how the accumulation of the plastics listed in box 2 in the habitats listed in box 3 threatens the success of a species.
  - ▷ e.g., an accumulation of water bottles in a bay threatens the fish that live there, because they may feed on microplastics that form as the water bottles degrade
- Box 5 represents how an animal species can eventually go extinct if no preventative measures are taken.
  - ▷ e.g., if the species of fish that lives in that bay belongs to a relatively small population, the more fish that die, the greater the chance that species will go extinct

13 EXTINCTION

Instruct students to begin completing their logic model by first filling out box 2, making use of the items shown on the gigapixel. Then, have them fill in the remaining boxes in a way that best suits their learning style. Review the completed logic models as a class and compare differences and similarities. Ask students to comment on whether or not they see a stronger connection between everyday plastic and species extinctions. Point out specifically the fact that there are two pathways to extinction and discuss the differences between them.

Optional: Have students use the AVARA app on the provided tablets to locate triggers 1 and 5 embedded in the gigapixel image and then watch the short films that appear on their devices.

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Coles Bay and University of Victoria* video, which explains how researchers collect samples of fish and study the contents of their stomachs in search of microplastics
- the *Coral* video, which explains how coral bleaching and pollution is degrading coral colonies
- the *Dandora* video, which shows how plastics can quickly accumulate in the environment
- the *Denman Island and University of British Columbia* video, which includes an interview with representatives of different coastal and First Nations organizations dedicated to restoring aquatic habitats
- the *Nigeria* video, which shows the impacts of forest clearing on nature and humans
- the *Port Renfrew* video, which highlights the story of Big Lonely Doug, Canada's second oldest Douglas fir tree

Virtual reality

Using the provided headsets, have students experience:

- the *Denman Island* video, which takes viewers on a boat ride off the coast of British Columbia

13 EXTINCTION

- the *Ivory Burn* video, which brings viewers back to the day when the president of Kenya ordered an ivory burn
- the *Dandora* video, in which viewers get to "walk" through the piles of plastic in the Dandora landfill

Augmented reality

Using the AVARA app on the provided tablets, and the wall-mounted vinyl triggers, have students explore:

- the *plastic bales* sculpture
- the *tusk pile* sculpture
- the *Sudan* sculpture
- the *Big Lonely Doug* sculpture (see lesson plan 10 on terraforming for the trigger)

Conclusion

Wrap up the lesson with a positive message about the important work being done by numerous organizations worldwide to preserve endangered habitats and protect wildlife that are suffering due to increasingly intense human land use. Consider watching the Seedbank video, which tells the story of a seed bank that houses the seeds of various trees, bushes, fruits and berries to ensure the survival of the world's plant species. Let students digest the fact that animals are not the only species that are in danger of going extinct — plants are included in this category as well. Explain to students that the first step in protecting endangered species is learning about the ways they are sensitive to human pressures, so they have already completed a major step towards the protection and conservation of some of the world's most important species.

Evaluation of student learning

Assess students' logic models. Do they make sense chronologically? Have students considered both terrestrial and aquatic species? Are the connections made between everyday plastics and declining animal populations simplistic or advanced? What is the level of vocabulary used when filling out the boxes in the model? Have students walk you through their model step-by-step to get their full interpretation.

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to protecting the world's endangered species.

13 EXTINCTION

For younger students

- Lead an activity that profiles different endangered species around the world. Have students draw a picture of their animal, or use pictures from magazines, and add a description below the picture that describes where it lives, what it eats, what makes it unique and why it is in danger. Create a portfolio that can be used to bring attention to these animals, or display the students' work in the school hallway as a gallery.
- Consider following these people and groups to keep up with their successes related to animal protection and habitat conservation:
  - ▷ Canadian Wildlife Federation (cwf-fcf.org/en/?src=topleftlogo)
  - ▷ Kids Discover (kidsdiscover.com/spotlight/endangered-species/2/)
  - ▷ National Wildlife Federation (nwf.org/Kids-and-Family)

For older students

- Have students assess how wildlife-friendly their school or home is. Have them research and create a checklist (much like a plumbing or electrical inspector would do) and walk around the grounds assessing each area for things that are working well or are in need of improvement. Examples include securing garbage in shelters or cans with locking lids, reducing water consumption with eco-friendly faucets, providing bird baths, etc. Have the students score the premises at the end of their survey and recommend ways to boost scores in the future. Take the next step and have students help make the necessary improvements!
- Join or follow a related worldwide initiative, such as:
  - ▷ Endangered species day (plasticpollutioncoalition.org/blog/2019/5/16/stop-plastic-pollution-on-endangered-species-day)
  - ▷ Endangered species coalition (www.endangered.org/10-easy-things-you-can-do-to-save-endangered-species/)
  - ▷ World Wildlife Foundation (worldwildlife.org/initiatives/protecting-species)

14 URBANIZATION

Grade Level

4–6 (can be modified for older grades)

Learning Goal

- To understand that now, more than ever, we need urban spaces to be clean, green and sustainable.

Learning outcomes

By the end of the lesson, students will be able to:

- Describe the difference between an urban and a rural environment.
- Talk about geographical differences in the distribution of cities and people across Canada.
- Explain the four Rs of recycling (reduce, reuse, recycle, repurpose) and how they might contribute to more environmentally friendly urban environments.
- Compare and contrast the four Rs.

Materials

Included:

- Gigapixel image
- The Four Rs of Recycling card (1)
- 10 Oculus headsets (optional)
- 10 headphones (optional)
- 10 iPads (optional)

Not included:

- Notebook or paper
- Pens or pencils
- Multiple copies of the Four Rs of Recycling card

Background information

Urban sprawl is not easily described, yet most people seem to know it when they see it. The term "urban sprawl" is a form of urbanization. It involves the movement of people from towns and cities to residential areas that spread over large rural or natural lands. In this way, cities and their suburbs slowly and systematically grow, limited only by geographical barriers. When urban sprawl occurs, large swaths of undeveloped land are converted to a mixture of land-use types, including residential, commercial, recreational and transportation. A common characteristic of some of the world's largest cities and suburbs that have reached their maximum extent is that they are slowly becoming overcrowded, as described in the following examples:

Los Angeles: Though it has become increasingly dense over time, Los Angeles represents the origination and model for the type of urban sprawl we see today: large areas of separated land use, single-family houses with yards and a reliance on the automobile. The development of the California freeway system in the early to mid-20th century was a catalyst for the development of large-scale urban sprawl.

Striking gravel pits are surrounded by the city of Los Angeles. Urban sprawl is designed to separate land use — residential from commercial from employment from industrial. Yet, as is the case here, land-use pressures sometimes encourage residential building close to sites that were once remote. Gravel pits supply the materials that will ultimately contribute to the development of the rapidly expanding city.

China: As with the early development of urban sprawl in the Los Angeles area, the critical infrastructure required for this type of expansion in China is the highway. Much like California's suburbs, China's new megacities are marked by low-density development, which presents numerous footprint issues as the global population grows.

Linked to urbanization in China is the construction of seawalls that are built to reclaim wetlands for urban and industrial expansion, resulting in a stark decline in biodiversity. The need for more land to support the world's most populous country, combined with environmental threats to existing settlement, has resulted in the construction of new seawalls covering over 60 per cent of the total length of China's coastline.

India: Zopadpattis are the most predominant informal settlements in India, and home to some of the lowest income people in the city of Mumbai. The Siddharth Nagar settlement is located in the business-dense neighbourhood of Worli. Since the time of British rule in India, Mumbai has been in a consistent struggle to find space for its ever-expanding population. Mumbai's population has shot up by a massive 98 per cent since 1911, and India's urban population density has increased 45 per cent in the past 15 years alone. It is estimated that a further 40 per cent of the country's population will live in urban areas by 2026.

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Connection to the Canadian Geography Framework

Concepts of Geographic Thinking

- Spatial significance
- Geographic perspective

Geographic Inquiry Process

- Ask geographic questions
- Interpret and analyze
- Evaluate and draw conclusions
- Reflect and respond

Geospatial Skills

- Foundational elements
- Technologies

Burtynsky photographs

Highway #5
Los Angeles, California, USA, 2009

Sidarth Nagar
Worli, Mumbai, India, 2016

Introduction

Use the information in the background to introduce the idea of urban sprawl to students. Ask them to list the different land types they are familiar with that are affected by or driven by urban sprawl (e.g., old-growth forests, industrial parks). Welcome stories from students who wish to share their experiences living in different residential settings.

Lead the discussion into one that focuses on waste management in different residential settings. Compare and contrast curbside collection with other possibilities, such as drop-off depots or a lack of municipally funded services. What advantages and disadvantages are associated with different mechanisms of waste disposal or recycling? Use the selected Burtynsky photographs (available in high resolution on the program website canadiangeographic.ca/anthropocene) as part of this warm-up.

Explain to students that the discontinuation of recycling services is an issue that is negatively affecting some cities across the world. In most cases, this is happening because of many factors, including China's recent refusal to accept foreign recyclables in an attempt to address its own pollution issues and a lack of buyers interested in purchasing recyclable materials at the end of their useful life. Many municipalities are finding it too difficult to pay the new extra costs to maintain their recycling programs.

With the future of recycling programs in jeopardy, and the rapid rates of urban sprawl affecting places all over the world, it is more important than ever that society works towards reducing its ecological footprint and its impact on the environment for future generations. Green living can be accomplished by everyone, everywhere, and the best place to start is with the four Rs of recycling (reduce, reuse, recycle, repurpose).

Gigapixel activity

Invite students to explore the gigapixel image and the different types of materials they see in it. Have them look for patterns and trends, such as the products that appear the most frequently, or the products that are consistently the dirtiest or the most damaged. Allow time for any questions that arise about what they see.

Test students' knowledge of the 4 Rs of recycling. It may be the case that most students have heard of the 3 Rs (reduce, reuse, recycle) but are unfamiliar with the fourth (repurpose). Work as a class to come up with a definition for each of the 4 Rs, making sure to highlight the differences between them.

Divide students into teams of 4–6 and hand each a copy of the Four Rs of Recycling card (alternatively, show them the card and have them draw their own template in their notebooks). Tell students that this is a Venn diagram, a type of drawing that, when completed, shows the relationships between and among groups of objects that share something in common.

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Nanpu Bridge Interchange
Shanghai, China, 2004

Salt River Pima-Maricopa Indian Reservation / Scottsdale
Arizona, USA, 2011

Have students walk around the gigapixel image and work in their teams to complete their Venn diagrams, writing down words or drawings that represent the items they see on the image and where they think they belong in the diagram.

As a class, review the placement of the items in each of the diagrams. Avoid approaching answers in a "right" or "wrong" fashion. Instead, discuss the reasons behind the placement of the items and why students chose to include them in their diagrams. Students may feel completely sure, a little sure or unsure of their choices — explore the reasons why with them.

Conclude the activity by covering the fact that students have just identified concrete steps that they can take to contribute to a greener city. By following the 4 Rs diligently, they will reduce the amount of solid waste they produce and ensure a more sustainable future. If enough citizens were to follow their lead, demands for material items would decrease and manufacturers would be forced to respond.

Optional: Students can also use the online interactive gigapixel instead of the giant floor mural (gigapixel-theanthropocene.org/Recycle/).

Learning extensions

Online video clips

Using a big screen, personal computers or the provided tablets, have students watch:

- the *Texas Oil* video that shows a prime example of urban expansion
- the *Full Cycle Part One* and *Full Cycle Part Two* videos, which follow recyclable materials from the curb to recycling facilities
- the *Epicerie LOCO* video that shows how easy it can be to shop sustainably for common household items
- the *Tom Szaky and LOOP* video that provides a powerful message to viewers about how they should be approaching recycling

Virtual reality

Using the provided headsets, have students experience:

- the *Recycled Life Cycle* video that shows the sequence of events when recycled materials move from a transfer station to a repurposing facility

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Augmented reality

Using the provided tablets and the triggers found in the wall-hanging print: Plastic bales, have students explore:

- the *plastic bales* sculpture using the AVARA app

Conclusion

Review the 4 Rs of recycling with students using an exit card activity. Have students independently respond to the following types of prompts:

- Write one thing you learned today.
- Explain how you could apply today's lesson tomorrow.
- Write one question you have about today's lesson.
- Did you enjoy working as part of a team today?
- Write something you were surprised by.

Evaluation of student learning

Assess students' Venn diagrams and their justifications for the placements that they chose. See if the deeper message of the immediate need for a more sustainable approach to living was understood, and how students made connections between this message and their everyday lives. Alternatively, have students assess each other's work following a clear set of criteria or a rubric based on your own design.

Learning to action

It is important to develop students' feelings of self-efficacy and their belief that they can succeed in making a difference when it comes to reducing their ecological footprint.

For younger students

- Compose a song with students about the four Rs of recycling so they may teach others about the importance of repurposing items rather than just recycling them.
- Lead an activity where students are challenged to come up with a 5th R that ties into the original 4, such as rebuying or refreshing. Have them design a logo with space for the 5 Rs and place posters around the school to help students think creatively about their recycling habits.

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- Consider following these people and groups to keep up with their innovative strategies for repurposing items:
  - ▷ Captain Planet Foundation (captainplanetfoundation.org/about/)
  - ▷ Meet the Greens (meetthegreens.org/)
  - ▷ Recyclezone (recyclezone.org.uk/)

For older students

- Lead an activity where students are challenged to come up with a 5th R that ties into the original 4, such as rebuying or refreshing. Have them design a logo with space for the 5 Rs and place posters around the school to help students think creatively about their recycling habits.
- Have students poll the school community to learn about how others apply the rules of recycling and create a word map of everyone's ideas.
- Join or follow a related worldwide initiative, such as:
  - ▷ Waste reduction week in Canada (wrwcanada.com/en)
  - ▷ Voices of youth (voicesofyouth.org/blog/teaching-new-generation-about-recycling-green-initiatives-youth-tomorrow)

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