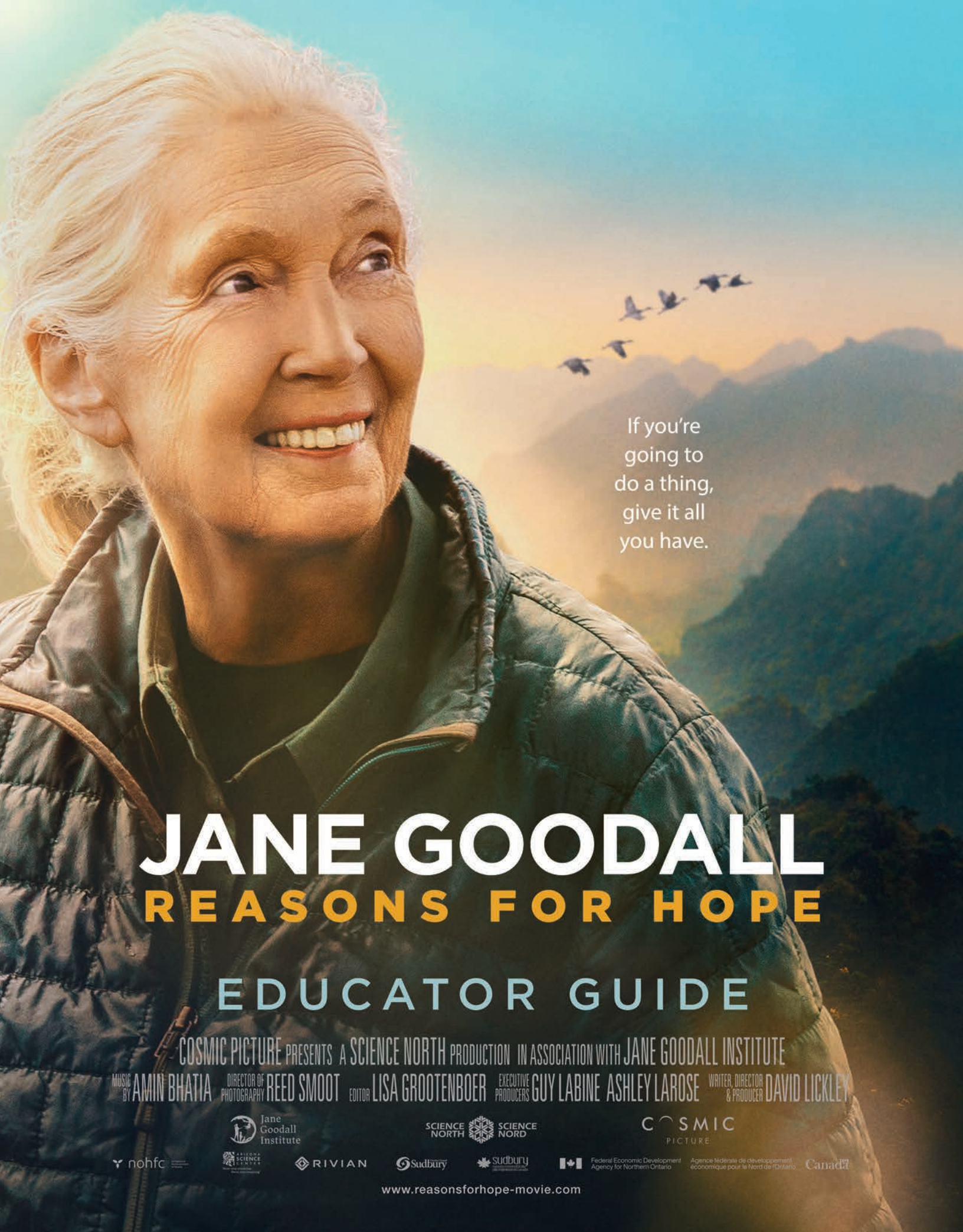

JANE GOODALL
REASONS FOR HOPE

EDUCATOR GUIDE

COSMIC PICTURE PRESENTS A SCIENCE NORTH PRODUCTION IN ASSOCIATION WITH JANE GOODALL INSTITUTE

MUSIC BY AMIN BHATIA DIRECTOR OF PHOTOGRAPHY REED SMOOT EDITOR LISA GROOTENBOER EXECUTIVE PRODUCERS GUY LABINE ASHLEY LAROSE WRITER, DIRECTOR & PRODUCER DAVID LICKLEY

Jane Goodall Institute · SCIENCE NORTH SCIENCE NORD · COSMIC PICTURE

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www.reasonsforhope-movie.com

EDUCATOR GUIDE
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Film Synopsis

Drawing on decades of work by the world's most famous living ethologist and environmentalist, Jane Goodall - Reasons for Hope, is an uplifting journey around the globe to highlight positive news stories that will inspire people to make a difference in the world around them.

Featured stories such as the Northern Bald Ibis' migration over the Alps in Austria and Italy, the re-introduction of the American Bison by the Blackfeet Nation in Montana, the worldwide recognized Sudbury, Ontario, Canada Regreening Story and inspiring youth-led initiatives involved in Jane Goodall's Roots & Shoots connect with historic footage of Jane's beginnings as a chimpanzee researcher.

Throughout, the film reinforces Jane's four pillars of hope that signal tremendous hope for the future: the amazing human intellect, the resilience of nature, the power and dedication of young people, and the indomitable human spirit.

Jane revolutionized how we view the world around us. Join her on this adventure of inspiration and hope.

Introduction

Dr. Jane Goodall is well known around the world for her work with animals, people, and the environment. She is a captivating speaker, a brilliant mind, and an inspiring source of hope for people, young and old. Science North worked with Cosmic Pictures to produce the new film for IMAX® and Giant Screen theater, Jane Goodall's Reasons for Hope, the amazing human intellect, the resilience of nature, the power and dedication of young people, and the indomitable human spirit.

The film highlights four incredible stories that embody those four pillars. However, we don't want the learning to stop in the theater. That's why we've produced twelve activities which will extend the learning into the classroom or the home.

How to use the activities

These activities are split into six sections: Jane's early work, each of the four pillars, and a final spotlight on green energy solutions. Most sections have an accompanying video. These are designed to highlight some of the science featured in the activities, but for the most part their use is optional. Each activity is intended to be used flexibly, and adapted to different age groups from kindergarten through grade 12. While the main body of each activity is written for a middle-ground audience, recommendations for adaptations to each activity are included for older and younger students, where such is needed. You, as a teacher or a parent, know your young learner best; adapt and change these activities as you need to in order to suit them.

While these activities are presented to match the order of the film, they are all fully independent of each other and can be completed in any order. You may choose to complete one, or even one part of one activity, and none of the others; you may choose to complete one section, or one activity from each section. In whatever combination, these activities are a complete experience.

DISCUSSION GUIDE

Reflection and discussion are important when learning about the environment, and our footprint on it. Talk to your students before and after the film to prepare them.

Before:

What is a place outdoors that is special to you?

What is your relationship with the environment around you?

What are some local environmental issues?

After:

What can you do that is good for the environment?

What gives you hope for the future?

What can you do to share that hope with others?

ACTIVITY 1:

Farmscape

SUMMARY:
Students will learn about three types of agroforestry and what their advantages, in order to design their own sustainable farm.

MATERIALS:

stardew.info/planner/

OR Legos

OR classroom craft materials such as paper, tape and markers

OR toy animals, trees, and food

SAFETY C0NSIDERATIONS:
If materials such as scissors or hot glue are being used, exercise caution to avoid cuts and burns.

Background Information:

The TACARE (Lake Tangayika Catchment Reforestation and Education) project was launched in Africa in 1994 as a community-centred conservation and development program. The goal is to create sustainable livelihoods while promoting environmental protection. To develop the project, the Jane Goodall Institute first surveyed communities to map their needs and priorities, working with their community partners to design the steps needed to move forward instead of imposing outside ideas. The TACARE project, which emerged from those efforts, is a methodology for how planning, policy, and technology can be used together to take care of the environment.

This new framework is aligned with the field of GeoDesign – a blend of science and values-based information that helps designers, planners, and stakeholders make better-informed decisions when planning the use or re-use of natural and built environments.

The TACARE project is multi-faceted in its approach, from infrastructure improvements, scholarships, and fuel-saving stoves to nurseries and tree-planting work which supports reforestation and grows economic opportunities. TACARE's health projects focus on access to family planning and counseling, as well as health interventions such as water and sanitation.

Also included in TACARE is the promotion of sustainable agricultural practices – primarily, agroforestry. They provide demonstration plots, and focus on training farmers and peer educators on agroforestry measures.

These measures result in increased biodiversity. Creating a biodiverse cropland creates habitat for animals, and their grazing in turn increases plant biodiversity by spreading seeds over greater areas of land. In this way, animals, people, and the environment feed into a system which promotes biodiversity and sustainability long-term between human management, the animals which live on that land, and the plants grown there.

Agroforestry is a method of sustainable farming that integrates the growing of trees with crops or livestock. It can be done by planting crops in forests or by planting trees on crop land, but the main stipulation is that there is more than one crop growing on the same land at the same time. It takes good planning and management, but the benefits are many. Agroforestry can help prevent erosion, introduce biodiversity, and protect crops. Positive competitive effects can also be present – for example, trees change the microclimate for the plants growing nearby, changing the amount of wind, sun, temperature, and humidity that the crop experiences. Plants such as legumes, which are good nitrogen fixers, can help trees access those resources as well. Trees and forests can form riparian forest buffers – these are woody plants on the edge of a stream or river. The tree roots and downed trees slow the flow of surface water, preventing erosion by forming a physical barrier which allows sediment to be trapped. They can also make good wind shields, protecting crops from high speed wind.

There are five recognized agroforestry systems

1 — Alley cropping

- Trees or shrubs are planted in rows, creating alleys in which crops can grow
- Biomass produced can be used on the farm
- Crop production is increased
- Microclimate benefits are to light, water, and nutrients in the soil

2 — Silvopasture

- Livestock graze and forage among a variety of ecotypes
- Many plants require grazing to maintain their populations
- Grazing can reduce competition from non-native plants
- Silvopasture can be established on almost any type of land
- Trees can produce fruits and nuts for livestock foraging
- Some pasture grasses grow better in some shade
- The animals must match the land type
- There must not be too many, and they must be moved regularly

3 — Forest farming

- Crops are grown in levels by planting food trees over ground crops which thrive in shaded/protected conditions.
- Intentionally uses vertical space and the interactions between plants and the microclimate
- Can include harvesting and scattering local seeds; thinning out competing plants; planting seeds, bulbs, or plant starts; adjusting soil pH or fertility; raising beds; and adding fencing.
- Ideal crops include ginseng, goldenseal, mushrooms, and decorative ferns
- Trees can be harvested for wood, fruit, and nuts

4 — Windbreaks/Shelterbelts

- One or more rows of closely spaced trees or shrubs planted at a right angle to the prevailing winds
- Protects crops, soils, animals, and building from winds
- Trees are planted in strips between fields, within fields, or near farm buildings

5 — Integrated riparian management

- Trees are planted along the edge of a water body
- Filters nutrients, pesticides, and animal waste from runoff
- Prevents erosion
- Creates wildlife corridors and habitats
- Protects cropland from flood damage

ACTIVITY 1:

Farmscape

Part 1 — DISCUSSION:
Use these questions as a guide to get students thinking. Rephrase the questions as needed to suit different age groups.

a. What do trees need to survive?

Water, nutrients, sunlight, space

b. What do crops need to survive?

Water, nutrients, sunlight, space

c. How can trees and crops help each other get the things they need?

Nutrient fixing, changing the microclimate, providing shade, creating biodiversity in the soil

d. In what ways can trees protect crops from conditions like wind and erosion?

They prevent erosion by creating a physical barrier with their roots, and protect crops from wind by being a physical barrier preventing the wind from accumulating speed over a flat surface.

e. How can farmers benefit from having both trees and crops?

Trees can be harvested for wood, fruit, nuts, and biomass, while providing benefits to the crops which allow the crops to produce more.

f. How can farm animals benefit from having trees where they graze and forage?

Additional shade, a variety of forage material, shelter

g. What might influence a farmer's decision on which method of agroforestry to use?

The natural conditions of the farmland (if there is a stream/lake/pond, or if it gets very windy); the kinds of crops they plant (mushrooms and legumes grow better in forest farming, whereas wheat or corn would do better in an alley cropping farm); if there are farm animals/livestock

ACTIVITY 1:

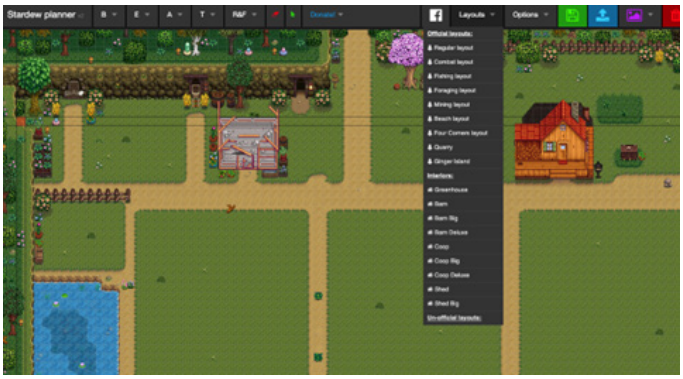
Farmscape

Part 2 —
HAVE STUDENTS PLAN THEIR OWN FARM.

a. Have students visit the site

stardew.info/planner/

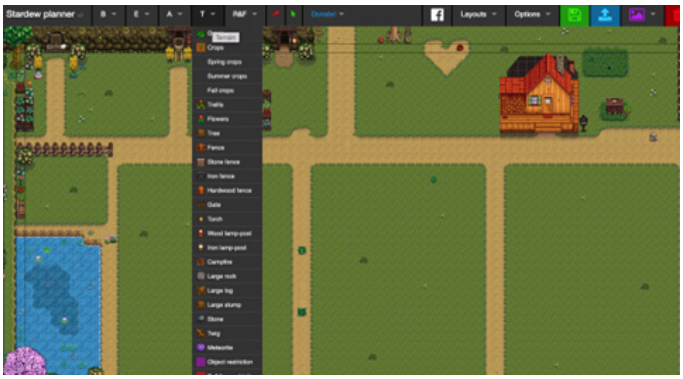
b. Select a base farm by selecting one of the layouts from the drop-down menu.



c. Evaluate the land you have. Are you at risk of high winds? Is there water which could cause erosion? Do you need a riparian management system or a windbreak?

d. Is there existing forest that can be used, will you plant your own, or is there both?

e. What do you plan to farm? Check out the crop options under the Terrain drop-down menu.



ADAPTATIONS:
If you don't have access to tablets or computers to use the Stardew Planner, or if the planner is too complex for the age group you're working with, you can have students plan and design their farm with other materials. They can use toys to represent food, animals, and trees, or they can build using Legos, or they can use craft materials to make an artistic representation of their farm. Use the materials that work best for you and your group.

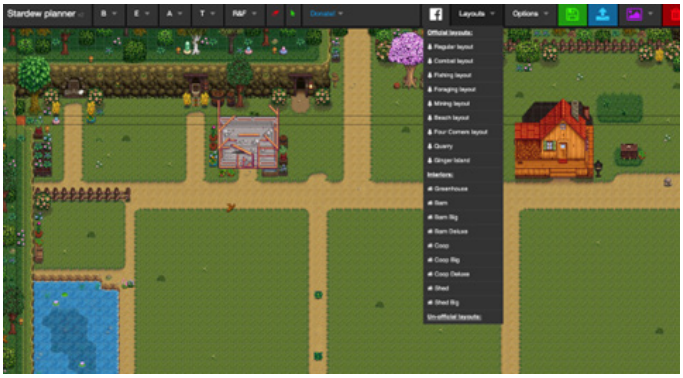
EXTENSIONS:

1. Present your farm to someone else. Which agroforestry method did you choose and why? What crops are you growing? Which kinds of trees did you choose? Why?
2. How could your farm be powered? Identify where you would place windmills or solar panels.

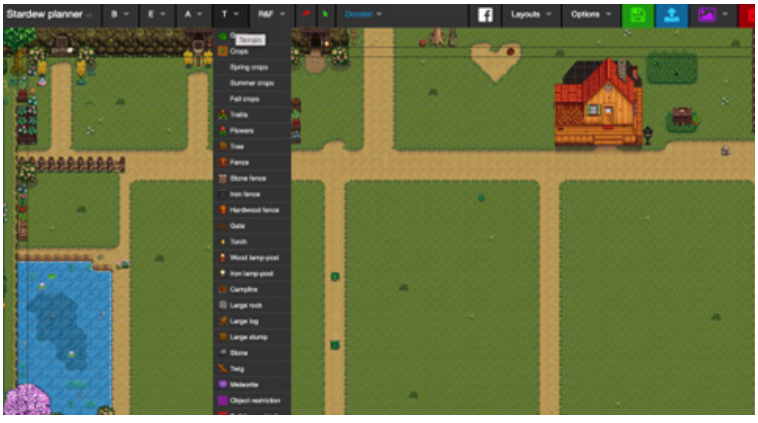
For additional resources, you can reach out to your local Roots & Shoots contact here:

rootsandshoots.global/

f. Do you want to plant trees for a wood harvest, a crop harvest, or a combination? Check out the tree options in the Artisan drop-down menu.



g. Will you have livestock on your farm? If so, make sure you place a hutch, barn, or stable and plan what your silvopasture should include. Find the buildings in the Buildings drop-down menu.



h. Place objects on your farm by selecting them in the drop-down menu. Wherever you click on the farm's grid system, that is where that item will be. Lay out and decorate your farm according to the plan you've made.

i. To delete an item, click on the red eraser icon at the top of the page. To select and move an item, click on the green curser icon.

j. You can save your farm as a picture by clicking the purple jpeg icon at the top right. You can erase and start your farm over by clicking on the red trash can. You can return to a project by uploading your downloaded copy by clicking on the blue upload icon. You can save your work by clicking on the green save icon.

k. Keyboard shortcuts and troubleshooting can be found by scrolling all the way down to the bottom of the page.

ACTIVITY 2:

Are You My Mommy?

CHAPTER:
The Amazing Human Intellect

SUMMARY:
Students will observe animal and human behavior to learn about how the Waldrapp team teaches the bald ibises in their care to be ready for life in the wild.

MATERIALS:
Videos, worksheets, electronic devices (tablet, phone, or computer)

SAFETY C0NSIDERATIONS:
Looking closely at a screen for too long can cause eye strain and headaches. Take breaks if needed.

Background Information:

Imprinting is the early practical experience in life that determines the social imprints, attitudes, and behavior of biological organisms in their latter parts of life. What an organism sees, experiences, and undergoes in the early chapters of its life is bound to create a huge effect on its behavioral psychology, life choices, and instincts later in life. Imprinting is a method by which the environment interacts with heredity in some "extra-sensitive phases" of life.

There are a variety of imprinting types. The most well-known is filial imprinting, where a newborn follows another animal that it recognizes or marks as its mother.

Usually, this happens between parents and the young, creating a vital social cohesion and establishing the means by which the species passes on behaviors. Sometimes an animal will imprint on another animal, such as a human, instead of on a member of its own species.

When poorly or unprofessionally done, a bird imprinting on a human instead of a bird of its own species means it will identify more closely with the human species than its own. It will be unable to communicate properly with humans, and equally unable to behave or communicate with its own species. For that reason, imprinted birds are usually not able to live in the wild.

Those using imprinting for conservation are careful not to allow that confusion by behaving and dressing in specific, researched ways. The Waldrapp Conservation and Research Team and their partners seen in the film use filial imprinting as a tool to teach the birds the behaviours they need to learn in order to re-establish a long-lost population in Europe. The juvenile imprinted birds can be taught migration routes.

In order to teach the bald ibises to migrate, they start with chicks. The team cuddles with them, feeds them, and spends lots of time with them, always wearing yellow – the same color as the plane's umbrella. They fly in the yellow microlight plane in front of the colony to teach them to follow. The bald ibises fly in formation naturally, and in the same year they hatch, can be taught to follow the plane to their overwintering site in Italy. There, the ibises are released into the wild to learn to feed by themselves and become independent from their human foster parents. When they grow old enough, the bald ibises will follow

their natural instinct to migrate back to the breeding sites in Austria, choosing their own route instead of the learned one. This is only possible because of the filial imprinting on two human foster mothers from the Waldrapp team. The ibises can migrate back and forth and can pass that behavior on to their own chicks.

ACTIVITY:

Scientists study animal behavior to understand more about a species. While sometimes they do so in person, often video is used in order to be less obtrusive and in order to avoid altering the animals' behaviors.

A video is provided here, which includes footage of the fledging chicks being fed by humans and of a chick being fed by a parent bird. Use the worksheet provided to analyze their behavior, and to identify what is being taught by the Waldrapp team during imprinting.

youtube.com/watch?v=CKml1AC1TEg

ADAPTATIONS:

This activity can be done individually or as a group discussion. If you don't have internet access to watch the videos, the extension can work as a standalone activity.

EXTENSIONS: Why fly in a V?

Bald ibises don't need to be taught to fly in formation - it's an innate behavior. The Waldrapp team has evidence to support the long-standing theory that there is an energy benefit to the V shape. The birds flap in phase – not at precisely the same time. Rather, they flap at just at the right moment to ride the updraft created by the wingtip vortex of the bird ahead of it. This means that they don't have to work as hard. The leader works the hardest, and the leader can change places with other birds in the formation to take breaks.

Fill a tub halfway with water. Fold up a sheet of tinfoil so it is about as wide as the container and two inches long. Press it down into the surface of the water and watch how waves form.

Add small floating items like beads to the water. The waves have energy that moves the beads.

Water and air are both fluids. The birds use waves in the air, created by the pressure imbalance between the top and bottom of their wings. By flying in formation, the ibises can take advantage of the energy in those waves to decrease the amount of energy with which they flap their wings to stay airborne, while still contributing to the wave.

You can show how that pressure imbalance creates lift by folding a small piece of paper gently in half, so that one end is rounded, and tape the flat edges together to create a wing shape. Put a pencil or a straw through the round end and blow gently over the top of the wing. The whole paper should lift slightly.

For an example of how air is displaced during flight, watch this video:

youtube.com/watch?v=2sh8_3-R90I

ACTIVITY 2:

Are You My Mommy?

WORKSHEET

Zoologists and other scientists who study animals often use video footage to analyze animal behavior. Scientists are looking for tiny behaviours, many of which last less than a second each, and those behaviors help us understand all sorts of useful information.

The first 10 seconds of the video are of two human surrogates feeding six ibis chicks. From left to right, they are Surrogate 1 and Surrogate 2, and Chicks 1 through 6. Use the chart to record every new behavior made by each subject. Describe each behavior in detail. Stop, start, and rewatch the video as many times as you need to. You may find it helpful to focus on one subject at a time.

Surrogate 1	Surrogate 2	Chick 1	Chick 2	Chick 3	Chick 4	Chick 5	Chick 6

The next 10 seconds of this video are of a mother ibis feeding her chick. In this case, we only have two subjects. Repeat the process from the last step.

Mother	Chick

ACTIVITY 2:

Are You My Mommy?

WORKSHEET

The last 10 seconds of the video are a side-by-side comparison. Use the video and your notes to answer the following questions.

1. How are the feeding behaviors of the human surrogates similar to those of the mother bird?

2. What behaviors do the chicks have in common?

3. What do the human surrogates do differently from the mother bird?

4. Do the techniques receive a similar response from the chicks?

5. Human surrogates and mother birds have different bodies and have to do the feeding task differently. How is the behavior of the surrogates designed to mimic that of the mother bird?

ACTIVITY 3:

Biologging Blitz

CHAPTER:
The Amazing Human Intellect

SUMMARY:
Students will use biologging data to solve a mystery.

MATERIALS:
Worksheet, data, a mobile device, Animal Tracker app

SAFETY C0NSIDERATIONS:
Part 2 of the activity includes non-graphic images of dead birds. Give students adequate warning and establish what to do if someone is upset by the contents.

Background Information:

Biologging is a practice used to collect a variety of data on living subjects. It is the recording of data using a small device attached to an animal.

Biologging can collect a variety of data, from body temperature and heart rate to GPS location. Often these tags are solar-powered so that they can continue to collect data without the battery running out of power. By this method, scientists on the Waldrapp team can collect data on the location of their flocks and their migration patterns over very long periods of time. When data is biologged, it is stored in the device internally, and the device must be removed and recovered to collect the data. Heart rate and other biometric data are usually biologged. GPS and accelerometric data can often be transmitted with a tracker and collected live.

Scientists can use that data for a number of purposes. For one, they can make sure the birds are following the migration routes between their feeding sites on the northern foothills of the Alps and the wintering site in Italy. If a position remains on the same location and the accelerometer indicates no body activity, the conservationists are alerted and try to find the bird. Often when this happens, it means the bird has died. By finding the bird's body, they can often tell if it was a case of electrocution, poaching, or something else entirely. Having that information means they can help reduce dangers to the birds. Poaching and electrocution make up 70% of deaths among the ibis colonies.

The data is also publicly shared on Animal Tracker. Citizen science is science that is done with the help of the public. For example, citizens can find and return trackers. As well, having the birds known to the public and endeared to people reduces instances of poaching.

ACTIVITY 3:

Biologging Blitz

Part 1 — MIGRATION

a. Download the Animal Tracker app from the Apple or Android app store.

b. Hand out the worksheet to students in groups or individually.

c. If you have limited internet access, click on the Settings wheel, and then choose 'Offline Mode'. A popup will appear asking you to configure your offline settings. Click to allow that to happen, and when configuration is complete, change the slider at the top right corner of the screen to turn offline mode on and off.

d. Click on the species tab and find the Northern Bald Ibis (Geronticus emerita) to learn more about the species. From that page, you can click to show the location of all bald ibises on the map, or to see the activity of 200 of the most recently active birds. When looking at activity, you can toggle to see the last two weeks, or the last 12 months.

e. Click on one of the blue dots representing an ibis to learn its name.

f. Find a blue dot that has made the migration in both directions, from Austria to Spain and from Spain to Austria.

g. Click on that dot to learn the bird's name.

h. Go to the map tab and type the bird's name into the search bar at the top of the screen.

i. Select the entry for details on that specific bird.

j. Fill out the worksheet with biologged data on your chosen bird.

ACTIVITY 3:

Biologging Blitz

Part 2 — FILES OF A PRIVATE EYE

a. Put students into groups.

b. There are two case files for two different birds: Dusti and Adalberto. Share a case file and the worksheet with each group.

c. Each case file contains real data from a bird that has died. Have students use the worksheet to work through the data to determine the cause of death of the bird.

d. When students have determined cause of death, have them design an invention that can protect birds from electrocution on power lines.

EXTENSIONS:

Choose a bald ibis to track over a longer period of time. Write down its name, generation, and colony. Every day, check on where the bird has moved. Print out a map for your journal and track your bird's journey. Put the date with each dot you make on the map.

Check out some bird-related citizen science projects that you can participate in from home, from school, or from a science centre or museum to help protect and monitor bird populations in North America:

birdscanada.org/discover-birds/bird-friendly-schools/citizen-science-at-school/

ADAPTATIONS:

The sections of this activity can stand alone and be done separately as per your own needs, interests, and ability, including the extensions.

Where access to devices is limited, project a single device for a larger group and conduct the activities as discussions instead.

Animal Tracker has a setting that can be used when there is no internet connection.

Ask for different levels of complexity in their worksheet answers, depending on the age of the student and the amount of time given. The optional advanced questions on the Migration worksheet are recommended for high school students.

With younger students with less advanced literacy skills, work through Files of a Private Eye as a group discussion, choosing only one case file.

ACTIVITY 3:

Biologging Blitz

Bird Operator's Report — ADALBERTO, ID 181752

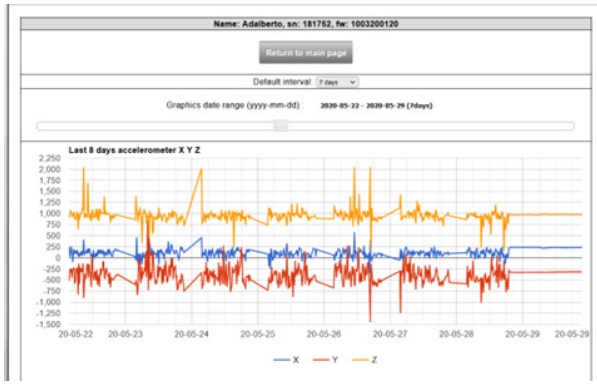
CONFIDENTIAL

For the eyes of the ELITE INVESTIGATION TEAM only.

ENCLOSED:

- **Accelerometer data**
- **GPS data**

Figure 1.



This chart shows that Adalberto has been moving regularly for days, with the movement mostly within daytime hours, and has suddenly stopped.

Figure 2.

device_id	UTC_date	UTC_time	data type	Latitude	Longitude	Altitude_m	speed km_h
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181752	05-18-20	15:06:00	GPS	46.140453	13.093212	200	1
181752	05-18-20	16:05:58	GPS	46.136135	13.088859	189	0
181752	05-19-20	8:50:23	GPS	46.137005	13.088841	171	0
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181752	05-21-20	16:02:44	GPS	46.136299	13.090735	185	2
181752	05-22-20	8:32:15	GPS	46.199524	13.171522	515	59
181752	05-22-20	9:32:01	GPS	46.150043	13.224361	194	0
181752	05-22-20	10:17:48	GPS	46.15176	13.149742	217	32
181752	05-22-20	11:01:52	GPS	46.18576	13.106921	137	2
181752	05-22-20	12:32:00	GPS	46.186367	13.10501	158	1
181752	05-22-20	13:32:59	GPS	46.191139	13.113452	260	35
181752	05-22-20	14:48:15	GPS	46.140667	13.09286	233	23
181752	05-22-20	15:16:56	GPS	46.13533	13.092343	239	60
181752	05-22-20	16:18:09	GPS	46.131592	13.102478	230	50
181752	05-23-20	8:30:31	GPS	46.144199	13.107458	171	8
181752	05-23-20	9:45:44	GPS	46.1581	13.10487	193	44
181752	05-23-20	10:00:45	GPS	46.18647	13.10535	149	36
181752	05-23-20	11:15:37	GPS	46.187397	13.106997	150	0
181752	05-23-20	12:30:33	GPS	46.185581	13.105019	170	4
181752	05-23-20	13:30:32	GPS	46.18396	13.103443	158	1
181752	05-23-20	14:15:32	GPS	46.184578	13.104465	147	2
181752	05-23-20	15:15:36	GPS	46.184105	13.103673	166	2
181752	05-23-20	16:15:44	GPS	46.186283	13.104112	159	0
181752	05-24-20	8:14:48	GPS	46.137352	13.094625	190	7
181752	05-24-20	9:59:56	GPS	46.126568	13.086186	213	2
181752	05-24-20	10:29:58	GPS	46.128559	13.087242	215	35
181752	05-24-20	11:45:35	GPS	46.18544	13.103292	141	2
181752	05-24-20	12:30:05	GPS	46.185646	13.10581	164	3
181752	05-24-20	13:30:06	GPS	46.187347	13.105855	159	1
181752	05-24-20	14:00:03	GPS	46.186203	13.10618	153	2

ACTIVITY 3:

Biologging Blitz

Bird Operator's Report — ADALBERTO, ID 181752

CONFIDENTIAL

For the eyes of the ELITE INVESTIGATION TEAM only.

INSTRUCTIONS:

The bird operators have reported the presence of dead body indicators in the data. Please confirm their findings in the data provided, and, if there are indeed dead bird indicators, please go to the scene for recovery.

Figure 2. (cont.)

device_id	UTC_date	UTC_time	data type	Latitude	Longitude	Altitude_m	speed km_h
181752	05-24-20	15:15:22	GPS	46.188755	13.107232	-1171	27
181752	05-24-20	16:15:14	GPS	46.187092	13.104261	156	0
181752	05-25-20	8:43:45	GPS	46.127605	13.084307	103	0
181752	05-25-20	9:43:43	GPS	46.127899	13.08442	152	4
181752	05-25-20	10:28:43	GPS	46.128357	13.083725	84	22
181752	05-25-20	11:28:51	GPS	46.127804	13.083665	164	0
181752	05-25-20	12:28:44	GPS	46.16914	13.092295	281	26
181752	05-25-20	13:58:49	GPS	46.164837	13.085127	131	3
181752	05-25-20	14:14:06	GPS	46.186794	13.107306	420	64
181752	05-25-20	15:13:45	GPS	46.185852	13.105093	148	1
181752	05-25-20	16:28:51	GPS	46.18576	13.104571	156	0
181752	05-26-20	8:28:09	GPS	46.143143	13.108452	176	0
181752	05-26-20	9:29:33	GPS	46.181904	13.090758	182	37
181752	05-26-20	10:58:11	GPS	46.141125	13.10074	245	82
181752	05-26-20	11:58:12	GPS	46.112526	13.100826	470	42
181752	05-26-20	12:28:11	GPS	46.160343	13.099486	212	51
181752	05-26-20	13:43:19	GPS	46.18589	13.102895	138	2
181752	05-26-20	14:43:12	GPS	46.185497	13.105195	162	1
181752	05-26-20	15:28:16	GPS	46.184505	13.104888	171	1
181752	05-26-20	16:58:35	GPS	46.162117	13.095556	234	51
181752	05-27-20	8:57:34	GPS	46.126442	13.091601	309	35
181752	05-27-20	9:57:33	GPS	46.179649	13.074672	437	39
181752	05-27-20	10:12:44	GPS	46.178173	13.004537	488	45
181752	05-27-20	11:12:36	GPS	46.14312	12.880693	160	1
181752	05-27-20	12:28:15	GPS	46.142738	12.880878	149	0
181752	05-27-20	13:27:34	GPS	46.146946	12.880107	240	29
181752	05-27-20	14:42:35	GPS	46.142872	12.880593	156	0
181752	05-27-20	15:42:36	GPS	46.143715	12.882122	156	0
181752	05-27-20	16:12:43	GPS	46.143757	12.881693	157	1
181752	05-28-20	8:42:34	GPS	46.14904	12.886657	175	1
181752	05-28-20	9:27:38	GPS	46.148891	12.88681	155	0
181752	05-28-20	10:27:36	GPS	46.149139	12.886893	180	1
181752	05-28-20	11:12:45	GPS	46.148888	12.886925	245	2
181752	05-28-20	12:27:33	GPS	46.148884	12.886679	153	29
181752	05-28-20	13:42:36	GPS	46.145828	12.886205	187	4
181752	05-28-20	14:12:36	GPS	46.146358	12.887136	211	30
181752	05-28-20	15:42:40	GPS	46.138973	12.882452	184	51
181752	05-28-20	16:12:35	GPS	46.14357	12.880663	172	2
181752	05-29-20	8:26:48	GPS	46.130146	12.870579	146	2
181752	05-29-20	9:26:53	GPS	46.130062	12.870653	122	2
181752	05-29-20	10:11:55	GPS	46.129959	12.870308	150	1
181752	05-29-20	11:26:47	GPS	46.130039	12.87052	154	0
181752	05-29-20	12:27:00	GPS	46.13018	12.870407	154	3
181752	05-29-20	13:26:56	GPS	46.130173	12.870457	150	2
181752	05-29-20	14:11:50	GPS	46.130112	12.870572	138	2
181752	05-29-20	15:41:52	GPS	46.130001	12.870455	166	1
181752	05-29-20	16:56:48	GPS	46.130028	12.870559	201	2
181752	05-30-20	8:41:15	GPS	46.130035	12.870595	151	0
181752	05-30-20	9:41:19	GPS	46.15675	12.883714	172	24
181752	05-30-20	10:42:38	GPS	0	0	0	0
181752	05-30-20	11:42:38	GPS	0	0	0	0
181752	05-30-20	12:42:38	GPS	0	0	0	0
181752	05-30-20	13:42:38	GPS	0	0	0	0
181752	05-30-20	14:42:38	GPS	0	0	0	0
181752	05-30-20	15:42:38	GPS	0	0	0	0
181752	05-30-20	16:42:38	GPS	0	0	0	0

This chart shows some of the data that has been transmitted from Adalberto's GPS biologging tag.

ACTIVITY 3:

Biologging Blitz

Forensics Report — ADALBERTO, ID 181752

CONFIDENTIAL

For the eyes of the ELITE INVESTIGATION TEAM only.

ENCLOSED:

- **Forensic Photo**

INSTRUCTIONS:
Please report your findings and the cause of death and take the appropriate actions.

Figure 1.

The forensic department confirmed your finding of singed feathers. They also found evidence of internal bleeding. Combined, they report indications of electrocution.

ACTIVITY 3:

Biologging Blitz

Forensics Report — ADALBERTO, ID 181752

INSTRUCTIONS:
When the body has been secured, record what you saw at the scene of death. Please return the body to the forensics department for further analysis.

CONFIDENTIAL
For the eyes of the ELITE INVESTIGATION TEAM only.

ENCLOSED:

- **Scene Photo**

Figure 1.

At the scene, you find the intact body of Adalberto. You find it at the base of an electrical pole, and you notice some feathers are singed.

ACTIVITY 3:

Biologging Blitz

Bird Operator's Report — DUSTI, ID 181756

CONFIDENTIAL

For the eyes of the ELITE INVESTIGATION TEAM only.

ENCLOSED:

- **Accelerometer data**
- **GPS data**

Figure 1.

This chart shows that Dusti has been moving regularly for days, with the movement mostly within daytime hours, and has suddenly stopped.

Figure 2.

device_id	UTC_date	UTC_time	data type	Latitude	Longitude	Altitude_m	speed km_h
181756	01-01-19	7:02:59	GPS	46.120014	13.28393	120	0
181756	01-01-19	9:17:09	GPS	46.12104	13.287436	168	2
181756	01-01-19	10:32:06	GPS	46.121738	13.290201	140	2
181756	01-01-19	11:17:06	GPS	46.121601	13.286592	122	27
181756	01-01-19	12:17:14	GPS	46.121273	13.286685	115	1
181756	01-01-19	13:17:06	GPS	46.121155	13.286877	124	1
181756	01-01-19	14:47:04	GPS	46.119911	13.284008	146	4
181756	01-01-19	15:17:06	GPS	46.121979	13.279235	152	53
181756	01-01-19	16:33:26	GPS	46.11908	13.276168	194	0
181756	01-02-19	7:32:09	GPS	46.118923	13.285198	168	0
181756	01-02-19	8:32:03	GPS	46.119785	13.284019	103	2
181756	01-02-19	9:17:04	GPS	46.120934	13.287403	129	2
181756	01-02-19	10:17:01	GPS	46.120312	13.28875	179	59
181756	01-02-19	11:17:02	GPS	46.120258	13.28228	111	1
181756	01-02-19	12:02:01	GPS	46.120457	13.284781	125	1
181756	01-02-19	13:17:04	GPS	46.121449	13.281672	121	0
181756	01-02-19	14:32:03	GPS	46.119942	13.284072	123	0
181756	01-02-19	15:32:02	GPS	46.121696	13.28235	147	32
181756	01-02-19	16:02:09	GPS	46.111935	13.272877	35	43
181756	01-03-19	7:02:06	GPS	46.120079	13.284157	127	0
181756	01-03-19	8:16:34	GPS	46.119682	13.285793	141	11
181756	01-03-19	9:01:37	GPS	46.077793	13.283502	443	61
181756	01-03-19	10:31:34	GPS	45.631527	13.04494	97	59
181756	01-03-19	11:17:55	GPS	45.4907	12.604868	47	54
181756	01-03-19	12:01:32	GPS	45.272778	12.299256	76	60
181756	01-03-19	13:46:35	GPS	44.849785	12.240211	32	40
181756	01-03-19	14:31:36	GPS	44.615223	12.231127	83	46
181756	01-03-19	15:17:02	GPS	44.508163	12.245907	32	52
181756	01-03-19	16:02:04	GPS	44.529003	12.228739	-16	33

ACTIVITY 3:

Biologging Blitz

Bird Operator's Report — DUSTI, ID 181756

CONFIDENTIAL

For the eyes of the ELITE INVESTIGATION TEAM only.

INSTRUCTIONS:
The bird operators have reported the presence of dead body indicators in the data. Please confirm their findings in the data provided, and, if there are indeed dead bird indicators, please go to the scene for recovery.

Figure 2. (cont.)

device_id	UTC_date	UTC_time	data type	Latitude	Longitude	Altitude_m	speed km_h
181756	01-04-19	7:30:02	GPS	44.519962	12.221652	-18	1
181756	01-04-19	8:15:01	GPS	44.519772	12.22425	0	33
181756	01-04-19	9:46:01	GPS	44.295654	12.216052	2	38
181756	01-04-19	10:15:09	GPS	44.148087	12.214724	75	41
181756	01-04-19	11:30:00	GPS	43.785671	12.198147	578	50
181756	01-04-19	12:00:00	GPS	43.68623	12.13512	897	50
181756	01-04-19	13:15:14	GPS	43.677101	12.116299	942	2
181756	01-04-19	14:15:00	GPS	43.56263	12.03144	520	40
181756	01-04-19	15:15:12	GPS	43.332821	11.698232	466	42
181756	01-04-19	16:15:03	GPS	43.260109	11.639552	317	2
181756	01-05-19	7:27:41	GPS	43.266605	11.636202	326	3
181756	01-05-19	8:57:36	GPS	43.267548	11.63872	312	14
181756	01-05-19	9:42:39	GPS	43.268951	11.628515	267	0
181756	01-05-19	10:27:40	GPS	43.2206	11.583792	245	41
181756	01-05-19	11:12:36	GPS	43.09005	11.376973	209	53
181756	01-05-19	12:42:37	GPS	43.019829	11.358455	80	2
181756	01-05-19	13:42:40	GPS	43.019989	11.358898	69	3
181756	01-05-19	14:57:42	GPS	43.013474	11.361798	58	1
181756	01-05-19	15:58:05	GPS	43.023201	11.362779	102	0
181756	01-05-19	16:12:36	GPS	43.023357	11.362701	110	1
181756	01-06-19	7:27:45	GPS	43.039516	11.333968	-316	3
181756	01-06-19	8:58:16	GPS	43.033268	11.35688	82	1
181756	01-06-19	9:43:23	GPS	43.033154	11.355577	22	2
181756	01-06-19	10:28:14	GPS	43.036045	11.354934	66	39
181756	01-06-19	11:12:52	GPS	43.093395	11.333195	101	2
181756	01-06-19	12:57:51	GPS	43.095482	11.332668	120	53
181756	01-06-19	13:58:44	GPS	43.209599	11.261525	182	39
181756	01-06-19	14:43:23	GPS	43.303116	11.231776	244	1
181756	01-06-19	15:58:17	GPS	43.317783	11.23426	109	38
181756	01-06-19	16:52:29	GPS	43.324947	11.235012	329	2
181756	01-07-19	7:28:41	GPS	43.321434	11.233207	306	38
181756	01-07-19	8:28:40	GPS	43.302147	11.233345	249	2
181756	01-07-19	9:58:48	GPS	43.30077	11.233922	186	0
181756	01-07-19	10:13:50	GPS	43.300922	11.233942	184	2
181756	01-07-19	11:28:42	GPS	43.302502	11.233468	212	1
181756	01-07-19	12:58:43	GPS	43.364483	11.107928	231	16
181756	01-07-19	13:28:43	GPS	43.405933	11.168273	248	33
181756	01-07-19	14:43:49	GPS	43.377453	11.253745	306	1
181756	01-07-19	15:43:47	GPS	43.377632	11.253485	295	1
181756	01-07-19	16:43:46	GPS	43.377651	11.253407	290	1
181756	01-08-19	7:14:15	GPS	43.377789	11.25351	275	1
181756	01-08-19	8:59:13	GPS	43.377647	11.25355	311	2
181756	01-08-19	9:14:15	GPS	43.377754	11.253431	267	3
181756	01-08-19	10:44:17	GPS	43.377708	11.2535	293	1
181756	01-08-19	11:59:21	GPS	43.344124	11.28452	331	48
181756	01-08-19	12:45:33	GPS	0	0	0	0
181756	01-08-19	13:45:33	GPS	0	0	0	0
181756	01-08-19	14:45:33	GPS	0	0	0	0
181756	01-08-19	15:45:33	GPS	0	0	0	0
181756	01-08-19	16:45:33	GPS	0	0	0	0
181756	01-08-19	17:45:33	GPS	0	0	0	0
181756	01-08-19	18:45:33	GPS	0	0	0	0

This chart shows some of the data that has been transmitted from Dusti's GPS biologging tag.

ACTIVITY 3:

Biologging Blitz

Forensics Report — DUSTI, ID 181756

CONFIDENTIAL

For the eyes of the ELITE INVESTIGATION TEAM only.

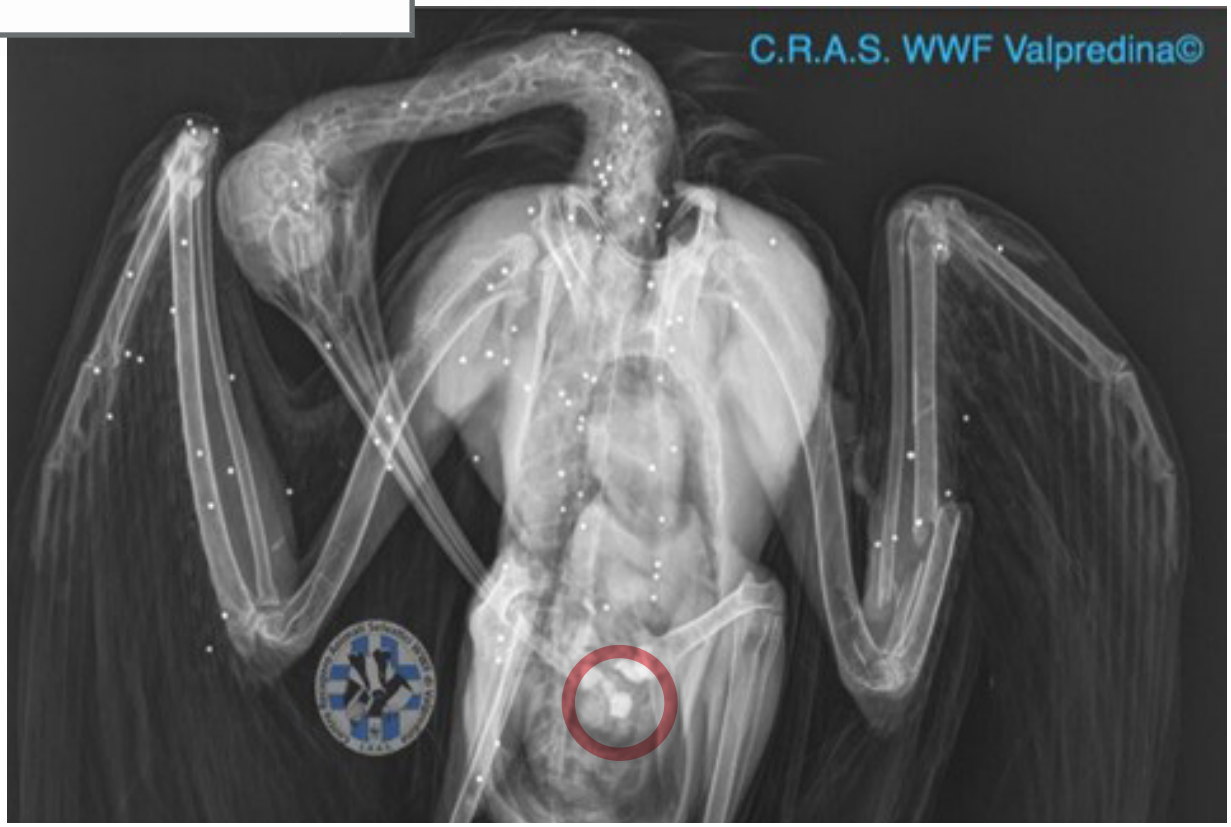
ENCLOSED:

- **X-rays**

INSTRUCTIONS:
Please report your findings and the cause of death and take the appropriate actions.

Figure 1.

The X-ray shows a metal bullet in Dusti's abdomen, the entry point for which was not clear in your scene survey.



ACTIVITY 3:

ACTIVITY 3: BIOLOGGING BLITZ

Forensics Report — DUSTI, ID 181756

CONFIDENTIAL

For the eyes of the ELITE INVESTIGATION TEAM only.

ENCLOSED:

- **Scene Photo**

INSTRUCTIONS:

When the body has been secured, record what you saw at the scene of death. Please return the body to the forensics department for further analysis.

Figure 1.

At the scene, you find the intact body of Dusti. There are no nearby poles or wires, no signs of predation, and no obvious causes of death upon a visual assessment.

REPORT
ELITE INVESTIGATION TEAM

ACTIVITY 3: BIOLOGGING BLITZ

WORKSHEET

Bird operators on the Waldrapp team look for three 'dead bird indicators':

- Horizontal movement is 0 – this means it is staying in one place.
- Acceleration is 0 – this means that no movement is being detected at all.
- Vertical height is ground level – this means the ibis is on the ground.

Alone, each of these indicators can have explanations.

1. Why might an ibis not be moving forward?

2. Why might an ibis not be moving?

3. Why might an ibis be on the ground?

4. Open your bird operator's report. The first figure is a chart, showing your ibis's movements from the last week. Circle on the graph where acceleration reaches 0. What is the date at that point?

The second figure is a table. It includes some data from your bird's GPS tag, which has been collecting data since it was released. You can see what date and time the data was collected, its GPS coordinates, its vertical height (altitude), and its speed. The data collected from the tag is in metric, which means it is measured in meters and in kilometers per hour.

Look in the data for the date at which acceleration reached 0 on the previous graph.

5. At what time did the ibis's altitude and speed both reach 0?

6. What were the ibis's last known coordinates?

REPORT
ELITE INVESTIGATION TEAM

ACTIVITY 3: BIOLOGGING BLITZ

WORKSHEET

The ibis's data is showing all three dead body indicators at the same time: acceleration is 0, altitude is 0, and speed is 0.

The next step is to look for a body. Sometimes there is no body, which usually means another animal has eaten it, or the body has been removed or hidden by poachers. That means we will never know the cause of death. Even when there is a body, though, cause of death can be unclear.

Open your Scene Findings, and inspect the photos provided.

7. Is there anything at the scene that hints at cause of death?

Because we cannot always tell cause of death from the scene alone, the body should go next to forensics. A veterinarian will examine the body for signs and symptoms. An X-ray can show pellets from a gun, which would indicate accidental hunting. Often the hunter has a license to hunt birds, and is therefore not a true poacher, but did not realize that the bird was a Northern Bald Ibis, which is illegal to shoot, until it was too late. An internal exam can show signs of internal bleeding, and the feathers can show signs of burns and singeing, both of which indicate electrocution from an electrical pole. These are the most common causes of death among bald ibises in Europe.

Open your Forensics Report and read what the veterinarian found.

8. How do you think your ibis died?

9. Electrical lines are responsible for the majority of bald ibis deaths. When they land in such a way that they are touching either two wires at the same time, or a wire and the pole, the electricity can pass through them. Draw a prototype of your own invention that could help prevent electrocution.

REPORT
ELITE INVESTIGATION TEAM

ACTIVITY 3: BIOLOGGING BLITZ

WORKSHEET

Animal Tracker app

When did the migration from Austria or Germany to Italy begin and end?

_____

_____

When did the migration from Italy to Austria begin and end? _____

_____

Why do you think migrations happen at those times of the year?

_____

_____

_____

Name of bird: _____

Most recent coordinates: _____

Date and time of most recent log: _____

In what country was your bird most recently recorded?

_____

How many miles has your bird travelled total? _____

How many countries has your bird travelled in or through?

_____

Describe your bird's ring. _____

Is your bird male or female? _____

What information do you have on where your bird hatched or was raised? _____

_____

To what generation does your bird belong? _____

Does your bird have any sightings? yes / no

If yes, describe the sighting: _____

_____

Click on the map to see your bird's activity. You can use your finger on the timeline to move through specific days or times, or you can let it play.

Circle in one color the area in which your bird has been logged during the last two weeks.

Draw lines in a different color indicating where your bird has traveled in the last 12 months.

REPORT
ELITE INVESTIGATION TEAM

ACTIVITY 3: BIOLOGGING BLITZ

WORKSHEET

(Optional, Advanced)

Select one day within the 2-week period of activity. Fill out this chart with the individual GPS points:

Highest Longitude: _____

Lowest Longitude: _____

Difference (highest – lowest): _____

Highest Latitude: _____

Lowest Latitude: _____

Difference (highest – lowest): _____

Longitude:	Latitude:

Create an x-y axis on graph paper, with the y-axis on the right-side end of the x-axis. Label the x-axis with the longitude, and the y-axis with the latitude. Chart each GPS point on your graph to make a map of where your bird travelled that day.

ACTIVITY 4:

Take Root

SUMMARY:
Students will explore how grasses and legumes prevent erosion via root networks by growing their own grasses and comparing how that soil erodes compared to an unseeded control plot.

MATERIALS:
Watering can, water, soil, seeds (native to your area), trays

youtube.com/watch?v=Zm5RIrn8FqE

SAFETY CONSIDERATIONS:
Be careful with heavy lifting of water, soil, and plants. Always bend from the knees when lifting heavy items.

Background Information:

Sudbury uses mainly native grasses (fall rye, Canada wildrye, little bluestem, and slender wheatgrass) and legumes (alsike clover) in its regreening efforts to stabilize and repair the soil.

When there is soil on rock but no plants, there is no root network to hold the soil together. That means that rain and moving water can easily move the soil, causing a very fast erosion effect, which exposes more rock, and creates less land where things can grow. Part of letting the ecosystem recover is introducing plants that can stabilize the soil and keep it in place. Trees are a vital part of this, but they grow slowly. Grasses and legumes are an important early step in regreening because they create a biodiverse ecosystem that is welcoming to life, while stabilizing the soil with their root networks.

Legumes are especially important due to the symbiotic relationships they form with nitrogen-fixing bacteria. Those bacteria take nitrogen out of the air to make ammonia (NH_3), which supplies plants with the nitrogen they need to photosynthesize. The presence of nitrogen-fixing bacteria in the soil is vital to the regreening efforts.

A video has been provided that demonstrates a forest floor transplant. Planting a mat can speed up the seeding process and has the added benefit of bringing back the beneficial bacteria and fungi that can help make the soil healthier at the same time. The final shot of the video is of an established transplant. You can see how it begins to spread and become a natural part of the forest floor.

EXTENSIONS:

Go on a nature walk and use the Seek app to identify the native grasses and flowers in your area. Check out where else that plant grows, when its growing season is, and what its taxonomy is in the app.

ADAPTATIONS:

Seeds for native grasses can be difficult to acquire. In Sudbury, they are sometimes acquired via collecting and propagating. If you cannot find native grass seeds, you can do this activity with a native wildflower mix or, if necessary, with ordinary grass seed. If you are using this activity as an organization that has students arriving and leaving quickly, grow the plots in advance and just do the erosion experiment with students.

a. Prepare two trays by filling each with 2-3 inches (5-7.5 cm) of soil.

b. In one tray, plant seeds for local grasses by sprinkling them on top and then covering them with a thin layer of soil.

c. Gently water the freshly seeded tray.

d. Observe daily until the grass has grown.

e. Pull up a single blade of grass. Observe how the roots keep soil tangled in them.

f. Using a watering can to simulate rain, pour some water over one end of each tray, one seeded and one unseeded. Which tray sees less soil movement?

g. Tip each tray so it is on an angle and pour the water again from the high end of the tray. Is there a difference in soil movement?

The roots of the grasses keep the soil from eroding as badly as the soil with nothing planted in it. These roots are especially helpful on a slope, where gravity works with the water to pull down the soil.

ACTIVITY 5:

Thirsty Trees

CHAPTER:
The Resilience of Nature

SUMMARY:
Students will explore the ways in which trees change the environment via a selection of simple experiments with a sapling.

MATERIALS:
A sapling (or other plant), soil, two large containers, food coloring, water, a measuring tape, a measuring jug, a scale

Optional: a cup, a straw, any pH indicator

SAFETY CONSIDERATIONS:
Be careful with heavy lifting of water, soil, and plants. Always bend from the knees when lifting heavy items.

Background Information:

All organic things are made up of molecules that include carbon. Carbon is stored in living things, and when living things die, that carbon returns to the environment. The movement of carbon through living things, the atmosphere, and the environment is called the carbon cycle. The carbon cycle moves very slowly. A lot of carbon is stored for a very long time and is released very gradually. A lot of that carbon is stored in fossil fuels, and that carbon is released when fossil fuels are burned. Burning fossil fuels adds carbon to the atmosphere a lot faster than the carbon cycle would naturally see.

A key part of addressing climate change is, therefore, finding ways to capture and store carbon. There are efforts underway to do so, but natural carbon sinks play a huge role.

Half of the dry weight of a tree is carbon. Trees take in atmospheric carbon in the form of carbon dioxide (CO_2). Trees hold the carbon part of the CO_2 molecule in their wood and release the oxygen. This helps give us air to breathe. It also means that trees are a vital natural carbon sink. When we cut down and burn trees, we release huge amounts of carbon into the atmosphere. When we plant trees, we add carbon sinks to the environment.

Trees capture more than just carbon. Trees and forests make incredible filtration systems for pollutants and contaminants in the environment – that's one of the reasons why the regreening effort in Sudbury focusses so much on planting trees. Trees take up large amounts of water – and all sorts of substances are dissolved in that water. Trees can prevent those dissolved

substances from reaching larger bodies of water. Planting forests near lakes in Sudbury has resulted in lakes becoming cleaner and has allowed many species to be reintroduced in those bodies of water.

To do all of that, though, trees need a lot of water. Sometimes, planting a lot of trees near a stream or a smaller pond can cause that water source to dry up, as the trees place a heavier demand for water on the land. That means we must manage reforestation and water conservation carefully in areas where there are water shortages.

ADAPTATIONS:
You can do part 2 of the carbon storage activity as a standalone if a sapling cannot be acquired.

We recommend using a flowering plant for the water filtration and absorption activity for the best effect. If you want to use a sapling, expect results to take longer, and make sure you are using a tree with deciduous leaves in a light color, as well as a dark food coloring, for better contrast.

Carbon Storage

a. Weigh the sapling.

b. Water makes up around half of a tree's weight; divide the weight of the sapling by 2 to find its dry weight.

c. Carbon makes up about half of a tree's dry weight. Divide the dry weight of the sapling by 2; that is how much carbon your sapling is storing!

d. Look up how much mass your sapling species gains in a year, on average. How much carbon will your sapling store in 5 years? In 10 years? In 100 years?

EXTENSIONS:
Trees also filter pollutants from the air. Fill a cup halfway with water and use a straw to blow into it as much as possible for a minute. Test the pH of the water – it should be slightly acidic.

Stop blowing into the cup and instead gently waft air into it. The water should slowly return to neutral.

It takes much longer for the water to return to neutral than it takes to acidify it. Trees filter pollutants from the air, allowing the process to happen less slowly. This process also cools the ambient temperature, which can help to combat urban heat islands.

Water: Filtration and Absorption

a. Make sure the pot your plant is in has drainage holes. If not, add them.

b. Place the pot in a large container.

c. Fill a similarly sized pot with soil. Place that pot in a second large container.

d. Make a mix of food coloring and water in a measuring jug.

e. Pour the water into both containers.

f. Mark on the container how high the water level is with the date. Mark the new level twice per day with the date and time.

g. Where does the water go?

   Trees store water, which means more water is absorbed where there are more trees.

h. Why did the plant change color?

   Trees can filter pollutants, mercury, and nutrients from water and soil. They change the makeup of the nutrients that make it into water systems. Thus, the planting of forests can improve water health. We can see how the tree absorbs and stores things from the water by how it absorbs and stores the food coloring.

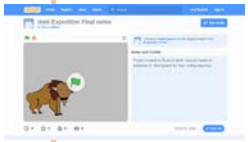
ACTIVITY 6:

Iinnii Expedition

CHAPTER:
The Indomitable Human Spirit

SUMMARY:
Students will play a game which highlights the relationships buffalo have with the world.

MATERIALS:



scratch.mit.edu/projects/746927874

SAFETY CONSIDERATIONS:
Staring at a screen for too long can cause headaches and eye strain. Take breaks if needed.

Background Information:

The American bison (Bison bison) is also culturally called *buffalo*, reflecting how the buffalo is a relation to the Siksikaitsitapi (the Blackfoot Confederacy). This activity guide will use the name bison when referring to ecology, and buffalo when referring to culture. Bison once roamed across North America from the Gulf of Mexico all the way to Alaska. They were, and are, a vital source of food and materials for the continent's First People, including Siksikaitsitapi, for whom the buffalo is central to life, economy, spirituality, and culture. The bison was hunted nearly to extinction by colonial settlers.

The Siksikaitsitapi see all living things as connected and related. The buffalo, the plants and rocks and soil of the plains, and the Siksikaitsitapi themselves, are all relations—connected to each other through kinship and cycles of mutuality.

The buffalo is a keystone species on the plains. A keystone species is one whose presence, or lack thereof, has an impact on every other living and nonliving thing, including people. The Siksikaitsitapi started the Iinnii (buffalo in the Siksikaitsitapi language) Initiative to bring buffalo back to their Traditional Homelands and once again see buffalo roaming freely across the plains after over a 100-year absence.

Thirty to sixty million bison once roamed across Turtle Island. Turtle Island is what many Indigenous Peoples, including the Siksikaitsitapi, call North America. We have a long way to go to realize this restorative vision. One of the central challenges is connecting large enough parcels of land and laying the foundation for the social acceptance of bison.

Bison are adaptable; they can live in mountainous areas with grassy meadows and forested areas with grassy understory, but the heart of their habitat is the prairies and plains, where grass is abundant.

The goal of the Iinnii Initiative is to provide plains bison with space to express their true being without human intervention. Accomplishing this would revitalize and change the relationships between land, animals, and people, restoring ecological processes that were disrupted or lost when colonization fragmented the land. Where bison roam, there is increased plant biodiversity. Plants that rely on bison to eat their seeds and thereby spread them elsewhere can spread again and mix with other plants. Increased plant diversity would change the ecosystem further, providing new food and habitat for the animals that rely on them.

Grazing also creates a different habitat structure by shortening the grass. Repeated, constant grazing in one area can cause serious ecological harm. However, different species thrive in places that have been grazed by bison compared to those that have not. When bison are free roaming, their grazing patterns are more dynamic, as they would not be rotating in specific, selected locations, but rather by where the best foraging is available and by the best migration routes at a given time. Restoring natural rhythms of grazing in the plains would increase biodiversity in those ecosystems.

Some amphibians, such as the boreal chorus frog, are adapted to breed in ephemeral pools created by bison wallows during migration. A wallow is when a bison lays down and takes a dirt bath. We can only guess at how far-reaching the impacts of a free-roaming bison population would be. We see only the tip of the iceberg and have much to learn about the world from the plains bison.

For the Siksikaitsitapi, reconnecting with their buffalo relations presents an opportunity for cultural connection, as well as food sovereignty. Food sovereignty is a system in which the people who produce food and the people who consume and distribute it are the same. We can also learn from the bison how to improve land stewardship practices. Regenerative grazing (the purposeful rotation of grazing sites) and other sustainable grazing practices reflect a guess at how grassland systems worked when the buffalo roamed freely and can only partially restore ecosystem dynamics. By connecting with free-roaming buffalo as relations, we can all learn what was lost and begin restoring lost processes, remembering what it is to live in kinship with the natural world, rather than looking at it as a resource. We can all learn to be fluent in the language of the Buffalo Way: embodying the principles of relationship, respect, reconciliation, renewal, and rights & reconciliation.

This work isn't without its challenges, however; when bison roam freely, sometimes they damage crops or yards, or they face dangers on roads and pose dangers to drivers. Proactive planning to build fences can help. We can also understand foraging patterns to try to predict how bison will move, to prevent conflict before it happens. Indigenous people learned a long time ago that bison are attracted to recently burned areas, for example, so cultural burning and controlled burns can be important tools for encouraging bison to avoid areas of potential conflict. Controlled burns are the purposeful

youtube.com/watch
?v=prwmdHbpYX0

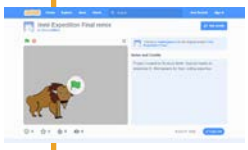
starting of fires within a controlled environment to aid in ecosystem progression. There are also safety concerns, which are hopefully mitigated by effective outreach and public education so that people know to live alongside potentially dangerous wildlife.

Bison can be partners to restore ecological health across entire landscapes, rather than just in fenced reserves, and this is what the Siksikaitsitapi Iinnii Initiative hopes to accomplish.

The video associated with this activity shows part of a bison migration, including grazing and a road crossing, which are both part of the game in this activity. Watch the video after the activity is complete to identify what these behaviors look like in living animals, and to get a sense of the scale of the migration.

ACTIVITY: IINNII EXPEDITION

a. Open this link:



scratch.mit.edu/
projects/746927874

Have students play through the game.

b. Have a conversation with your students about their learning using these discussion questions. There are no right or wrong answers; they are designed for reflection first and foremost.

- How do you relate to the world around you?
- How do you connect with nature?
- How do your actions and choices affect others – not just people, but animals and the land, too? How can you make choices that have a positive impact?

EXTENSIONS:

Bison face specific needs and challenges during migration. Ground the lesson in the students' sense of place by identifying needs and challenges shared by those living in their community. Ask them what people need to thrive and survive in their community, and how they meet those needs. Ask them what happens when people struggle to meet those needs, and what can be done to help them.

You can look inside the project to see the code used to make the game run. Ask students to design and code a new challenge for Iinnii in the game.

Visit this link for more information on the Indigenous-led organization leading the Iinnii Initiative:

indigenousled.org/reasons-for-hope

ADAPTATIONS:

The game can be played from a tablet or on a computer. Students with motor impairments may prefer one or the other.

For students whose reading level is not yet high enough to play the game individually, or for students with visual impairments, project the game onto a screen and play it as a group, describing the scenes and reading out loud as needed.

ACTIVITY 7:

Web of Life

CHAPTER:
The Indomitable Human Spirit

SUMMARY:
Students will collectively spin a web representing the relationships in an ecosystem and identify how all living and nonliving things in that ecosystem, including themselves, are connected.

MATERIALS:
2 Ropes (long) or many ropes tied together

SAFETY CONSIDERATIONS:
Do not allow rope to wrap around the neck or limbs.

Background Information:

Many Indigenous Peoples, including the Siksikaitsitapi (Blackfoot Confederacy), consider the world around them to be full of relations. The plains bison, culturally called buffalo, but also the other animals, the plants, the rocks, the land itself, and the water, all have a spirit, and all are relations of the Siksikaitsitapi.

The world is made of relationships. The ways in which living and nonliving things interact in the environment make up an ecosystem – and humans are part of those ecosystems, too. This means that while humans can play a part in the disruption of ecosystems, we can also play a part in their restoration.

The Siksikaitsitapi are working to restore the buffalo, which in the Siksikaitsitapi language is called Iinnii, to the plains. Their hope is to establish a free-roaming herd on the buffalo's traditional lands. At this link is the story of the Iinnii stone, told in the Siksikaitsitapi language and translated in writing into English:

glenbow.org/blackfoot/EN/html/traditional_stories.htm#iniskim

The plains bison is a keystone species. A keystone species is a species whose relationships in an ecosystem are integral to that ecosystem, Without the keystone species' relationships, the ecosystem is completely changed. Bison dig in the dirt to protect themselves from biting insects, which opens up the earth for seeds to sprout and animals to burrow. Bison carry seeds in their coats for incredibly long distances, and leave fertilizer dung in their place, facilitating the spread of important plants. Many species of insects lay their eggs in bison dung, which in turn feeds many birds. Buffalo provide a vital food source for wolves, but also humans.

In the 1800s, the buffalo were hunted nearly to extinction by settlers. By 1880, there were fewer than one hundred buffalo remaining.

With the loss of the bison, all of those relationships were lost – plants became rare, unable to spread their seeds and unable to find earth to grow in. Some species of birds became rare, with fewer insects to feed on. Wolves declined in the plains, forced to hunt livestock due to scarcity. In response to the threat to their livestock, humans hunted the wolves, and contributed to their decline. The Blackfoot people who relied on the buffalo also suffered incredible losses, both culturally and physically.

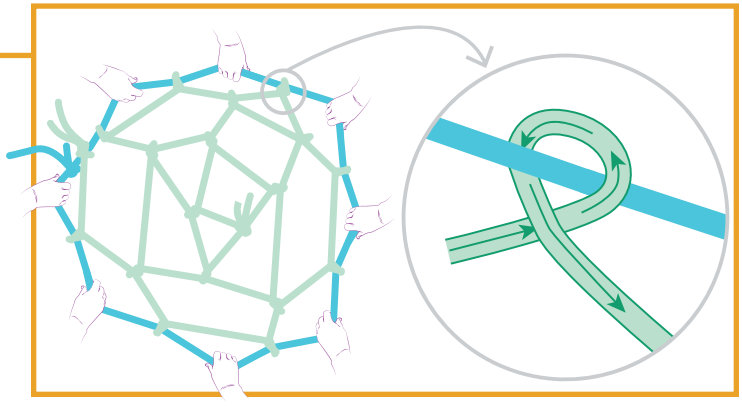
Once, the buffalo took care of the Siksikaitsitapi. Now, the Siksikaitsitapi are taking care of the buffalo. With their return, and the return of holistic grazing, the ecosystem is beginning to recover.

Iinnii Initiative: The Return of the Buffalo

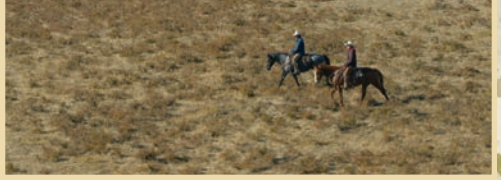
Watch this video about the collaboration between the Wildlife Conservation Society and members of the Blackfoot Confederacy for a look at the impact of the buffalo's disappearance and return.

Activity:

1. Choose an ecosystem that the students are familiar with in their own environment. This can be done by identifying a specific place, if they haven't yet learned about ecosystems, or by asking them to identify an ecosystem that exists near them.
2. Tie the first rope into a circle.
3. Have each student put one hand on the rope and pull it taut into a circle.
4. Step into the circle with the second rope.
5. Tie a knot between two students' hands with the new rope.
6. Alternating students, such that there is a gap between each new knot, make your way around the circle.
7. Continue inwards until there is no room for more knots.



8. Tie the second rope off and let go.
9. As each knot is tied, ask students to identify a relationship in the ecosystem they chose (e.g., deer eat leaves from trees, lizards sun themselves on rocks, people swim in the water, hawks eat squirrels). Make sure they include how people interact with that ecosystem.
10. When the web is complete, have one student pluck the rope. Ask the rest of the class if they feel the vibration from this action. Repeat a few times.



11. Discuss how the connectedness of the web's relationships means that if one part of the ecosystem is disturbed, everything feels it.
12. Ask students how the breakdown of one of the relationships they brought up might impact a different relationship (e.g., if a lot of the trees were gone because the deer ate too much, the birds who nest would have nowhere to live).
13. Have one student drop the rope. The whole web should become unstable.
14. When a relationship collapses, it has widespread effects, but there are things we can do to help. Have students pick up the rope again and make a plan for how to keep it stable if someone drops it again.
15. Have one student drop the rope and test their plan.

ADAPTATIONS:

Gear the complexity of the conversation to the knowledge level of the students. Frame discussions during this activity through places they know, with the priority being seeing and recognizing relationships over individuals, while pitching the level of conversation at an appropriate level for the age.

If you are working in a group too small to make the web, use string and a needlepoint hoop instead, to make the web and see the vibrations from plucking the string, and then loosen and make inside hoop smaller to make the knots fall.

EXTENSIONS:

Watch this video with the students. It includes creative works by Indigenous people, including youth.

youtube.com/watch?v=xoPHVxtsy4w

Ask students to reflect on their place in an ecosystem, and their relationships with the animals and the land. As individuals or in groups, have them create an artistic work – art, poetry, a skit, a story – inspired by their relationships with the land.

Their work can be shared online, on their preferred platforms, using the hashtag #MyReasonsForHope. See what others have created to engage in a network of youth inspiring change.

Visit this website for more information about the Indigenous-led organization leading the Iinnii Initiative:

indigenousled.org/reasons-for-hope

ACTIVITY 8:

Animals, People, the Environment, and You

CHAPTER:
The Power of Youth

SUMMARY:
Students will design and enact a Roots & Shoots project to tackle an issue related to animals, people and the environment that they are passionate about.

MATERIALS:
rootsandshoots.global

Background Information:

Roots & Shoots is a youth initiative started by the Jane Goodall Institute. It is designed to empower youth to take action on issues they care about and that are relevant to their community. The online guide is localized to different regions of the world, and guides youth through the process of mapping their community's needs, their own interests, existing work, and more, to design a project that is relevant, exciting, and centered on local relationships between animals, people, and the environment.

A video has been provided that highlights youth projects from around the world. Many of these projects are by Roots & Shoots members! Watch the video to draw inspiration for this activity.

youtube.com/watch ?v=akdjtMSNA7k

SAFETY CONSIDERATIONS:
Be mindful of hazards when designing and enacting your project. At each stage, have a group discussion about potential risks and how to avoid them.

If you plan to organize a Roots & Shoots activity or event, please get in touch with your local chapter first. You can reach them through the Roots & Shoots global website.

rootsandshoots.global/

Activity:

Go to rootsandshoots.global and find your nearest Roots & Shoots chapter.

rootsandshoots.global/

Email the contact you find on the map to receive localized instructions on how to sign up and how to design your own project. Adult assistance is required; at a school, the teacher can be the adult and they can work on the project as a class. At a museum, science center, or other public organization, run only the mapping portion of the activity, and invite visitors to continue their projects at home. At home, parents can create smaller-scale projects with their children, neighbors, friends, or extended family, or keep it within their immediate family if preferred.

EXTENSIONS:

Check out this site:

climate.
sciencenorth.ca

And make an account with the Change Agent Network here to get inspired by watching videos of people working on climate change problems around the world.

climate.
sciencenorth.ca/
dashboard

Play games, investigate your interests and potential actions, and explore the Change Agent Network Dashboard.

ADAPTATIONS:

Make sure the project you design is suited to the institution in which it is being worked on. A project done by a family is going to look different in scale and scope than one done at a science center or museum, or in a classroom.

ACTIVITY 9:

That's Showbiz: Your Climate Stories

CHAPTER:
The Power of Youth

SUMMARY:
Students will use environmental theatre and theatrical play to create a call to climate action.

MATERIALS:
Costume and craft supplies (optional)

SAFETY CONSIDERATIONS:
Do not allow rope to
If materials such as scissors or hot glue are being used, exercise caution to avoid cuts and burns.

Be careful of trips and falls when using costumes and building sets.

If you plan to organize a Roots & Shoots activity or event, please get in touch with your local chapter first. You can reach them through the Roots & Shoots global website:

rootsandshoots.global/

Background Information:

Communication via storytelling has several advantages. Stories allow us to organize, structure, and comprehend new information, and to contextualize that information in ways which might not have been arrived at if the information was just presented as a list of facts. Confronting new information through stories allows people to make subtle changes to their own worldview in ways that are less jarring, and that make people less defensive. Engaging with ideas in a story can be a dry run for encountering that idea in daily life. As such, storytelling is an important vehicle for climate education, and, in turn, action.

Learning via storytelling also provides a motive for learning – watching a play is a lot more fun than reading a pamphlet. People are more likely to choose to engage with something that adds entertainment to education. The stories being told, and the connection formed between performer and audience, create stronger links to the material for both parties.

Performers in theatre also forge these strong connections to the material, especially when they are part of the creation of the story. In cases where community members mapped a relevant issue and created and performed a work of theatre on that issue, longer-term engagement and effort related to that issue in the community were seen.

The work of selecting an issue, deciding how to present it, and then telling a story and sharing it with others creates connections for both performers and audience members, and can inspire long-term action.

Activity:

1. Perform a community analysis activity to determine what the play should be about.
    a. Identify an issue related to animals, people, and the environment that is relevant to you and where you live.
    b. Identify who the main players are in that issue – for example, levels of government, corporations, non-profits, individuals, etc. The participants should be included as players.
    c. Identify actions you think can be taken by those individuals, including participants, to address the issue.
2. Create a story.
    a. Decide if you want to use allegory (metaphor) or tell a more direct story.
    b. Find opportunities for the audience to participate and be part of the story.
    c. Resolve your story with a call to action.
3. Optional: Design costumes, a stage, and a set.
4. Perform your play for an audience to inspire them with your story.

ADAPTATIONS:
When adapting this activity to a space in which people are passing through, you can create a set and props, leave out costumes, and encourage visitors to improvise and play to create a story on the spot. Provide relevant ideas and prompts to help inspire them to tell a locally relevant story. With older students, consider having them create a short film instead of a play. Do not share videos outside of your immediate context without consent.

EXTENSIONS:
Keep a journal (can be photo, video, written, a combination, or something else entirely) documenting the process of creating this work, what it means to you, and how it was received. How did your own attitudes change? How did the audience's attitudes change?

ACTIVITY 10:

A Call to Action!

CHAPTER:
Climate Change

SUMMARY:
In this investigation, students will analyze climate change data to respond to the United Nation's call to action to lessen the impact of climate change on Earth.

MATERIALS:
- ○ It's Time for Change Formative Assessment Probe handout
- ○ Global Action on Climate Change vVideo
- ○ NASA's Climate Time Machine
- ○ Science journal - 1 per student
- ○ Pen/pencil - 1 per student
- ○ Classroom computer, screen and speakers

SAFETY CONSIDERATIONS:
none

Key Terms:

Temperature - the measurement of how hot or cold something is

Perennial ice cover - the amount of ice that comes back each year in an area

Climate change - change in the average conditions, such as temperature and rainfall, in an area over a long period of time; can be caused by human actions

Background Information:

Earth's atmosphere is a transparent layer of gases that allows sunlight to pass through, to reach and warm Earth's surface. The radiation from the Sun absorbed by the Earth warms the surface, which then emits radiation of longer wavelengths (infrared) that do not pass through the atmosphere but are absorbed by it, keeping the Earth warm. This is called the greenhouse effect because it is similar to the way the inside of a greenhouse is heated by the Sun. Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable for life on Earth.

ADAPTATIONS:
Some students may need assistance with reading the agree/ disagree questions on the handout, as well as the before/after responses.

Subtitles may need to be added to the video for students who are hearing impaired.

Visually impaired students will need assistance with the carbon time machine website data and the interactive sea ice map. An adult or helpful partner will need to guide them through, explaining what is happening in the graphs over time.

Activity:

1. Introduce students to the investigation by asking the whole group:

o How many of you have heard of climate change? Give me a thumbs up or down to show me whether you have heard of climate change or not!

Give students an opportunity to hold their thumbs up/ down in front of them in response to the question.

2. That's great, so many of you have heard about climate change! Let's see what we already know about global climate change by evaluating the statements in the *It's Time for Change Formative Assessment Probe*.

o Please take a few minutes to read each statement and check-off the Agree/Disagree options in the "Before" column, based on whether you agree or disagree with the statement.

Once students have had the opportunity to agree or disagree with each probe statement, facilitate a class poll in order to gather student thoughts.

Highlight trends/patterns and outliers within the class data, but do not confirm or deny answers at this point.

Possible student responses may include: I agree that climate change is something that happened long ago and isn't happening in the present because I learned about how the Earth went through periods of changes, like the Ice Age; I Agree that climate change describes a change in the average conditions, such as temperature and rainfall, in an area over a long period of time because I learned that climate involves weather, like temperature and rainfall; I agree that the effects of climate change are small and don't have negative impacts on the environment because I haven't seen my own environment change all that much.

3. Thanks for sharing your thoughts with the class! In just a moment, we are going to hear from Secretary-General António Guterres and his call for global action on climate change.

- António Guterres, is the ninth Secretary-General of the United Nations, he took office in January 2017.

- Having witnessed the suffering of the most vulnerable people on Earth, in refugee camps and in war zones, the Secretary-General is determined to make human dignity the core of his work, and to serve as a peace broker, a bridge-builder and a promoter of reform and innovation.

4. While you listen to the Secretary-General speak, keep in mind these questions:

- What is the problem that the Secretary-General posed to the global community?

- Who is he calling on to take action?

5. Play Global Action on Climate Change video in its entirety.

6. After, facilitate a class discussion of the main ideas:

- What is the problem that the Secretary-General posed to the global community?

Prompt students to share their ideas aloud with the class.

Possible student responses may include:
To take action in order to lessen the impact of climate change on the global community;
To use the science and technologies available to help make changes that will impact the effects of climate change.

- Who is he calling on to take action?

Prompt students to share their ideas aloud with the class.

Possible student responses may include:
Scientists; Governments; Globalcitizens.

- I wonder why Mr. Guterres is so concerned about climate change! This must be a really important issue if he is calling on all those people to help solve the problem. Let's take a look at some interactive data that can help us understand the effects of climate change.

Display NASA's Climate Time Machine on the screen.

Then, click on Global Temperature.

Let's see how Earth's global temperature has changed over time.

While we are looking at this data, write down any significant changes you see on the map.

- The colours on the map represent temperatures all over the globe.

- Blue colouration indicates cooler temperatures and red indicates warmer temperatures.

Press the play button on the interactive Global Temperature Map.

What significant changes did you see happen on the map?

- Possible student responses may include: The Earth has gotten much warmer all over the world; Temperatures have gotten much warmer since the 1980s.

Yes! Earth has warmed up significantly since the 1980s! How might increases in temperature impact life on Earth?

- Possible student responses may include: Animals could get sick; Animals could die; Ecosystems can change.

I agree, it could be harmful to plants and animals for the temperatures to continue to get warmer. Changing temperatures can result in changes to the habitat an animal lives in and make it very difficult to survive.

Now let's take a look at another interactive data set: sea ice levels around the globe.

- Click on the Sea Ice icon to lead the interactive map.

This visualization shows the annual Arctic sea ice minimum since 1979. At The end of each summer, the sea ice cover reaches its minimum extent, leaving what is called the perennial ice cover. The word perennial means to come back each year.

- Press the play button on the interactive Sea Ice map.

How might less sea ice have an impact on life on Earth?

- Possible student responses may include: The animals that live on the ice will not have a place to live.

You're right, the animals that live on the ice will not have a place to live. The destruction of habitat often results in the loss of animal life and could even lead to extinction!

Lastly, let's look at the sea level changes that scientists predict will happen if the large Greenland ice sheet were to continue to melt.

- Areas in red on each of the maps are predicted to be underwater if the ice sheet were to melt completely!

Click on the Sea Level interactive map.

Press play to show the sea level changes for the Southeast United States, Northern Europe, the Amazon Delta, and Southeast Asia.

What will happen to areas near the coastlines if the Greenland ice sheet melts?

- Possible student responses may include: Many coastal areas will be underwater.

How do you think coastal flooding will impact the people and animals that live in these coastal regions?

- Possible student responses may include: They will have to move; Their homes will be underwater.

Based on what you all have said, it seems like this is a real threat to humans and animals alike!

Closure:

Wow, it seems like there are a lot of ways in which climate change has had an impact on the world, such as rising global temperatures, sea ice melt, and sea level changes! Based on your investigation and class discussions, how would you describe climate change?

- Prompt students to share their thoughts aloud with the class.
- Possible student responses may include: Based on the data we analyzed and discussed, I think climate change is about the climate changes an area experiences over time, like rainfall and temperature.

Based on your investigations and class discussions, would you say that Mr. Guterres's call to action is justified? Why or why not? Cite specific evidence to support your response.

- Prompt students to share their thoughts aloud with the class.
- Possible student responses may include: Yes, climate change is a big problem and is causing issues around the world, like an increase in global temperatures, changes in sea ice melt and sea level changes.

  I would agree! Although climate change is a big problem to tackle, we have all been called to act!

Now that we know more about climate change, let's revisit our formative assessment probe!

- Take some time to reread each of the statements.
- In the "After" column, check the Agree/Disagree box for each of the statements, then provide an explanation for your final thoughts about each statement in the "Explanation" column.
- After, compare your initial and final thoughts regarding climate change. How are your thoughts about climate change different now?

Discuss student responses and explanations to the statements, highlighting changes from initial to final thoughts.

At this point in the learning progression, students should have selected the following for each statement:

Statement 1 - Climate change is something that happened long ago and isn't happening in the present. Disagree.

- Reasoning: Although Earth's climate has changed in the past, climate change continues to be a present-day problem. Scientists have tracked data such as rising global temperatures, sea ice melt, and sea level changes to provide evidence that climate change is occurring today.

Statement 2 - Climate change describes a change in the average conditions, such as temperature and rainfall, in a region over a long period of time. Agree.

- Reasoning: Climate change describes changes in average climate conditions over time.

Statement 3 - The effects of climate change are small and don't have negative impacts on the environment. Disagree.

- Reasoning: Climate change is having significant impacts on the environment, including a decrease in environment and harsh environmental conditions for plants and animals.

EXTENSIONS:

Based on the evidence you collected in your research, write a paragraph supporting Mr. Guterres's call to action or refuting Mr. Guterres's request for help.

When constructing your formal argument, include the following: your claim, clear reasons and relevant evidence to support your claim using credible sources, and a concluding statement.

Carbon Footprint:

Complete the carbon footprint calculator for you and your family. You may need to work with an adult in your household to get all of the answers to the questions!

epa.gov/carbon-footprint-calculator/

- What actions can you take, as suggested by the EPA's carbon footprint calculator, that would lower your carbon footprint?

Use these actions to write a climate change pledge!

- What will you pledge to do to answer Mr. Guterres's call to action?

- How will you educate others about climate change and encourage them to take action as well?

ACTIVITY 10:

A Call to Action!

WORKSHEET

Time for Change!

Review the statements below about climate change. Check the "Agree" or "Disagree" box in the "Before" column to show whether you agree or disagree with each statement.

Before		Statement	After		
Agree	Disagree		Agree	Disagree	Explanation
		Climate change is something that happened long ago and isn't happening in the present.			
		Climate change describes a change in the average conditions, such as temperature and rainfall, in an area over a long period of time.			
		The effects of climate change are small and don't have negative impacts on the environment.			

6.E1U1.6 *Time for Change Formative Assessment Probe* handout.

ACTIVITY 11:

Resource Responsibility

CHAPTER:
Natural Resources

SUMMARY:
In this activity, students will determine if the natural resource is renewable or nonrenewable and evaluate its impact on the environment to guide decisions about obtaining energy for their home.

MATERIALS:
- Natural Resource Card Sort
- Natural Resource Cost-Benefit Analysis handout
- Scissors
- Pencil

SAFETY CONSIDERATIONS:
If materials such as scissors or hot glue are being used, exercise caution to avoid cuts and burns.

Key Terms:

Natural resources - materials found in nature that can be used by people

Renewable resource - a natural resource that cannot be used up or that can be replaced within a human life span

Nonrenewable resource - a natural resource that cannot be replaced after used

Background Information:

Natural resources fall into two categories: renewable resources and nonrenewable resources. These natural resources are used by people to create electricity. Cost benefit analysis of a resource helps to provide information about the environmental impact of a natural resource. In this activity, students will determine if the natural resource is renewable or nonrenewable and evaluate its impact on the environment to guide decisions about obtaining energy for their home.

Activity:

1. Recently we have been exploring natural resources. We discovered that natural resources are materials that occur in nature that can be used by people. Natural resources include water, plants, minerals and more. Today, we are going to explore two categories or groups of natural resources: renewable and nonrenewable.

o Let's look at renewable first. What does it mean to renew something? For example, I renewed a book from the library.

Possible student responses include: to get it again; to use something again

A renewable resource is a material that cannot be used up or it can be renewed or replaced within a human life span.

o Now let's look at nonrenewable. When we put the prefix "non" in front of a word, what does that do to the meaning of the word? For example, I cooked my scrambled eggs in a nonstick pan.

Possible student responses include: not
- A nonrenewable resource is a material that is found in nature that can be used up or cannot be replaced in a human life span.

2. Distribute the Natural Resource Card Sort.

a. First cut out each picture card.

b. Then, I want you to sort the images as renewable (can be used over and over without running out) or nonrenewable (once it is used up it is gone).

c. Monitor students as they are working through their sort. Do not provide correct answers at this time. Question students regarding their reasoning for sorting each card.

3. When students have completed the sort, engage in class discussion.

a. Which cards did you sort into the renewable category? Why?

Possible student responses include:
- The renewable resources are the wind, water and solar panels because we will never run out of wind, flowing water, or sunlight.

b. Which cards did you sort into the nonrenewable category?

Possible student responses include:
- oil, natural gas, and coal because those take a long time to make, and they can run out and then we won't be able to create energy.

4. Once the class has reached a consensus about which resources are renewable versus nonrenewable, distribute the Natural Resource Cost-Benefit Analysis handout.

a. Each of the resources you sorted is currently used to produce electricity.

b. When considering how we use natural resources to make electricity, we don't only consider how quickly they can be replaced. We also need to consider how using those resources impacts the environment.

c. On this handout, each renewable and nonrenewable resource has two statements. Read each statement and decide if the impact of using that resource is positive or negative.

d. Place a checkmark in the box that matches your selection: positive or negative.

e. Be ready to explain your answers during the whole group discussion.

5. Closure: Review the students' answers to the Cost-Benefit Analysis handout using the following question prompts:

a. Which descriptions do you think are positive?

Possible student responses include:
- wind is clean; Oil has lots of different uses, natural gas is inexpensive; hydroelectric power is "green" and "clean"; solar energy can save you money; coal reserves will last about twice as long as oil

b. Which descriptions do you think are negative?

Possible student responses include:

- wind turbines can be noisy; Oil energy produces toxic gases; natural gas releases toxic methane gas; interruptions of natural water flow can have a great impact on the river ecosystem and the environment; solar panels will not work well on cloudy days; Coal-fired power plants are also the greatest contributor to mercury pollution

c. Now that we know there are positives and negatives to all ways of making electricity using natural resources, which methods do you think have the least negative impact?

Possible student responses will vary depending on if they are looking at environmental issues, fiscal issues, or personal moral issues.

ADAPTATIONS:

Visually impaired students will need someone to describe what is shown on each card sort picture. Some students will need their cards to be pre-cut.

Some students may need the handout to be read to them or may utilize text-to-speech on a digital version so they can hear it be read to them as they follow along.

EXTENSIONS:

- Social Studies Connection: Students will research what other countries are doing with their renewable and nonrenewable resources. What is their main source of energy for electricity in that country? How is their country doing fiscally?
- ELA Connection: Have students explore and read articles from the internet about our renewable resources in the United States. What are recent changes in developing cleaner energy in the United States? What is our government's role in this movement? Students could present a narrative paper with their findings.

ACTIVITY 11:

Resource Responsibility

Natural Resource Card Sort

Directions: Sort the images as either renewable or nonrenewable resources.

4.P4U3.4 *Natural Resource Card Sort.*

ACTIVITY 11:

Resource Responsibility

Natural Resource Cost Benefit Analysis

Directions: Read the description next to the image and decide if it is a cost or a benefit.

Image	Description	Negative (-)	Positive (+)
	Wind is a clean, renewable energy source and is one of the most cost-effective sources of electricity.		
	Wind turbines can be noisy and visually unappealing.		
	Oil has lots of different uses. It can be used to make electricity, gasoline and diesel fuel for cars and trucks.		
	Oil energy produces toxic gases that pollute the Earth that causes changes to the Earth's climate.		
	Natural gas is an inexpensive way to create energy.		
	Burning natural gas releases toxic methane gas that is harmful to the environment.		
	Hydroelectric power is one "green" and "clean" alternative energy source.		
	Interruptions of natural water flow can have a great impact on the river ecosystem and the environment.		
	If you live in an area with many cloudy days or are simply having some storms and darker days for an extended period, solar panels will not work well.		
	Using solar energy can result in saving money. Over a 20 year period, you could save anywhere from $10,000 to $30,000.		
	Coal reserves will last about twice as long as oil and gas reserves at current rates of use.		
	Coal-fired power plants are also the greatest contributor to mercury pollution.		

ACTIVITY 12:

A Green Future

CHAPTER:
Finale

SUMMARY:
Students will design and build a toy vehicle that moves using only green energy.

MATERIALS:
Craft materials, scissors, glue, tape, magnets; Optional: alligator clips, solar panels, engines, switches

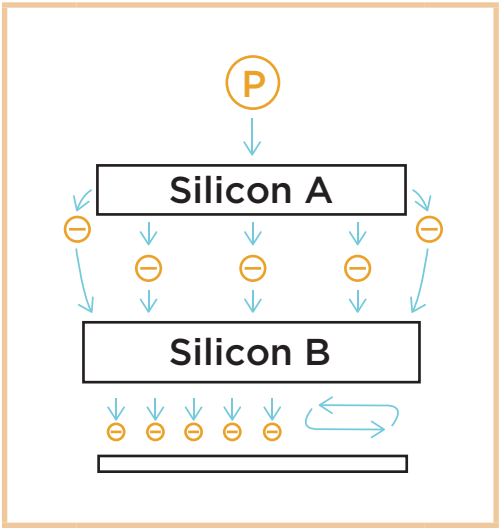
SAFETY CONSIDERATIONS:
Be careful to avoid cuts and burns with craft materials.

Background Information:

To make significant and lasting climate impact, we need to move from fossil fuels to green energy solutions such as solar and wind energy.

There are a lot of people focused on how we can make that shift from fossil fuels to renewable energy happen. In the United Arab Emirates, solar power might make up almost half of the country's energy by the year 2050. They've built solar power stations in three major regions and are hoping to expand even further. The Orkney Islands in Scotland are harnessing the power of the tide to generate electricity. Tidal power is appealing because it doesn't rely on weather conditions; the tide is consistent and predictable. The Henvey Inlet Wind Farm in Georgian Bay generates enough electricity in a year to power 100,000 homes. The local Indigenous community of Henvey Inlet owns half of the project, making it a groundbreaking collaboration. Those turbines will be contributing to Ontario's power for the next 20 years. Japan and South Korea are using green energy to move people – maglev trains use magnetic fields to move at high speeds using only electricity for power.

Solar energy converts sunlight into electrical energy. It does so using solar cells, which are grouped into a solar panel. Each solar cell is made of two types of silicon, one which loses electrons (Silicon A in Figure 1) and one which collects electrons (Silicon B). Energy in sunlight comes in bursts called photons. Those photons knock into the silicon (Silicon A) causing it to lose electrons. Those electrons are taken by the other type of silicon (Silicon B) and collected on an aluminum layer. From there, the electrons can move and flow, creating an electric current.



Wind turbines generate electricity using motion. Most electricity is generated by spinning a turbine, which spins a generator, which uses magnetic force to generate electricity. There are a variety of ways to make the turbine spin: wind turbines use the powers of drag and lift on the blades to generate the spinning movement that is required for the generation of electricity. A traditional electricity turbine is spun by the heat generated by the burning of fossil fuels, so using wind to generate the same power is much better for the environment.

There are much smaller wind turbines being used to generate electricity in parts of Europe, as well, called tulip turbines. Tulip turbines take up less space and make less noise. They are named for the shape of their blades, which curve in the shape similar to tulip petals. The whole shape spins to turn the turbine, adjusting easily to changing wind directions.

Maglev is short for magnetic levitation. Powerful electromagnets suspend, propel, and guide high speed trains, producing no carbon emissions. The magnet's magnetic field becomes supercharged at extremely low temperatures, allowing the magnets to become strong enough to levitate a train when opposing poles are facing each other. The opposing poles repelling each other creates both forward and upward momentum, lifting and propelling the train forward.

youtube.com/watch?v=25NPkgN7q1g

A video has been put together showcasing a variety of green energy solutions from the film. These include carbon-storing algae, an artificial tree that absorbs atmospheric carbon, the electric vehicles that powered parts of the shoot, and the construction of a windmill.

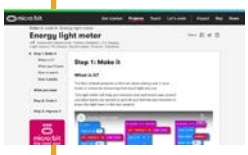
ACTIVITY 12:

A Green Future

ADAPTATIONS:
This activity can be done with materials available – where no circuit supplies can be used, students can make waves in water, or make wind with a handheld fan, or use repelling magnets, as examples, to move their vehicle without needing a motor or a solar panel.

Repeat the testing and reiteration steps as needed, or as there is time for.

EXTENSIONS:
Use a micro:bit to measure the levels of sunlight in various locations at various times to determine the best place to put a solar panel, where it will get the most sun for the most time.



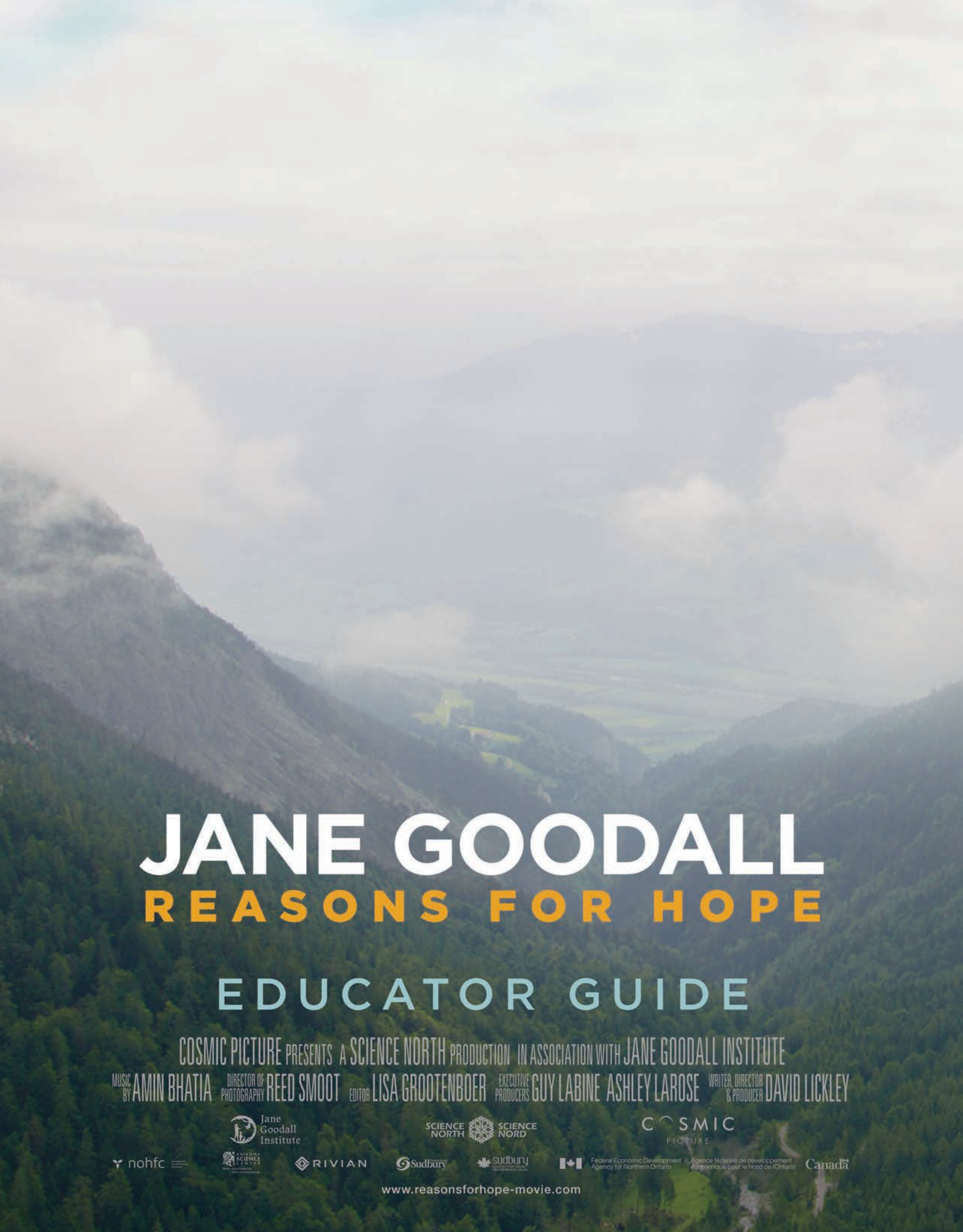
microbit.org/projects/make-it-code-it/energy-light-meter

Activity:

Students will build a toy vehicle. The vehicle must move without using a battery or electricity. Students should be encouraged to come up with creative solutions using the engineering design process.

If you have the materials available, students can create a circuit powered by a solar panel to use a motor to move their vehicle.

1. Research – what already exists? How have other people solved similar problems? What about those solutions works, and what would you like to do better or differently?
2. Brainstorming – Come up with four ideas for your toy vehicle. Label each idea with some simple details such as materials, and how it will move.
3. Prototyping – Select one idea to move forward with. Build out the details – what will you need, and how much? How far will it be able to travel? What pieces do you need to build? Draw a more detailed sketch, including measurements for size.
4. Feedback – exchange ideas with at least one other student. Make sure all feedback is constructive. Identify one thing you think is unique or interesting about their design. Identify one thing you have a question about. Identify one thing you think could make the design better.
5. Prototyping – build the first version of your vehicle.
6. Testing – test your vehicle to see if it moves the way you expect it to. Measure how far it could go and look for any points where something doesn't work as expected. What worked well? What didn't work well? How could you fix it?
7. Reiteration – make changes to your vehicle to fix the things that didn't work well.
8. Testing – test your vehicle again.
9. Repeat the testing and reiteration phases until the vehicle works.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