BEAKERBOX
CLEMSON® SCIENCE OUTREACH

PLANTS AND HUMANS

Students use a card game to explore types of adaptations that plants have evolved to survive environmental challenges, apply this knowledge to technologies humans have used in agriculturally and medicinally important plants, and evaluate infographics to explore how scientific information is communicated.

SOUTH CAROLINA STATE STANDARD	8-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer their ancestral relationships. *Clarification Statement: Emphasis is on explanations of the ancestral relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.* *State Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures.* 8-LS4-5. Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms. *Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and on the impacts these technologies have on society and scientific discoveries.* *State Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.*
NEXT GEN STANDARD	MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer their ancestral relationships. MS-LS4-5. Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.
LEARNING OBJECTIVE(S)	- Students will make starting inferences regarding how plant adaptations support survival in some challenging conditions while not lending benefit in others - Students will encounter examples of how humans have influenced the inheritance of desired traits in some organisms of agricultural importance and how humans have used some plants for medicinal and therapeutic purposes - Students will explore how scientific information is communicated by evaluating infographics further

	developing their scientific literacy skills - Students will engage in argumentation regarding how humans use technologies to influence the inheritance of desired traits in organisms Optional Extension Activity - Students will evaluate the technologies humans use to influence the inheritance of traits in plants and will develop an argument regarding how they may or may not help address challenges of climate change.
ESTIMATED TIME	Part I: 30-45 minutes plus an additional 10-15 minutes per round if you add extra rounds Part II: 45-60 minutes Part III: 45-60 minutes

WHAT YOU'LL NEED:

For Part I: This activity requires 20 Plant Adaptation Cards and 8 Plant Challenge Cards per group. Both are available in the Appendix, with the Plant Adaptation Cards over 5 pages and the Plant Challenge Cards over 2 pages. Four sets of laminated cards are provided with each box and PowerPoint slides of the Plant Challenge Cards are available on the BeakerBox website.

For Part II: This activity requires 6 Ancestral Plant Comparison Cards and 6 Modern Plant Comparison Cards, both in the Appendix. Four sets of laminated Plant Comparison Cards are provided with each box, and PowerPoint slides of Plant Comparison Cards are available on the BeakerBox website.

For Part III: This activity requires Genetic Modification Infographics 1 through 5 and the Infographic Vocabulary Glossary. One set of laminated Infographics and Glossary is provided with each box. Note that students also have the Infographic Vocabulary Glossary within their materials.

For optional extension activity: This optional activity requires Climate Infographics 1 through 5 and uses the same Infographic Vocabulary Glossary used in Part III. One set of laminated infographics is provided with each box.

WHAT YOUR STUDENTS SHOULD KNOW BEFORE:

Some general knowledge of adaptation may be helpful, but not necessary since this activity is designed for students to predict and learn about the effects adaptation may have on plants.

WHAT TO DO BEFORE YOUR CLASS:

Make sure you have the appropriate cards and infographics for each part of the activity you are implementing (See WHAT YOU'LL NEED above). Plan for how you will group students to complete each part of the activity. For example, grouping to play the card game in Part I, grouping to complete the card sort and discussion in Part II, and how students will access the infographics in Part III.

HOW SET UP YOUR CLASS:

Students will work in groups. Group size may depend on how you decide to play the card game in Part I and how you plan to have students complete Part III (station rotations or small groups). We recommend groups of no larger than 3-4 students.

For Part I: There are 3 options to play this game: Team vs Nature, Team vs. Team, everyone for themselves

1. Team vs Nature: Students work as a small group to pick the best cards to play for each challenge card. Each plant card that survives the challenge card goes to the team. Each plant that dies from the challenge card goes to nature. Either nature wins or the team wins- this is a good option for a non-competitive/ cooperative group.
2. Team vs. Team. Seat students in groups of four with two two-person teams within each group. Divide the cards randomly between the two groups (10 each). Each team will play a plant card. Each plant that survives the challenge card, the team keeps, each plant that dies goes to the nature pile. The team at the end with the most cards wins. This is a good option for students who like group competition.
3. Everyone for themselves: seat 4 students to a group. Divide the cards evenly among the 4 students (5 each). Each person will place a plant card for each challenge card. Students keep the plant cards that survive and give the plant cards that die to the nature pile. Once all cards are played, the student with the most cards at the end wins. This is a good option for students who enjoy individual competition.

WHAT YOU NEED TO KNOW FOR YOUR SAFETY:

None

This lesson has been designed to follow three dimensional learning, as described in NGSS standards. In this teacher version, we annotate the associated Science and Engineering Practices and Cross-Cutting Concepts using icons (from these NGSS Planning Cards) before the relevant student question and blue and green text, respectively, within the student instructions. Additionally, content and questions that specifically address the Disciplinary Core Idea is represented in orange text. Sample student responses, classroom recommendations, and other hints are in *red italicized text*. See https://scienceweb.clemson.edu/beakerbox/ for additional files such as non-annotated student versions, Spanish versions of student materials, and slides.

PLANTS AND HUMANS

PART I: What adaptations do plants have that help them survive in their environments?

Phenomenon: Consider the environments plants grow in such as a yard, around the school, the medians of highways, cracks in the sidewalk, forests, and so on. Examine the pictures of different environments and think about various challenges plants might face in each environment that could impact their survival.

 **Swamp**	 **Tidal Creek**	 **Grass Field**
 **Golf course**	 **Beach Dunes**	 **Scrub**
 **Virginia Creeper (Native to South Carolina)**	 **Spanish Moss growing in a tree**	 **Urban forest**

1. Thinking back to the pictures or other environments that plants grow in, what are some adaptations that plants have to help them survive in their environments?

Answers will vary:
Possibilities include deep roots (e.g. dune grass), ability to absorb water from the air (e.g. Spanish moss), appendages for climbing trees (e.g. Virginia creeper), "knees" for exchanging oxygen and CO2 in the swamp (e.g. cypress trees), sprawling root systems (e.g. grasses in an urban forest), adaptations to survive in various environments like high salinity and low light

2. How do you think humans can/do use plant adaptations to support human society?

Answers will vary:
Medicine
Agriculture
Entertainment, Golf
Keep soil/ sand from eroding (e.g., beach dunes)
Selecting plants adapted to drought to grow in more dry areas
Selecting plants for aesthetic beauty in gardens and plantings
Grasses for parks and golf courses – soft to play on
Planting trees and shrubs to serve as windbreaks, slowing down wind
Planting trees in urban areas to cool areas in the summer
Planting trees along roadways to slow people down

PLAYING THE PLANT ADAPTATION GAME

Plants face a lot of different challenges from their environments. In this game, you will explore some changes or events in the environment that impact plants and that some plants have adapted to survive.

- Read through all of the plant cards to get a sense of the adaptations for each of the plants. You may notice the icons in the bottom left corner of some plant cards, the meanings of which are described in the table below.

Item	Icon	Description
Fork		Is eaten by humans
Tractor		Selectively adapted by humans
Medicine bottle/pill capsule		Used in traditional medicine (the use of natural products to treat illness, prevent disease, and maintain health)
State of South Carolina		Native to the state of South Carolina

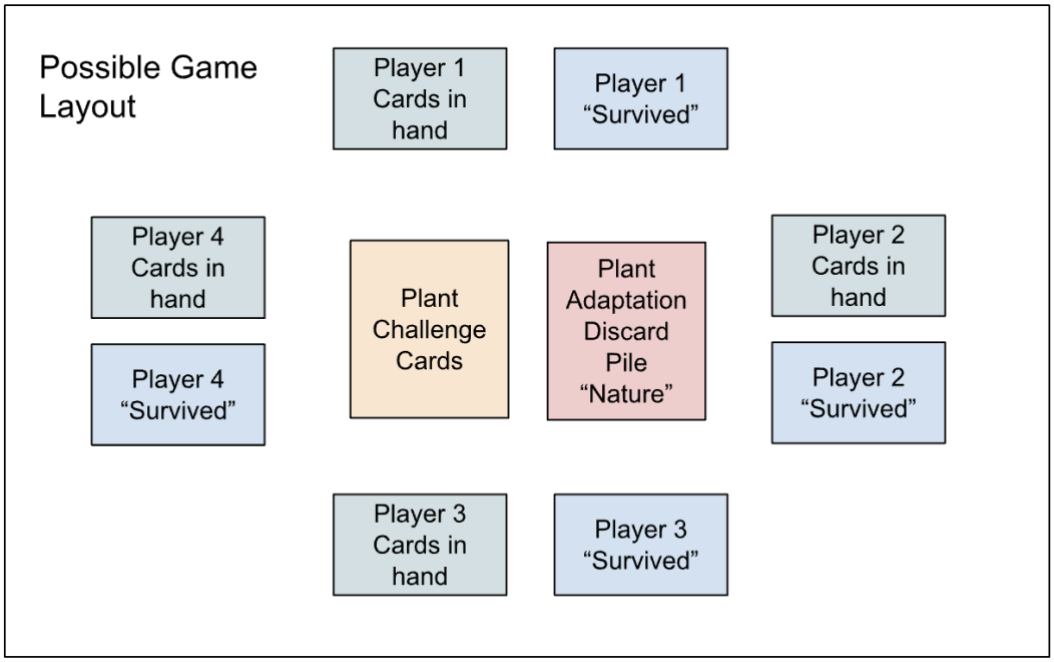
3. Now that you have looked through the cards, for what purposes do humans use and/ or adapt plants? (Challenge: come up with some additional responses compared to question 2.)

Answers will vary:
Humans modify plants for food
Humans use plants for medicine, food, and products
Humans modify food plants to survive and grow in different environments
Humans modify plants to be pest resistant or harvest oils to create pesticides

GOAL
In this activity, your aim is to keep as many plant cards as possible from the beginning of the game to the end.

SETUP

- With instructions from your teacher, decide on the version of the game you will play:
  a. Team vs. Nature (Group of students playing cooperatively)
  b. Team vs. Team (Group of students playing in teams against each other)
  c. Everyone for Themselves (Individual students playing against each other)
  Note: Teachers may dictate the type of game play or allow each group of students to choose their game play. Collaborative game play might result in more discussion among team members whereas individual game play may decrease conversation due to its competitive nature.
- Shuffle the PLANT ADAPTATION CARDS and then divide them so each team/player has the same number of cards. If there is an uneven number of cards remaining, leave the extras out of the game. ***Each player may read the cards in their hand.***
- Shuffle the PLANT CHALLENGE CARDS and then place them in the center. You'll want to put the side with a thick black border and the name of the challenge facing up.
- *Alternatively, teachers can hold the plant challenge cards and display them by holding them up or using the slides provided on the BeakerBox website.*



GAMEPLAY

- For each round, the top challenge card represents the event for that round. (Alternatively, the teacher or one player could play the challenge cards at random)
- Each team plays one plant "against" the challenge.
- Once all teams/players have played a card, turn the challenge card over to see which plants survived and which plants were killed by the challenge.
- If your plant survived, you should put that next to you in your "survived" pile. ***You may NOT play this card again***, but this will help you keep track of how many of your plants survived.
- If your plant was killed, place it in the "nature" pile indicating these plants were returned to nature. These cards will not be played again.
- Repeat this until all plant adaptation cards have been played.
- After all the plant adaptation cards have been played, count the number of plant cards in the "survived" pile and record each team's/player's score in the data table.
- The team/player with the most "survived" cards wins!
- Play multiple rounds as you wish.

There are 8 different challenges that your plants may face, so you should take a minute to look through your cards and think about whether each plant in your hand would survive or die given that challenge.

Your plants may be challenged by:

1. Herbivores
2. Low Light
3. Extreme Cold
4. Fire
5. A Bulldozer
6. Drought
7. High Water
8. Pests

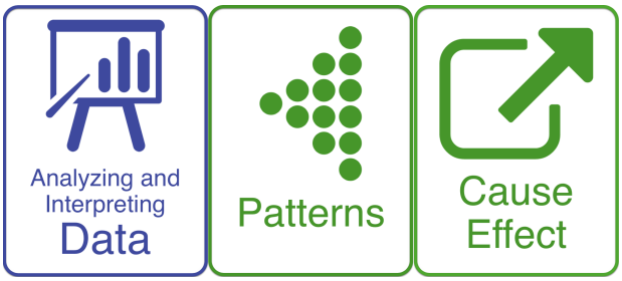
Team/ Player	**Round 1**	**Round 2 (Optional)**
1		
2		
3		
4		

POST GAME ANALYSIS



4. Take a look at the Pests Plant Challenge Card. Pull the Plant Adaptation Cards for all plants that can survive pests. Read the descriptions of the plants' characteristics and adaptations. What characteristics do you notice that allow different plants to survive pests?

Nearly all plants resists pests because of a bioengineered, chemical, or structural defense.
--Bioengineered/modified by humans: corn, rice, and sugarcane
--Naturally produce a chemical like an oil or sap: cypress, eucalyptus, milkweed, mint, and poison ivy
--Structural protection like strong stalks (bamboo), thick bark (redwood), and leathery leaves (fern)



5. Specifically look at the Plant Adaptation Cards for corn, rice, and sugarcane.
   a. What do these plants have in common about their ability to survive pests?

Corn, rice and sugarcane have been modified by humans to survive pests.

   b. What icons do these Plant Adaptation Cards have in common?

Fork and tractor

   c. Why are some plants modified by humans for society and others are not?

Some plants are less useful to humans because they cannot be used for food, medicine, building houses, stabilizing runoff, aesthetically unpleasing, deterring pests, and supporting soil health.

PART II: How have humans influenced the desired traits of organisms?



6. Brainstorm ways humans have influenced the desired traits of organisms.

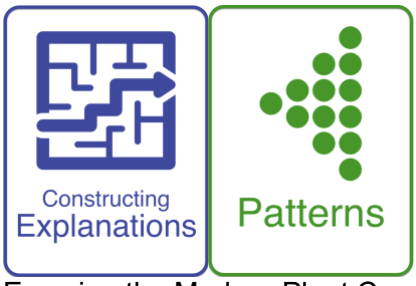
What I Know: *Answers will vary. Accept student thinking but be aware of incomplete knowledge or common, yet incorrect ideas.*
We influence plants for larger size, color, taste, growing period, etc.

What I Wonder: *Answers will vary. Accept all questions that are on topic. Consider placing questions that are more broad or a little removed from the topic in a "parking lot" to be answered later.*
How do people decide what to modify?

7. **Card Sort:** Examine the Ancestral Plant Comparison cards labeled A-F with an orange border displaying early forms of modern day foods from plants. What fruit or vegetable do you think are shown on each of these cards?

Students will predict using prior knowledge. All predictions that are plant based are acceptable. (e.g. pomegranate, papaya, asparagus, melon, ginger, peach, cherry)

- *Alternatively, teachers can display these images using the slides provided on the BeakerBox website and have the class guess as a group.*



8. Examine the Modern Plant Comparison cards labeled G-L with a purple border displaying modern day food from plants. Determine which image from the A-F Plant Comparison cards matches with Plant Comparison cards labeled G-L. You should form 6 pairs of cards.
    a. Check your Plant Comparison Card pairs with your teacher before moving on to the next step. Teacher Signature: _____

Key for Plant Comparison Cards:
A&G are watermelon, B&I are banana, C&K are carrots, D&H are corn, E&L are eggplant, and F&J are apples

b. What anatomical similarities and differences do you notice?

Seeds, skin/rind, color, size, shape - answers will vary regarding similarities and differences students notice relative to these anatomical features; students may also recognize other features such as where the plants grow (e.g., on a tree, underground, etc.)

c. Write a scientific explanation, which includes a claim, evidence, and reasoning, of how you connected the ancestral plant with the modern plant.

Through the use of anatomical similarities and differences (evidence), a plant's ancestral relationship can be inferred (claim) because they are related/ genetically related/ share similar DNA/inherited traits (reasoning).

Answer structure may vary and students may use different vocabulary when providing reasoning depending on prior knowledge.

Note: This is a great place to use sentence stems if students are struggling. Plant _____ is ancestral to plant _____.The data shows they are related because _____. The science of inheritance supports this claim because _____.

Possible answer with this structure: Plant A is ancestral to Plant G. The data shows they are related because they have a similar shape, seeds, and rinds. The science of inheritance supports this claim because traits are passed down and therefore they share similar DNA.



9. **How** do you think the ancestral plant became the modern day plant? Generate two mechanistic ideas with your classmates.
Mechanisms are processes that cause something to happen.

There are no wrong answers. Acknowledge every student's ideas.
Keep an eye out for any commonly held incorrect ideas - like plants "choosing" to adapt in certain ways.

Potential responses:
Pollinator extinction, domestication, ecosystem disruption, changes in herbivory, traits selected over time, bioengineering, artificial selection, natural selection, etc.



10. As a class, generate questions about how humans have modified plants to support the survival of humans. Reference question 5 when generating questions. You may also look back at the Plant Adaptation Cards you examined for question 5.

Answers will vary. Please accept all questions. If students struggle asking scientific questions, use some of the potential questions below to "prime the pump" and model questioning. It may open students up to asking more questions.

Potential questions:
What time of year are the plants grown?
How were the seeds planted?
How would farmers adjust to new pests/challenges to provide the success of crops?
How do humans breed plants?
How long does it take to modify plants? What does it mean to modify plants? What kinds of plants are modified?
When plants are bred for one characteristic, does it affect other characteristics?
How do humans breed a plant for one particular characteristic?
What does it mean to be genetically modified?
How do humans genetically modify plants?
Can humans change one characteristic without changing other characteristics?
Do changes in plants cause changes in other organisms?
What are the goals humans have for modifying plants?
Why do plants need to be modified?
Why do humans want certain plant structures?
Why were corn and rice chosen to be modified?
How do environmental conditions impact traits that are modified?
Are the modification techniques different for each plant?
Why do we change the foods we eat?

Part III: How has technology changed the way humans have influenced the desired traits of organisms?

Information about Scientific Communication

Science communication can be defined as a way of delivering information from the scientific community to a more general audience like non-scientists. Science communication can include delivering a speech/presentation, having a conversation, writing an article, blogging, posting on social media, or creating a piece of artwork. Great science communication can be very tricky to accomplish and is a skill that needs to be practiced.

Infographics are one way scientists can communicate information to the general public. Consider the following characteristics of science communication as you look at the infographics in the following activity. This will potentially help you answer the strengths and weaknesses column in question 11.

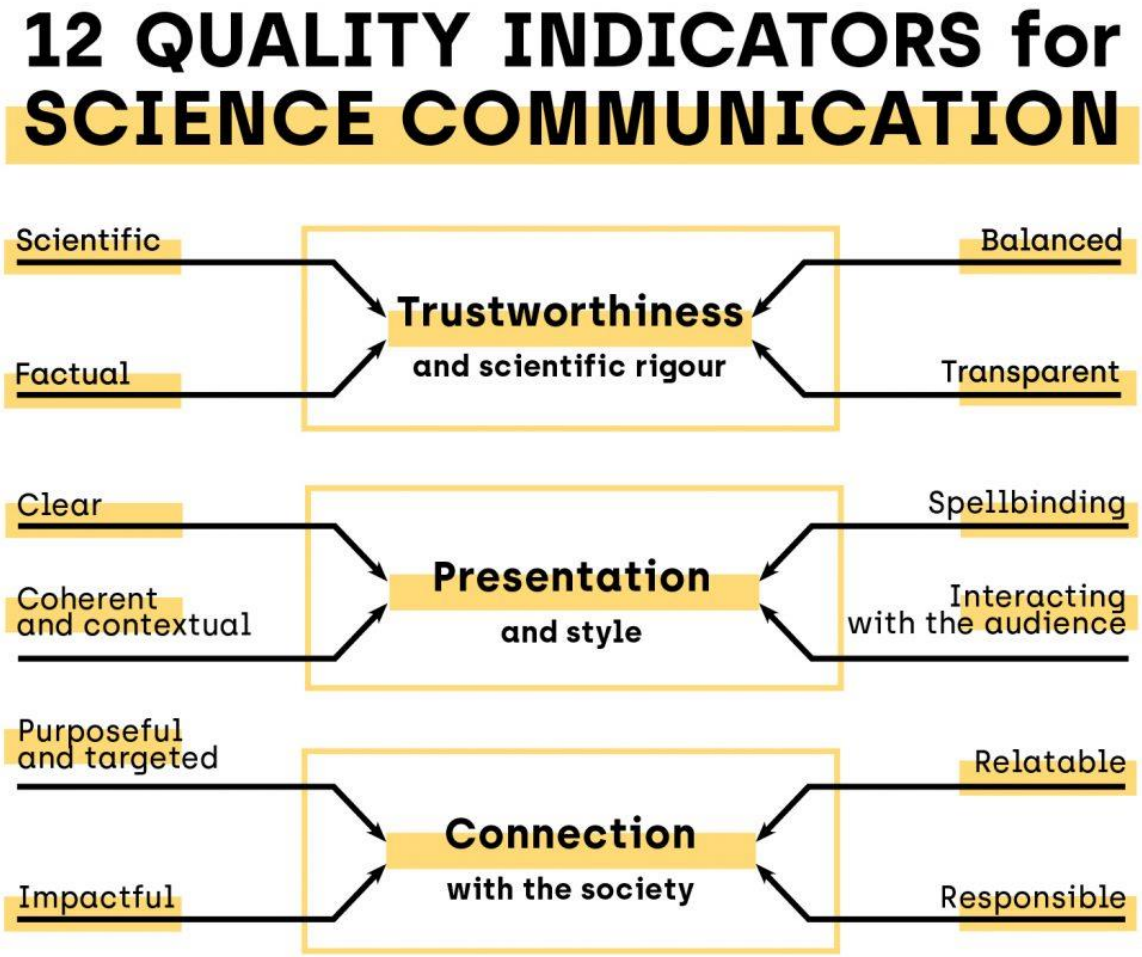


Figure 1: Image from: https://questproject.eu/12-quality-indicators-for-science-communication/



12. Explore the provided resources to learn more about how humans have influenced the desired traits of organisms.
    Note: The Genetic Modification Infographics for this question are included in the appendix if you need additional copies. Also in the appendix is a glossary of terms in the infographics that students may not be familiar with; this glossary is also included in the student copy.
    a. Examine each of the five infographics to explore how humans work to modify organisms.
       Note: Teachers can determine the best way to have students access the information in the provided materials. For example, students could engage in station rotations and look at every resource, students could access the information through a jigsaw activity and bring information back to home groups, or you can project each infographic.
    b. Write down at least one thing you learn and one question you have in the chart below.
    c. Utilize the *12 Quality Indicators for Science Communication* to evaluate each infographic, identifying at least one strength and one weakness.

Info-graphic #	What you Learned	What questions do you have about ways humans have influenced the inheritance of traits?	Identify one strength and one weakness of each infographic
1			Strength: Weakness:
2			Strength: Weakness:

3			Strength: Weakness:
4			Strength: Weakness:
5			Strength: Weakness:

d. Share what you learned from the infographics. Share what questions the infographics raised for you. Discuss strengths and weaknesses of the infographics.
Note: Teachers facilitate a class discussion examining the information students recorded in the station rotation table. Students could share out questions on sticky notes, index cards, or a virtual tool (e.g. Padlet) to create a driving question board. Finally, a discussion about the strengths and weaknesses of infographics serving as a means of science communication and how they may contribute to or help combat misinformation will conclude the activity. Being able to judge quality science documents contributes to students' scientific literacy.

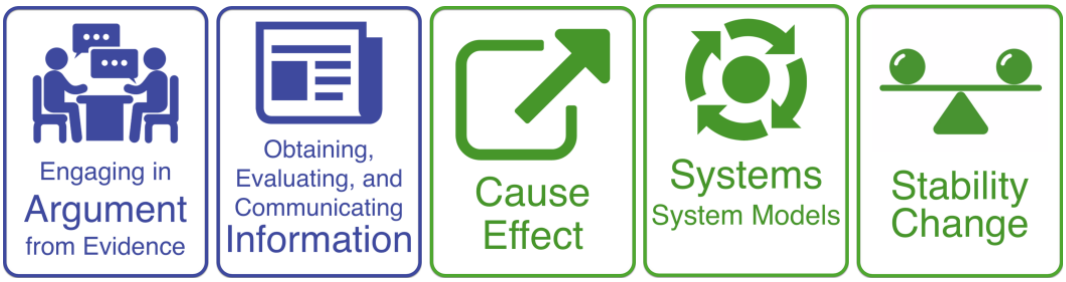
Scientific literacy defined:

- *is "an evolving combination of the science related attitudes, skills, and knowledge students need to develop inquiry, problem solving, and decision making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them" (Council of Ministers of Education, Canada, [CMEC], 1997, as cited in Lederman & Abell, 2014, p. 548).*
- *incorporates personal and societal issues*
- *"illuminates how science permeates and interacts with many areas of human endeavor and life situations…sometimes called science for citizenship" (Lederman & Abell, 2014, p. 546)*

13. Lesson Wrap up: Reflect on what you learned about while exploring the infographics. Fill out the chart below regarding your thinking about how humans have influenced traits and used technology to create genetically modified organisms (GMOs).
Students could complete this on their sheet, on a sticky note, or an exit ticket.

3 Things I Learned today:
2 Things I found interesting:
1 Thing I still have questions about:

OPTIONAL EXTENSION ACTIVITY



Philosophical Chairs Prompt: Is it worthwhile that humans are working to produce plants that can withstand the effects of climate change? Why or why not?

a. Examine the infographics with information about how the climate worldwide is currently changing.
b. Compare the information you have gathered about how humans influence the inherited traits of plants (pay attention to the research and development time on climate infographic 5).
c. Construct an argument using evidence from the provided information to prepare to engage in a philosophical chairs discussion. Use the prompt above and the questions below to help guide your thinking.

Some other questions to think about while crafting your argument:

- Who will be most affected by climate change? Why?
- Whose responsibility is it to help those affected by climate change? Why?
- What are the repercussions if humans are unable to produce plants that can withstand climate change?

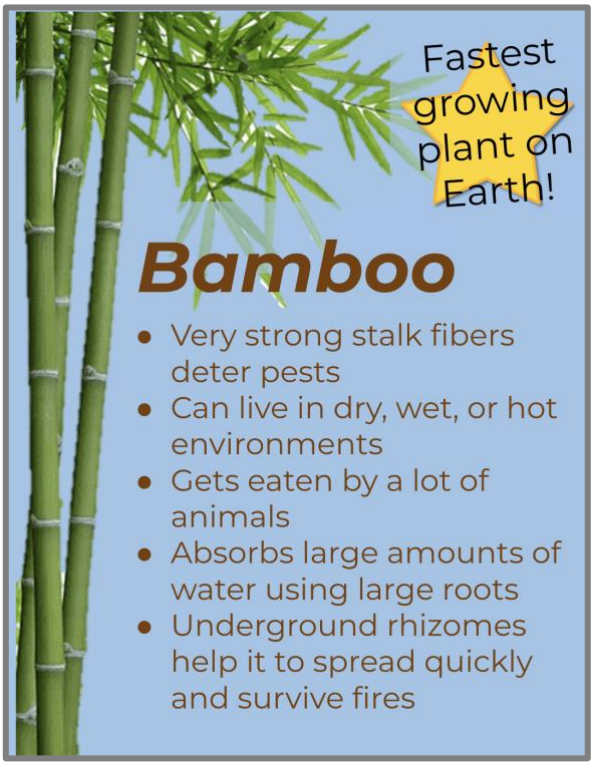
Note: This extension activity could become a multidisciplinary unit. There may be opportunities to collaborate with social studies teachers incorporating concepts of human geography, map reading, cultural impacts, resource sharing, treaties, economics, etc. Additionally, you may partner with ELA instructors to consider perspective taking and reading different mediums. Partnering with math teachers may provide additional opportunities for analyzing and interpreting graphical representations of climate change data (percentages, rates, probability, etc).

Additional resources for this philosophical chairs extension activity:
Communications by Design - Philosophical Chairs Graphic Organizer
https://cbdconsulting.com/free-resources/articles/an-engaging-critical-thinking-activity-philosophical-chairs/

NWESD - Philosophical Chairs Scaffolded Protocol
https://files.nwesd.org/jlongchamps/ELL/Mar%2028/GraphicOrganizerforDebate-Version2.pdf

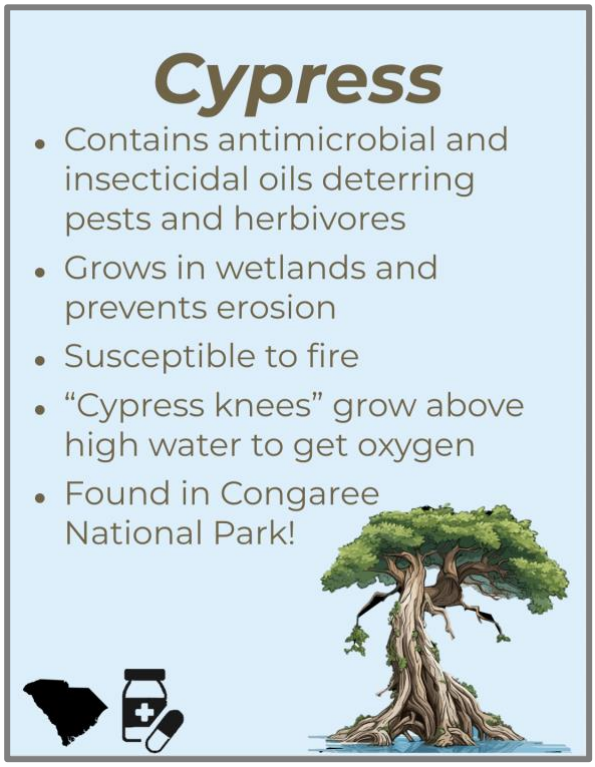
AVID - Philosophical Chairs Information and Graphic Organizers
https://www.osceolaschools.net/site/handlers/filedownload.ashx?moduleinstanceid=2280&dataid=26434&FileName=AVID_Philosophical%20Chairs%20Instructions.pdf

Appendix: Plant Adaptation Cards

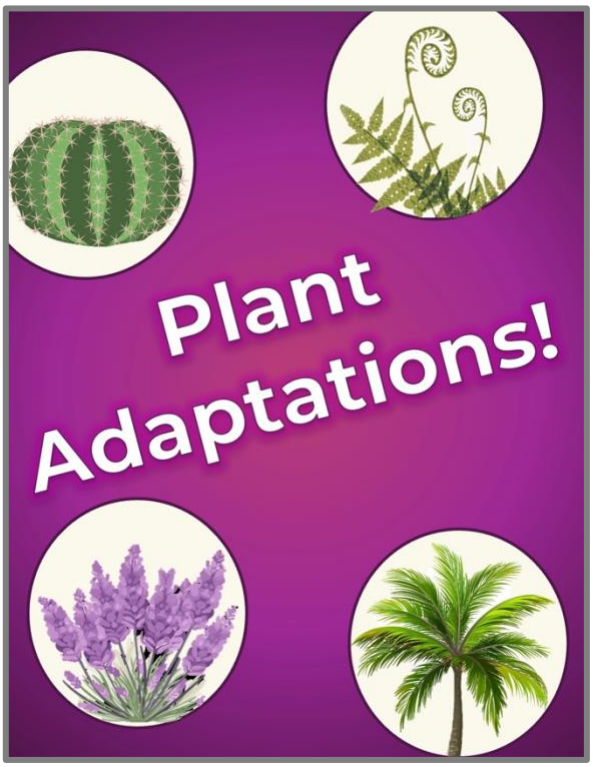


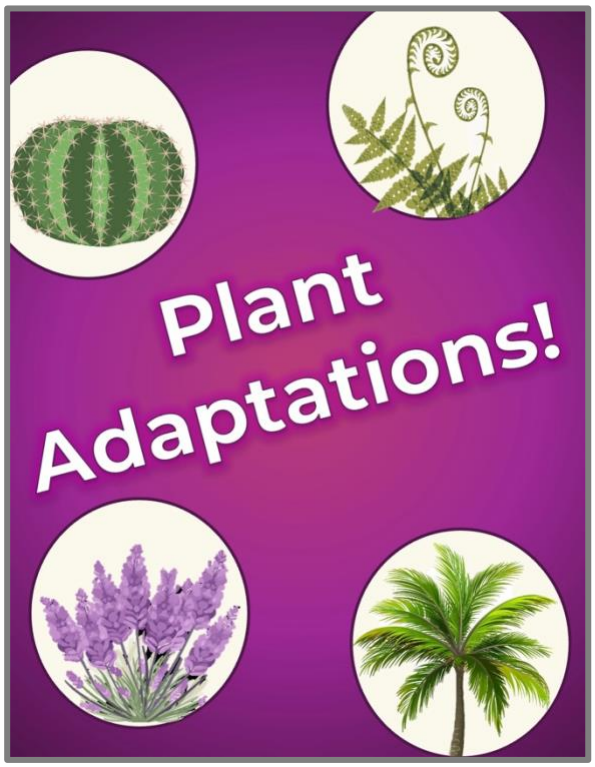


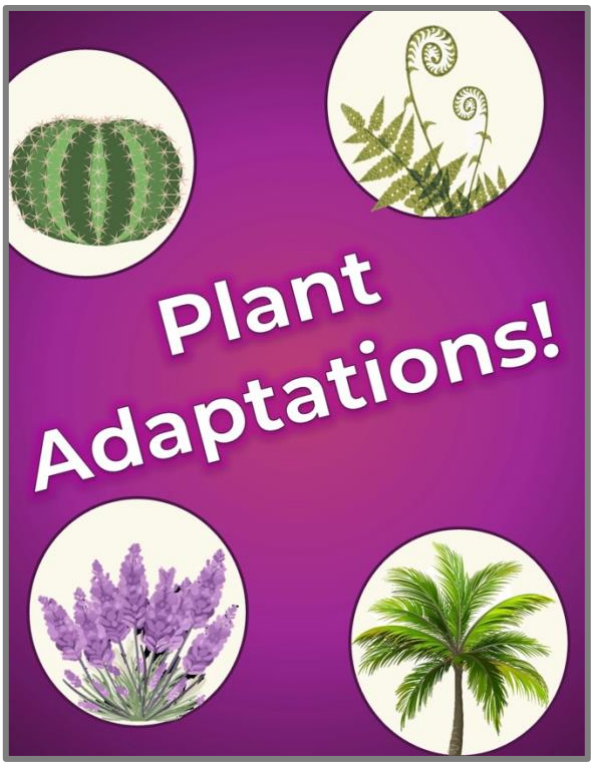


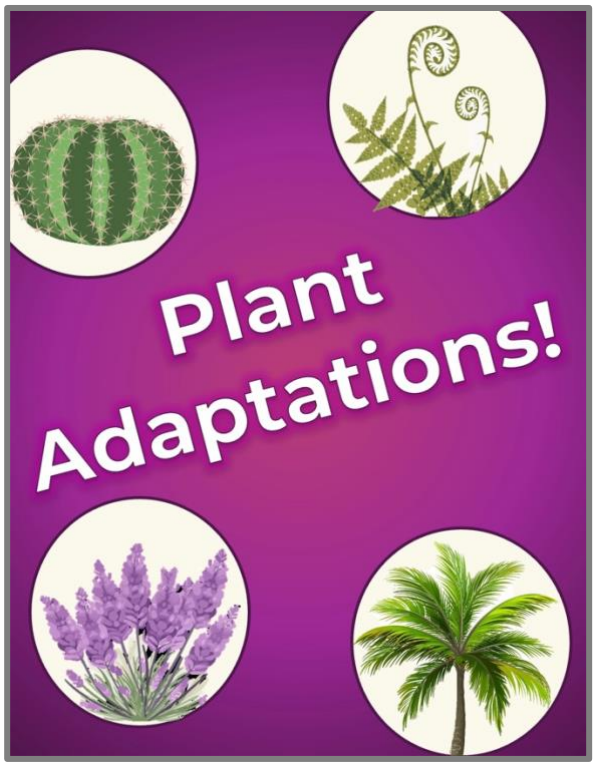


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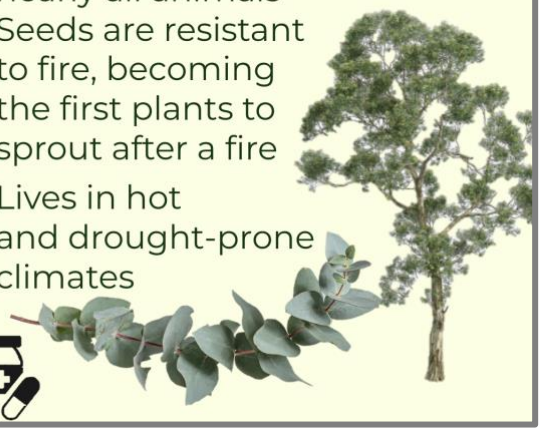
Elderberry

- Traditional medicine used to treat colds and flu, and to boost immunity
- Often found by lakes, ponds, or roadsides
- Seeds contain a toxin to prevent mammals from eating them
- Berries are enjoyed by lots of birds and ***when cooked*** can be used in pies and jellies



Eucalyptus

- Oils repel insects
- Traditional medicine used to treat coughs and colds
- Poisonous when eaten for nearly all animals
- Seeds are resistant to fire, becoming the first plants to sprout after a fire
- Lives in hot and drought-prone climates



Fern

Resilient!

- Underground rhizomes protect from fire
- Leathery leaves deter insects and animals
- Traditional medicine used to treat lung and digestive problems
- Grows in the shade
- Survives mild droughts, cold, and flooding

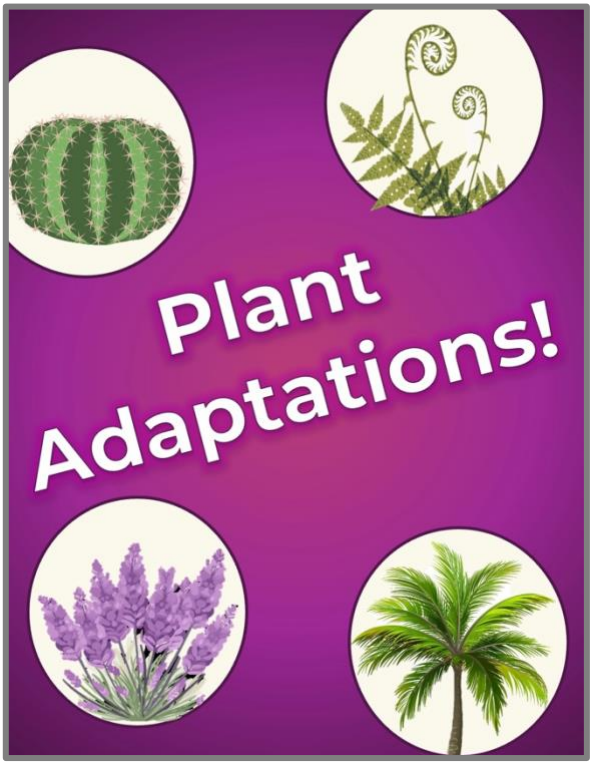


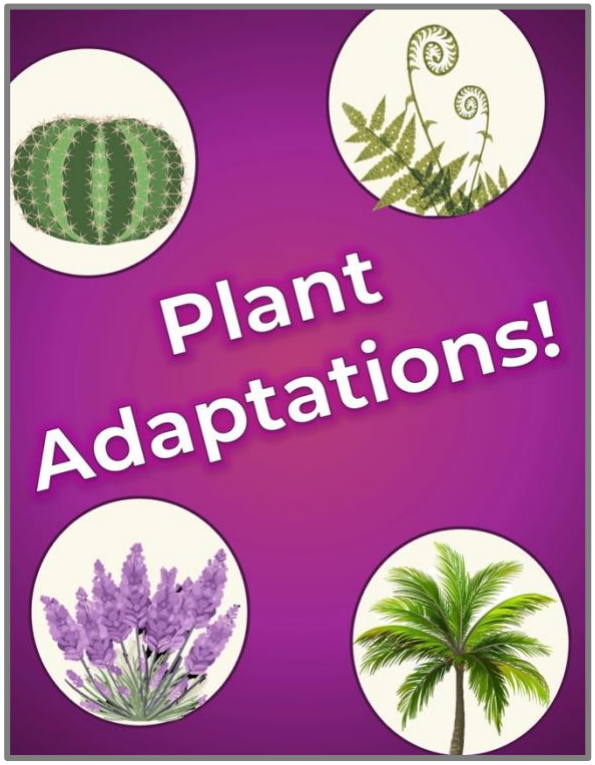
Hibiscus

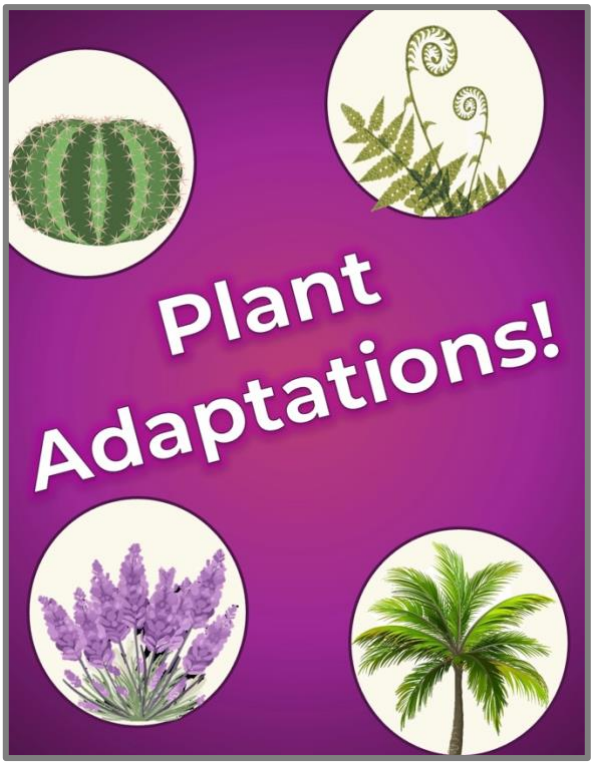
- Grows best in sunny, warm, humid, tropical environments
- Bright colors and nectar attract pollinators like hummingbirds and butterflies
- Flowers are edible
- Traditional medicine used for heart health

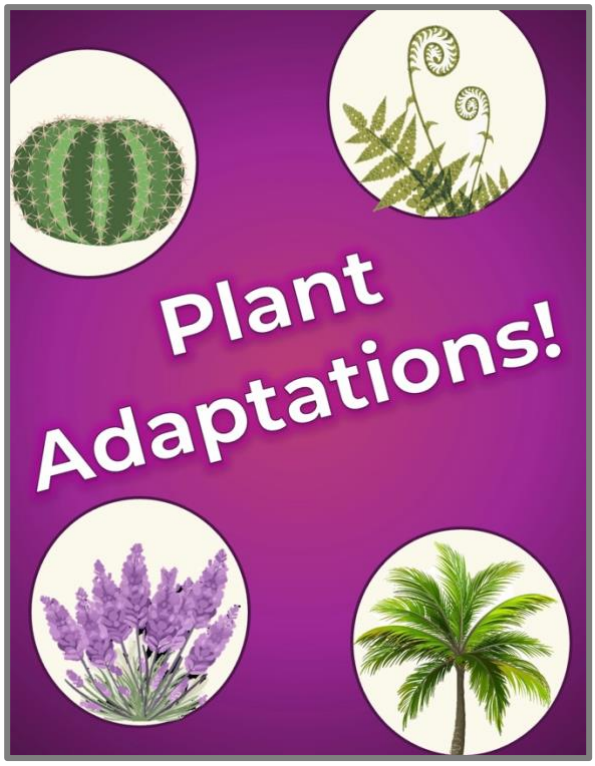


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Magnolia

- Bark has fire resistant cork layer
- Deep tap root keeps them standing during hurricane winds
- Traditional medicine used to treat anxiety and prevent malaria
- Tough leaves deter insects and animals



Milkweed

- Grows in lots of soil types including rocky, clay, sandy, or soil with very little moisture
- Produces a sticky white sap with a chemical that is poisonous to most insects and animals
- The only place a monarch butterfly can lay eggs



Mint

- Produces an oil with a strong scent that deters insects
- Traditional medicine used to treat stomach issues like nausea
- Used in teas and as flavoring
- Produces menthol molecules that cause a cooling sensation

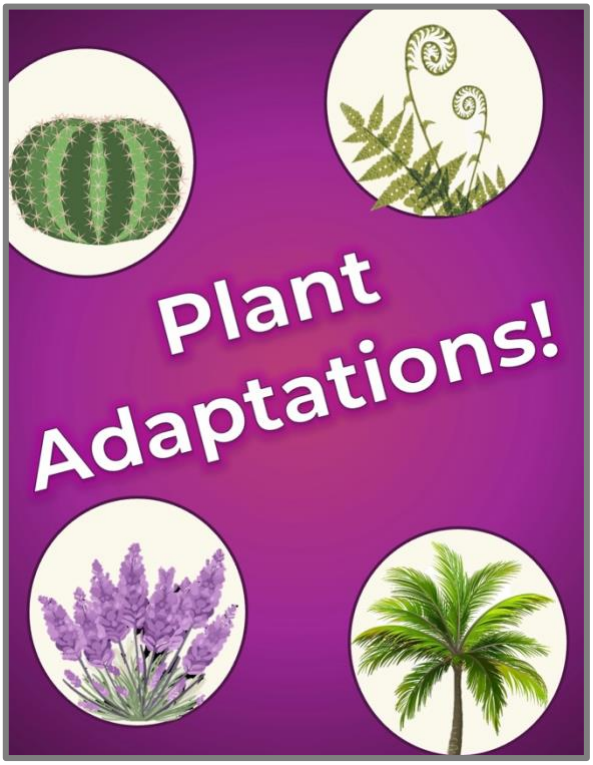


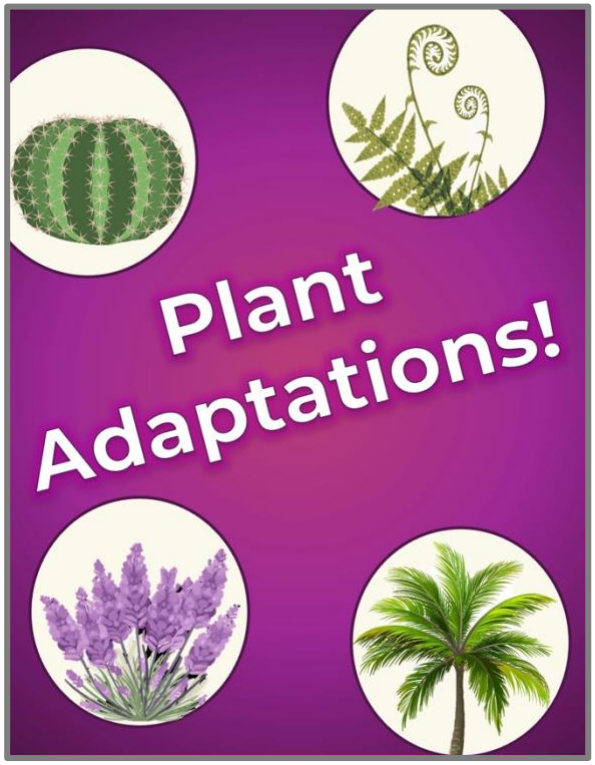
Moss

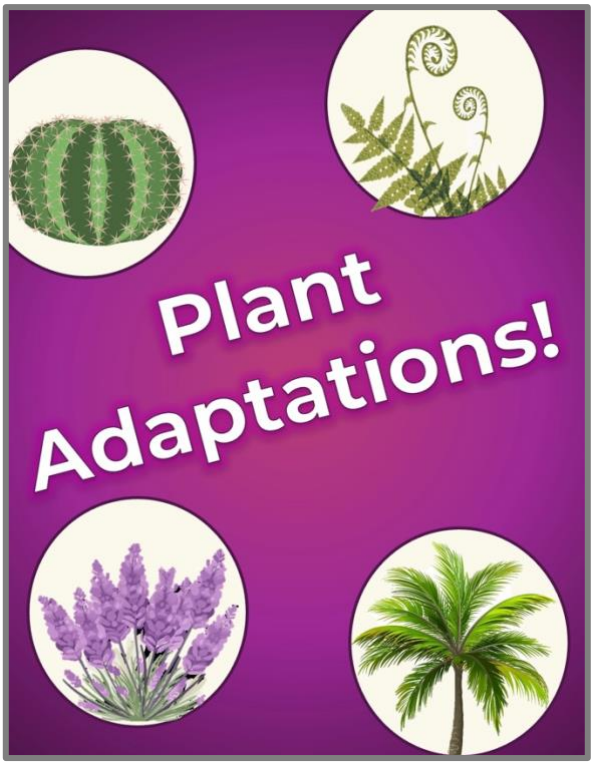
- Lives anywhere with water– even on rocks!
- Incredibly resilient, able to grow in the shade, survives drying out, and produces "anti-freeze"
- Cherokee tribe used moss as an antibiotic and anti-inflammatory

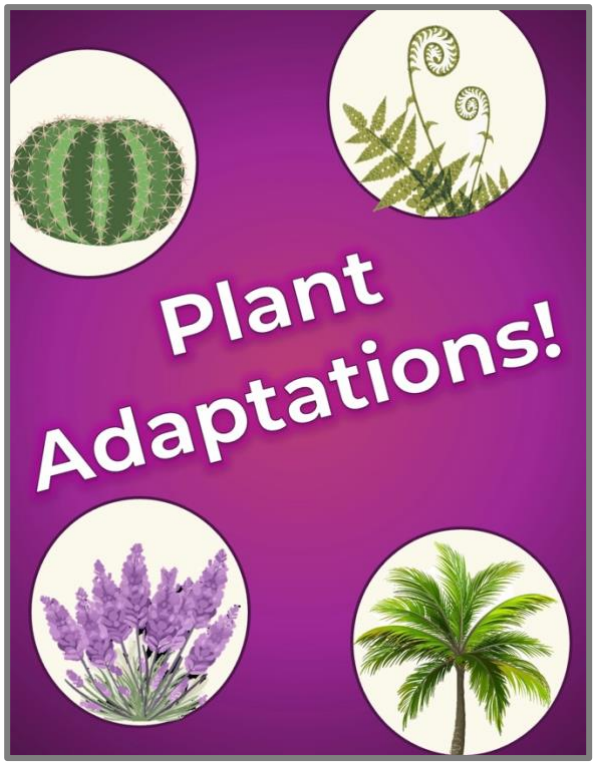


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Pitcher Plant

- Lives in warm environments and wetlands
- Carnivorous: traps and digests insects for nitrogen
- Trichomes ("trapping hairs") in the pitcher prevent insects from climbing out
- Fires are key to restore their habitats



Poison Ivy

Toxic!

- Produces a chemical irritant to repel insects and animals
- "Leaves of three, let it be"
- Can grow in very dry soil



Potato

- Tubers adapted for starch storage help the plant survive harsh winters and fires
- Tubers grow underground
- Vulnerable to disease and lack of water
- Artificially selected to be BIG!



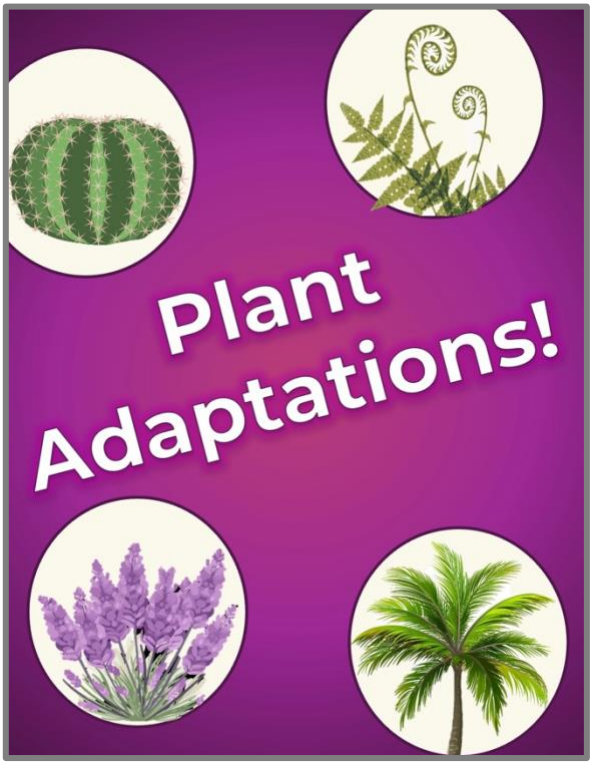


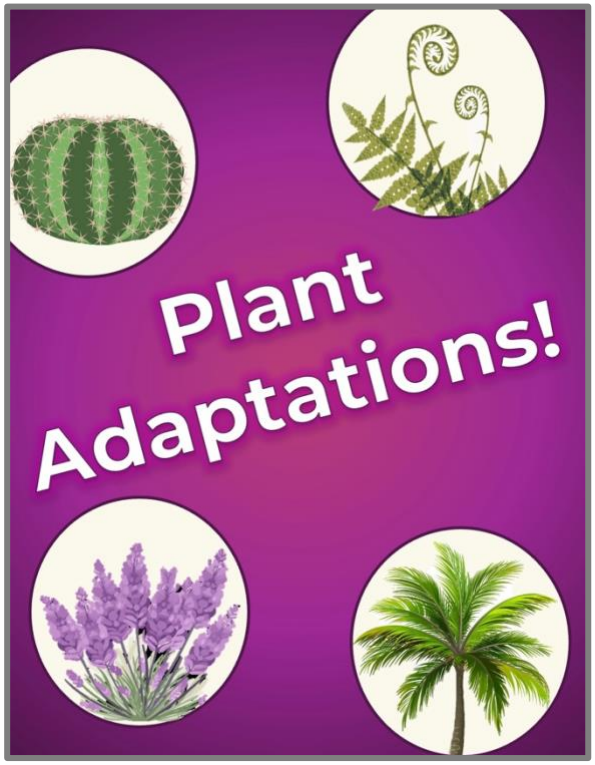
Prickly Pear Cactus

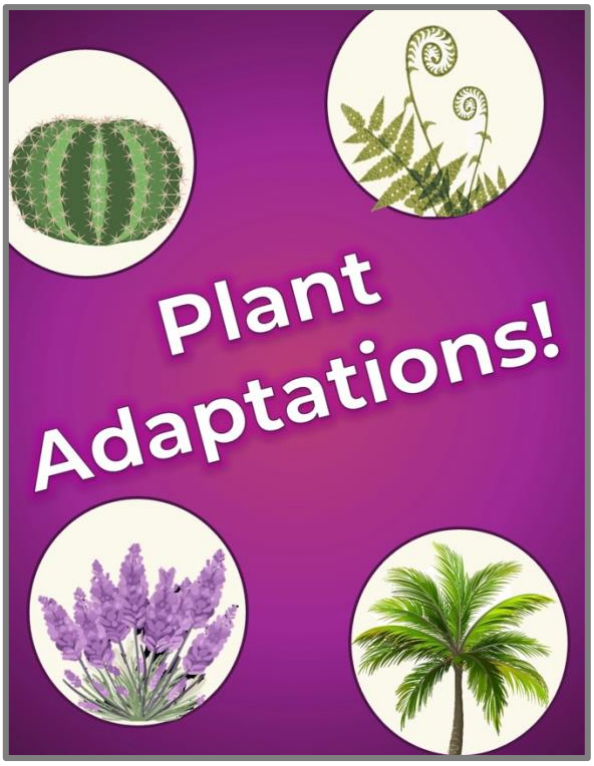
- Opens stomata at night to preserve water in hot and dry climates
- Leaves adapted to be spines to deter herbivores and prevent evaporation of water
- Traditional medicine used for >100 ailments like burns, ulcers, and diabetes
- Vulnerable to pests

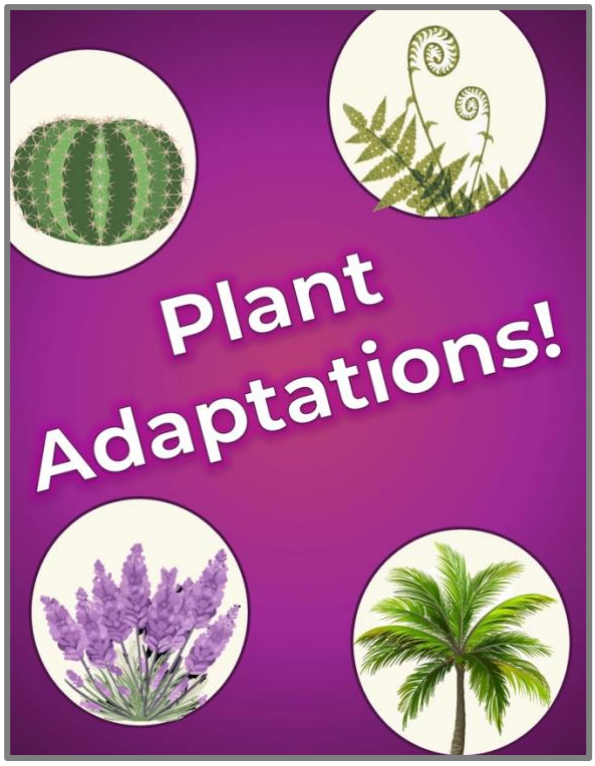


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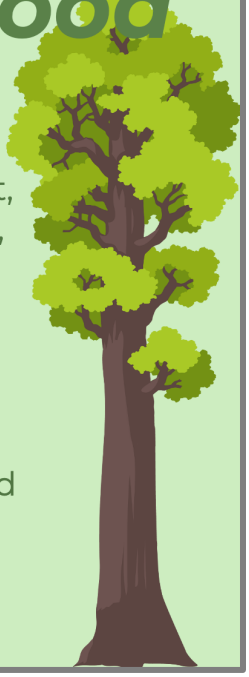




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Redwood

- Thick bark and tannin-rich wood are resistant to rot, insects, predation, and even fire!
- Requires lots of sunlight to grow
- Only grows in the Northern Pacific Coast as they need moisture from coastal fog



Rice

Most valuable crop in the world!

- Domesticated and bred for pest resistance by humans
- Adapted to being submerged in water, such as developing tissue with air pockets



Sugarcane

- Stalks can withstand fire and flooding
- Genetically modified to resist the sugarcane borer insect
- Grows best in tropical environments with lots of water
- Spreads quickly using underground rhizomes

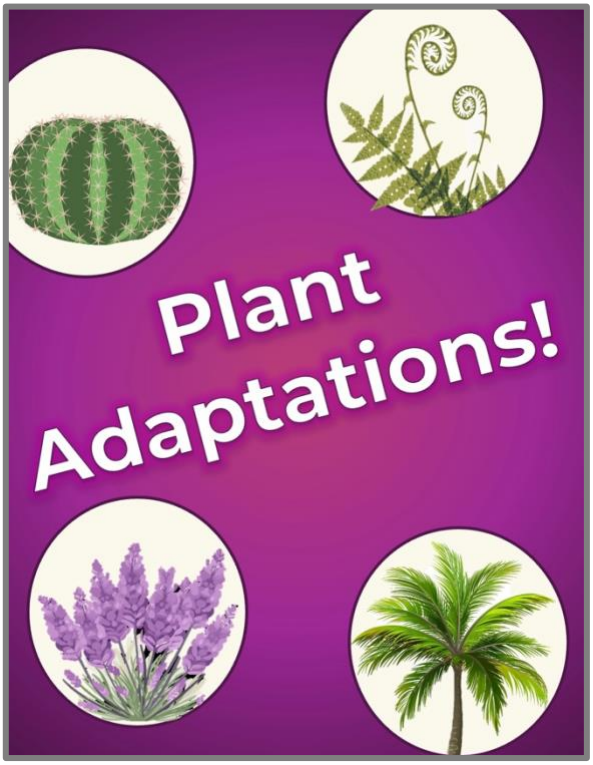


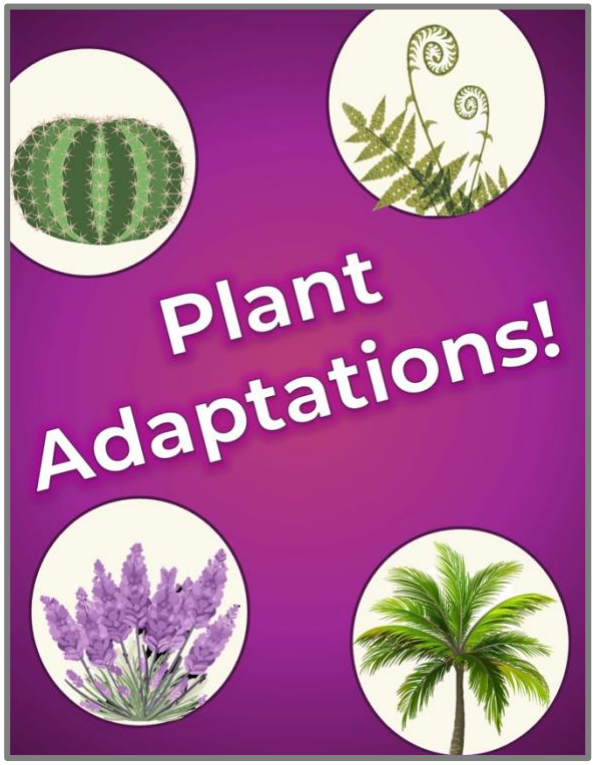
Water Lily

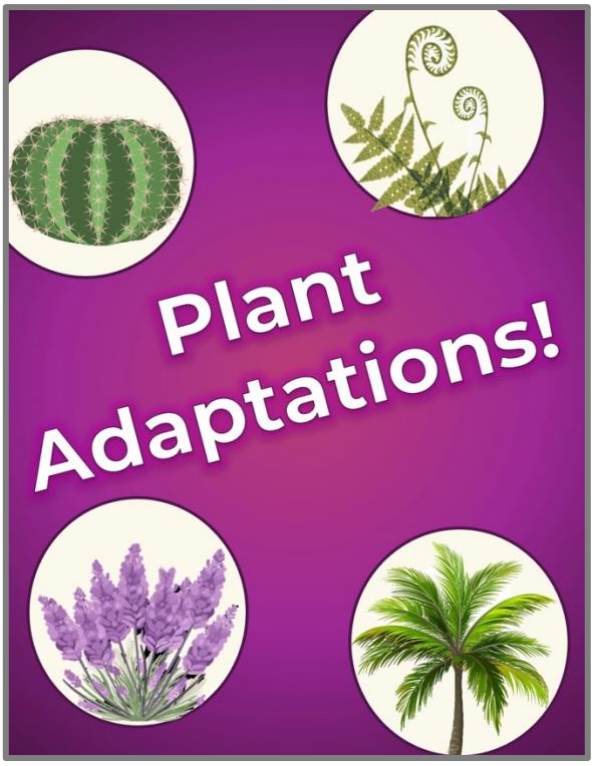
- Lives in water
- Large, broad leaves with air spaces enable it to float and get sunlight
- Specialized air canals to allow oxygen to reach the roots
- Preyed on by insects

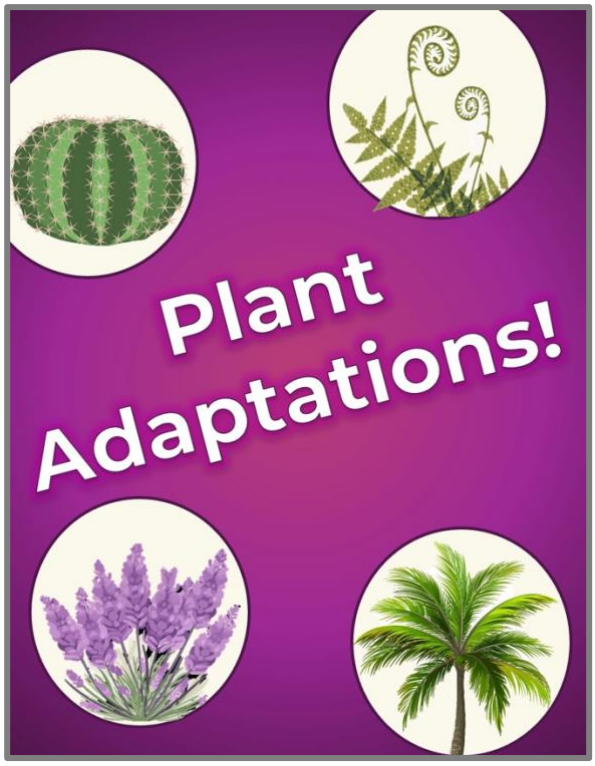


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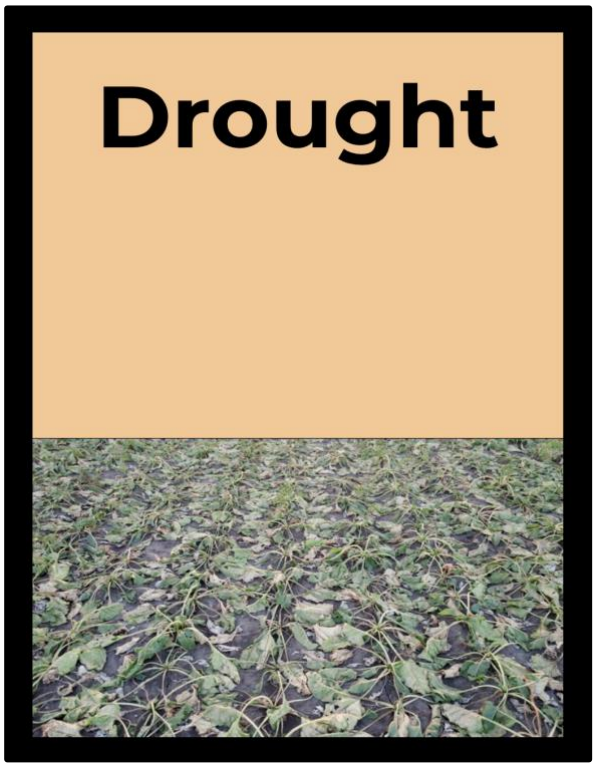




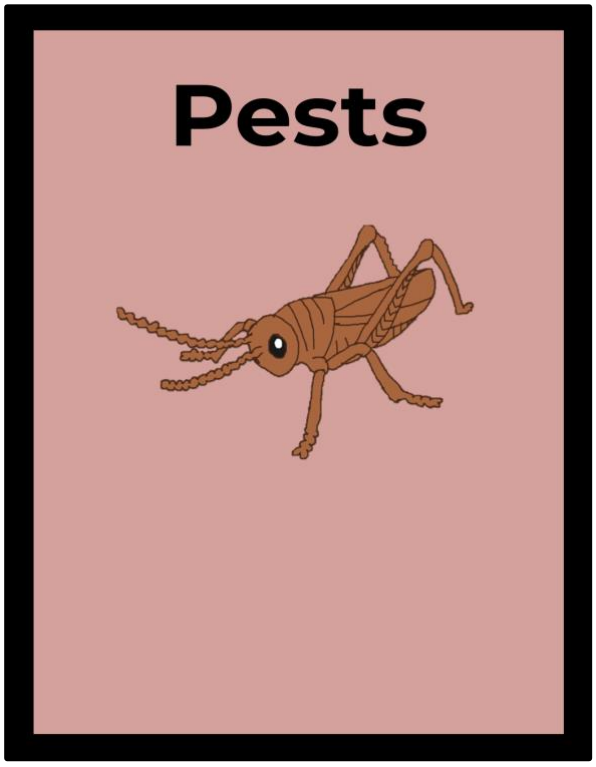
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Appendix: Plant Challenge Cards









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Dies:	Survives:
• Carrot • Cypress • Elderberry • Hibiscus • Magnolia • Mint • Pitcher Plant • Potato • Redwood • Rice • Sugarcane • Water Lily	• Bamboo • Corn • Eucalyptus • Fern • Milkweed • Moss • Poison Ivy • Prickly Pear Cactus

Dies:

- all plants

Dies:	Survives:
• Carrot • Elderberry • Hibiscus • Moss • Potato • Prickly Pear Cactus • Water Lily	• Bamboo • Corn • Cypress • Eucalyptus • Fern • Magnolia • Milkweed • Mint • Pitcher Plant • Poison Ivy • Redwood • Rice • Sugarcane

Dies:	Survives:
• Carrot • Corn • Eucalyptus • Hibiscus • Magnolia • Milkweed • Mint • Poison Ivy • Potato • Prickly Pear Cactus • Redwood	• Bamboo • Cypress • Elderberry • Fern • Moss • Pitcher Plant • Rice • Sugarcane • Water Lily

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Fire



Extreme cold



Herbivores



Low Light



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Dies:

- all but carrot, fern, moss, and potato

Dies:	Survives:
• Carrot • Corn • Cypress • Elderberry • Hibiscus • Milkweed • Mint • Moss • Poison Ivy • Prickly Pear Cactus • Rice • Water Lily	• Bamboo • Eucalyptus • Fern • Magnolia • Pitcher Plant • Potato • Redwood • Sugarcane

Dies:

- all but fern and moss

Dies:	Survives:
• Bamboo • Carrot • Corn • Hibiscus • Mint • Moss • Pitcher Plant • Potato • Rice • Sugarcane • Water lily	• Cypress • Elderberry • Eucalyptus • Fern • Magnolia • Milkweed • Poison Ivy • Prickly Pear Cactus • Redwood

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Appendix: Ancestral Plant Comparison Cards

A



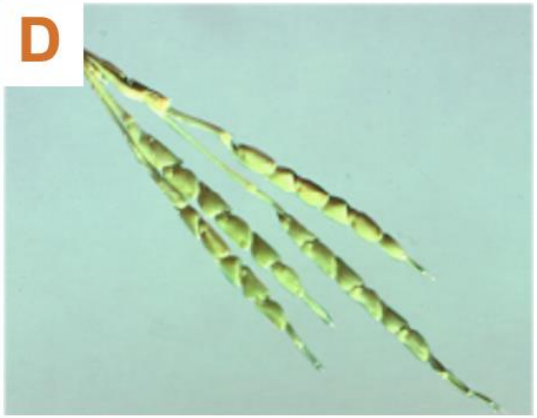
B



C



D



E



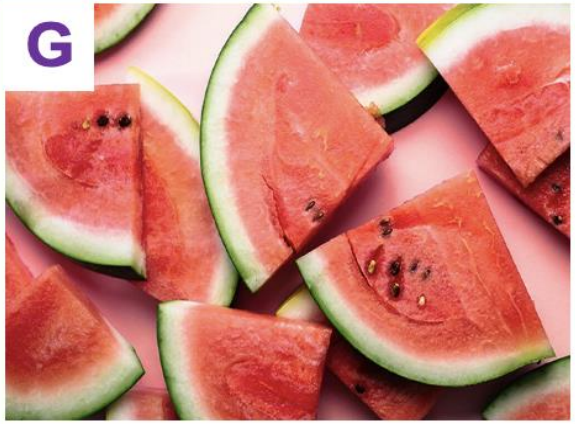
F



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Appendix: Modern Plant Comparison Cards

G



I



K



H



L



J



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Genetic Modification Infographic 1

Crop Modification Techniques

BIOLOGY FORTIFIED

Cross Breeding

Combining two sexually compatible species to create a variety with the desired traits of the parents



The Honeycrisp Apple gets its famous texture and flavor by blending the traits of its parents.

Mutagenesis

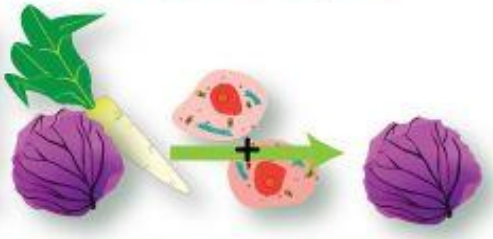
Use of mutagens such as radioactivity to induce random mutations, creating the desired trait



Radiation was used to produce a deeper color in the red grapefruit.

Protoplast Fusion

Fusion of cells or cell components to transfer traits between species



Male sterility is transferred from radishes to red cabbage by fusing their cells. Male sterility helps plant breeders make hybrid crops.

Polyploidy

Multiplication of the number of chromosomes in a crop to impact its fertility



Seedless watermelons are created by crossing a plant with 2 sets of chromosomes with another that has 4 sets. The seedless fruit has 3 sets.

Genome Editing

Use of an enzyme system to modify DNA directly within the cell



Genome editing was used to develop herbicide resistant canola to help farmers control weeds.

Transgenesis

Addition of genes from any species to create a new variety with desired traits

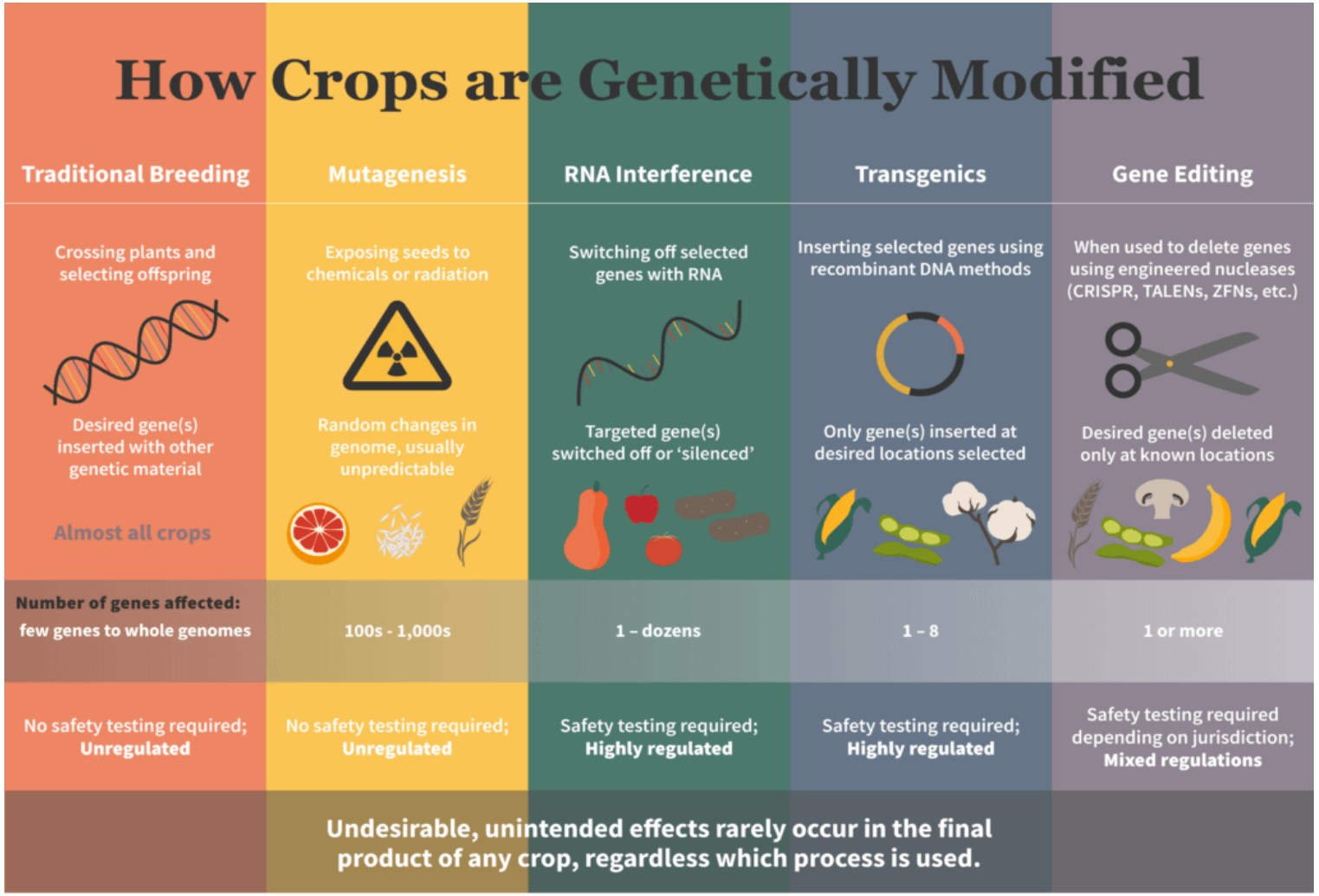


The Rainbow Papaya is modified with a gene that gives it resistance to the Papaya Ringspot Virus.

www.biofortified.org

Follow us on Twitter (@franknfoode) or join our Facebook Page
By Layla Katiraee (@BiochicaGMO) in collaboration with Karl Haro von Mogel (@kjhvm)
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Genetic Modification Infographic 2



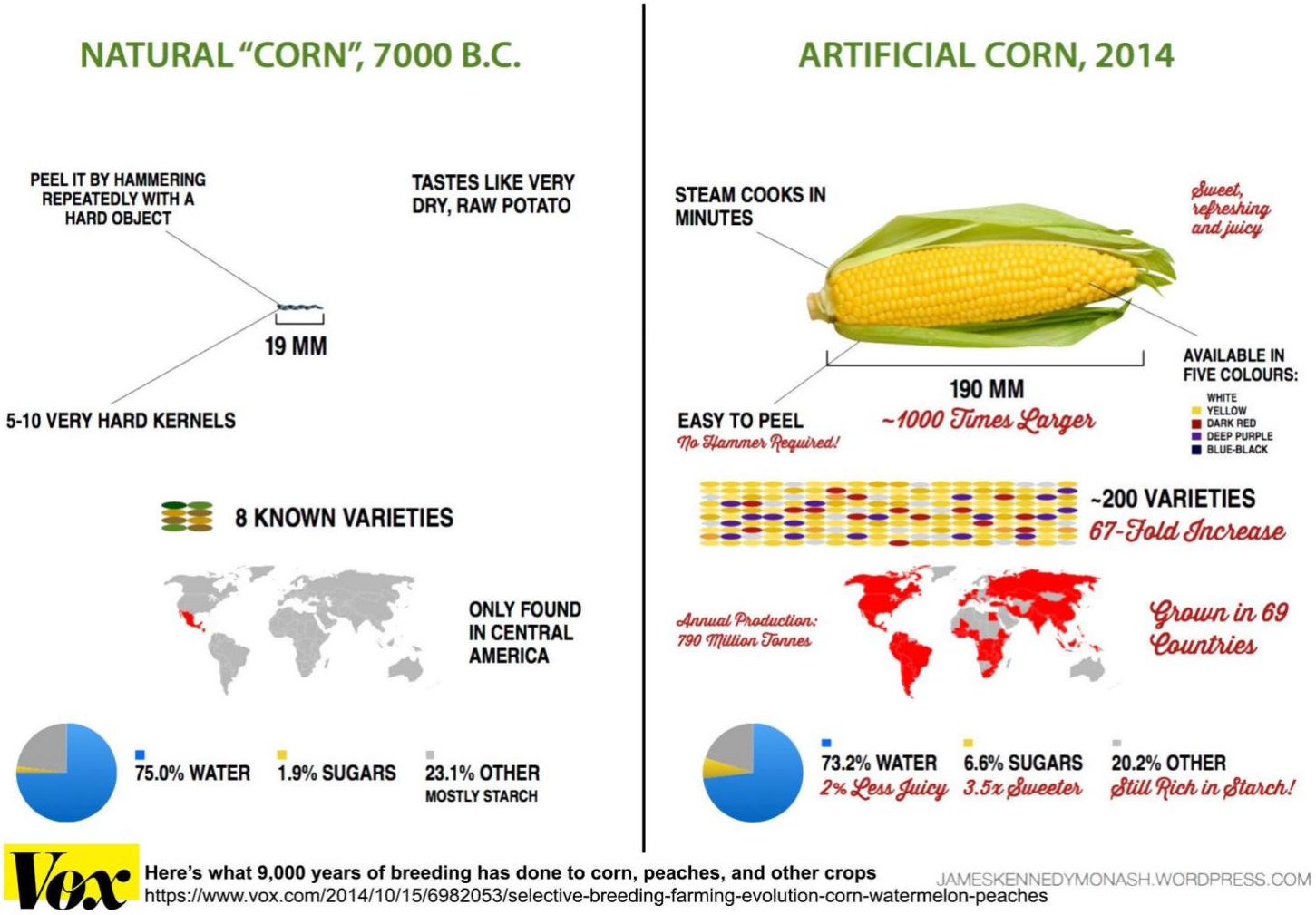
Genetic Literacy Project
SCIENCE NOT IDEOLOGY

Sources: Biotechnology Provides New Tools for Plant Breeding, University of California Davis Publication 8043; Plant Breeding: Induced Mutation Technology for Crop Improvement, F.J. Novak, H. Brunner, International Atomic Energy Agency, 1992; Atomic Gardens: Public Perceptions and Public Policy, B. Dick, M. Jones, Life Sciences Foundation Magazine: RNAi for Crop Improvement, International Service for the Acquisition of Agri-Biotech Applications Pocket K No. 34. **Infographic by Kayleen Schreiber, PhD; advisor: Wayne Parrott, PhD.**

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Genetic Modification Infographic 3

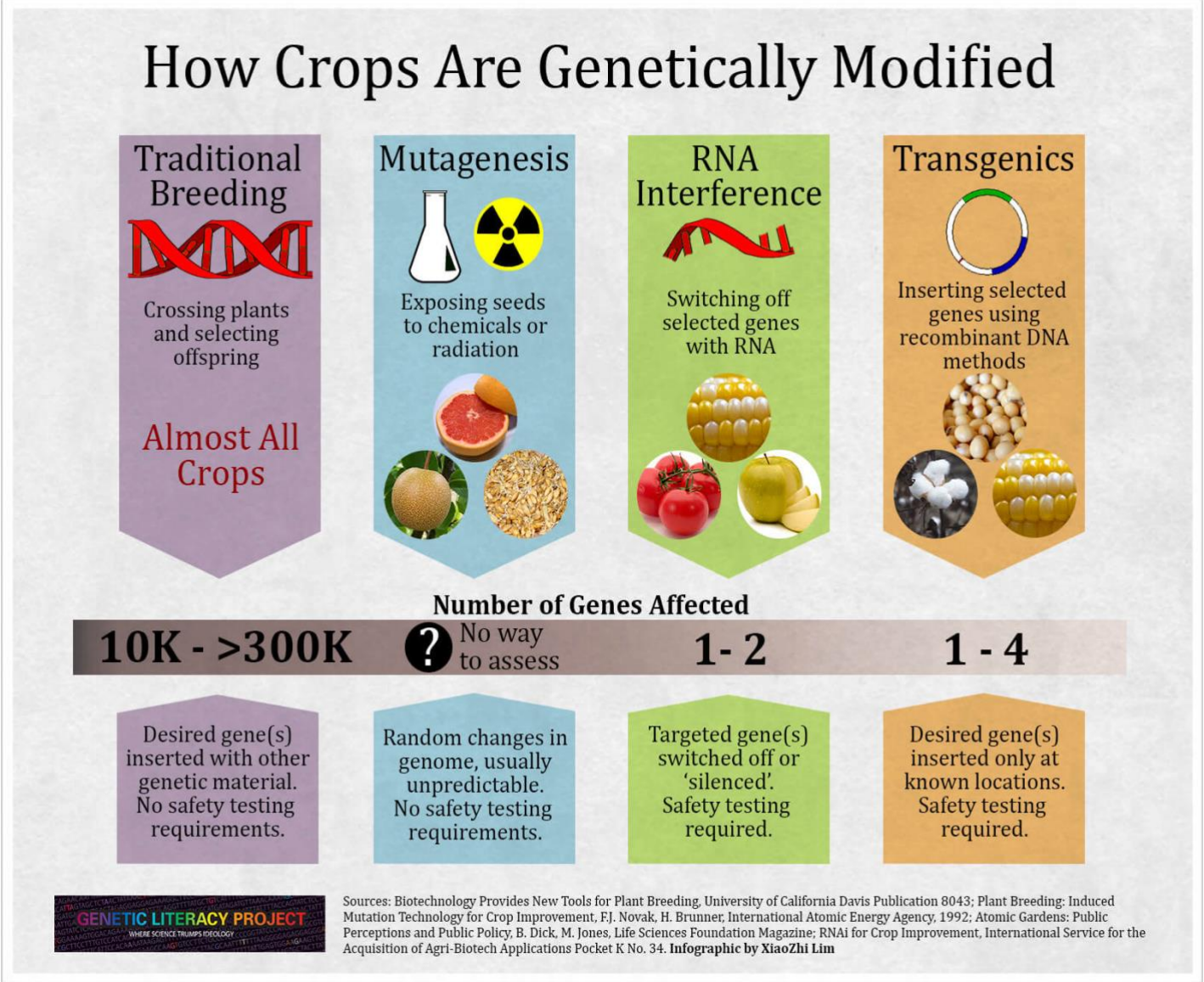


This infographic provides examples of how traditional plant breeding has been used to modify agricultural crops. Traditional plant breeding and selection of the best offspring (artificial selection) was used to develop modern corn and additional modifications have been made through various biotechnological processes.

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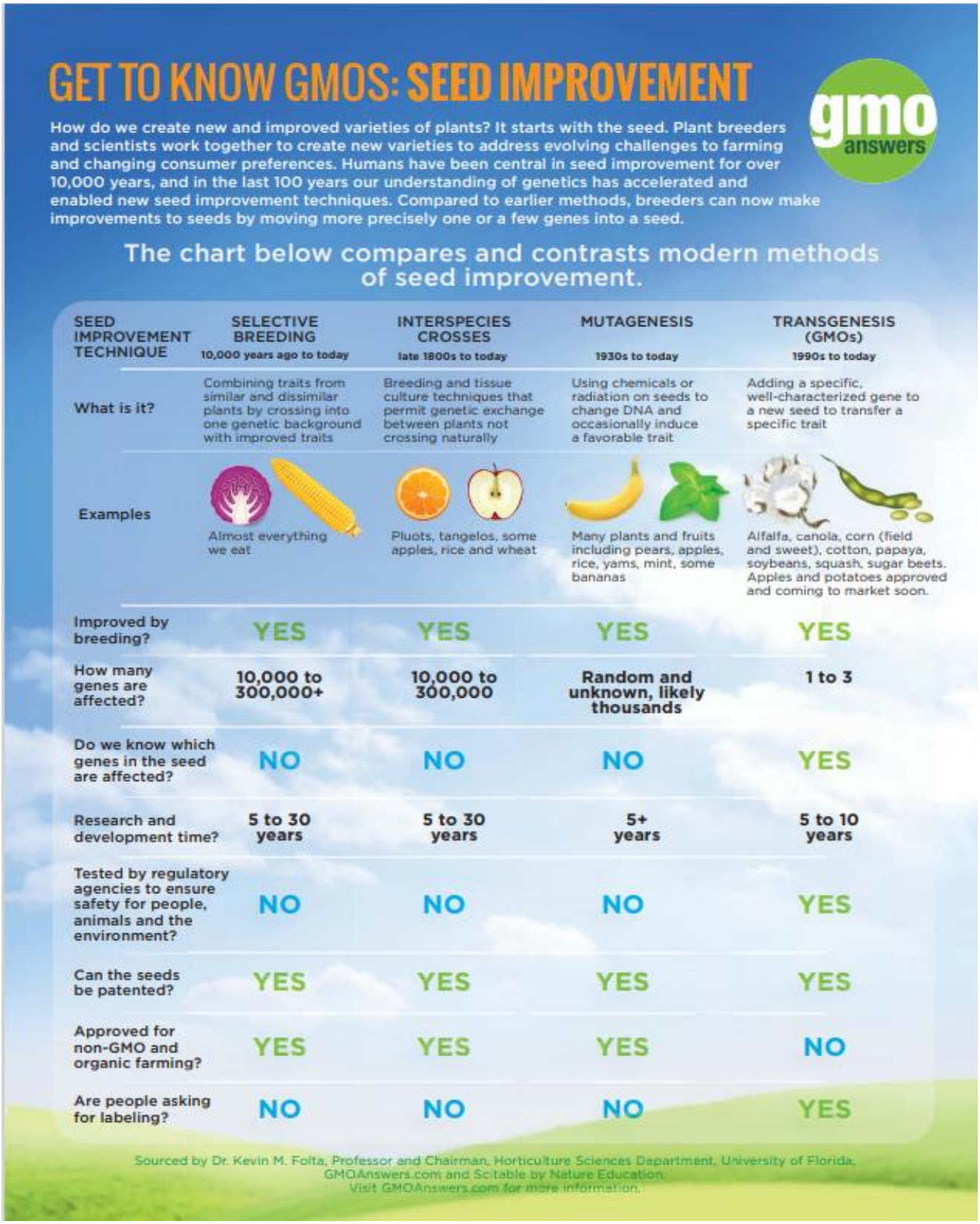
Genetic Modification Infographic 4



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Genetic Modification Infographic 5



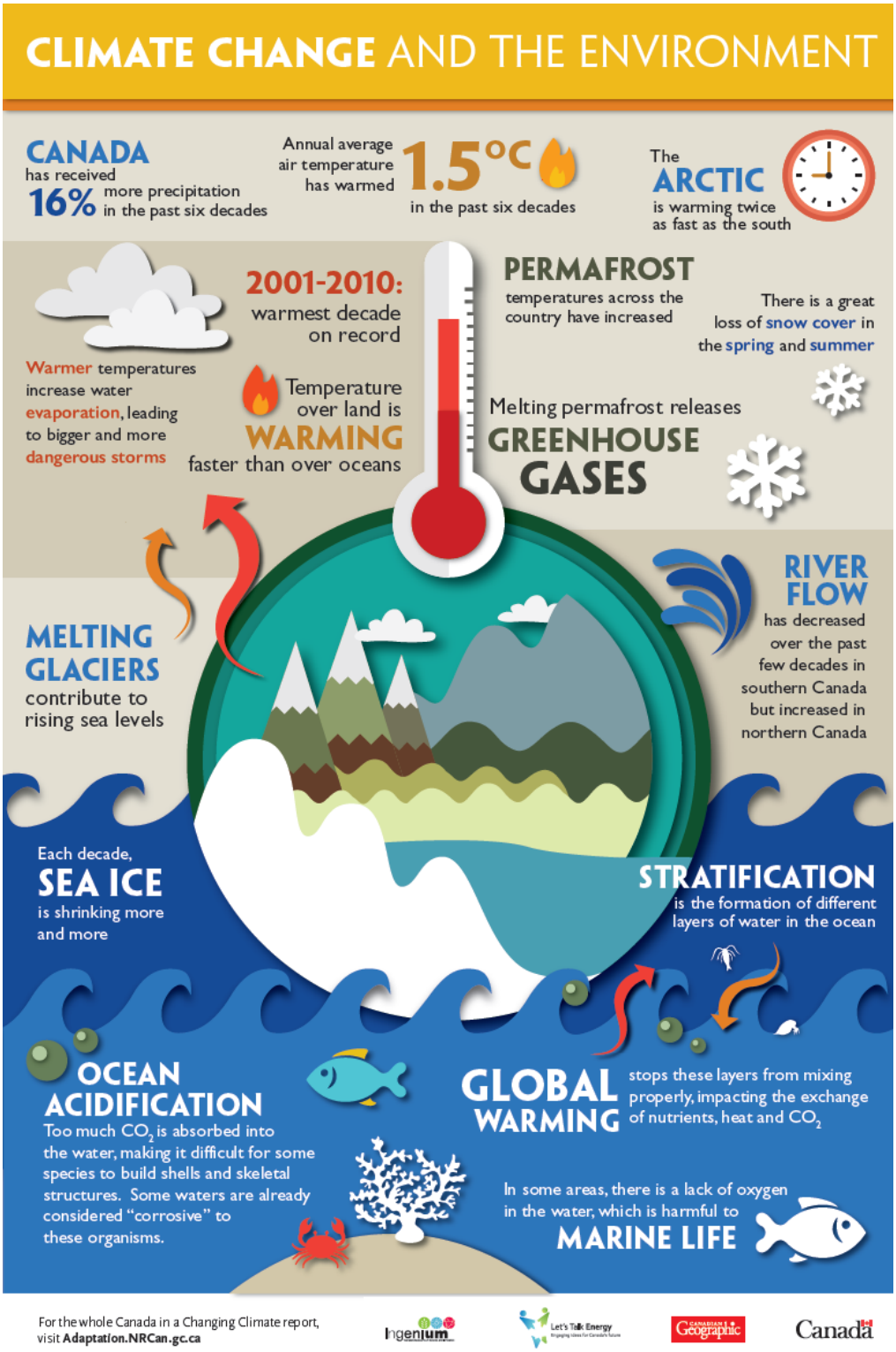
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Infographic Vocabulary Glossary

Artificial	Not naturally occurring, occurring through human selection
Balanced	Taking everything into account; fairly judged or presented
Chromosome	A threadlike structure found in the nucleus of most living cells that carries the genetic information
Clear	Explained well, in an understandable manner
Coherent	Logical and consistent explanation or argument
Contextual	Relating to a particular setting or circumstance
Corrosive	Having the quality of corroding or eating away, erosive, harmful, or destructive
DNA	Deoxyribonucleic Acid: a molecule found in living cells that contains the genetic information for an organism's development and function. Consists of a double strand of nucleotides.
Enzyme	A protein molecule that helps speed up chemical reactions in the body
Factual	Concerned with what is actually the case rather than interpretations of or reactions to it. Actually occurring.
Fusion	The process resulting in the joining of two or more things together
Gene	A segment of DNA that contains information for making proteins; the basic unit of heredity that is passed from parent to child; A sequence of DNA found on a chromosome.
Impactful	Having great power or force or potency or effect
Mutagens	A physical or chemical agent that changes an organism's DNA causing a mutation
Nucleases	An enzyme (see above) that breaks nucleic acids (like DNA and RNA) by cutting the bonds that link them together
Oceania	A geographical region in the Pacific Ocean that includes Australasia, Melanesia, Micronesia, and Polynesia
Offspring	The young or children of a parent; the descendants of a person, animal, or plant

Permafrost	Any ground that remains completely frozen at 32°F (0°C) or colder for at least two years straight. Common in regions with high mountains and in higher latitudes.
Pluots	A hybrid fruit created through the cross between a plum and an apricot
Purposeful	Intentional; having or showing a purpose
Recombinant DNA	Combining different pieces of DNA
Relatable	Enabling a person to feel that they can relate to someone or something
Responsible	Capable of being trusted
Rhizome	A horizontal underground stem that grows in plants
RNA	Ribonucleic Acid; a molecule found in living cells and some viruses that is essential for most biological functions. Consists of a single strand of nucleotides.
Scientific	Related to or exhibiting the methods or principles of science. Practicing or using thorough or systematic methods.
Spellbinding	Holding one's attention completely as though by magic; fascinating
Tangelos	A citrus fruit hybrid, a cross between an orange or tangerine and a pomelo or grapefruit.
Targeted	Directed at a particular audience
Tissue culture	A technique that involves growing cells or tissues from an organism in a controlled environment
Traits	Genetically determined characteristic; A distinguishing quality or characteristic
Transparent	Easy to perceive or detect

Climate Infographic 1

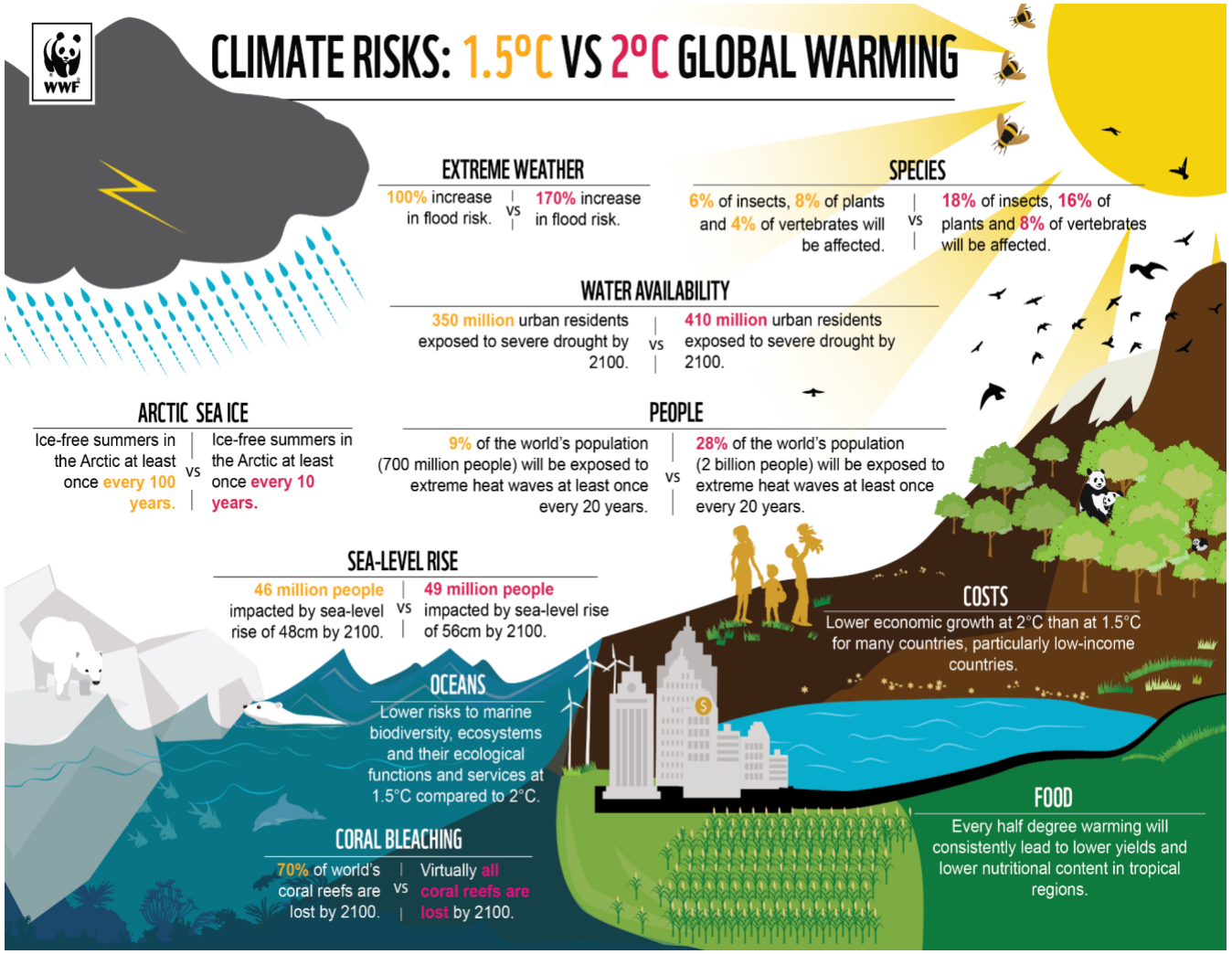


This infographic explains the environmental effects of the 1.5°C (2.7°F) increase in average temperatures that have occurred in the past 60 years (since about 1960).

Infographic from: https://www.cakex.org/tools/educational-climate-adaptation-lesson-plans-and-infographics

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Climate Infographic 2



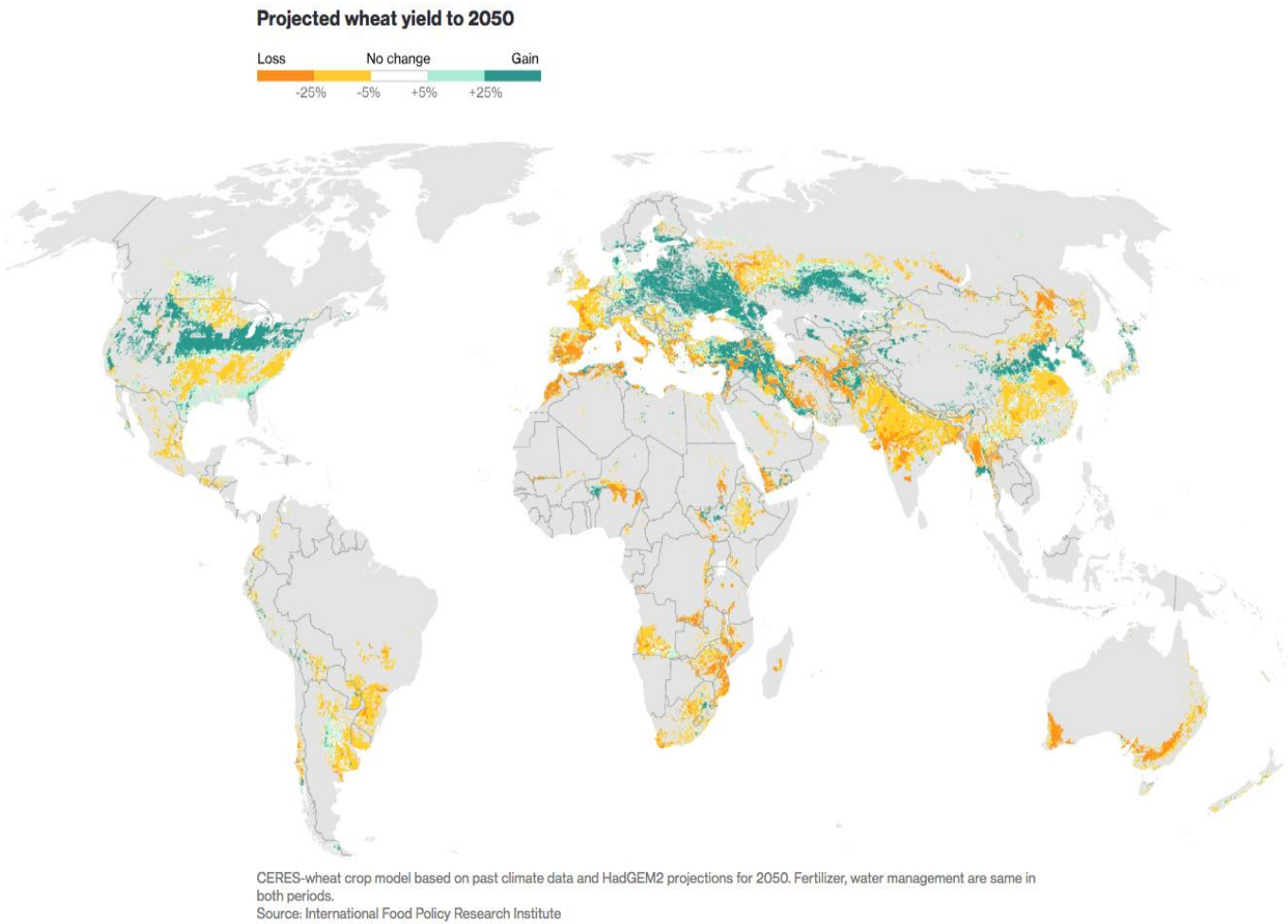
This infographic explains the impact an extra 0.5°C (0.9°F) increase in average global temperature can have on weather, species, sea level, food production, and habitats such as coral reefs and the arctic.

Infographic from: https://visme.co/blog/climate-change-facts/

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Climate Infographic 3



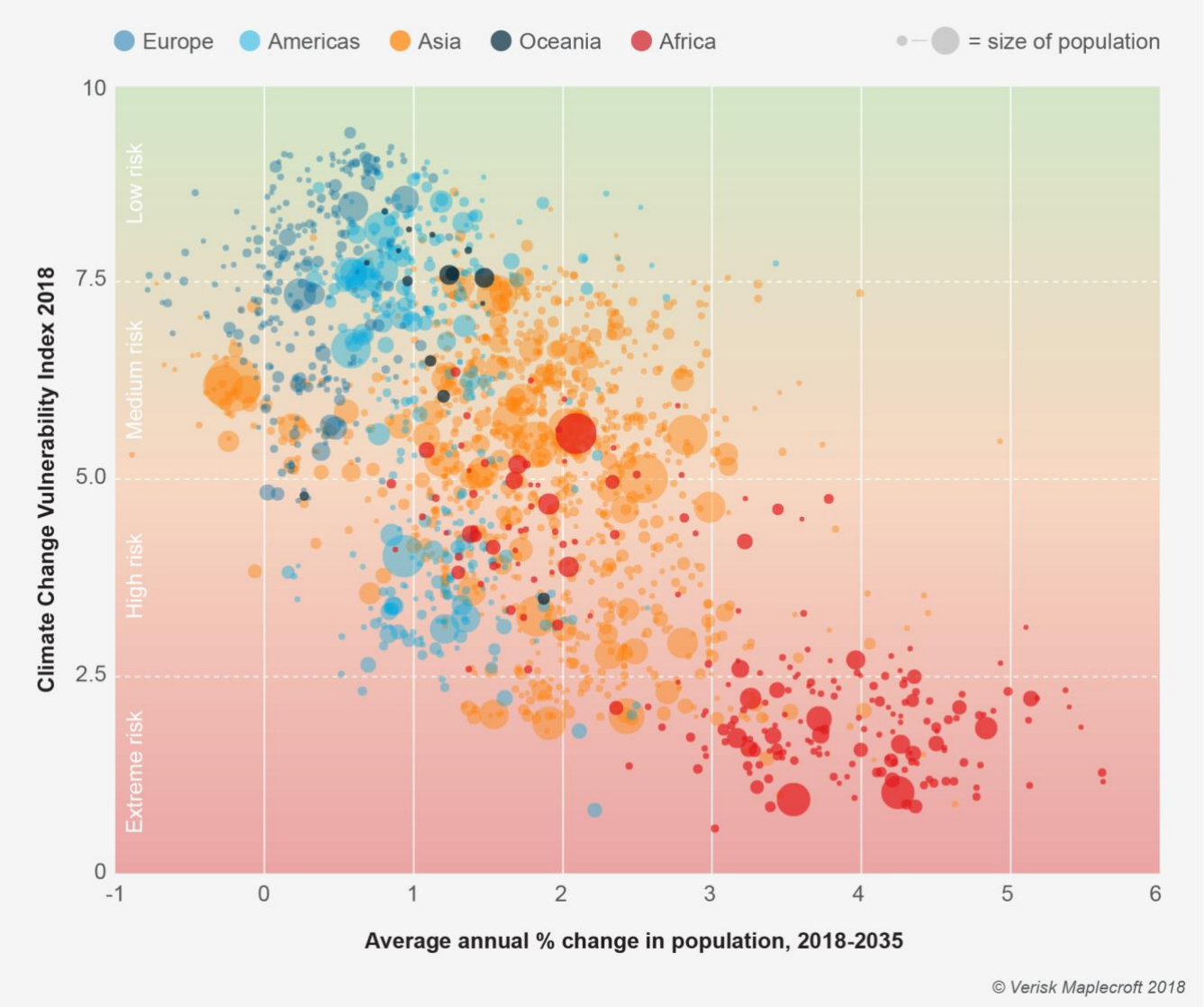
This infographic displays the shift in predicted wheat harvested in different regions of the world by 2050. Dark green indicates a gain (increase) in wheat production and orange represents a decrease (loss) of wheat produced. Wheat is a major food source both for humans and livestock and therefore is a resource to nations.

Infographic from: https://visme.co/blog/climate-change-facts/

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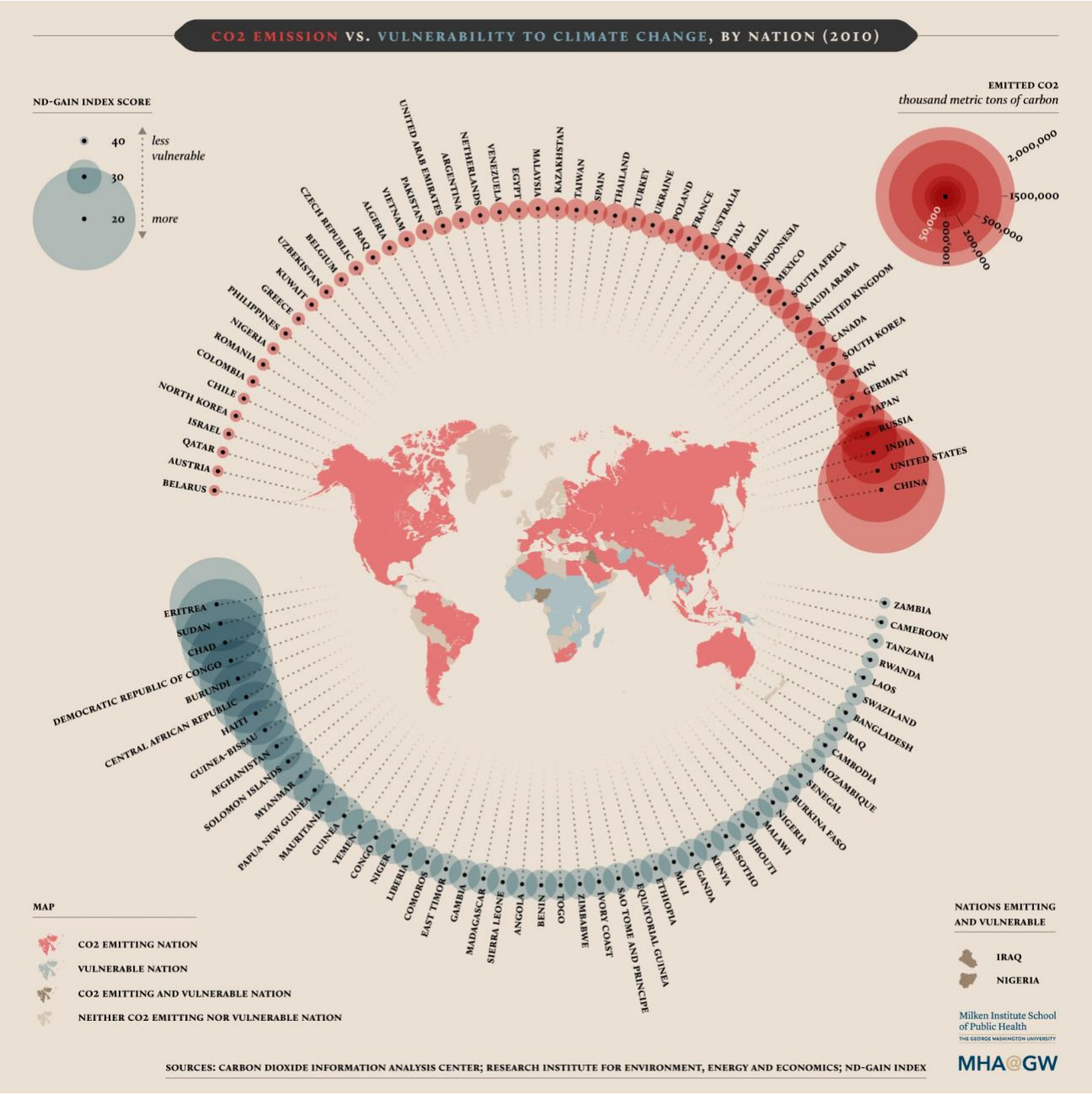
Climate Infographic 4



This infographic compares a United Nations prediction of population growth in cities from 2018 to 2035 (x axis) to a measure of how vulnerable each city is to the effects of climate change (y axis). Note that the y-axis places “extreme risk” closer to the bottom and “low risk” closer to the top. As indicated in the legend, larger circles represent a larger number of people living in each city, and the color represents the continent on which the city is located. A dot placed farther right means the city has experienced a greater change in population and a dot placed closer to the y-axis indicates that the city has not changed as much in population.

Infographic from: https://visme.co/blog/climate-change-facts/

Climate Infographic 5



The Milken Institute School of Public Health created this graphic in 2015 as a comparison between two data groups. In this visualization, the red circles represent countries which emit the most carbon dioxide. The blue circles represent the countries which are the most vulnerable due to carbon dioxide emission.

Infographic from: https://visme.co/blog/climate-change-facts/

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