Biotechnology Printable Pages

Genetic Engineering Guide

Goals:

1. Consider each plant and location.
2. Decide the trait that needs to be modified.
3. Select a type of tool to modify the trait.
4. Choose what you would add or change.

Toolkit:

- **Gene insertion:** Allows you to give your plants traits of other organisms
- **Gene editing:** Allows you to change current traits in your plant
- **Crossbreeding:** Allows you to give your plants traits of other members of its species by breeding those members together

Issues modifications might address:

Drought, nutrition, space, food waste, pests, and others

Genetic Modification Card — Cotton

Scenario:

Sebastian's cotton plants are constantly eaten by an invasive species. His family grows cotton on their farm in Mexico, but lately most of their crops have been getting eaten by caterpillars. How can Sebastian's cotton be modified to resist these insects?

Genes in other organisms:

Gene CRY3Bb: Gene in soil bacteria that produces a chemical toxic to insects

Gene PYR: Gene in bacteria that helps them produce an essential nutrient

Gene CP4 EPSPS: Gene in soil bacteria that makes them resistant to herbicides (chemicals that kill weeds)

Toolkit choice (check one):

☐ Gene insertion ☐ Gene editing ☐ Crossbreeding

Which gene would you add or change? _____

Genetic Modification Card — Rice

Scenario:

Angel is a rice farmer in t he Philippines. Globally, every year lack of access to nutritious food, and especially essential vitamins, kills many children, including in the Philippines. How can Angel's family's rice be modified to be more nutritious?

Genes in other organisms:

Gene psy: Gene in maize that helps create vitamin A

Gene SIGLK2: Gene in tomatoes that controls the amount of sugar and flavor

Gene crtI: Gene in soil bacteria that helps create vitamin A

Toolkit choice (check one):

☐ Gene insertion ☐ Gene editing ☐ Crossbreeding

Which gene would you add or change? _____

Genetic Modification Card — Tomatoes

Scenario:

Carla lives in a city in Chile where the only space she has available to grow food is indoors. Carla wants to grow tomatoes, but their long vines and need for light make it difficult to grow enough tomatoes indoors to feed a family. How can Carla's tomatoes be modified for city life?

Genes in other organisms:

Gene SIER: Controls whether a tomato plant will grow tall

Gene SP5G: Controls when a tomato plant will flower or bear fruit

Gene SGR1: Controls how red a tomato will be

Toolkit choice (check one):

☐ Gene insertion ☐ Gene editing ☐ Crossbreeding

Which gene would you add or change? _____

Genetic Modification Card — Apples

Scenario:

Jaylan is an apple farmer in the United States. He wants to make sure his apples are eaten and not wasted. Sliced apples turn brown after being exposed to air. Often people throw browned apples away even though they are still okay to eat. How can Jaylan's apples be modified to make people less likely to waste them?

Genes in other organisms:

Gene PPO: Produces an enzyme that browns apples

Gene CLV1: Controls how well apples respond to pests

Gene GA30X1: Controls the size an apple tree will grow

Toolkit choice (check one):

☐ Gene insertion ☐ Gene editing ☐ Crossbreeding

Which gene would you add or change? _____

Genetic Modification Card — Maize (Corn)

Scenario:

Grace farms maize in Kenya. Kenya has a severe drought. Maize does not grow well without water and this has left many families without enough to eat. How can Grace's maize crop be modified to grow better in Kenya's current climate?

Wild Relatives of Maize:

Wild type relative A: Naturally sensitive to drought, grows poorly when lacking water

Wild type relative B: Naturally grows maize that's high in sugar and tastes sweet

Wild-type relative C: Naturally drought-resistant, grows well even when water is scarce

Toolkit choice (check one):

☐ Gene insertion ☐ Gene editing ☐ Crossbreeding

Which gene would you add or change? _____

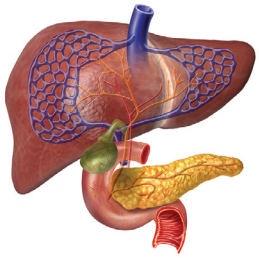
Organ Card: Kidney

Cell types: More than 20 cell types

Structure: Around 10 to 12 cm in adults and contains about 1 million mini filtering units

Blood vessels: Kidneys have large arteries the branch into smaller arteries. They contain many blood vessels.

Organ Card: Liver

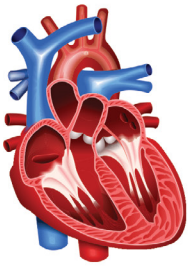


Cell types: 4 cell types

Structure: Around 14 cm in diameter, split into two main parts; each part contains around 8,000 smaller areas

Blood vessels: A large vein drains blood out of the liver. It does not contain many small blood vessels.

Organ Card: Heart



Cell types: 4 major cell types

Structure: Around the size of a fist, divided into four chambers; each chamber is surrounded by a muscular wall

Blood vessels: Blood is pumped through each of the four chambers, as well as through branching arteries and veins.

Organ Card: Lung

Cell types: More than 40 cell types

Structure: The main entrance branches into two areas, each of which divide many times into tiny sections

Blood vessels: Lungs are covered with arteries and veins that branch into many smaller blood vessels.

Challenge Card for: _____ Difficulty score

Cell complexity:
Does this organ contain many different types of cells?

_____

Structural complexity:
Is the organ structure complex? Is it large?

_____

Blood vessels:
Would many blood vessels need to be printed?

_____

Overall difficulty (add difficulty scores):

Challenge Card for: _____ Difficulty score

Cell complexity:
Does this organ contain many different types of cells?

_____

Structural complexity:
Is the organ structure complex? Is it large?

_____

Blood vessels:
Would many blood vessels need to be printed?

_____

Overall difficulty (add difficulty scores):

Challenge Card for: _____ Difficulty score

Cell complexity:
Does this organ contain many different types of cells?

_____

Structural complexity:
Is the organ structure complex? Is it large?

_____

Blood vessels:
Would many blood vessels need to be printed?

_____

Overall difficulty (add difficulty scores):

Challenge Card for: _____ Difficulty score

Cell complexity:
Does this organ contain many different types of cells?

_____

Structural complexity:
Is the organ structure complex? Is it large?

_____

Blood vessels:
Would many blood vessels need to be printed?

_____

Overall difficulty (add difficulty scores):

Bioremediation Solution Cards

Rain Garden

A rain garden is a group of plants that can quickly absorb and filter **runoff** from roofs, driveways, and sidewalks. The plants trap water and help it be absorbed into the soil more quickly. Rain gardens reduce the amount of standing water where mosquitoes can breed. The plants, fungi, and bacteria in the garden may also filter out some of the **pollutants** from the water. This helps to keep pollution out of the storm drains and waterways.

Evergreen Tree

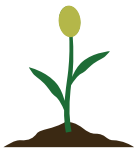
This type of tree can trap air pollution in its needle-like leaves, branches, and trunk. Evergreen trees have leaves all year round. Like all other plants, an evergreen tree absorbs carbon dioxide from the air. Because it is so tall and is alive during every season, it can absorb a large amount of carbon dioxide over time.

Sunflower

This plant uses its roots to absorb heavy metals, like lead, from the soil. Like the evergreen tree, it also absorbs carbon dioxide. But the sunflower dies off when the temperature gets too cold.

Water Hyacinth

This kind of plant lives in water. It can remove heavy metals like lead from water. It can also remove pollutants from water. It grows incredibly quickly.

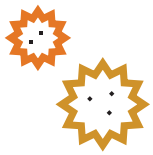


Cover Plants

These are plants that are planted in areas with bare soil, like empty farm fields or construction sites. One example is the mustard plant. These kinds of plants keep soil, pollution, and heavy metals from being washed away by rain. They can absorb harmful materials and remove them from the soil, as well. They can also take carbon dioxide out of the air and help trap it in soil.

Aquatic Bacteria

Certain kinds of bacteria can remove pollution and waste from water, such as motor oil or poop from humans or other animals. These bacteria break pollution and waste down into materials that are not harmful.



Soil Bacteria

Certain kinds of bacteria can help remove heavy metals like lead from soil. They use the heavy metals for energy and break them down into materials that are not harmful. Sometimes this process can take a long time.

Genetically Modified Bacteria

Scientists can change the **genome** of certain bacteria to help them break down heavy metals and pollution faster than bacteria found in nature.

Genetically Modified Plants

Scientists can add **genes** to a plant that help it make its own protection against pests. For example, there is a certain kind of bacteria that make a substance that kills flies. If genes from those bacteria are added to a plant, the plant can make the substance and protect itself from flies.

Biochemical Pesticide

A **biochemical pesticide** is **nontoxic** and is produced naturally by a living thing. One example is a scent that attracts certain kinds of pest insects to a trap or prevents them from mating.

Microbial Pesticide

Microbial pesticides use bacteria, fungi, viruses, or other small living things to kill pests or plants. For example, a certain fungus can grow on a caterpillar that is a pest. The fungus absorbs water and nutrients from the caterpillar until the caterpillar dies. Then the fungus can spread through the air to other caterpillars.

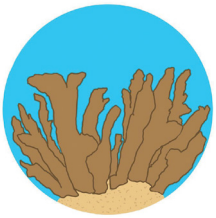
Elkhorn Coral Cards

Myxococcales level: 4

Heat resistance: 5

Deep sea level: 7

Oxygen strength level: 8

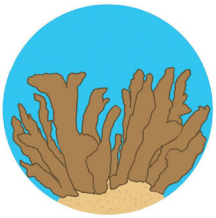


Myxococcales level: 2

Heat resistance: 6

Deep sea level: 5

Oxygen strength level: 7



Myxococcales level: 1

Heat resistance: 6

Deep sea level: 3

Oxygen strength level: 2

Myxococcales level: 8

Heat resistance: 7

Deep sea level: 7

Oxygen strength level: 7

Myxococcales level: 0

Heat resistance: 1

Deep sea level: 1

Oxygen strength level: 3

Myxococcales level: 2

Heat resistance: 1

Deep sea level: 3

Oxygen strength level: 3

Myxococcales level: 4

Heat resistance: 2

Deep sea level: 5

Oxygen strength level: 1

Myxococcales level: 3

Heat resistance: 6

Deep sea level: 4

Oxygen strength level: 4

Myxococcales level: 6

Heat resistance: 5

Deep sea level: 3

Oxygen strength level: 6

Myxococcales level: 9

Heat resistance: 8

Deep sea level: 6

Oxygen strength level: 7

Myxococcales level: 1

Heat resistance: 4

Deep sea level: 2

Oxygen strength level: 6

Myxococcales level: 4

Heat resistance: 6

Deep sea level: 1

Oxygen strength level: 7

Scenario Cards

Scenario: Habitat Loss and Pollution

Runoff from agricultural lands and other sources has polluted shallow waters. The pollution makes it difficult for corals to grow in shallow waters and increases the growth of harmful algae. Only elkhorn corals that can live in deeper water can survive.

Action: Discard all Elkhorn coral cards with deep sea levels 4, 3, 2, or 1.

Scenario: Climate Change

Oceans are warming due to climate change. This heat can stress coral and cause coral bleaching. Some elkhorn coral live alongside helpful heat-resistant algae that help the corals survive even with coral bleaching.

Action: Discard all elkhorn coral cards with heat resistance levels 5, 4, 3, 2, or 1.

Scenario: Invasive Species

The lionfish is an invasive species to the Caribbean. It eats fish that would usually eat algae off coral. This upsets the reef ecosystem and means less oxygen is available for coral. Some coral can survive on less oxygen.

Action: Discard all elkhorn coral cards with oxygen strength levels 6, 5, 4, 3, 2, or 1.

Scenario: Disease

White band disease is spread by aquatic snails and stimulated by human pollution. It destroys the coral tissue in elkhorn coral, slowly killing entire reefs. Only elkhorn corals that support large amounts of a bacteria called Myxococcales will be able to survive.

Action: Discard all Elkhorn coral cards with Myxococcales levels 6, 5, 4, 3, 2, or 1.

Biotechnology: Biobanking

Biobanking is a preservation technique that can store biological material, including DNA, for long periods of time. Scientists and researchers are able to study these preserved materials in controlled settings. They could also be used to reintroduce the biobanked genetic diversity back into an ecosystem.

Action: Must be played before using the cloning and selective breeding cards.

Biotechnology: Cloning

Cloning uses preserved cells and DNA to create copies of a previously existing living thing. Scientists and researchers might use cloning to help introduce genetic diversity into species that are endangered.

Action: Choose three elkhorn coral cards to revive from your discarded pile.

Biotechnology: Selective Breeding

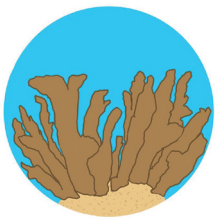
Selective breeding is when humans choose two animals within a species to mate, to try to produce **offspring** with desirable traits. Scientists can use biobanked materials to selectively breed elkhorn coral for more genetic diversity.

Action: Choose two coral cards that are still in the game to represent parents, and take a new blank Elkhorn Coral Card. Create a new Elkhorn Coral Card from your blank that uses the traits of the parents (Figure 6-15 shows an example). Add the new card to the game.

Biotechnology: Gene Drive

Gene drive is a technique using **CRISPR** that modifies specific genes and makes sure the modified genes are inherited by the next generation. Gene drives can change the genetic makeup of a species over time.

Action: Gene drive prevents the corallivorous snail from passing on white band disease. All elkhorn corals remaining in the game cannot contract this disease.



Myxococcales level:

Heat resistance:

Deep sea level:

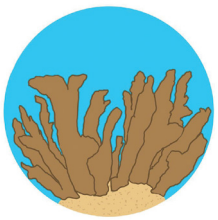
Oxygen strength level:

Myxococcales level:

Heat resistance:

Deep sea level:

Oxygen strength level:



Myxococcales level:

Heat resistance:

Deep sea level:

Oxygen strength level:

Myxococcales level:

Heat resistance:

Deep sea level:

Oxygen strength level:

Figure 6-14: Blank Elkhorn Coral Cards—use these to create new cards.

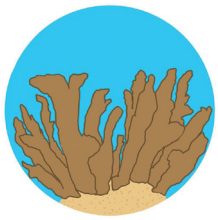
(EXAMPLE PARENT 1)

Myxococcales level: 4

Heat resistance: 5

Deep sea level: 7

Oxygen strength level: 8



(EXAMPLE PARENT 2)

Myxococcales level: 2

Heat resistance: 6

Deep sea level: 5

Oxygen strength level: 7

(EXAMPLE NEW CORAL)

Myxococcales level: 4

Heat resistance: 6

Deep sea level: 7

Oxygen strength level: 8

Figure 6-15: Example of how a new coral card can inherit selected traits from two parent cards.

Tiger

Cheetah

Lion

Leopard

Black Panther

Snow Leopard

Cougar

Lynx

Manul

Tiger