BIOLOGY TWO

	AB	Ab	aB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
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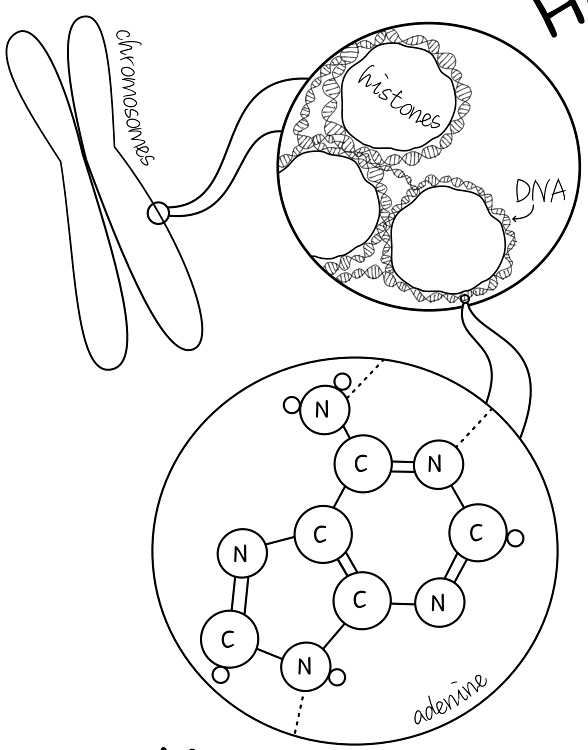
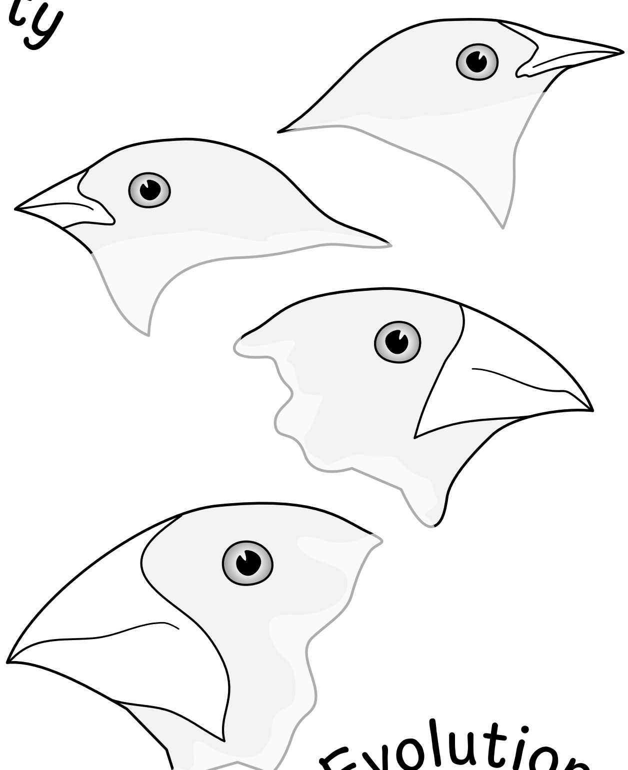
Heredity





Genetics

Evolution

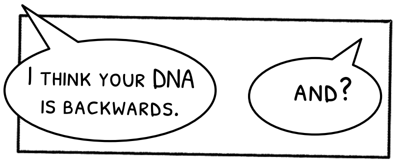
BIOLOGY

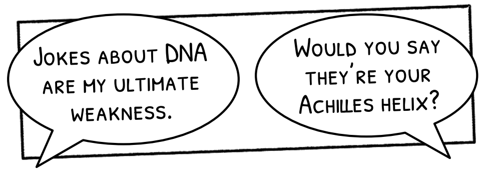
~ SPRING 2022 ~

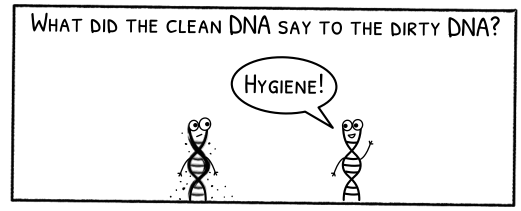
	Date	Topic	Page(s)
Week 1	Monday, Jan 24	What is a species?	6-7
	Wednesday, Jan 26	Life finds a way	8-9
	Friday, Jan 28	*Activity: Vegetative propagation with potato*	10-15
Week 2	Monday, Jan 31	Mendel's famous experiment	16-17
	Wednesday, Feb 2	Inheritance explained	18-21
	Friday, Feb 4	*Deep dive: Why aren't Zebras domesticated?*	
Week 3	Monday, Feb 7	The laws of heredity 1	22-25
	Wednesday, Feb 9	The laws of heredity 2	26-29
	Friday, Feb 11	*Deep dive: Hemophilia and the royal families of Europe*	
Week 4	Monday, Feb 14	Pet pedigree puzzle	30-33
	Wednesday, Feb 16	Bigger Punnett squares	34-37
	Friday, Feb 18	**Heredity Quiz Show**	38-41
Week 5	Monday, Feb 21	What is a gene?	
	Wednesday, Feb 23	Chromosomes and linked traits	
	Friday, Feb 25	*Activity: Gummy worm karyotypes*	
Week 6	Monday, Feb 28	Protein synthesis	
	Wednesday, Mar 2	Blood types explained	
	Friday, Mar 4	*Activity: What's the blood type?*	
Week 7	Monday, Mar 7	Meiosis and mistakes	
	Wednesday, Mar 9	Mutations	
	Friday, Mar 11	*Deep dive: Red-green colorblindness*	
Week 8	Monday, Mar 14	Nature and nurture	
	Wednesday, Mar 16	Calico cat puzzle	
	Friday, Mar 18	*Deep dive: Why Red Delicious are the least delicious apples*	
Week 9	Monday, Mar 21	Modifying genes and gene therapy	
	Wednesday, Mar 23	**Genetics Quiz Show**	
	Friday, Mar 25		
Week 10	March 28- April 1	SPRING BREAK	

Live classes are held each Monday and Wednesday. Activities and reading assignments listed on Fridays are completed independently. There are two sessions of each of the Monday/Wednesday classes. The first session starts at 11 am EST. The second session starts at 1:00 pm EST. Each live class lasts between 30 and 45 minutes.

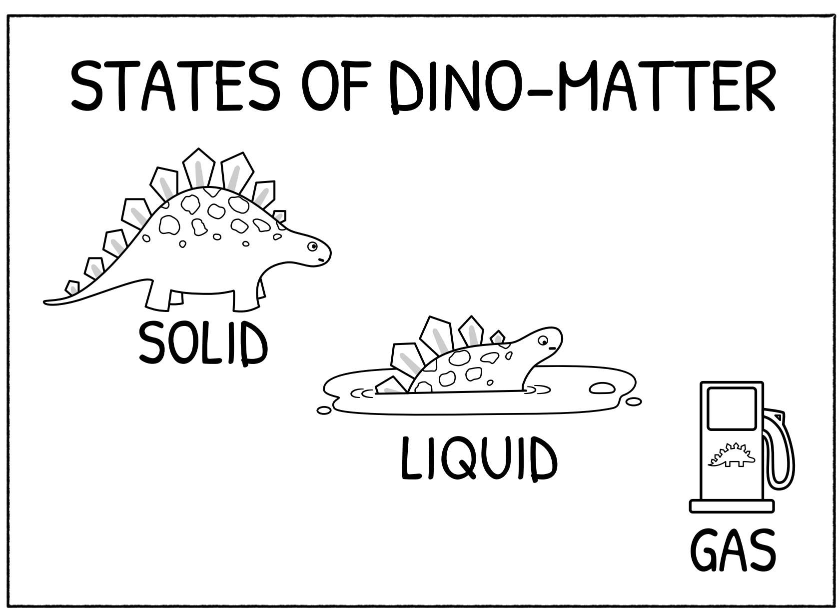
The classes are recorded and can be watched anytime after the recording date. Each week also has optional activities or reading assessments (deep dives). Students who complete and submit all activities and assignments will receive a bonus certificate of completion.







	Date	Topic	Page(s)
Week 11	Monday, Apr 4	Endangered vs invasive species	
	Wednesday, Apr 6	Darwin and the Galapagos	
	Friday, Apr 8	*Activity: Journey of the HMS Beagle*	
Week 12	Monday, Apr 11	Survival of the fittest	
	Wednesday, Apr 13	Color-changing moths	
	Friday, Apr 15	*Deep dive: When Sherpas climb Mt. Everest*	
Week 13	Monday, Apr 18	Genetic drift	
	Wednesday, Apr 20	Phylogenies and family trees	
	Friday, Apr 22	*Activity: Model a gene in a population*	
Week 14	Monday, Apr 25	What is a species really?	
	Wednesday, Apr 27	How are animals related?	
	Friday, Apr 29	*Deep dive: How DNA analysis rewrote phylogenetic trees*	
Week 15	Monday, May 2	Australia vs New Zealand	
	Wednesday, May 4	The fossil record	
	Friday, May 6	*Activity: Build your own phylogeny*	
Week 16	Monday, May 9	Timeline of life on Earth	
	Wednesday, May 11	**Evolution Quiz Show**	
	Friday, May 13	*Summary anchor diagram*	



How to use this course:

For younger students (2nd-5th grade) we recommend a "get the basics" approach that focuses on the Mon/Wed classes. For older or more advanced students (6th-8th grade) we recommend completing each of the Friday activities and assignments to reinforce the concepts covered.

Option One: Get the Basics

Ideal for younger students

Participate in Mon-Wed classes only. Friday activities, articles, and other assignments are optional. They can be skipped, saved for later, or completed depending on your preference.

Option Two: The Full Course

Ideal for older students & advanced learners

Participate in Mon-Wed classes and do the Friday activities and reading assignments.

Complete all quizzes and assignments to receive a certificate of completion at the end of the course.

Tips for best learning:

- ☑ Read the pages that go with each lesson before watching the video. Take 10-15 minutes before class to see if you can fill in the blanks. If you can't fill in everything, that's okay! Listen during class to see if you can complete the page.
- ☑ If a lesson moved too fast, rewatch it later to help learn the concepts.
- ☑ Download the answer key for the notes, but don't look at the answers until after you give things a try yourself!

Project Supply List:

Jan 28 - Vegetative Propagation with Potato
- Potato or sweet potato (for quicker results, use one where the eyes have already begun to sprout)
- Knife
- 4 large pots or burlap sacks
- Potting soil

Jan 24-Feb 18 - Heredity Anchor Diagram
- Paper and art supplies

Feb 25 - Gummy Worm Karyotypes
- Enough gummy worms or other oblong-shaped colorful candy to create 16 pairs of chromosomes
- Chocolate (to melt and cover some of the gummy worms,)
- Knife or scissors

Mar 4 - What's the Blood Type?
- Home blood typing kit (optional)

Mar 18 - Apple Variety Taste Test
- Several varieties of apple including Red Delicious, Granny Smith, and three other types.
- Knife

Feb 21-Mar 25 - Genetics Anchor Diagram
- Paper and art supplies

April 8 - Journey of HMS Beagle
- Printable world map
- Paper and scissors
- Yarn or art supplies such as crayons, colored pencils, markers, or paint

April 22 - Model a Gene in a Population
- 20 black marbles and 20 white marbles (or other items that can be drawn randomly in a sample such as beans, candy, coins, or dice marked with tape, etc)

May 6 - Build your own phylogeny
- Paper and art supplies

Apr 4-May 13 - Evolution Anchor Diagram and Timeline
- Paper and art supplies

Which science standards are covered in this course?

The standards listed below are the national science standards for K-12 education in the United States. They are commonly referred to as Next Generation Science Standards or NGSS.

MS-LS1-4. *Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.* ***Apr 4, Apr 6, Apr 11, Apr 13***

MS-LS1-5. *Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.* ***Mar 14***

MS-LS3-1. *Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.* ***Feb 21, Feb 23, Feb 28, Mar 2, Mar 9, Apr 4***

MS-LS3-2. *Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.* ***Jan 26, Jan 31, Feb 2, Feb 7, Feb 14***

MS-LS4-1. *Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.* ***Apr 25, Apr 27, May 4, May 9***

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 evolutionary relationships.* ***Apr 20, Apr 27***

MS-LS4-3. *Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.* ***Apr 20***

MS-LS4-4. *Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.* ***Apr 11, Apr 13***

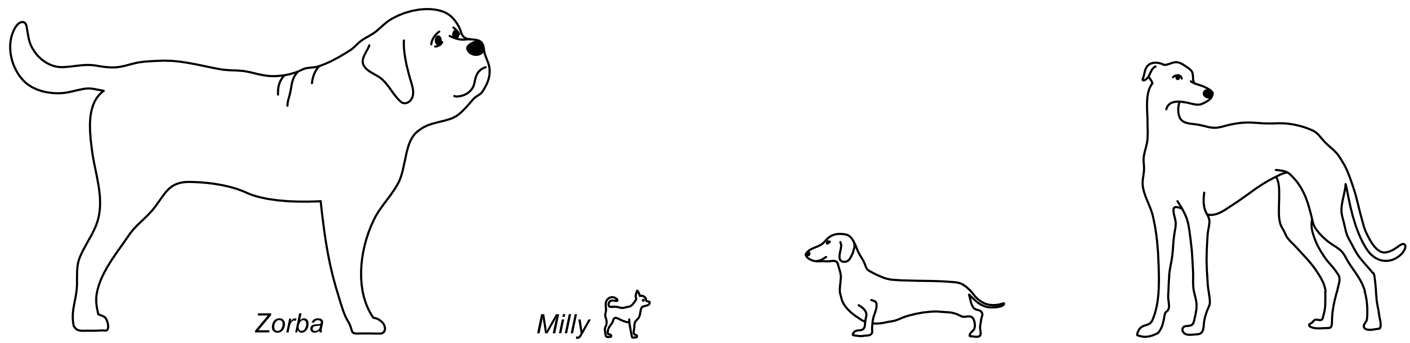
MS-LS4-5. *Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.* ***Mar 21***

MS-LS4-6. *Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.* ***Apr 18***

Date	Topic	NGSS	Page(s)
Wednesday, Jan 26	Life finds a way	MS-LS3-2	-
Monday, Jan 31	Mendel's Famous Experiment	MS-LS3-2	
Wednesday, Feb 2	The laws of heredity 1	MS-LS3-2	
Monday, Feb 7	The laws of heredity 2	MS-LS3-2	
Monday, Feb 14	Punnet squares	MS-LS3-2	
Monday, Feb 21	What is a gene?	MS-LS3-1	
Wednesday, Feb 23	Chromosomes and linked traits	MS-LS3-1	
Monday, Feb 28	Protein synthesis	MS-LS3-1	
Wednesday, Mar 2	Blood types explained	MS-LS3-1	
Wednesday, Mar 9	Mutations	MS-LS3-1	
Monday, Mar 14	Nature and nurture	MS-LS1-5,	
Monday, Mar 21	Modifying genes and gene therapy	MS-LS4-5	
Monday, Apr 4	Endangered vs invasive species	MS-LS1-4, MS-LS3-1	
Wednesday, Apr 6	Darwin and the Galapagos	MS-LS1-4	
Monday, Apr 11	Survival of the fittest	MS-LS1-4, MS-LS4-4	
Wednesday, Apr 13	Color-changing moths	MS-LS1-4, MS-LS4-4	
Monday, Apr 18	Genetic Drift	MS-LS4-6	
Wednesday, Apr 20	Phylogenies and family trees	MS-LS4-2, MS-LS4-3	
Monday, Apr 25	What is a species really?	MS-LS4-1	
Wednesday, Apr 27	How are animals related?	MS-LS4-1, MS-LS4-2	
Wednesday, May 4	The fossil record	MS-LS4-1	
Monday, May 9	Timeline of life on Earth	MS-LS4-1	

What makes a species?

The domestic dog includes hundreds of different breeds with diverse personalities, shapes, and sizes. The biggest dog, an English Mastiff named Zorba, weighed more than 143 kg (315 pounds) and measured 94 cm (37 inches) tall from ground to shoulder. The smallest dog, a Chihuahua named Milly, is just under 10 cm (4 inches) tall and weighs just 0.5 kg (about 1 pound). Mastiffs, Chihuahuas, Dachshunds, and Greyhounds are all called dogs, but they are incredibly different animals!



English Mastiff
70-91 cm / 28-36 in
54-104 kg / 120-230 lbs

Chihuahua
15-25 cm / 6-10 in
1.4-3 kg / 3.3-6.6 lbs

Dachshund
20-23 cm / 8-9 in
7-14 kg / 16-32 lbs

Greyhound
68-76 cm / 27-30 in
26-40 kg / 57-88 lbs

1. What makes a dog a dog? Share your opinion:

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2. If the characteristics you described above were used as the official definition of a dog, would cats also be called dogs?

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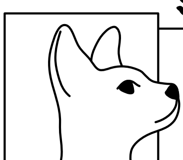
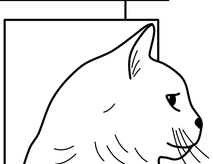
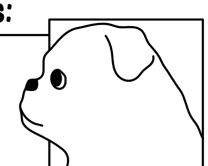
3. List three similarities and differences between cats (*Felis*) and dogs (*Canis*):

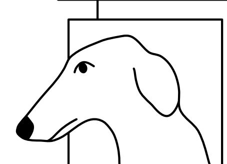
Similarities between cats and dogs:

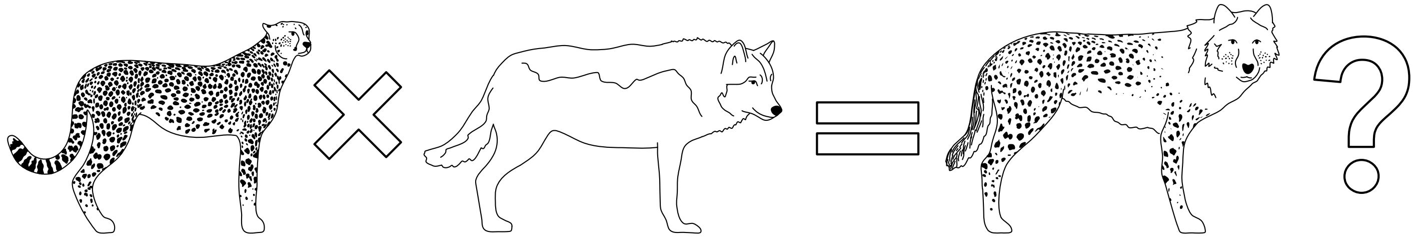

SPHYNX CAT


MAINE COON

Differences between cats and dogs:


PUG


BORZI



4. Coyotes, wolves, and dogs can all interbreed, creating hybrids like the wolfdog, coywolf, coydog or dogote. Lions and tigers can also be bred to create hybrids, which are called ligers or tigons. In your opinion, would it be possible to cross a cheetah with a wolf? If so, what would you call this hybrid? A woltah? A cheef?

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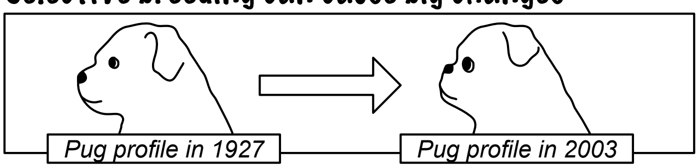
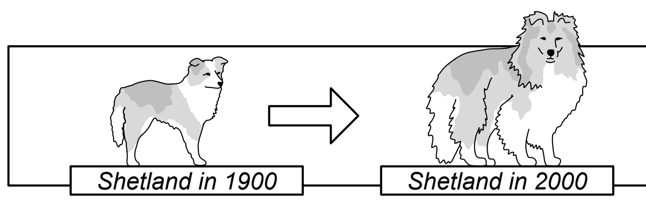
Selective breeding can cause big changes



Breeders prized the "squished face" appearance of the Pug and chose dogs with shorter and shorter snouts. Because of their face shape, modern Pugs are susceptible to eye trouble and breathing problems.



In 1900, Shetland Sheepdogs were reported to weigh between 7 and 10 pounds and have medium length fur. The modern Shetland Sheepdog has doubled in size and has much longer fur.

5. Suppose that a settlement on Mars uses Great Danes for pulling sleds while a different settlement uses Chihuahuas for hunting cockroaches that hide in small spaces. If the people in the first settlement selectively breed their Great Danes to be larger and stronger while the people in the second settlement breed their Chihuahuas to be smaller and faster, what would you expect Mars dogs to look like after approximately 1,000 years have passed? Would Great Danes and Chihuahuas be different species from each other then?

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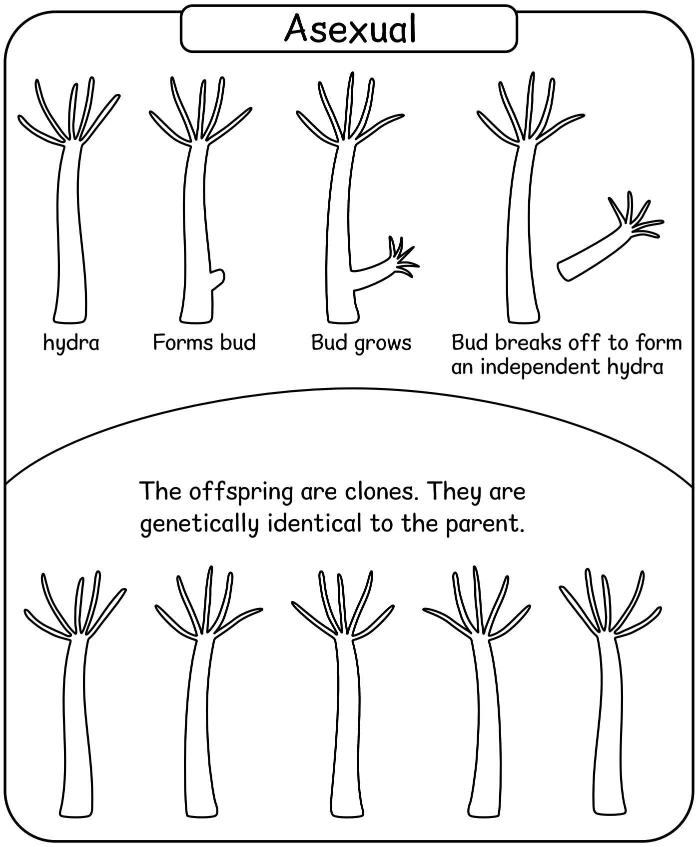
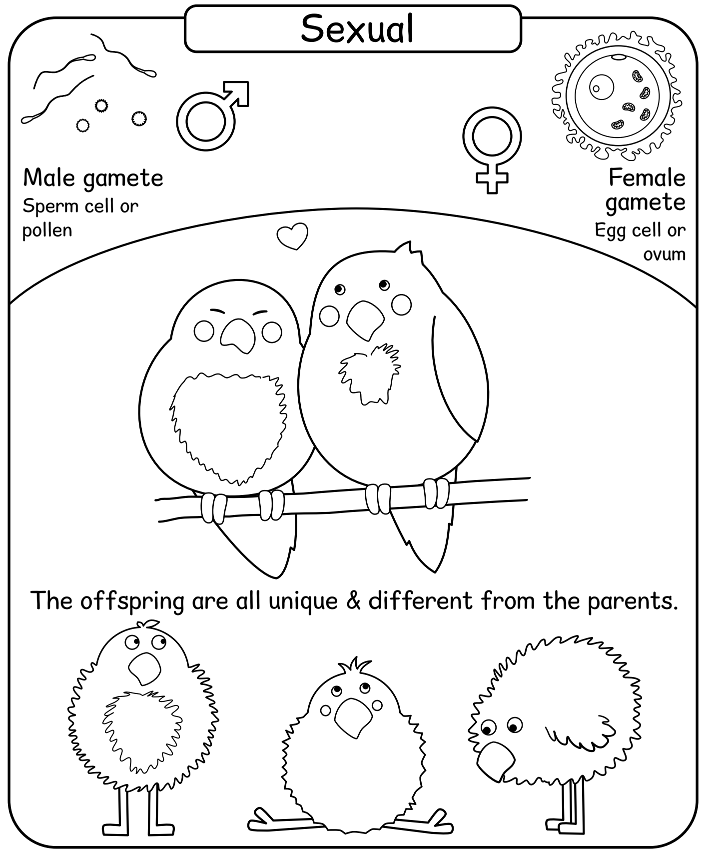
Martian Great Dane in 3022

Martian Chihuahua in 3022

Life finds a way

The **ability to reproduce** is one of the key characteristics in most definitions of life. There are two main strategies: asexual reproduction, which creates identical clones, and sexual reproduction which creates offspring that are different from each parent.





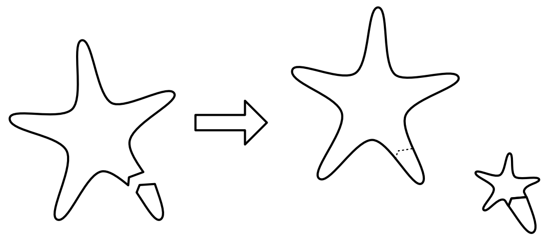
Record the primary advantages and disadvantages in each category below. Consider the following:

- Speed of reproduction: Is the next generation formed and independently growing within minutes or days? Does it take years to form an independent next generation?
- Genetic diversity: is the diversity high (which provides greater resistance to disease) or low (which makes a population more at risk from disease)?
- Does reproduction require a mate? Could one individual reproduce?

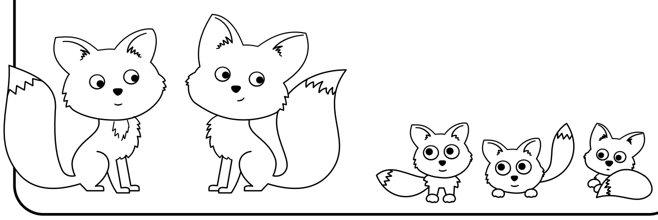
ASEXUAL REPRODUCTION		SEXUAL REPRODUCTION	
advantages:	disadvantages:	advantages:	disadvantages:

Match each reproductive strategy with the correct definition:

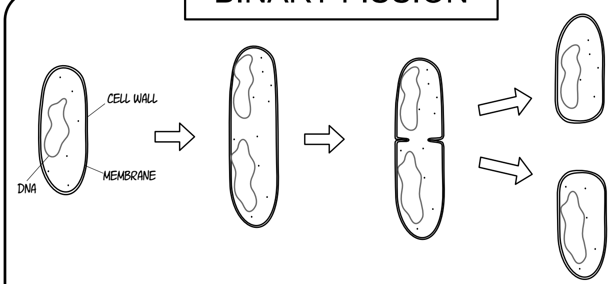
FRAGMENTATION



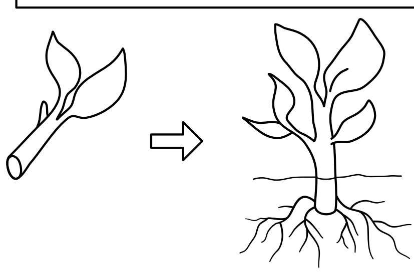
SEXUAL REPRODUCTION



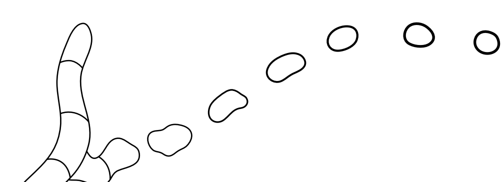
BINARY FISSION



VEGETATIVE PROPAGATION



SPORE FORMATION



Genetic information from two individuals is combined to create offspring that are genetically different from both parents. This reproductive strategy is common among animals, fungi, and plants.

An organism is split into pieces. Each of those fragments then develops into adult individuals that are clones of the original organism. Molds, lichen, sponges, certain worms, and sea stars all use this reproductive strategy.

The division of one cell into two identical cells. This reproductive strategy is used by many types of single-celled life forms including bacteria and archaea.

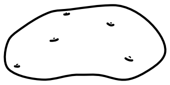
A specialized cell is formed that can withstand harsh environmental conditions such as drought or extreme heat. Once conditions improve, this cell germinates and begins growing. This reproductive strategy can be either sexual or asexual. Commonly used by fungi.

A form of reproduction occurring in plants where a fragment or cutting is separated from the parent plant and grows as a separate individual. Commonly used with food crops such as bananas, sweet potato, sugarcane, and pineapple.

Hands-on Science Project

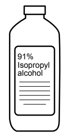
PROPAGATE A POTATO

MATERIALS:

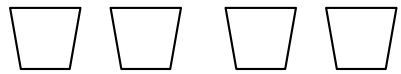


Potato or sweet potato

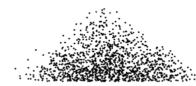
Knife



Rubbing Alcohol



4 identically-sized pots or bags
Use a large pot or bucket with drainage holes, or a large burlap sack.

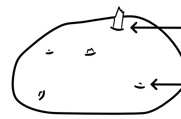


Potting soil
Enough to fill all 4 containers

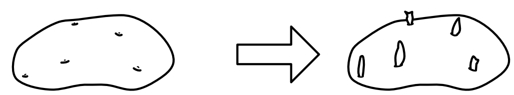
For best results, use sprouting potatoes

Most commercially-available potatoes are treated with chlorpropham, a compound that prevents sprouting. For best results, select a tuber where you can see small sprouts or swelling in the "eyes" of the tuber. If you do not see any sprouts or signs of budding, let the potato sit in a dark location at room temperature until sprouts form.

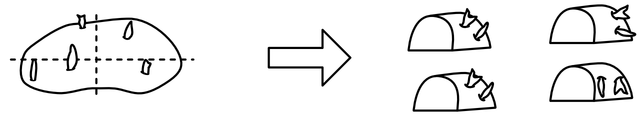
Potatoes are tubers, specialized root structures that store starch. Tubers contain buds that can grow into new plants!



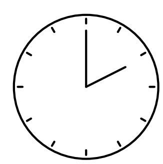
1. Place the potato in a dark and warm area (such as a kitchen cupboard) and let it sit there until sprouts have formed at the eyes. This may take between 1 to 3 weeks.



2. When the potato has sprouts, clean the knife with rubbing alcohol. Use the clean knife to cut the potato into 4 pieces that are roughly equal in size. Make sure that each piece of potato has at least one or two "eyes" with sprouts. If there are many sprouts on the piece of potato, break off some of the sprouts so there will be no more than two sprouts per quadrant.

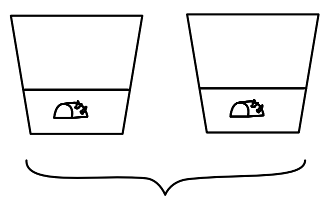


3. Let the cut pieces sit at room temperature for 24 hours. This drying process helps prevent mold from growing on the potatoes after they are planted.

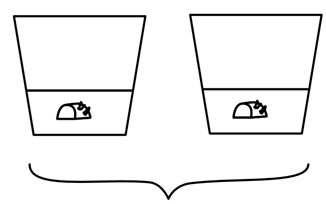


4. Fill the pots or burlap bags 1/3 full with potting soil. Place one potato piece in each container so that the potato is approximately 5 cm or 2 inches below the surface of the soil.

5. Water the soil in each pot so that it is moist. Place two of the pots in a very sunny location and the other two pots in a shady location.



Place two pots in a bright location, either under lamps or next to a window that receives several hours of full sunlight.



Place two pots in a location with less light (but not dark).

6. Care for the plants by keeping the soil moist with regular watering. Do not let the soil become too wet or waterlogged, and be careful that it doesn't dry out completely.

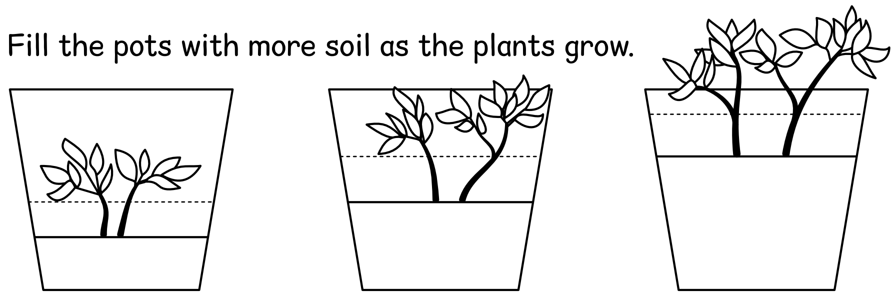
Indoors or Outdoors?

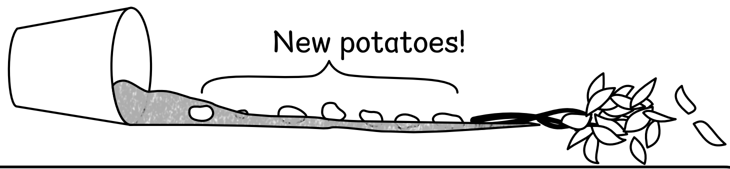
This activity can be done either indoors or outdoors. If you have space and it's winter time, we recommend indoors! If you have cats or dogs, take care that they don't eat the above-ground leaves and stems of the potato plant, which are poisonous. If you would prefer to plant your potatoes outdoors, plant them no earlier than 4 to 6 weeks before the average last frost. They are cold hardy and can handle some freezing or near-freezing temperatures. Whether the plants are indoors or outdoors, they will need at least 10 to 12 weeks of growth to produce a crop of new tubers.

7. After sprouting, continue to add additional layers of potting soil until the pot is full. Record your observations about the size and appearance of the above-ground plants at regular intervals.

8. After 10 to 15 weeks or when the plants begin to die back, pour out the potting soil and sort through it to find the new potato tubers. (See page 13 for more detailed instructions).

How many tubers did you find? Which plants produced the most potatoes?

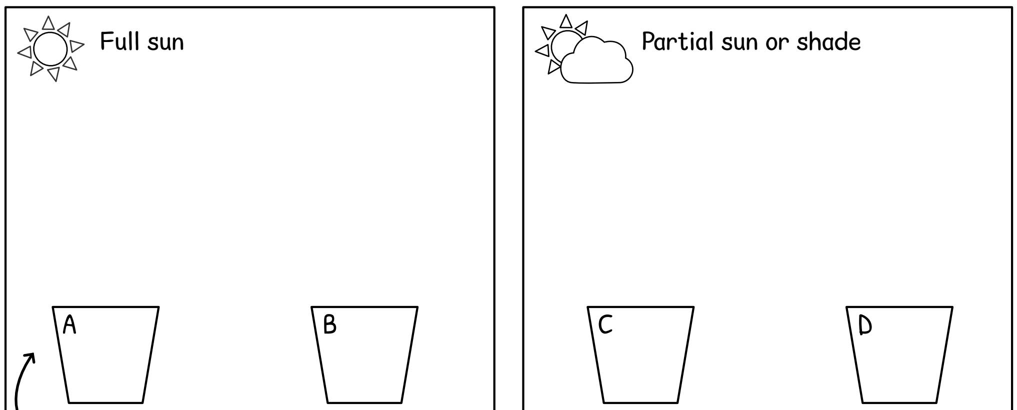




Observations just after the first sprouts emerge:

Noting the date is a vital part of recording

DATE:



Draw the soil line and a simple representation of your tubers in these pots!

____

____

Write a line or two about what you observe.

Observations 1 week after the first sprouts emerge. Draw the approximate size and shape of the potato plants growing in each container.

DATE:

____

____

____

Observations 3 weeks after
the first sprouts emerge:

DATE:

Observations 6 weeks after
the first sprouts emerge:

DATE:

Observations 10 weeks after
the first sprouts emerge:

DATE:

DATE:

POTATO HARVEST

Before harvesting your potatoes, answer the following questions:

1. Which plants have the most above-ground material? Count the approximate number of leaves on each plant and record their numbers.

The plant with the most above-ground mass: ____________________

The number of leaves on each plant:

______ A ______ B ______ C ______ D

2. How different were the light conditions between your "full sun" and "partial sun" plants? If possible, study the locations for one day and count the number of hours of direct light each plant experienced.

____

____

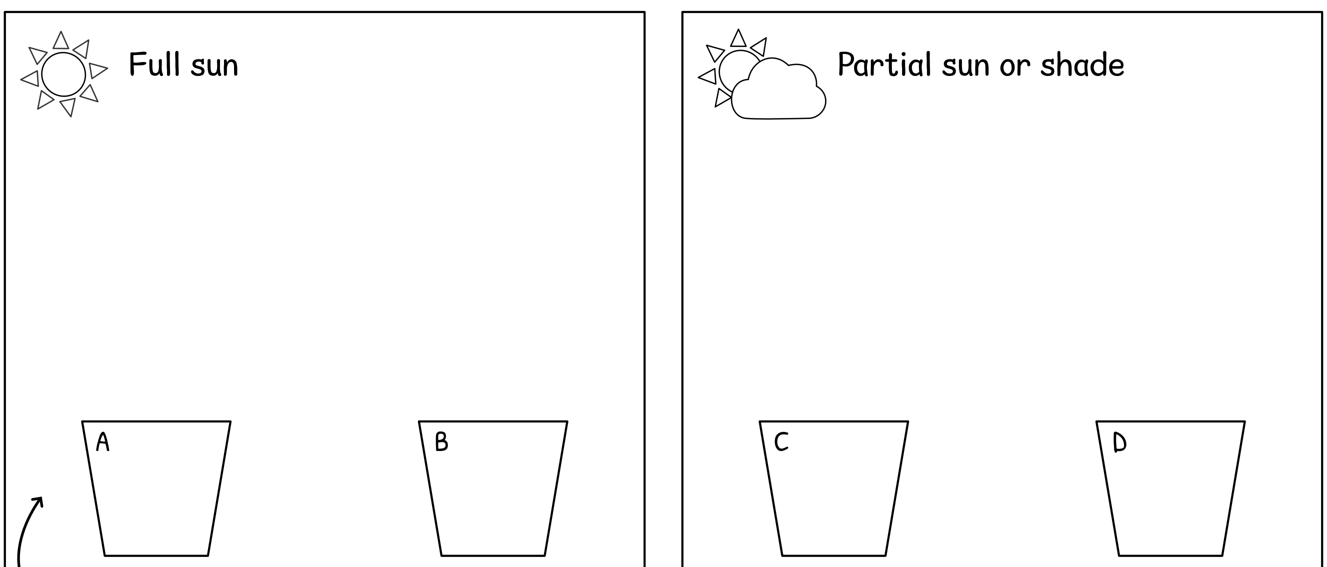
____

4. Plants get their energy from photosynthesis, which requires light. Which plants were able to do the most photosynthesis during the experiment? What did the plant do with the energy it gathered from photosynthesis?

____

____

____



Draw the above ground portion of your potato plants. Then draw a guess of what you think the root structure will look like. How many tubers do you expect to find?

When to harvest potatoes

Farmers usually wait until the tops of the potato plants have turned yellow and died back before harvesting. This allows the plant to store the most starch in the tubers.

With potatoes grown indoors, you can wait for the plants to go dormant or you can harvest them anytime after 10-12 weeks of growth. The choice is yours. Harvesting before 10 weeks will result in very small (pea and marble size) potatoes.

How to harvest potatoes

If the plants are in containers, take them outside and empty the dirt from the container. Sift through all the dirt and separate the tubers from the roots and potting soil.

If the plants are in the ground, loosen the soil around them with a shovel. Pull up the plants and then thoroughly explore the area with shovel and hands to be sure you found all of the tubers.

Wash and dry the potatoes and store them in the fridge until ready to eat. If the skin of a new potato is scratched or damaged during harvesting, then they won't store for as long and should be eaten sooner rather than later.

POTATO HARVEST

After harvesting your potatoes, answer the following questions:

1. Which plants produced the greatest number of tubers? Count the record the number of tubers from each plant.

A	B	C	D

2. Which plant produced the greatest biomass of tubers? In other words, which plant grew the most food? If you don't have a scale to weigh the potatoes, that's okay! Compare the size of the potatoes from each plant and draw pictures to represent the potato production of each.

A	B	C	D

3. The main variable studied in this experiment was light. Ideally, everything else would have been the same for each potato plant. But in real life, experiments don't always have ideal conditions! Were there any other variables that impacted your plants, such as disease, an injury, waterlogged roots, or drought stress?

____

____

____

CONCLUSIONS

DATE:

Your potatoes were genetically identical clones. Did they grow into identical plants or did they look different from each other? What impact did light have on the production of your potatoes? Do you have any advice for someone who wants to grow their own potato clones?

____

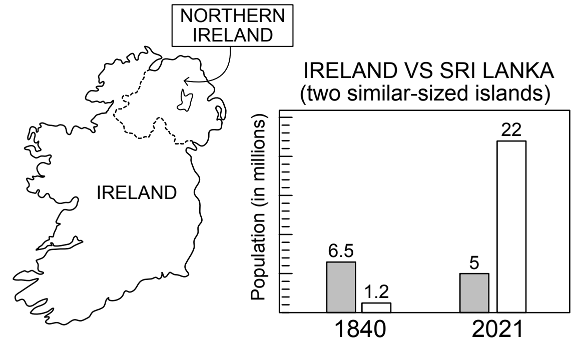
____

____

____

Potato Blight and the Irish Potato Famine

From 1845-1852, Ireland experienced a devastating famine when a fungus-like microorganism called Phytophthora infestans caused a serious disease known as potato blight. The blight caused the Irish to lose about ¾ of their most important food crop and resulted in over a million people dying of starvation and millions emigrating away from the island in the following years when the potato harvest was poor. Ireland is possibly the only country in the world that has a lower population today (5 million) than in 1840 (about 6.5 million).



How Potatoes are Grown Today

Potatoes can be infected by many different pathogens including viral, fungal, bacterial, and protozoan! Because they are susceptible to so many diseases, many of which are hard to detect, the crops of modern potato farmers actually start out in test tubes!

Tissue Culture

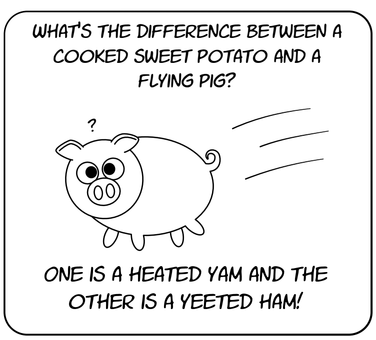
(Also called micropropagation)

Growing cells in an artificial medium like agar or broth.

It's called tissue culture and it all begins with a small piece of plant about the size of a flake of pepper. This flake of green leaf tissue is taken from a parent plant which was grown in a controlled environment free from viruses.

The disease-free bit of the plant (meristem) is placed in a test tube that is has all the nutrients that the plant needs in order to grow. The test tube remains in the sterile lab until the cells have grown into a "plantlet," a small plant with distinct roots, stem, and leaves.

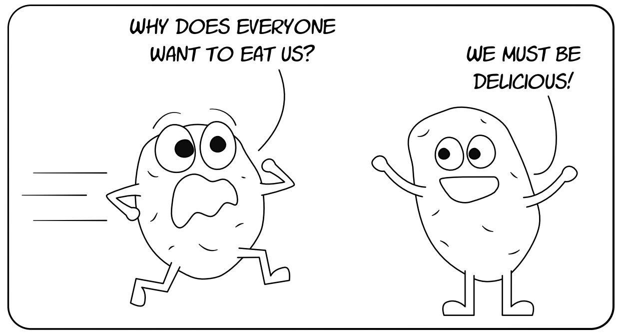
When the plantlets are large enough, they are moved to a greenhouse and planted in the ground. Then, just like regular potatoes, they grow for a few months, forming miniature tubers. After harvesting, these small tubers (called seed potatoes) are sorted and stored until it's time to plant the large crop of potatoes in regular fields.

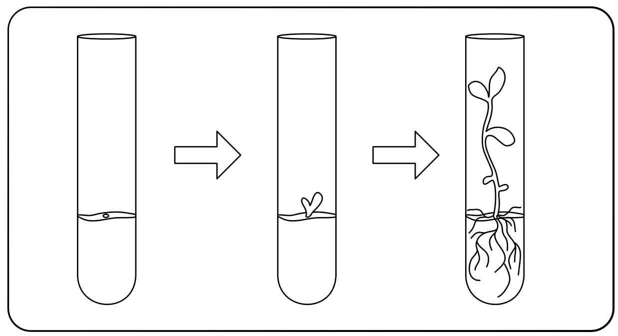


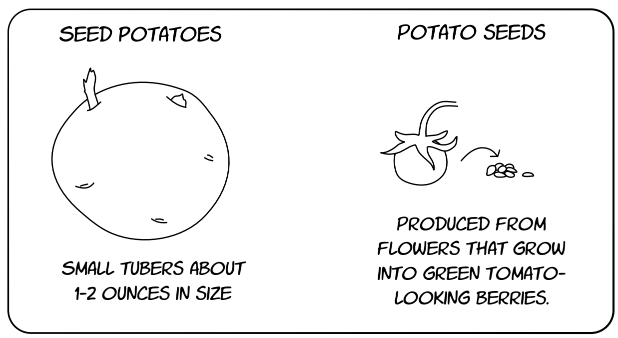
Certified seed potatoes have been tested multiple times to be sure they are free from bacterial, fungal, and viral infections.

When the seed potatoes are ready to be planted, a large machine uses sharp spikes or suction cups to grab each seed potato and drop it into the designated furrow of soil.

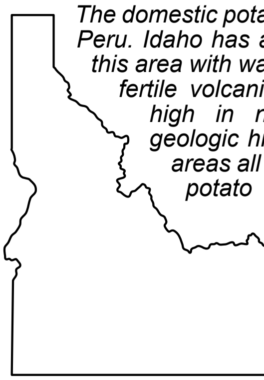
The buds on the seed potatoes sprout into plants and as the plants grow, so does their network of tubers underground. it is now up to the farmer to care for the potatoes by irrigating and fertilizing them. They'll be ready to harvest between 80 to 115 days after planting. At harvest, they're carefully dug up and stored between 10 and 14 days in cool temperatures (≈15°C) to allow the skins time to harden and minor injuries to seal. Then they're sent to a grocery store near you!







Why is Idaho famous for its potatoes?



The domestic potato originated in the mountains of Peru. Idaho has a similar climate and geology to this area with warm sunny days, cool nights, and fertile volcanic soil that is well-draining and high in nutrients. The high elevation, geologic history, location, and surrounding areas all combine to make Idaho ideal for potato production. The state grows about 13 billion pounds of potatoes every year.

Idaho even has a museum dedicated to the potato with an exhibit of the world's largest potato chip!

The question of inheritance

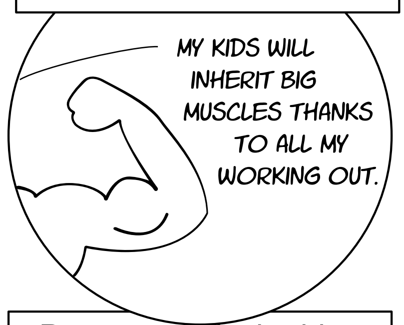
Throughout history people have had different ideas about how traits are inherited. The three ideas described below were common when Mendel was alive. Which of these ideas best explains what you have observed about traits and how they are inherited? Rate them from one star (not accurate, e.g. there are lots of counter examples for this idea) to four stars (this idea explains inheritance very well).

LAMARCKISM

Lamarckism is the belief that acquired traits can be inherited. Giraffes are able to lengthen their necks by constantly stretching, so their offspring will inherit a longer neck.

☆☆☆☆

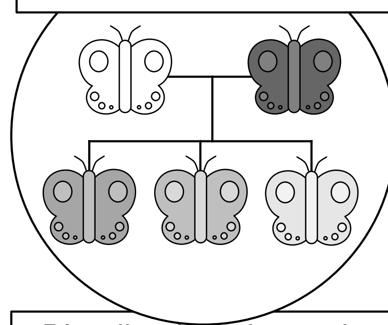
PANGENESIS



Pangenesis is the idea that every part of the body produces small particles called gemmules which are then passed on to offspring.

☆☆☆☆

BLENDING



Blending inheritance is the idea that each trait will be inherited by the offspring at about the average level of each parent. For example, your hair color falls between your parents' hair colors.

☆☆☆☆

Gregor Mendel

Mathematician, biologist, abbot, and founder of genetics

FILL IN THE BLANKS USING THESE WORDS:

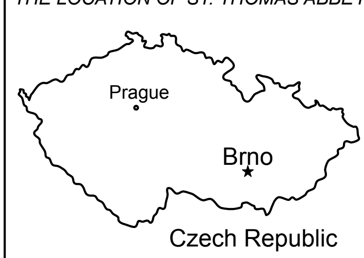
garden inheritance traits pea genetics

Gregor Mendel was a monk at St. Thomas Abbey. During Mendel's lifetime, the question of how ________ were passed from one generation to the next was one of the great mysteries of science. Popular ideas to explain ______________ included Lamarckism, the idea that acquired traits could be passed on to offspring.

In the 1850s, Mendel conducted experiments to discover how inheritance worked. He studied the characteristics of ________ plants, such as green and yellow seeds. His experiments were conducted in a small ____________ next to the abbey.

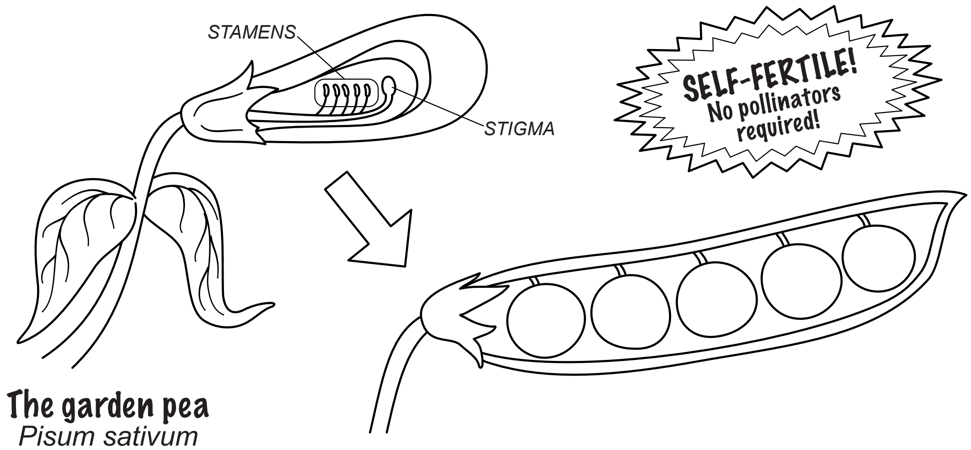
His conclusions were incredibly advanced for his time and he is widely considered to be the founder of modern ______________.

THE LOCATION OF ST. THOMAS ABBEY

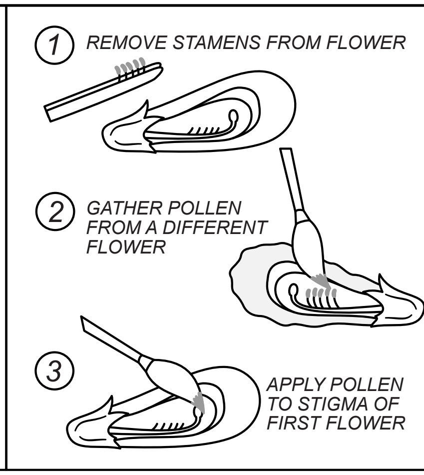


GREGOR MENDEL 1822-1884

A famous experiment

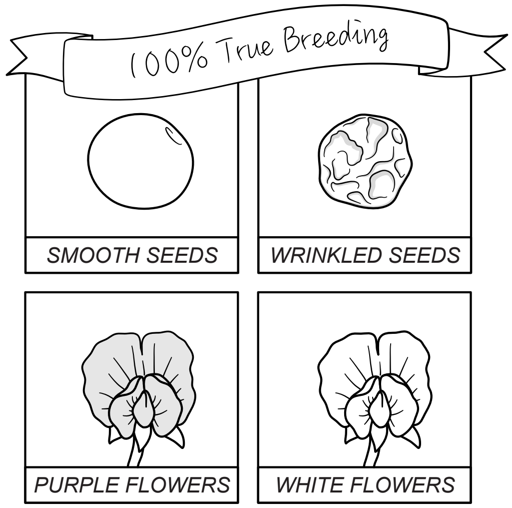


The garden pea
Pisum sativum

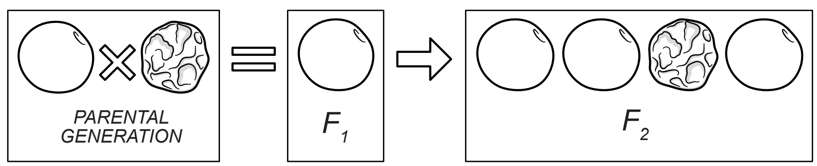


Peas are self-fertile. They do not need pollinators and unless a person intervenes, the pollen on the stamens will fertilize the stigma and produce a pea pod filled with seeds. To cross-pollinate two different pea plants, Mendel used tweezers to remove the stamens from one flower (1) and used a paintbrush to gather pollen from the flower of a different plant (2). The pollen was then applied to the stigma of the first plant to produce hybrid seeds (3).

MEET THE PARENT PEAS!



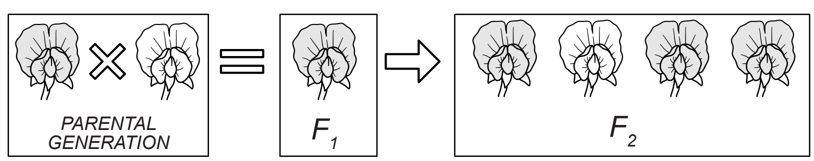
THE EXPERIMENT



A pea plant with smooth seeds is cross-fertilized with a plant that has wrinkled seeds.

ALL of the seeds in that first generation (called the F_1 generation) are smooth.

When those first generation seeds (F1) are self-fertilized, the next generation shows a 3 to 1 ratio of smooth to wrinkled seeds.



We see the same result with flower color.

If you were Mendel, how would you explain these results? Why is one trait disappearing in the F_1 generation and then coming back again in the next?

Disappearing and reappearing traits?

Mendel's results explained

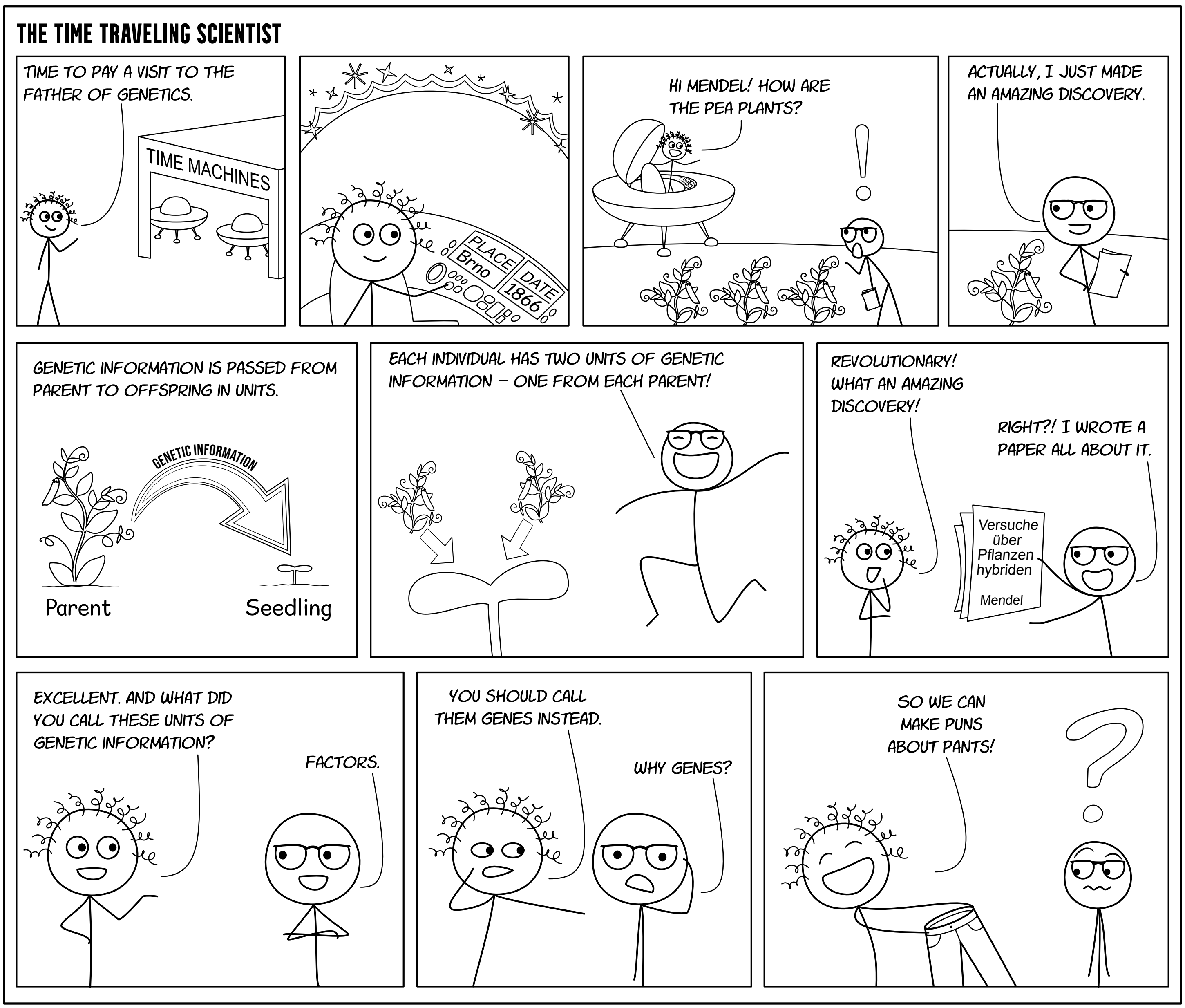
FILL IN THE BLANKS USING THESE WORDS:

alleles inherited generation ignored traits dominant

When crossing two true-breeding pea plants with different traits, Mendel found that the F_1 or first ______________ of plants looked identical to one of the parent plants. The trait from the other parent had “disappeared.” But when these plants were self-pollinated, they were no longer true-breeding. Both of the _______ appeared with a consistent ratio: ¼ of the plants had the trait that had disappeared while ¾ of the plants had the other trait.

To explain this phenomenon, Mendel said that each plant ____________ two factors, one from each parent. Some factors were ______________ and others were recessive. Today, we call these factors genes or ___________.

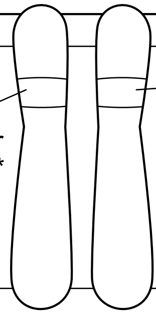
He published his research, but it was ______________ for more than thirty years. Mendel wasn't recognized for his work until other scientists discovered the same facts in the 1900s.



Genotype

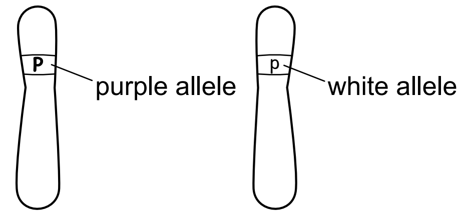
the genetic information

In this example, we use "**P**" to represent the _________ for purple flower color and "p" to represent the allele for white flower color.

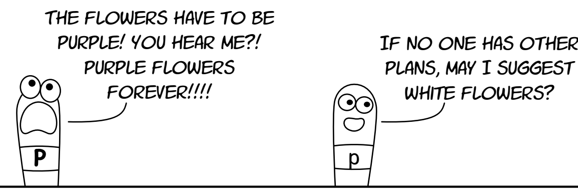


The gene for flower color.*

There isn't just one gene for flower color! There are different versions of this gene. One has instructions for purple flowers. Another version has instructions for white flowers. Different versions of the same gene are called **alleles**.



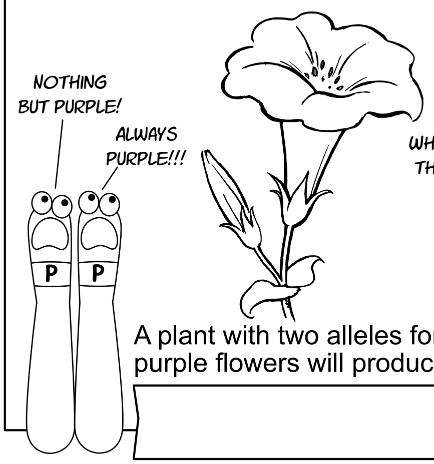
We'll learn more about what genes are (segments of DNA) and where they are located (on chromosomes) in the next unit. For now, we can think of them as little bosses telling the organism what to do.



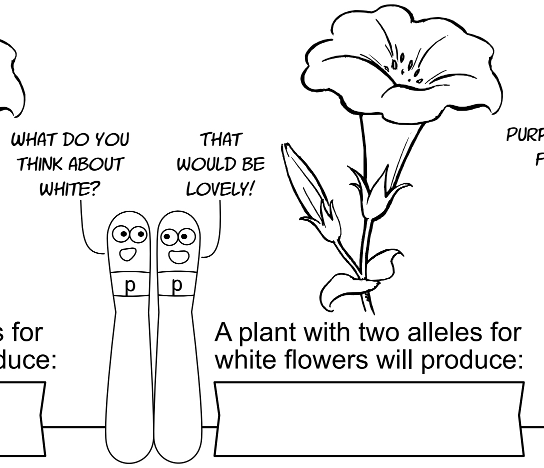
Phenotype

the observed trait

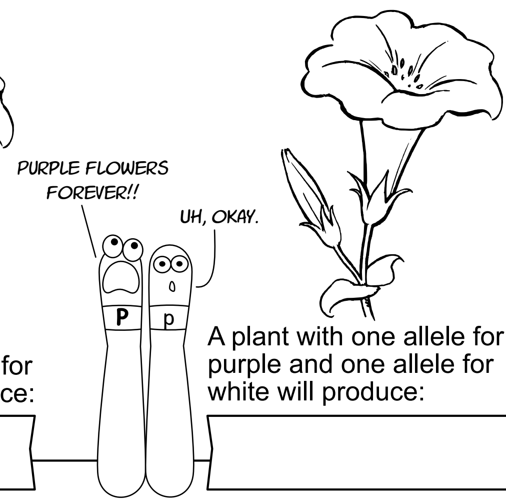
In this example, there are two phenotypes: purple flowers and white flowers. Write the expected phenotype in each box below. Then color the flowers accordingly.



A plant with two alleles for purple flowers will produce:

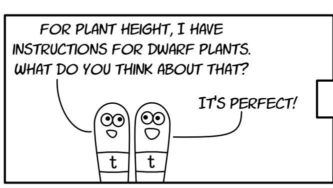


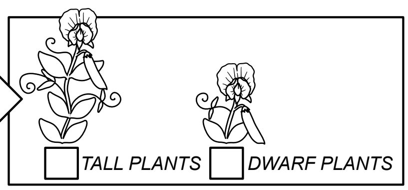
A plant with two alleles for white flowers will produce:



A plant with one allele for purple and one allele for white will produce:

*In the example above, the purple allele is **dominant** and the white allele is **recessive.** The traits below also have a dominant allele (represented by a capital letter) and a recessive allele (lower case letter). Use this information to indicate the phenotype that will be produced from each pair of alleles.*

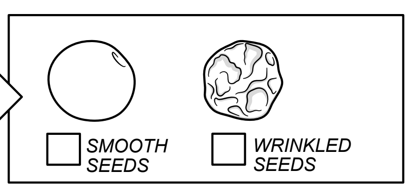




*For plant height, if the **genotype** is:*

Tt

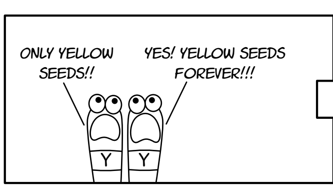
*The **phenotype** will be:*

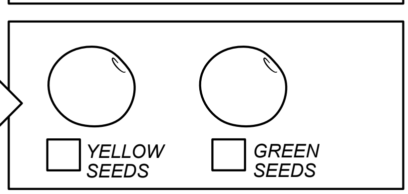


*For seed texture, if the **genotype** is:*

Ss

*The **phenotype** will be:*



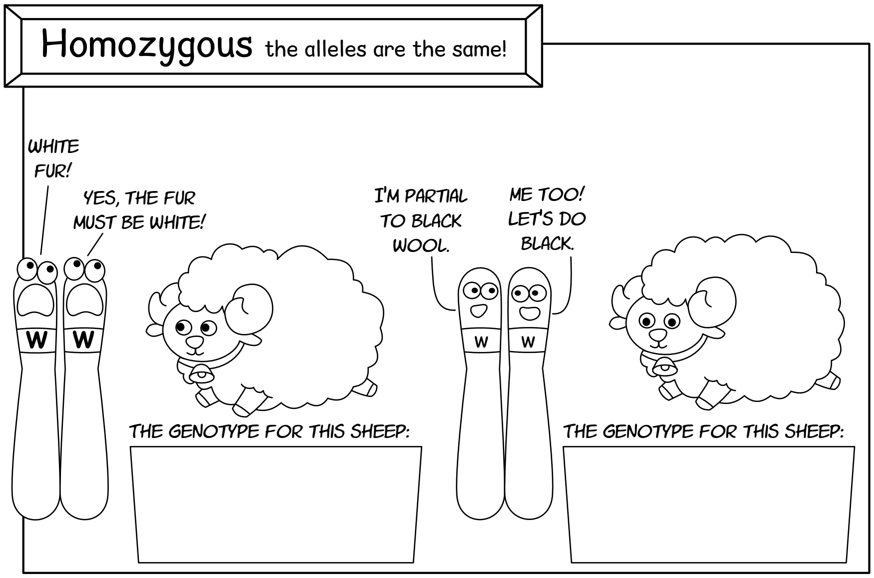


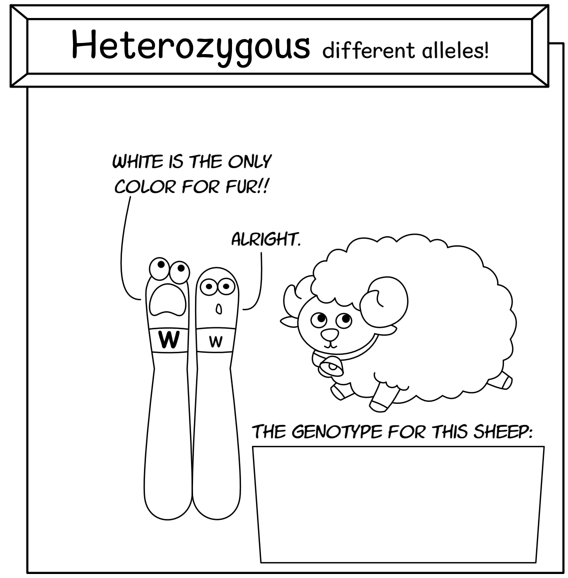
*For seed color, if the **genotype** is:*

yy

*The **phenotype** will be:*

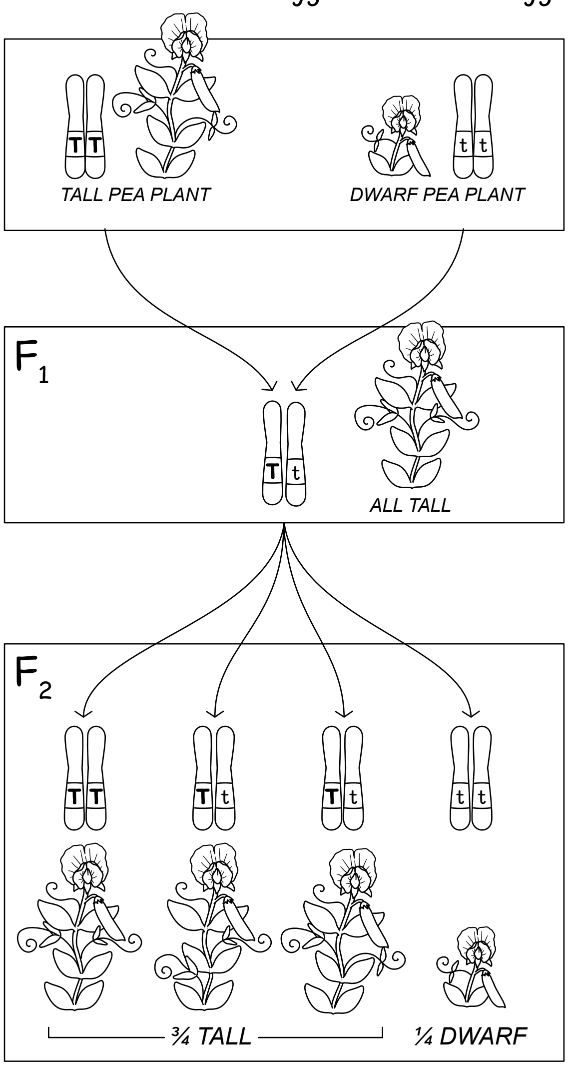
The traits Mendel studied follow a **dominance / recessive** pattern. The trait of wool color in sheep does as well, which explains why black sheep are less common than white. Color in the sheep below with the correct phenotype and then label each block below as either "Homozygous dominant," "Homozygous recessive," or "Heterozygous."





Mendel's results explained (in more detail)

Write either "heterozygous" or "homozygous" in each of the labels below.

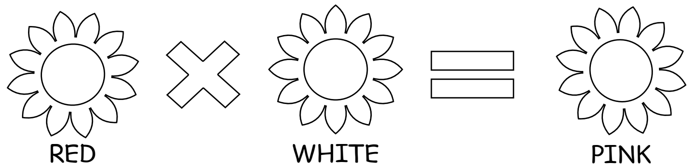


The plants in the parent generation are true-breeding or ____________________ for their trait, which is plant height. The tall plants always produce seeds that grow into tall plants. The dwarf plants always produce seeds that grow into dwarf plants.

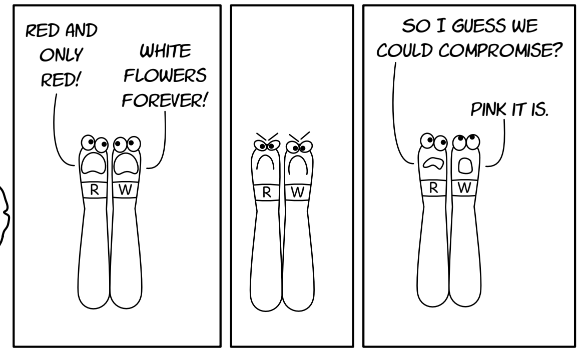
The F_1 generation received one allele from each parent plant and are _____________________ for plant height. All of the plants in this generation are tall. The plants will be self-fertilized to form the F_2 generation.

In the F_2 generation, a quarter of the plants show the phenotype of dwarfism. These plants are _______________ recessive. Two of the three tall plants are __________________, which means they are no longer true-breeding for the trait of plant height.

In real life, things are often more complicated...

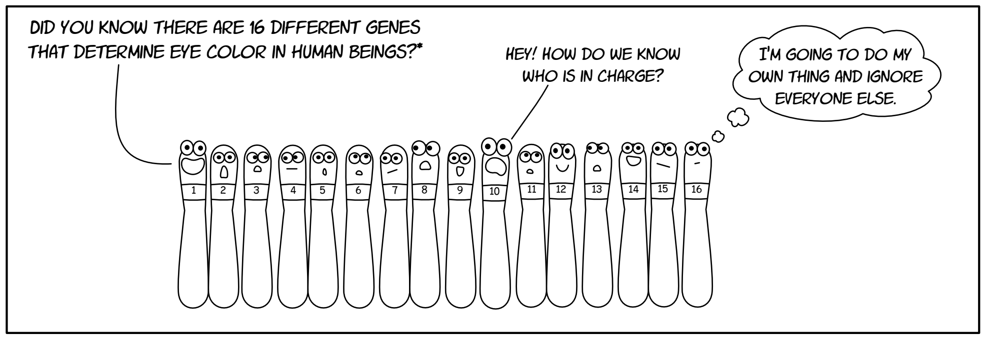


In cases of incomplete dominance, the heterozygous phenotype is different than either of the homozygous phenotypes!



Most human traits are controlled by multiple genes and have complicated inheritance patterns. We sometimes think of eye color as being a trait that follows Mendelian inheritance patterns with brown eyes being dominant and blue eyes being recessive.

But it's not that simple! With more than 16 different genes playing a role in the process, two blue-eyed parents can indeed have a brown-eyed child. The same is true with many other traits including hair color, earlobes, and more.



** For further reading, see Genotype-phenotype associations and human eye color by Desiree White in the Journal of Human Genetics. Published Oct 14, 2010.*

Draw lines to match each term with the correct description:

Recessive

Dominant

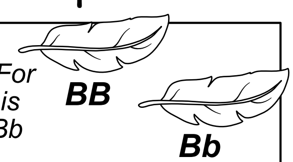
Homozygous

Heterozygous

Genotype

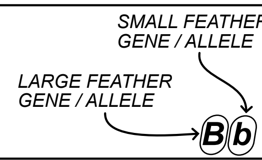
Phenotype

Only one copy (allele) of a gene is needed for the trait to be expressed. For example, if the trait for large feathers is represented by B, then both BB and Bb would result in big feathers.

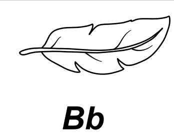


The copies (alleles) of the gene are both the same. This word comes from the Greek word "homos," which means same, and "zugos," which means yoked.

The genetic information of an organism. The term can also refer to the genetic information of a specific trait.

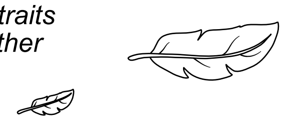


There are two different versions (alleles) of the gene. This word comes from the Greek words "heteros," which means different, and "zugos," which means yoked.



The trait will only be expressed if there are two identical copies (alleles) of the gene. For example, if small feathers are represented by b, then only the genotype of bb will produce small feathers.

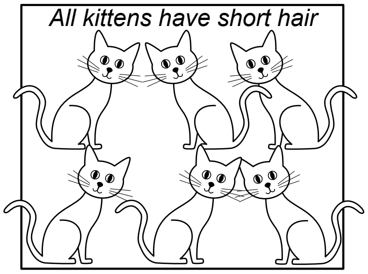
The observable characteristics or traits of an individual, such as having either small or large feathers.



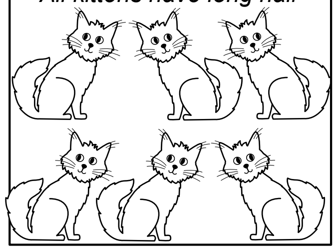
Laws of heredity

Yujun buys two pure-bred cats, each with a pedigree showing that all of their ancestors have the same trait for hair length. One cat is long haired. The other is short haired. Now the cats are going to have kittens. Yujun knows that hair length is a recessive/dominant trait but doesn't remember which trait is dominant. Match each of the possible outcomes with the correct conclusion.

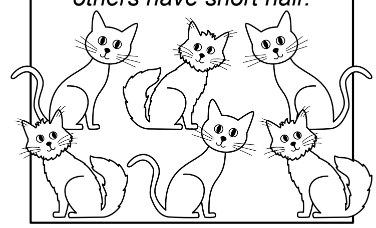
All kittens have short hair

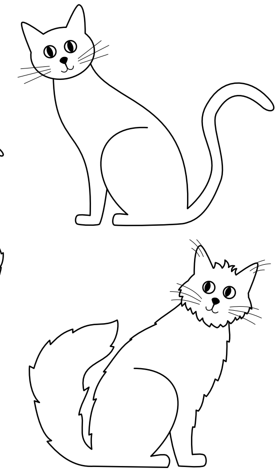


All kittens have long hair



Some kittens have long hair, others have short hair.





LONG HAIR IS A DOMINANT TRAIT

SHORT HAIR IS A DOMINANT TRAIT

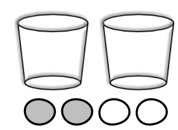
AT LEAST ONE OF THE CATS WAS NOT PURE-BRED.

1. SEGREGATION - the alleles are distributed randomly

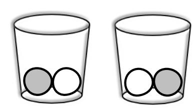
Mendel's first law states that the chance of inheriting an allele (or genetic factor) is random. For example, in the case of yellow or green seeds in pea plants, if the parent is heterozygous (Yy) there is a 50% chance the offspring will receive the dominant yellow (Y) allele and a 50% chance they will receive the recessive green (y) allele. This is called the principle of segregation.

Try it yourself!

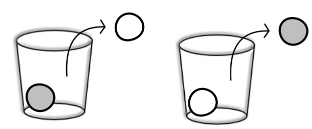
Supplies: *2 cups and 4 objects to represent dominant and recessive alleles. The objects should have the same shape and size but different colors. You could use dried peas, beans, marbles, dice, marshmallows or any items of the same size. Just make sure they are marked or colored so that you can tell tell them apart.*



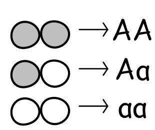
STEP 1 Place 1 object of each color in each cup. Assign one of the colors to be dominant (A) and the other to be recessive (a).



STEP 2 Without looking, draw one object from each cup.



STEP 3 Record whether you picked two dominant (**AA**), one of each (**Aa**), or two recessive (**aa**) in the tables below. Go back to **STEP 1** and repeat until the table is full.



AA	Aa	aa

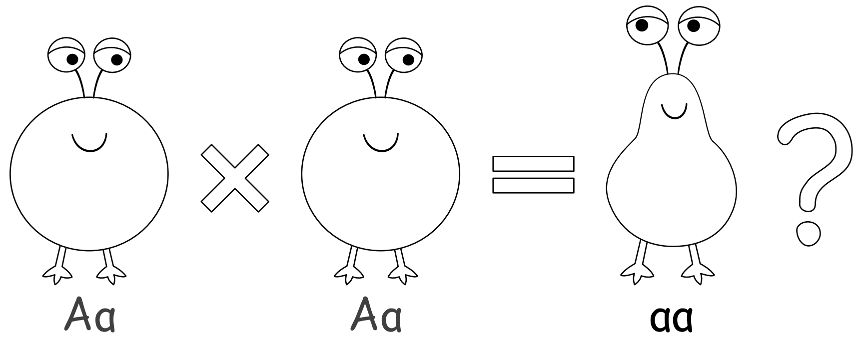
STEP 4 Color each cell green if it holds **aa** and yellow if it holds **AA** or **Aa**.
When complete, do you expect the table will have more yellow or green squares? ________________

Count the number of yellow and green cells in your table. ________Yellow ________ Green

Mendel's first law predicts 30 yellow (AA and Aa) and 10 green (aa). Were your results similar to this? If you repeated this activity 3 more times, would you expect the overall ratio to be closer to or further away from ¾ yellow and ¼ green?

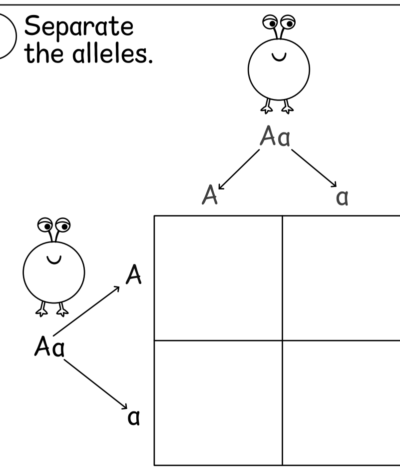
Punnett Squares

Since the probability of getting one allele or another is 50/50, we can use a tool called a Punnett square to see all of the possible combinations AND how likely they are to occur! For example, if a round shape is dominant and pear shape is recessive, a punnet square shows us how likely it is that two heterozygous aliens would produce a pear-shaped alien:

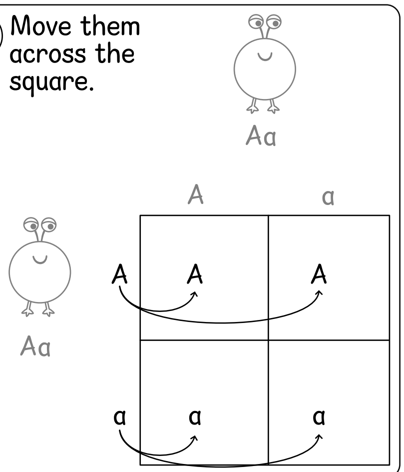


Round body shape (A) is dominant and pear body shape (a) is recessive. How many of the offspring will be pear-shaped (aa) from a heterozygous cross (Aa x Aa)? A Punnett square can tell us the answer!

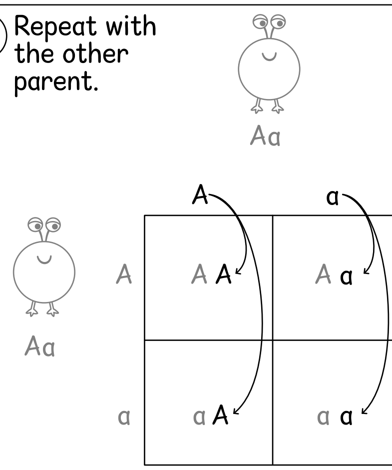
1 Separate the alleles.



2 Move them across the square.

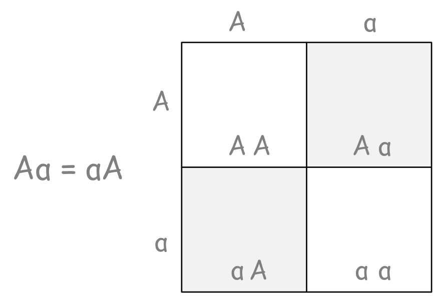


3 Repeat with the other parent.

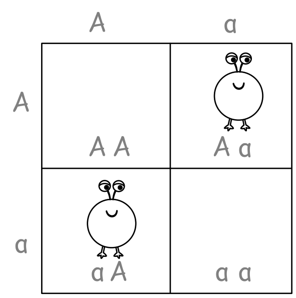


4 Evaluate your results!

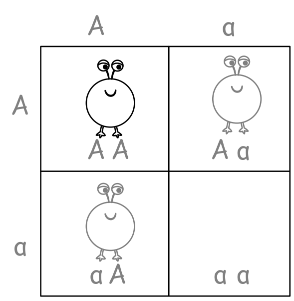
We have the genotypes. Now it's time to translate them into phenotypes! First, note that Aa is the same as aA.



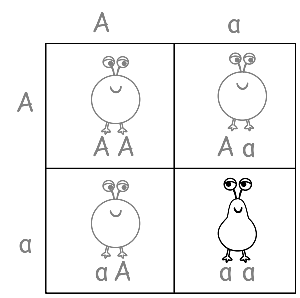
5 The phenotype for Aa is round.



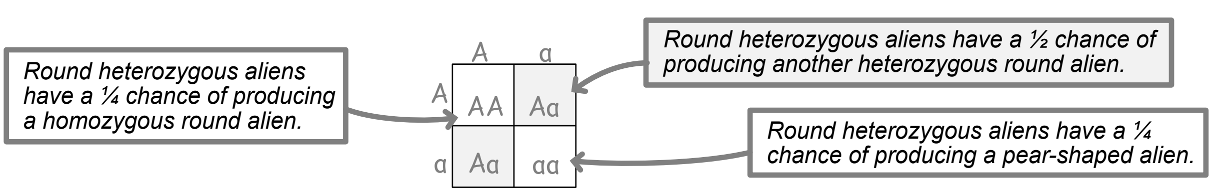
6 Homozygous for the round allele (AA) also has the round phenotype.



7 The phenotype for aa is pear-shaped.

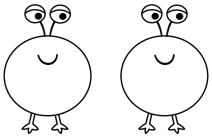


8 Because each of the 4 outcomes is equally likely, the chance of any given square is 25% or ¼.



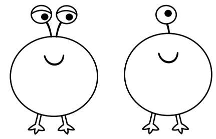
Practice some crosses!

Fill in the Punnett squares for each of the following crosses. Two eyes (B) is a dominant trait. One eye (b) is recessive. Write down the chance of producing a one-eyed alien for each cross. If no squares are “bb,” then a one-eyed alien can’t be produced from that cross (0% chance). If one square is bb, the chance is 25%. If two squares are bb, the chance is 50%. If three squares are bb, the chance is 75%. If all four squares are bb, the chance is 100%.



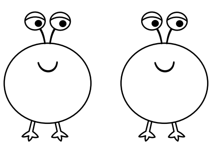
Bb x Bb

_____%
chance of bb



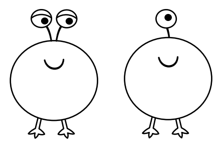
BB x bb

_____%
chance of bb



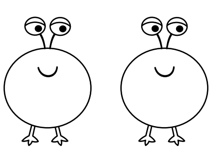
BB x BB

_____%
chance of bb



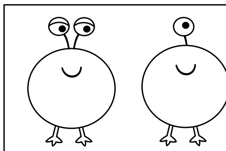
Bb x bb

_____%
chance of bb



BB x Bb

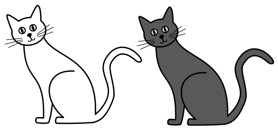
_____%
chance of bb



bb x bb

_____%
chance of bb

With cats, white fur is dominant (W) and black hair (w) is recessive. **Before** you fill out each Punnett squares, check a box to make a prediction about whether the cross will produce black kittens. **After** filling out the Punnett square, mark the percentage of black kittens the cross produced.



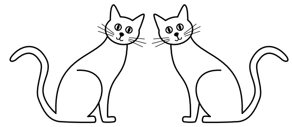
Ww x ww

Will there be black kittens?

yes no

Black kittens produced:

0% 25% 50% 75% 100%



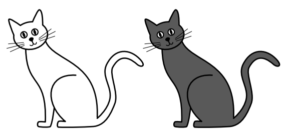
WW x Ww

Will there be black kittens?

yes no

Black kittens produced:

0% 25% 50% 75% 100%



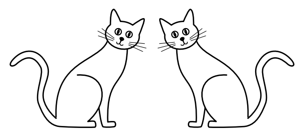
WW x ww

Will there be black kittens?

yes no

Black kittens produced:

0% 25% 50% 75% 100%



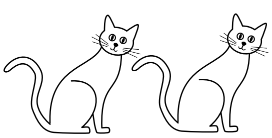
Ww x Ww

Will there be black kittens?

yes no

Black kittens produced:

0% 25% 50% 75% 100%



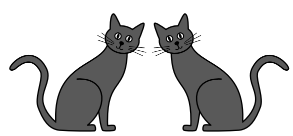
WW x WW

Will there be black kittens?

yes no

Black kittens produced:

0% 25% 50% 75% 100%



ww x ww

Will there be black kittens?

yes no

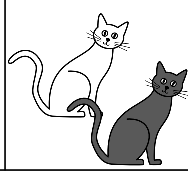
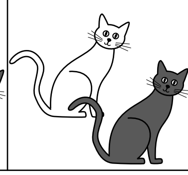
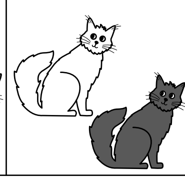
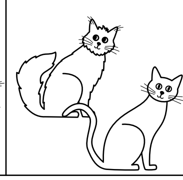
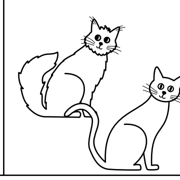
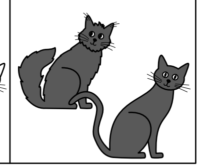
Black kittens produced:

0% 25% 50% 75% 100%

2. INDEPENDENT ASSORTMENT - traits are inherited independently

Mendel's second law of inheritance says that the inheritance of one trait (such as a cat having long hair or short) has no influence on the inheritance of another trait (such as the color of the cat's fur). This is called the principle of independent assortment. It applies to a lot of traits, but not all of them! Some genes are inherited together because they are located close together on the same chromosome.

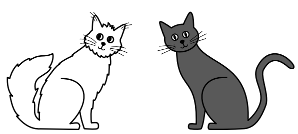
When talking about hair color, it doesn't matter if the hair is long or short; cats with the **W** *allele will be white, while cats with the* **ww** *genotype will be dark-haired.*

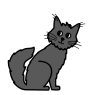
Genotype	SS	Ss	ss	WW	Ww	ww
Phenotype	*SHORT HAIR* 	*SHORT HAIR* 	*LONG HAIR* 	*WHITE HAIR* 	*WHITE HAIR* 	*DARK HAIR* 

When talking about hair length, it doesn't matter what color the hair is; cats with the genotype of **SS** *or* **Ss** *will have short hair. Long hair is only produced by the genotype* **ss***.*

Could this pair of cats produce a black long-haired kitten? Check yes or no. Then show why or why not.

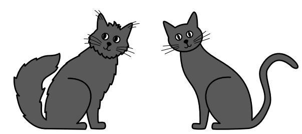
- ☐ YES
- ☐ NO

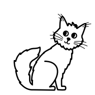




Could this pair of cats produce a white long-haired kitten? Check yes or no. Then show why or why not.

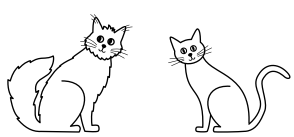
- ☐ YES
- ☐ NO

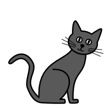




Could this pair of cats produce a black short-haired kitten? Check yes or no. Then show why or why not.

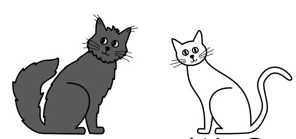
- ☐ YES
- ☐ NO

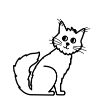




Could this pair of cats produce a white long-haired kitten? Check yes or no. Then show why or why not.

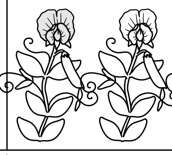
- ☐ YES
- ☐ NO





The traits of pea height (tall or dwarf) and the trait of flower color (purple or white) are inherited independently.

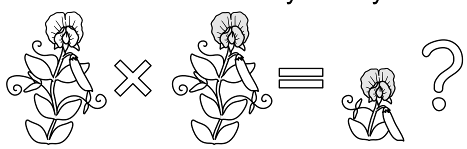
When talking about flower color, it doesn't matter if the plants are tall or dwarf; peas with the **P** *allele will be purple while peas with the* **pp** *genotype will be white.*

Genotype	TT	Tt	tt	PP	Pp	pp
Phenotype	*TALL PLANTS* 	*TALL PLANTS* 	*DWARF PLANTS* 	*PURPLE FLOWERS* 	*PURPLE FLOWERS* 	*WHITE FLOWERS* 

When talking about plant height, it doesn't matter what color the flower is; peas with the genotype of **TT** *or* **Tt** *will be tall. Dwarf pea plants are only produced by the genotype* **tt**.

Could this cross produce a dwarf pea plant with purple flowers? Check yes or no. Then show why or why not.

☐ YES
☐ NO



Ttpp TtPp

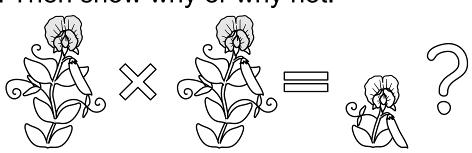
Could this cross produce a tall plant with white flowers? Check yes or no. Then show why or why not.

☐ YES
☐ NO

ttpp ttPp

Could this cross produce a dwarf plant with white flowers? Check yes or no. Then show why or why not.

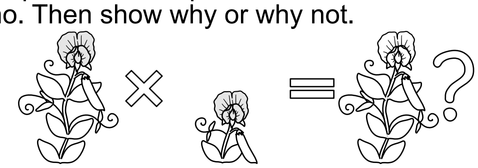
☐ YES
☐ NO



TTPP TtPp

Could this cross produce a tall plant with white flowers? Check yes or no. Then show why or why not.

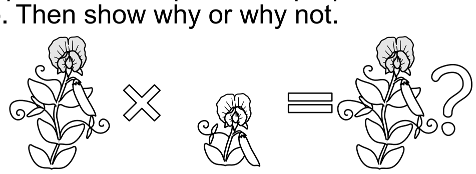
☐ YES
☐ NO



TtPp ttPp

Could this cross produce a tall plant with purple flowers? Check yes or no. Then show why or why not.

☐ YES
☐ NO



TtPp ttpp

Could this cross produce a dwarf plant with white flowers? Check yes or no. Then show why or why not.

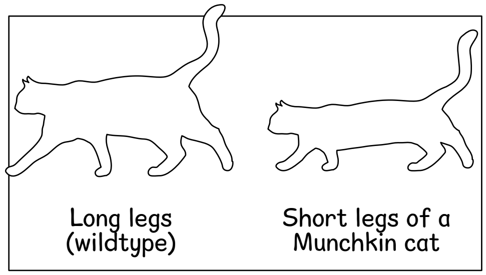
☐ YES
☐ NO

ttPP ttPp

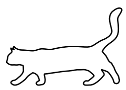
The Munchkin Mutation

Riley is fostering a pregnant Munchkin cat named Percy for their local animal shelter. The short legs of the Munchkin are caused by a dominant mutation (**M**). The mutation is lethal if homozygous (the **MM** genotype fails to develop in utero). Heterozygous (**Mm**) gives the Munchkin phenotype of short legs, and homozygous recessive (**mm**) results in long legs (**wildtype**).

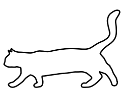
The animal shelter has a waiting list of people ready to adopt Percy's kittens. They want to know what the probability is of the kittens being Munchkins, but no one knows if Percy's mate was a Munchkin (**Mm**) or not (**mm**). Calculate the probability of Munchkin kittens from each possible cross.



Possibility 1: Munchkin x Munchkin cross

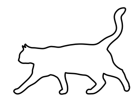


Mm

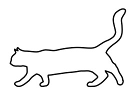


Mm

Possibility 2: Munchkin x Wildtype cross



mm



Mm

What is the probability of Munchkin kittens if both parents are Munchkins?

- [ ] 100% - every kitten will be a Munchkin.
- [ ] Approximately 67% - 2 out of every 3 kittens will be a Munchkin.
- [ ] 50% - there's a 50/50 chance of the Munchkin trait.
- [ ] 25% - there's a 1 in 4 chance of the Munchkin trait.

What is the probability of Munchkin kittens if one parent is a Munchkin and the other is wildtype (has long legs)?

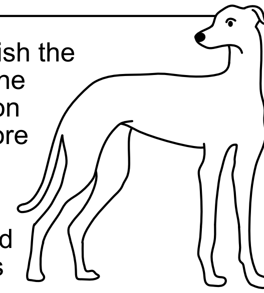
- [ ] 100% - every kitten will be a Munchkin.
- [ ] Approximately 67% - 2 out of every 3 kittens will be a Munchkin.
- [ ] 50% - there's a 50/50 chance of the Munchkin trait.
- [ ] 25% - there's a 1 in 4 chance of the Munchkin trait.

If Percy is pregnant with only two kittens, what are the possible outcomes for this litter?
Mark all genotype combinations that are possible.

- [ ] Mm and Mm
- [ ] Mm and mm
- [ ] mm and mm

Ethics and Genetics

The study of genetics is about more than traits and DNA. It often impacts social and ethical questions as well. Read the following paragraphs and then write your opinion about the concerns associated with each example. There are no “right” answers here! These questions are as much about what you value as they are about heredity and genetics.

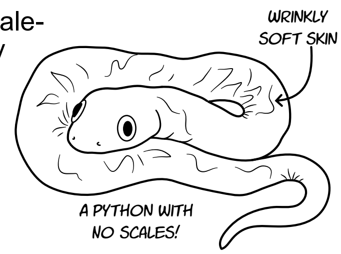


A group of dog breeders have developed a new dog breed called a Tardal.* In working to establish the Tardal as an officially recognized breed, full health histories are completed for all Tardal dogs. The studies reveal that Tardals are intelligent, loyal, and have the fastest running speed of any dog on Earth, capable of running at 70 mph. But in addition to these desirable traits, Tardals are 11x more likely than other dogs to experience hip and ankle dislocation. They also have a life expectancy that is significantly shorter than other dogs, living for just 4 to 5 years.

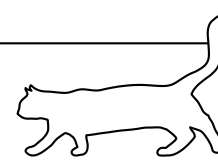
Should this new dog breed be accepted, a move that would cause it to become a common breed among dog owners? Or should people stop breeding Tardals be because of the health concerns associated with the breed? Write your recommendation:

The Tardal is an imaginary dog breed invented for this lesson.

Remy breeds ball pythons and in one of their recent clutch of eggs they discovered a scale-less snake. Rare python morphs are valuable and Remy knows they can earn money by breeding the snake to produce more pythons without scales. But this scale-less snake has incredibly soft skin. It needs special care when shedding to avoid infection. Even with soft bedding, it is easily injured and often experiences minor cuts and scrapes from everyday movements.



Do you think Remy should breed the scale-less snake? Why or why not?



The Governing Council of the Cat Fancy* currently refuses to recognize Munchkins as a breed because of health issues associated with the short legged trait. Some Munchkin owners claim that the cats are healthy and happy with no more health concerns than the average cat. Others claim that the mutation hinders Munchkins ability to move and causes discomfort.

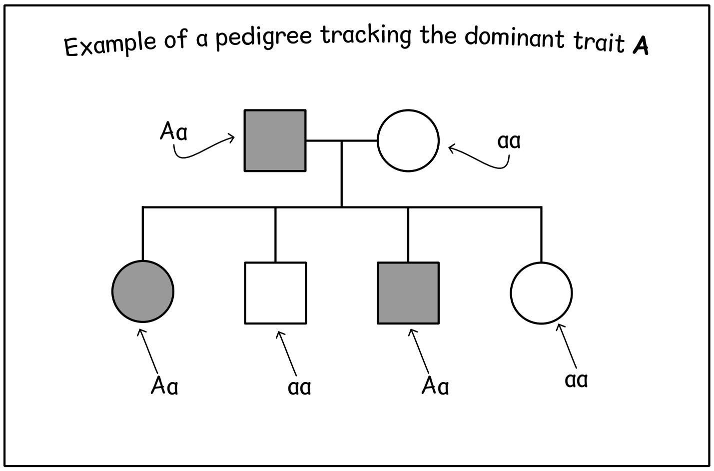
If you were a member of the GCCF, would you be in favor of recognizing Munchkins as a breed, be neutral on the issue, or be in favor of prohibiting further breeding of Munchkins?

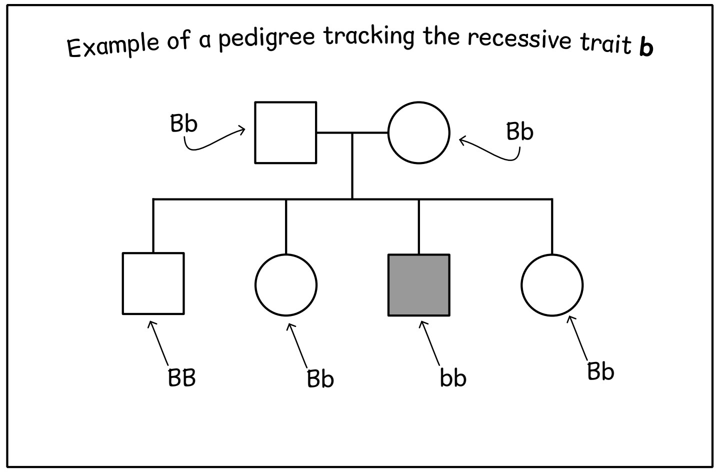
**An organization that registers pedigreed cats in the United Kingdom*

How to Read A Pedigree Chart

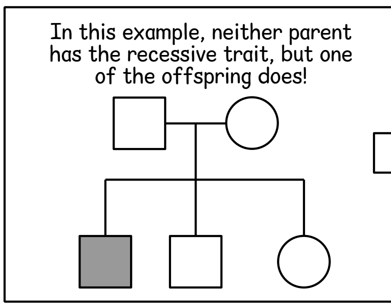
A pedigree chart is a family tree that tracks how a trait has been passed along. It typically follows the rules below:

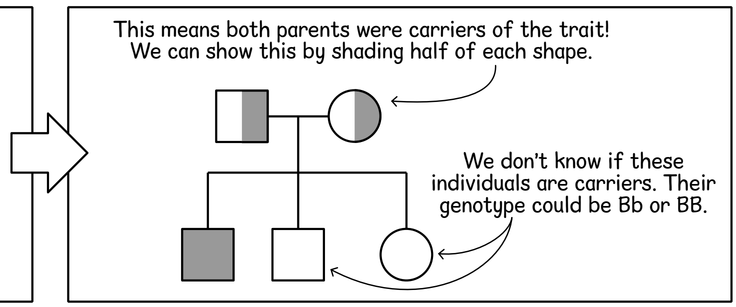
- Males are represented by squares, and females are represented by circles.
- A filled shape means the individual exhibits the trait.
- Horizontal lines between two individuals exhibit mating pairs.
- Vertical lines descend from parents to a horizontal line that connects the offspring.



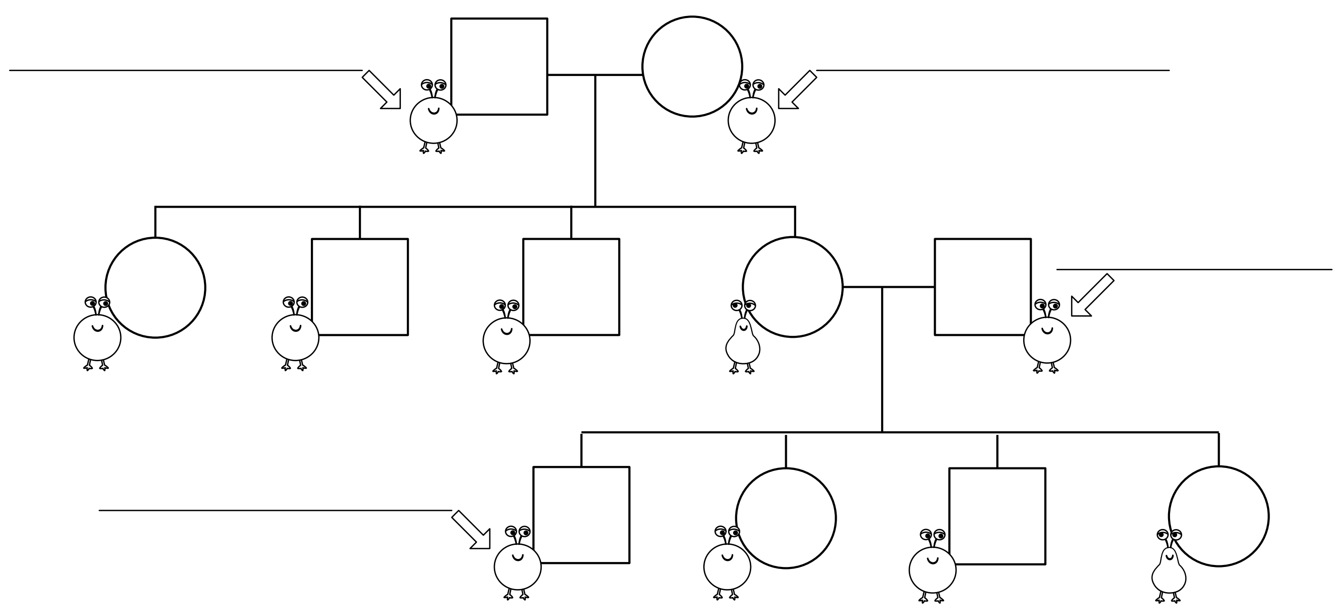


Each individual receives their alleles from their parents. When tracking recessive traits, sometimes it helps to identify the heterozygous individuals that carry the trait. These **carriers** are marked with half-shading.



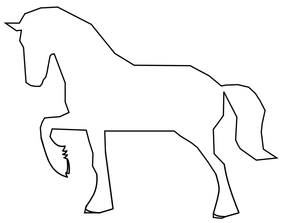


Color in this pedigree for tracking **pear shape** in the aliens. Remember, round body shape is dominant (RR) and pear shape is recessive (rr). The phenotype is known for all individuals. Can you determine the genotypes of the aliens indicated by the arrows?

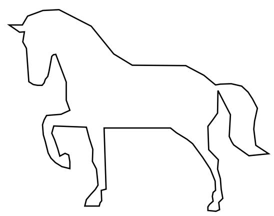


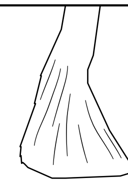
Pet Pedigree Puzzle #1

Profile of a breed with feathered feet

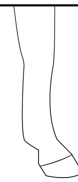


Profile of a breed without feathered feet



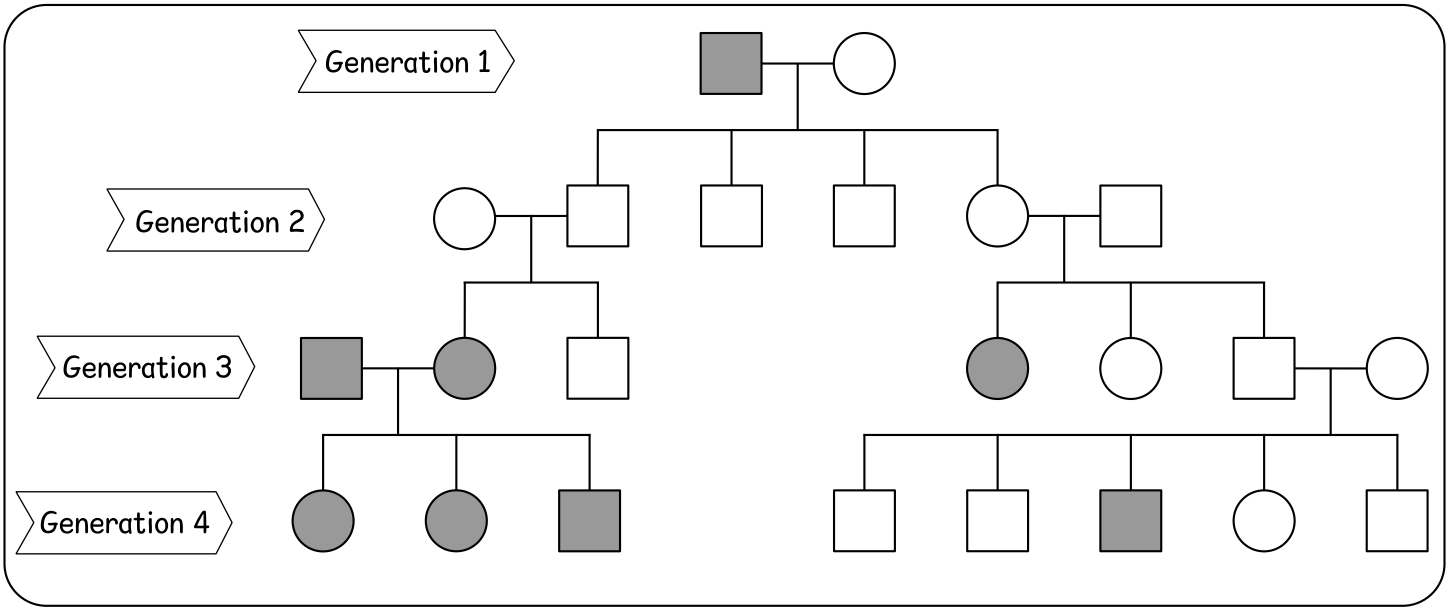


The "feathered" foot has long hair on the lower leg that covers the hoof.



A non-feathered foot has short hair.

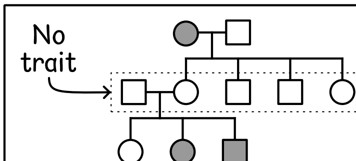
Below is a pedigree chart for the trait of "feathered feet," the long hair that cover the hooves of certain horse breeds like Clydesdales, Shires, Friesians, and Ardennes.* Each shaded shape represents a horse with feathered feet.



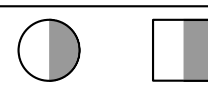
Can a dominant trait skip a generation? What about a recessive trait? Explain.

AA, Aa, or aa?

Is the trait mapped in this pedigree chart dominant or recessive? Explain how you know.



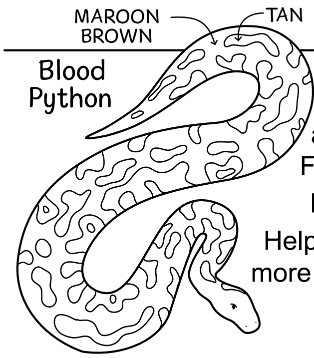
When tracking a recessive trait, a half-shaded shape is used to indicate a carrier.
Can you identify a horse or horses in this pedigree that must be carriers of the trait?
If yes, shade in their shapes.



A carrier of the trait!

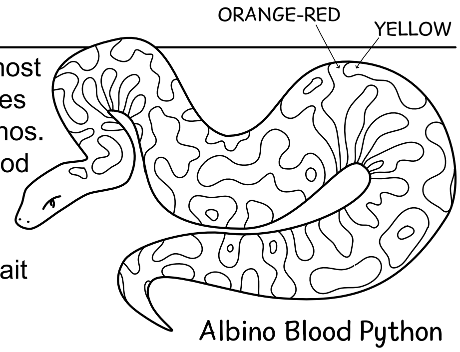
**While a cross between a feathered horse (such as a Clydesdale) and a non-feathered horse (such as a Thoroughbred) will result in a horse that is non-feathered, the genetics of feathering have not been studied in detail. It's likely to include more than one gene and be more complicated than the hypothetical example used here!*

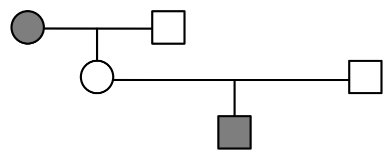
Pet Pedigree Puzzle #2



At Ella's pet store, albino blood pythons have been the most popular snake breed. Ella has space to breed two snakes and wants to choose a pairing that will produce more albinos. Fortunately, Ella has pedigree charts of the store's four blood pythons: Julius Squeezer, Basil, Medusa, and Naga.

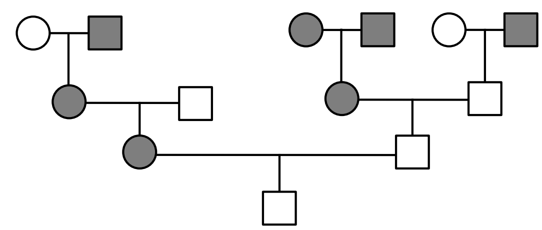
Help Ella make the choice that will give the highest chance of more albino pythons! Remember that albinism is a recessive trait and the pedigrees only show phenotype, not genotype.





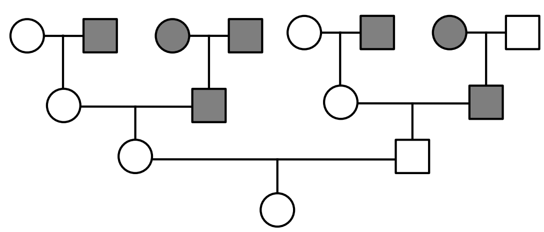
Julius Squeezer

Julius Squeezer is the an albino blood python with beautiful cream and orange coloring.



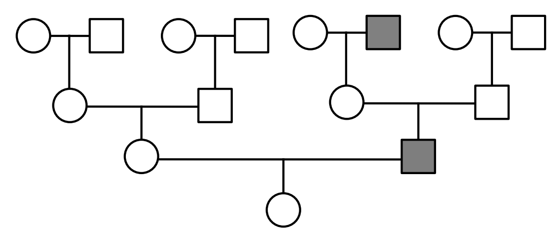
Basil

Basil has standard coloring and a very friendly temperament. He is easy to hold.



Naga

Naga has standard coloring and an aggressive temperament. Gloves are required for handling.



Medusa

Medusa has standard coloring and loves to swim. She takes a plunge anytime she's around water.

What genotype is Julius Squeezer? The standard color allele is represented by **A**. The albinism allele is represented by **a**.

☐ **AA** or **Aa** ☐ **Aa** ☐ **aa**

What genotype is Basil?

☐ **AA** or **Aa** ☐ **Aa** ☐ **aa**

What genotype is Naga?

☐ **AA** or **Aa** ☐ **Aa** ☐ **aa**

What genotype is Medusa?

☐ **AA** or **Aa** ☐ **Aa** ☐ **aa**

Which snakes should Ella select for breeding and why?

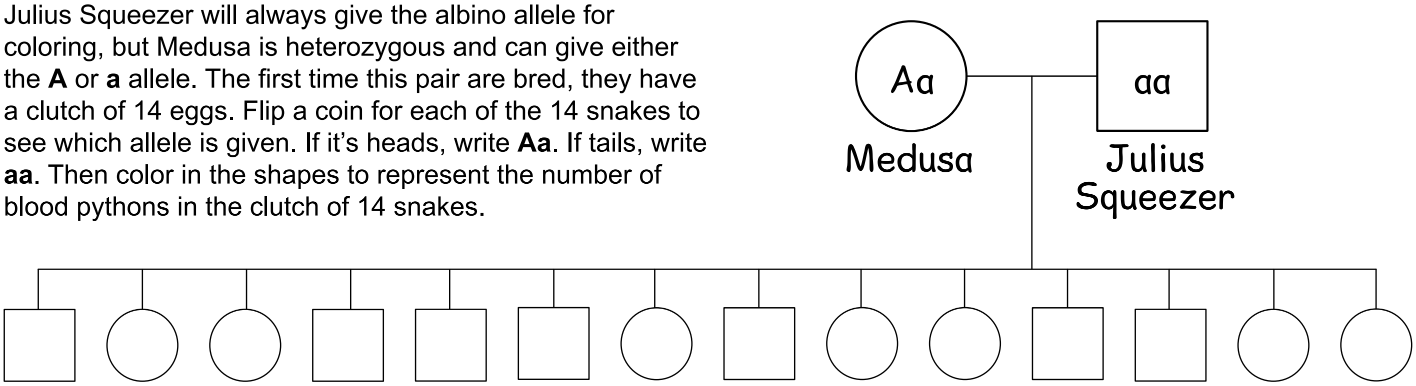
____

____

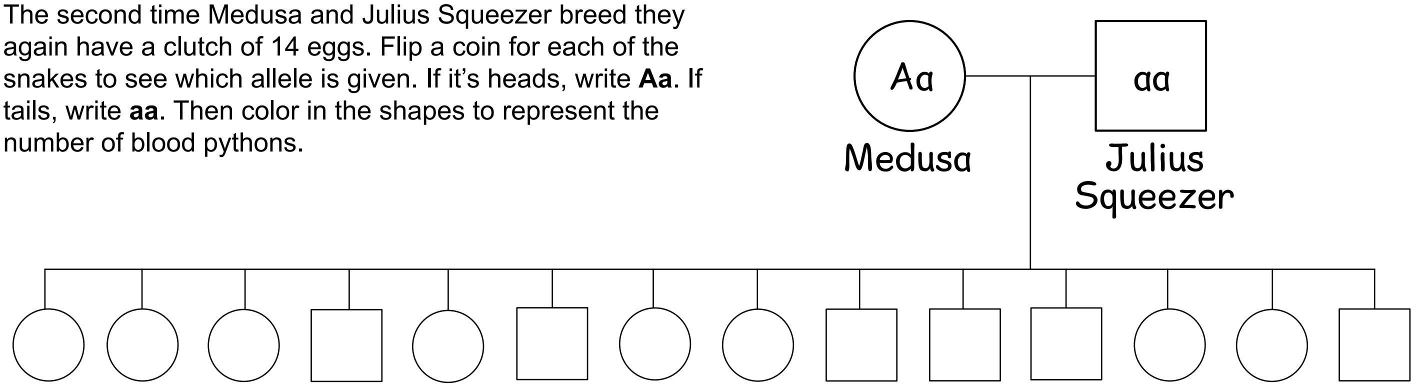
Mendel's First Law is like flipping a coin...

The probability of an aa x Aa cross giving albino snakes may be 50/50, but that doesn't mean you'll see that exact ratio in real life! Explore Mendel's first law by using a coin to determine whether these snakes produce albino blood pythons. Color the albinos (**aa**) orange. Use brown to mark the standard coloring (**AA** or **Aa**) which is also called **wildtype**.

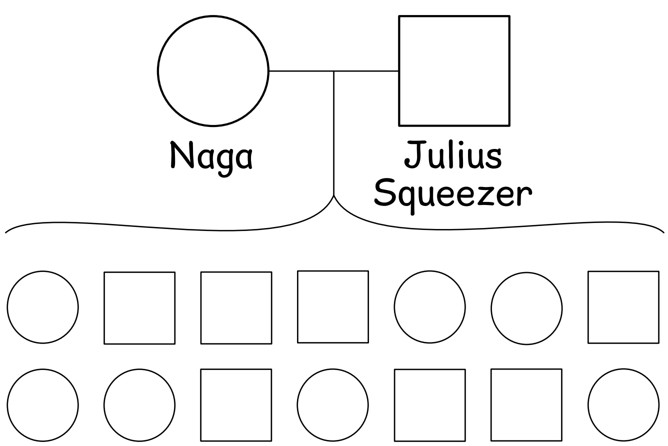
Julius Squeezer will always give the albino allele for coloring, but Medusa is heterozygous and can give either the **A** or **a** allele. The first time this pair are bred, they have a clutch of 14 eggs. Flip a coin for each of the 14 snakes to see which allele is given. If it's heads, write **Aa**. If tails, write **aa**. Then color in the shapes to represent the number of blood pythons in the clutch of 14 snakes.



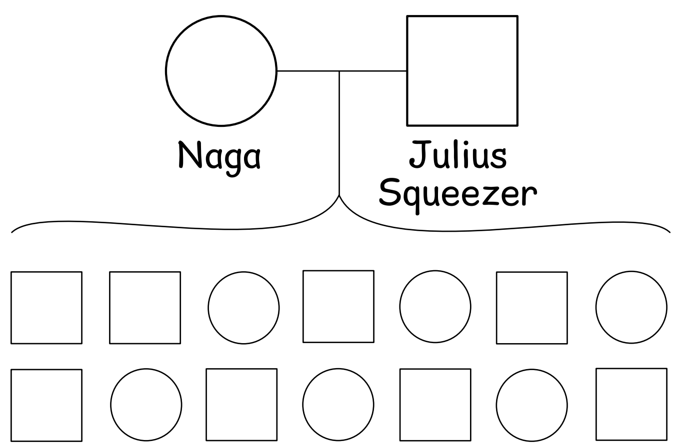
The second time Medusa and Julius Squeezer breed they again have a clutch of 14 eggs. Flip a coin for each of the snakes to see which allele is given. If it's heads, write **Aa**. If tails, write **aa.** Then color in the shapes to represent the number of blood pythons.



Assuming Naga is heterozygous (**Aa**), flip a coin to see what proportion of this clutch of eggs would be expected to be albinos. Then color in the results.



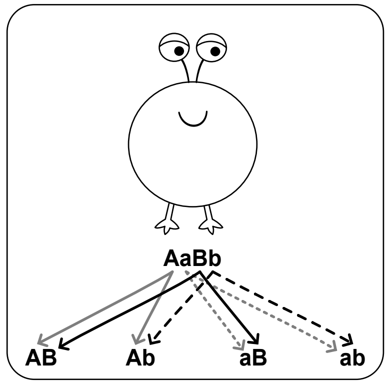
Assuming Naga is homozygous (**AA**), what proportion of this clutch of eggs would be albinos? Do you need to flip a coin here?

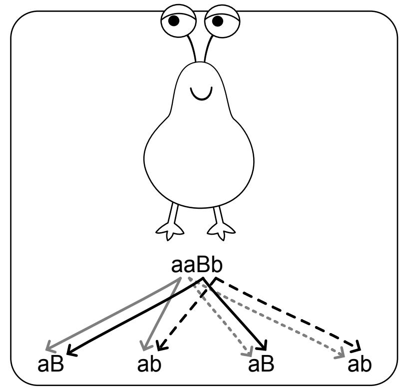


Bigger Punnett Squares!

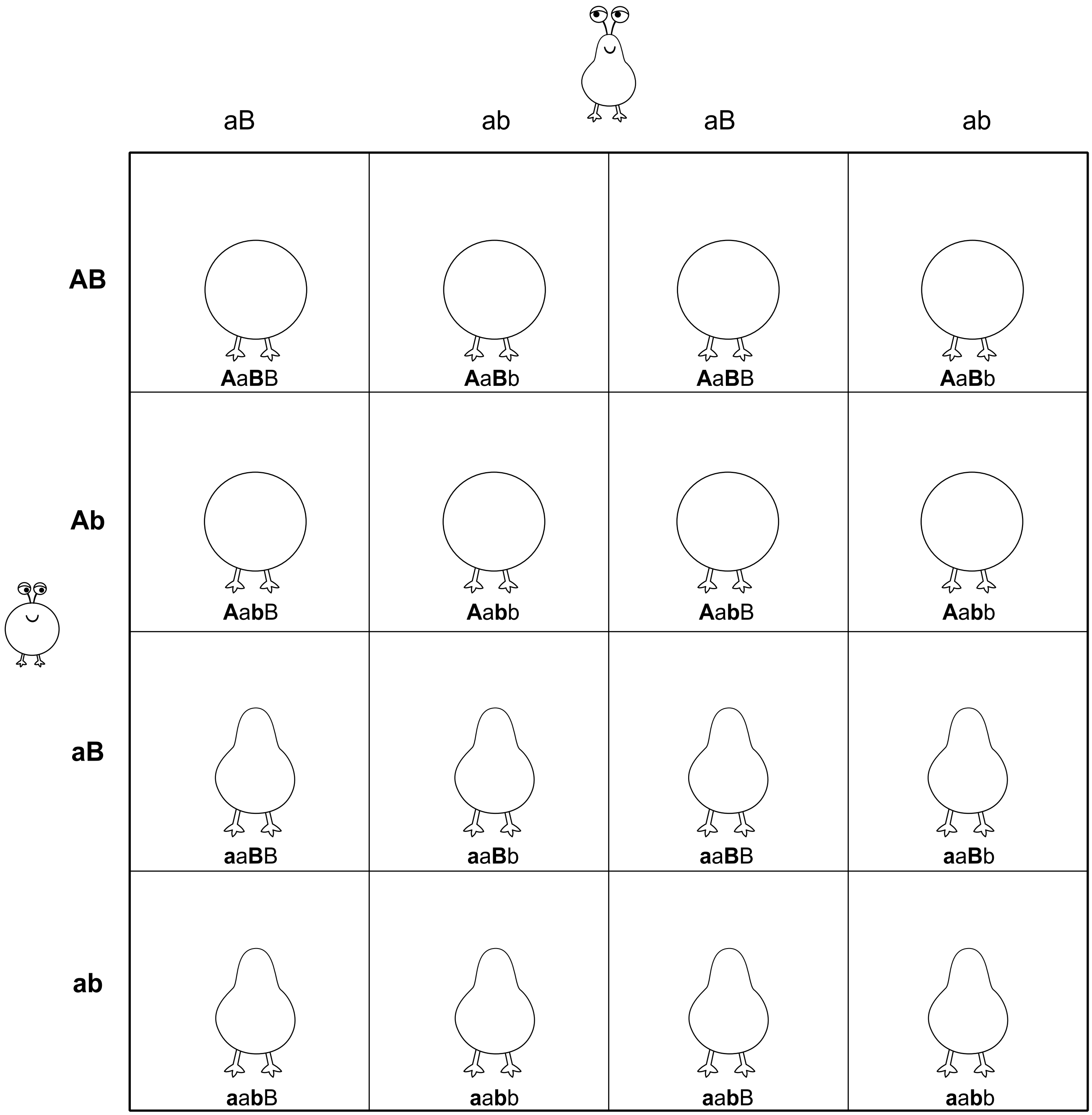
When we consider two traits at once, we concatenate (or join) the genotypes. For example, an alien that is double heterozygous for roundness (**Aa**) and number of eyes (**Bb**) has the genotype **AaBb.** An pear-shaped alien that is heterozygous for eyes would have the genotype **aaBb.**

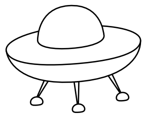
The double heterozygous alien has an equal chance of passing along each of the 4 allele pairs: **AB**, **Ab**, **aB**, and **ab**. The pear-shaped alien also has an equal chance of passing on each of the 4 possible allele pairs.





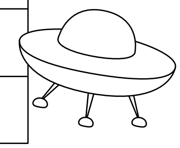
Fill in the punnet square below by drawing the correct number of eyes on each alien for the cross AaBb x aaBb. Remember BB or Bb result in the phenotype of two eyes, and only bb gives the phenotype of one eye.



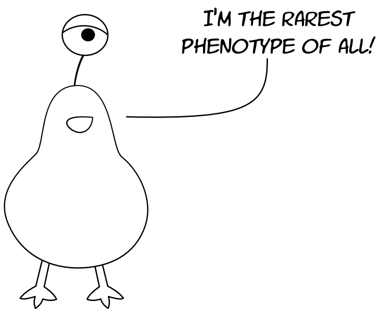


Genotype:	Phenotype:
AA	Round body shape
Aa	Round body shape
aa	Pear body shape

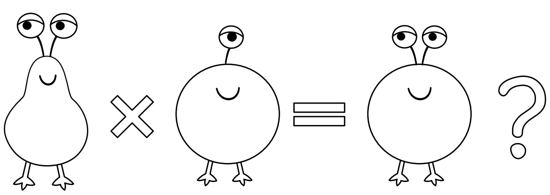
Genotype:	Phenotype:
BB	Two eyes
Bb	Two eyes
bb	One eye

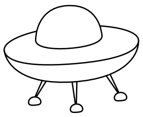


Create a Punnett square for the cross **AaBb×AaBb.** Will you see the rare pear-shaped one-eyed alien (**aabb**) from this cross? If so, what is the chance of seeing it? 1/16, 2/8, 1/4 or 1/2?



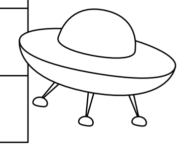
Create a Punnett square for the cross **aaBb** × **Aabb.**
What is the chance of seeing a round two-eyed alien (**AaBb**) from this cross?



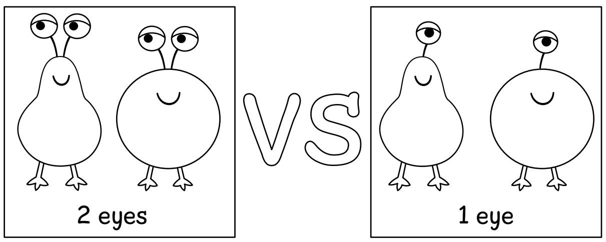


Genotype:	Phenotype:
AA	Round body shape
Aa	Round body shape
aa	Pear body shape

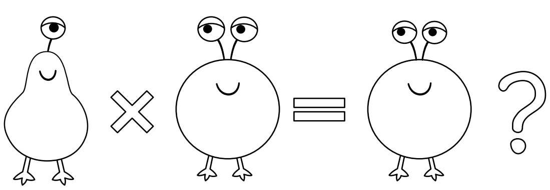
Genotype:	Phenotype:
BB	Two eyes
Bb	Two eyes
bb	One eye

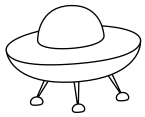


Create a Punnett square for the cross **AABb×AaBb.** How many of the offspring, on average, will have one eye? 1/16, 2/8, 1/4 or 1/2? Will there be any pear-shaped one-eyed aliens or will they all be round?



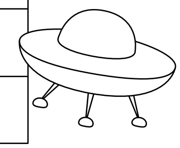
Create a Punnett square for the cross **aabb** × **AABB.**
What is the chance of seeing a round two-eyed alien that is heterozygous for both traits (**AaBb**)?



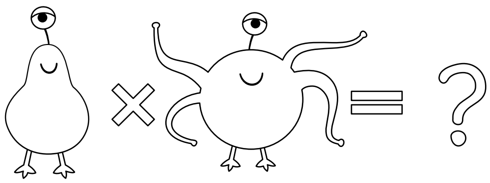


Genotype:	Phenotype:
AA	Round body shape
Aa	Round body shape
aa	Pear body shape

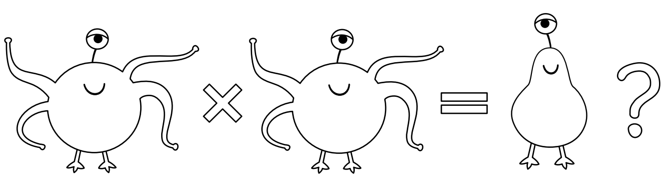
Genotype:	Phenotype:
CC	Tentacle arms
Cc	Tentacle arms
cc	No arms



A new dominant trait of tentacle arms has been discovered. What will be the results of a cross between a heterozygous tentacled round alien and a pear-shaped no-arms alien? (**aacc**×**AaCc**) Fill out the square, then write the ratios for each of the outcomes.



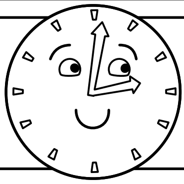
Can two round-eyed tentacle-arm aliens produce a pear-shaped no-arms alien? If yes, what do the genotypes need to be for this cross, and what is the chance of the pear-shaped no-armed offspring?



genotype

genotype

Probability of no-arm pear-shaped



Quiz Time!

ANSWER THE QUESTIONS TO SEE WHAT YOU LEARNED ABOUT HEREDITY!

1. Which statement is true?
   A. Members of the same species must be approximately the same size.
   B. Members of the same species can breed with each other and produce offspring.
   C. Scientists always agree on whether animals are in the same species.
   D. Only animals have species.

2. Which type of reproduction will result in the most genetic diversity?
   A. Fragmentation
   B. Binary fission
   C. Vegetative propagation
   D. Spore formation
   E. Sexual reproduction

3. Every trait is controlled by a single gene, and each gene is determined by two alleles.
   A. True
   B. False

4. Select each true statement below.
   A. A dominant trait can skip a generation.
   B. A recessive trait can skip a generation.
   C. When two parents share the same genotype, their offspring will share the same genotype.
   D. When two parents share the same phenotype, their offspring will share the same phenotype.

5. What does the notation BB mean to a geneticist?
   A. Two dominant alleles
   B. Two recessive alleles
   C. At least one dominant allele
   D. One dominant and one recessive allele

6. If a homozygous black guinea pig (BB) is crossed with a homozygous white guinea pig (bb), what is the probability that an offspring will have black fur?
   A. 0%
   B. 25%
   C. 50%
   D. 75%
   E. 100%

7. If an organism is homozygous dominant for a trait that follows Mendelian inheritance patterns, which of the following must be true?
   A. Its offspring will also have a homozygous genotype.
   B. Its offspring will also have a heterozygous genotype.
   C. Its offspring will exhibit the dominant phenotype for the trait.
   D. The organism's parent(s) also had a homozygous genotype for the trait.
   E. None of the above

8. Select each true statement below.
   A. If you know an organism's genotype for a trait, then you also know its phenotype.
   B. If you know an organism's phenotype for a trait, then you also know its genotype.
   C. A parent always has the same genotype as its offspring.
   D. A parent always has the same phenotype as its offspring.

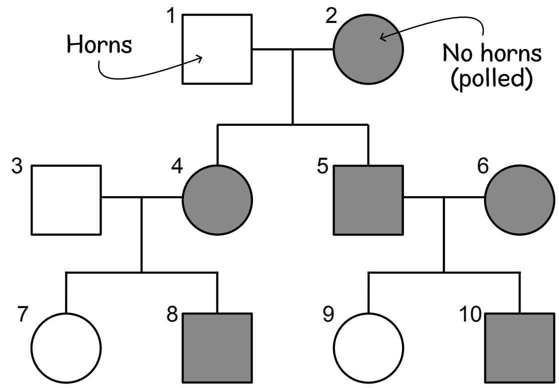
9. An organism that has two different alleles for a single trait is said to be _____________ for that trait.

10. An organism has a phenotype for a dominant trait while some of its offspring have the phenotype for the recessive trait. What can we conclude about this organism?
    A. It is heterozygous for the trait.
    B. It is homozygous dominant for the trait.
    C. It is homozygous recessive for the trait.
    D. There is not enough information to tell.

11. True or False: all alleles are either dominant or recessive.
    A. True
    B. False

12. What is a Mendelian trait?
    A. A trait that involves alleles
    B. A trait that is passed down by dominant and recessive alleles of one gene
    C. A trait where different alleles are equally and independently expressed
    D. A trait exhibited by pea plants

Below is a pedigree chart for tracking **hornless cattle**, a Mendelian trait. Cattle without horns are called *polled* cattle and are usually viewed as more desirable than cattle with horns. Each of the cattle is numbered for reference.



13. Is the hornless trait (polling) a dominant or recessive trait in cattle? Explain how you know.

14. We can assign the alleles A and ɑ to the trait “no horns” exhibited in the pedigree chart. In that case, what is the specific meaning of both A and ɑ?

15. Label each member of the pedigree chart whose genotype can be fully identified. Are there any that you can’t determine? Explain.

16. List the numbers of each individual that has horns in the pedigree above:

17. List the numbers of the individuals that are heterozygous in the pedigree above:

18. If we cross two cattle with horns, could the offspring have no horns? Explain.

19. If we cross two cattle with no horns, could the offspring have horns? Explain.

Heredity Word Search

There are a lot of new words to learn when studying biology. Repetition is the best way to learn them, and word games can be part of that! Find each of the hidden words in the word-search. The words can run in any direction: horizontal or diagonal, and the letters might go left to right or right to left!

GENE	RECESSIVE	CARRIER
ALLELE	PHENOTYPE	PROBABILITY
HOMOZYGOUS	GENOTYPE	HEREDITY
HETEROZYGOUS	CODOMINANCE	OFFSPRING
PUNNETTSQUARE	PEDIGREE	TRAIT
DOMINANT	HYBRID	

Y S E V I G N Y A F F Y

T U R K Y E A L Q L J E T

I M A Y Y P F W X B L B T I

L W U S G E N O T Y P E C S D

I X Q G L U K G T U B O L P B E

B S S P H C P E E R G I D E P J R

A L T I A R T U I T U I B F H S D E

B V T D P U Q T S I T N E I C S X Y H

O L E H Z P C W J S R A O D A I R P E L

R W N Y M P O K S U E T B D E F W Q B S Z

P U N W L S V T S O N V S U O G Y Z O M O H

Q U X N X G C Z G R V I H F M E S S T Z P

P K X D I R B Y H R O S F U I T Q P Q H

M W U K X R Z O E V H S C U N R R J E

G E N E M O O C D W P E V W A V T N

C Z A T R R E I R R A C C W N N O

A S Y E X S H Z I R M E L E T T

R X T Z T Z A N I W C R O U Y

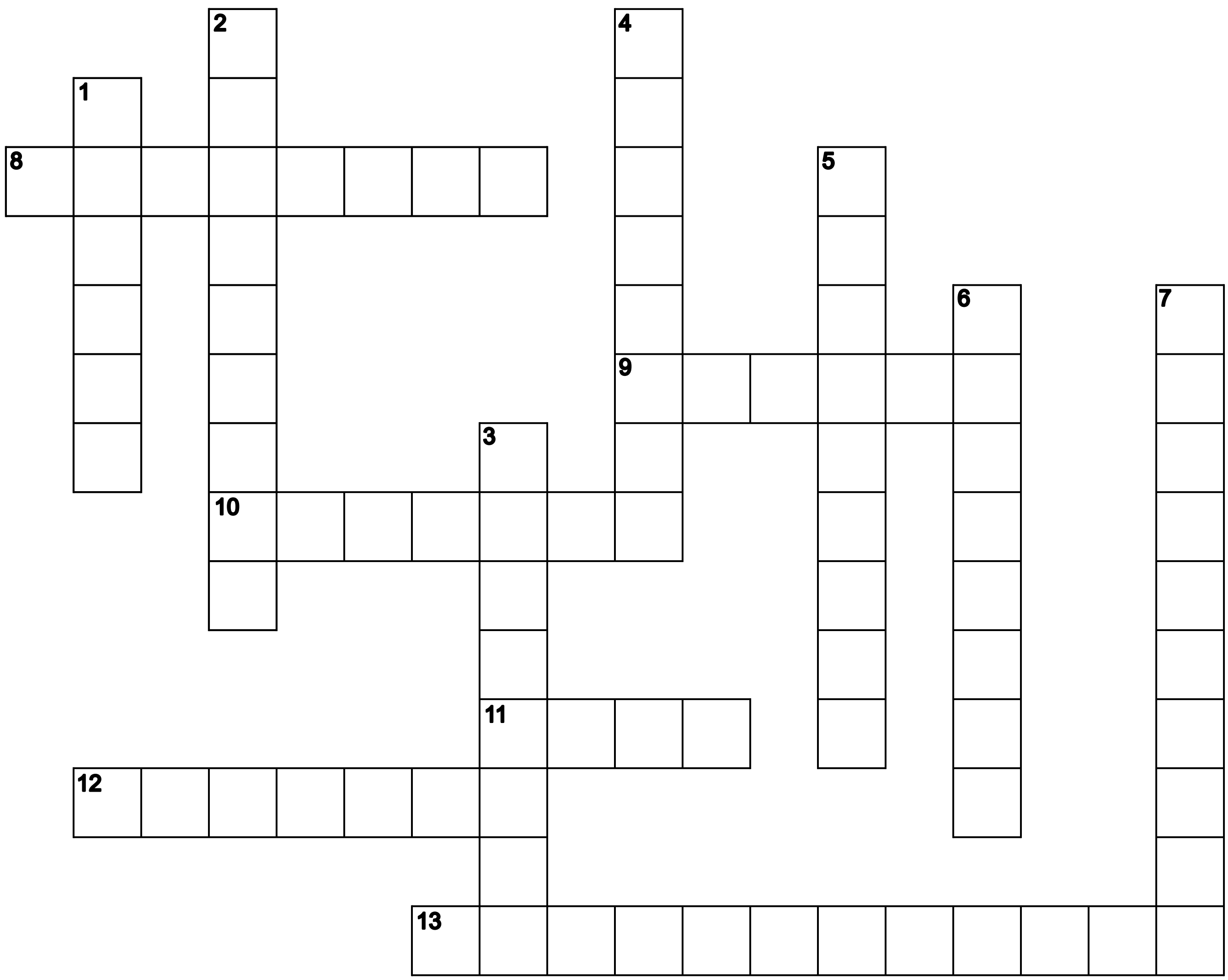
K E N I J Z G E X U L K C P

H Z E C Y A R O L U C Y E

V E L Q B M K L A L W E

C O D O M I N A N C E

Heredity Crossword Puzzle



VERTICAL Words

1. What is the name of the father of genetics?
2. What is the term for an organism's physical appearance or visible traits?
3. The name for a chart of the ancestry or heritage of an individual.
4. A trait that will appear in the offspring if one of the parents contributes an allele for it.
5. A trait that will only appear in the offspring if both parents contribute an allele for it.
6. The scientific study of heredity.
7. The term for the condition where both copies of the allele are the same.

HORIZONTAL Words

8. The passing of traits from parents to offspring.
9. The term for a possible form of the gene.
10. A type of square used to keep track of the possible combination of alleles that can result from a cross.
11. A segment of DNA on a chromosome that codes for a specific trait.
12. A person who has one recessive allele for a trait and one dominant allele, but does not have the trait.
13. The term for the condition where there are two different alleles for a trait.