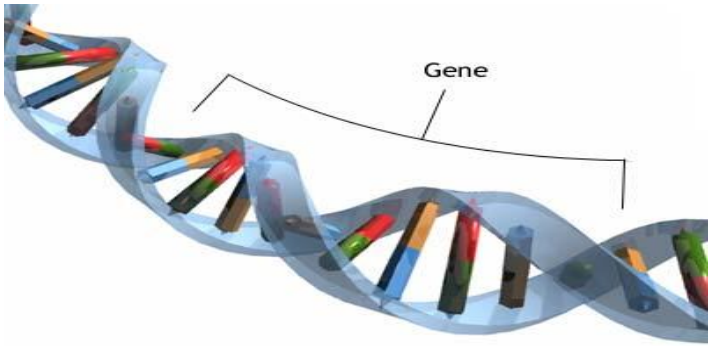
GENETICS UNIT:



Order of teaching	Slide #	Title	# pages	# of pds
My parents wrecked my favorite genes.	3-4	Genetics vocab Differentiated for ALL readers	8	1
Father of genetics	5-19	“	3	1-2
Squaring it up	20-21	“	5	1
You’re such a square	22-23	“	8	8
Phenylthiocarbimide- says what?! Lab	24-32	PTC Tasting Lab	7	1
Yellow and Blue make? Other inheritance patterns	33-48	“	11	1-2
A twisted tale – the story of DNA.	49-55	“	2	1
My fruit is alive! DNA extraction lab	56-63	“	6	1
My DNA speaks to me. Protein synthesis	64-70	Protein synthesis	22	1-2
Oh-me, oh mei-osis notes – Just like me & Game of chance activites	71-85	“	7	2-3
Track the trait pedigrees	86-89	“	7	1
Pick me, pick me! Hybrid article analysis	90-95	“	3	1
Mix it up! Hybrid matching game	96-97	Hybrid matching cards	50	1
Get your hybrid here – Hybrid sales campaign	98-99	Hybrid sales campaign	4	2-5
An engineered reading	100-105	“	3	1
Opinion matters – Genetic engineering PSA	106-117	“	2	5-7
Genetics Study Guide	118	“	9	1-2

https://www.youtube.com/watch?v=B_PQ8qYtUL0

Our study of genetics could help us make a better world!

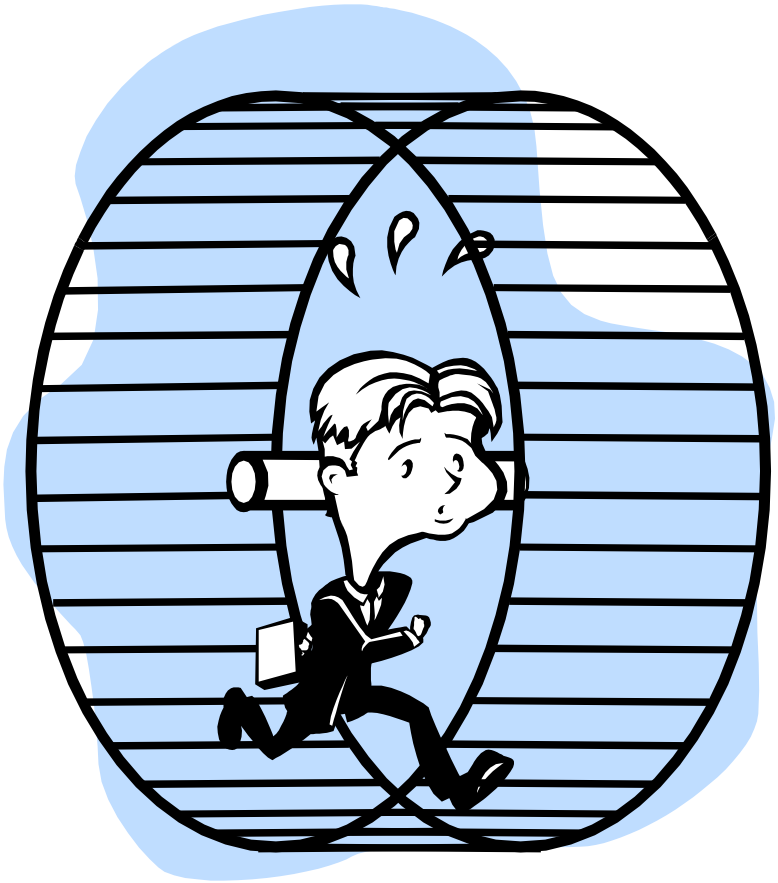
My Parents Wrecked My Favorite Genes

Objective: To learn how genes play a role in inherited characteristics

Bell work:

1. What is does it mean to inherit?

What Do YOU Think?



Genetics… what's the purpose? To provide you (and other living things) with the traits that make you, well… YOU! That's genetics! Take a few minutes to read the passage "My Parents Wrecked My Favorite Genes." When complete, find the correct term for the definitions on your sheet. Remember to use good *reading strategies* as you read!

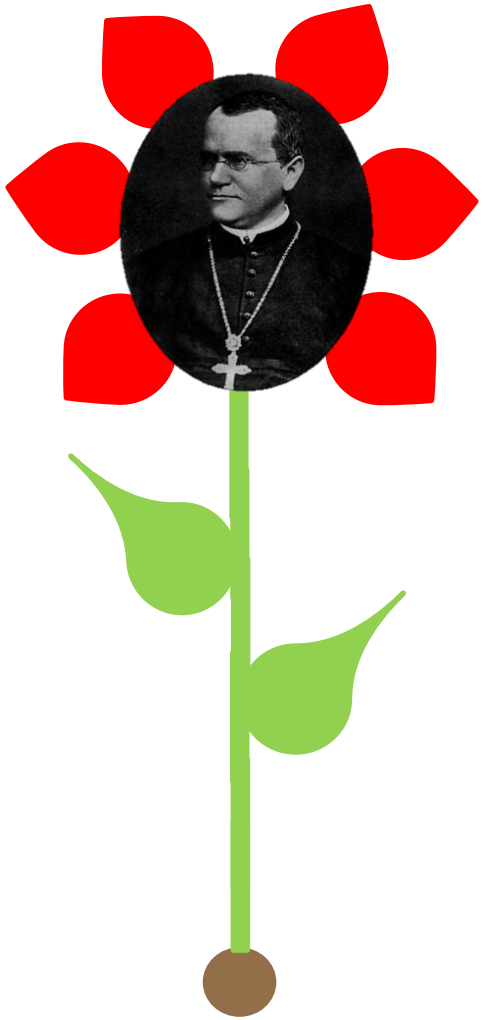
Father of Genetics

Objective: To describe the contributions of Gregor Mendel in the area of genetics

Bell work:

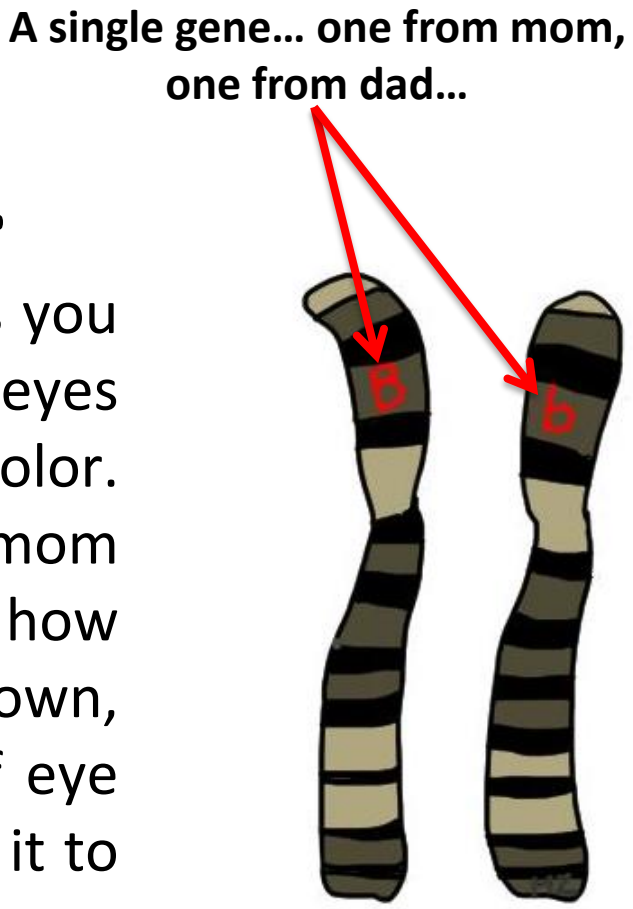
1. Why don't you look like your pet hamster?!

You get your genes from your mom and dad - that's why you look like a combination of them and not your pet hamster. That is, unless your *parents* were hamsters!



It’s all in your genes…

On every gene is the code that provides you with your traits. For example, brown eyes are among the many options for eye color. You receive one half of the code from mom and one half from dad. Depending on how those codes match up, you may have brown, blue, green, or some other variation of eye color. Let’s take this concept and apply it to Gregor Mendel and his famous pea experiments…

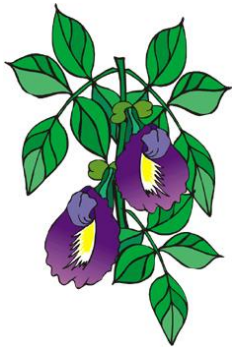
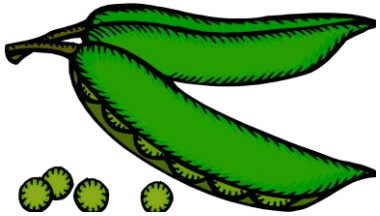
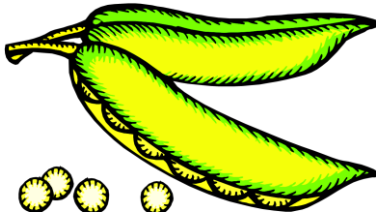


So who was this Mendel guy anyway?

In 1854, a monk named **Gregor Mendel** researched how traits were inherited by plants. At the time, it was believed that offspring would inherit a blending of the traits of each parent. Over 8 years, Mendel studied inheritance by working with **pea plants** because they were easy to breed and because they had a variety of traits.

Give Peas a Chance…

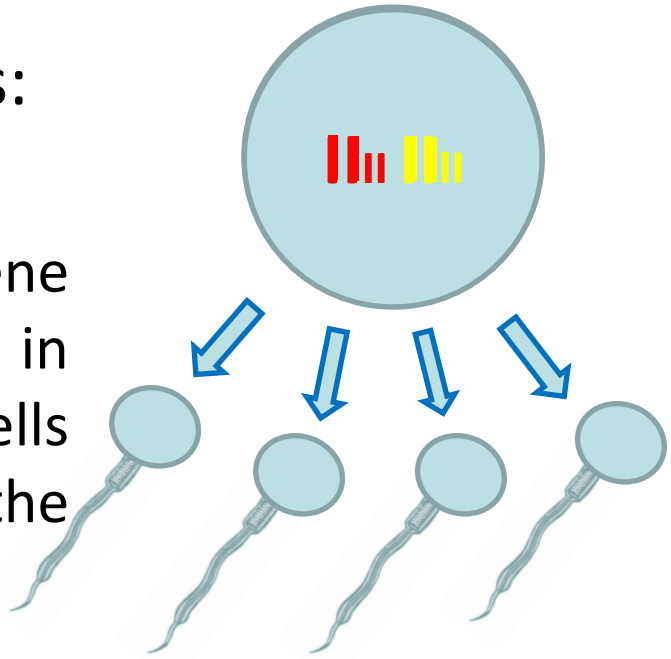
Mendel found in his experiments that the different traits could be:

Dominant		**OR**		**Recessive**
Tall Plant		vs.		Short Plant
Purple Flower		vs.		White Flower
Green pea		vs.		Yellow pea

And there are MANY more traits that pea plants exhibit.

How did Mendel's Work Help Genetics?

Mendel developed the following laws:



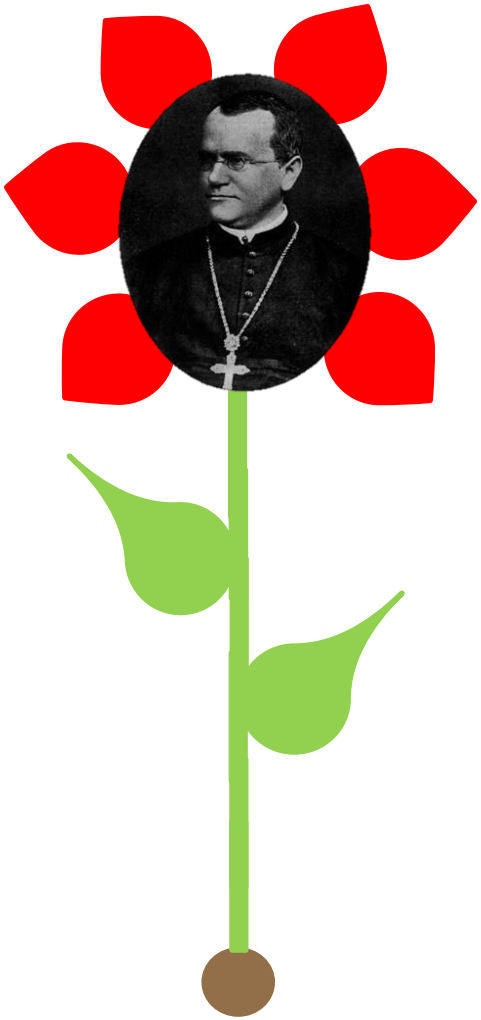
Law of Segregation: The two parts of a gene pair or alleles separate from each other in the formation of sex cells. Half the sex cells carry one allele, and the other half carry the other allele.

Law of Independent Assortment: traits are passed on independently of other traits from parent to offspring.

Help Mendel!

Watch this short and sweet video about our favorite monk.

Think you can recreate Mendel's work? Try your hand at it with this interactive site: Mendel's Web-lab



Let's Put It All Together...

Mendel found in his experiments that the different traits could be:

Dominant OR **Recessive**

Meaning that the dominant trait was the one that **showed up** in the population more often, while the recessive trait **hid** in, or "receded" into, the background. We call those dominant and recessive genes "**alleles**." Depending on how those alleles pair up, you may see the dominant ***or*** the recessive trait.

Dominant alleles are represented with a **capital letter**: B

Recessive alleles are represented with a **lowercase letter**: b

Two of the **same alleles** are considered **homozygous or purebred**: BB, bb

Two **different alleles** are considered **heterozygous or hybrid**: Bb

Putting them together can make several combinations:

BB: homozygous dominant – two dominants = **DOMINANT**

Bb: heterozygous dominant – dominant covers up recessive = **DOMINANT**

bb: homozygous recessive – two recessive = **RECESSIVE**

Let's Put It All Together…

Dominant

TT, Tt

Tall

OR

Recessive

tt

short

The **letter combination** of alleles is called the **genotype**: For example in the tall versus short plant above, if T = dominant, and t = recessive, what would the genotypes be?

The **physical expression** is called the **phenotype**: For example, the phenotype is what we physically "see." So, in the pea plant example above, what would we "see" for the dominant trait? The recessive trait?

Now, let's practice as we learn about Young Rat Love…

Two young rats are in love and want to start a family! Let's see if we can predict what their children will look like.

We'll start by looking at the alleles that control fur color. Keep in mind that a rat has two genes for every trait (one from mom and one from dad), and one of those two genes gets passed along to its offspring. We have a male with the genotype **Aa**, which is the agouti (brown and black mix) phenotype, and the female has the genotype, **aa**, and has a black phenotype. Let's figure out what color fur their offspring might have.

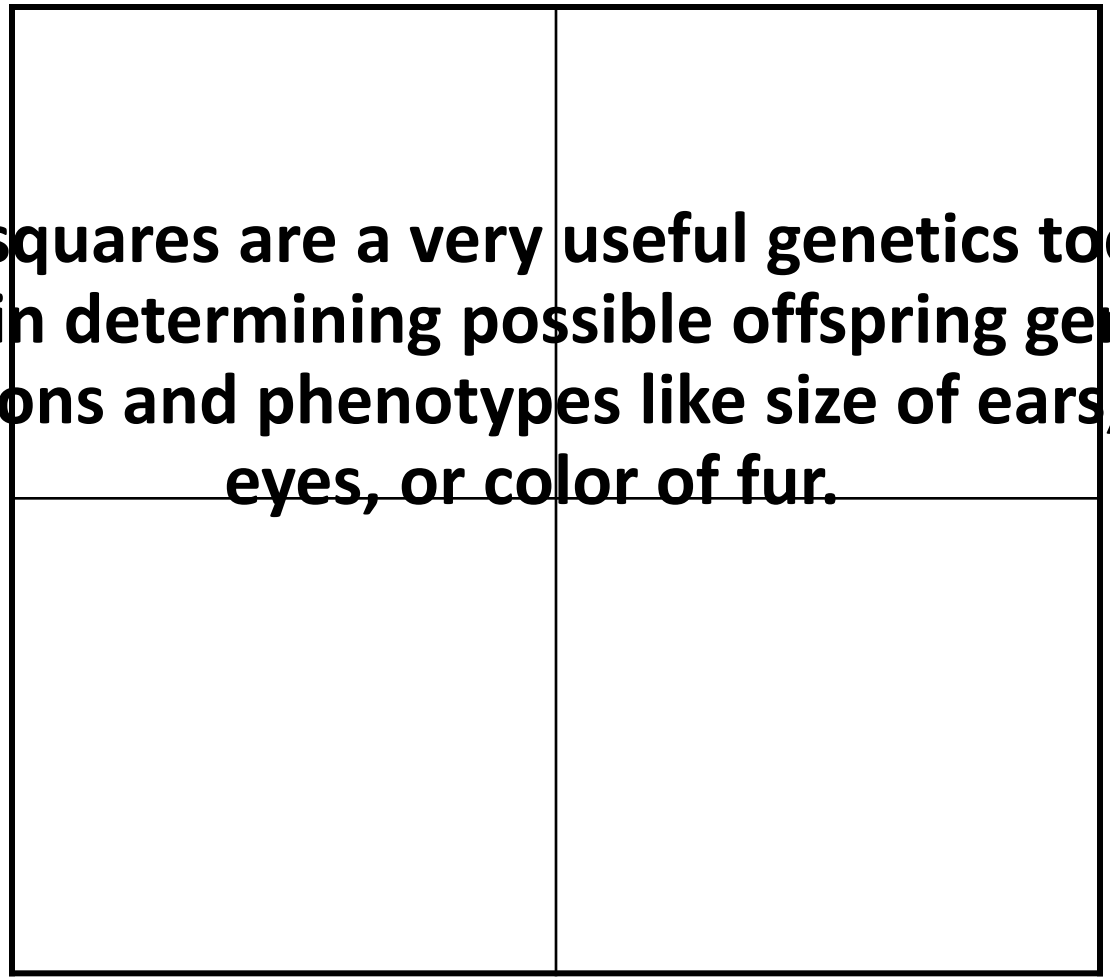
MALE

Genotype: Aa
Phenotype: Agouti

FEMALE

Genotype: aa
Phenotype: Black

We start by creating the box like the following:



Punnett squares are a very useful genetics tool. They help us in determining possible offspring genotype combinations and phenotypes like size of ears, color of eyes, or color of fur.

Now we have all of the possibilities available from this pair of rats. According to the Punnett Square, 2 out of 4 boxes, or 50%, would have the genotype **Aa**, which is the agouti phenotype (remember that the dominant trait covers up the recessive trait when they are together), and 2 out of 4 boxes, or 50%, would have the genotype **aa**, which is the black phenotype.

GENOTYPES:

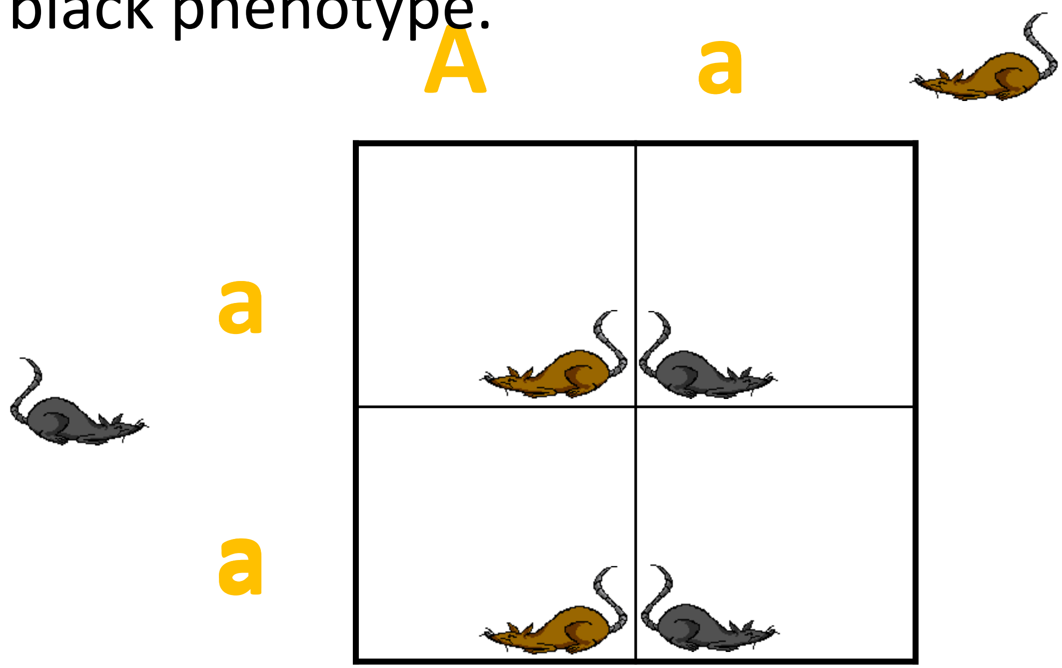
Aa: 50%

aa: 50%

PHENOTYPES:

Agouti: 50%

Black: 50%



Let's practice!

Did you get them right?

Identify whether each is homozygous (purebred) or heterozygous (hybrid):

1. GG - Ho
2. Gg - He
3. gg - Ho
4. Rr - He
5. RR - Ho
6. Aa - He
7. aa - Ho
8. Ss - He
9. LL - Ho
10. rr - Ho

More practice!

Find the probability of offspring for each problem:

11. D = dimples d = no dimples

    A male who is Dd mates with a female who is homozygous recessive for the trait.

a. What is the female's genotype?

dd

b. Complete a punnett square to determine the **probability** that they will produce a child with dimples.

Dimples: DD or Dd

TWO boxes or 50% of children have dimples: Dd

	D	d
d		
d		

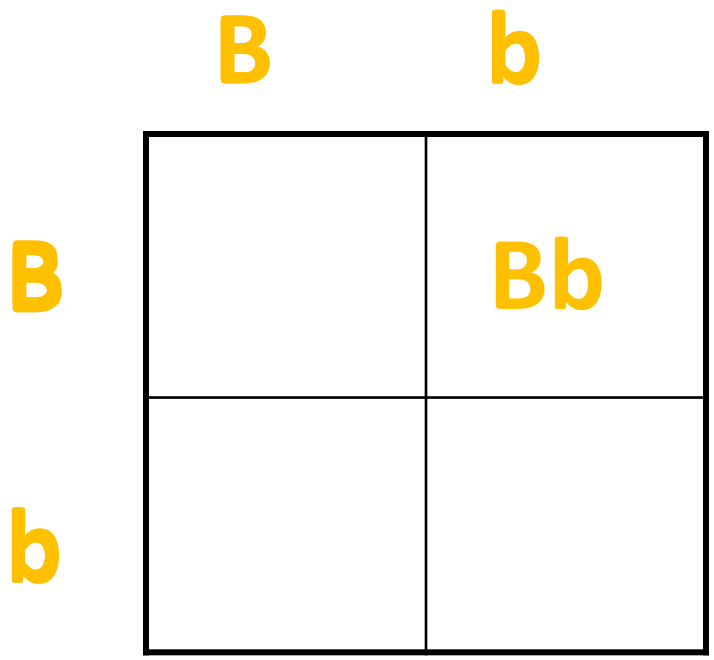
EVEN MORE PRACTICE!!!

12. B = Brown eyes b = blue eyes

A woman that is heterozygous for brown eyes has children with a man who is also heterozygous for brown eyes.

a. Draw a punnett square showing the types of offspring possible for this cross.

b. What is the probability that they would have a child with blue eyes?



Blue eyes = bb = 1/4 boxes = 25%

Squaring it Up

Objective: To determine how traits are passed from parent to offspring

Bell Work:

1. Two short-haired guinea pigs are mated several times. Out of 100 offspring, 25 of them have long hair. What are the probable genotypes of the parents?

25/100 = ¼

Offspring Outcome:

¼ SS ½ Ss ¼ ss = short

Ss _____ X _____ **Ss**

Try your hand at these Punnett Squares and see if you can "Square It Up!"

You're Such a Square!

Objective: To determine the probability of inheriting a trait

Bell work:

1. What do each of the four boxes represent in a Punnett Square?

Four possible offspring that a breeding pair can have. Each square equals 25% of the total.

You're Such a Square… Or Are You?

Let's see how many of these Punnett Squares you can complete correctly…

Phenylthiocarbamide Says WHAT?!

Objective: To determine if you are a Taster or Non-Taster and then apply that information to predicting the possible genotypes and phenotypes for your parents.

Hypothesis: Hypothesize as to whether you think you will be a Taster or a Non-Taster.

Phenylthiocarbamide Says WHAT?!

Have you ever wondered why your hair is so straight? How you got your cute freckles or your beautiful brown eyes? You get those traits from your parents! But did you know that some traits CAN'T be seen? In this lab, you'll determine if you have a trait that can be TASTED! Then, trace it through your family to determine if your parents have the same trait you do.

Here's What You'll Need to Conduct This Experiment:

One Phenylthiocarbamide (PTC) paper test strip

Background:

Phenylthiocarbamide is a chemical that is used to test for a genetic trait. PTC paper determines if someone is a Taster (can taste PTC) or a Non-taster (cannot taste PTC). The trait for tasting and not tasting is passed in the DNA from parent to child.

What You Do:

1. Remove food items from your mouth
2. Place the piece of PTC testing paper on your tongue and close your mouth.

Don't YELL OUT LOUD what you think the paper tastes like – you might affect someone else's data!

3. Describe what the paper tastes like: **Write your response on your paper – please be specific in your description!**
4. Based on your results from #3, are you a Taster or a Non-taster?

Write your response on your paper

Data and Observations:

How many students in the class tasted PTC?

Raise your hand if you tasted the PTC

How many students in the class could not taste PTC?

Raise your hand if you could not taste the PTC

Create a bar graph of the class results for the PTC test.

- Create a title for your graph

  Based on what we are testing, what do you think the title should be?

- On the x-axis you will put the two categories:

  <u>Tasters & Non-tasters</u>

- On the y-axis you will put the:

  <u>Number of students</u>

Make sure that your scale spans the length of the graph so you use as much of it as possible.

TITLE:_____

The Results: What Happened?

4. Based on the graph above, do you think that PTC tasting is dominant or recessive for your class? Explain your answer.

PTC tasting is a dominant trait because more individuals in the classroom are tasters vs. non-tasters. Dominant traits occur more likely in populations than recessive traits because dominant traits can take on two genotypic forms: homozygous dominant and heterzygous, whereas recessive traits require two recessive alleles to present itself phenotypically.

5. To complete a Punnett square for PTC tasting, what letters should we use to represent Tasters and Non-tasters?

Taster: T

Non-taster: t

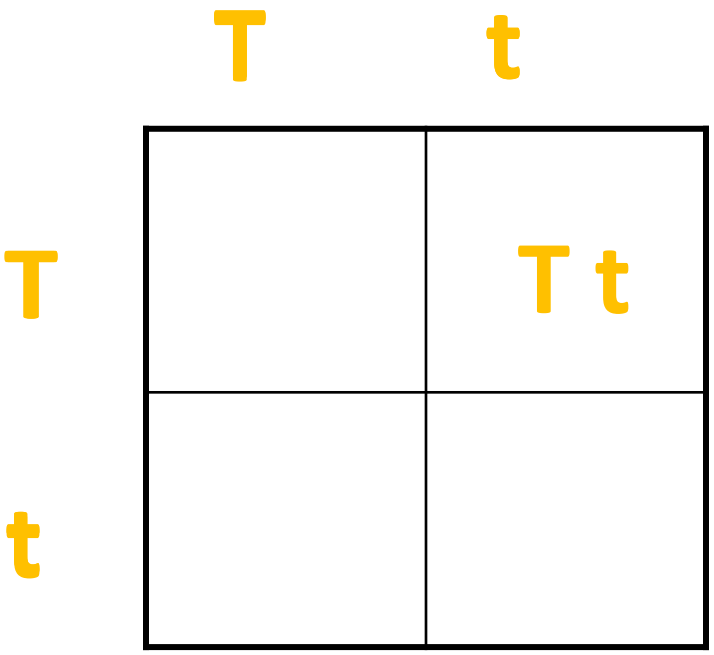
6. Complete a Punnett square for a cross between two parents who are both heterozygous for tasting PTC.

What is the genotype for Parent #1?

Tt

What is the genotype for Parent #2?

Tt



Answer the following questions using the results from the Punnett square

7. What are the possible genotypes for their children?

TT, Tt, tt

8. What is the ratio of genotypes for their children?

1 TT : 2 Tt : 1 tt = 1 : 2 : 1

9. What are the possible phenotypes for their children?

TT= Taster; Tt= Taster; tt= Non-taster

10. What is the ratio of phenotypes for their children?

3 Tasters : 1 Non-taster = 3 : 1

11. What is YOUR phenotype?

Are you a Taster or a Non-Taster?

Extension:

12. What is YOUR genotype? (Note: If you are a taster, you cannot determine your exact genotype so you must use "T _" to indicate that the second allele is unknown.)

Tasters = T _ Non-taster = tt

13. Given your genotype from #12, what genotypes are possible for your parents?

For Tasters T _ = TTxTT; TTxTt; TTxtt; TtxTt; Ttxtt

For Non-tasters tt = TtxTt; Ttxtt; ttxtt

14. Given the genotypes in #13, what phenotypes are possible for your parents?

For Tasters = Taster x Taster (TTxTT; TTxTt; TtxTt), Taster x Non-taster (TTxtt; Ttxtt)

For Non-tasters = Taster x Taster (TtxTt), Taster x Non-taster (Ttxtt), Non-taster x Non-taster (ttxtt)

Extension: *(continued…)*

15. If you are a Taster, do both of your parents have to be Tasters? Explain using the answers you provided in questions 13 and 14.

No, only one of your parents needs to be a Taster because the dominant trait is expressed even when crossed with a Non-taster parent.

16. If you are a Non-taster, is it possible that both of your parents could be Tasters? Explain using the answers you provided in questions 13 and 14.

Yes, both parents can be Tasters. They would have to be heterozygous for the trait and would have a 25% chance of having a Non-taster child.

Extension:

17. *Partner up with a student in the classroom. Pretend that you have offspring with your partner and complete the following using your genotype given in #12 above:*

List all of your possible crosses Ex: Tt (you) x Tt (partner)

What did YOU find?

18. List all of the possible phenotypes of your OFFSPRING given the crosses from #17 above. Draw your own Punnett Squares below.

What did YOU find?

Yellow and Blue Make…?

Objective: To understand other inheritance patterns

Bell work:

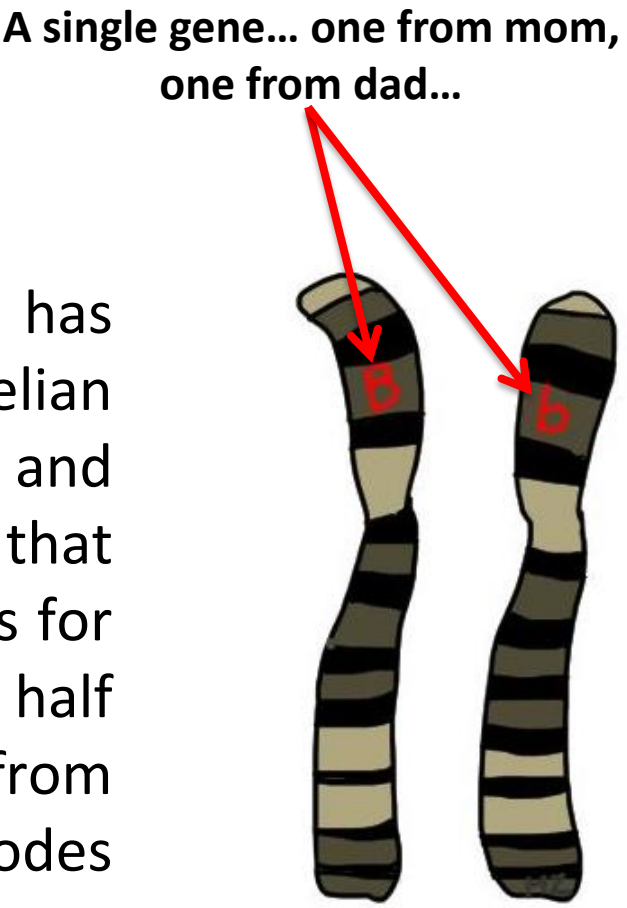
A man with straight hair marries a woman with curly hair. They have a child with wavy hair. How do you explain this?

Some traits are not determined by simple dominant-recessive relationships but instead blend together. Let's learn about it!

INCOMPLETE DOMINANCE,
CODOMINANCE,
MULTIPLE ALLELES
& POLYGENIC INHERITANCE

It’s all in your genes…

So, everything we have studied so far has been applied to the simple Medelian genetics principles of dominant and recessive traits. We already mentioned that brown eyes are among the many options for eye color. Remember, you receive one half of the code from mom and one half from dad and depending on how those codes match up, you may have brown, blue, green, or some other variation of eye color. How does that happen?



A Little Review…

Mendel found in his experiments that the different traits could be:

Dominant **OR** **Recessive**

TT, Tt Tall Plant  vs.  Short Plant **tt**

Meaning that when there are two alleles present in the **HETEROZYGOUS** state, the **DOMINANT** trait tends to **COVER** up the **RECESSIVE** trait.

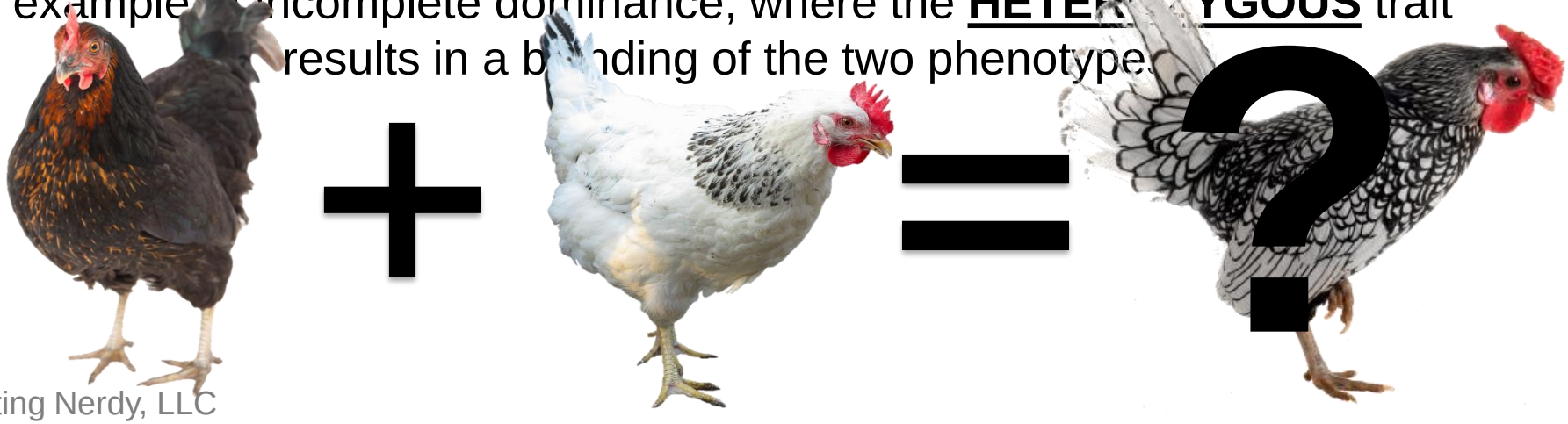
Mendelian genetics is GREAT, but how do you explain how you have green eyes when mom has brown and dad has blue? What about your brother's wavy hair when everyone in your family has curly hair, except mom, who has straight hair?

Let's find out…

INCOMPLETE DOMINANCE: WHEN DOMINANT & RECESSIVE TRAITS ARE COMBINED IN THE HETEROZYGOUS STATE AND RESULT IN A BLENDING OF THE TRAITS

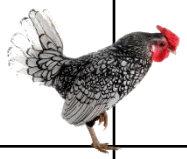
Parents have only two alleles, and often times, inheriting those traits may result in a blending of traits. In Incomplete dominance, neither the dominant or recessive is shown, but instead they blend together to create an entirely different phenotype.

Let's say a **black** Andalusian chicken and a **white** Andalusian Chicken mate, creating a clutch of eggs that are all **blue chicks**. This is an example of incomplete dominance, where the **HETEROZYGOUS** trait results in a blending of the two phenotypes.



Incomplete Dominance

Let's complete a Punnett Square to see how all of this works:

	B	B
W		
W		

BW = blue

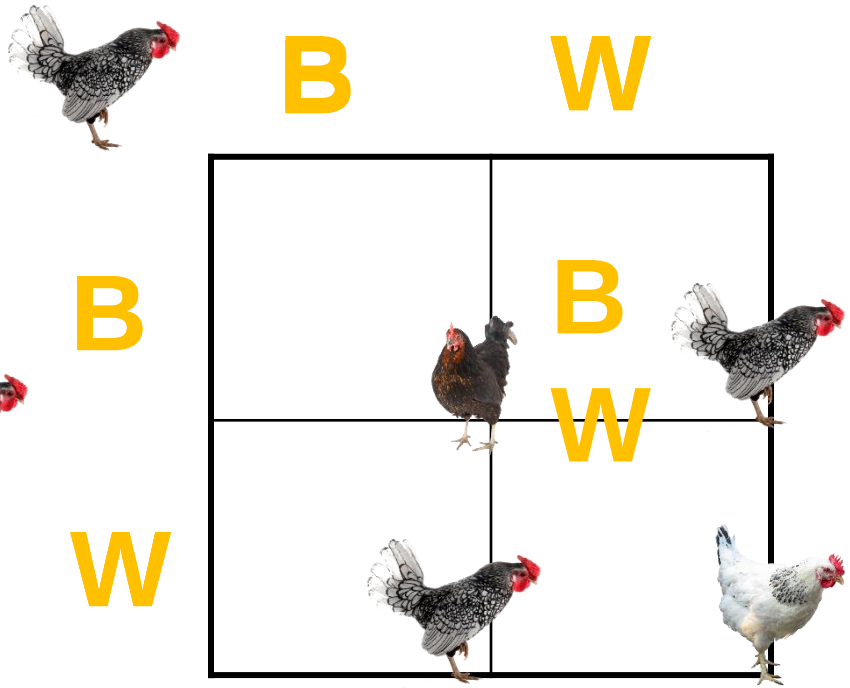
Because of Incomplete Dominance, all of the offspring will be blue.

+

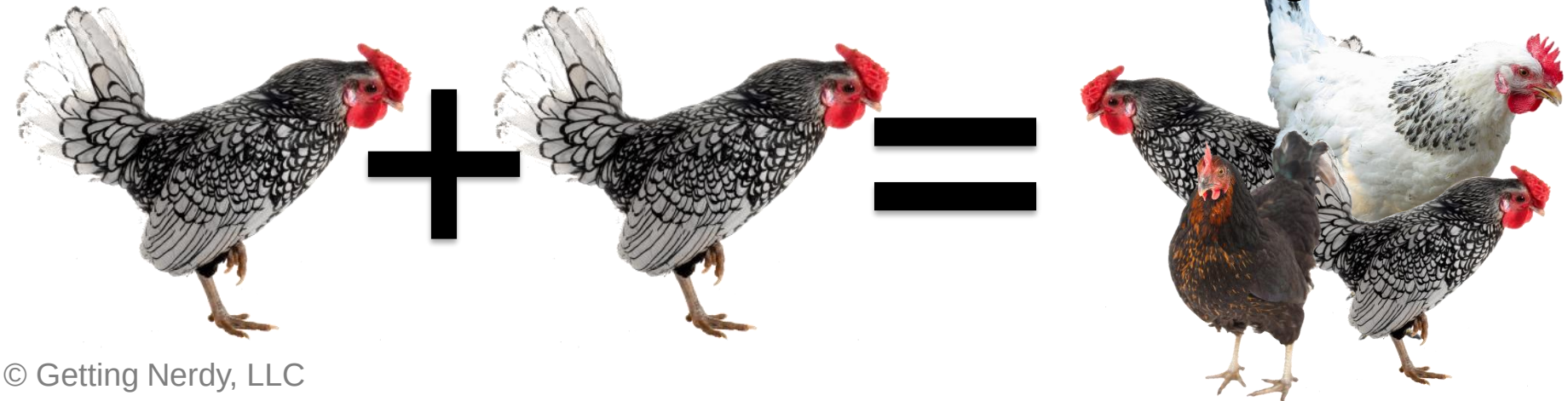
=

Incomplete Dominance

What if we cross our **blue** chicken with another **blue** chicken?



Here we see a variety of traits, where the homozygous genotypes result in the black and white phenotypes again…



CODOMINANCE: WHEN DOMINANT & RECESSIVE TRAITS ARE COMBINED IN THE HETEROZYGOUS STATE AND RESULT IN BOTH TRAITS BEING EXPRESSED

Similar to our dog breeding example from before, **codominance** is expressed in the heterozygous form. In this example, let's use two peonies, one that is **white**, the other **peach**. When crossed together, the **HETEROZYGOUS** trait results in the expression of both phenotypes, a **white & peach** peony.

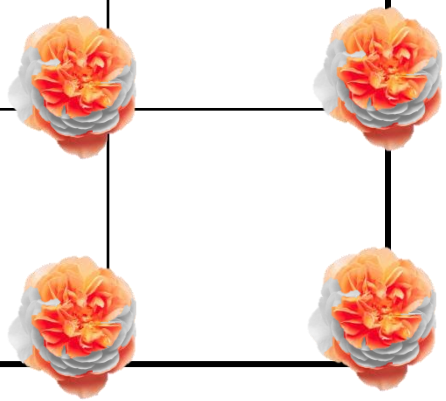
CODOMINANCE

Let's complete a Punnett Square to see how all of this works:

P P

W

W



Codominance results in a white and peach phenotype expression in all of the offspring

PW = peach and white

+

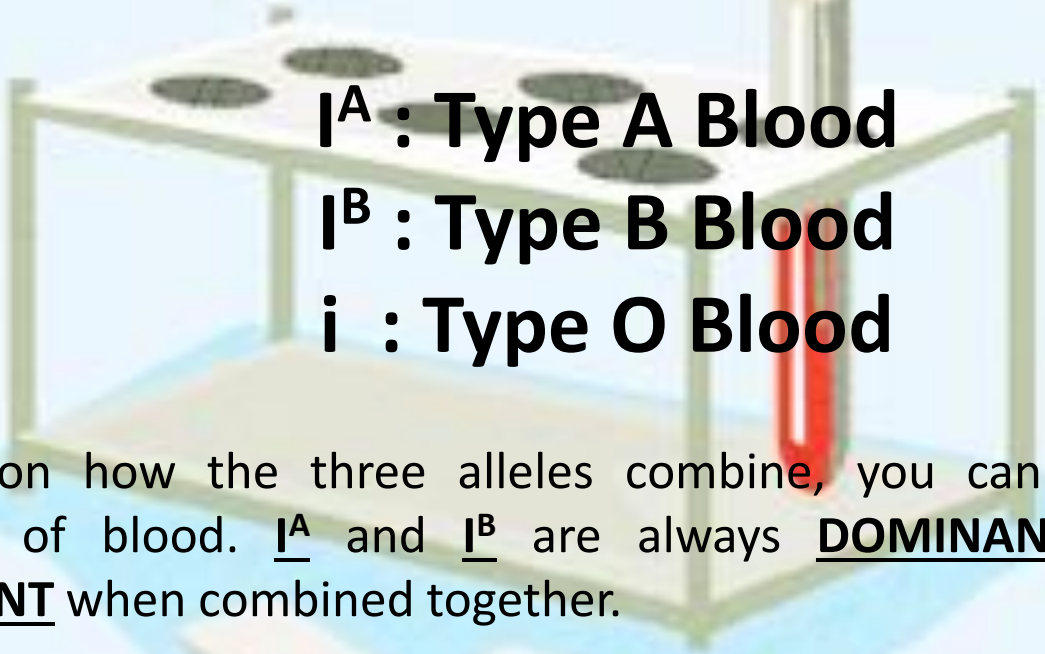
=

MULTIPLE ALLELES: WHEN THERE ARE MORE THAN TWO ALLELES FOR A SPECIFIC TRAIT

Remember that parents only have two alleles they can pass on to their offspring. However, when ***4 or more*** **phenotypes** exist in a population, then there must be several different alleles (more than 2) to choose from. The classic example we use in biology is Blood Type.

Multiple Alleles

There are 4 phenotypes for human blood: **A, B, AB, and O.** There are three alleles that you can possibly inherit from your parents.



I^A : Type A Blood

I^B : Type B Blood

i : Type O Blood

Depending on how the three alleles combine, you can have one of four phenotypes of blood. I^A and I^B are always **DOMINANT** over **i**, but are **CODOMINANT** when combined together.

$I^A I^A$, I^A i : Type A Blood

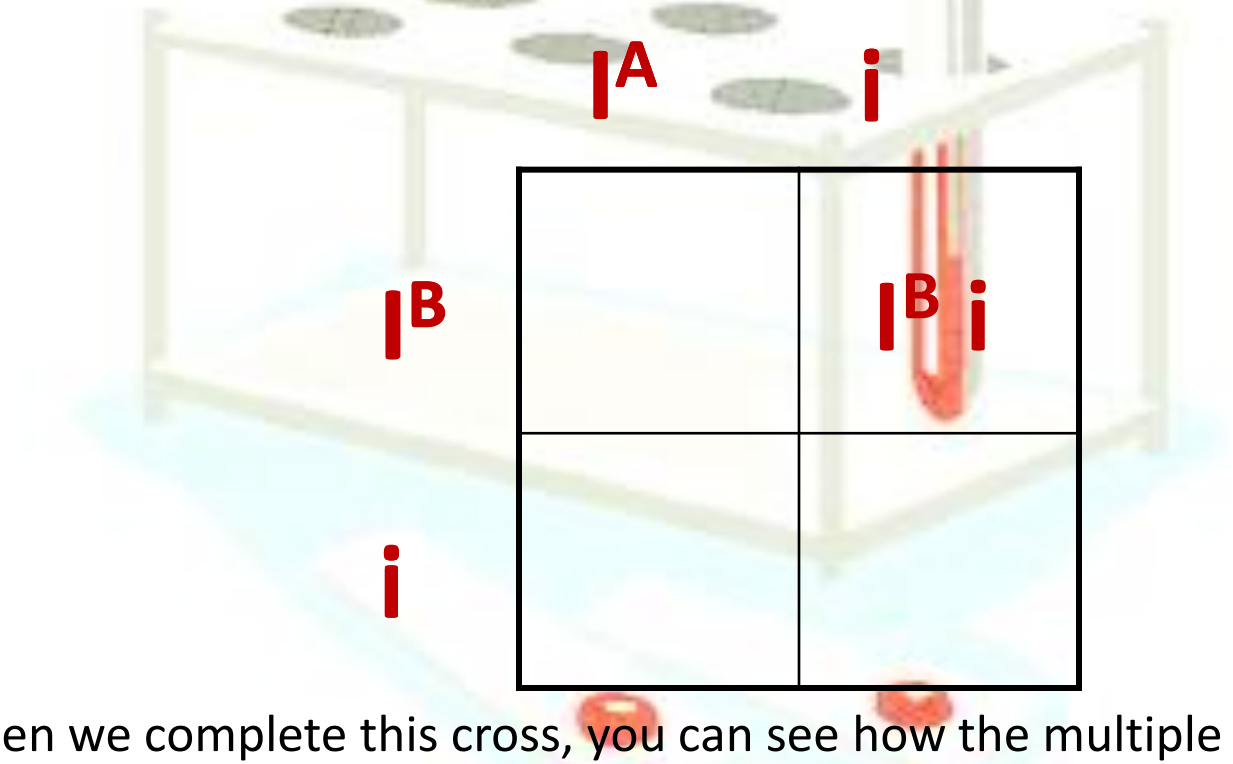
$I^B I^B$, I^B i : Type B Blood

$I^A I^B$: Type AB Blood

i i : Type O Blood

Multiple Alleles

Let's look at a Punnett Square to see how blood type is inherited:
Let's cross two individuals, one who is **HETEROZYGOUS** for **Type A Blood** and another who is **HETEROZYGOUS** for **Type B Blood**



When we complete this cross, you can see how the multiple alleles result in several phenotypes. The **DOMINANT** I^A and I^B win out over the **RECESSIVE** **i** resulting in the **Type A and Type B Blood.** We see **CODOMINANCE** occur when I^A and I^B combine, resulting in **Type AB Blood.** And the **RECESSIVE** **i** combines with it's buddy to form **Type O Blood.**

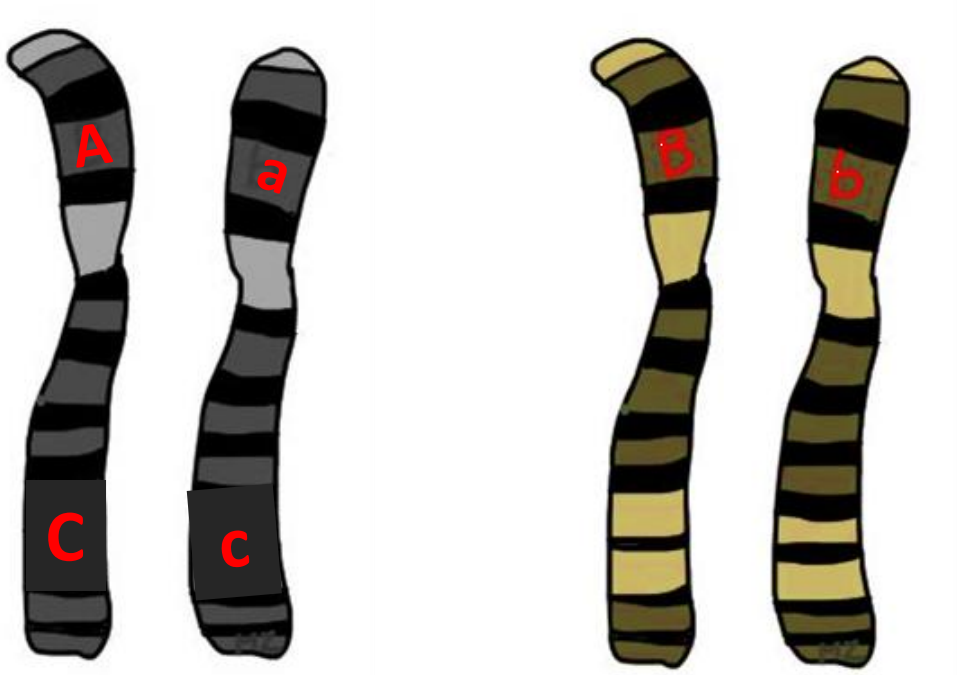
Polygenic Inheritance: when a trait is controlled by more than one (Poly=many) gene

Sometimes, more than one gene may control the expression of a trait or characteristic. Eye, hair and skin color, as well as body shape and height are all examples of polygenic inheritance that occurs in humans.

Eye color is controlled by three different genes, 2 of which are on one chromosome, and the 3rd on a second chromosome. This results in 6 alleles that control what color your eyes are, from light blue to dark brown, depending on how those alleles are combined.

POLYGENIC INHERITANCE

Since six different alleles may control eye color, the combination of alleles from each gene may look something like this (for our purposes, we are simplifying this cross using **Aa**, **Bb** and **Cc** as our alleles):



Remember that you only get one of each chromosome from each parent, so you may get a dominant or recessive trait from each gene.

Let's pretend that two people mate with the genotypes **AaBbCc x AaBbCc**

What sort of genotype combinations can results from this breeding pair?

Polygenic Inheritance

Depending on the number of **DOMINANT** genes you inherit, you can have very dark eyes (**SIX DOMINANTS**) or very light eyes (**SIX RECESSIVES**). Variations in between would result in intermediate hues. This concept applies to height, sizes, shapes, and colors of many other traits as well!

When we cross **AaBbCc x AaBbCc**, the results of the general population look like a bell curve, with lots of variety within the offspring genotypes and phenotypes!

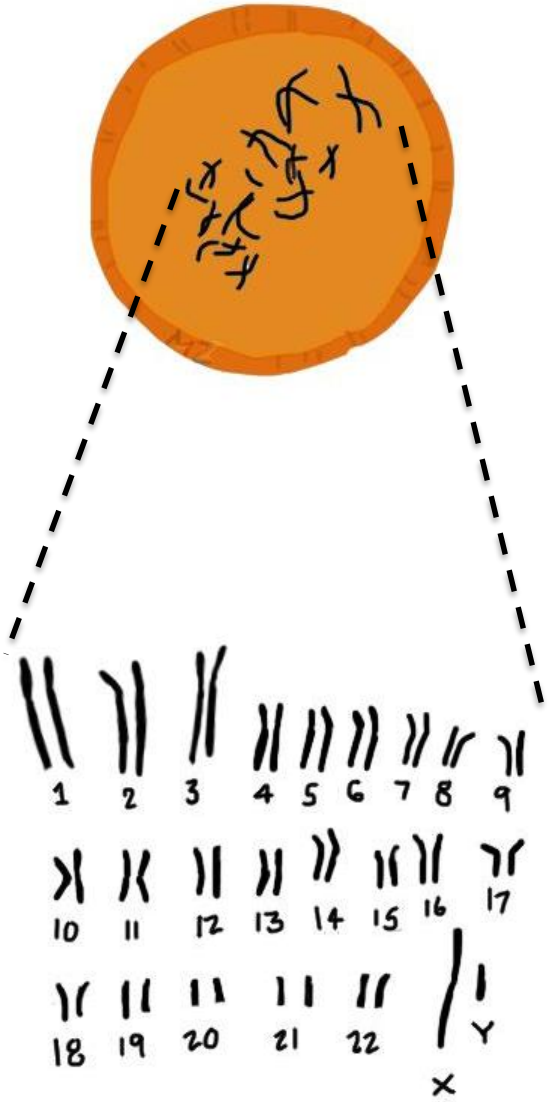
This example of Polygenic Inheritance is a challenging one, but it demonstrates how this type of inheritance can result in so many phenotypes within a population. Keep mind, however, that environmental factors such as diet and other conditions can affect whether these traits are fully expressed. For example, you may not reach your full height if you are malnourished.

	ABC	**ABc**	**AbC**	**aBC**	**abC**	**aBc**	**Abc**	**abc**
ABC	AABBCC	AABBCc	AABbCC	AaBBCC	AaBbCC	AaBBCc	AABbCc	AaBbCc
ABc	AABBCc	AABBcc	AABbCc	AaBBCc	AaBbCc	AaBBcc	AABbcc	AaBbcc
AbC	AABbCC	AABbCc	AAbbCC	AaBbCC	AabbCC	AaBbCc	AAbbCc	AabbCc
aBC	AaBBCC	AaBBCc	AaBbCC	aaBBCc	aaBbCC	aaBBCc	AaBbCc	aaBbCc
abC	AaBbCC	AaBbCc	AabbCC	aaBbCC	aabbCC	aaBbCc	AabbCc	aabbCc
aBc	AaBBCc	AaBBcc	AaBbCc	aaBBCc	aaBbCc	aaBBcc	AaBbcc	aaBbcc
Abc	AABbCc	AABbcc	AAbbCc	AaBbCc	AabbCc	AaBbcc	AAbbcc	Aabbcc
abc	AaBbCc	AaBbcc	AabbCc	aaBbCc	aabbCc	aaBbcc	Aabbcc	aabbcc

So what does this all mean anyway?

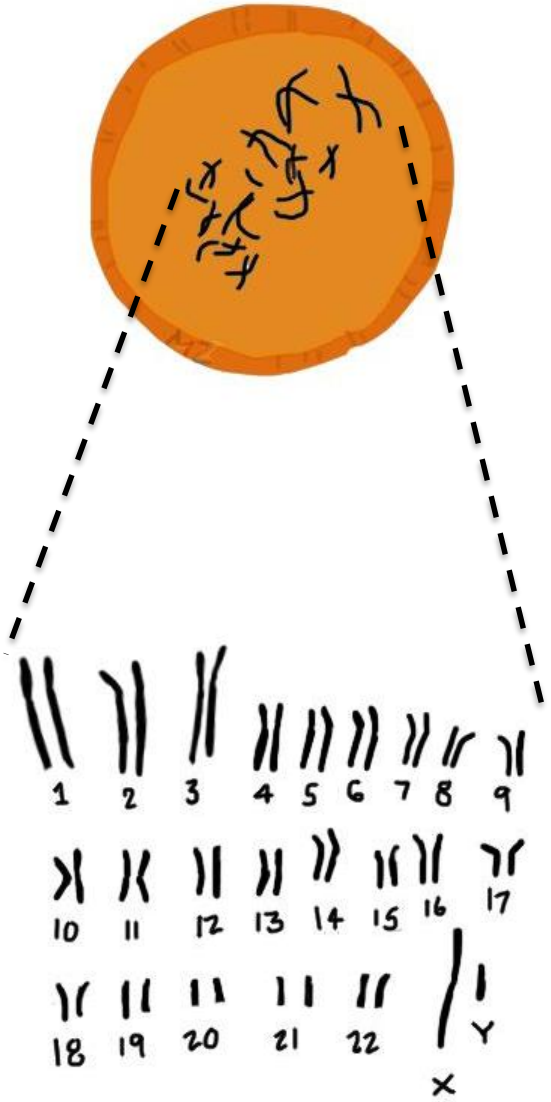
- You have 23 pairs of chromosomes, located in every cell of your body
- The genes on your chromosomes control what your traits "look like" through phenotype expression
- Some traits follow simple dominant/recessive relationships.
- Some traits are more complex, combining to form completely new phenotypes or show both the dominant and recessive traits in the phenotype
- Other traits require the help of multiple genes in order to fully express the phenotype

That's why we share so many similar characteristics yet are separated by many subtle differences!



Let's Put It All Together…

Now try your hand at some Punnett Square practice with these special types of inheritance.



A Twisted Tale…

Objective: To determine how traits are passed from parent to offspring

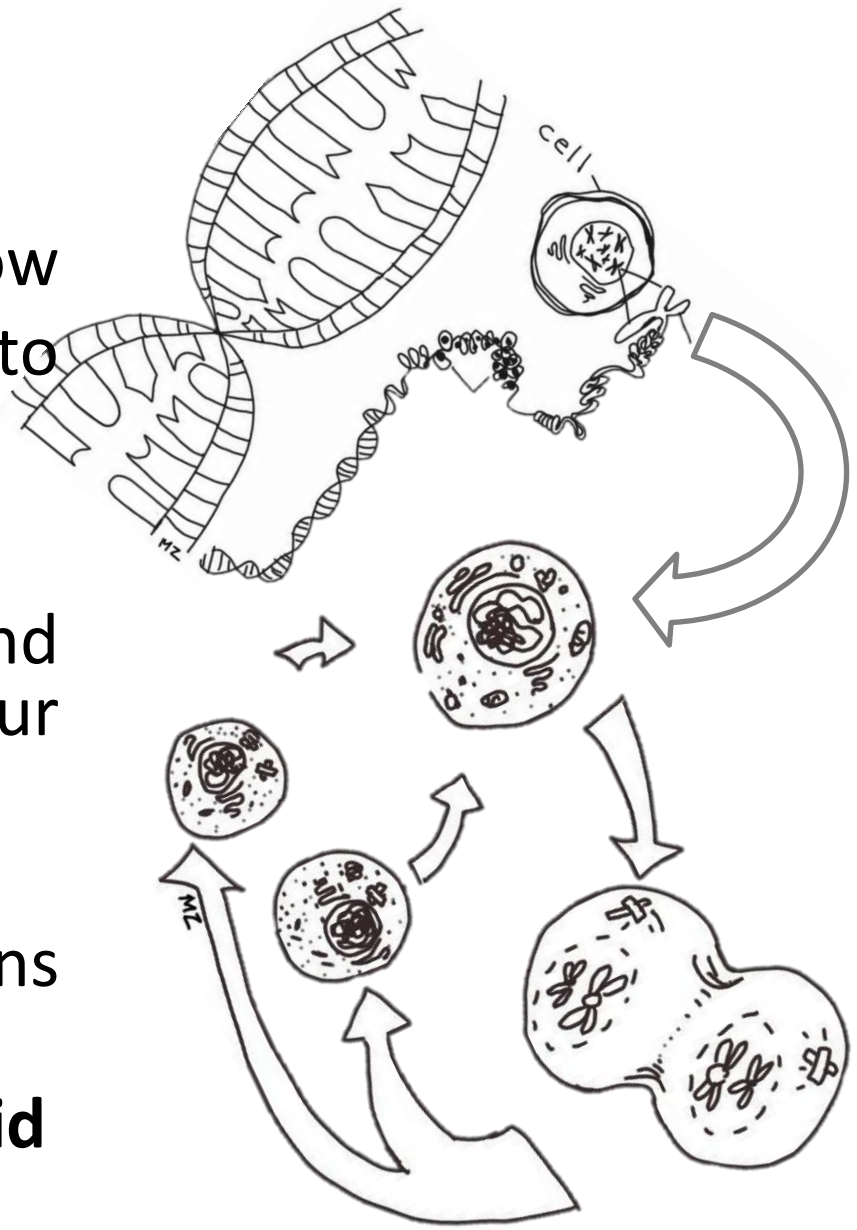
Bell work:

1. In what organelle do we find the instructions for our traits?

   Nucleus

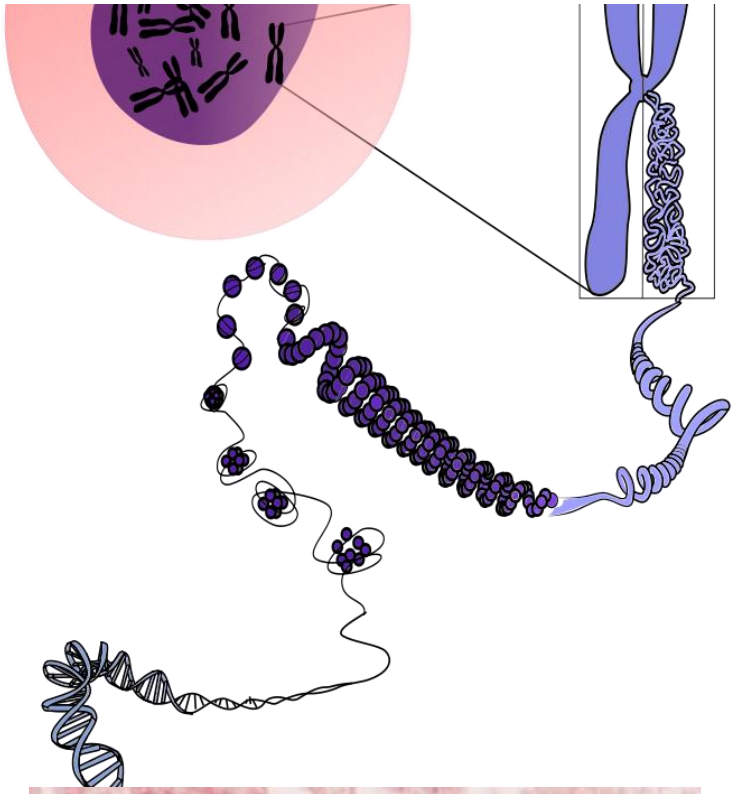
2. What are those instructions called?

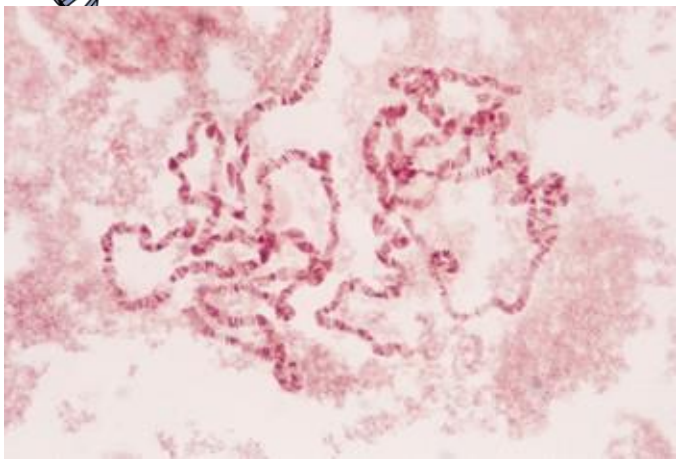
   DNA: Deoxyribonucleic acid



Let's start at the source…

DNA, or deoxyribonucleic acid, resides inside the **nucleus** of every living cell. It was discovered in 1869 but the structure remained a mystery. In 1952, using X-ray photography, Rosalind **Franklin** observed DNA, but could not identify the shape. A year later, Francis **Crick** and James **Watson** used her images to describe the twisted ladder or **DOUBLE HELIX** structure of DNA.



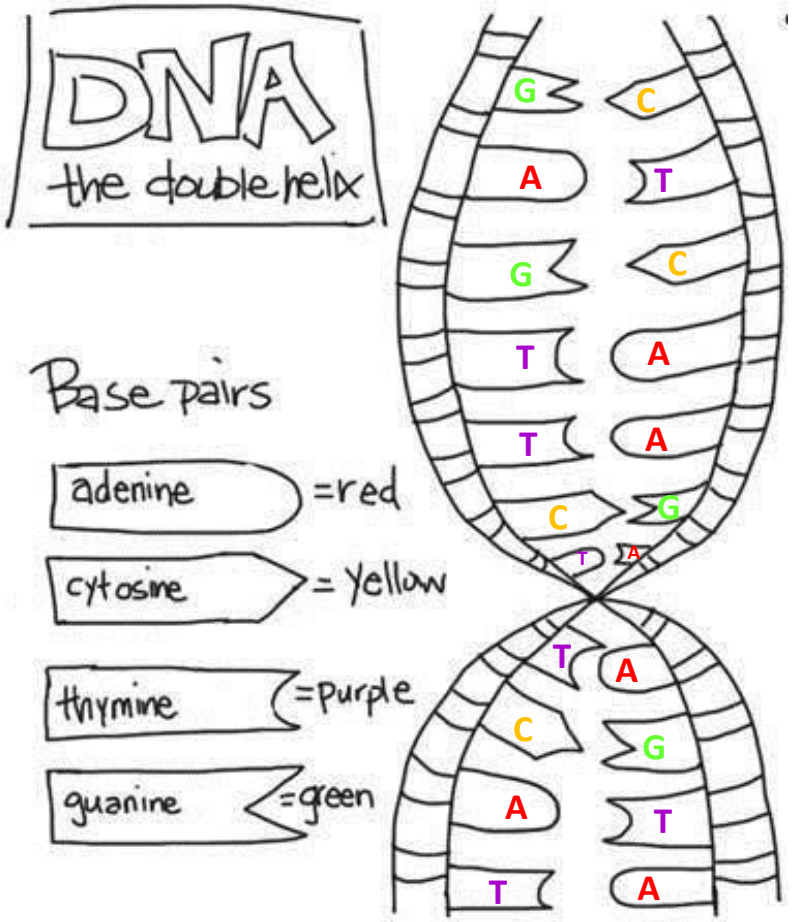


The **steps** of the ladder are made up of pairs of molecules called **nitrogen bases**.

There are 4 kinds: Adenine, Thymine, Cytosine, & Guanine

ADENINE ONLY pairs with **THYMINE**

CYTOSINE ONLY pairs with **GUANINE**



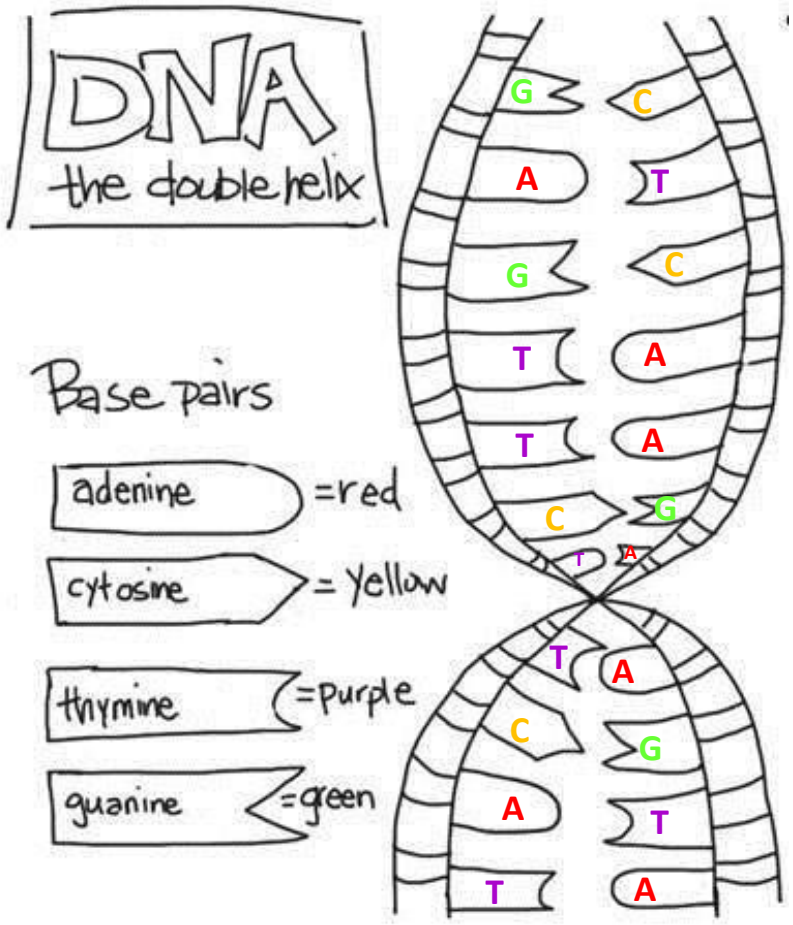
In 1950, Erwin **Chargraff** analyzed the base pair composition of DNA. He discovered that:

% **ADENINE** = % **THYMINE**

AND

% **CYTOSINE** = % **GUANINE**

Meaning, there is the **same amount** of Adenine and Thymine and the **same amount** of Cytosine and Guanine, providing evidence that they pair with one another.



We go together like peas and carrots!

Use the rules of base-pairing to make a strand of DNA by writing the correct base in the top row to match the base provided in the bottom row:

New DNA strand

C	G	T	T	A	G	C	T	T	C	G	G	A	T	A	A	C	T	G
G	C	A	A	T	C	G	A	A	G	C	C	T	A	T	T	G	A	C

Original DNA strand

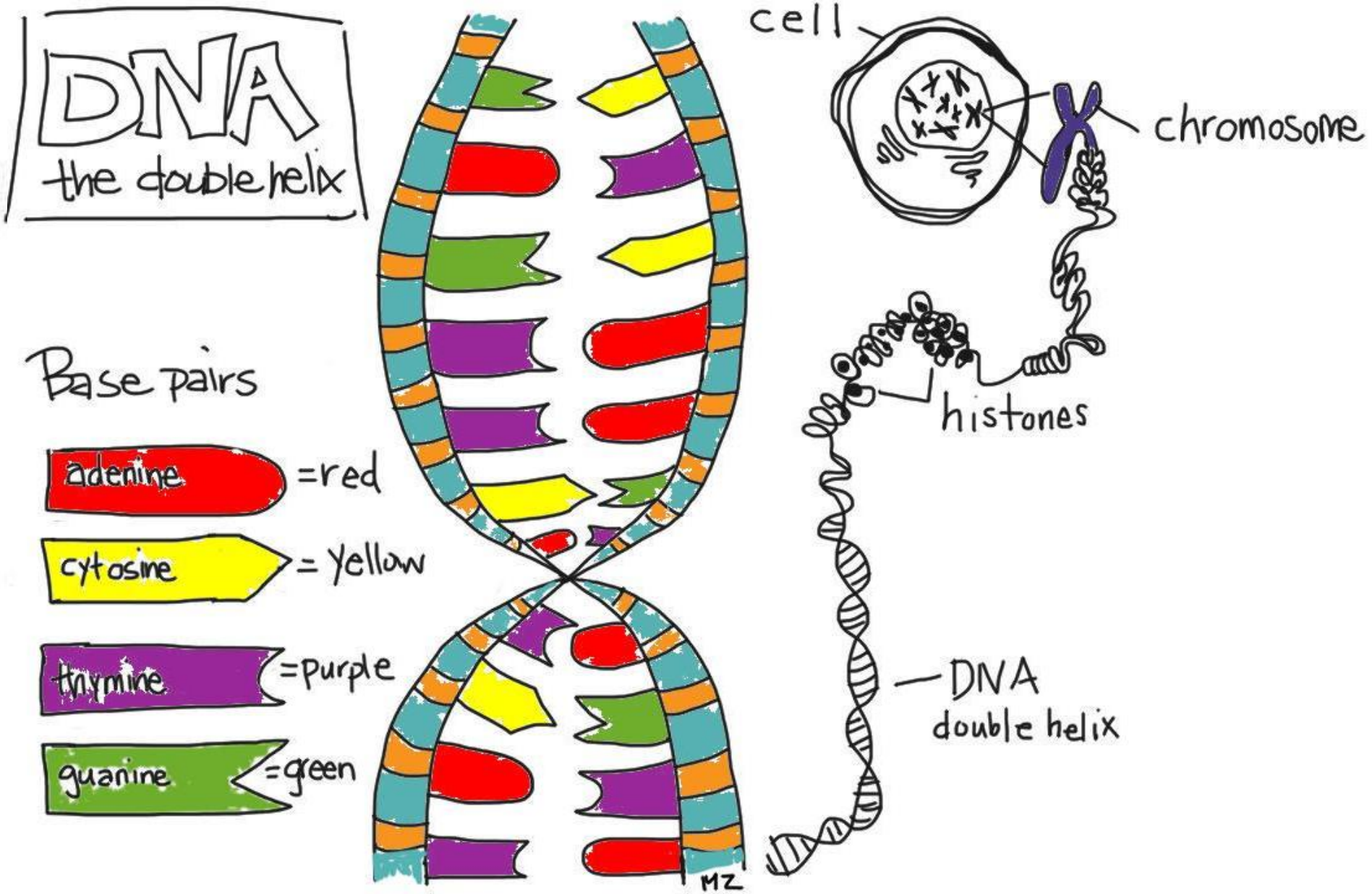
We go together like peas and carrots!

Can you make another?

New DNA strand

G	C	A	A	T	C	G	T	C	A	A	T	G	C	G	A	T	C	C
C	G	T	T	A	G	C	A	G	T	T	A	C	G	C	T	A	G	G

Original DNA strand



Now color your DNA double helix using the base pair color key. Color the sides of the ladder in any colors you choose.

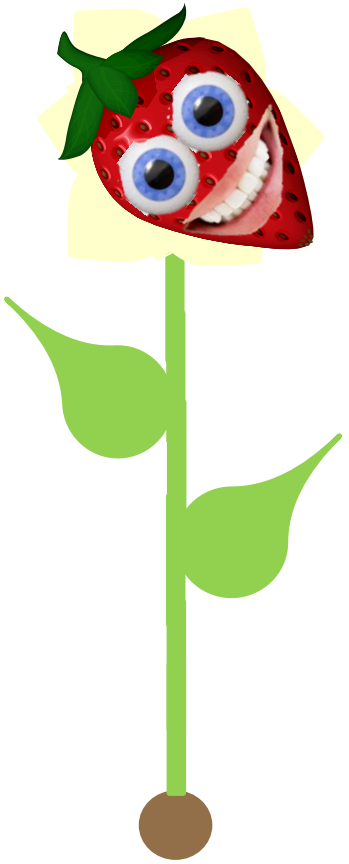
How did you do?

My Fruit is Alive…?

Objective: To extract DNA from fruit

Hypothesis: What do you think DNA will look like to the naked eye?

Background Information: Strawberries are alive? Yep, you'd better believe it. Think about it… a plant starts from a seed. It sprouts from the ground as a spindly, pale green stick. Then, it grows leaves as cells quickly multiply into hundreds, then thousands, and then hundreds of thousands of cells, and eventually creates a tiny white flower that blooms, gets pollinated and turns into a strawberry. You pick it. You eat it. If your fruit comes from cells… it's alive.



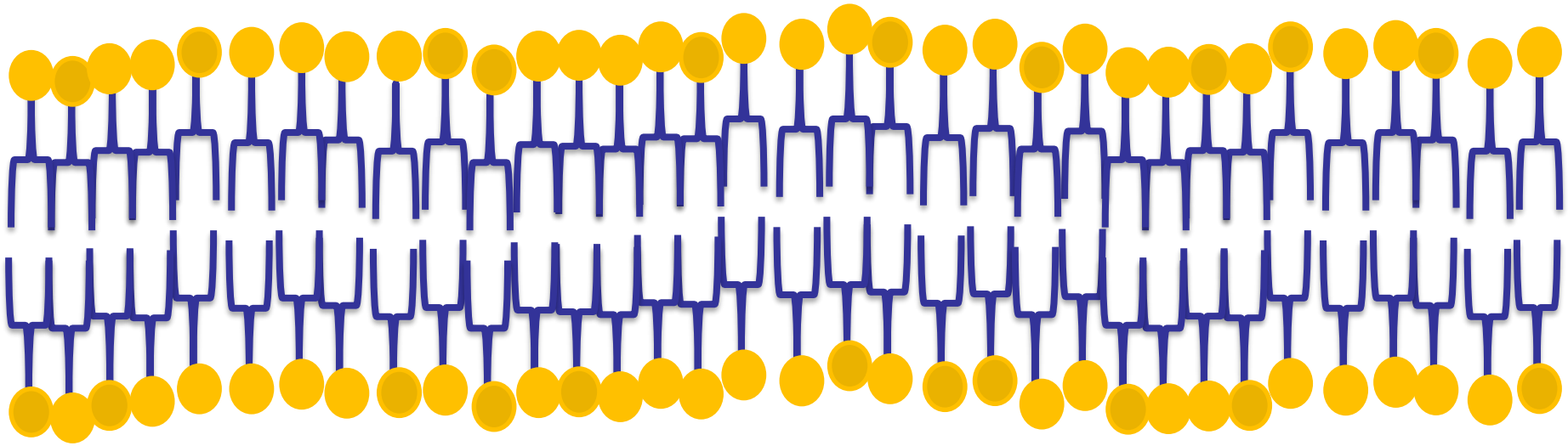
Before You Begin:

1. Where is DNA located within a cell?

Inside the nucleus

2. The cell membrane is a phospholipid bilayer. What are lipids?

Fats



My Fruit is Alive…?

Here's what you'll need to conduct this experiment:

A group of 2-4 people

¼ cup of fruit (strawberries, kiwi, banana)

Ziploc bag

10 mL extraction buffer

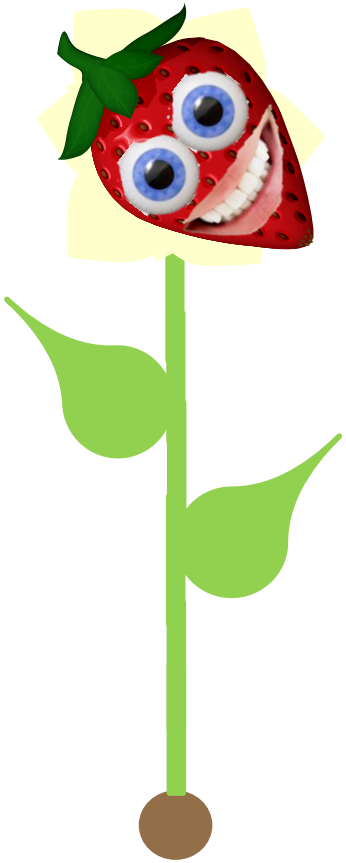
Small coffee filter

Small funnel

Test tube with a rack

20 mL 90-100% Isopropyl Alcohol (VERY COLD)

Wooden Skewer



My Fruit is Alive…?

What You Do:

1. Place your fruit into a Ziploc ™ Bag and seal it shut
2. Have one member of your group gently smash your fruit for a few minutes inside the baggie. It should be completely pulverized.
3. Add 10 ml Extraction Buffer and mix it with the fruit. Avoid making a lot of soap bubbles if possible.
4. Place the coffee filter in the funnel and place the funnel in the top of the test tube in the test tube rack.
5. Open the Ziploc ™ bag and pour your extract through the filter.
6. Remove the filter and gently squeeze any excess liquid out of the filter into the funnel, capturing it in the test tube. You should have approximately 5 mL of liquid in the test tube.

My Fruit is Alive…?

What You Do: *(continued…)*

7. Add 20 mL of ice cold isopropyl alcohol to the liquid in the test tube. Be sure to pour the alcohol carefully down the side of the tube so that it forms a separate layer on top of the fruit liquid.
8. Observe the liquids for about a minute and record your observations in your chart.
9. Insert the wooden skewer and stir in the tangle of DNA, wrapping the DNA around the stirrer.
10. Gently lift the skewer out of the solution to view the DNA as it hangs from the skewer. You can transfer the DNA to a piece of saran wrap or a clean tube.
11. To view the DNA specimen under a microscope, place the glob on a clean slide and gently stretch the DNA apart using two toothpicks or dissecting pins. The fibers will be easiest to view in the stretched area.

What Happened? The Results:

1. Think about what soap does for your dishes. What do you think the purpose of the soap is in this experiment?

The soap breaks apart the cell and nuclear membranes which are both made of fats. This releases the DNA into solution.

2. Describe the structure of DNA as it exists inside the cell. Are you able to observe this structure when you extracted it from the fruit solution?

DNA exists as a double helix inside the cell's nucleus. When extracted, it doesn't resemble that structure because we cannot view the DNA that close.

3. If NoHair McNair was standing one hundred feet away, you wouldn't be able to see the one strand of hair on his head, but if he was wearing a wig that resembled a unicorn's mane, you would be able to see the hair. How is this similar to our DNA extraction today? Explain.

We extracted thousands of strands of DNA from the fruit today. A single strand would be invisible to us, but when the strands are clumped together, we are able to view them.

What Happened? The Results:

(continued…)

4. What are some ways that DNA extraction can be used today?

Determining "whodunnit?", such as crime scene investigators who use DNA to figure out who the guilty party truly is. We can also use DNA to identify an organism that is recently discovered or to identify organisms that are already expired. DNA extraction can be used in gene manipulation to create genetically modified food, animals, or medicines.

What are some other ways we can use DNA extraction?

What do YOU think?

What does all of this say about you?!

Watch this short and sweet video about our favorite genetic strand and learn how all of this "encodes" for who YOU are!

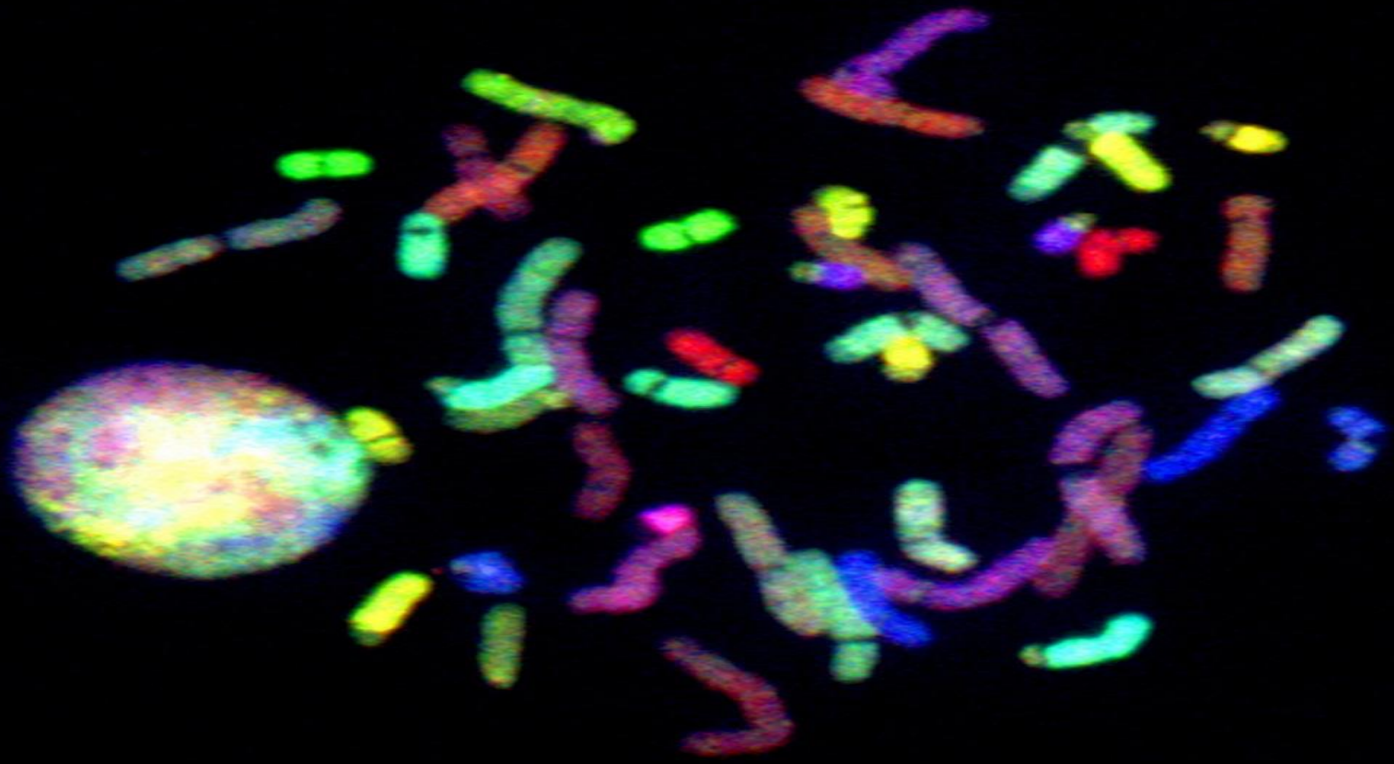
My DNA Speaks To Me…

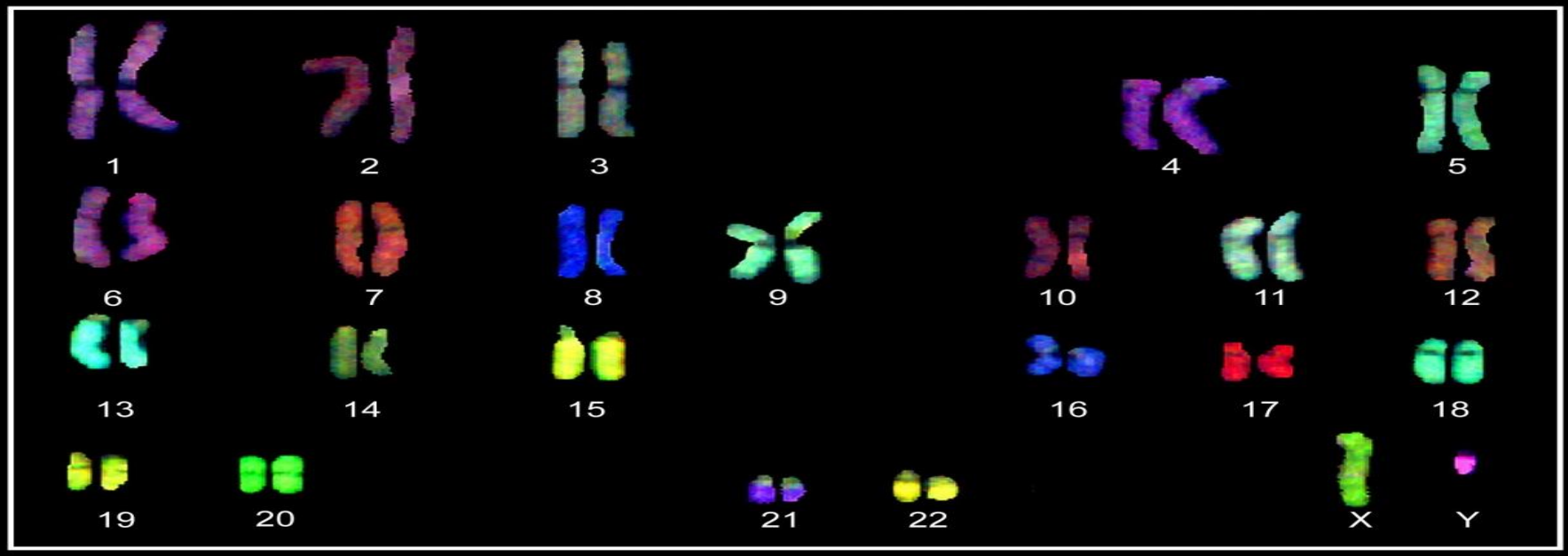
Objective: To learn how DNA translates to physical characteristics

Bell work:

What is the shape of DNA?

Double Helix/Twisted Ladder/Spiral Staircase




1
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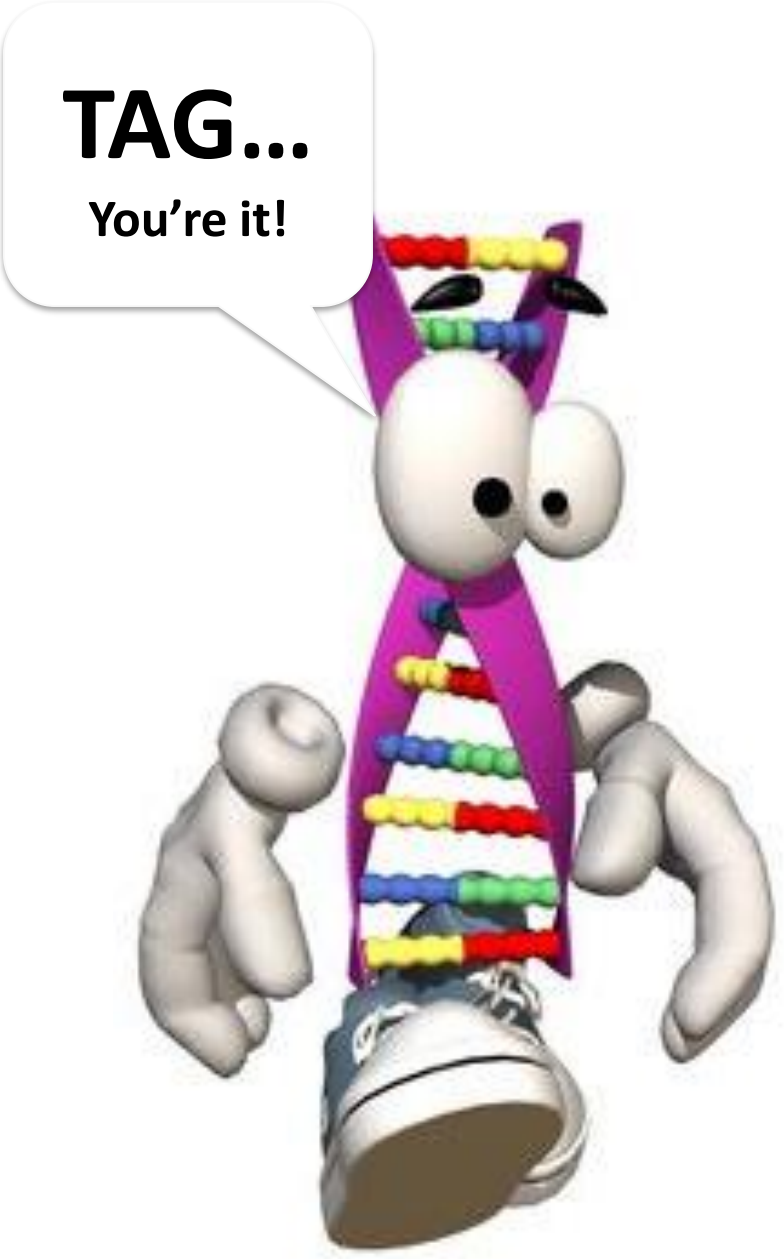
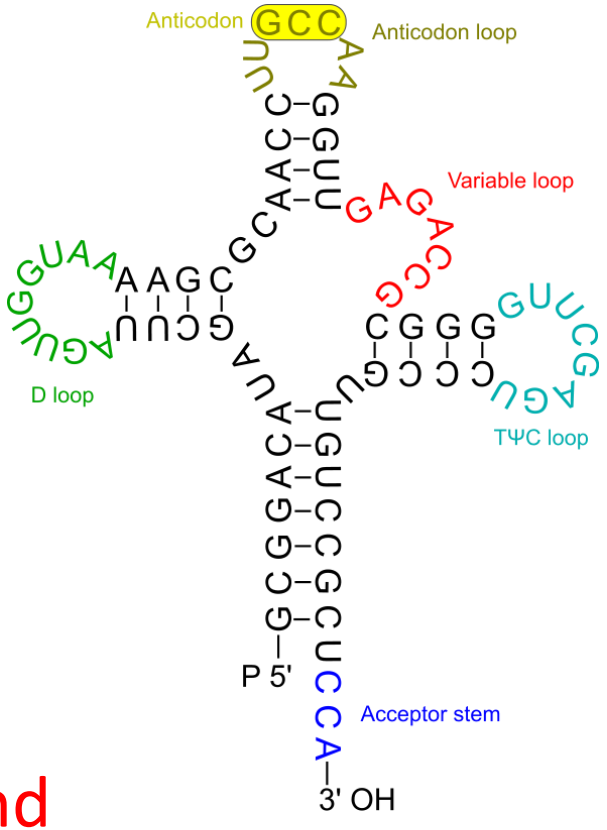
21
22
X
Y

DNA has a language all its own - it speaks in words three letters long. Each grouping of letters calls for a particular amino acid. String the amino acids up in a long chain, and you have a protein - the building block of all things living!



Our cells use DNA as the instructions for all kinds of things, including making **PROTEINS**. DNA is too large to leave the nucleus, so it uses a strand of **RNA** to make a "template" of the DNA. It sends the RNA out to the **RIBOSOMES** for translation into a protein. When it makes RNA, it uses **URACIL** instead of **THYMINE**.

So, if CYTOSINE pairs with GUANINE and ADENINE now pairs with URACIL, what will the new strand of RNA look like?



New RNA strand

C	G	U	U	A	G	C	U	U	C	G	G	A	U	A	A	C	U	G
G	C	A	A	T	C	G	A	A	G	C	C	T	A	T	T	G	A	C

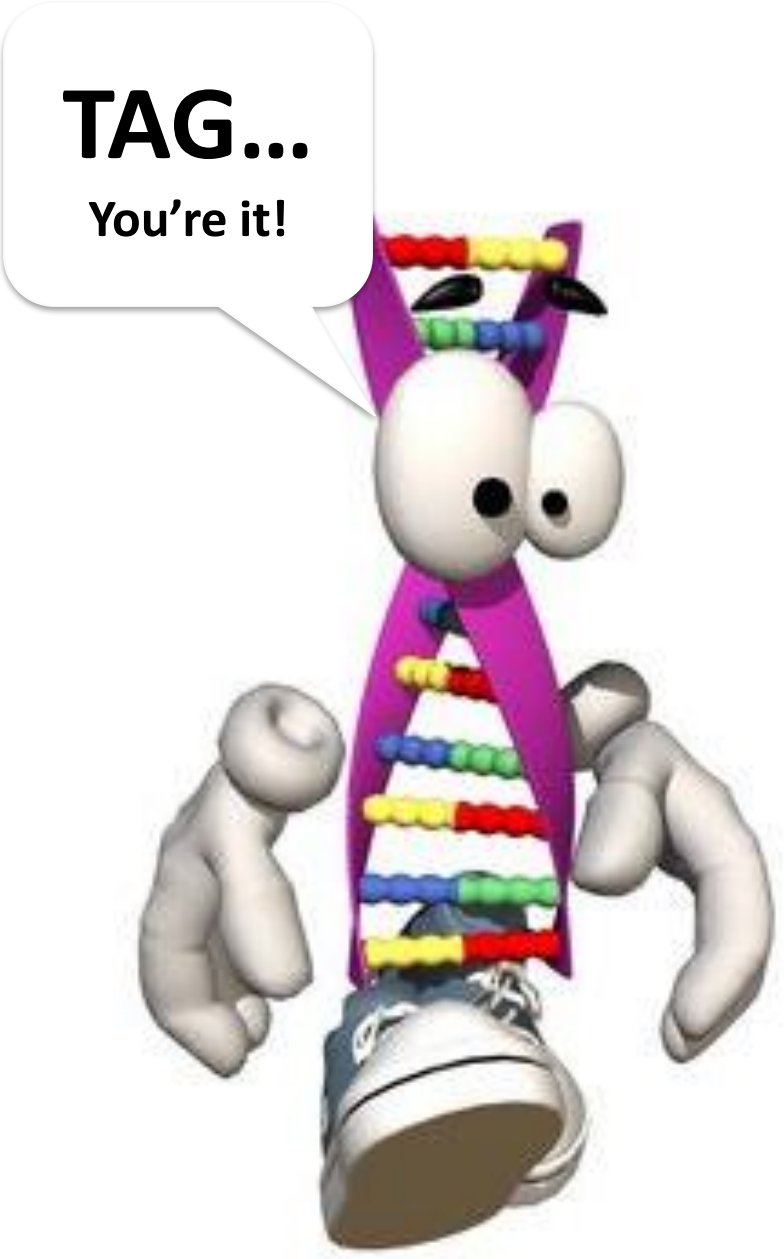
Original DNA strand

Objective: To use amino acids (words) to build proteins (sentences) using various sequences of DNA.

Here's what you'll need to conduct this activity:

Laminated nucleus sheet with DNA strands

tRNA/amino acid "word" cards printed on cardstock



Background Information:

DNA is like a book. It's made up of millions of nitrogen bases in different sequences, which is what makes each and every one of us unique, and every book a new adventure. Every single chapter in the book describes how to make a particular protein. There are several steps to synthesizing proteins.

The first step is transcription. During transcription, a copy of DNA is made in a single strand called mRNA but in RNA, thymine is replaced with uracil. mRNA then leaves the nucleus to join the ribosomes in the cytoplasm. At the ribosome rRNA helps tRNA link amino acids together to make a polypeptide (protein) chain. It starts with the TAG codon and stops with a codon like ACT, ATG, or ATT.

So…

the mRNA strand of **AUGUUC**

would then be translated by tRNA into

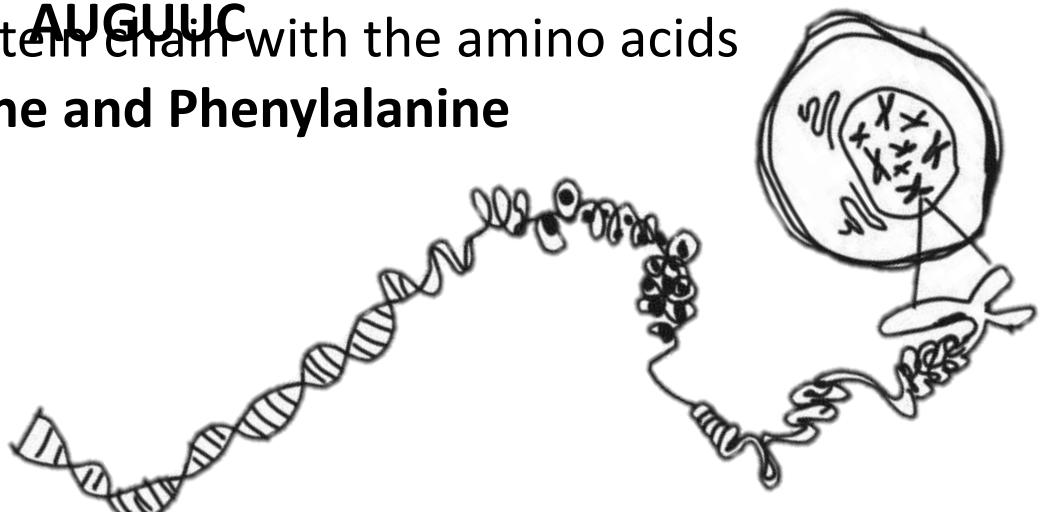
TACAAG

would transcribe to

UACAAG

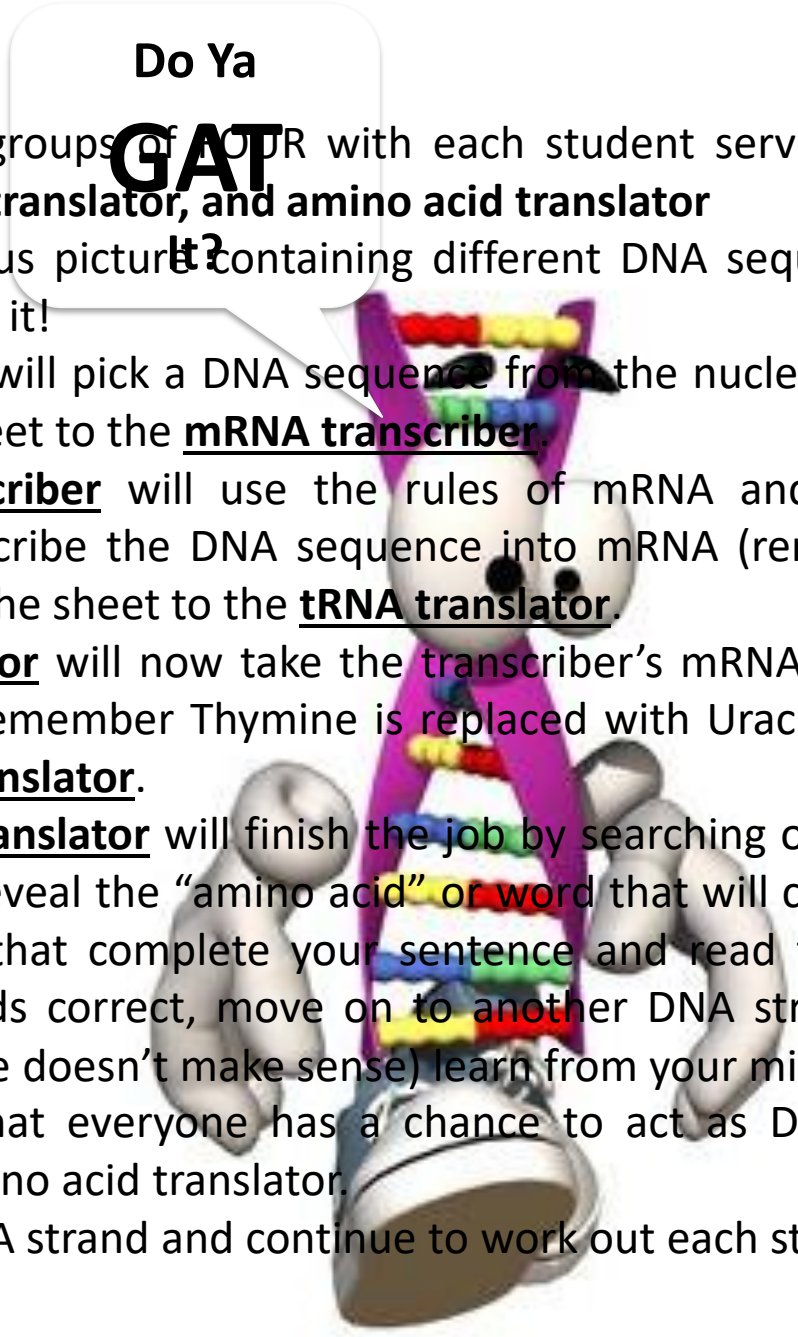
which creates a protein chain with the amino acids

Methionine and Phenylalanine



What you do:

1. You will work in groups of FOUR with each student serving the role of: **DNA, mRNA transcriber, tRNA translator, and amino acid translator**
2. Look at the nucleus picture containing different DNA sequences in the center of your desk – Don't move it!
3. The **DNA** student will pick a DNA sequence from the nucleus and write it down on your sheet. Pass the sheet to the **mRNA transcriber**.
4. The **mRNA transcriber** will use the rules of mRNA and DNA nucleotide base pair matching to transcribe the DNA sequence into mRNA (remember Thymine is replaced with Uracil). Pass the sheet to the **tRNA translator**.
5. The **tRNA translator** will now take the transcriber's mRNA sequence and write out the tRNA sequence (remember Thymine is replaced with Uracil). Pass to the final student - the **amino acid translator**.
6. The **amino acid translator** will finish the job by searching out the correct tRNA card, flip the card over to reveal the "amino acid" or word that will complete the sentence. Write down the words that complete your sentence and read the statement aloud to your group. If it sounds correct, move on to another DNA strand in your nucleus. If it is incorrect (sentence doesn't make sense) learn from your mistakes and move on ☺.
7. Switch roles so that everyone has a chance to act as DNA, mRNA transcriber, tRNA translator, and amino acid translator.
8. Begin the next DNA strand and continue to work out each strand.



Oh Me, Oh Mei-osis!

Objective: To learn how gametes pass on characteristics

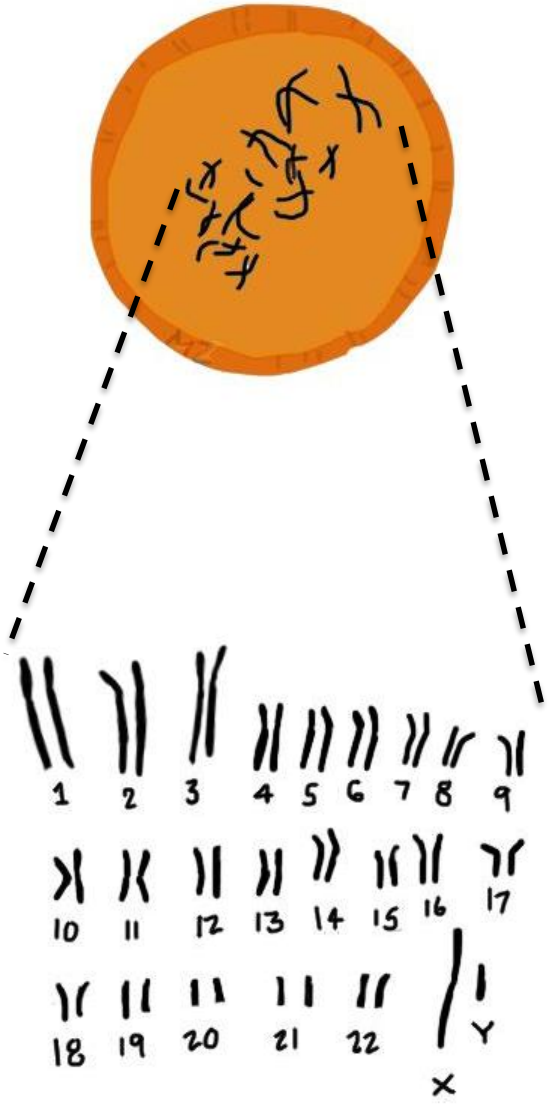
Bell work:

Looking back at protein synthesis, describe in your own words how you used a strand of DNA to create a protein.

There are several steps to synthesizing proteins. The first step is transcription. During transcription, a copy of DNA is made in a single strand called mRNA but in RNA, thymine is replaced with uracil. mRNA then leaves the nucleus to join the ribosomes in the cytoplasm. At the ribosome, rRNA helps tRNA link amino acids together to make a polypeptide (protein) chain.

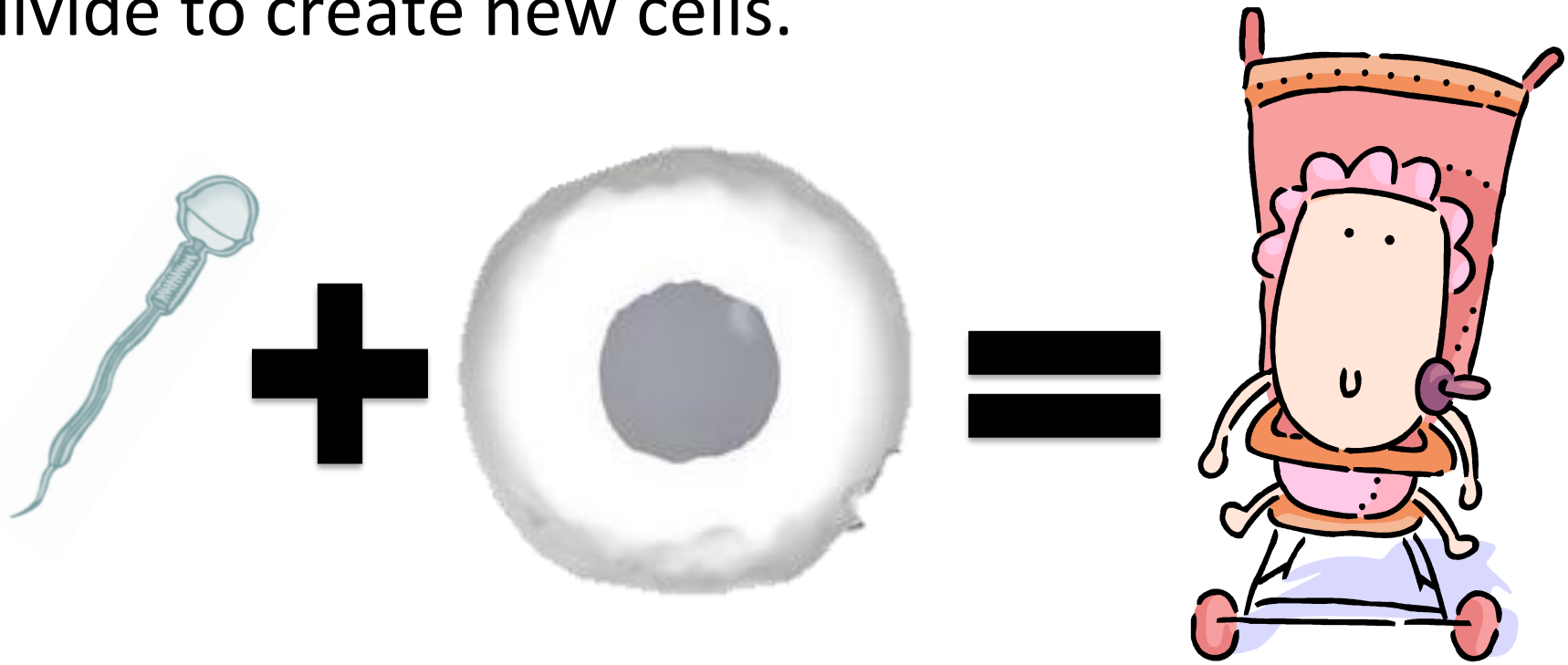
What's it all about?

- DNA is located in the nucleus of the cell and provides the instructions for everything your cells do, written in the sequence of base pairs
- Those instructions are passed from parent to offspring through gametes, or sex cells, like sperm and egg
- When they combine in fertilization, you get one of each chromosome from mom and one from dad
- Those chromosomes contain the recipe for proteins that express themselves as phenotypes for hair color, eye color, height, etc., and you inherit a mix of those phenotypes from each of your parents.



Gam… Meets?

Gametes are **sex cells**, like **sperm** and **egg**. They are created in a cellular process called **Meiosis**. Similar to mitosis, sex cells going through meiosis divide to create new cells.



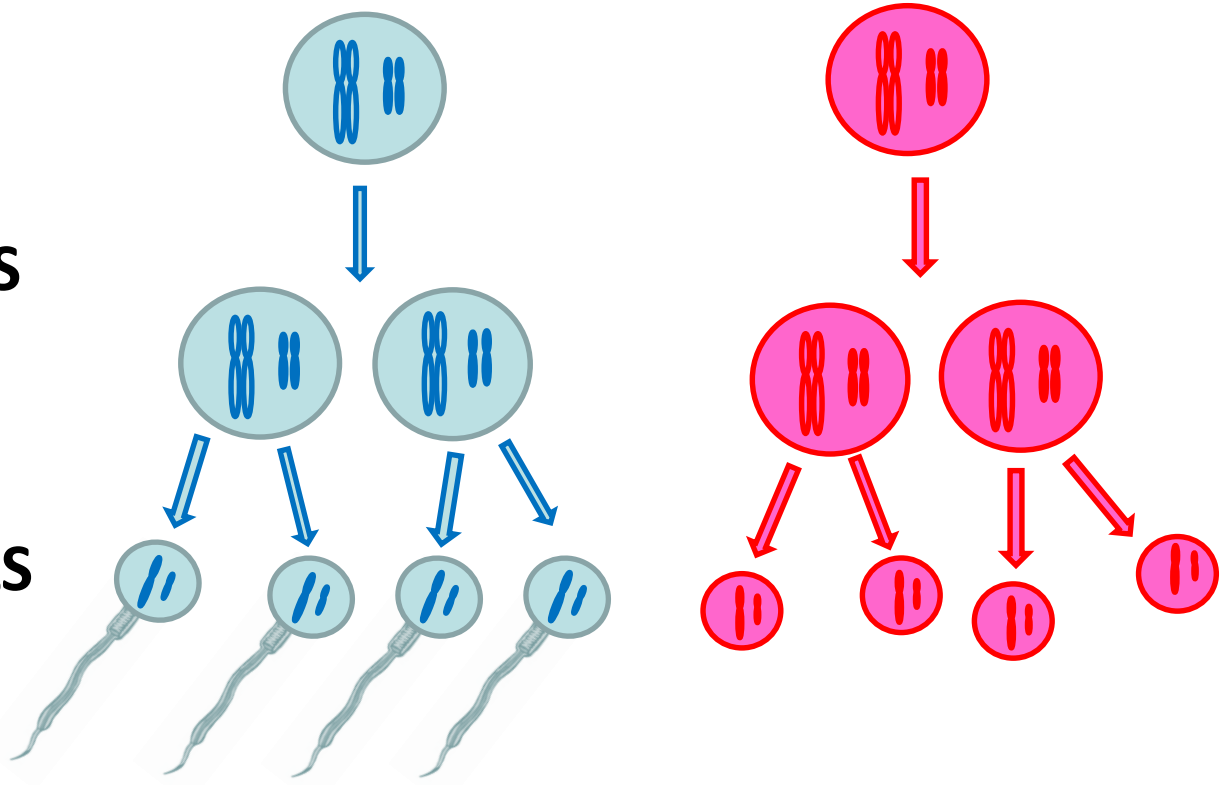
There are two main differences between mitosis and meiosis:

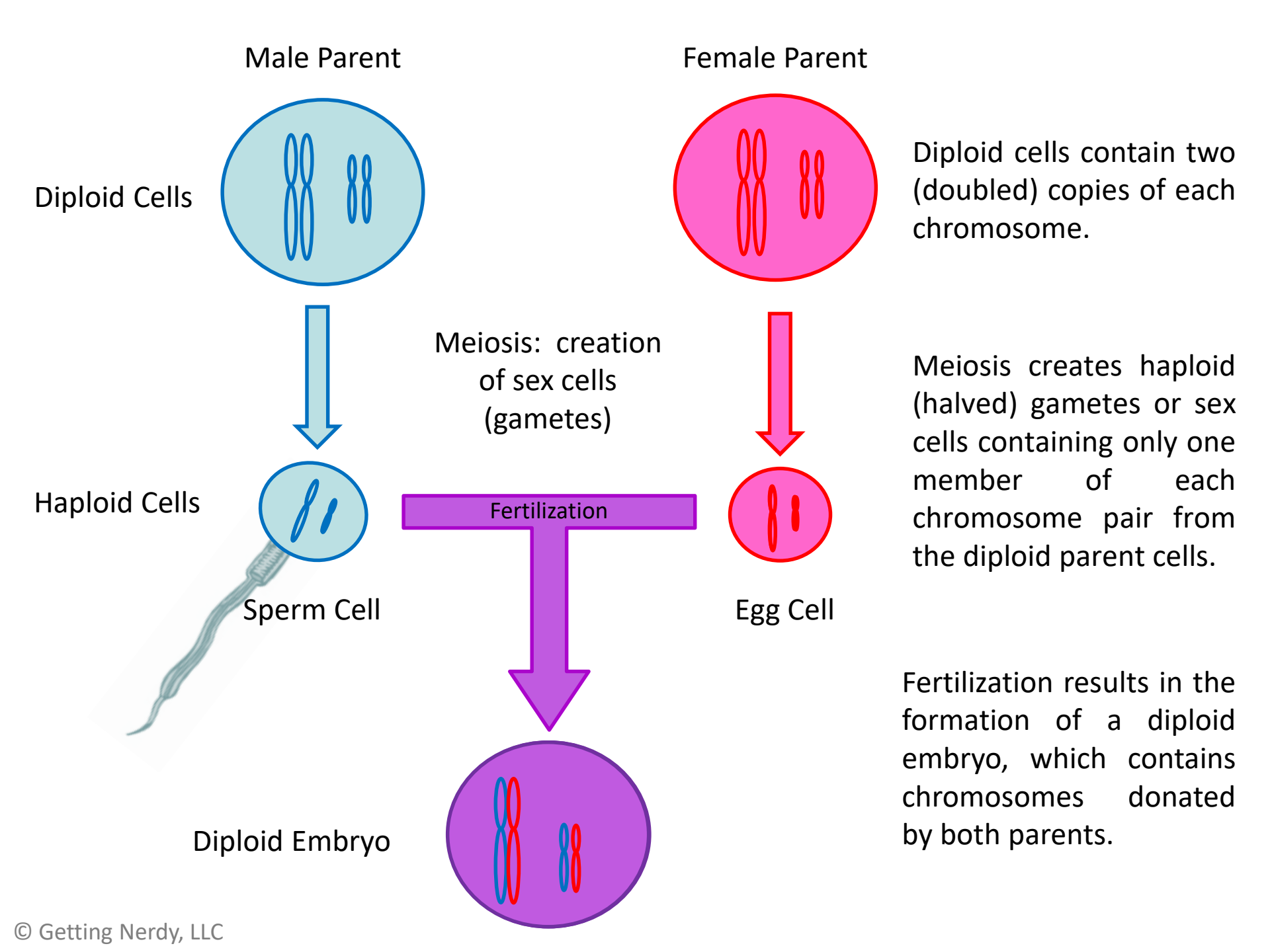
FIRST, they go through the division process **TWICE**!

SECOND, when they divide, they create cells that have **HALF** the number of **CHROMOSOMES** than all of the other cells in your body! That's 23 CHROMOSOMES and we call that **HAPLOID**!

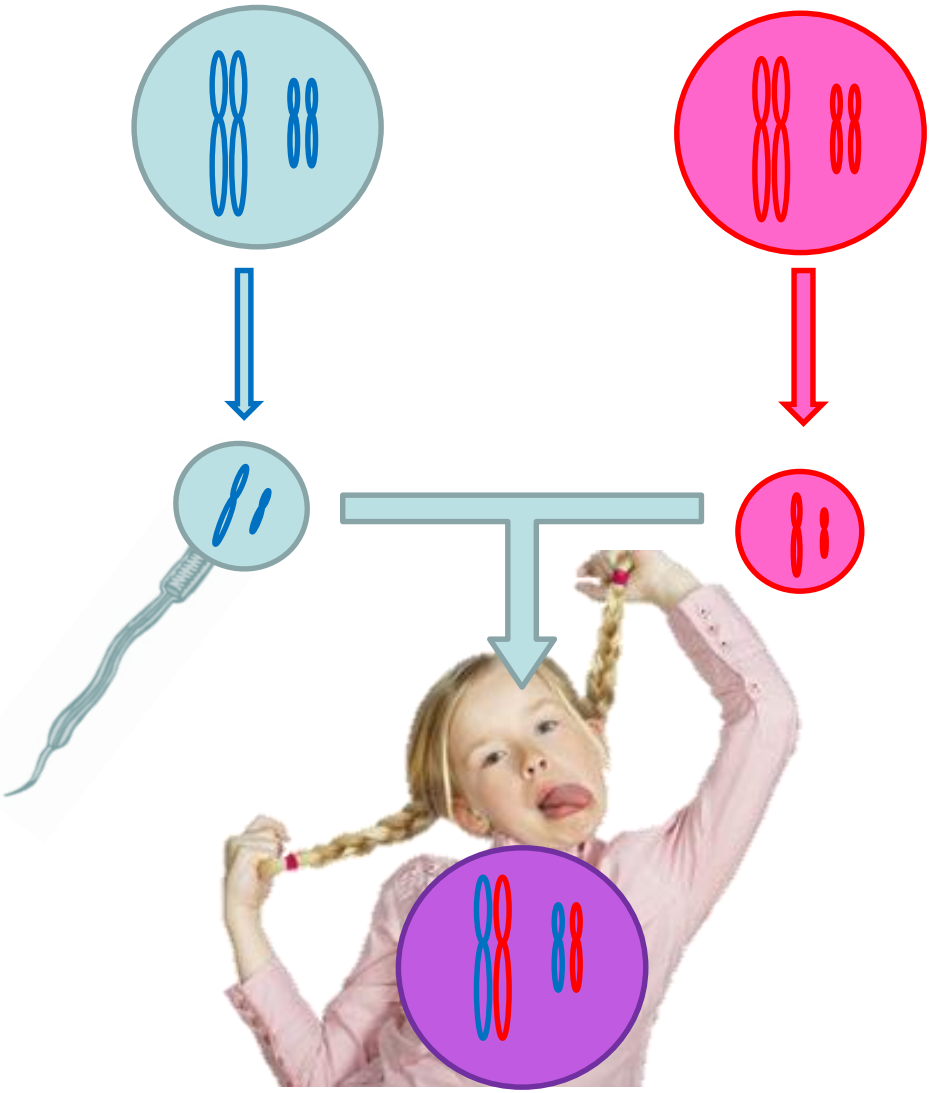
DIPLOID CELLS

HAPLOID CELLS





This way, when the sperm and egg join in fertilization, you get **23 chromosomes from mom and 23 chromosomes from dad** – a total of **46** chromosomes in ALL (**DIPLOID or DOUBLE**)! This DNA combination is in every one of your body cells and is unique to YOU!



So, what if…

1. An aquatic rat has 92 chromosomes in a brain cell. How many would be in it's sperm or egg?

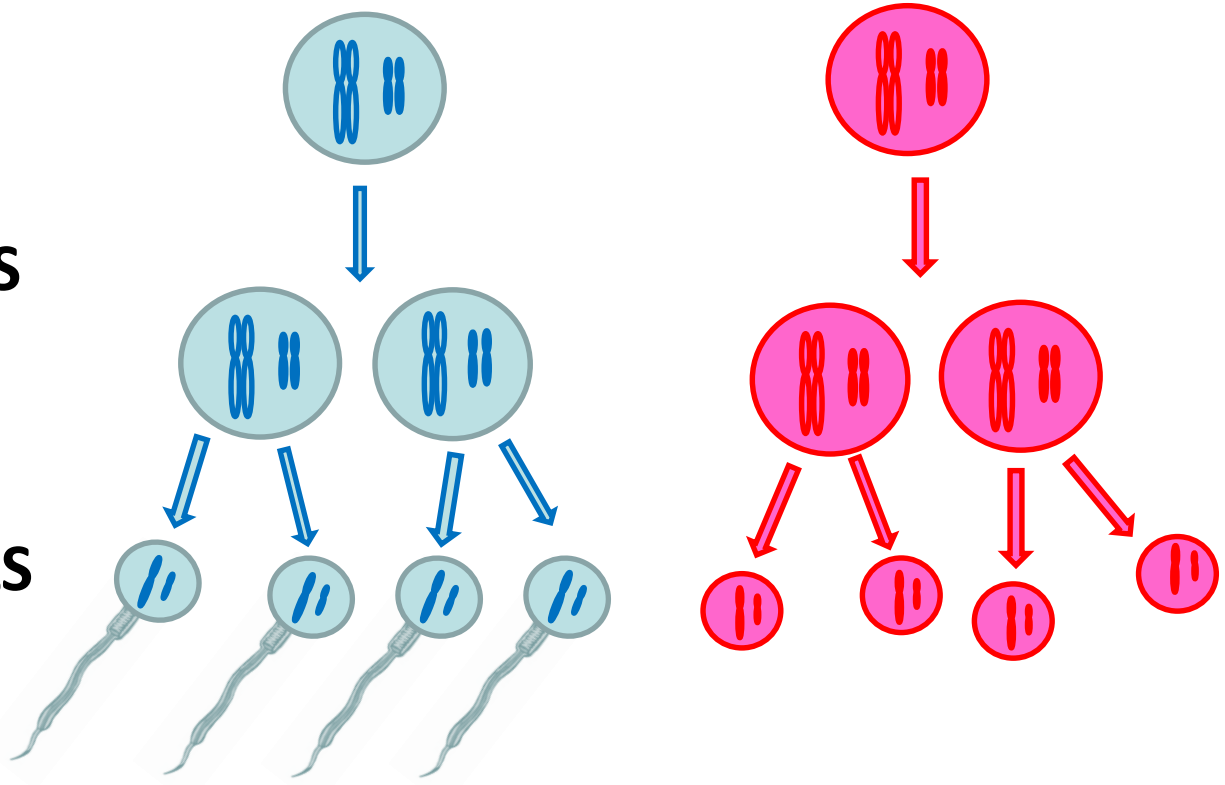
46 chromosomes in its gametes

2. A coyote has 39 chromosomes in a sperm cell, how many chromosomes would be in it's skin cell?

78 chromosomes in its skin cells

DIPLOID CELLS

HAPLOID CELLS



Oh Me, Oh Mei-osis: Just Like Me…

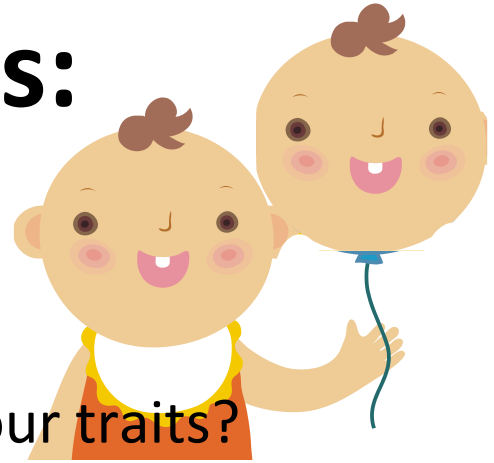
Objective: To determine how common certain phenotypes are within a population.

Hypothesis: Based on the number of people in your class, how many do you think will have the same phenotypes on certain traits as you do?

Oh Me, Oh Mei-osis: Just Like Me…

What You Do: Use the chart on your paper to survey yourself for each of the traits. Then, survey your class mates. When you are done, complete the graph on the following page. For each of **your** traits, create a bar graph indicating the number of people that shared your traits. Compare your chart with others in your class, then answer the questions that follow.

Oh Me, Oh Mei-osis: Just Like Me…



Answer the following on your paper:

1. How many people in your class shared all of your traits?
2. How many people in your class shared zero traits?
3. How do your results compare to your prediction? Explain your answer.
4. In this survey, we compared only a handful of the over 100,000 traits that make up the human genome. Based on this and your results, what do you think are the chances that you would find another person in your school, in this country, or even the world, who has the exact same traits as you? Discuss.

You should observe that it is highly unlikely that anyone in the world will have the same traits as you do, unless of course, you are a TWIN!

Oh Me, Oh Mei-osis!
A Game of Chance…

Objective: To demonstrate the passing of traits from parent to offspring

What You Need to Conduct This Experiment:

Two Pennies

Two People

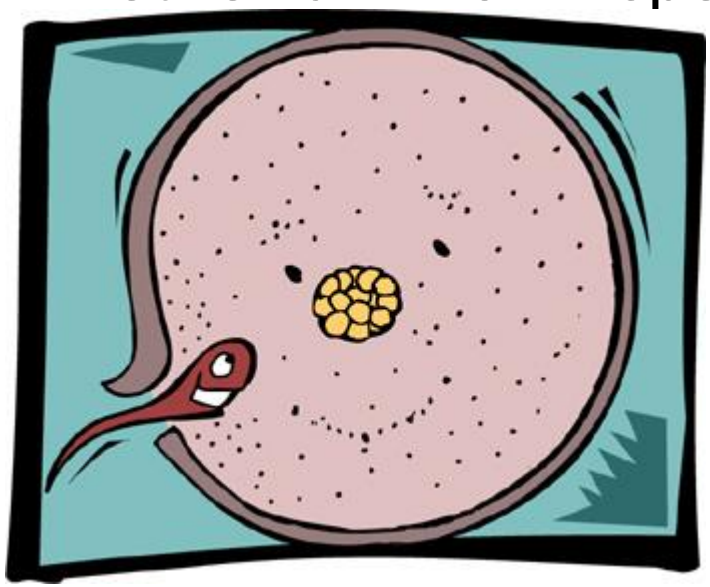
Before you Begin:

Who determines the gender of offspring: the male (father) or female (mother)? Why do you think this?

A Game of Chance…

What You Need to Know:

There are two sex chromosomes that a person can inherit: X and Y. If you are female (XX), you can only give an X chromosome to your offspring. Males (XY), however, can give either, since they make sperm that are either X or Y. So, it is the male who determines the sex of the child, based solely upon whether an X or Y sperm fertilizes the egg first.



What You Do:

For this activity, you are going to pair up with one of your classmates. First, one of you will flip a coin to determine the gender of your offspring. Remember that the male in the relationship determines the gender of the offspring.

If the male flips a HEADS (X), you are having a baby girl! If the male flips a TAILS (Y), you are having a baby boy!

Then, for the traits in the table, each person will flip their coin at the same time to determine which trait you get from mom, and which trait you get from dad. Whatever combination of alleles you get, you will record that in the column under "Genotype". Then you will record the trait that you SEE under "Phenotype". Afterwards, you will draw your baby on the template using the traits they "inherited" from you.

The Results: What Happened?

1. What percent chance is there of producing a male offspring? Female? Explain.

   There is a 50% chance that the offspring will be male or female. Because males have both X and Y chromosomes, they create both X and Y sperm. Depending on which sperm reaches the egg first, there is an equal chance that the offspring will be either gender.

2. What do the coins represent in this exercise?

   The alleles for each gene

3. What determines the phenotypes of the offspring?

   The combination of alleles; the genotype.

4. What are the possible genotypes for the parents of a child with unattached earlobes?

   UU x UU, UU x Uu, UU x uu, Uu x Uu

The Results: What Happened? *(continued…)*

5. How would it be possible for the offspring to show a trait that neither parent shows physically? Explain.

A child can show the trait that neither parent shows physically if both parents are heterozygous for the trait and pass on the recessive trait to their offspring.

6. Colorblindness is a sex-linked trait that affects males more often than it does females. It requires only one affected sex chromosome to be expressed in males, but in females it requires two affected sex chromosomes. On what chromosome do you think the trait for colorblindness is found? Explain.

The colorblind gene is found on the X chromosome. In males, colorblindness is expressed because the Y chromosome does not have the necessary genes to "cover up" the trait when combined with the affected X chromosome. In females, if an affected X and a normal X are inherited, the affected X is hidden by the normal X, allowing the girl to have normal vision. However, if she receives two affected X's from her parents, she will inherit the colorblind trait and the resulting phenotype.

Track the Trait…

Objective: To demonstrate how to trace a trait through a family tree

Bell work:

Look at the figure to the right

1. What shape do you think represents a female?

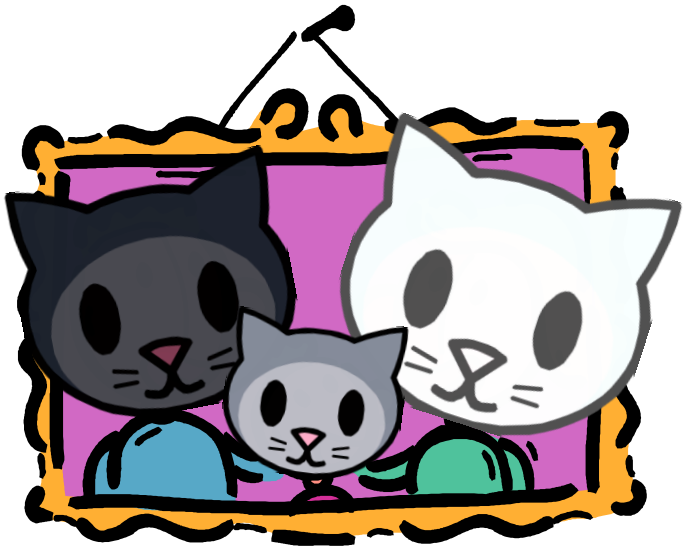
A circle

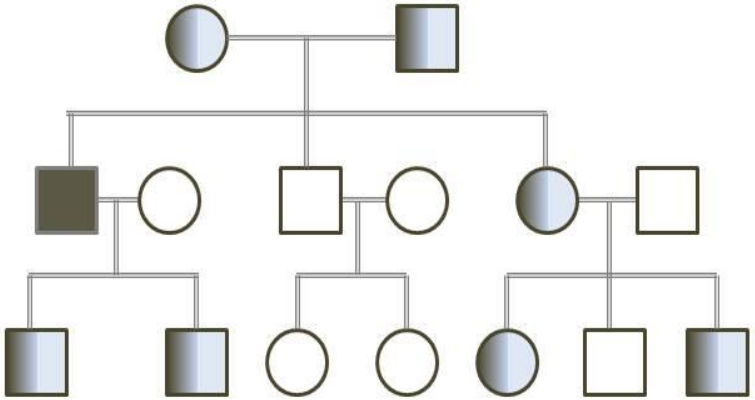
2. What about a male?

A square

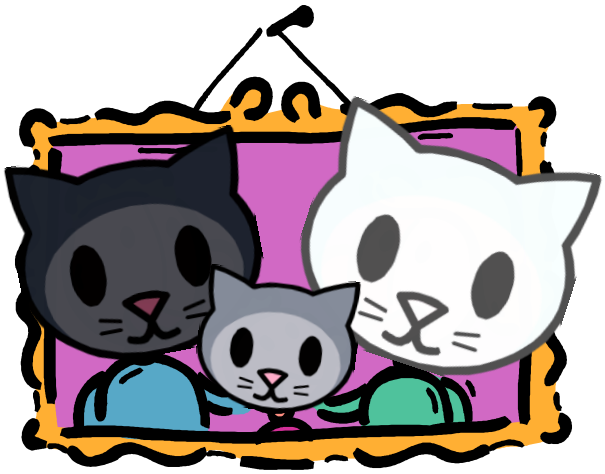
3. What do you think represents a carrier of a trait?

A half shaded circle or square





Track the Trait…



What You Need to Know:

A pedigree is a way of tracing a trait through a family tree. Rules for reading a pedigree are as follows:

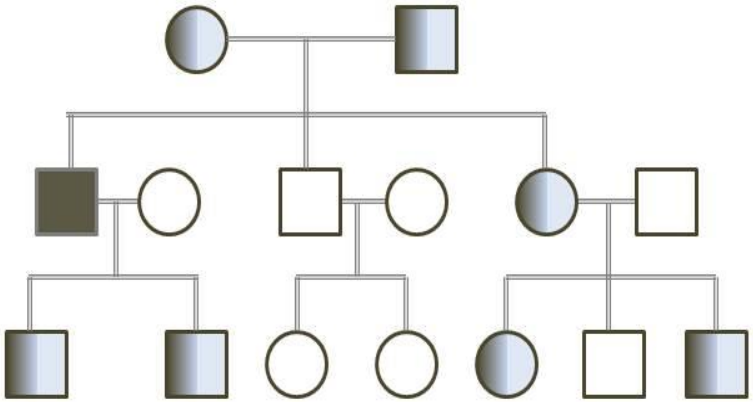
We use specific shapes and shading to signify certain individuals:

Affected female = solid circle

Affected male = solid square

Unaffected female = clear circle

Unaffected male = clear square



HETEROZYGOUS HYBRID CARRIER

Carrier female = half shaded circle

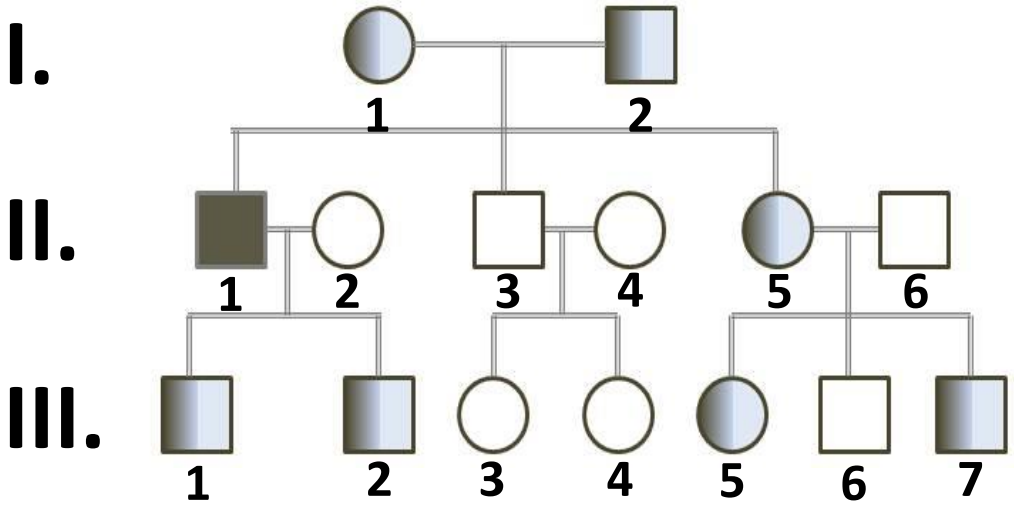
Carrier male = half shaded square

Track the Trait…

We use specific numbers to specify the different generations and the birth order of individuals:

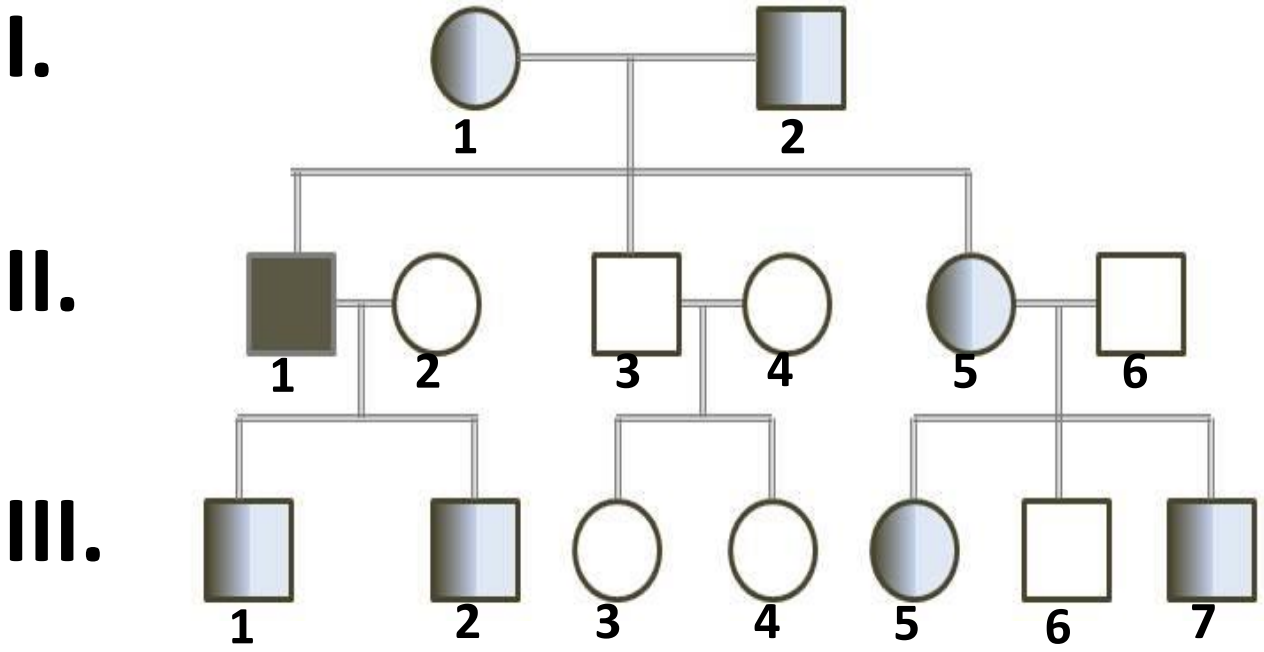
Generations (entire lines of individuals) are identified by Roman numerals (I, II, III, IV…).

Siblings are placed in birth order from left to right. All individuals are labeled with numbers (1, 2, 3, 4, 5…).



We would name a child II-3 if he/she was in the second generation and was the 3rd child. Is the child in position II-3 in the above picture a boy or girl?

Now, put your knowledge to the test. Complete the following pedigrees on your paper and see if you can Track the Trait!



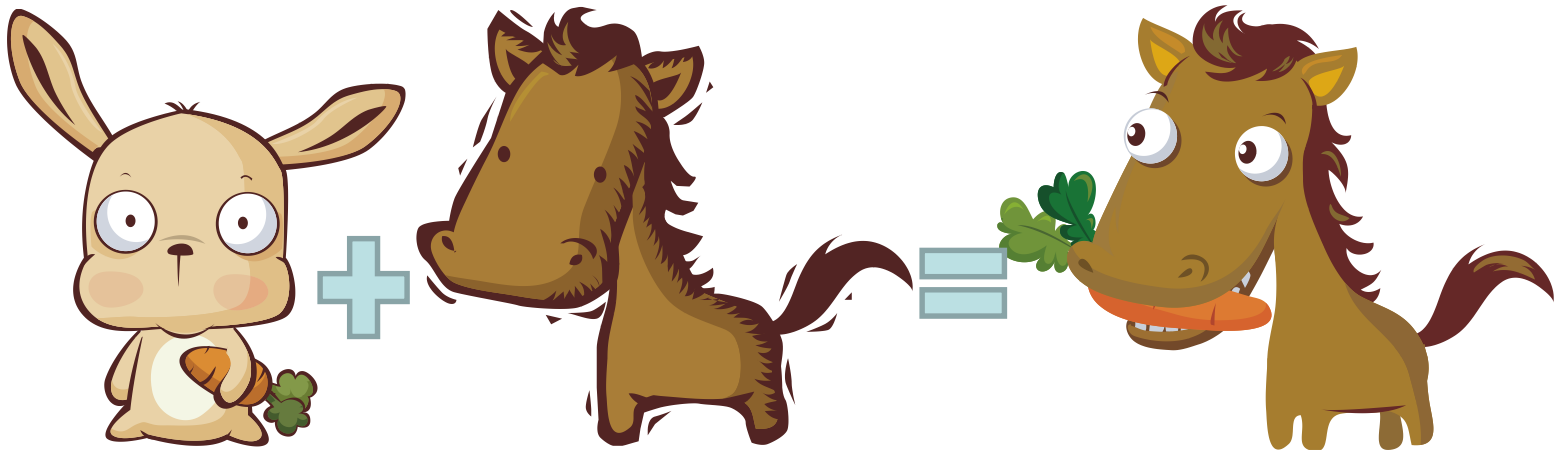
Pick Me, Pick Me!

Objective: To understand the process of hybridization, a type of selective breeding.

Bell work:

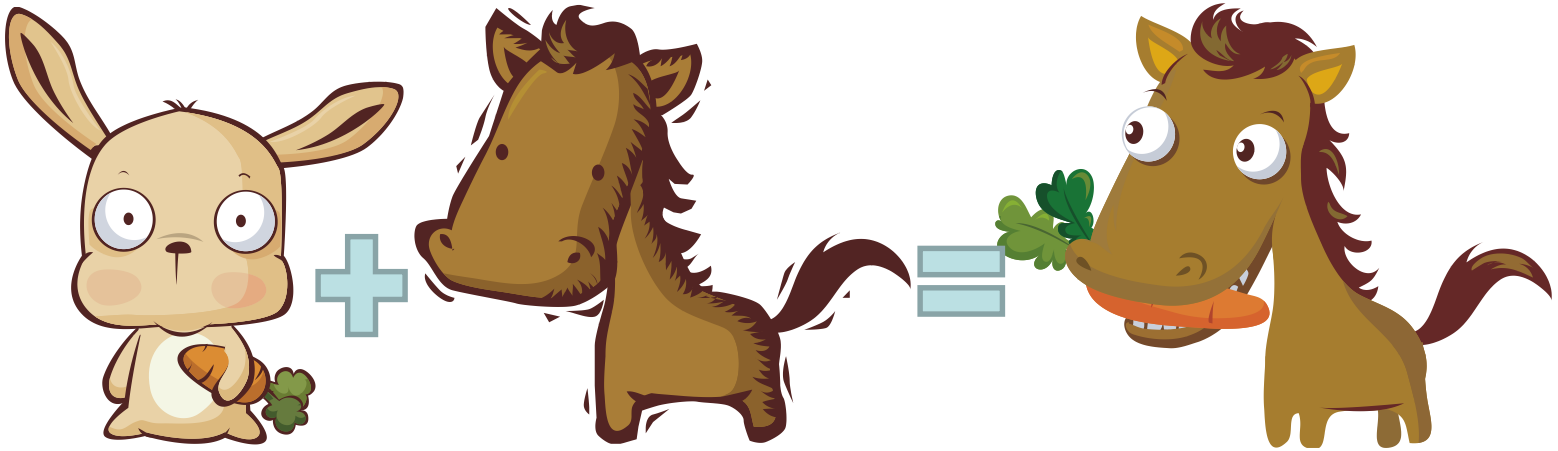
What does the word “hybrid” mean to you? Give some examples of hybrids.

What Do YOU Think?



Pick Me, Pick Me!

Wouldn't it be great to create an organism that has all the traits you desire and is made just for YOUR needs? You CAN with a form of selective breeding called hybridization!



Pick Me, Pick Me!

Background Information:

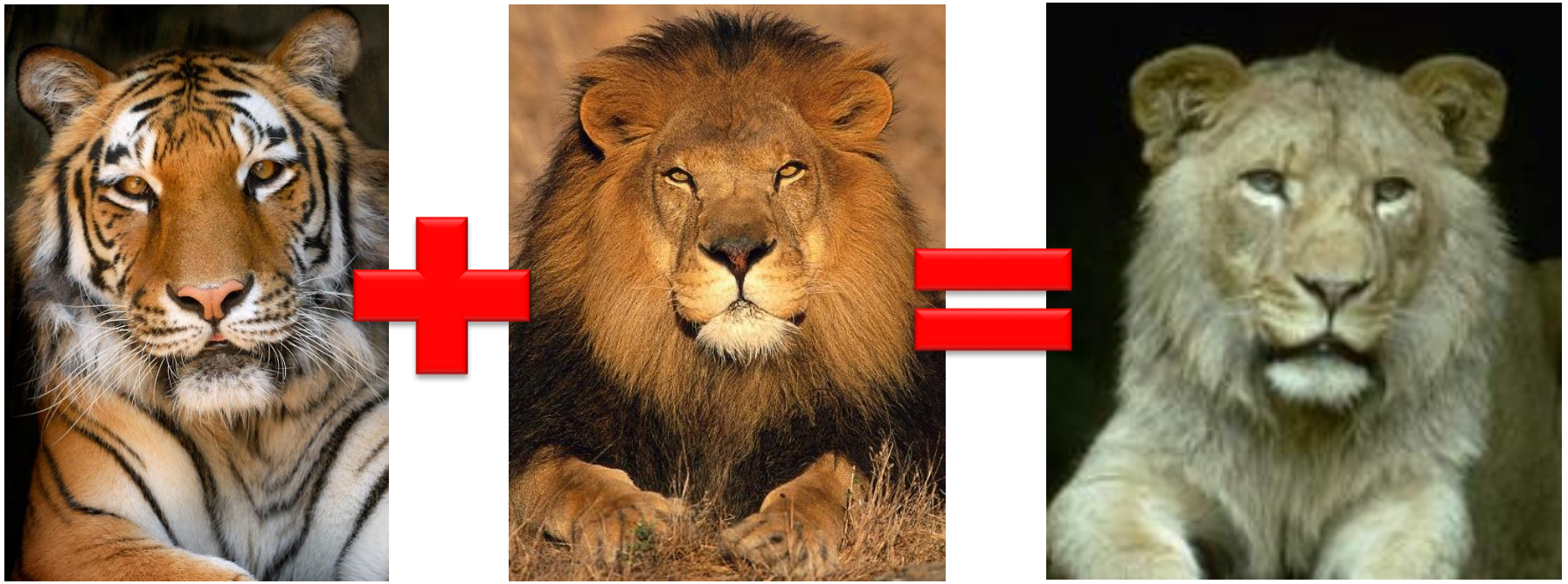
Selective Breeding is the process by which humans breed animals or plants to achieve desired traits. This is typically carried out with domesticated organisms, however, humans have bred wild animals as well.

THE MULE: IS THE RESULT OF BREEDING A FEMALE HORSE (MARE) TO A MALE DONKEY (JACK). THE MULE IS SUPERIOR TO THE HORSE IN STRENGTH, ENDURANCE, INTELLIGENCE AND DISEASE RESISTANCE.

Pick Me, Pick Me!

Hybridization is a form of selective breeding that has been around for as long as man has lived and worked with domesticated animals. Hybrids are bred by mating two species of organisms (usually plant or animal) that belong to the same genus. The offspring will have traits that both parents exhibit.

THE LIGER: IS THE RESULT OF BREEDING A FEMALE TIGER TO A MALE LION. THE LIGER HAS BOTH STRIPES AND SPOTS. THE STRIPES ARE INHERITED FROM THE TIGER PARENT AND THE SPOTS FROM THE LION PARENT. ON THEIR HIND LEGS, LIGERS STAND APPROXIMATELY 12 FEET TALL. AT MOST, LIGERS MAY WEIGH UP TO 1,000 POUNDS.



Pick Me, Pick Me!

There is one major drawback for hybrids; most are sterile, meaning that they make sperm and egg that can't create offspring. This occurs because most hybrids are derived from parents with different numbers of chromosomes and the parent chromosomes have different structures. These differences cause an issue when the hybrid makes gametes, or sex cells, during meiosis. The chromosomes have difficulty pairing up during meiotic division because of their structural and numerical variations and thus the sex cells are created inconsistently, making the sperm and egg unviable - they just don't work. This is one of the reasons why hybrid organisms often don't do well in nature- they can't create a sustainable population within their ecosystem because they can't reproduce. Their uniqueness dies with them.

Here's what you'll need to conduct this activity:

Read the following article from the NY Times:

"Remarkable Creatures: Hybrids May Thrive Where Parents Fear to Tread"

When complete, answer the accompanying questions. Remember to use good reading strategies as you try to find important information within the text.

Let's Mix It Up:

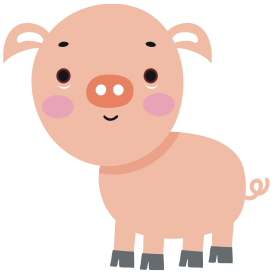
A Venture into Hybridization

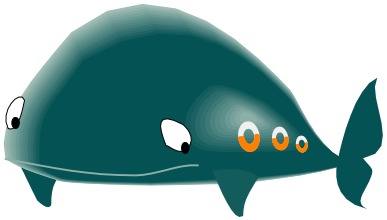
Objective: To demonstrate how hybrids inherit specific traits from each parent.

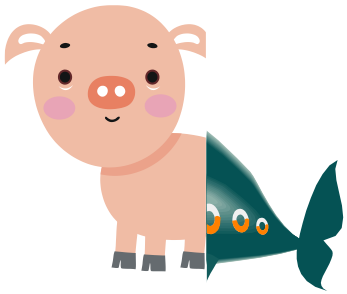
Bell work:

Explain how hybrids can be evolutionary dead ends.

Often times, hybrid organisms may be born with out working sperm or egg, resulting in a new species that may not be able to reproduce effectively, and are therefore unable to create more of its kind.

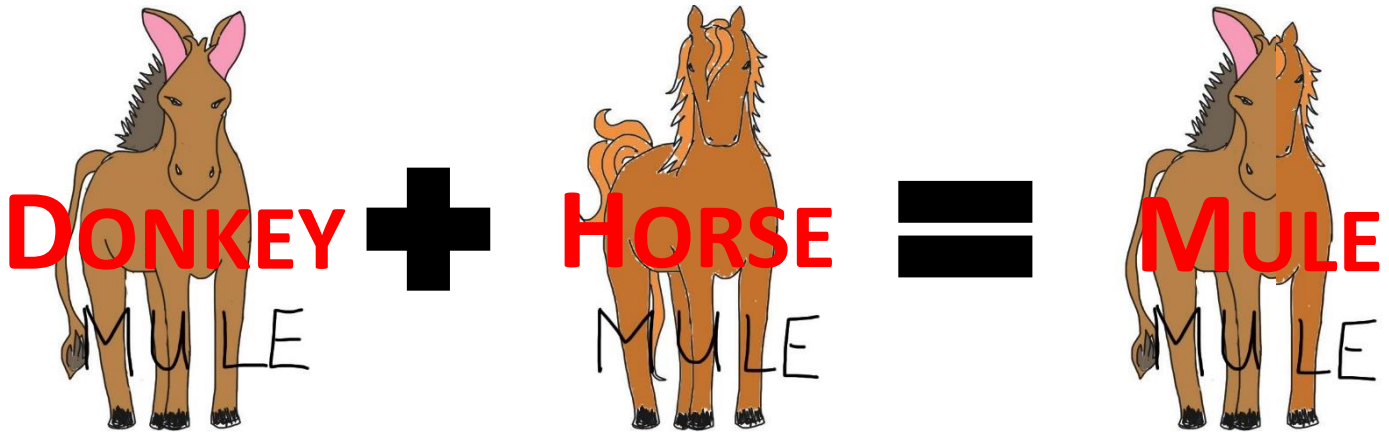






What You Do:

On the back of each animal card is information about each parent. The information details things about each organism's habitat, its special traits and abilities and the disadvantages and drawbacks of that particular organism. When producing hybrids in nature, or by selective breeding, often times the hybrid's habitat range expands or may even diminish. Special traits are magnified or enhanced, and even disadvantages may altogether disappear. Some characteristics are even mixtures of both parents and may be present in the hybrid! Using these guidelines, complete the following hybrid crosses using the mix-up cards for each match below and complete the questions for each union.

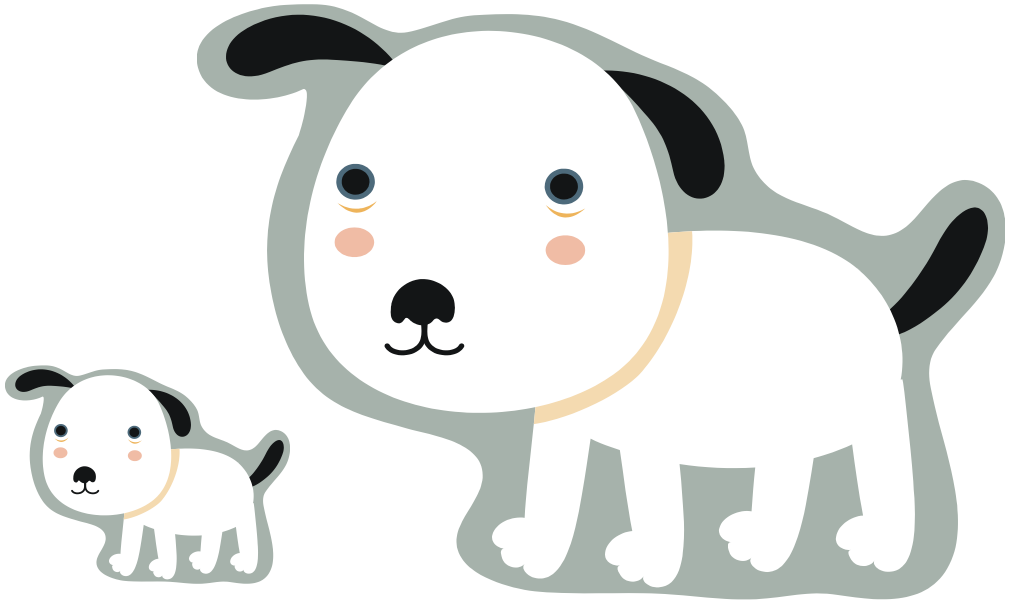


Get Your Hybrid Here!

A Selective Breeding Sales Campaign

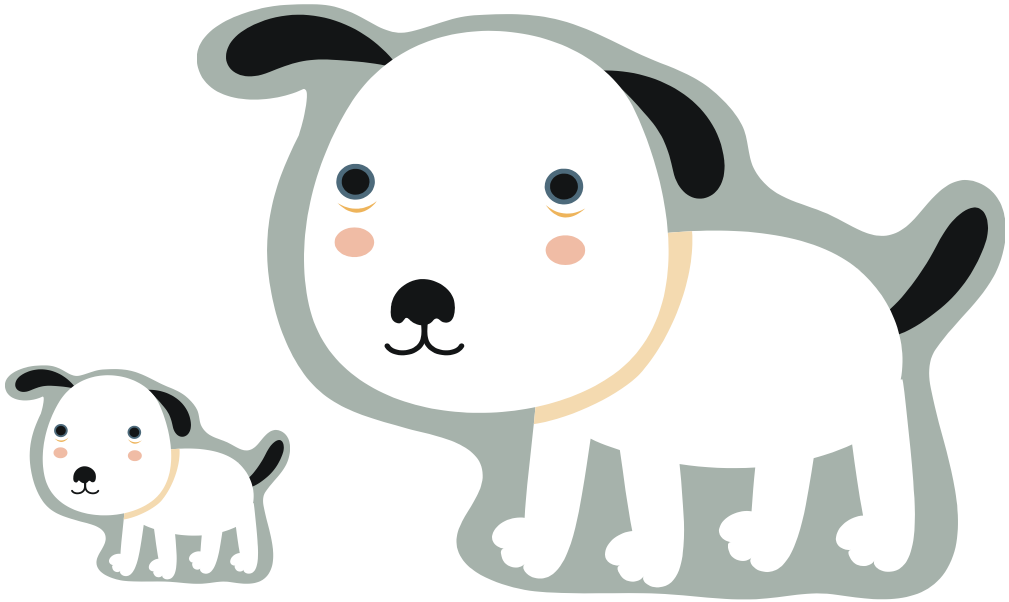
Objective: To show understanding of selective breeding by creating a hybrid organism from two genetically similar organisms

From a tea cup poodle to a 150lb Mastiff, dogs are varied groups of animals. But how is it that they are all from the same species, *Canis familiaris*, yet they look so different? Why, it's selective breeding, of course!



Get Your Hybrid Here!

What You Do: Welcome aboard Selective Breeding & Hybridization, Inc! We're glad you've joined our selective breeding team! As a new employee, your first task is to create an Ad Campaign for our new line of "hybridized" organisms. Each hybrid organism is selectively bred from two organisms that are similar, each with unique and useful traits. You choose the parents and the hybrid organism they create. Then, your job is to do the research needed to tell our customers about the original parent organisms and why this hybrid was created.



An Engineered Reading…

Objective: To identify methods geneticists use to obtain specific traits within organisms

Bell work:

What are some reasons a scientist might want to remove DNA from an organism? Explain.

What do YOU think?

Do you think your parents were satisfied with the traits you received as a baby? Do you think we can pick the traits that we want in our offspring? If you answered no, then you must not know about the advances we have made in science! Take a few minutes to read the passage "You Wanna Mix My DNA With What?!" When complete, answer the questions on your sheet. Remember to use good *reading strategies* as you read!

How Did You Do?

1. What is genetic engineering?

The ability to alter the DNA of an organism in order to get the traits that are desired

2. How do gene splicing and gene therapy differ? How are they alike?

Gene splicing, or recombinant DNA, involves bringing together genetic material from multiple organisms, creating a new sequence that would not be found in any of the original organisms. Gene therapy is completed by adding or deleting segments of genes to correct or get rid of genetic disorders. Gene splicing results in DNA that has the selected traits of both organisms while gene therapy results in the treatment or removal of a disorder or disease from the original organism. Both involve removing sections of DNA from an organism to alter the phenotype of an organism.

How Did You Do?

3. What types of diseases can gene therapy be used to treat?

Gene therapy can be used to treat diseases like cystic fibrosis, sickle cell anemia, and muscular dystrophy.

4. How are viruses used in gene therapy?

Viruses are often used in gene therapy because they naturally bind to their hosts and introduce their genetic material, making it easier to deliver the new genetic material.

5. What is the importance of the Human Genome Project?

The main goal of this project was to ultimately find where certain genes were on chromosomes so that we may correct genetic disorders or eliminate them altogether.

6. What is selective breeding and how is it beneficial?

Selective breeding is when we select two organisms with desired traits to serve as parents of the next generation. It can result in an organism that has the best traits of both parents.

How Did You Do?

7. Besides horse breeders, who else might use selective breeding?

What Do YOU Think?

8. What is inbreeding?

When two organisms that have very similar or the same characteristics are mated resulting in the prevalence of genetic disorders.

9. Why do genetic disorders become more apparent in offspring that are a result of inbreeding?

Recessive disorders are seen more often because the gene pool is limited in cases of inbreeding.

10. What has happened to the population of cheetahs as a result of the ice age and inbreeding?

Cheetahs inherit from a small gene pool, so they have similar genes and lack genetic diversity. Male cheetahs often produce deformed sperm cells, causing 75 % of the baby cheetah population to not live past three months.

How Did You Do?

11. What interesting type of cat can be made from hybridization?

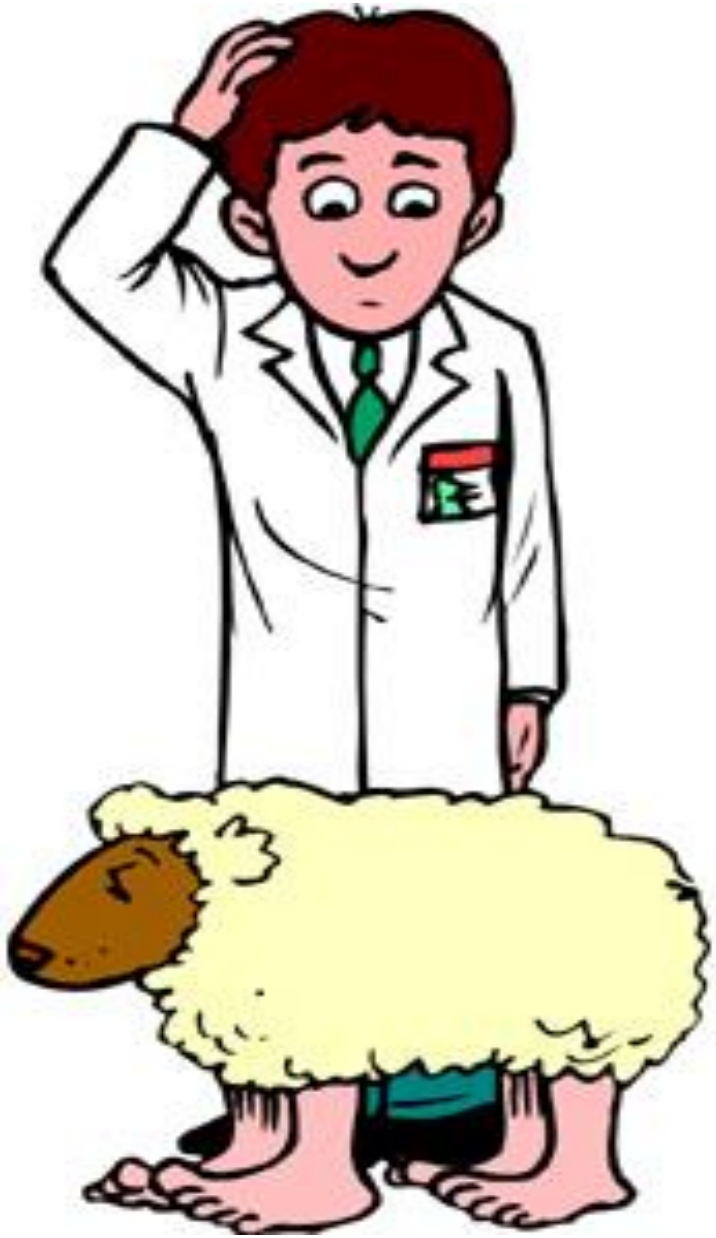
Liger

12. How is cloning like asexual reproduction?

Cloning is when a new organism is made that has the exact same genes as the organism from which it was produced, creating an exact copy of the organism from which it came. Asexual reproduction is when an organism divides or makes an exact copy of itself, such as in mitosis.

Opinion Matters…

Have you ever felt so concerned about something you wanted to shout it from the rooftops? A PSA, or Public Service Announcement allows you to do just that! One such controversial topic is genetic engineering. Genetic engineering is a way for scientists to explore the natural world by modifying the DNA in organisms. This is often a very touchy subject because people have a variety of viewpoints. In this activity, you will work in groups to write a PSA from the perspective of someone whose opinion matters!



Opinion Matters…

Objective: To research a type of genetic engineering and create a public service announcement from a chosen perspective.

Here's what you'll need to conduct this activity:

Genetic Engineering Viewpoints

Six-sided die

Technology for creating your PSA, such as:

- PowerPoint
- Prezi
- Video camera
- Movie editing software

Opinion Matters…

Background Information:

Genetic engineering is a way for scientists to use biology and technology to alter the DNA of an organism in order to get the traits that are desired. Genetically modified organisms are used in medicine, agriculture, and scientific research. Genes of organisms can be engineered in several ways, including processes such as gene splicing, cloning, and gene therapy.

Opinion Matters…

What You Do: Once in your group, you will roll the dice two times. Once for the type of genetic engineering and once for the point of view you will write your PSA from.

Types of Genetic Engineering

Roll the dice to see what type of genetic engineering your group will focus on.

DESIGNER BABIES: embryo screening, premarital screening

GENETICALLY MODIFIED/TRANSGENIC ANIMALS: for research, unique pets

CLONING: domesticated/companion animals and extinct or endangered species

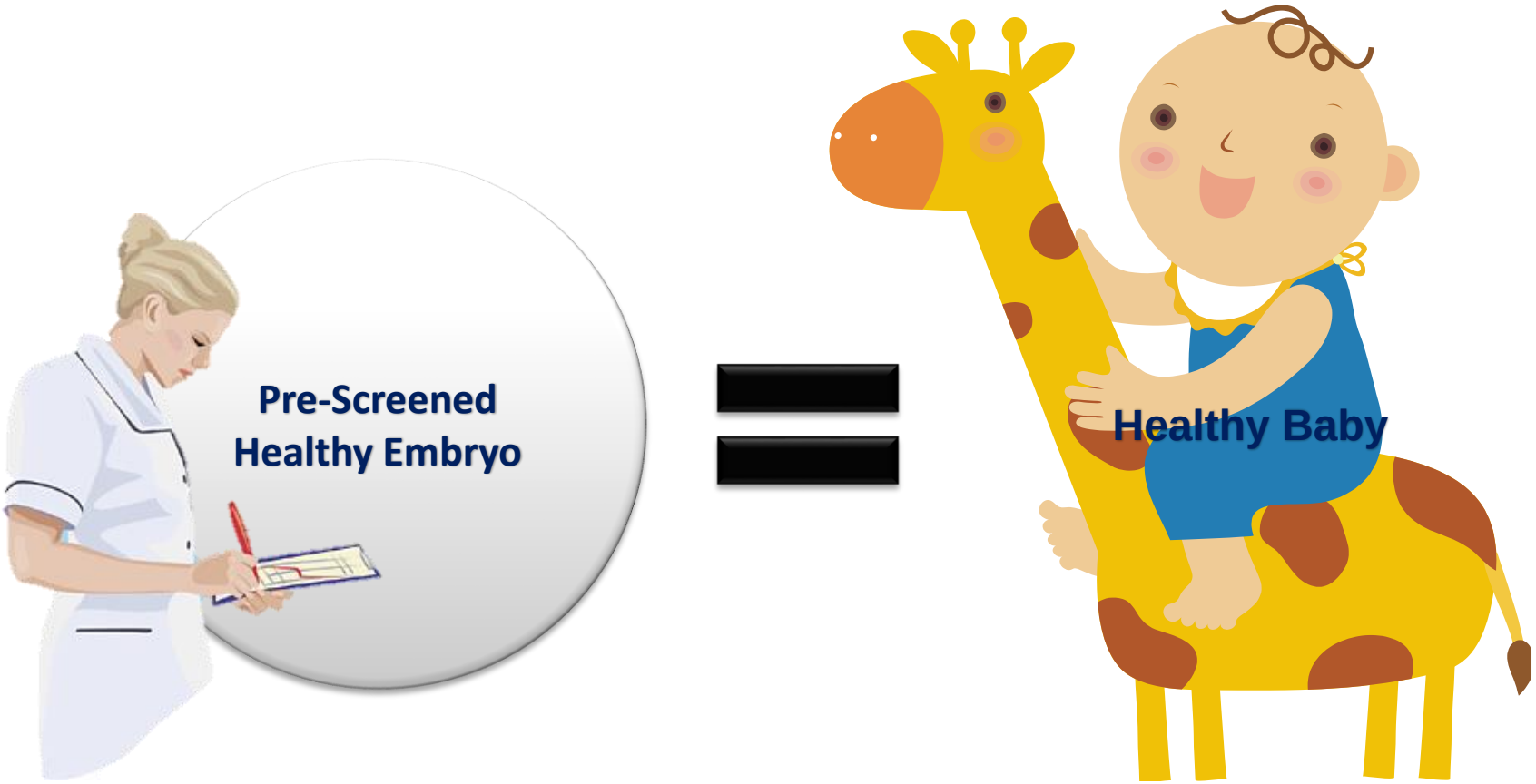
GENETICALLY MODIFIED FOOD: to prevent disease, pest damage, and increase yield

GENE THERAPY: treat and/or eliminate genetic diseases

GENETICALLY ENGINEERED ORGANS: grown in the lab for transplantation and research

Check out the following slides to get an idea of what each one of these topics is about!

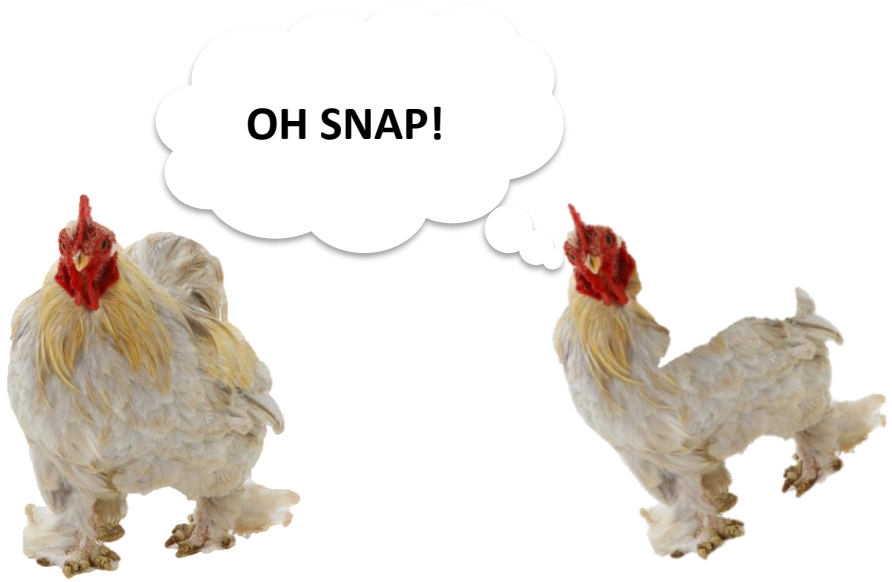
DESIGNER BABIES: Geneticists screen embryos for genetic defects and choose only those who are free of disease to be implanted into the uterus.



In the Future, who knows what's possible…
Make your own baby? Pick the traits you want!

GENETICALLY MODIFIED/TRANSGENIC ANIMALS: Attaching bioluminescent genes to specific sections of DNA can help scientists to trace specific traits within an organism, for example, what genes make eyeballs or fur, which genes may cause Ovarian Cancer or Lung Cancer, or, the newest fad, making glow in the dark pets!

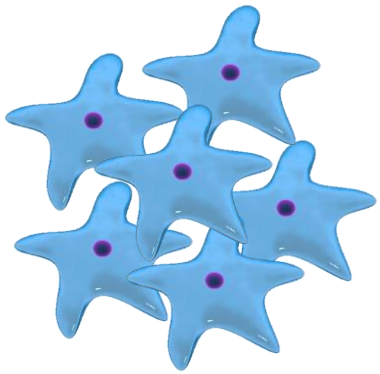
CLONING: Scientists can create exact copies of organisms to increase livestock and harvest quantities, bring back extinct species, or even bring back a beloved family pet.



GENETICALLY MODIFIED FOOD: Genetic engineering can make crops that can grow in poor soil conditions, resist disease, tolerate drought, repel insects, produce larger fruits, and produce a higher yield, making it easier for people who live in harsh conditions to grow food.

GENE THERAPY: Scientists can genetically engineer organisms is by adding or deleting segments of genes to correct or get rid of genetic disorders. Gene therapy can be used to treat diseases like cystic fibrosis, sickle cell anemia, and muscular dystrophy, and often uses viruses as hosts to introduce new genetic material.

GENETICALLY ENGINEERED ORGANS: The controversy is growing over the use of stem cells to create organs for transplant and research.



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Opinion Matters…

What You Do: Once in your group, you will roll the dice two times. Once for the type of genetic engineering and once for the point of view you will write your PSA from.

What type of genetic engineering will you be discussing?

Whose point of view will you be using?

Research the type of genetic engineering that you rolled for using the sites below and any other sites approved by your teacher:

http://actionbioscience.org/biotechnology/

http://actionbioscience.org/genomics/

http://www.genome.gov/Issues/

Genetics Study Guide

Objective: To prepare for your upcoming genetics test.

Complete the study guide using your notes from each lesson. Be sure to answer each question to the best of your ability.

So, now what…?

What's the purpose? To provide you (and other living things) with the traits that make you, well… YOU! That's genetics… but how does genetics affect populations of organisms in the long run?! THAT's Evolution- and that's a whole other story!