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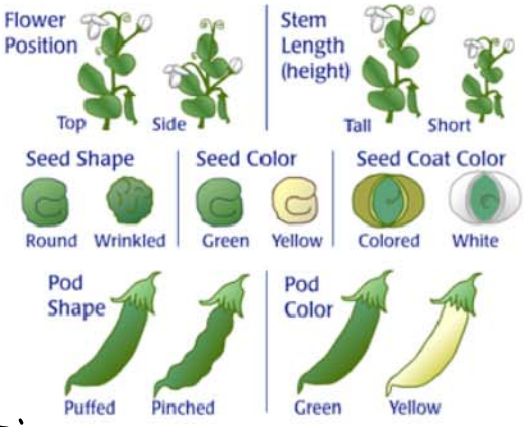
FOCUS: Genes & the Nature of Inheritance

EQ: Can you explain why offspring resemble each other and their parents? What are genes? What do they do? Where did your genes come from? Can you explain what it means for a trait to be dominant or recessive? Under what conditions will offspring display a dominant trait? A recessive trait?

Can you demonstrate how to use a Punnett square to predict phenotypes and genotypes for potential offspring between two parents?

Gregor Mendel: "The Father of Genetics"

- Gregor Mendel was a European monk who lived in the mid-1800s and worked as a teacher at his monastery.
- With training in physics, math, and botany, he used his knowledge to perform genetics experiments using pea plants in the monastery garden.
  - ***Why pea plants?***
    - Easy to breed.
    - Many different visible, obvious traits.
    - Fast generation time.



Mendel's Scientific Inquiry Process

- ***Step 1:*** Posing a question

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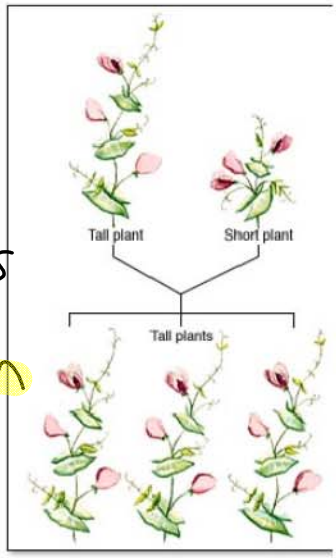
- Why do offspring look like their parents?

- ***Step 2: Developing a*** hypothesis
  - There is some substance that is physically passed from parent to offspring that determines specific traits.

- ***Step 3: Designing an*** experiment
  - Experiment 1 – Cross purebred plants with opposite traits.
    - ***Purebred***: The offspring coming from a line of many generations with the same traits.
    - **Parent Generation:** Tall plants x short plants
  - Experiment 2 – Cross the offspring of the First Filial Generation (F Generation).
    - ***F_1 Generation***: The first generation of offspring of the parent generation.
      - Ex: You are the F_1 Generation from your parents. Your children will be the F_2 generation.



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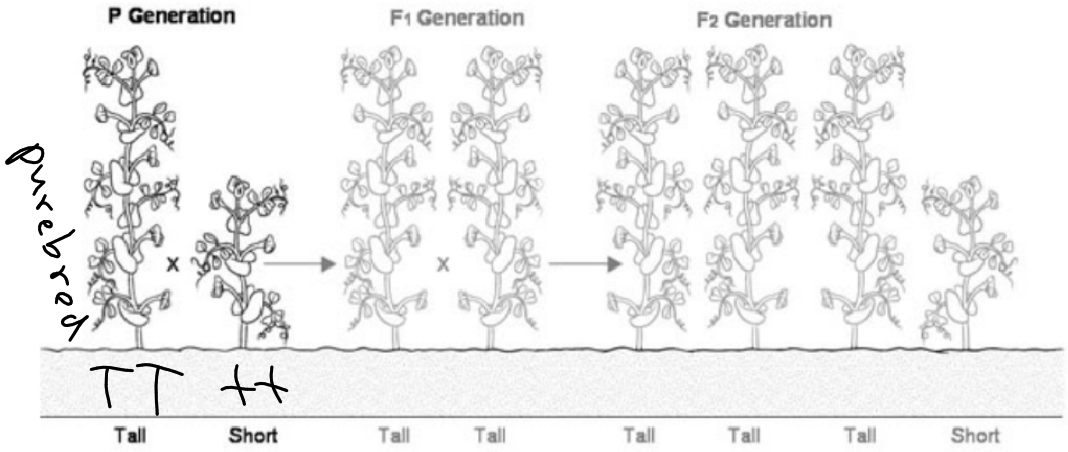
- ***Step 4: Collecting and Analyzing*** data

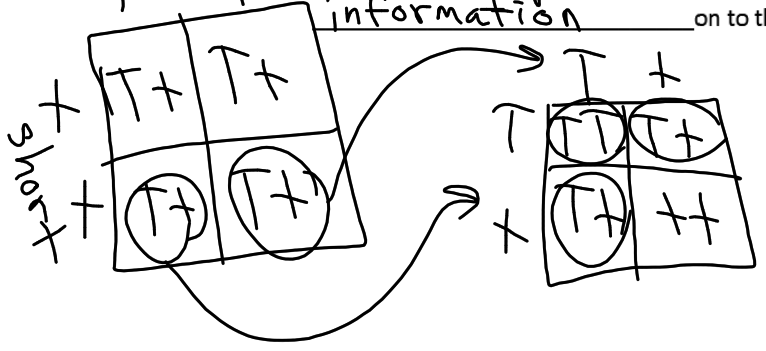
Parent Generation	*F_1 Generation*	*F_2 Generation*
TALL x SHORT	100% tall OFFSPRING	75% TALL, 25% SHORT
YELLOW SEEDS x GREEN SEEDS	100% yellow SEEDED	75% YELLOW, 25% GREEN
SMOOTH POD x PINCHED POD	100% smooth PODS	75% SMOOTH, 25% PINCHED
ROUND SEED X WRINKLED SEED	100% round SEEDS	75% ROUND, 25% WRINKLED



- ***Step 5: Drawing*** Conclusions

tall
- After all his experiments, Mendel concluded that:
  - Each parent passes pieces of genetic information on to their offspring.

T T



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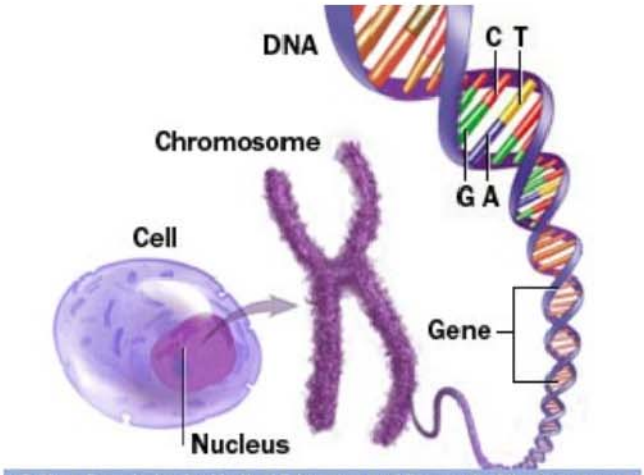
- Some of these pieces of information are strong while other pieces of information are weak.
- Mendel called the strong pieces of information dominant and the weak pieces of information recessive.
- Dominant traits are expressed whenever they are present in an organism, but recessive traits are only expressed when they are inherited from both parents.

- ***Step 6:*** Sharing your results
  - Mendel's experimental results were published by the Natural Science Society journal in 1865 under the title, "*Experiments on* Plant Hybridization".

What do we know NOW that Mendel did not know in 1865?

1. Every part of the human body is made up of tiny units called cells and every cell is controlled by a nucleus.
2. Every nucleus within every cell in the human body contains identical DNA, the molecule that carries the code that determines all of your body's traits.
3. All of the DNA within a nucleus is divided up between 46 different chromosomes, or rod-shaped chunks of DNA that come in 23 pairs.



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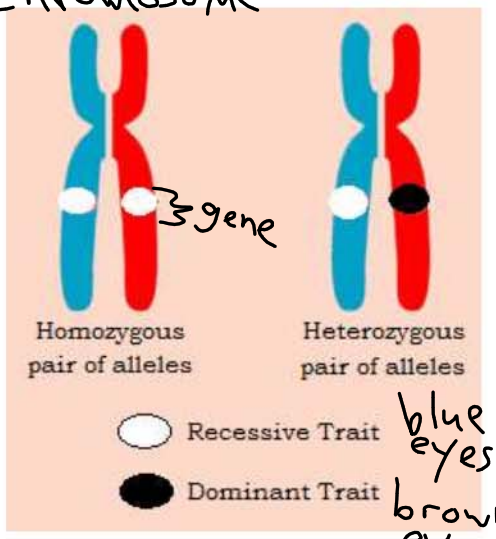
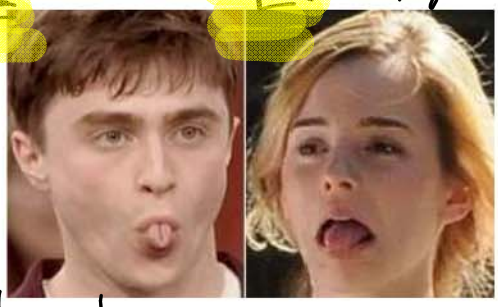
4. Each chromosome contains a unique sequence of genes, or segments of DNA that code for specific traits or characteristics. The genes are lined up on the chromosome like beads on a string.
5. Each gene comes in a pair and can exist as one of two possible versions of a gene. Each version is called an allele.
6. A child inherits one allele from each parent for a total of two alleles for each gene that exists.
7. The human genome contains 35,000 different genes. If each gene has 2 versions, then there are 70,000 different possible genes in the human genome.



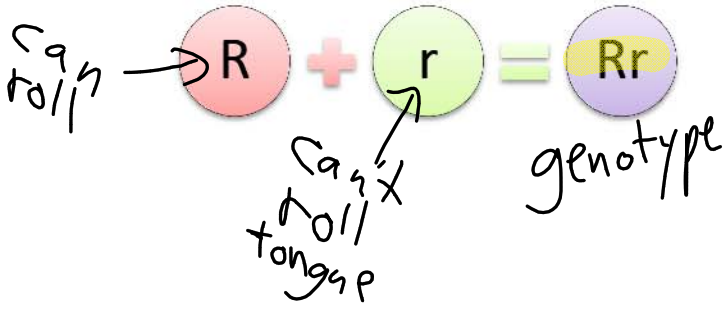
Important Pre-Requisite Vocabulary

- Phenotype: The physical appearance or observable trait in an organism caused by a gene.
  - ***Example:*** If I said, "Harry can roll his tongue", I would be describing Harry's phenotype for the tongue-rolling gene.

photo of a phenotype



- Genotype: The combination of alleles an organism has that produces a specific trait.



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- ***Example:*** If I said, "Bob received a dominant tongue-rolling gene from his mother and a recessive tongue-rolling gene from his father", I would be describing Bob's genotype.

- homozygous: Describes a genotype made of two identical alleles.
  - "homo" = same
    - dominant + dominant from Mom & Dad
    - recessive + recessive from Mom & Dad
- heterozygous: Describes a genotype made of two different alleles.
  - "hetero" = different
    - dominant + recessive from Mom & Dad
- dominant allele: A gene version strong enough to be expressed, even if it is paired with a different gene.
  - Represented by a capital letter
  - Ex 1: Brown eyes (B)
  - Ex 2: Rolling tongue (R)
  - Ex 3: Widow's peak (W)

tall = T
short = t

- recessive allele: A weak version of a gene that can only be expressed if it is paired with another weak version of the same gene.
  - Represented by a lower-case letter
  - Ex 1: Blue eyes (b)
  - Ex 2: Unable to roll tongue (r)
  - Ex 3: No widow's peak (w)

homozygous dominant RR

homozygous recessive rr

Rr ← heterozygous

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Let's Practice:

BB
Bb
bb
RR
Rr
rr

Trait:	YOUR Phenotype:	All Possible Genotypes:
Eye Color	Brown	BB or Bb
Tongue Rolling	can roll	RR or Rr
Widow's Peak	no yes	ww WW or Ww

After Gregor Mendel

- Mendel's experiments went largely unnoticed by the scientific community until after his death.
- Around 1900, several scientists rediscovered Mendel's work; one of them was Reginald Punnett.

Who was Reginald Punnett?

- Punnett was a professor at Cambridge University working in the study of zoology, but with a deep interest in genetics.
- Wrote the first textbooks on genetics: Mendelism (1905).
- Developed a tool for predicting the possible genetic outcomes of offspring between two parents.
- His tool was called the Punnett Square
- If Mendel and Punnett could have worked together, Mendel's experimental results could have been explained by the following:

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- Experiment 1 – Cross purebred plants with opposite traits.
  - The phenotypes of this cross are Tall x short
  - The genotypes of this cross are TT x tt
  - Put into a Punnett Square, it would look like this:

tt

	T	T
t	Tt	Tt
t	Tt	Tt

heterozygous

Phenotype Results:
100% tall
0% short

Genotype Results:
100% Tt
dominant

- Experiment 2 – Cross the offspring of the F, generation.
  - The phenotypes of this cross are tall x tall
  - The genotypes of this cross are Tt x Tt
  - Put into a Punnett Square, it would look like this:

	T	t
T	TT	Tt
t	Tt	tt

Photo Physical appearance

Phenotype Results:
75% tall
25% short

Genotype Results:
25% TT
50% Tt
25% tt

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Practice: Choose *2 possible crosses* from the *F_1 generation* results above and complete the Punnett analyses for both. 2

1. *First possible cross:*
   - The phenotypes of this cross are Tall x Tall
   - The genotypes of this cross are TT x Tt
   - Put into a Punnett Square, it would look like this:

	T	T
T	TT	TT
t	Tt	Tt

Phenotype Results:
100% tall
0% short

Genotype Results:
50% TT
50% Tt

2. *Second possible cross:*
   - The phenotypes of this cross are Tall x short
   - The genotypes of this cross are Tt x tt
   - Put into a Punnett Square, it would look like this:

	T	t
t	Tt	tt
t	Tt	tt

Phenotype Results:
50% Tall
50% short

Genotype Results:
50% Tt
50% tt