

Genetics: The Science of Heredity



Lesson 1
A Priest-Scientist
Gregory Mendel

Who was Gregory Mendel?

- Gregory Mendel was an Austrian monk.
- He lived between 1822 to 1884.
- When he was a young boy, he was interested in the plants that grew on the family farm.
- Mendel was the gardener of the monastery where he lived as a monk. He did experiments on hundreds of pea plants there.
- He kept careful records and used mathematics to make sense of what he observed.



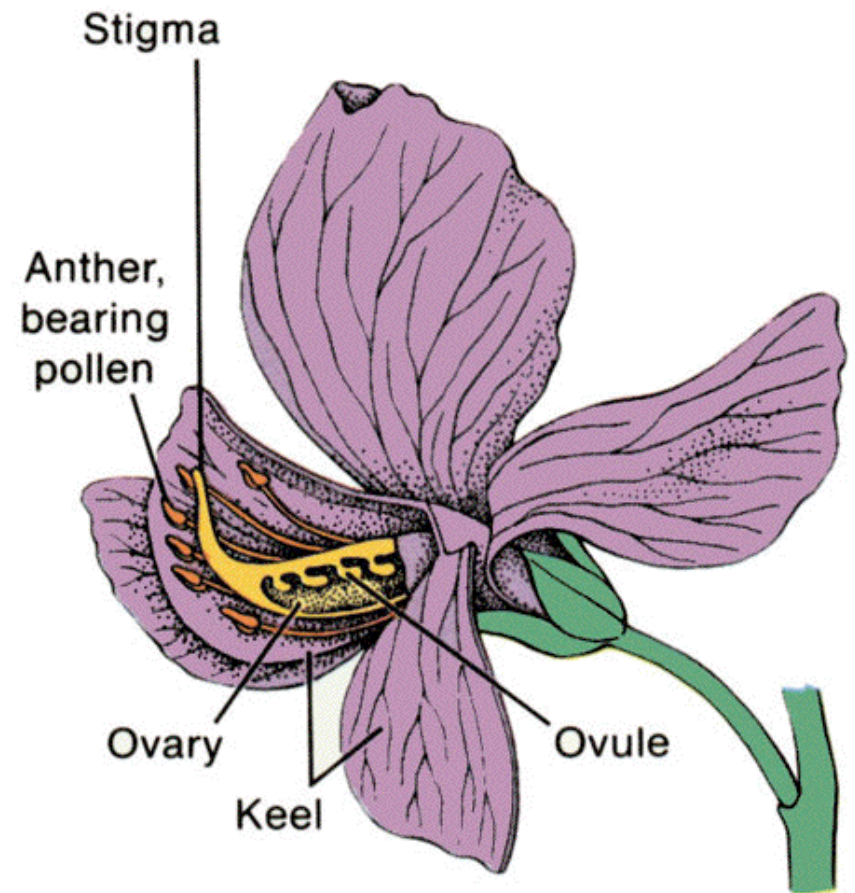
Heredity

- Heredity is the passing of traits from parents to offspring.
- Mendel experimented with heredity of certain traits found in peas.
- Mendel studied each trait separately and discovered certain patterns in the way traits are inherited in peas.
- Mendel's work has become the basis of genetics, the study of heredity.

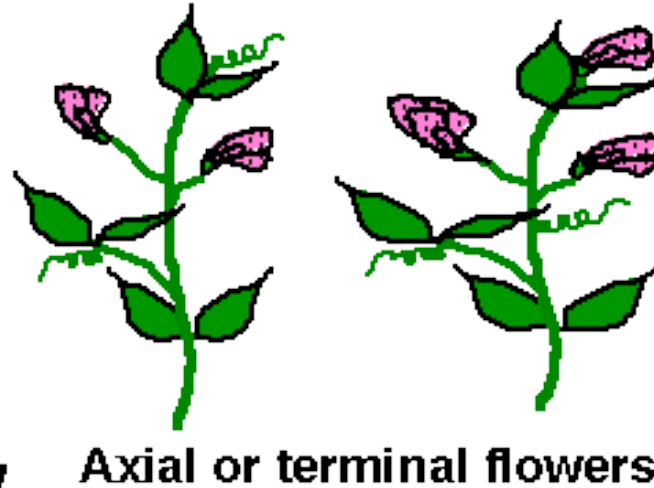
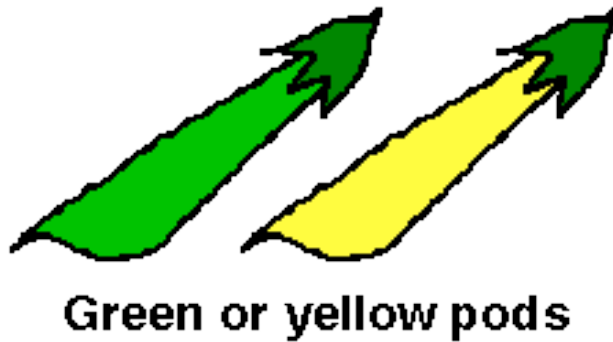
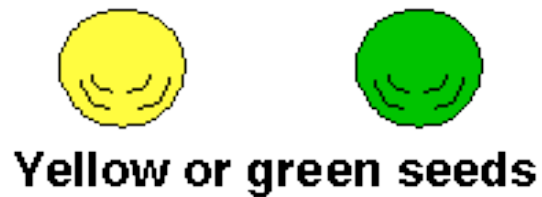


Mendel's Pea Experiments

- Mendel chose pea plants because their traits were easy to see and distinguish.
- He crossed plants with two different traits, for example purple flowers with white flowers.
- He started his experiments with purebred plants.
- Purebred plants **ALWAYS** produce offspring with the same trait as the parent. For example, if the parent is tall, all offspring will be tall. If the parent is short, all offspring will be short.

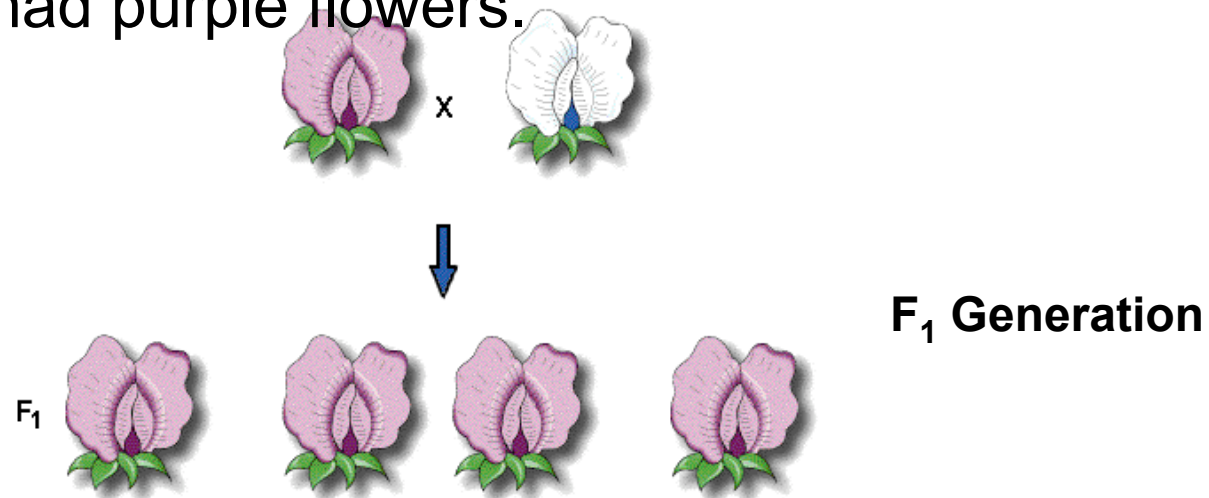


Some Pea Traits that Mendel Studied



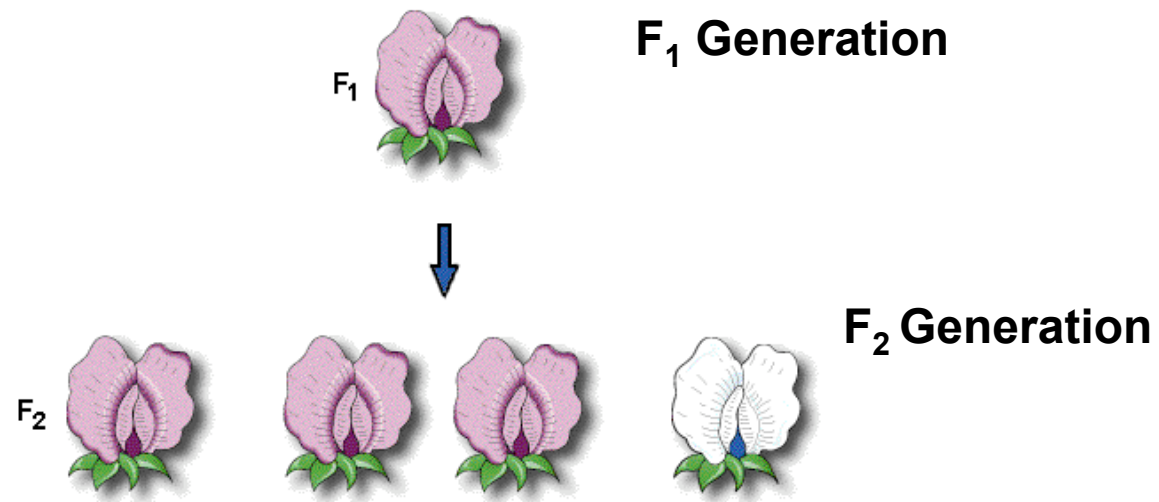
F₁ Generation

- Mendel called the parent plants the **P** generation.
- He called the offspring from the parents the **F₁** generation.
- F is from the Latin word, *filial*, which means son.
- When Mendel crossed pure pea plants with purple flowers with pure pea plants with white flowers, all the F₁ generation had purple flowers.



F₂ Generation

- When he crossed the F₁ generation peas with one another, only some of the offspring had purple flowers. These formed the F₂ generation.
- Mendel found that in the F₂ generation, $\frac{3}{4}$ of the plants had purple flowers and $\frac{1}{4}$ of them had white flowers.



Lesson 1 Review

- Who was Gregory Mendel?
- Why did he choose peas for his experiments?
- What is heredity?
- What is genetics?
- What is a purebred plants?
- What is the P generation?
- What is the F₁ generation?
- What is the F₂ generation?

Lesson 2

Understanding Mendel's Experiments

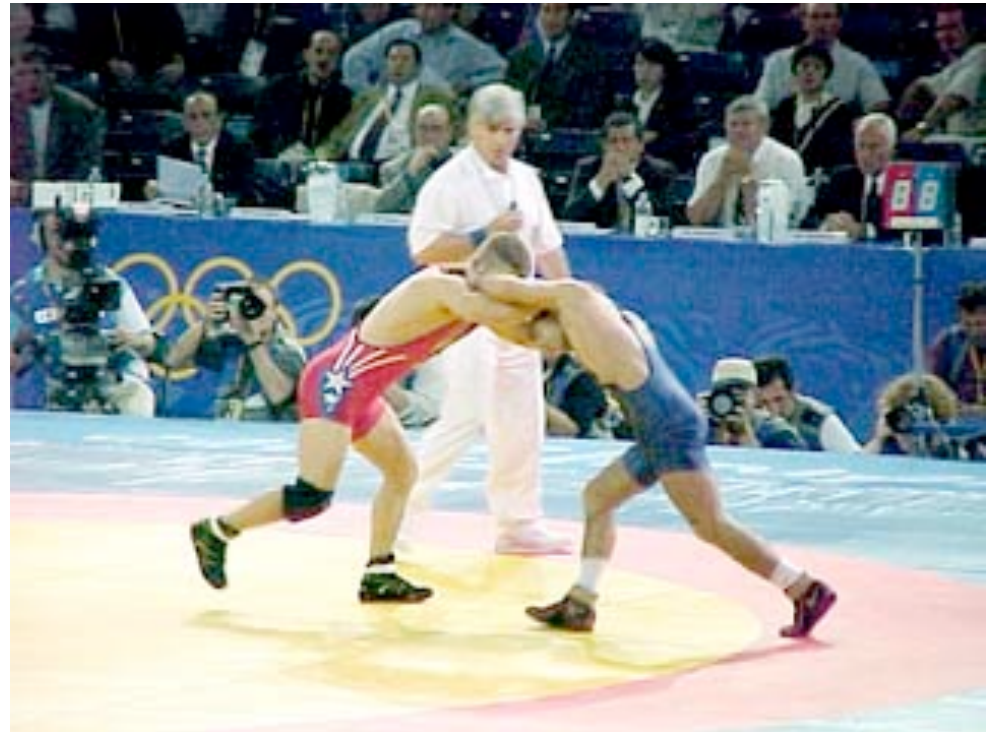
Mendel's Amazing Discovery

Mendel did the same experiment with all 7 traits that he studied and discovered the same pattern each time: In the F1 generation, one trait was always hidden. That trait appeared in the F2 generation in about $\frac{1}{4}$ of the plants.



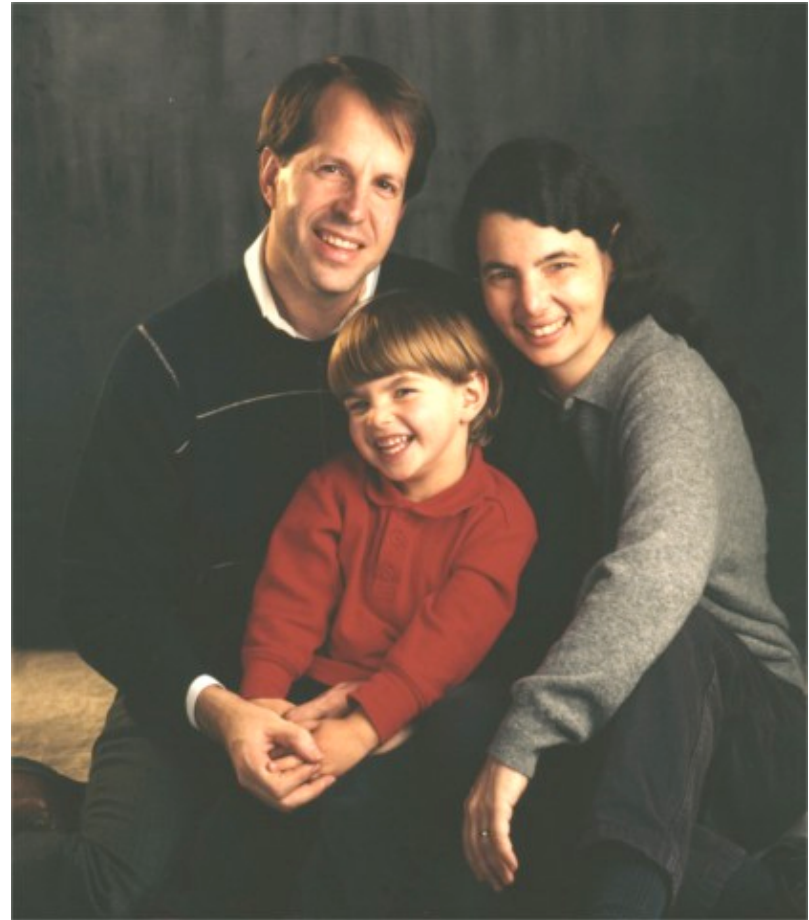
Dominant and Recessive Traits

- It seemed to Mendel, that for each characteristic in peas, one trait was stronger than the other.
- He called the “stronger” one, the **dominant** trait.
- He called the “hidden” one, the **recessive** trait.



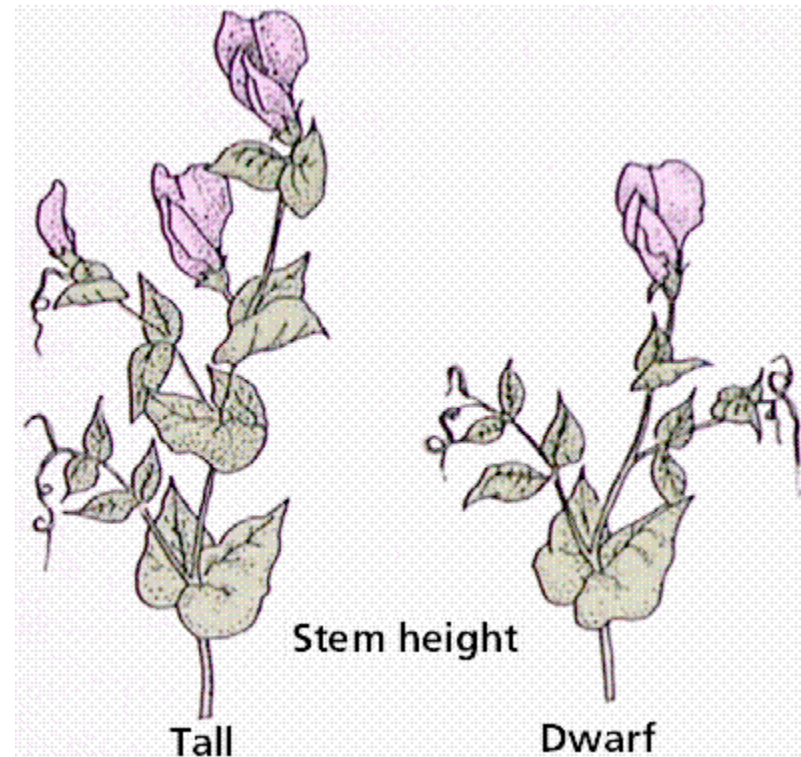
Genes and Alleles

- The traits of peas (and yours) are controlled by factors that scientists call genes.
- You inherit your genes from your parents.
- The different forms of a gene are called *alleles*.
- You inherit a combination of two alleles from your parents.

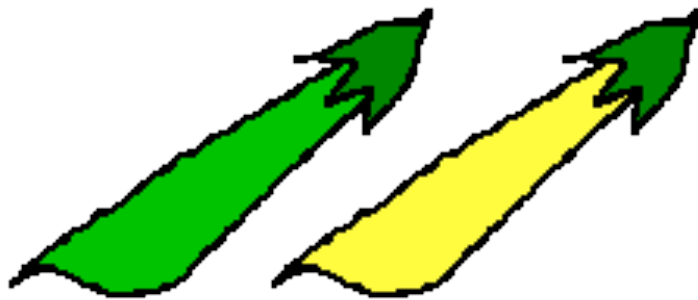


Dominant and Recessive Traits in Peas

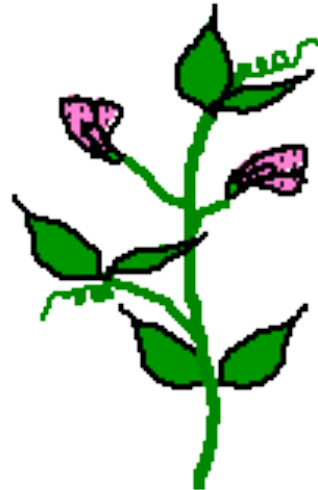
- For each of the 7 traits that Mendel studied in peas, there is a dominant allele and a recessive allele.
- If a plant inherits both a dominant allele and a recessive allele, the dominant allele masks the recessive allele.



Some Pea Traits that Mendel Studied



Green or yellow pods



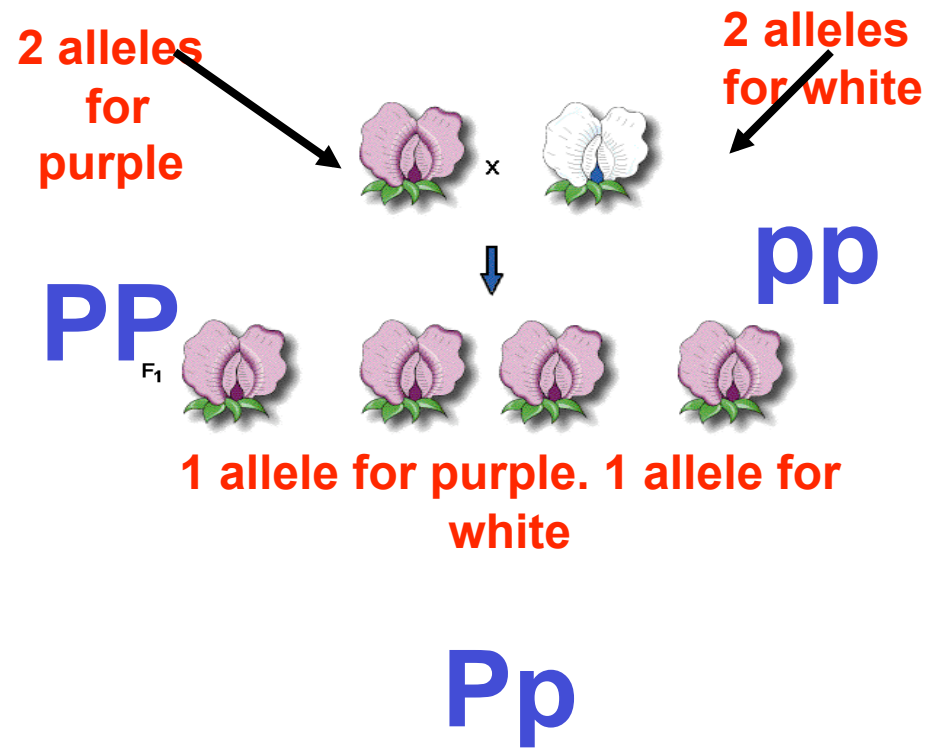
Axial or terminal flowers



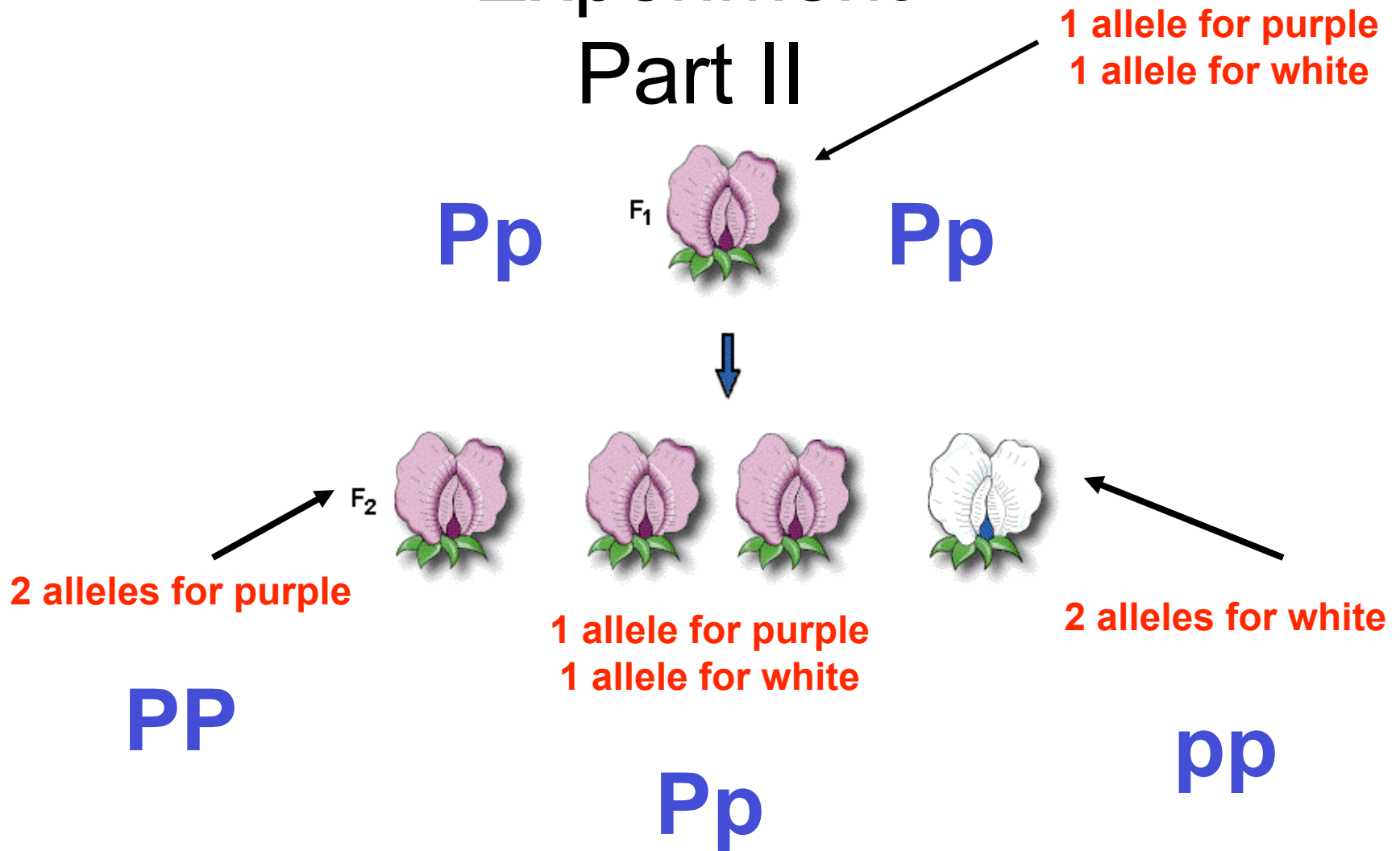
Purple or white flowers

Understanding Mendel's Experiments

Part I



Understanding Mendel's Experiment Part II



Lesson 2 Review

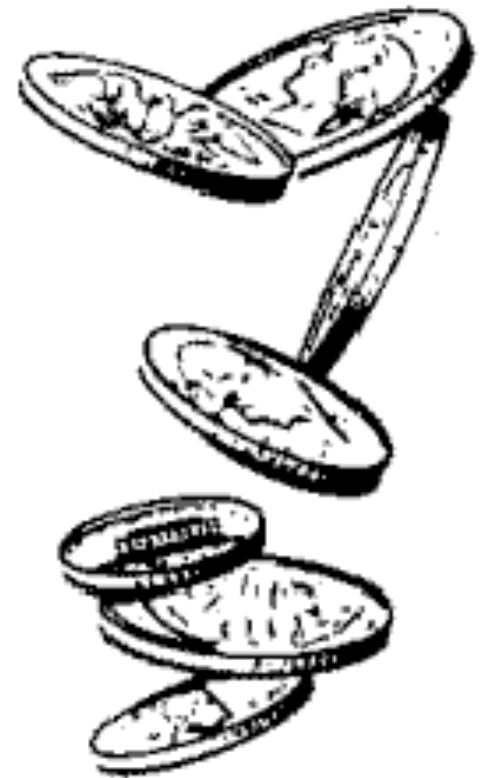
- What did Mendel find to be the same with all 7 traits of the pea plant that he studied?
- What are genes?
- What are dominant alleles?
- What are recessive alleles?
- What happens if a pea plant inherits two dominant alleles of the same gene?
- What happens if a pea plant inherits a dominant allele and a recessive allele of the same gene?
- What happens if the pea plant inherits two recessive alleles of the same gene?

Lesson 3

Probability and Genetics

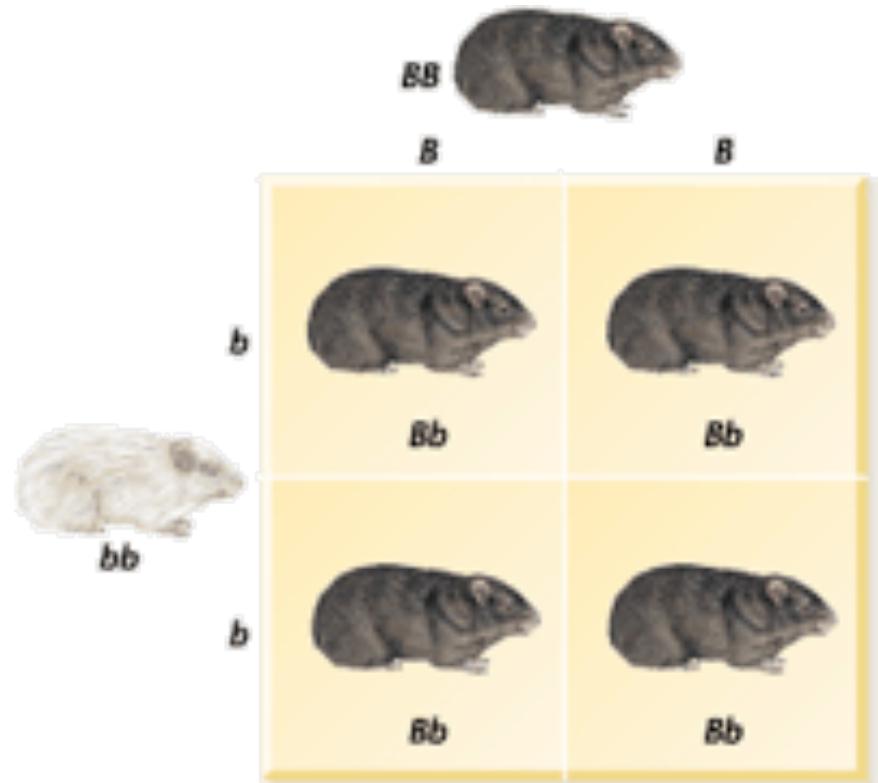
Probability

- Probability is the likelihood that a particular event will occur.
- The laws of probability determine what is likely to occur, not what does occur.
- Mendel was the first scientist that applied the principles of probability to genetics.



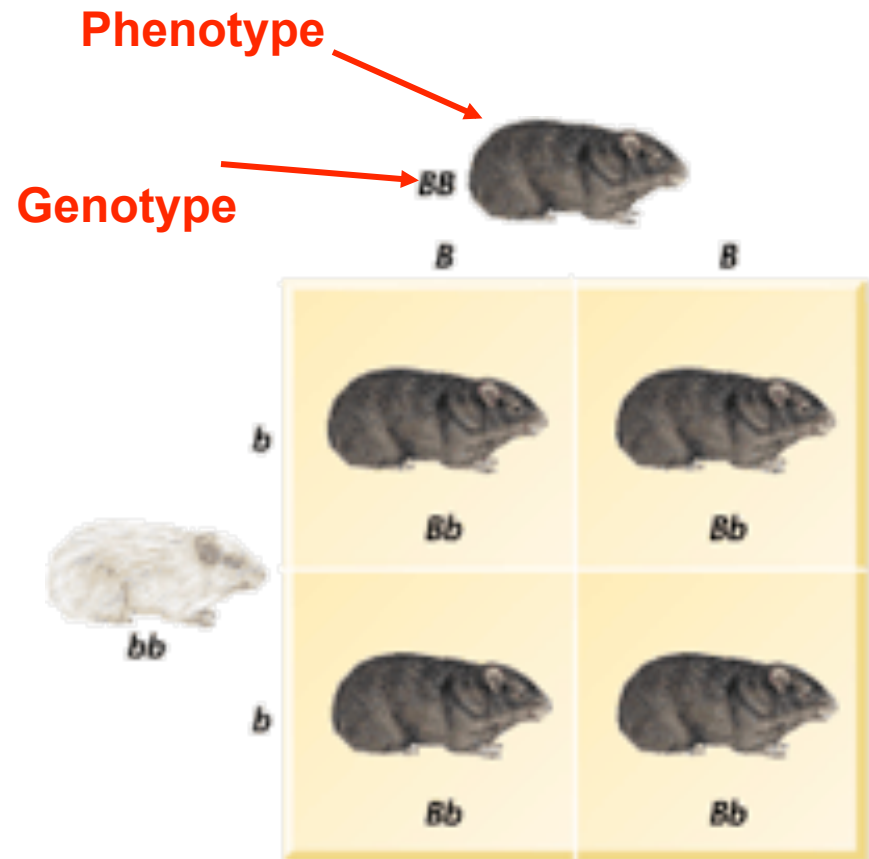
Punnett Square

- *Punnett square* is a table that shows all the possible combinations of alleles that can result when two organisms cross.
- Using Punnett square, geneticists can predict the probability of occurrence of a particular trait.
- The allele that each parent will pass to its offspring is based on chance, just like tossing a coin.



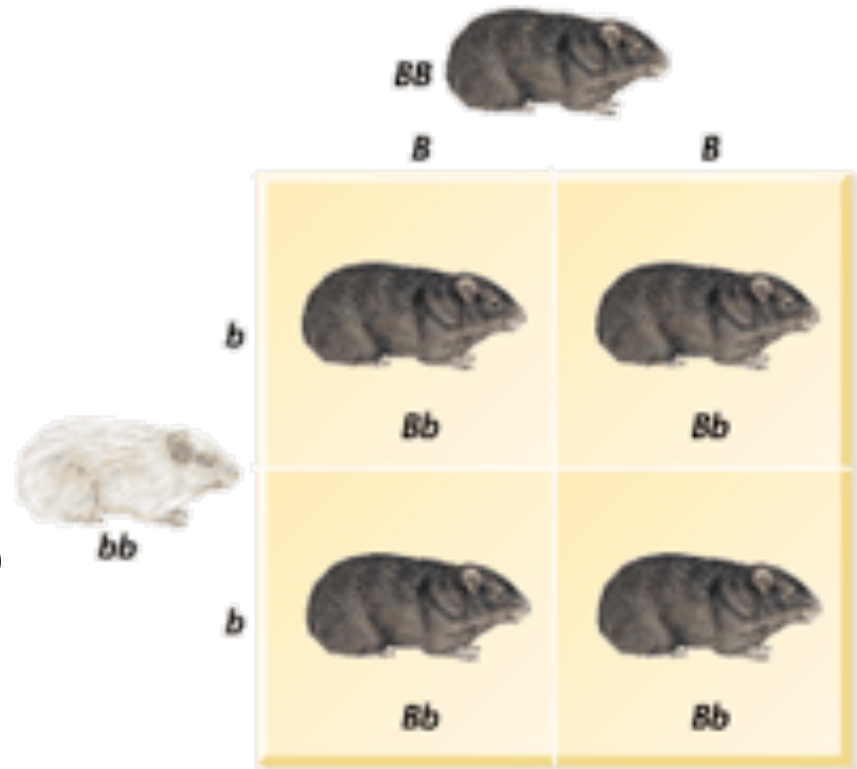
Genotypes and Phenotypes

- Genotype: Indicates the alleles that the organism has inherited regarding a particular trait.
- Phenotype: The actual visible trait of the organism.



Homozygous and Heterozygous

- *Homozygous*: An organism with two identical alleles for a trait (a *purebred* organism).
- *Heterozygous*: An organism that has two different alleles for a trait (a *hybrid* organism).



Codominance

- In codominance, the alleles are neither dominant, nor recessive. Neither allele is masked by the other.

Roan Cow

Is both white and red



Review

- What is probability? How is it related to genetics?
- What is the Punnett Square? How is it helpful to geneticists?
- What is a genotype?
- What is a phenotype?
- What is a homozygous organism?
- What is a heterozygous organism?
- Explain codominance.

Paper Pets

Traits	Dominant	Recessive
Body Color	Blue (B)	Red (b)
Gender	XX (Female)	XY (Male)
Eyes	Round (R)	Square (r)
Nose	Triangular (T)	Oval (t)
Teeth	Pointed (P)	Square (p)

Paper Pets

	Phenotype	Genotype
Color	red	bb
Gender	Male	XY
Eyes	Round	Rr, RR
Nose	oval	tt
Teeth	Pointed	Pp, PP

Lesson 4

Chromosome Theory

What are Chromosomes

- Chromosomes are made of chromatin.
- Chromatin is found in the nucleus of cells and is made of about 40% DNA and 60% Protein.
- The DNA of a chromosome is a very long, double stranded fiber that extends unbroken through the entire length of the chromosome.
- The amount of information a chromosome contains would fill about 280 printed books of 1000 pages each.
- Chromosomes come in different sizes.



The Number of Chromosomes

- Most cells in different organisms have between 10 to 50 chromosomes in their nucleus.
- Humans have 46, which consists of 23 pairs.
- Each chromosome in a pair is nearly identical to the other chromosome in the pair.
- Humans that have even one missing or one extra chromosome usually die before birth or have serious defects.
- Down Syndrome happens when a person is born with an extra copy of chromosome number 21.



The Number of Chromosomes in Different Organisms

- Humans: 46
- Dogs: 78
- Silkworms: 56
- Hamster: 44

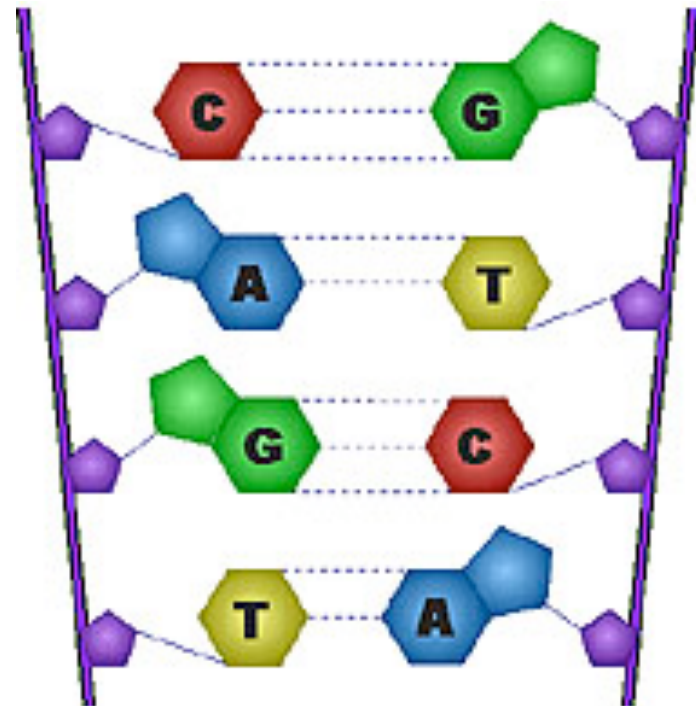
DNA

- DNA was discovered in 1869 by a German chemist named Friedrich Miescher.
- In 1953, two scientists, James Watson and Francis Crick put together the information discovered by many scientists over the years and came up with the structure of the DNA molecule as a “*double helix.*” (*helix means spiral*)



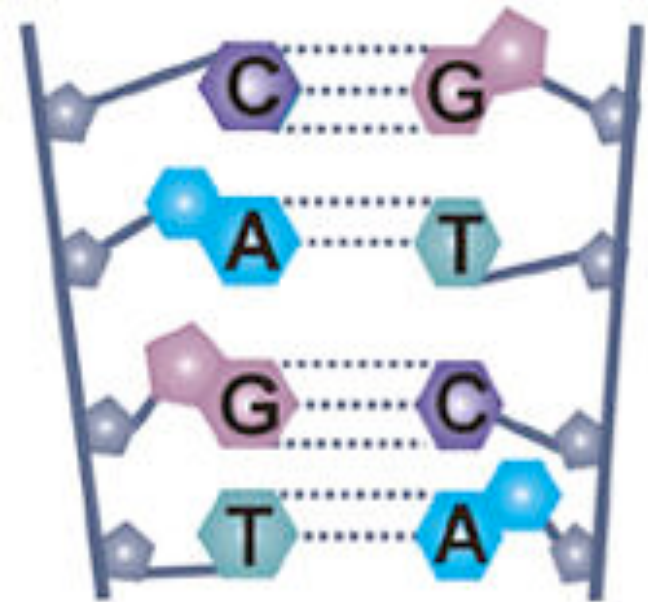
The Structure of DNA

- The DNA molecule is made of smaller molecules called *nucleotides*.
- Each nucleotide is made of 3 smaller molecules: a *sugar*, a *phosphate*, a *nitrogen base*.
- There are 4 different nitrogen bases in a DNA molecule:
 1. Adenine (A)
 2. Guanine (G)
 3. Cytosine (C)
 4. Thymine (T)



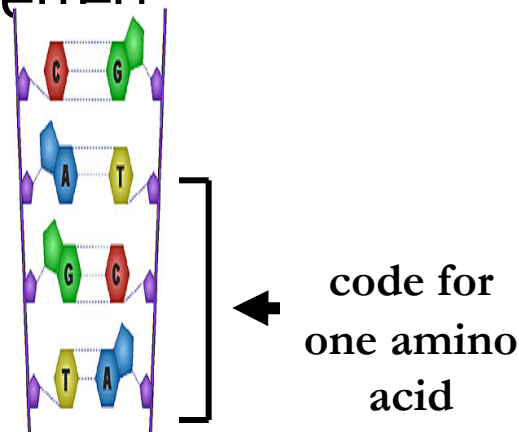
Nitrogen Bases of the DNA

- Each nitrogen base of a DNA molecule forms a pair with only one other nitrogen base:
 - ❖ Adenine (A) always pairs with Thymine (T)
 - ❖ Cytosine (C) always pairs with Guanine (G)



Genes and DNA

- The sequence of 3 nucleotides on the DNA molecule code for the production of a specific amino acid, the building block of proteins.
- The genetic code is the same in almost all organisms.
- Humans have 60,000 genes.
- The chromosome theory states that when the DNA that makes up chromosomes is transferred from parents to offspring, the information encoded in the genes is also transferred



Lesson 4 Review

- What are chromosomes made of?
- Explain the number of chromosomes in different organisms.
- Why is a DNA molecule called a double helix?
- What are nucleotides?
- How do nitrogen bases in the DNA molecule pair up with each other?
- What is a gene?

Lesson 5

Meiosis

Chromosomes in Eggs and Sperms

- In 1882, Belgian scientist Pierre-Joseph van Beneden discovered that the number of chromosomes in sex cells (eggs and sperms) are half the number than in the other cells.
- Each of your cells have 46 chromosomes. You inherited 23 from your mother's egg cell and 23 from your father's sperm cell.



Meiosis

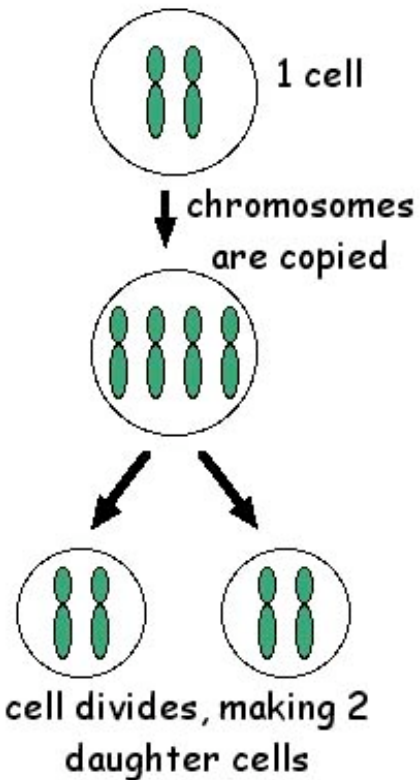
- Meiosis is the process of cell division in which sex cells (eggs and sperms) are formed.
- Meiosis results in 4 daughter cells from each parent cell, each with half the number of chromosomes found in the parent cell.



Mitosis and Meiosis

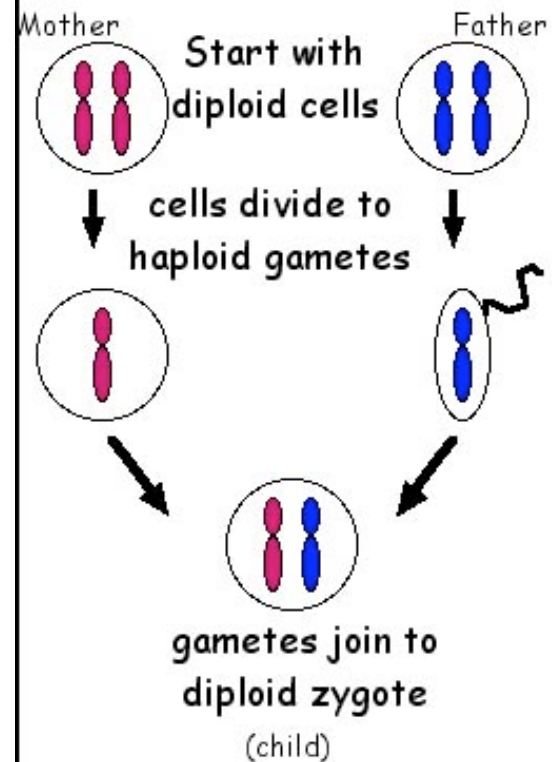
Mitosis:

(Only one of the 23 pairs of chromosomes is drawn)

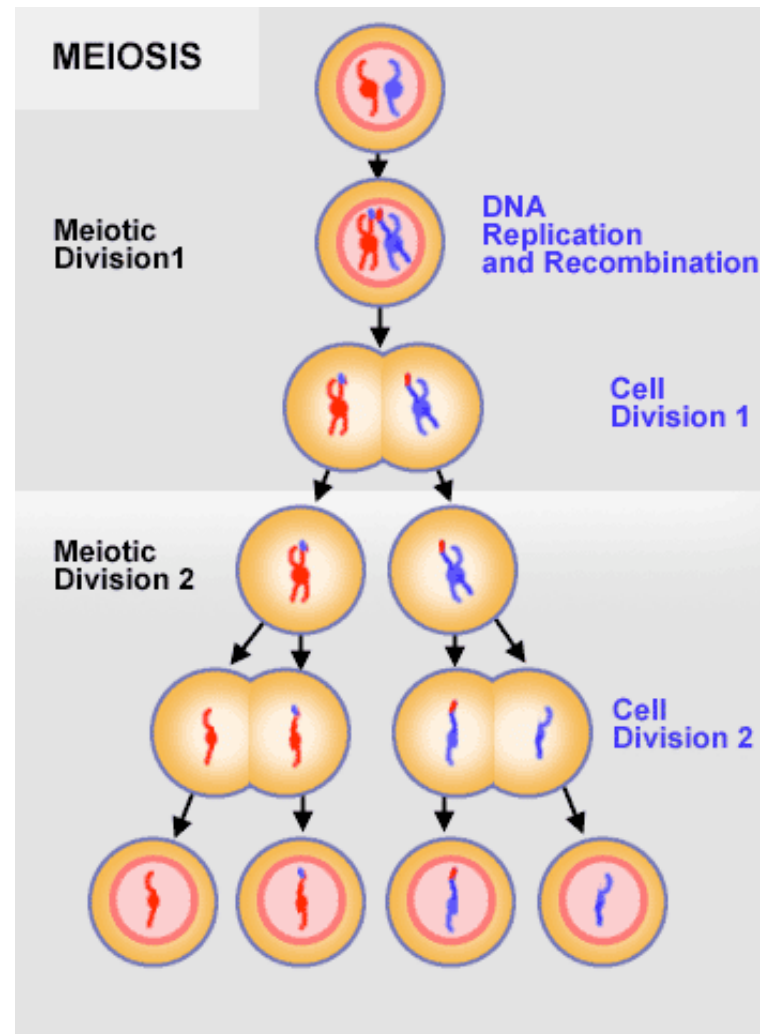


Meiosis:

(Only one of the 23 pairs of chromosomes is drawn)



2 Mitosis = 1 Meiosis



Comparing Meiosis and Mitosis

Mitosis	Meiosis
One cell division	Two cell divisions
Two daughter cells	Four daughter cells
Daughter cells have the same number of chromosomes as the parent cells.	Daughter cells have half the number of chromosomes as the parent cells.

**Animating changes
of the nucleus
during mitosis.**

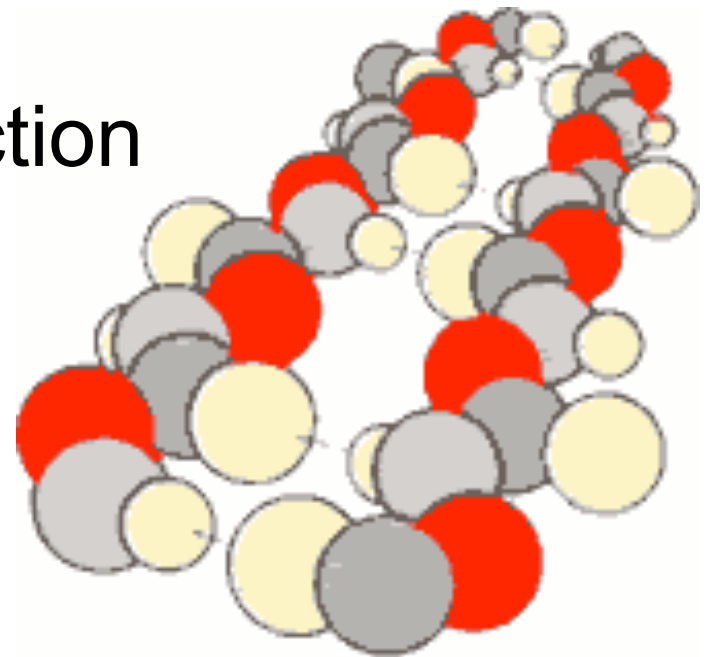
**Animating changes
of the nucleus
during meiosis.**

Lesson 5 Review

- How is the number of chromosomes in sex cells different than in other cells?
- What is Meiosis?
- During Meiosis, how many daughter cells are produced from each parent cell?
- During Meiosis, how many cell divisions occur?

Lesson 6

Protein Production

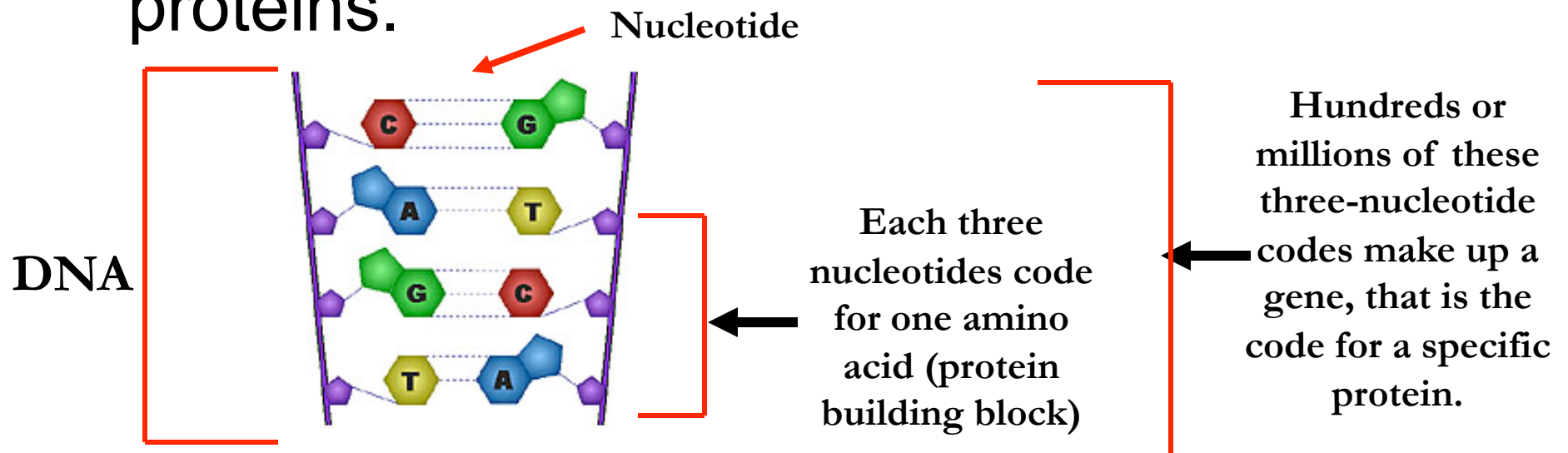


Proteins

- Proteins are the tools of heredity.
- Cells use the information in their DNA to produce particular proteins.
- Proteins affect what the cells will be like:
 - ✓ You will have arms rather than fins.
 - ✓ You will have two eyes rather than three.
 - ✓ You will have hair rather than feathers.

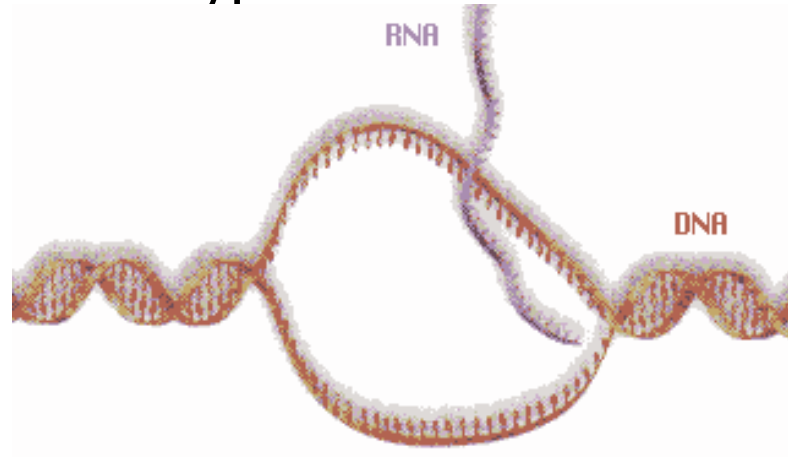
Genes are Codes for Proteins

- The sequence of 3 nucleotides on the DNA molecule code for the production of a specific amino acid, the building block of proteins.



RNA (Ribonucleic Acid)

- One type of RNA is like the messenger that takes the genetic information from the DNA inside the nucleus to the Ribosome inside the cytoplasm.
- Proteins are made on ribosomes in the cytoplasm using information from RNA.
- There are three types of RNA.



Three types of RNA

1. mRNA (Messenger RNA): Get genetic information from the DNA and take it to the ribosome. On the ribosome, this information determines the types of amino acids that are needed to make proteins.
2. rRNA (Ribosomal RNA): The site where proteins are put together. Ribosomes are made mostly of rRNA.
3. tRNA (Transfer RNA): Carry specific amino acids to the ribosome where they are put together to make proteins.

Protein Production

