Unit 4: Genetics

Unit Overview:

Genetics is one of the most exciting and upcoming fields in biology. Since the discovery of the double helix structure of DNA in the 1950's by James Watson and Francis Crick, genetics has forged ahead at a breakneck pace. Just 20 years ago, cloning was thought to be nearly impossible. Today, the cloning of mammals can be achieved in the laboratory. Many people wonder how long it will take before we are able to clone a human. How did this genetic revolution begin? Where is it headed? In this unit, students will learn foundational principles of genetics, including the structure and function of DNA, how to calculate offspring ratios, and some of laboratory techniques used in genetic research.

Lesson 1 Chromosomes, Genes, Alleles and Mutations—IB Topic 4.1 (3 days)

This lesson gives students an understanding of:

- The difference between chromosomes, alleles and genes.
- The causes and results of mutation.

Materials needed: Internet access.

Lesson Introduction/Springboard Activity:

Ask students if they look like their parents? Some may look like their mother, and some like their father. Maybe they are a combination of both, or look nothing at all like their parents. Resemblance is due in part to the inheritance of traits, which are found on genes. Genes exist in different versions, or alleles, which account for variability, even when it is found in the same family.

Suggested Teaching Strategies:

Be aware there may be students in class who have been adopted, or for other reasons do not know one or both of their biological parents. When talking about resemblance, be sensitive to this issue. This may be a good time to bring up the role of nature versus nurture. Genes are not the only factor that influences appearance. Environment also plays a role.

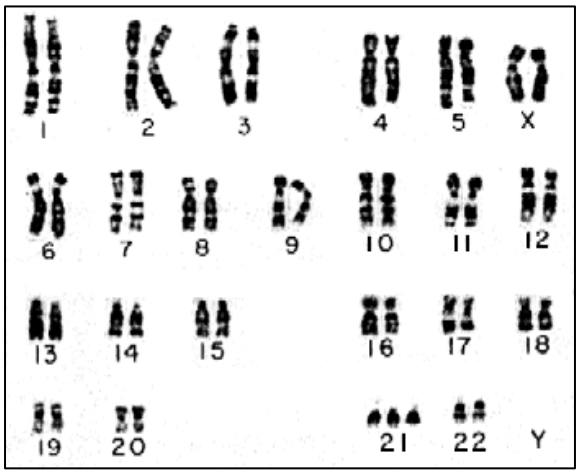
Daily Specifics:

***Day 1*:** Present 4.1 PowerPoint/Class notes--Chromosomes, Genes, Alleles and Mutations. Students follow along and take notes in their student workbook.

Vocabulary

- Histone
- Karyotype
- Gene
- Allele
- Genome
- Down Syndrome
- Sickle Cell Anemia

Development

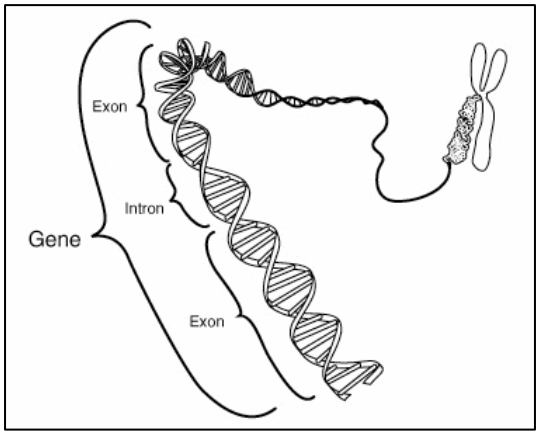


A karyotype shows the presence or absence of chromosomes, as well as the size of a persons chromosomes. Since each person has two sets of every chromosome, the homologues are placed together. Chromosomes are numbered in sequence from the largest ones in size to the smallest, with the exception of the sex chromosomes X and y.

In the karyotype to the left, there is an extra 21st chromosome, which indicates Down Syndrome.

Genes are sections of DNA which code for a particular trait. Genes can be anywhere from several hundred to several thousand base pairs long.

Alleles are different versions of genes. Each person usually has two alleles for each gene. For example, the gene for hair color may be represented by a blond allele and a brown allele.



***Day 2*:** Web Activity: DNA Interactive. **www.dnai.org**. Click on the "code" subheading, and follow the online directions

***Day 3*:** Go over study guide and web activity.

Lesson Review

Q: What are the tight coils of DNA/protein called?
A: Histones.

Q: What can be seen by a karyotype?
A: The number and size of a person's chromosomes.

Q: What are alleles?
A: Alleles are different versions of genes.

Q: What is a mutation?
A: A mutation is a change in the base sequence of a gene. It can be as small as one base pair difference.

Q: What causes Down Syndrome and Sickle Cell Anemia?
A: Down Syndrome is caused by an extra 21st chromosome. Sickle Cell Anemia is caused by a base pair substitution, which converts GAG to GTC.

Lesson 2 Meiosis—IB Topic 4.2 (3 days)

This lesson gives students an understanding of:

- How gametes are formed.
- The Law of Segregation.
- The Law of Independent Assortment.

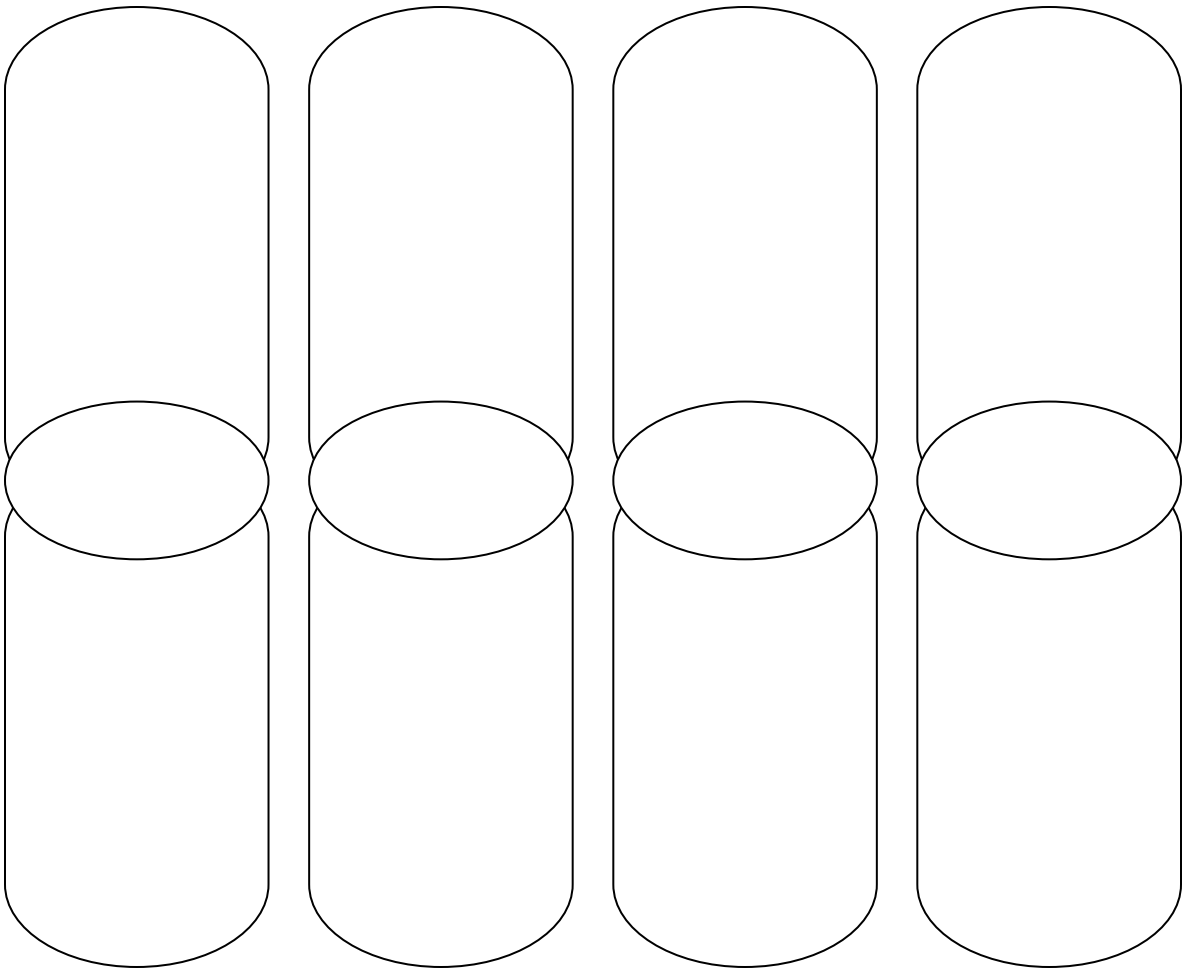
Materials Needed:

1 deck of cards
1 roll tape masking tape
African dance music and music player (other types of music may be substituted)

Lesson Introduction/Springboard Activity: The same parents give birth to two daughters, and they are completely different. How can this be? Both girls came from the same parents. The answer lies in how the parent's gametes (sperm and egg) were formed. Humans have two sets of every type of gene they need. They get one set from their own mother, and one set from their own father. When it comes time to make gametes, only one of those two sets are passed on. Therefore, daughter #1 may have inherited her eyes from her mother's mother, whereas daughter #2 may have inherited her eyes from her mother's father. This variability is illustrated by the Law of Segregation and the Law of Independent Assortment, which are examined in this lesson.

Suggested Teaching Strategies:

The Meoisis Mating Dance is a fun activity, and the more creative students get with the mating dance the better. Students can be told of this activity in advance of class, and are encouraged to bring in props such as robes and grass skirts. Regarding the chromosomes, below is a template to make a set of four chromosomes. Each template should be copied four times onto four different colors of photocopy paper. Then they should be cut out and pasted together so that one side is one color and the other side is another color. Then, label chromosomes #1-3, with the fourth and "X" or "y" (X on one side and y on the other). The mother will start with a set of four two-toned chromosomes, and the father will have another set of two-toned chromosomes. For example, mom's chromosome #1 may be red on one side and yellow on the other. Dad's chromosome #1 may be blue on one side and green on the other. When the tribal chief (teacher) signals the couple, they throw their chromosomes up into the air and let them fall to the ground. Different colors should randomly face up. This represents the origin of that chromosome, which is either the mother's mother, mother's father, father's mother, and father's father. The point here is to show students that with each "shuffle of the reproductive deck", a different combination may result.



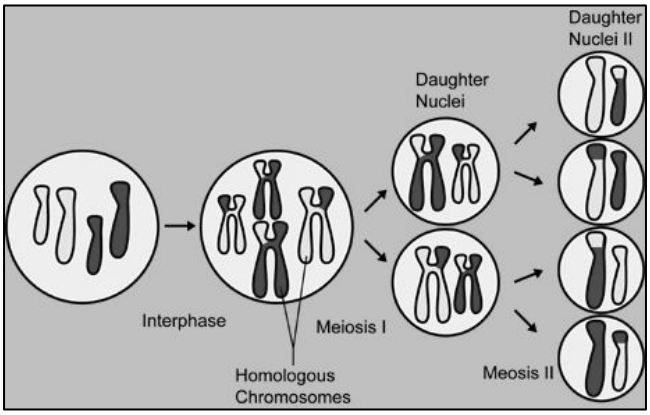
Daily Specifics:

***Day 1*:** Present PowerPoint/Class Notes 4.2 Meiosis. Students follow along and take notes in their student workbook.

Vocabulary

- Gametes
- Diploid
- Haploid
- Homologous chromosomes
- Law of Independent Assortment
- Law of Segregation
- Non-disjunction
- Monohybrid cross

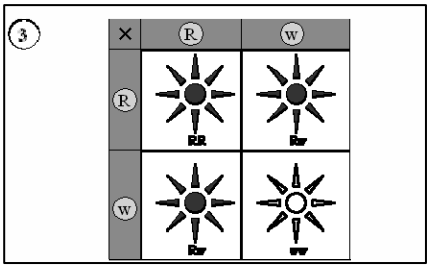
Development



The goal of meiosis is to produce gametes. During this process, a cell goes from a diploid number of chromosomes to a haploid number of chromosomes.

The Law of Independent Assortment states that each homologue sorts independently from each other homologue.

The Law of Segregation simply states that homologues normally separate during meiosis. When separation does not occur, it is called non-disjunction, and can result in genetic disorders such as Down Syndrome, Turner Syndrome, and Klinefelter Syndrome.



In a monohybrid cross, two heterozygous genotypes are mated. The resulting offspring ratios show a 75% chance that the phenotype will exhibit the dominant trait, and a 25% chance that it will exhibit the recessive trait.

Probabilities are often close to, but not identical to actual data collected. Just like there is a 50% chance that an offspring will be either male or female, many families have offspring which skew towards one gender of the other.

Day 2: 4.2 Lab—Meiosis Mating Dance. Instructions and chromosome template are on previous page.

***Day 3*:** Go over study guide and lab.

Lesson Review

Q: What are homologous chromosomes?
A: Homologous chromosomes are the same size and show the same banding pattern.

Q: What happens to the "n" number during meiosis.
A: A cell is reduced from diploid to haploid.

Q: Which law states that homologues sort independently of each other?
A: The Law of Independent Assortment.

Q: Name one genetic disorder caused by non-disjunction.
A: Down Syndrome.

Q: In a monohybrid cross, what is the probability that the offspring will exhibit the recessive trait?
A: 25%

Lesson 3 Theoretical Genetics—IB Topic 4.3 (3 days)

This lesson gives students an understanding of:

- The rules that govern the probability of offspring ratios.
- The difference between dominant and recessive traits.
- How to set up and solve a punnett square.

Materials Needed:

- Pencil and paper

Lesson Introduction/Springboard Activity:

How come two brown-eyed parents can have a blue eyed child? The answer is that blue eye color is a recessive trait. In the last lesson, students learned that humans have two sets of genes for each trait. Now students learn that some genes are dominant, and some are recessive. In order for a recessive trait to express itself phenotypically, a person must carry two copies of the allele. Therefore, it is possible that both parents each had only one copy of the blue eyed gene, yet both passed their copy to the offspring, giving them blue eyes. This concept can be illustrated by drawing a punnett square.

Suggested Teaching Strategies:

One of the easiest punnett squares to learn is that of gender. Students already know that when a child is born, there is a 50 percent chance it will be either a male or a female. Drawing a punnett square using the alleles "X" and "y" illustrates clearly why this is the case.

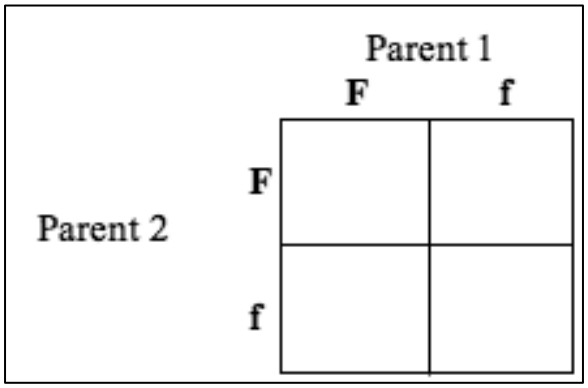
Daily Specifics:

Day 1: Present PowerPoint/Class Notes 3.3 Theoretical Genetics. Students follow along and take notes in their student workbook.

Vocabulary

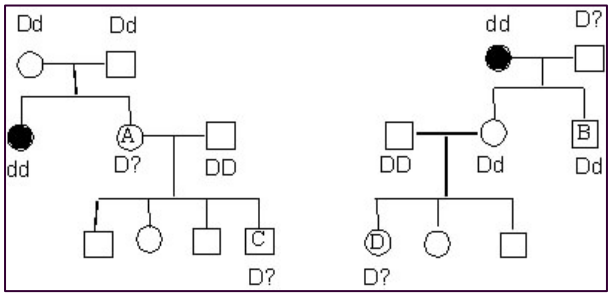
- Genotype
- Phenotype
- Dominant allele
- Recessive allele
- Codominant alleles
- Locus
- Homozygous
- Heterozygous
- Test cross
- Punnett square
- Pedigree chart
- Sex linkage

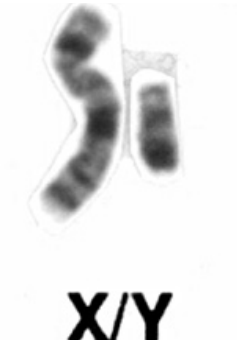
Development



When working a punnett square, the letters of each genotype are separated and put on the outside of the square. Then the new combinations are brought together inside each square.

In a pedigree chart, data over multiple generations is shown. Circles and squares usually represent different generations, and those shapes which are connected horizontally were parents of the offspring below.





Sex chromosomes look different from each other. The X chromosome is larger than the y chromosome. Two X chromosomes, a genotype of XX, indicate female gender, whereas an X and a y chromosome, a genotype of Xy, indicates male gender.

Sex-linked disorders are genetic variants which are carried on the sex chromosomes. The majority of sex-linked disorders are found on the X chromosome, although there are also disorders of the y chromosome.

Day 2: 4.3 Activity: Practicing Punnett Squares.

Day 3: Go over Study guide and Activity.

Lesson Review:

Q: If a genotype consists of one dominant allele and one recessive allele, what will the pheonotype be?
A: The phenotype will exhibit the dominant trait.

Q: Name one human phenotype which illustrates codominance.
A: Blood type.

Q: Which sex chromosome is larger?
A: The X chromosome.

Q: Where are sex-linked disorders found?
A: On the sex chromosomes.

Q: List two examples of sex-linked disorders.
A: Hemophilia and colorblindness.

Lesson 4 Genetic Engineering and Biotechnology—IB Topic 4.4 (3 days)

This lesson gives students an understanding of:

- Research methodology used in genetics.
- Hands-on experience with gel electrophoresis.

Materials Needed:

- 1 gel electrophoresis chamber
- 1 bottle of melt and pour agarose
- 1 bottle TBE buffer solution
- 1 power supply

- 1 set of electrophoresis dyes from Carolina.com

Lesson Introduction/Springboard Activity:
Three identical triplets each roll a rock along the ground for one minute. The first triplet rolls a 1 kg rock, the second a 10 kg rock. The third rolls a 100 kg rock. At the end of one minute, which rock has moved the farthest? Assuming the identical triplets are of equal strength, it would make sense that the 1 kg rock traveled the farthest, since it has the lowest mass and was therefore the easiest to move. This is the principle used in a genetic laboratory technique called gel electrophoresis. First, DNA in cut into pieces using restriction enzymes. Then the pieces are run through a gel using an electrical charge. The larger pieces stay closer to the starting points, whereas the smaller pieces travel further. In this way, a banding pattern is established. One person's banding pattern can differ from another, hence the term "DNA fingerprint." This technique can be used for paternity testing, crime scene investigations, and many other applications. In this lesson, students will run their own gel and see first hand how they look.

Suggested Teaching Strategies:
A good pre-lab to this activity is to take a black vis-à-vis (water soluble) marker and draw a line on chromatography paper. Place one end of the paper in water, and let the water wick through the paper. As it reaches the line, it will separate the pigments in the black marker, and a rainbow of color will appear. The separation of pigments is due to their difference in mass, which illustrates the same principle of gel electrophoresis.

Daily Specifics:
***Day 1*:** Present 4.4 PowerPoint. Students follow along and take notes in their student workbook.

Vocabulary
Polymerase chain reaction
Gel electrophoresis
Genetic screening
Human Genome Project
Gene therapy
Clone