EDUCATION
GEORGIA AQUARIUM

Lesson Plan
9-12 GENETIC HIJINX

Essential Questions:

1. How are traits expressed through genetics?
2. How are traits passed from one generation to another?

GSE Standards:

- **SB2:** Obtain, evaluate, and communicate information to analyze how genetic information is expressed in cells.
- **SB3:** Obtain, evaluate, and communicate information to analyze how biological traits are passed on to successive generations.

NGSS Standards:

- **HS-LS3-1:** Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- **HS-LS3-3:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Materials:

- Punnett Square Worksheet
- Pencil

Vocabulary:

- Genetics
- Heredity
- Alleles
- Genotype
- Phenotype

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Background:

- **Genetics** is the study of biological inheritance.
- A gene is the basic and physical unit of heredity.
  - Genes are made up of DNA.
  - Each chromosome contains many genes.
- **Heredity** is the characteristics passed on from one generation to the next.
- These characteristics are passed on through the genes offered by each parent.
- **Alleles** are different versions of the gene, commonly with one being dominant and one being recessive.
- Dominant alleles are the genes that will be expressed over the recessive allele, which does not necessarily mean that they are frequently found in the population.
- Recessive alleles are only expressed when no dominant allele is present.
- Each allele is paired, two for each gene. In sexual reproduction, one allele comes from each parent.
- The combination of alleles an organism has is its **genotype**. Conversely, the expression of their genes, or the physical appearance, is the **phenotype**.
  - Within a genotype, they can either be:
  - **Homozygous**: same letters either both uppercase or both lowercase (TT or tt)
  - **Heterozygous**: when the letters are different (Tt)
- A **mutation** is a change in a DNA sequence.
- In sexual reproduction, each gamete carries only one allele randomly selected from the parent.
- Genetic diversity occurs at 3 levels in a species' gene pool:
  - Within individuals.
  - Genetic diversity helps determine evolutionary potential. Gene pools are becoming diminished and fragmented into gene puddles among individuals in a population.

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Background:

- Genetically effective population size (Ne) – the number of individuals that would result in the same level of inbreeding, or decrease in genetic diversity through time, if the population were an idealized, panmictic (randomly mating) population.
- Punnett squares are the graphical representation of the possible genotypes of an offspring.
- To be able to work out a square, you will need the genetic composition of the parents.
- The various possible combos of their gametes are in a format where each square is one fertilization event.
- Punnett squares can be used to predict the genotypes and phenotypes of offspring in the F1 and F2 generations of genetics:
  - The offspring of the parental generation, or P generation. The F1 generation is made up of the children of the parents.
  - The offspring of the F1 generation, or grandchildren of the parents. The F2 generation has more genetic diversity and different phenotypes than the F1 generation.
- A **genome** is the entire set of DNA instructions found in a cell.
  - In humans, the genome consists of 23 pairs of chromosomes located in the cell's nucleus.
- There are four nucleotide bases that make up genetic code in DNA.
  - Those are T (thymine), A (adenine), G (guanine), and C (cytosine).
  - Sequences of these bases determine the genetic information for an organism.
- Genes that code for proteins compromise open reading frames (ORFs), consisting of a series of codons that specify the amino acid sequence of the protein that the gene codes for.
- The ORF begins with an initiation codon - usually (but not always) ATG - and ends with a termination codon: TAA, TAG or TGA.
- Searching a DNA sequence for ORFs that begin with an ATG and end with a termination triplet is one way of looking for genes.

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Background:

- Although ORF scans work well for bacterial genomes, they are less effective for locating genes in DNA sequences from higher eukaryotes, such as humans and sharks.
- There have been many technological advances that allow ORF scans to become more advanced and able to locate genes in DNA sequences found in more genetically complex organisms.
- Other technological advances allow for entire genomes to be sequenced.
- CRISPR is a gene editing technology that uses a bacteria's immune system to target DNA sequences and cut them.
- This makes it possible to correct errors in the genome and turn genes on or off.
- CRISPR has use in gene therapy, repairing defective DNA and working to cure genetic disorders caused by single gene mutations such as cystic fibrosis.
- Gene editing can also alter the genome of human embryos to treat genetic diseases, which has become a topic of ethical concern.

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Background:

Punnett Square Example 1: TT x tt

	T	T
t	Tt	Tt
t	Tt	Tt

- The above Punnett square contains a dominant homozygous (TT) parent, a recessive homozygous (tt) parent, and four heterozygous (Tt) offspring.
- There is a 100% chance of offspring being heterozygous (Tt).
- Each T and t represents an allele.

Punnett Square Example 2: TT x Tt

	T	T
T	TT	TT
t	Tt	Tt

- The above Punnett square contains a dominant homozygous (TT) parent, a heterozygous (Tt) parent, two homozygous (TT) offspring and two heterozygous (Tt) offspring.
- There is a 50% chance of offspring being homozygous (TT) and a 50% chance of offspring being heterozygous (Tt).

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Background:

Punnett Square Example 3: TtHh x TtHh

	Th	tH	TH	th
Th	TThh	TtHh	TTHh	Tthh
th	Tthh	ttHh	TtHh	tthh
TH	TTHh	TtHH	TTHH	TtHh
th	Tthh	ttHh	TtHh	tthh

- Punnett squares can also be used to analyze combinations of genes.
- Punnett squares for two genes are called dihybrid crosses.
- In this example, both parents are heterozygous for two genes (Tt and Hh).
- The offspring are: TThh (12.5%),Tthh (18.75%), TTHh (6.25%), TtHh (25%), ttHh (12.5%), TtHH (6.25%), TTHH (6.25%), tthh (6.25%).

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Lesson Structure:

1. Review fundamentals of Punnett squares with students.
2. Discuss phenotypes and genotypes and how they are different.
3. Review alleles and how those are passed down through generations.
4. Review simple Punnett squares (TT and tt, TT and Tt).
5. Review complex Punnett squares (dihybrid crosses).
6. Have students use the partially filled out Punnett square to fill in the remaining blanks.
7. Identify the genotype of both parents.
8. On the back, identify the percentage of each possible genetic offspring.
9. After filling out the worksheet, ask students to hypothesize what would happen if two offspring were to mate. Have them choose two offspring and fill in a new Punnett square.
10. Fill in a third Punnett square and observe the genetic diversity of the third generation.

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Evaluate:

1. Ensure that students have successfully filled out all of their Punnett squares correctly.
2. Ask students to evaluate all three Punnett squares and discuss whether or not their offspring are genetically diverse.
3. Have students compare their completed Punnett squares to another classmate's, identify any differences, and why they may have different or similar results.
4. Emphasize that in order for populations to be diverse, their genetic makeup also needs to be diverse.

Extend:

1. Host a debate with students. Divide students into two teams and have them debate the ethics of CRISPR/gene editing.
2. Create a word bank of codons and characteristics (example: ATGCATGATTGA represents black hair, ATGGATTGA represents brown eyes). Have students partner up and create codon strings. Have each partner identify the characteristics of the other's genome.
3. To add another challenge, insert a codon string that is ONE letter away from a defined codon, but do not define it.
4. Have students identify the "suspicious" codon.

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Punnett Square
WORK SHEET

Directions:

1. Using the partially filled out Punnett square, fill in the remaining blanks.
2. Identify the genotype of both parents.
3. On the back, identify the percentage of each possible genetic offspring.

	Ry	ry	R_	ry
Ry	RR _ y	Rryy	RRYy	Rr_y
rY	RrYy	r_Yy	RrYY	rrYy
_y	Rryy	rryy	R_Yy	rryy
R_	RRYy	Rr_y	RRYY	RrYy

Parent 1:_____ Parent 2:_____

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Punnett Square
ANSWER KEY

Directions:

1. Using the partially filled out Punnett square, fill in the remaining blanks.
2. Identify the genotype of both parents.
3. On the back, identify the percentage of each possible genetic offspring.

	Ry	ry	RY	ry
Ry	RRyy	Rryy	RRYy	Rr_y
rY	RrYy	rrYy	RrYY	rrYy
ry	Rryy	rryy	RRYy	rryy
RY	RRYy	RrYy	RRYY	RrYy

Parent 1: Rryy

Parent 2: RrYy

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Punnett Square
ANSWER KEY

RRyy	1/16	6.25%
RrYy	4/16	25%
RRYy	3/16	18.75%
Rryy	3/16	18.75%
rrYy	2/16	12.5%
rryy	2/16	12.5%
RrYY	1/16	6.25%