Grade Level: 6-8
Time Estimate: 3-5 days

INTRODUCTION TO GENETICS PART 1 / INSTRUCTOR INFO

Summary

This lesson includes vocabulary, content, examples, and activities to help students learn and understand the basics of genetics and how OCEARCH uses this to study sharks. Students will also learn how to predict genetic traits of sharks using the Punnett Square.

Part 1. Introduction
Part 2. What are Genes and What Do They Do?
Part 3. Inheritance of Traits
Part 4. Predicting Shark Genetics – Punnett Square
Activity 1. Predicting Shark Genes – The Punnett Square
Activity 2. Pre-Lesson Activity – Name Those Traits!

Goals & Objectives

The students will:

- be able to distinguish between recessive and dominant traits;
- learn what genes are and how they determine traits;
- learn how to calculate the likelihood of receiving a genetic trait;
- and learn how to use the Punnett Square to determine recessive and dominant traits.

// STANDARDS

This lesson aligns with the following TEKS:
6th Grade Science: 2A, 2C, 2D, 2E, 3A, 4A, 12A,
7th Grade Science: 2A, 2C, 2D, 2E, 3A, 4A, 14A, 14B, 14C
8th Grad Science: 2A, 2C, 2D, 2E, 3A, 4A

This lesson aligns with the following Next Generation Science Standards (NGSS):
MS-LS3 Heredity: Inheritance and Variation of Traits

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

Develop and use a model to describe phenomena. (MS-LS3-1),(MS-LS3-2)

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms

Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary to MS-LS3-2)*

LS3.A: Inheritance of Traits

Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1)

Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

LS3.B: Variation of Traits

In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2)

In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)

Helpful Tips

1) The content in this lesson is based on the conservation work of OCEARCH™ and the Global Shark Tracker™. Spend a few minutes getting familiar with the website and the tracker if you have not done so already. The Global Shark Tracker™ is also available as an app for iPhone and Android.
2) This lesson plan is designed to be adaptable to suit your specific needs. Use the entire lesson plan or just parts of it. This material can be expanded to be an entire unit or condensed for just one day in the classroom.
3) Vocabulary words will be underlined as they first appear in the lesson plan. A complete list of vocabulary words is included as well.
4) Answers to questions and prompts for discussions will appear in *italics*.
5) Optional activities and content (side notes) will appear in a box. Use these to enhance your lesson and adapt it to suit your needs!
6) Have questions for OCEARCH Expedition Leader, Chris Fischer? Email info@OCEARCH.org to schedule a Skype session and let your students/child talk directly to Chris and the OCEARCH crew!
7) Email all questions about this lesson to info@OCEARCH.org.

Vocabulary

Alleles – Different forms of a gene. Alleles produce variations in the genetically inherited trait.
Cell – Basic building block of all living things. All organisms are composed of cells.
Chromosomes – Structures found inside the nucleus of a cell that carry all of the genetic information as DNA.
DNA – Stands for deoxyribonucleic acid. DNA is the hereditary material located inside the nucleus.
Dominant trait – Dominant allele of a gene and is represented by a capital letter (e.g., A). A dominant trait will appear in the offspring even if only one parent passes it on to offspring (children).
Genes – Found on chromosomes and carry information about an individual's traits.
Genetics – The study of genes and how hereditary traits are passed from parents to offspring.
Geneticist – A person who studies genetics.
Genotype – Contains heredity information that contains an individual's genetic code, or genetic makeup. A genotype is represented by alleles, or the different forms of a gene.
Heredity – Passing of genetic traits from parents to offspring.
Heterozygous – Two different alleles, or form of a gene. A dominant and a recessive allele are present and represented by a capital letter (dominant allele) and a lower-cased letter (recessive allele).
Homozygous – Two of the same allele, or form of a gene. It is represented by either two dominant alleles (e.g., AA) or two recessive alleles (e.g., aa).

Mendel's first law of genetics – States that a trait is always determined by two factors, one inherited by the mother and one inherited by the father.
Nucleus – Serves as the cell's command center, much like the brain is the control center for the entire body.
Phenotype – Physical appearance of an individual based on its genetic makeup.
Punnett Square – Table or diagram that is used to predict genetic outcome of offspring.
Recessive trait – Recessive allele of a gene and is represented by a lower-cased letter (e.g., a). A recessive trait will only appear in the offspring (children) if both parents pass it down.
Traits – Genetically determined characteristic.

Grade Level: 6-8
Time Estimate: 5-15 mins

INTRODUCTION TO GENETICS

/ PRE-LESSON ASSESSMENT

Use the following true/false, fill in the blank, and multiple choice questions as an introduction/warm-up to the lesson topics. You can do this in a verbal or written format, as a game, individually, in groups, or as a whole class! A handout is provided if you wish to hand the questions out in a quiz format.

The questions do not need to be graded. They are intended to give the students an idea of what they will be learning and to see what they already know.

1) True or False Our bodies are made up of tiny, microscopic cells.

Answer: *True*

2) True or False Heredity explains how traits or characteristics are passed from parents to children.

Answer: *False*

3) True or False A phenotype refers to an individual's actual physical appearance.

Answer: *True*

4) In sharks, coloration may be dark (D) or light (d). What proportion of offspring in the following cross would be dark.

Dd x dd

a. 0%
b. 25%
c. 75%
d. 100%

Answer: *c*

5) An allele is_____.

a. part of DNA that carries hereditary information passed from parents to children.
b. one of two or more alternate forms of a gene.
c. the internal heredity information that contain genetic code.
d. a recessive gene that shows its specific trait when both parents pass the gene to the child.

Answer: *b*

Name: _____ Date: _____

Introduction to Genetics

Select the correct answer(s) to each of the following questions.

1) True or False Our bodies are made up of tiny, microscopic cells.

2) True or False Heredity explains how traits or characteristics are passed from parents to children.

3) True or False A phenotype refers to an individual's actual physical appearance.

4) In sharks, coloration may be dark (D) or light (d). What proportion of offspring in the following cross would be dark.

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d. a recessive gene that shows its specific trait when both parents pass the gene to the child.

Grade Level: 6-8

INTRODUCTION TO GENETICS / LESSON PLAN

PART 1. INTRODUCTION **3-5 mins**

What is genetics and why is it so important? Genetics is the science of genes and heredity. Our bodies are made up of tiny, microscopic cells. Each cell has a nucleus that contains 46 chromosomes. Each chromosome has hundreds to thousands of genes that describe everything about you! From your hair color to your height, eye color, allergies, and your overall health are already decided for you and encoded in your genes! This special code is referred to as the genetic code. Heredity explains how these traits or characteristics are passed from parents to offspring (children). Let's explore more about how this works!

Who introduced the world to genetics?

Gregor Mendel, a monk from Austria, was the first person to discover how genes indeed mark our traits. He first made this discovery while growing peas in the monastery gardens. Mendel noticed that not all the peas were the same. A great observation! Some pea pods were smooth, while others were rough. Some pea plants themselves were tall, while others were short. In addition to height, pea plants differed in color. Some pea plants were white, while others were purple. Mendel knew that these plants reproduced by pollination. So, to determine how these traits were being passed down from parent to offspring, Mendel decided to *control* which plants were involved in pollination. By controlling the pollination, he could then examine the offspring and determine how traits were inherited, or passed down from the parent plant to the offspring plant.

These experiments led to Mendel's first law of genetics which states that a trait is always determined by two factors, one inherited by the mother and one inherited by the father. Offspring will inherit only one of these factors. This was fascinating work that has led to many scientific breakthroughs! Let's explore how Mendel's work in genetic traits has help today's scientists in studying genetic relationships among sharks!

Part 2. What are Genes and What Do They Do? (15 minutes)

Within a cell's nucleus, you will find DNA or deoxyribonucleic acid (Figure 4). DNA is a double helix composed of an organism's genetic information. A gene is a segment of the DNA that is passed from the parents to the offspring. This is where your genetic traits come from! Genes are then packaged further into units called chromosomes. There are 23 pairs of chromosomes in the human body. That's 46 chromosomes total! You get 23 chromosomes from your mother and 23 chromosomes from your father. There are hundreds to thousands of genes in each chromosome! Genes carry information about who you are, including your hair color, height, and eye color!

Figure 4. Double helix DNA and chromosome.
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium

Part 3. Inheritance of Traits (15 minutes)

What is genetics and why is it so important to study? Well, genetics is the study of genes and heredity. A geneticist is a person who studies genetics. Genotype is used to describe the genes of an organism. It is important to note here, that not all genes passed down from the parents will show up in the offspring. The reason for this is some genes are dominant and some are recessive. A dominant gene will show up no matter what other genes are present. A recessive gene will show up only if it is paired with another recessive gene. In other words, dominant genes will always mask (or cancel out) the recessive gene.

Now let's look at the alleles that make up these genes! Two copies of each gene are called alleles (Figure 5). In other words, an allele is one of two or more alternate forms of a gene. To illustrate a

specific trait, scientists use letters to represent alleles and therefore the genotype. Capital letters represent a dominant form of a trait, whereas a lowercase letter represents a recessive form of the trait (Table 1).

How can you tell if the gene shows up in the offspring? If the alleles that make up the gene are identical or homozygous, the genotype may be represented as AA or aa. If the alleles are different or heterozyous, the genotype will be represented as only Aa. A dominant allele always masks the recessive allele. For example, brown eyes is a dominant trait (Aa or AA) and blue eyes is a recessive trait (aa). Therefore, if your mother has brown eyes, her genotype is either Aa or AA. The dominant allele (A) masks the recessive allele (a). If your father has blue eyes, his genotype can only be aa. Phenotype describes the "physical" appearance of an organism. For example, if your mother has the genotype Aa for brown eyes, her phenotype for eye color is brown eyes. If your father's genotype is aa for eye color, his phenotype is blue eyes.

Table 1. Symbols of Genotypes

Symbol	Genotype
AA	Homozygous dominant
Aa	Heterozygous hybrid
aa	Homozygous recessive

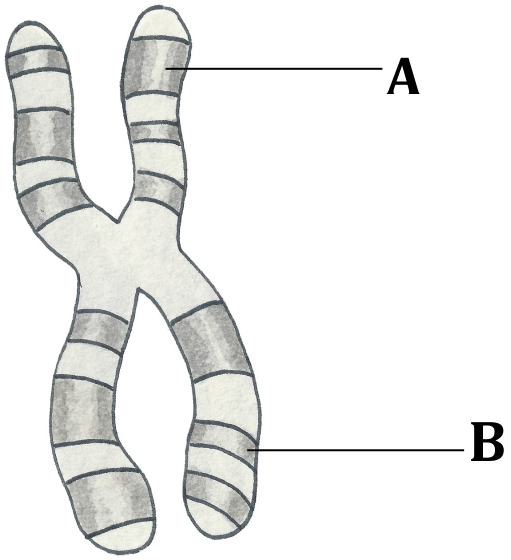


Figure 5. Alleles on a chromosome.
Illustration Credit: Sarah Rich – Landry's Downtown Aquarium

Part 4. Predicting Shark Genetics – Punnett Square (30 minutes)

Now that you've learned genes carry information about who we are, let's look at how scientists use this information to predict genotypes and phenotypes! One of the most important features of genetics is determining the probability of inheriting different traits. Scientists use this information when breeding different animals and in determining traits among family members. Dr. Reginald Punnett, an early 20th century English geneticist, designed a technique that could easily and quickly calculate the probability of inheriting a trait. This mathematical technique is now called the Punnett Square. The Punnett Square technique allows scientists to calculate and determine the genotype and phenotype of offspring (children), if we know the genotypes of the parents.

How do you set up a Punnett Square?

1. The first thing you will want to do is record the genotypes and phenotypes of the parents. For example, let's look at hair color. The genotype of brown hair may be Aa or AA, whereas the genotype of blonde hair would be aa.
2. Next, write out your cross equation. For this example, let's say that the father has brown hair and his genotype is represented as Aa. The mother has blonde hair and her genotype is represented as aa.
3. Once your cross is established, you can set up a blank Punnett Square.
4. Then you can split the genotype into it's alleles (A, a) and (a, a). It does not matter where the parent's alleles are placed on the Punnett Square. For example, the mother's alleles may be placed on top of the square or on the side of the square.
5. Once the parent's alleles are positioned on the square, you can determine the possible genotypes of the offspring by filling out the squares.
6. Once the genotypes are determined, you can then determine the phenotype of the offspring.

Example 5.1.

The cephalofoil (hammer-shaped head) of hammerhead sharks can be long or short. A long cephalofoil is a dominant trait. A short cephalofoil is s recessive trait. If a female hammerhead shark that is a heterozygous hybrid for the trait mated with a male hammerhead shark that is also a heterozygous hybrid for the trait, what are the possible genotypes and phenotypes of the offspring? What is the probability of having offspring with a short cephalofoil? What is the probability of having offspring with a long cephalofoil?

Answer:

1. First record what the genotype and phenotype of the parents are.

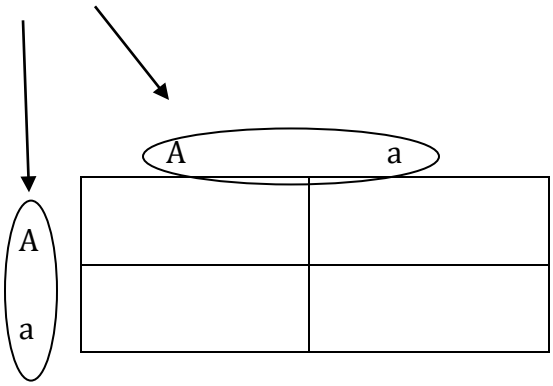
Female: genotype = Aa; phenotype = long cephalofoil
Male: genotype = Aa; phenotype = long cephalfoil

2. Write out the cross. *Aa x Aa*

3. Next, set up a blank Punnett Square.

4. Then you can split the genotype into it's alleles (A, a) and (a, a). Remember, it does not matter where the parent's alleles are placed on the Punnett Square.

Cross: Aa x Aa



5. Once the parent's alleles are positioned on the square, you can determine the possible genotypes of the offspring by filling out the squares.

Cross: Aa x Aa

	A	a
A	AA	Aa
a	Aa	aa

Genotypes: AA, Aa, aa

6. Now determine phenotype.
   AA = long cephalofoil
   Aa = long cephalofoil
   aa = short cephalofoil

What is the probability of having offspring with a short cephalofoil?
Anwer: *Only 1 of the 4 squares has a phenotype of short cephalofoil. Therefore ¼ or 25% of the offspring will have a short phenotype.*

What is the probability of having offspring with a long cephalofoil?
Answer: *3 out of 4 squares have a phenotype of a long cephalofoil. Therefore, ¾ or 75% of offspring will have a long cephalofoil.*

Practice Problem: Genetics

Name: _____

Date: _____

Use the steps below to answer the following genetics questions.

1. The first thing you will want to do is record the genotypes and phenotypes of the parents. For example, let's look at hair color. The genotype of brown hair may be Aa or AA, whereas the genotype of blonde hair would be aa.

2. Next, write out your cross equation. For this example, let's say that the father has brown hair and his genotype is represented as Aa. The mother has blonde hair and her genotype is represented as aa.

3. Once your cross is established, you can set up a blank Punnett Square.

4. Then you can split the genotype into its alleles (A, a) and (a, a). It does not matter where the parent's alleles are placed on the Punnett Square. For example, the mother's alleles may be placed on top of the square or on the side of the square.

5. Once the parent's alleles are positioned on the square, you can determine the possible genotypes of the offspring by filling out the squares.

6. Once the genotypes are determined, you can then determine the phenotype of the offspring.

Example 5.1.

The cephalofoil (hammer-shaped head) of hammerhead sharks can be long or short. A long cephalofoil is a dominant trait. A short cephalofoil is s recessive trait. If a female hammerhead shark is a heterozygous hybrid for the trait mated with a male hammerhead shark that is also a heterozygous hybrid for the trait, (a) what are the possible genotypes and phenotypes of the offspring? (b) What is the probability of having offspring with a short cephalofoil? (c) What is the probability of having offspring with a long cephalofoil?

a.

b.

c.

Introduction to Genetics

ACTIVITY 1. Predicting Shark Genes: The Punnett Square

(30 – 45 minutes)

Introduction

This activity provides more example genetics problems for students to solve. This is a great chance for the students to gain more experience in preparing Punnett Squares and calculating percentages for different traits (e.g., genotype and phenotype).

Materials

- Worksheet provided
- Writing utensil

Instructions

1. Print out the worksheet provided for each student.
2. The students can work on this in class or as a homework assignment.

Activity 1. Predicting Shark Genetics

Name: _____

Date: _____

Instructions

Answer the following questions.

1. Shark pectoral fins can either be long or short. Long pectoral fins are a dominant trait (L). Short pectoral fins are a recessive trait (l).

a.) If a male great white shark with a homozygous dominant genotype for the trait (LL) mated with a female great white shark with a heterozygous genotype for the trait (Ll) what are the possible genotypes and phenotypes of their offspring?

b.) What is the male's genotype and phenotype?

.

c.) What is the female's genotype and phenotype?

2. Shark teeth can be sharp or dull. Sharp teeth is a dominant trait and can be identified with (S) and dull teeth is a recessive trait (s).

a.) If a male tiger shark with a homozygous dominant genotype for the trait (SS) mated with a female tiger shark with a homozygous recessive genotype for the trait (ss), what are the possible genotypes and phenotypes of their offspring?

b.) What is the male's genotype and phenotype?

.

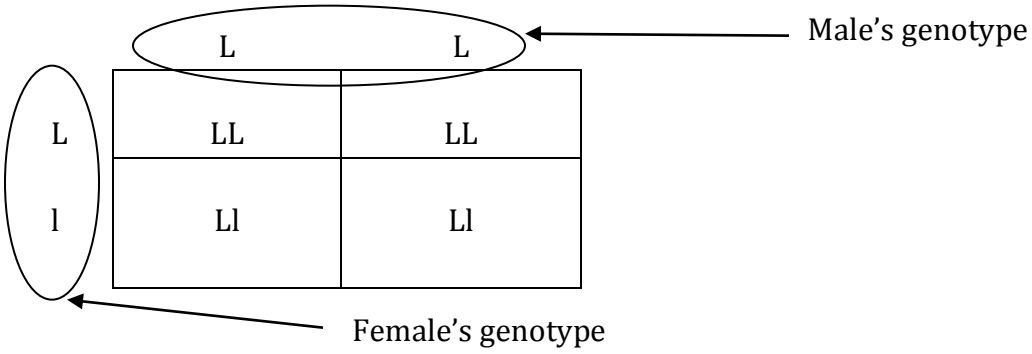
c.) What is the female's genotype and phenotype?

Answer Key

Practice Problem 1. Shark pectoral fins can either be long or short. Long pectoral fins are a dominant trait (L). Short pectoral fins are a recessive trait (l).

a.) If a male great white shark with a homozygous dominant genotype for the trait (LL) mated with a female great white shark with a heterozygous genotype for the trait (Ll) what are the possible genotypes and phenotypes of their offspring?

Answer: *First draw out your Punnett Square. The male's genotype is on the top and the female's genotype is on the side. But remember, it does not matter where you place the parents' genotype on the Punnett Square.*



Half of the offspring (50%) have the homozygous dominant trait for long fins. Half of the offspring (50%) have the heterozygous trait for fin size. Since one of the alleles is dominant, it will mask the recessive allele, and the offspring will still have long fins. Therefore, all offspring will have long fins.

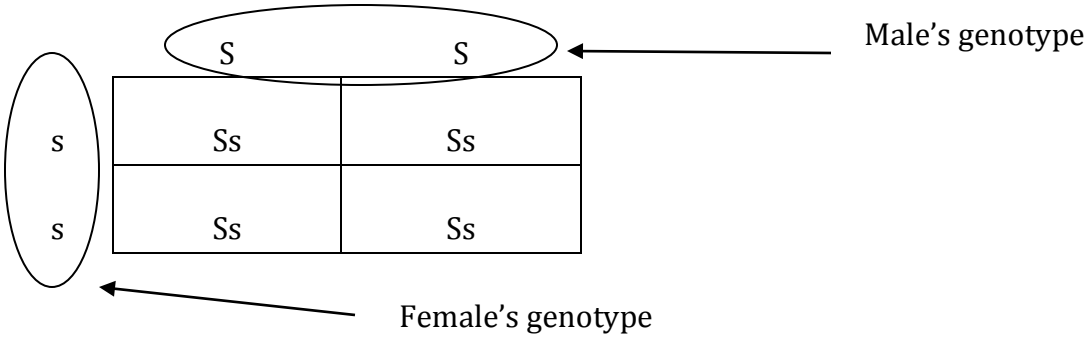
b.) What is the male's genotype and phenotype?
Answer: *Genotype is LL and phenotype is long fins.*

c.) What is the female's genotype and phenotype?
Answer: *Genotype is Ll and phenotype is short fins.*

Practice Problem 2. Shark teeth can be sharp or dull. Sharp teeth is a dominant trait and can be identified with (S) and dull teeth is a recessive trait (s).

a.) If a male tiger shark with a homozygous dominant genotype for the trait (SS) mated with a female tiger shark with a homozygous recessive genotype for the trait (ss), what are the possible genotypes and phenotypes of their offspring?

Answer: First draw out your Punnett Square. The male's genotype is on the top and the female's genotype is on the side. But remember, it does not matter where you place the parents' genotype on the Punnett Square.



Since the male tiger shark has a homozygous dominant genotype, the dominant allele masks all the recessive alleles. Therefore, 100% of the offspring will possess a heterozygous genotype. The phenotype of all of the offspring (100%) will be sharp teeth!

b.) What is the male's genotype and phenotype?
Answer: *Genotype is homozygous dominant SS. Phenotype is sharp teeth.*

c.) What is the female's genotype and phenotype?
Answer: *Genotype is homozygous recessive genotype ss. Phenotype is dull teeth.*

Introduction to Genetics

ACTIVITY 2. PRE-LESSON ACTIVITY: Name Those Traits

(45 – 60 minutes)

Introduction

This activity may work best if done BEFORE the lesson is taught! This lesson will help the students make the connection between genes and their role in inheritance through reproduction and the diversity of traits.

Materials

- Trait Chart provided
- Popsicle sticks of 2 different colors (or strips of paper)
- Paper
- Colored pencils

Instructions

Part 1:

1. Collect 30 popsicle sticks.
2. Paint/color 15 sticks one color (ex. red) and the other 15 sticks a different color (ex. blue)
3. The red and blue popsicle sticks should be numbered 1-15 on one end of the sticks (and on both sides).
4. On the other end of the stick for each set of popsicle sticks, include letters that represent dominant allele (one side of stick) and recessive allele (other side of stick). Use the Trait Chart provided for the allele letters. **NOTE:** the letters you use for the alleles should match the alleles provided.
5. Pass out all of the sticks to the kids. Explain to the students that each stick has a letter and a number. At this point, *do not* explain what dominant and recessive traits mean.
6. Call the students to the front by number (1-15) and have the 1s across from each other, the 2s across from each other, and so on to 15. Let the students choose (randomly) which allele (dominant or recessive) they want facing up. It works best if this remains random. **NOTE**: If the students know the dominant allele always masks the recessive allele, you may end up with ALL dominant traits, which may not be as fun!
7. Divide the chalkboard or whiteboard into 2 sections. On the board, have a table premade with the first column labeled with *numbers (1-15)*, the second column labeled *Genotype*, and the third column labeled *Phenotype*. See the Trait Chart below. Your table should look the same, but empty. Then have the kids call out their genotype by number (1-15) and write it on the board in the second column. For example, both students with the number 1 popsicle stick will call out

their alleles. Both alleles make up the genotype. On the other side of the board, include what each number or gene represents for the students. For example, let the student know that B or b are alleles that explain the body shape of the shark: (B) is the dominant allele that gives the shark a long body and (b) is the recessive allele that gives the shark a short body.

8. Once the genotypes are written on the board, have the students record what the phenotype is based on the genotype.

<u>Part 2:</u>

1. The second part of this activity allows the students to draw their offspring! What do the offspring look like after the two sharks mated? The students can use the worksheet provided to draw their new shark.

Table 1. Trait Chart

Order to Call Out	Genotypes	Phenotype
1	BB or Bb bb	Long body shape Short body shape
2	SS or Ss ss	Pointed snout Round snout
3	DD or Dd dd	Pointed dorsal fin Curved dorsal fin
4	AA or Aa aa	Dorsal fins far apart Dorsal fins close together
5	FF or Ff ff	Heterocercal caudal fin Homocercal caudal fin
6	LL or Ll ll	Long pectoral fins Short pectoral fins
7	TT or Tt tt	Teeth pointing inward Teeth protruding out
8	KK or Kk kk	No barbels barbels
9	NN or Nn nn	Nares not near mouth Nares near mouth
10	EE or Ee ee	Large eyes Small eyes
11	MM or Mm mm	Spiracles No spiracles
12	QQ or Qq qq	Countershading No countershading
13	GG or Gg gg	Gray body color Blue body color
14	HH or Hh hh	No spots Spots
15	XX XY	No claspers Claspers

Activity 2. PRE-LESSON ACTIVITY: Name those Traits!

Name: _____

Date: _____

Instructions

Now that you understand dominant and recessive traits, here is your chance to draw the offspring of your 2 sharks! Use the phenotypes of the sharks from Part 1 of Activity 2 to draw your new shark in the box below!

1. What is the phenotype of your shark? (Hint: What traits showed up in the crossing?)