SELECTIVELY BREEDING HARD CLAMS

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Grade Level
High School

Subject area
Biology/AP Biology

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Title Selectively Breeding Hard Clams

Focus Use knowledge of hard clam genotypes and inheritance patterns to cross parents and predict offspring phenotypes

Grade Level High School Biology or AP Biology

VA Science Standards

BIO.5 The student will investigate and understand that there are common mechanisms for inheritance. Key ideas include

c) the variety of traits in an organism are the result of the expression of various combinations of alleles;

BIO.7 The student will investigate and understand that populations change through time. Key ideas include

b) genetic variation, reproductive strategies, and environmental pressures affect the survival of populations;

NOTE: This lesson plan is not intended to be used for teaching about meiosis, the law segregation, or the law of independent assortment. Students should already be partially familiar with many of the vocab words below. This lesson is intended to take what the students have learned and apply it to a non-model organism that could have real world effects. The PowerPoint briefly touches on meiosis as the method of inheritance but focuses mainly on how genotypes and phenotypes effect an organism and how those can be passed down to the next generation. There are examples of Dominance, Recessiveness, Incomplete Dominance, and Codominance. By the end of the lesson, student should understand the differences between these and how they are reflected in homozygous and heterozygous individuals. This lesson attempts to teach students how to conduct Punnett squares and calculate phenotypic proportions with different hard clam traits and alleles.

Learning Objectives

- Students will conduct Punnett squares
- Students will calculate phenotypic proportions
- Students will identify inheritance patterns
- Students will select parent clams to produced desired offspring
- Students will assess why clam growers may want a clam with specific phenotypes
- Students will assess how selective breeding can produce desired offspring

Time Required: 75 minutes

Key words, vocabulary:

Allele: one of two or more variants of a gene that determines a particular trait for a characteristic
Autosome: any of the non-sex chromosomes

Codominance: in a heterozygote, complete and simultaneous expression of both alleles for the same characteristic
Diploid: describes a cell, nucleus, or organism containing two sets of chromosomes (2n)
Dominant: describes a trait that masks the expression of another trait when both versions of the gene are present in an individual
Gamete: a haploid reproductive cell or sex cell (sperm or egg)
Gene: the physical and functional unit of heredity; a sequence of DNA that codes for a specific peptide or RNA molecule
Genome: the entire genetic complement (DNA) of an organism
Genotype: the underlying genetic makeup, consisting of both physically visible and non-expressed alleles, of an organism
Haploid: describes a cell, nucleus, or organism containing one set of chromosomes (n)
Heterozygous: having two different alleles for a given gene on homologous chromosomes
Homologous chromosomes: chromosomes of the same length with genes in the same location; diploid organisms have pairs of homologous chromosomes, and the members of each pair come from different parents
Homozygous: having two identical alleles for a given gene on the homologous chromosomes
Incomplete dominance: in a heterozygote, expression of two contrasting alleles such that the individual displays an intermediate phenotype
Inheritance: the reception of genetic qualities by transmission from parent to offspring
Law of Dominance: in a heterozygote, one trait will conceal the presence of another trait for the same characteristic
Law of Independent assortment: genes do not influence each other with regard to sorting of alleles into gametes; every possible combination of alleles is equally likely to occur
Law of Segregation: paired unit factors (i.e., genes) segregate equally into gametes such that offspring have an equal likelihood of inheriting any combination of factors
Locus: the position of a gene or other genetic material on a chromosome
Mutation: a permanent variation in the nucleotide sequence of a genome
Phenotype: the observable traits expressed by an organism
Punnett square: a visual representation of a cross between two individuals in which the gametes of each individual are denoted along the top and side of a grid, respectively, and the possible zygotic genotypes are recombined at each box in the grid
Recessive: describes a trait whose expression is masked by another trait when the alleles for both traits are present in an individual
Wild type: the most commonly occurring genotype or phenotype for a given characteristic found in a population

Background Information:

Inheritance is the principle of parents passing on their genetic information to their offspring. This starts during meiosis, where diploid parents produce haploid gametes through the duplication of the genome, the separation of homologous chromosomes, and the segregation of individual chromosomes to a gamete. The combination of genetic material that ends up in each gamete can be explained through the law of independent assortment and law of segregation (see definitions). The phenotype, or observable trait of an organism, is the result of an organism genotype, or underlying genetic makeup. There may be variation among a population or species at a specific locus or gene, which are known as alleles. New alleles are created through mutation and a diploid individual will receive one allele from each parent. Different allele combinations may produce different genotypes and possibly different phenotypes. When a diploid organism has two of the same alleles, this is known as homozygous. When a diploid organism has two different alleles, this is known as heterozygous. How a specific genotype, homozygous or heterozygous, is reflected in an individual's phenotype depends on how alleles at a specific locus interact with one another. One allele may be dominant over the other allele and under the law of dominance a heterozygote individual will have one trait (or allele) concealed by another trait (or allele) for the same characteristic. This results in dominant and recessive alleles which are usually denoted by capital (dominant) and lower case (recessive) letters. The most common allele within a population or species, whether it be recessive or dominant to another allele, is known as the wild type. Mendelian inheritance includes autosomal dominant and autosomal recessive inheritance. Autosomal, or not sex linked, dominant inheritance occurs when the wild-type is recessive, and the new or mutant allele is dominant to the wild-type allele. Autosomal recessive inheritance occurs when the wild type is dominant, and the new or mutant alleles is recessive to the wild-type allele. However, there are non-Mendelian inheritance patterns that do not stick to the strict rules of dominant and recessive. Codominance occurs when a heterozygous have complete and simultaneous expression of both alleles for the same characteristic, i.e., a black cat and a white cat producing a black and white patched kitten. Incomplete dominance occurs when heterozygous has expression of two contrasting alleles such that the individual displays an intermediate phenotype, i.e., a black cat and a white cat producing a grey kitten. Based upon the known genotypes, phenotypes, and inheritance of each parent for a specific characteristic, the proportion of offspring with each possible genotype and phenotype can be estimated using a Punnett square. The possible allele for each characteristic of interest that could occur in the gametes of each parent are denoted along the top and side of a square grid. The allele from each parent is combined in each box to produce the genotype of the possible offspring.

The specific selection of parents to produce offspring with desired traits has occurred since the beginning of mankind, long before inheritance patterns and genotypes were known. The principles of inheritance and prediction of offspring traits can be applied to any organism and are enhanced if genotypes and patterns of inheritance for a trait are known. Aquaculture production has been using artificial selective breeding to improve the quantity and quality of its organism. A main aquaculture species within Virginia is the hard clam, *Mercenaria mercenaria.* In a hatchery, they select male and female adult hard clams based on phenotypes and family lines to produce the next generation. Hatcheries will induce male and female clams to spawn (release their gametes) by regulating water temperature and food availability. Males and females release their gametes into the water around them and eggs are externally fertilized, becoming larvae and ultimately juveniles. Juvenile hard clams are brought up in a controlled environment within and around the hatchery to increase survival before juveniles are transported to grow out locations in shallow coastal mud and sand flats. Growers will maintain clam plots, protecting them from predators, until clams have reached the desired size for the growers to sell.

While genotypes and inheritance knowledge has been used in aquaculture, desired traits like shell color, growth, and disease resistance have not been fully genotyped for the hard clam. There is ongoing research to find the genes and specific alleles responsible for different phenotypic traits within the hard clam. Once genotypes and inheritance patterns are discovered, they can be applied to enhance the hard clam aquaculture efforts. This lesson plan is a hypothetical example of how genotype, phenotype, inheritance knowledge could be applied in a selective breeding circumstance with the hard clam to produce the desired traits for color, growth, and disease resistance.

Student handouts and other materials needed:
- Genotype table cutout (recommended more than one)
- Worksheet #1 (one for each student)
- Worksheet #2 (one for each student)
- Worksheet #2 – AP (one for each student)
- Extra Punnett square pages 1&2 (one for each student)
- Clams 1-12 cutout (one)
- Slideshow

Materials & supplies:
- Color Printer
- Paper
- at least 4 cups
- Scissor

Teacher Preparation:
Split the class into ~6 groups
For AP biology, have students complete Part 1 on their own
For Part I: Cut up Genotype table so that each genotype is on its own slip of paper. Set up at least 3 cups, one for each trait. Label each cup; "Shell Color", "Growth", "Disease". Place RR, RW, & WW in "Shell color" cup. Place GG, Gg, & gg in "Growth" cup. Place DD, Dd, & dd in "Disease Resistance" cup. Depending on the size of the class, more than one set of cups can be created. Recommended more than one set of 3 cups per class, but each group does not need their own set.
For Part II: Cut out each of the 12 clams and place into another cup. Possibly prepare Punnett square template on board for class to use. 2 by 2 and 4 by 4.

Procedure:
I. Background and Introduce Activity:

- Instructors should load the accompanying PowerPoint presentation and walk-through slides #1- 16. Suggested talking points in comment section

II. Activity: * It is up to the teacher's discretion on how many groups and how large of groups should be made, but approximately 3-6 students per group*

Part I- Randomly select clam genotypes and create Punnett squares
- Slides #17-27

- Groups or individual AP students will select different genotypes/phenotypes from each cup for each parent clam. They will then fill out the table on their worksheet with these genotypes/phenotypes and use them to perform the following Punnett squares, calculate phenotype proportions, and identify pattern of inheritance.

Part II- Select clams based on genotypes and inheritance patterns for growers

- Slides #28-32
- Six groups will select two of the premade clams from a cup. Students will read the growers desired clam phenotypes and write which genotypes are needed to produce these clams. Then, if a group believes they have one or two clams that could be a parent, they can nominate their clam along with what clam mate it should go with. Slide 32 should be left on the board. The class must work together to identify the right combination of parents for each grower. Remember, one clam must be female, and one must be a male. Punnett squares are not required for this part, but extras are available for students if needed. Punnett squares for each grower may be drawn on the board by the class to verify the class selected clams will produce the desired offspring.
- AP - Six groups will select two of the premade clams from the cup. Students will read the growers desired clam phenotypes and write which genotypes are needed to produce these clams. Then, if a group believes they have one or two clams that could be a parent, they can nominate their clam. Slide 32 should be left on the board. As a class, students should decide which clams should be used to produce the desired offspring of the growers. Growers may not be skipped. Must start with grower #1 and go down the line to grower # 6. Once the male and female clam have been selected by the class, the teacher will take the clams from their respected groups and those clams will not be available for later spawns. The class must work together to identify the right combination of parents for each grower. Punnett squares are not required for this part, but extra are available for students if needed. Punnett squares for each grower may be drawn on the board by the class to verify the class selected clams will produce the desired offspring.

Cut out material and set up cups prior to class – 15 minutes
Introduction Presentation– 15 minutes
Activity I – 25 minutes
Activity II – 25 minutes

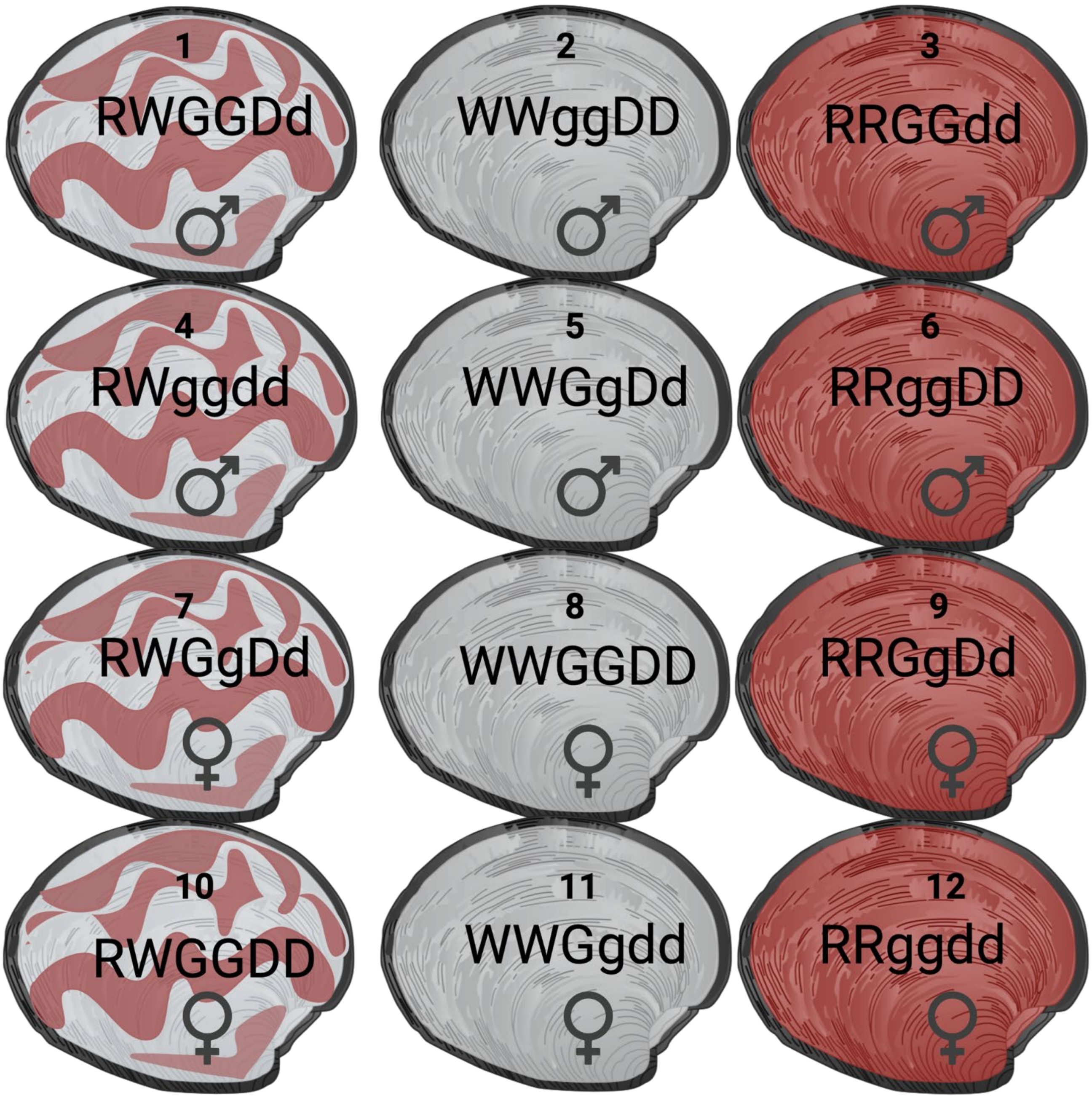
Assessment:

Instructors should assess students based on both worksheets, participation within their group, and contributions to the class discussion.

References:

Concepts of Biology - 1st Canadian Edition by Charles Molnar and Jane Gair is licensed under a Creative Commons Attribution 4.0 International License, except where otherwise noted.

RR	RW	WW
GG	Gg	gg
DD	Dd	dd


1
RWGGDd
♂
2
WWggDD
♂
3
RRGGdd
♂
4
RWggdd
♂
5
WWGgDd
♂
6
RRggDD
♂
7
RWGgDd
♀
8
WWGGDD
♀
9
RRGgDd
♀
10
RWGGDD
♀
11
WWGgdd
♀
12
RRggdd
♀

Worksheet #1: Part I – Practice Punnett Squares with random genotype combinations

Name: ___________________

Date: ____________________

Scenario

You own a hard clam hatchery and have been working closely with your local marine research institute to genotype a few key phenotypes that you have observed among your clams. These are also desired phenotypes by local growers who buy clams from you to grow and sell. You have been having issues selecting the right parents to get the desired offspring for the growers. Finally, the scientist has found specific alleles for the desired phenotypes and has given you the list of genotypes that are among your clams. Each of these alleles has a different pattern of inheritance. Let's practice with some of the possible combinations that may occur among your clams.

Possible Genotypes and Phenotypes of Clams

Color Genotype & Phenotype	RR Red	RW Mottled	WW White
Growth Genotype & Phenotype	GG Fast growing	Gg Fast Growing	gg Normal growing-WT
Disease Genotype & Phenotype	DD Non-disease resistant-WT	Dd Non-disease resistant-WT	dd Disease resistant

WT = Wild Type

Your Selected Clam Genotype

	Color	Growth	Disease
Clam #1			
Clam #2			

Instructions

1) From each phenotype cup, you will draw the genotype for each parent clam. We are just assuming these are opposite sexes. After drawing once, return paper before drawing again for the other parent clam.
2) Write down the genotype drawn from each cup for each parent clam (#1 & #2) in the above table
3) After receiving each genotype (drawing 6 times, twice from each cup), answer the questions below.

Questions

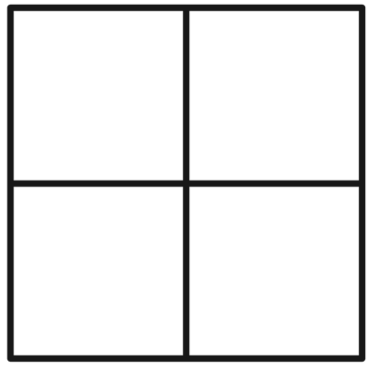
1) Complete the Punnett square for color and give the proportions of each phenotype
    a. Proportion of Red:
    b. Proportion of White:
    c. Proportion of Mottled:

2) What type of inheritance does the color phenotype follow?

3) Complete the Punnett square for growth and give the proportion of each phenotype
    a. Proportion of fast growing:
    b. Proportion of normal growing:

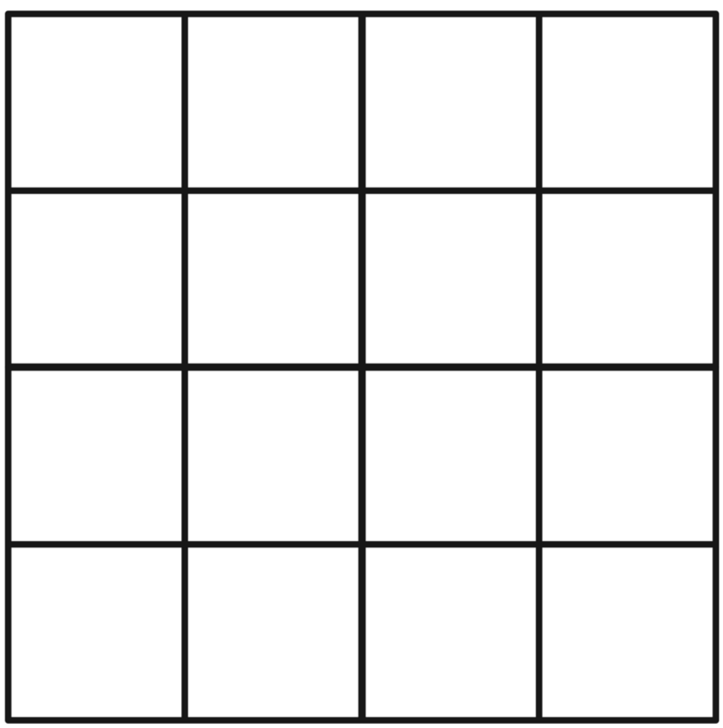
4) What type of inheritance does the growth phenotype follow?

5) Complete the Punnett square for disease and give the proportion of each phenotype
    a. Proportion of disease resistant:
    b. Proportion of non-disease resistant:
    c. Proportion of carriers for disease resistant:



6) What type of inheritance does the disease phenotype follow?

7) Complete the Punnett square for color and growth and give the proportion of each phenotype
   a. Proportion of red and fast growing:
   b. Proportion of white and fast growing:
   c. Proportion of mottled and fast growing:
   d. Proportion of red and normal growing
   e. Proportion of white and normal growing:
   f. Proportion of mottled and normal growing:



8) Complete the Punnett square for growth and disease and give the proportion of each phenotype
    a. Proportion of fast growing and disease resistant:
    b. Proportion of normal growing and disease resistant:
    c. Proportion of normal growing and non-disease resistant:
    d. Proportion of fast growing and non-disease resistant:

KEY - Worksheet #1: Part I – Practice Punnett Squares with random genotype combinations

Name: ____________________

Date: _____________________

Scenario

You own a hard clam hatchery and have been working closely with your local marine research institute to genotype a few key phenotypes that you have observed among your clams. These are also desired phenotypes by local growers who buy clams from you to grow and sell. You have been having issues selecting the right parents to get the desired offspring for the growers. Finally, the scientist has found specific alleles for the desired phenotypes and has given you the list of genotypes that are among your clams. Each of these alleles has a different pattern of inheritance. Let's practice with some of the possible combinations that may occur among your clams.

Possible Genotypes and Phenotypes of Clams

Color Genotype & Phenotype	RR Red	RW Mottled	WW White
Growth Genotype & Phenotype	GG Fast growing	Gg Fast Growing	gg Normal growing-WT
Disease Genotype & Phenotype	DD Non-disease resistant-WT	Dd Non-disease resistant-WT	dd Disease resistant

WT = Wild Type

Your Selected Clam Genotype

Example	Color	Growth	Disease
Clam #1	RW	Gg	Dd
Clam #2	WW	gg	Dd

Instructions

1) From each phenotype cup, you will draw the genotype for each parent clam. We are just assuming these are opposite sexes. After drawing once, return paper before drawing again for the other parent clam.
2) Write down the genotype drawn from each cup for each parent clam (#1 & #2) in the above table
3) After receiving each genotype (drawing 6 times, twice from each cup), answer the questions below.

Questions

1) Complete the Punnett square for color and give the proportions of each phenotype
    a. Proportion of Red: 0/4
    b. Proportion of White: 2/4
    c. Proportion of Mottled: 2/4

	R	W
W	RW	WW
W	RW	WW

2) What type of inheritance does the color phenotype follow?
   Codominant Inheritance

3) Complete the Punnett square for growth and give the proportion of each phenotype
    a. Proportion of fast growing: 2/4
    b. Proportion of normal growing: 2/4

	G	g
g	Gg	gg
g	Gg	gg

4) What type of inheritance does the growth phenotype follow?
   Autosomal Dominant Inheritance

5) Complete the Punnett square for disease and give the proportion of each phenotype
    a. Proportion of disease resistant: 1/4
    b. Proportion of non-disease resistant: 3/4
    c. Proportion of carriers for disease resistant: 2/4

	D	d
D	DD	Dd
d	Dd	dd

6) What type of inheritance does the disease phenotype follow?
   Autosomal Recessive Inheritance

7) Complete the Punnett square for color and growth and give the proportion of each phenotype
   a. Proportion of red and fast growing: 0/16
   b. Proportion of white and fast growing: 4/16
   c. Proportion of mottled and fast growing: 4/16
   d. Proportion of red and normal growing: 0/16
   e. Proportion of white and normal growing: 4/16
   f. Proportion of mottled and normal growing: 4/16

	RG	Rg	WG	Wg
Wg	RWGg	RWgg	WWGg	WWgg
Wg	RWGg	RWgg	WWGg	WWgg
Wg	RWGg	RWgg	WWGg	WWgg
Wg	RWGg	RWgg	WWGg	WWgg

8) Complete the Punnett square for growth and disease and give the proportion of each phenotype
    a. Proportion of fast growing and disease resistant: 2/16
    b. Proportion of normal growing and disease resistant: 2/16
    c. Proportion of normal growing and non-disease resistant: 6/16
    d. Proportion of fast growing and non-disease resistant: 6/16

	GD	Gd	gD	gd
gD	GgDD	GgDd	ggDD	ggDd
gd	GgDd	Ggdd	ggDd	ggdd
gD	GgDD	GgDd	ggDD	ggDd
gd	GgDd	Ggdd	ggDd	ggdd

Worksheet #2: Part II – Decide which clams to breed based on grower's request

Name: ___________________

Date: ____________________

Scenario

Genotyping your clams is not cheap. You have selected 12 clams that you think encompass a wide range of phenotypes for the research scientists to genotype. It is hatching season and growers are giving you their list of desired clams. You must strategically select the best pair of male and female clams to produce the desired offspring of the growers. You do not want to create any offspring not wanted by the grower. If needed, you may use each clam more than once. Good Luck!

Instructions

1) Six groups will select two of the genotyped clams from the cup. Write them down:

   Female Clam Genotype: _____________________

   Male Clam Genotype: _______________________

2) Read the growers desired clam phenotypes and write which genotypes are needed to produce these clams.
3) Then, if your group believes they have one or two clams that could be a parent, nominate your clam along with what clam mate it should go with. *You may have a clam with the right genotype(s), but there may not be the right mate available*
4) The class must work together to identify the right combination of parents for each grower. There may be multiple clam # combination options, you only need to identify one. Remember, one clam must be female, and one must be a male.

Punnett squares are not required for this part, but extras are available for you if needed. Punnett squares for each grower may be drawn on the board to verify the class selected clams will produce the desired offspring.

Grower #1 wants white and mottled clams.

   Genotype of offspring needed: _______________

   Parents genotype combination(s) needed: __________________

   Could one of your clams be used? ___________________

   Clam #s selected: ____________________

Grower #2 wants fast growing clams.

Genotype of offspring needed: _______________

Parents genotype combination(s) needed: __________________

Could one of your clams be used? ___________________

Clam #s selected: ____________________

Grower #3 wants red clams with disease resistant.

Genotype of offspring needed: _______________

Parents genotype combination(s) needed: __________________

Could one of your clams be used? ___________________

Clam #s selected: ____________________

Grower #4 wants mottled clams that have normal growth.

Genotype of offspring needed: _______________

Parents genotype combination(s) needed: __________________

Could one of your clams be used? ___________________

Clam #s selected: ____________________

Grower #5 wants all mottled clams that have non-disease resistance, but you plan to keep some of the clams and want them to be homozygous for non-disease resistance.

Genotype of offspring needed: _______________

Parents genotype combination(s) needed: __________________

Could one of your clams be used? ___________________

Clam #s selected: ____________________

Grower #6 wants both white and mottled clams that have fast growth, but you plan to keep some of the clams and want them all to be heterozygous for fast growth.

Genotype of offspring needed: _______________

Parents genotype combination(s) needed: ___________________

Could one of your clams be used? ____________________

Clam #s selected: _____________________

Exit questions:

Why would growers want clams with specific traits or phenotypes?

How can selective breeding benefit an aquaculture production?

If you could ask the clam farmer one question, what would it be?

KEY - Worksheet #2: Part II – Decide which clams to breed based on grower's request

Name: ___________________

Date: ____________________

Scenario

Genotyping your clams is not cheap. You have selected 12 clams that you think encompass a wide range of phenotypes for the research scientists to genotype. It is hatching season and growers are giving you their list of desired clams. You must strategically select the best pair of male and female clams to produce the desired offspring of the growers. You do not want to create any offspring not wanted by the grower. If needed, you may use each clam more than once. Good Luck!

Instructions

1) Six groups will select two of the genotyped clams from the cup. Write them down: Example

   Female Clam Genotype: ____ #7 RW Gg Dd _________________

   Male Clam Genotype: ______#6 RR gg DD_________________

2) Read the growers desired clam phenotypes and write which genotypes are needed to produce these clams.
3) Then, if your group believes they have one or two clams that could be a parent, nominate your clam along with what clam mate it should go with. *You may have a clam with the right genotype(s), but there may not be the right mate available*
4) The class must work together to identify the right combination of parents for each grower. There may be multiple clam # combination options, you only need to identify one. Remember, one clam must be female, and one must be a male.

Punnett squares are not required for this part, but extras are available for you if needed. Punnett squares for each grower may be drawn on the board to verify the class selected clams will produce the desired offspring.

Grower #1 wants white and mottled clams.

Genotype of offspring needed: __WW & RW_____________

Parents genotype combination(s) needed: ___ WW & RW _______________

Could one of your clams be used? __Yes, #7_________________

Clam #s selected: ___#7/#10 with #2/#5__or #1/#4 with #8/#11___________

Grower #2 wants fast growing clams.

Genotype of offspring needed: ____GG or Gg___________

Parents genotype combination(s) needed: ___GG & GG or GG & Gg________

Could one of your clams be used? ___yes, #7________________

Clam #s selected: __#1/#3 with #7/#10/#8/#11/#9 or #5 with #10/#8__________

Grower #3 wants red clams with disease resistant.

Genotype of offspring needed: ___RRdd____________

Parents genotype combination(s) needed: ___RRdd & RRdd_____

Could one of your clams be used? __No_________________

Clam #s selected: __Only #3 with #12______________

Grower #4 wants mottled clams that have normal growth.

Genotype of offspring needed: __RWgg_____________

Parents genotype combination(s) needed: __WWgg & RRgg________________

Could one of your clams be used? __Yes, #6_________________

Clam #s selected: __Only #2 with #12__________________

Grower #5 wants all mottled clams that have non-disease resistance, but you plan to keep some of the clams and want them to be homozygous for non-disease resistance.

Genotype of offspring needed: __RWDD_____________

Parents genotype combination(s) needed: ___RRDD & WWDD_______________

Could one of your clams be used? ___Yes, #6________________

Clam #s selected: ____#6 & #8________________

Grower #6 wants white clams that have fast growth, but you plan to keep some of the clams and want them all to be heterozygous for fast growth.

Genotype of offspring needed: ____WWGg___________

Parents genotype combination(s) needed: _____WWGG & WWgg_____________

Could one of your clams be used? ____No_______________

Clam #s selected: ____#2 & #8________________

Exit questions:

Why would growers want clams with specific traits or phenotypes?

Growers may want clams that are a specific color because of consumer preferences, they may want a clam that grows faster because the sooner those clams can be sold, and they may want clams that are disease resistant to prevent mortality in the event of a disease outbreak.

How can selective breeding benefit an aquaculture production?

Selectively breeding individuals can produce more offspring that are adapted to a specific environment or have a specific phenotype that allow for high survival and better economic value.

If you could ask the clam farmer one question, what would it be?

Worksheet #2: Part II – Decide which clams to breed based on grower's request – *AP Classes*

Name: ___________________

Date: ____________________

Scenario

Genotyping your clams is not cheap. You have selected 12 clams that you think encompass a wide range of phenotypes for the research scientists to genotype. It is hatching season and growers are giving you their list of desired clams. You only have time to induce each of your 12 genotyped clams to spawn once this season. You must strategically select the best pair of male and female clams to produce the desired offspring of your growers. You do not want to create any offspring not wanted by the grower. Good Luck!

Instructions

1) Six groups will select two of the genotyped clams from the cup. Write them down:

   Female Clam Genotype: _____________________

   Male Clam Genotype: _______________________

2) Read the growers desired clam phenotypes and write which genotypes are needed to produce these clams.
3) If your group believes they have one or two clams that could be a parent, nominate your clam.
4) As a class, you should decide which clams should be used to produce the desired offspring of the growers.

Growers may not be skipped. Must start with grower #1 and go down the line to grower # 6. Once the male and female clam have been selected by the class, the teacher will take the clams from their respected groups and those clams will not be available for later spawns. The class must work together to identify the right combination of parents for each grower. Punnett squares are not required for this part, but extra are available for you if needed. Punnett squares for each grower may be drawn on the board to verify the class selected clams will produce the desired offspring.

Grower #1 wants white and mottled clams that are disease resistant

Genotypes needed: __________________

Clam #s selected: ____________________

Grower #2 wants red clams that are disease resistant

Genotypes needed: ___________________

Clam #s selected: _____________________

Grower #3 wants all the colors with fast growth, but you plan keep some for future breeding and want them to be homozygous for fast growth

Genotypes needed: ___________________

Clam #s selected: _____________________

Grower #4 wants mottled clams that are both disease and non-disease resistant

Genotypes needed: ___________________

Clam #s selected: _____________________

Grower #5 wants all mottled clams that have fast growth, but you plan to keep some of the clams and want them to be heterozygous for fast growth

Genotypes needed: ___________________

Clam #s selected: _____________________

Grower #6 wants both white and mottled clams that are half fast growing and half normal growing. You realize you have two possible sets of parents for this cross but have already used two possible parent pairs in other crosses and they are not ready again to spawn. What two parents will give you this desired out come?

Genotypes needed: ___________________

Clam #s selected: _____________________

Extra credit: What two parents already used in earlier spawns would have also given you the desired offspring?

Exit questions: Why would growers want clams with specific traits or phenotypes? How can selective breeding benefit an aquaculture production?

KEY - Worksheet #2: Part II – Decide which clams to breed based on grower's request – *AP Classes*

Name: ___________________

Date: ____________________

Scenario

Genotyping your clams is not cheap. You have selected 12 clams that you think encompass a wide range of phenotypes for the research scientists to genotype. It is hatching season and growers are giving you their list of desired clams. You only have time to induce each of your 12 genotyped clams to spawn once this season. You must strategically select the best pair of male and female clams to produce the desired offspring of your growers. You do not want to create any offspring not wanted by the grower. Good Luck!

Instructions

1) Six groups will select two of the genotyped clams from the cup. Write them down: Example

   Female Clam Genotype: ____ #7 RW Gg Dd _________________

   Male Clam Genotype: ______#6 RR gg DD_________________

2) Read the growers desired clam phenotypes and write which genotypes are needed to produce these clams.
3) If your group believes they have one or two clams that could be a parent, nominate your clam.
4) As a class, you should decide which clams should be used to produce the desired offspring of the growers.

   Growers may not be skipped. Must start with grower #1 and go down the line to grower # 6. Once the male and female clam have been selected by the class, the teacher will take the clams from their respected groups and those clams will not be available for later spawns. The class must work together to identify the right combination of parents for each grower. Punnett squares are not required for this part, but extra are available for you if needed. Punnett squares for each grower may be drawn on the board to verify the class selected clams will produce the desired offspring.

Grower #1 wants white and mottled clams that are disease resistant

Genotypes needed: ___ RWdd x WWdd________

Clam #s selected: ______11 x 4______

Grower #2 wants red clams that are disease resistant

Genotypes needed: ____ RRdd x RRdd___________

Clam #s selected: ______3 x 12______________

Grower #3 wants all the colors with fast growth, but you plan keep some for future breeding and want them to be homozygous for fast growth

Genotypes needed: ___ RWGG x RWGG ___

Clam #s selected: _____1 x 10_______________

Grower #4 wants mottled clams that are both disease and non-disease resistant

Genotypes needed: __WWDd x RRDd_______

Clam #s selected: _____5 x 9_______________

Grower #5 wants all mottled clams that have fast growth, but you plan to keep some of the clams and want them to be heterozygous for fast growth

Genotypes needed: __ WWGG x RRgg____

Clam #s selected: _____8 x 6_______________

Grower #6 wants both white and mottled clams that are half fast growing and half normal growing. You realize you have two possible sets of parents for this cross but have already used two possible parent pairs in other crosses and they are not ready again to spawn. What two parents will give you this desired out come?

Genotypes needed: ___ RW x WW ____Gg x gg _______________

Clam #s selected: ____7 x 2________________

Extra credit: What two parents already used in earlier spawns would have also given you the desired offspring?

11 x 4

Exit questions: Why would growers want clams with specific traits or phenotypes? How can selective breeding benefit an aquaculture production?
Growers may want clams that are a specific color because of consumer preferences, they may want a clam that grows faster because the sooner those clams can be sold, and they may want clams that are disease resistant to prevent mortality in the event of a disease outbreak. Selectively breeding individuals can produce more offspring that are adapted to a specific environment or have a specific phenotype that allow for high survival and better economic value.