Name_____ Period _____Date_____

GloFish® Heredity: Using Punnett Squares to Predict Offspring Genotypes and Phenotypes

Objective

The learner will use Punnett squares to make predictions about the possible outcomes of genetic variations when breeding golden zebrafish with genetically modified GloFish® fluorescent fish.

Introduction

GloFish were developed when scientists removed a fluorescence gene from a sea coral and added it to a zebrafish embryo. The fluorescence gene became part of the DNA found in the developing zebrafish. The resulting genetically modified fish can pass the fluorescence gene along to its offspring.

Each different form of a gene is called an allele. In GloFish, scientists have been able to produce fish with three different fluorescent colors. There are three alleles for the gene that carries the fluorescent color. When a GloFish is bred with a golden zebrafish, the color allele is dominant and shows in the phenotype or appearance of the fish. A dominant allele is represented by a capital letter. A recessive allele can be masked and will not be expressed if a dominant allele is present. Recessive alleles are often represented by lower case letters. These letters are used when referring to the genotype which is the allelic combination of the fish. For example, capital R would represent the allele for Starfire Red® color. The Starfire Red allele is dominant over the golden zebrafish allele for color, which is represented by the lower case letter w. An offspring that received an R from one parent and w from the second parent would have the genotype Rw. This Rw genotype would produce the Starfire Red phenotype. The other color genotypes for GloFish are Electric Green® (represented by a G) and Sunburst Orange® (represented by O).

Offspring inherit one allele from each parent. The alleles can be received in different combinations but each genotype must include two alleles. If a GloFish had the genotype RR, then the genotype would be called homozygous dominant because the inherited alleles from each parent were the same. The genotype of ww would be called homozygous recessive since both alleles call for the same recessive phenotype found in the wild-type golden zebrafish. A GloFish that receives an R allele from one parent and a w allele from the other parent would have the Rw genotype and be called heterozygous.

You can predict the likelihood (probability) of passing down the fluorescent colors of the zebrafish to their offspring by using a Punnett square such as the one shown below. A Punnett square is a graphic view of probability. In a Punnett square, the possible alleles the mother and father can contribute for a specific trait are listed at the top and left side of

the table. The inside of the square shows the possible genotypes the offspring could receive from the parents.

In the Punnett square below, a Starfire Red® homozygous dominant mother is crossed with a wild-type golden zebrafish father. Notice that the genotype of all the offspring is heterozygous. The phenotype of all the offspring would be Starfire Red.

	R	R
w	Rw	Rw
w	Rw	Rw

A Punnett square can be used to predict the percentage of offspring that may have specific genotypes or phenotypes. The Punnett square below shows the allelic combinations possible in the offspring of a cross between a heterozygous Starfire Red and a homozygous recessive male.

	R	w
w	Rw	ww
w	Rw	ww

The likelihood of these two parents producing an offspring with Starfire Red phenotype is 50%. The offspring with the Rw genotype would have the Starfire Red phenotype. Similarly, the offspring of this cross has a 50% chance of expressing the wild-type golden phenotype. If 60 offspring were produced from the cross, it is expected that half of the baby fish would be red and half would be golden.

The genotype possibilities for a cross between two heterozygous Starfire Red fish are shown in the Punnett square below. Notice this cross can produce three different allele combinations; RR, Rw and ww. There is a 50% chance that the offspring will be heterozygous Starfire Red since there are two different combinations that will result in the Rw genotype. The likelihood of these parents producing offspring that are homozygous Starfire red (RR) is 25%. Similarly, 25% of the offspring would be expected to have the homozygous recessive (ww) genotype.

	R	w
R	RR	Rw
w	Rw	ww

National Standards Addressed

Science as Inquiry A—Abilities necessary to do scientific inquiry
Life Science C—Molecular basis of heredity

Materials Per Group

Ruler
Paper or science journal

Procedures

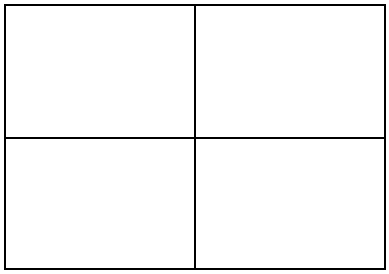
Part A: Practice Predicting Using Punnett Squares

1. Draw a Punnett square showing the possible offspring combinations for the crosses stated on the student answer page.

2. Use the Punnett squares to answer the questions related to each cross.

Cross 1: A homozygous dominant Starfire Red® mother with a heterozygous father.

Punnett Square



1. What percentage of offspring should have the same genotype as the father?

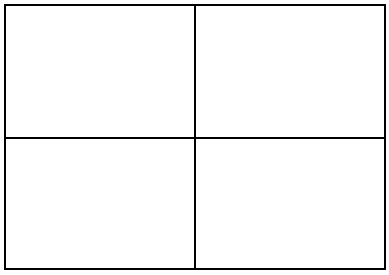
2. What percentage of offspring should have the phenotype of Starfire Red®?

3. If these fish produce 20 offspring, how many should be Starfire Red?

4. What percentage of offspring should have the same genotype as the mother?

Cross 2: A heterozygous Electric Green® mother with a heterozygous Electric Green father.

Punnett Square



5. What percentage of offspring should have the same phenotype as the father?

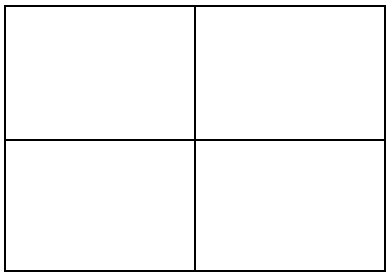
6. What percentage of offspring should be homozygous dominant?

7. If these fish produce 20 offspring, how many should be homozygous dominant?

8. Out of the 20 offspring, how many should be golden color?

Cross 3: A homozygous dominant Sunburst Orange® mother with a homozygous recessive wild type father.

Punnett Square



9. What percentage of offspring should have the wild type phenotype?

10. What percentage of offspring should have the mother's phenotype?

11. If these fish produce 45 offspring, how many will have the same phenotype as the mother?

12. What will be the genotype of the offspring?

Part B: The Problem

After completing a lab in school using GloFish®, a biology class decides to start their own breeding program. They have chosen to start their program using one wild type golden zebrafish and one Electric Green® GloFish.

1. Determine and illustrate the crosses the class will need to make with their starter fish and then their offspring in order to produce homozygous dominant GloFish. Once the Punnett squares are drawn, write a paragraph explaining the crosses chosen using the words homozygous dominant, homozygous recessive, heterozygous, phenotype, and genotype (Question 3 below).

Punnett Squares (Please draw additional squares on the back if needed.)

2. If the class gets Electric Green® GloFish®, how will they determine if the fish are homozygous dominant or heterozygous for the color?

3. Write a paragraph explaining the crosses chosen using the words homozygous dominant, homozygous recessive, heterozygous, phenotype, and genotype.

Elaborations or Extensions

After completing this activity, students could write a procedure for a lab to breed the GloFish and golden zebrafish to get the same results as the Punnett square activity in Part B.

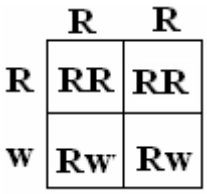
GloFish® Heredity:
Using Punnett Squares to Predict Offspring Genotypes and Phenotypes
Answer Sheet

Intended Grade Level
9th, 10th and 11th

Teacher Information
Be sure students understand the transition from determining the ratio by changing fraction into a percent.

Possible Answers to Discussion Questions

Cross 1: A homozygous dominant Starfire Red® mother with a heterozygous father.



1. What percentage of offspring should have the same genotype as the father?

   50%

2. What percentage of offspring should have the phenotype of Starfire Red?

   100 %

3. If these fish produce 20 offspring, how many should be Starfire Red?

   20

4. What percentage of offspring should have the same genotype as the mother?

   50%

Cross 2: A heterozygous Electric Green® mother with a heterozygous Electric Green father.

	G	w
G	GG	Gw
w	Gw	ww

5. What percentage of offspring should have the same phenotype as the father?

   50%

6. What percentage of offspring should be homozygous dominant?

   25%

7. If these fish produce 20 offspring, how many should be homozygous dominant?

   5

8. Out of the 20 offspring, how many should be golden color?

   5

Cross 3: A homozygous dominant Sunburst Orange® mother with a homozygous recessive wild type father.

	O	O
w	Ow	Ow
w	Ow	Ow

9. What percentage of offspring should have the wild type phenotype?

   0%

10. What percentage of offspring should have the mother's phenotype?

    100%

11. If these fish produce 45 offspring, how many will have the same phenotype as the mother?

    45

12. What will be the genotype of the offspring?

    Heterozygous

Part B: The Problem

After completing a lab in school using GloFish®, a biology class decides to start their own breeding program. They have chosen to start their program using one wild type golden zebrafish and one Electric Green® GloFish.

1. Determine and illustrate the crosses the class will need to make with their starter fish and then their offspring in order to produce homozygous dominant GloFish. Once the Punnett squares are drawn, write a paragraph explaining the crosses chosen using the words homozygous dominant, homozygous recessive, heterozygous, phenotype, and genotype (Question 3 below).

   Students set up Punnett squares and can cross GG X ww and then cross Gw X Gw to have a 25% chance of getting GG, or they could cross Gw X ww and then cross Gw X Gw to have a 25% chance of getting GG.

2. If the class gets Electric Green GloFish, how will they determine if the fish are homozygous dominant or heterozygous for the color?

   The class would have to continue crossing the Electric Green GloFish for many generations until the adults no longer produced any offspring with the wild phenotype. To test any particular Electric Green GloFish, it could be crossed with a wild-type zebrafish. The percentage of wild-type offspring will indicate whether the fish in question is homozygous dominant or heterozygous for the color.

3. Write a paragraph explaining the crosses chosen using the words homozygous dominant, homozygous recessive, heterozygous, phenotype, and genotype.

   If the class crosses a homozygous dominant mother with the Electric Green phenotype to a homozygous recessive male with the golden phenotype, all of the offspring will have the heterozygous genotype. Also, all of the offspring will have the Electric Green phenotype. Then they would need to cross two of the offspring with the heterozygous genotype. This would give the student a 25% chance of getting offspring with the homozygous dominant genotype.