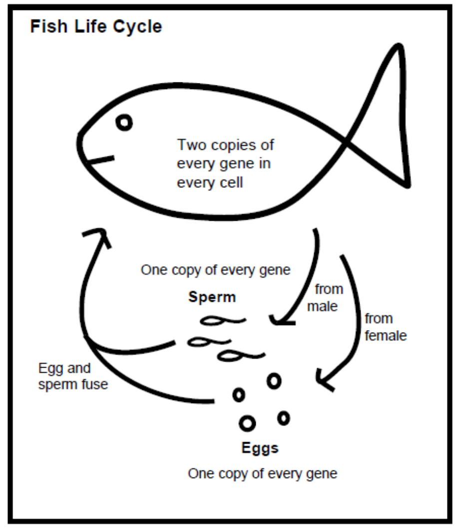
Name:________________________________

# Toothpick Fish




**Purpose:** In this lab, we are going to experiment with genes and the environment for a population of "toothpick" fish. You will learn about the relationships between many different aspects of fish life: genes, traits, variation, survival, and reproduction. The activity here is a simulation, but it models the way fish and other organisms live in nature.

**Materials (for each group):**

- 1 "gene pool" container (e.g. a petri dish)
- 8 green toothpicks
- 8 red toothpicks
- 8 yellow toothpicks

**Introduction**:
The colored toothpicks represent three different forms of a gene (green, red, and yellow) that controls one fish trait: fish color. The table tells you which forms, or alleles, of the gene are dominant, which are recessive, and which are equal (or incompletely dominant).

| | |
|---|---|
| Green allele (G) is… | • Dominant to all other color alleles |
| Red allele (R) is… | • Recessive to green<br>• Equal to yellow* |
| Yellow allele (Y) is… | • Recessive to green<br>• Equal to red* |

*combining red and yellow alleles results in a fish with orange skin color

REMEMBER: EACH TOOTHPICK REPRESENTS A GENE, NOT A FISH

**Directions:**

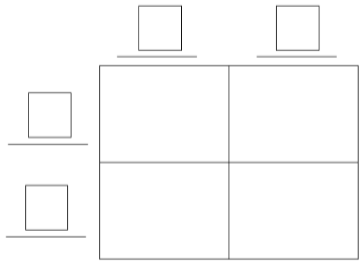
1) Count your toothpicks to make sure you have 8 of each color (for a total of 24 toothpicks) and place them in the "gene pool" half of your petri dish.

2) Figure out which gene combinations give rise to which fish colors and fill in the chart below:

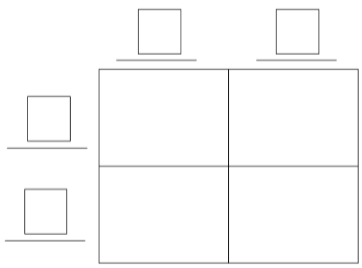
| **Phenotype (fish color)** | **Possible Genotypes** |
|---|---|
| Green | |
| Red | |
| Yellow | |
| Orange | |

3) Based on the genotypes you listed in the table for question 2, answer the questions below (you may want to use Punnett Squares to help you determine the answers).

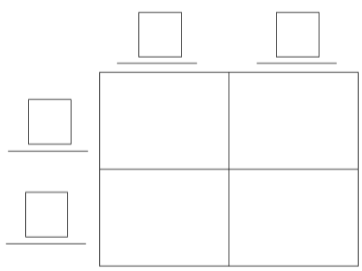
   a. Can two red fish mate and have green offspring? Why or why not?

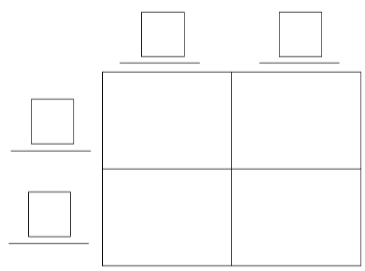


   b. Can two orange fish mate and have red offspring? Why or why not?



   c. Can two green fish mate and have orange offspring? Why or why not?





4) Make a first generation of fish. To do this, pull out genes (toothpicks) in pairs without looking and set them aside carefully so that they stay in pairs. This simulates the way offspring are formed by the sperm from the male fish combining randomly with eggs from the female fish. Once you have drawn your twelve pairs, record the results in Table A. An example fish in the first generation is given in Table A in the shaded boxes (do not include this fish in your calculations).

5) Count the numbers of each color of fish offspring and record the numbers in Table B for the 1$^{st}$ generation.

   The stream where the fish live is very green and lush with lots of vegetation and algae covering the streambed and banks. The green fish are very well camouflaged from predators in this environment and the red and orange fish are camouflaged fairly well also. However, none of the yellow fish survive or reproduce because predators can easily spot them in the green algae environment. **If you have any yellow fish (fish in which both toothpicks are yellow), set those toothpicks aside in the "dead fish" container.**

6) Put all the genes you have left back in the gene pool **(remember, you have set aside the genes for any yellow fish in the "dead fish" container)**. Draw a second generation of fish, again without looking. Record your gene pairs in Table A. Total up the fish of each color and record the numbers in the 2nd generation row in Table B. Remember, the yellow fish die in this environment so after filling out Tables A and B, set aside the genes for any yellow fish you may have in the second generation and return the surviving fish to the "gene pool" petri dish.

7) The well-camouflaged fish live longer and have more offspring, so their numbers are increasing. Draw toothpicks to make a third generation of fish. Record your data in Table A and the colors of each fish in Table B. Now, return the survivors to the gene pool (be sure to set aside any genes from yellow offspring).

   STOP HERE. DO NOT PROCEED TO STEP 8 UNTIL AFTER YOU HAVE DISCUSSED AND ANSWERED THE FOLLOWING THREE QUESTIONS WITH YOUR GROUP MEMBERS.

   a. Have all the yellow genes disappeared?

   b. Has the population size changed? In what way? Would you expect this to occur in the wild?

   c. How does the population in the third generation differ in color compared to the population in the earlier generations?

8) Draw more pairs of genes to make a fourth generation of fish. Record the data in Table A, but do not remove the yellow fish because…

   **An environmental disaster occurs!** Factory waste harmful to algae is dumped into the stream, killing much of the algae very rapidly. The remaining rocks and sand are good camouflage for the yellow, red, and orange fish. Now the green fish are easily spotted by predators and can't survive or reproduce.

   Because green fish don't survive, set them aside in the "dead fish" container. Now record the surviving offspring (all but the green) in the last row of Table B.

   a. Has the population changed compared to earlier generations? How?

   b. Have any genes disappeared entirely?

   c. Yellow genes are recessive to green; green genes are dominant to both red and yellow. Which color of genes disappeared faster when the environment was hostile to them? Why?

Table A. Genotypes and Phenotypes of Fish Generations 1-4

| | - - - G E N E R A T I O N - - - | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1st | | 2nd | | 3rd | | 4th | |
| | Genotype | Phenotype | Genotype | Phenotype | Genotype | Phenotype | Genotype | Phenotype |
| Ex | GR | green | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |

Table B. Offspring Color for Toothpick Fish Generations

| **Environment** | **Generation** | **# Green** | **# Red** | **# Orange** | **# Yellow** |
|---|---|---|---|---|---|
| There is lots of green seaweed growing everywhere. | 1st | | | | |
| | 2nd | | | | |
| | 3rd | | | | |
| The seaweed all dies, leaving behind bare rocks and rocks. | 4th (survivors only) | | | | |

**Discussion Questions:**

- Hatchery fish populations often have less genetic biodiversity than wild fish populations. How might lowered biodiversity affect a fish population's ability to adapt to environmental disasters such as the pollution described in this simulation?

- If the fish from a particular stream have become genetically adapted to their home stream over many generations, what might happened if their fertilized eggs are used to "restock" a different stream that has  become depleted of fish?

- Can you think of any examples from the real world where lowered genetic diversity is impacting a species' ability to survive?