**Subject area/course:** Science/Biology - Genetics

**Grade level/band:** 10

**Task source:** New Hampshire Task Bank; Author: Megan Brown and Maureen Munn, The GENETICS Project. University of Washington. Modified by: Rita Ciambra, Valerie Cunha, John Duplinsky, Marilyn Shepardson, and Michelle Webber; Science Department, Spaulding High School, Rochester, NH.

**Toothpick Fish Inquiry Task**

**STUDENT INSTRUCTIONS**

1. **Task context**:

***Essential Question:*** *How can factors within an ecosystem effect changes in the population and genetic biodiversity of the Toothpick Fish species?*

The purpose of this activity is to experiment with genes in an environment for a population of “toothpick” fish, explaining the relationships between genes, traits, variation, survival, and reproduction. The activity is a simulation, but it models the way actual fish and other organisms live in nature. This activity will require you to understand the basic concepts of genetics and natural selection as well as to make predictions about and explain the effects of changes in your “toothpick” fish’s environment. A word bank is available on the last page of this task for reference.

1. **Final product**:

**There are three parts to this task:**

**Part C:** Using Evidence and Applying What You’ve Learned

**Part B:** Organizing, Presenting, and Analyzing Data

**Part A:** Introduction and Make a Hypothesis

**Part A: Introduction and Make an Initial Hypothesis.**

**Introduction:**

The colored toothpicks represent three different alleles (green, red, and yellow) that control one fish trait: skin color (orange, green, red, or yellow). The table below explains which alleles of the gene are dominant, which are recessive, and which share incomplete dominance. Remember, each toothpick represents an allele; two toothpicks represent a genotype of an individual fish.

|  |  |
| --- | --- |
| Green Allele (G) | Dominant to all other color alleles |
| Red Allele (R) | Recessive to green, incomplete to yellow**\*** |
| Yellow Allele (Y) | Recessive to green, incomplete to red**\*** |

***\* Combining red and yellow alleles result in a fish with orange skin color.***

**Environment:**

The Toothpick Fish population lives in the Mt. Washington Valley River in New Hampshire. This shallow river is slow moving and full of vegetation; algae, Eurasian milfoil, plankton, and lily pads. Local predators include great blue herons, eastern snapping turtles, osprey, bald eagles, and raccoons. Osprey and bald eagles hunt from the sky, using visual cues to spot their prey. Great blue herons wade through the shallow water and spear prey with long, sharp beaks. Genetic biodiversity within a population is essential to its survival. The genetic make-up of a population can be dramatically affected by human activities impacting their habitat as well as interdependence with other species such as predators or competitors. Scientists are currently researching Toothpick Fish and factors which effect changes in their population.

1.In the space provided below, generate a hypothesis about which Toothpick Fish offspring are most likely to survive in the environment described above and why.

**Performance Task Instructions:**

1. Use the information from the introduction to complete the table below.

**Table 1: Phenotypes of Toothpick Fish and their Possible Gene Combinations**

|  |  |
| --- | --- |
| **Phenotype** | **Possible Allele Combinations** |
| Green |  |
| Red |  |
| Yellow |  |
| Orange |  |

1. Based on the allele combinations in the table above, answer the questions below using Punnett Squares.

**What is the likelihood (percentage) that:**

Green offspring will be produced if two red fish mate? Support your claim with evidence and reasoning.

|  |  |
| --- | --- |
|  |  |
|  |  |

|  |  |
| --- | --- |
|  |  |
|  |  |

Red offspring will be produced if two orange fish mate? Support your claim with evidence and reasoning.

Orange offspring will be produced if two green fish mate? Support your claim with evidence and reasoning.

|  |  |
| --- | --- |
|  |  |
|  |  |

**Part B: Organizing, Presenting, and Analyzing Data.**

Follow the steps below and record your observations on your data sheet.

1. Place eight of each colored toothpick into the brown paper bag (total of 24 toothpicks).
2. Make a first generation of fish. To do this, pull out alleles (toothpicks) in pairs without looking and set them aside carefully so they stay in pairs. This simulates the way offspring are formed by sperm combining randomly with eggs. Once the twelve pairs are drawn, **record** the genotypes and phenotypes of the resulting pairs in Table 2 and Table 3.
3. Count the number of each phenotype in the first generation and **record** those numbers in Table 4.
4. The following spring, scientists make observations showing an increase of osprey in the area. Remove the yellow toothpick fish from your population and set aside those toothpicks, they are no longer part of the gene pool. *Hint: remember that a pair of toothpicks equals a fish.*
5. Put the remaining alleles back into the gene pool (brown paper bag). Draw a second generation of fish, again without looking. **Record** the allele pairs in Table 2 and Table 3.
6. Count the number of each phenotype in the second generation and **record** the numbers in Table 4.

*That summer, scientists make observations showing an increase in bald eagles migrating to the area.*

1. Remove the yellow toothpick fish from your population and set aside those toothpicks, they are no longer part of the gene pool. *Hint: remember that a pair of toothpicks equals a fish.*
2. Put the remaining alleles back into the gene pool (brown paper bag). Draw a third generation of fish, again without looking. **Record** the genotypes and phenotypes in Table 2 and Table 3.
3. Count the number of each phenotype in the third generation and record the numbers in Table 4.

**Stop Answer the following questions before continuing.**

1. Why has the population of fish with yellow alleles been affected by the osprey and bald eagles?
2. Have all the yellow alleles disappeared? Why or why not?
3. Explain why it is unlikely for the yellow allele to completely disappear in a real-life, large population of fish. Use evidence from this inquiry task to support your answer.
4. Put the remaining alleles back into the gene pool. This time, **DO NOT** remove the yellow fish.
5. Draw a fourth generation of fish, again without looking. **Record** the genotypes and phenotypes in Table 2 and Table 3.
6. Count the number of each color of fish offspring and **record** the numbers in Table 3.

 such as loss of habitat or change in predator type and number. Use this

 information to determine the effect on the Toothpick fish population.

**Stop** An environmental disaster occurs! There has been an accidental discharge of

Toxic waste into the area. First determine what the impact of this disaster will

**Formulate a Revised Hypothesis:**

1. In the space provided, revise your initial hypothesis based on this environmental event. Consider the cause and effect relationship of the environmental disaster in the ecosystem. Support your new hypothesis with evidence from this inquiry task.

1. Remove all of the fish from the population that would be impacted by this negative human activity. *Hint: remember that a pair of toothpicks equals a fish.*
2. **Record** the surviving offspring in Table 4.
3. Place all of the toothpicks back in the bag and set aside.

**Graphing:**

Using the data from Table 4, create a complete line graph showing the phenotypes of each of the toothpick fish over the four generations. Be sure to include legend/key.

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**Stop Answer the following questions using the data you have gathered during this inquiry task.**

**Part C: Using Evidence and Applying What You Learned.**

1. Compare the phenotypes of the surviving generation to the phenotypes of the first generation. Explain why these phenotypes had changed.
2. Hatchery fish populations often have less genetic biodiversity than wild fish populations. How would lowered diversity affect a fish population’s ability to adapt to environmental disasters, such as the pollution disaster described in this performance task? Use data or evidence from this inquiry task to support your claim.
3. Successfully restocking one stream with eggs from another stream is a common hatchery practice. If fish from a particular stream have become genetically adapted to their home stream over many generations, what might happen if their fertilized eggs are used to “restock” a different stream that has become depleted of fish? Use data or evidence from this inquiry task to support your claim.

**Word Bank**

|  |  |
| --- | --- |
| Allele | alternative form of a gene |
| Biodiversity | variety of life in an area |
| Depleted | to reduce |
| Dominance | an observed trait in an organism that masks the recessive form of the trait |
| Environment | an organism’s surroundings (biotic and abiotic factors) |
| Gene | segment of DNA that codes for a trait |
| Generation | a group of individuals born and living at the same time |
| Genotype | the combination of alleles within an individual |
| Hatchery | a place where fish are hatched and raised |
| Incomplete Dominance | a pattern of inheritance in which neither allele is dominant over the other and traits are combined |
| Phenotype | physical appearance of an individual |
| Population | a group of organisms all of the same species |
| Recessive | the allele that is masked by the dominant allele |
| Trait | characteristic that is inherited, can be dominant or recessive. |
| Variation | differences or variety |

Performance task adapted from Toothpick Fish (April, 2001) – A Middle School Activity for Teaching Genetics and Environmental Science. Developed by: Megan Brown and Maureen Munn, The GENETICS Project. The GENETICS Project University of Washington http://chroma.mbt.washington.edu/outreach/genetics Department of Molecular Biotechnology Education Outreach

**Additional Information**

1. **Knowledge and skills you will need to demonstrate on this task:**
* Generate a hypothesis based on given information.
* Collect and analyze data throughout the performance assessment.
* Utilize prior understanding of Mendelian Genetics to predict genetic outcomes of potential breeding crosses of fish.
* Create a complete graph including title, key, and axes labels.
* Interpret collected data and apply conclusions to a real world instance.
1. **Materials needed:**

The following materials should be provided at each lab station:

* + Brown paper bag (gene pool container)
	+ 8 green toothpicks
	+ 8 red toothpicks
	+ 8 yellow toothpicks
	+ 4 Colored pencils or markers (green, red, orange, yellow)
	+ Writing utensil and ruler

 You will also need:

* Computer/iPad
* Graphic organizer
* Notebook/scrap paper
* Toothpick fish data tables
1. **Time requirements:**

You will have approximately one and a half 90-minute blocks or three 45-minute class sessions to complete this task. Your teacher will provide additional details.

1. **Scoring:**

Your work will be scored using the Toothpick Fish Rubric. You should make sure you are familiar with the language that describes the expectations for proficient performance.