**Health in Our Hands: The Mystery of the Monkeyflower**

**What causes similarities and differences between organisms?**

[**Materials list**](https://docs.google.com/document/d/1QbVrH0-Kh_3fJzq-ZvpSr9Fdjllo5_7XXZ4XLh3IJR4/edit) **-**

**Bundle of PEs selected for this unit**

**Structures and functions:**

* [**HS-LS1-1**](https://www.nextgenscience.org/pe/hs-ls1-1-molecules-organisms-structures-and-processes)Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
* [**HS-LS1-2**](https://www.nextgenscience.org/pe/hs-ls1-2-molecules-organisms-structures-and-processes) Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

**Inheritance and variation of Traits**

* [**HS-LS3-1**](https://www.nextgenscience.org/dci-arrangement/hs-ls3-heredity-inheritance-and-variation-traits)Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
* [**HS-LS3-2**](https://www.nextgenscience.org/pe/hs-ls3-2-heredity-inheritance-and-variation-traits)Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
* [**HS-LS3-3**](https://www.nextgenscience.org/pe/hs-ls3-3-heredity-inheritance-and-variation-traits)Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

**Natural selection and evolution**

* [**HS-LS4-2**](https://www.nextgenscience.org/pe/hs-ls4-2-biological-evolution-unity-and-diversity) Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
* [**HS-LS4-3**](https://www.nextgenscience.org/pe/hs-ls4-3-biological-evolution-unity-and-diversity) Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
* [**HS-LS4-4**](https://www.nextgenscience.org/pe/hs-ls4-4-biological-evolution-unity-and-diversity) Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
* [**HS-LS4-5**](https://www.nextgenscience.org/pe/hs-ls4-5-biological-evolution-unity-and-diversity) Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

**Curriculum storyline**

[**Learning Set 1**](https://docs.google.com/document/d/1m-lh2Eiawrq5VSh1bn1dQxdoYpuhP90CAa7o2VlhCtE/edit)

| **Question(s) to figure out**  | **DCI**  | **Scientific Practice(s)** | **CCC** |
| --- | --- | --- | --- |
| How are the traits of the two varieties of monkeyflowers similar or different? | LS1.A: Structure and Function | Plan and carry out investigation  | Pattern  |
| **Purpose** This learning set introduces the mystery story of the monkeyflower to the students through an immersive graphic novel and a plant experiment with monkeyflowers. The graphic novel and plant experiment are based on the scientific work of Dr. David Lowry, and his research about speciation of monkeyflowers at Michigan State University https://davidbryantlowry.wordpress.com/people/. In this learning set, the students will conduct a field observation and try to answer a question that will help them recognize the similarities and differences between organisms and later understand the concepts of variation in traits and natural selection: What are the similarities and differences in traits between the two varieties of monkeyflowers?**Learning Goals** - The students generate various questions about the two different varieties of monkeyflower.- The students conduct an outdoor observation to compare and contrast traits in different organisms.- The students develop and use models to explain the hierarchical structural organization of monkey flowers (an organism). - The students use models to explain how the subsystems work together to maintain the overall function of monkeyflower (living organisms).  |

| **Instructional sequence overview** | **Instruction days** |
| --- | --- |
| ***Lesson 1 - Introducing the phenomenon: The Mystery of the Monkeyflowers*** Students are introduced to the two different monkeyflower plants and make observations and ask questions about the differences between the plants. Students are also introduced to Module 1 of the comic book. They create a driving question (DQ) flowchart to organize their questions. | 2 |
| ***Lesson 2 - Becoming science researchers: Conducting an outdoor investigation***The students read Module 1 of the story about the bee scientists, Maia and William and the mystery plant. The students conduct an outdoor observation on characteristics of organisms in the schoolyard to trigger a discussion about the differences and similarities between traits of organisms. Then they set up the investigation and conduct initial measurements and observations.  | 2 |
| ***Lesson 3 - How do the parts of the monkeyflower work together to keep the monkeyflower plant alive?*** Each group of students studies the different parts of two varieties of monkeyflowers. Each group observes (both at macro and micro level) each part and examines their structure, roles, and importance. They build a model by combining all the information from each group. Then they discuss how each of the parts works together to sustain the plant as a whole.  | 2 |
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| ***Lesson 4 Wrapping up - What are the similarities and differences in traits between the two varieties of monkeyflowers?***The students go back and revisit the DQ flowchart. Based on what they figured out in previous lessons, they examine the similarities and differences in traits between the two varieties of monkeyflowers. | 1 |

[**Learning Set 2**](https://docs.google.com/document/d/1O8OGbnCA4EFeOHOOasl7yeLp-cEu0J1E9rag-rip_2E/edit?usp=sharing)

| **Question(s) to figure out**  | **DCI**  | **Scientific Practice(s)** | **CCC** |
| --- | --- | --- | --- |
| What causes the similarities and differences between monkeyflower traits? | LS1.A: Structure and FunctionLS3.B: Variation of Traits | Developing and using modelsConstructing a scientific explanation | System and system modelsStructure and function |
| **Purpose** In this learning set, the students will figure out the process of sexural reproduction of plants and the structure and function of DNA. Through the pipe cleaner and bead hands-on simulation, students will figure out how the traits are passed from parents to offsprings. Then, they will engage in various activities to support their understanding of the relationships between DNA, proteins and traits.**Learning Goals** - The students ask questions about what causes the differences between two monkeyflowers.- The students simulate the process of meiosis and explain how it can result in genetic variation. - The students use models that support their figuring out the structure of DNA.- The students use a computer simulation to figure out how DNA can be used to make proteins and what happens when mutations (unexpected changes in DNA) happen.- The students explain how different traits of organisms are associated with genes that code for proteins. |

| **Instructional sequence overview** | **Instruction days** |
| --- | --- |
| ***Lesson 1 - Mystery story*** The students read comic module #2 and go back to the DQ flowchart to make hypotheses for sub-driving question (SDQ).  | 1 |
| ***Lesson 2 - How are traits passed from parent to offspring?*** The students review their prior knowledge about genes and inheritance. Then, students use pipe cleaners and beads to simulate and figure out meiosis, and Medelian inheritance with the story of scientists who worked on genetics.  | 3 |
| ***Lesson 3 - How do monkeyflowers inherit their traits from parents?*** The lesson introduces the variation of color of monkeyflowers. The students continue to use the pipe cleaner and beads activity to simulate from Monkeyflower parents to offspring to figure out meiosis with crossing over and genetic variation caused by recombination and independent assortment. | 2 |
| ***Lesson 4 - What is DNA and what does is look like?***The students begin reading Module 3 of the mystery story and extract DNA from strawberries. The students use physical models and visual representations to identify the important structural characteristics relevant to DNA and make claims based on evidence for the structure of the DNA. | 3 |
| ***Lesson 5 - How does DNA affect monkeyflower traits?***The students use the computer simulation(s) to figure out transcription and translation. Then they go back to their physical models and figure out transcription and translation sequences of their monkeyflower DNA sequence. | 3 |
| **Lesson 6 : How can changes in the structure of DNA affect an organism's traits?**The students use the computer simulation(s) to figure out mutations.  | 2 |
| **Lesson 7:** ***Mystery story - How are Plant A and Plant B genetically similar and different?*** All student groups bring their pieces of a sequence of monkeyflower DNA together to compare plants A and B. They generate an explanation from the evidence about the genetic similarities and differences between Plants A and Plant B. | 3 |
| ***Lesson 8- Wrapping-up - revisiting the Driving Question Flowchart***The students revisit the DQ flowchart and reflect upon their learning. | 1 |

[**Learning Set 3**](https://docs.google.com/document/d/1ngDyTtYB8eJQbo1OSEKe8vRKyIuMuRFgKEshyEQqcJc/edit?usp=sharing)

| **Question(s) to figure out**  | **DCI**  | **Scientific Practice(s)** | **CCC** |
| --- | --- | --- | --- |
| How does changing the environmental conditions affect the survival of different monkeyflowers? | LS4.C: Adaptation | Constructing explanations | Cause and effect |
| **Purpose** In this learning set, the students will continue their experiments with the monkeyflowers to examine how adaptive traits can become non-adaptive traits if the environmental conditions change. The students will plan and carry out an investigation to examine what happens to the coastal and inland monkeyflowers when their environmental conditions change. **Learning Goals** - The students will plan and carry out an investigation to examine what happens to the coastal and inland monkeyflowers when their environmental conditions change.- The students will analyze and interpret data to explain what happens to the coastal and inland monkeyflowers when their environmental conditions change.- The students will construct a scientific explanation of how the changes in the environment affect monkeyflowers with different traits.  |

| **Instructional sequence overview** | **Instruction days** |
| --- | --- |
| ***Lesson 1 - What happens if environmental conditions change?***The students will read **Module 4 pages 1-3** of the story. Triggered by the story, they will then plan and carry out the salt resistance experiment. Once their experiments ends, they will analyze the data from their experiment. | 3-4 |
| ***Lesson 2 - What does other data tell us?***The students combine their classroom data to compare and analyze.  | 2 |
| ***Lesson 3 - Communicating findings to Maia and William***Writing a scientific explanation - As researchers, the students write a report to Maia and Williams communicating the findings from the salt experiment to them. They will finish reading Module 4 of the mystery story. | 2 |
| ***Lesson 4 - Wrapping-up - revisiting the Driving Question Flowchart***The students will revisit the DQflowchart and reflect upon their learning. | 1` |

[**Learning Set 4**](https://docs.google.com/document/d/16OaL-KR6xFxRofaI5_fddk5wSiY3e-zwH0ZujsmgXUU/edit?usp=sharing)

| **Question(s) to figure out**  | **DCI**  | **Scientific Practice(s)** | **CCC** |
| --- | --- | --- | --- |
| How do the differences between monkeyflowers happen over time? | LS4.B: Natural Selection | Constructing scientific explanation | Cause and effect |
| **Purpose** In this learning set, the students will focus on the sub-driving question, “How do the differences between monkeyflowers happen over time?” and learn how traits evolved over time through natural selection. The students use the context of stickleback fish in Loberg Lake to figure out the principles of natural selection. Then, they will apply the concept of natural selection and adaptation to the changes of monkeyflowers. Finally, the students will construct an argument and scientific explanation to demonstrate their understanding.**Learning Goals** - The students ask questions about how the organisms change over time.- The students analyze and interpret data to identify that individuals in a population typically vary in their traits which can be changed over time.- The students analyze and interpret data to figure out the heritable traits pass by way of genes from parent to offspring.- The students make an argument that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.- The students make an argument that natural selection can cause trait variation to become more or less common in a population over time.- The students construct a scientific explanation to explain that natural selection can cause trait variation to become more or less common in a population over time. |

| **Instructional sequence overview** | **Instruction days** |
| --- | --- |
| ***Lesson 1 - How do the differences between monkeyflowers happen over time?***In this lesson, students are introduced to a new organism that might have changed like the monkeyflowers. This will help them figure out how the monkeyflowers might have changed over time.  | 1 |
| ***Lesson 2 – Is the lateral plate trait variable among individuals in the population?*** The students collect a random sample of stickleback fish from Loberg Lake and arrange them by lateral plate number on a labeled bar graph. They repeat the process for three sampling periods. | 2 |
| ***Lesson 3 – Is the lateral plate trait heritable?***The students analyze a scatter plot showing data from different stickleback crosses. The plot shows a positive correlation between lateral plate number in parents and offspring. Then, working in pairs, they sort cards representing stickleback genotypes to find the gene that correlates with lateral plate phenotype. | 3 |
| ***Lesson 4 – Is there a reproductive advantage to having a low number of lateral plates in Loberg Lake?*** The students gain more practice with the components of an argument. First, they match “evidence cards” to reasoning, then they identify claims about who has the reproductive advantage in Loberg Lake. Students then choose which of the arguments are plausible.  | 2 |
| ***Lesson 5 – Is natural selection causing the lateral plate number in the population of sticklebacks to change over time?***The students make an argument that the stickleback fish case is an example of natural selection and natural selection can cause trait variation to become more or less common in a population over time. | 2 |
| ***Lesson 6 – Is natural selection causing the difference between two types of monkeyflower over time?***The students figure out and explain how the three principles of natural selection connect to the monkeyflower.  | 2 |
| ***Lesson 7 - Wrapping-up - revisiting the Driving Question Flowchart models*** The students will revisit the DQ flowchart and reflect upon their learning.  | 1 |