The Art of Hiding

hhmi | BioInteractive

Phenomenal Image
Educator Materials

HOW TO USE THIS RESOURCE

The image for this resource, which shows a moth that uses mimicry to avoid predators, can serve as a phenomenon to explore the key concepts described below. The pedagogical practice of using phenomena to provide a context for understanding science concepts and topics is an implementation practice supported by the Next Generation Science Standards (NGSS). Phenomena are observable occurrences that students can use to generate science questions for further investigation or to design solutions to problems that drive learning. In this way, phenomena connect learning with what is happening in the world while providing students with the opportunity to apply knowledge while they are building it.

The "Implementation Suggestions" and "Teaching Tips" sections provide options for incorporating the image into a curriculum or unit of study, and can be modified to use as a standalone activity or to supplement an existing lesson. The "Student Handout" includes a reproduction of the image and the "Background Information" section.

Additional information related to pedagogy and implementation can be found on this resource's webpage, including suggested audience, estimated time, and curriculum connections.

KEY CONCEPTS

- Mimicry is an evolved resemblance between an organism (the mimic) and another entity (the model), which can be a nonliving object or an unrelated species.
- The evolutionary advantages for mimicry include avoiding predators or avoiding detection by prey. Selective pressures influence the traits exhibited by mimics.

BACKGROUND INFORMATION

This small tropical moth, *Macrocilix maia*, is found in India, China, Malaysia, and other parts of Asia. *M. maia*'s claim to fame is that it is excellent at pretending to be something it is not. The patterns on this moth's wings look like two flies feeding on bird droppings, which have dashes of white to make them look wet and fresh. This unappetizing appearance, combined with the moth's unpleasant smell, keeps away predators that see only smelly bird droppings and hungry flies rather than a tasty moth.

M. maia's features are an example of mimicry. **Mimicry** is when an organism (called a **mimic**) resembles something else (called a **model**), usually in a way that benefits the mimic. The model can be a nonliving object, an unrelated species, or even an entire scene in the case of *M. maia*. Examples of mimicry have provided evidence for the theory of evolution by natural selection. What do you think are the evolutionary benefits of pretending to be something you're not?

IMPLEMENTATION SUGGESTIONS

The following suggestions outline several options for incorporating the image into a unit of study as a phenomenon:

Engagement, establishing prior knowledge, and providing context:

- Begin the lesson by telling students they will be examining an image of an insect called *Macrocilix maia.*
- Divide students into groups of two or three and provide each group with a copy of the image. Ask the groups to list their observations of the image. Encourage them to use the sentence stems "I notice…," "It reminds me of…", and "I wonder…"

- Use a think-pair-share protocol to have students share their observations and questions about the image. Record class observations, noting when students make similar observations and drawing attention to the range of student-generated questions.
    - Students may make observations about the patterns on the insect's wings. They may say that markings on the upper wings remind them of bugs, such as flies, and that the markings on the lower wings look like brown stains (which could remind them of dirt, droppings, etc.).
    - Students may observe that the insect appears to be a moth or a butterfly. They may wonder what is the difference between a moth and a butterfly.
    - Students might wonder about the traits and ecology of the insect: where it lives, how large it is, what it eats, what eats it, etc.
    - Students may wonder if there is something wet or sticky on the insect's lower wings.
    - Students may wonder why the insect has the markings it does on its wings.
- Ask students to consider possible reasons that an organism would have these kinds of markings. Students should generate these ideas individually, then share in their small groups. Each group should select one or two possible reasons to share with the class. Record the groups' ideas so that students can return to them throughout the lesson sequence. Students may suggest the markings:
    - keep the organism from being detected by predators or prey
    - make the organism appear "yucky" or distasteful to predators
    - are related to mating or communication with other members of the same species
- As a class, select one or two hypotheses about why *M. maia* has these markings to explore together. Ask students to consider what kinds of evidence would be needed to support or refute these hypotheses.
    - It may be helpful to model an example. For instance, one hypothesis could be that the markings help *M. maia* avoid being detected by predators. This could be tested by comparing the rates at which predators approach insects with and without the markings.
    - Have students design experiments to test their hypotheses. It may be helpful to have students share their experimental designs within groups or to collect them as a formative assessment.
- At this point, have students read the "Background Information" for the image, noting in particular the term "mimicry" and the distinction between a "mimic" and a "model."
- Ask students to identify other examples of mimicry they are familiar with. If students are not familiar with other examples of mimicry, invite them to do additional research.
- Transition to the next set of activities by telling students that they will be exploring several examples of mimicry in more detail.

Exploration, assessment, and extension:

- Exploration/Investigation:
    - Have students create a table for tracking examples of mimicry. The table should include the following columns: "Mimic," "Model," "Benefit to Mimic (if any)," and "Effect on Model (if any)."
        - Students can begin by adding the *M. maia* example to their table. In this example, *M. maia* is the mimic, its model is a scene of flies eating bird droppings, and the mimic benefits by deterring predators. It is unclear how this mimicry affects the species involved in the model (flies and birds). Students could argue that flies and birds would be unaffected, that flies and birds could benefit from having fewer potential predators around, that flies could be harmed by having fewer animals around to leave droppings, etc.
        - Students can also add some of the examples of mimicry that they discussed or researched in the previous section. Two such examples are described below.
            - One example is of the venomous coral snake and the similarly colored, but nonvenomous, Mexican milk snake. In this case, the milk snake is the mimic, and the coral snake is the model.

The mimic benefits from resembling the model because it can deter predators. The model may be harmed if the predators learn that the mimic is not venomous and start attacking both it and the model. (Mimicry in which a relatively harmless species mimics the warning signals of a more harmful model is known as **Batesian mimicry**.)

- Another example is of the monarch butterfly, which is poisonous to birds, and the similarly colored viceroy butterfly. The viceroy was once thought not to be poisonous, but more recent research suggests that it is unpalatable to birds. If this is the case, the monarch and viceroy could be considered co-mimics/co-models. This mimicry can benefit both because it makes it easier for predators to encounter, and thus learn to avoid, butterflies with their colors. (Mimicry in which harmful species mimic each other's warning signals is known as **Müllerian mimicry**.)

- Have students watch the video *Moth Mimicry: Using Ultrasound to Avoid Bats* and complete the accompanying "Student Worksheet." This video describes how certain nontoxic moths mimic the ultrasound signals of toxic moths in order to avoid being eaten by bats. The video also shows some of the experiments that scientists used to investigate the moths' strategies.
  - Ask students to add this example of mimicry to their table. As with the other examples, they should identify the mimic, the model, how the mimic benefits from the mimicry, etc.
  - You may also wish to discuss the concept of **coevolution**, which is mentioned in Question 6 of the "Student Worksheet" for the video. Ask students how coevolution is involved in the moth/bat relationship, having them provide examples from the video. Remind them that coevolution occurs when two species reciprocally affect each other's evolution.
- Have students work through one or both of the following Data Point activities. These activities explore research on different examples of mimicry using published scientific figures.
  - "Mimicry in a Diverse Community of Arthropods" focuses on an experiment involving several species of arthropod mimics with similar colors. The activity unpacks a figure showing how often these mimics, as well as a nonmimic species, are captured by different types of predators.
  - "Evolution of Ant-Mimicking Beetles" looks at the evolutionary origins of beetles that mimic ants in order to parasitize ant colonies. Students examine pictures of these beetles, the ants they mimic, and a phylogenetic tree showing the evolutionary relationships among multiple beetle lineages that do and do not mimic ants.
    - Students will need a working familiarity with phylogenetic trees to fully understand Figure 2 in this activity. It may be helpful to review the term "most recent common ancestor." You may also want to discuss whether traits found in some, but not all, descendent species of a common ancestor are more likely to have been derived from that common ancestor or to have evolved independently.
  - For each Data Point, students should first read the caption for the figures, noting their observations or questions in the accompanying "Student Handout." They should then read the "Background Information" section, noting any big ideas or other questions.
  - Have students consider selected discussion questions from the Data Points individually, then discuss in small groups. Suggested questions for "Mimicry in a Diverse Community of Arthropods" include:
    - What were the differences in predators' responses to mimic versus nonmimic species?
    - Why was it important to include a nonmimic organism in the experiment?
  - Suggested questions for "Evolution of Ant-Mimicking Beetles" include:
    - How might the body plans and behaviors of the ant-mimicking beetles affect their fitness when living in army ant colonies?
    - Using principles from the theory of evolution by natural selection, describe how the body plans of ant-mimicking beetles may have evolved over time.
  - After completing these activities, ask students to add the new examples of mimicry to their table.

- Assessment:
  - Have students revisit their initial hypotheses about why *M. maia* has the markings it does, as well as the experiments they designed to investigate their hypotheses. Ask students to revise their hypotheses and/or experimental designs based on what they've learned from the previous activities.
  - Have students review and compare the examples of mimicry that they have collected in their table, noting similarities, differences, and common themes.
    - If you previously discussed coevolution with your students for the *Moth Mimicry* video, you could consider revisiting that concept with the other mimicry examples. Ask students whether coevolution could apply to the other examples they collected and, if so, what species and changes it might involve. Students could give their answers using the Claim-Evidence-Reasoning (CER) framework.
  - Remind students that, as stated in the "Background Information" for the *M. maia* image, examples of mimicry have provided evidence for the theory of evolution by natural selection. Ask students to select an example of mimicry from their table and explain what evidence it provides for evolution by natural selection.
    - Students could again give their explanations using the CER framework, using the claim that their example provides evidence for evolution by natural selection. Their evidence and reasoning for the claim should demonstrate an understanding of mimicry, natural selection, and the connection between mimicry and evolutionary fitness.
- Extension:
  - A potential point of confusion for students is whether **camouflage** is a type of mimicry. You may wish to have them explore camouflage in more detail so that they can see how it compares to mimicry.
    - Emphasize that the definition of mimicry can be complex and that scientists may consider some, but not all, types of camouflage as mimicry. For example, Font (2019) and others have argued that mimicry requires the mimic to be *recognized* as something it is not rather than avoiding detection completely. By this definition:
      - Camouflage that causes the organism to be perceived to be a nonliving, inedible, and/or uninteresting object *is* considered mimicry. This type of strategy is known as **masquerade**. More information about masquerade and other forms of mimicry can be found in Font (2019) and Jamie (2017).
      - Camouflage that causes the organism to blend into its surroundings and become "invisible" is *not* considered mimicry. This type of strategy is known as **crypsis**.
    - Introduce students to specific examples of crypsis using the following BioInteractive resources:
      - The video *Nature's Cutest Symbiosis: The Bobtail Squid* and its supporting activity describe how bobtail squid use a strategy called counterillumination to blend into their surroundings, allowing them to hide from both predators and prey.
      - The short film *The Making of the Fittest: Natural Selection and Adaptation* explores adaptive changes in coat color that help rock pocket mice blend into their environments and avoid predators.
    - Have students create a concept map relating the terms mimicry, camouflage, crypsis, and masquerade, including examples of each. Once students are comfortable with these four terms, you can ask them to explain which of the terms apply to the example of *M. maia*. Students should support their claims with evidence and reasoning.

TEACHING TIPS

- Present students with the image first, before they read the background information.
- Background information may be edited to support student proficiency, course sequence, etc.
- The image may be projected in lieu of handouts.

- Printed images can be laminated for use in multiple classes.

RESOURCE-PAIRING SUGGESTIONS

- Natural selection and adaptation
- Predator-prey interactions

SOURCE

Image from William Piel and Antonia Monteiro, Yale-NUS College and the National University of Singapore

REFERENCES

Font, Enrique. "Mimicry, Camouflage and Perceptual Exploitation: the Evolution of Deception in Nature." *Biosemiotics* 12, 1 (2019): 7–24. https://doi.org/10.1007/s12304-018-9339-6.

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CREDITS

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