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**ABSTRACT**

As visual creatures, humans sometimes have difficulty understanding how other organisms encounter their environments through nonvisual means. Many organisms rely predominantly or exclusively on senses other than sight, including olfaction, chemoreception, and thermoreception. This lesson will give high school students insights into how other organisms encounter their environment, the benefits and limitations of different senses, and why we should be aware of other organisms' perceptions. Educating students about sensory ecology introduces fundamental concepts in physiology, ecology, and animal behavior. Students will learn a new vocabulary term (*umwelt*) and about the sensory ecology of other organisms via an active-participation presentation, collect and analyze data on sensory disruption of classmates, and put their new knowledge to work by brainstorming ways in which human activity interacts with the sensory ecology of wildlife through case studies (Common Core State Standard HS-LS2-7).

**Key Words:** Sensory ecology; *umwelt*; animal behavior; environmental science.

**○ Introduction**

Sensory ecology, or the study of how organisms perceive and interact with their environment, is a field at the interface of behavior, physiology, and evolutionary biology, and it is often neglected in scientific studies (Dangles et al., 2009). Introducing the topic of sensory ecology to students can foster an increased awareness of, and sensitivity to, the environment and the organisms within it (Auer, 2008). This lesson provides a four-part introduction to sensory ecology through hands-on activities, interactive lectures, readings, and group discussions, as well as optional independent research. The activities address Common Core State Standard HS-LS2-7.

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**○ Part 1A: Resource Navigation Exercise (20 minutes)**

Resource acquisition is a necessary component of organismal survival that requires both navigation to and recognition of desired resources. Both of these processes require sensory activity on the part of the organism. This warm-up exercise will encourage students to become more aware of their own sensory activity through gradual sensory deprivation.

1. Introduce the vocabulary word *umwelt*. Define it (with help from the class, if anyone already knows).

**Umwelt.** /*umvelt*/. (plural *umwelten* or *umwelts*). Definition: the world as perceived by an organism, based on its sensory abilities. It is a word of German origin commonly used by scientists studying animal behavior. A good way to think about an organism's *umwelt* is to imagine if you were to become that creature. How would the world look/smell/sound/feel?

2. Introduce the lesson: Why think about *umwelts*? Ask everyone to turn to a partner and come up with one thing that all organisms need in order to survive (expected answers: food, shelter, etc.); brainstorm on the board.

**Make the point:** An organism's ability to survive is critically connected to its *umwelt*, because one of the most important ways in which organisms use their senses is to navigate to resources.

3. Announce that to help everyone get in touch with his or her own *umwelt*, we have an exercise. Assemble groups of four or more students and assign each group to a different location in the classroom. Place a basket of mixed fruit (see Table 1) in the center of the room.

**Table 1. Materials list for each module of this lesson.**

Part 1A	Part 2	Part 3
<ul style="list-style-type: none"> <li>• Resource Navigation Exercise datasheet</li> <li>• Basket with 1:3 ratio of yellow Asian pears to red apples (all roughly the same size and shape)</li> <li>• Blindfolds and pairs of thick socks or gloves</li> <li>• Stopwatch</li> </ul>	<ul style="list-style-type: none"> <li>• Projector</li> <li>• Computer with ability to view PowerPoint presentations (such as Microsoft Office, open office software, or Internet access to Google docs)</li> <li>• Slides for presentation, "Sensory Ecology: the Umwelt Concept," found on the CAMEOS website (see text)</li> </ul>	<ul style="list-style-type: none"> <li>• Sensory Ecology Scenarios worksheet</li> </ul>

**Make the point:** Acquiring resources requires using one’s senses to recognize the resource. In this case, the pears (not the apples) are the desired resource.

- Assign one student from each group to be the data collector. This student will time each round with a stopwatch and record that time on the Resource Navigation Exercise data sheet (Figure 1).
- There will be three rounds. At the start of each round, each group will send representatives to navigate the classroom to get a pear and bring it back to their group. The only rule is that there is NO TALKING among group members. In other words, one cannot help the people who are “up” for their turn.
- Run the activity, announcing at the start of each round what the details will be:
  - Round 1: No props. (No need to announce this.)
  - Round 2: Use blindfolds.
  - Round 3: Use blindfolds and thick socks or gloves on both hands.
- Debrief by holding a discussion (and allowing students to choose a fruit to eat, if they would like to). Suggested “sensemaking” questions: What senses/strategies did people use to navigate to and acquire the pears? How did strategies change, depending on the impairment of certain senses? How might strategies have had to change if the fruit basket were moved to a different location in the classroom, unbeknownst to blindfolded students?

**Make the point:** When we talk about the umwelt as the perceived world of an organism, we are talking about an interaction between two things: an organism’s sensory abilities and the (potentially shifting) surrounding environment.

**○ Part 1B: Behavioral Data Analysis (run time dependent on student familiarity with graphing)**

Being a scientist involves analyzing and interpreting data. This activity will help students build basic skills in those areas by graphing and comparing class averages for resource navigation under different sensory capacities.

- Draw the Class Average Datasheet (Figure 2) on the board, and have students fill in their individual group data to share with the class. Groups should then calculate the class mean for each “Treatment” (each round) by averaging across groups, and help to fill in the “Class Average” row with that average time. Finally, they should graph the data (Figure 3).

**Data Collector:**

**Teammates:**

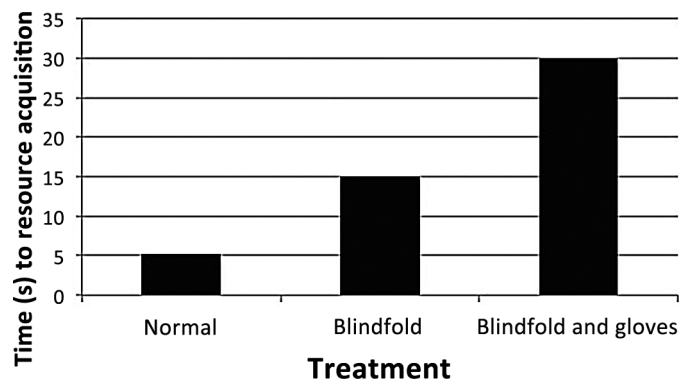
**Date:**

	Time (s)	Observations
<b>Round 1</b>		
<b>Round 2</b>		
<b>Round 3</b>		

**Figure 1.** Resource Navigation Exercise datasheet.

	Round 1	Round 2	Round 3
<b>Group 1</b>			
<b>Group 2</b>			
<b>Group 3</b>			
<b>Class Average</b>			

**Figure 2.** Class Average Datasheet for behavioral data analysis.



**Figure 3.** Hypothetical graph for behavioral data analysis, based on fictional data.

- How might the sensory abilities of organisms influence their relationship to their environment? Can you think of examples?
- What are some examples of wild animals that have *umwelts* that are very different from a human's?
- In what environments might it be detrimental to have a human's *umwelt*?
- What are some ways you could determine an organism's *umwelt*?

**Figure 4.** Suggested additional discussion questions.

2. Discuss results: After averaging across all groups with their different strategies for navigation and resource recognition, which treatment resulted in the fastest resource acquisition? The slowest? What might this indicate about the relative importance of different senses for human activities? For further questions, see Figure 4.

## ○ Part 2: Introduction to Sensory Ecology & Umwelt (25 minutes)

“Sensory Ecology: The Umwelt Concept” is an active-participation lecture that builds on sensory ecology concepts from part 1. This presentation provides more in-depth information (e.g., sensory capabilities of different organisms), examples from the animal kingdom (e.g., magnetoreception in homing pigeons), and thought questions (e.g., “Why might humans in general need to understand the *umwelts* of other organisms?”). It will prepare students to consider how an understanding of *umwelts* can be applied to solve conflicts between organisms and human activities (in part 3).

By the end of this presentation, students should be:

- able to define the terms “*umwelt*” and “sensory ecology”;
- aware of a range of nonhuman senses;
- thinking critically about how these nonhuman senses may influence organism behavior and ecology; and
- considering the relevance of *umwelts* to scientific study as well as to their own daily human lives.

Presentation slides include teacher notes (available at <http://bml.ucdavis.edu/education/comeos/resources/sensory-ecology>).

## ○ Part 3: Putting Science into Action (30 minutes)

Many issues in conservation pertain to understanding and making decisions with regard to other organisms' *umwelts*. Part 3 requires students to combine new knowledge of sensory ecology with problem-solving skills to address scenarios based on real organisms and threats from humans (e.g., bats and glass windows). Students will formulate and justify solutions using their newfound sensory ecology knowledge, reinforcing the importance of *umwelt* to scientific problem solving and environmental management. This activity builds critical-thinking skills and creativity in scientific problem solving. It also provides an opportunity to evaluate student understanding of lesson material. Scenarios are available online at <http://bml.ucdavis.edu/education/comeos/resources/sensory-ecology>.

1. Divide the students into three or more groups for discussion. Give each group one of the three scenarios with questions.

Suggested supplementary articles have been provided and can be distributed to students or assigned for reading later.

2. In their groups, have students discuss the scenario and propose answers to the questions. If the supporting article is used, they should discuss that as a group as well.
3. As a group, have students present their scenarios and solutions to the class, with class discussion following each presentation.

## ○ Practical Assignment (optional)

The quantity of information related to sensory ecology and *umwelts* is vast and ever increasing. This suggested homework assignment will reinforce the main points of the lesson and give students the opportunity to practice important informational research skills (e.g., finding and citing references).

For homework, students will research and write a report that:

- describes the sensory abilities and subsequent *umwelt* of an organism of their choosing;
- describes (from research or personal thinking) how human activities might affect that organism's surroundings, senses, and/or behavior; and
- suggests ways to improve (if negative) or maintain (if neutral or positive) the relationship between humans and that organism.

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This lesson was trial-run with a group of 14 graduate students and professors in biology, and also received feedback from a California teaching-certification-program instructor. Overall, comments on the structure and originality of the lesson were positive. The authors suggest allotting one or two class periods for the entire lesson, using the parts as logical divisions. The lesson has not been tested in a high school classroom, and we are therefore limited in our ability to gauge time or most effective group sizes. However, the content was deemed appropriate for high school by the aforementioned audience.

## References

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