Getting Started

All Virtual Labs pose science problems in a real-world context. In Critters, students systematically test four variables — temperature, humidity, light, and terrain — to determine what environmental conditions an imaginary animal prefers. The lab encourages students to think about animal habitats, animal behavior, and both biotic and abiotic factors. It can also serve as a springboard for a discussion of endangered species, habitat destruction, animal husbandry, and scientific procedure.

Intro & Mission

In Critters, students are asked to use their scientific inquiry process skills to solve the following problem:

The Hillsdale Zoo wants to update its collection to bring in more visitors. It locates an interesting creature, Critterius hirsutus, that might do the trick. But these “critters” are rarely seen in captivity because they are so difficult to keep. The Zoo has asked your team of zoologists for help.

The Problem: The Zoo’s new animals require special living conditions, but you don’t know exactly what they are.

Your Mission: Figure out what temperature, humidity, light, and terrain conditions the Zoo’s new critters like best.

Explore

In the Explore Lab, students determine what temperature the animals prefer by observing their behavior in a two-chambered test enclosure. Students set the temperature in the two chambers separately, and then record how many test animals choose each chamber. As there are three available temperature conditions (Hot, Warm, and Cool) and only two chambers, students must first test two temperatures and then test the “winner” against the remaining temperature.

Investigation in the Explore Lab is open-ended, but students can get some guidance from the Briefing Document, which contains suggested explorations. The teacher’s role is primarily one of facilitation. For example, you might take some of the following actions:

- Have students examine the test enclosure and data displays before beginning the experiment. You may need to explain what “terrain” means.
- Visit students as they work in the Lab and ask questions about what they are doing.
- Make sure students test all three temperature conditions, not just two.
- Encourage students to collect their data systematically and to record it on a data sheet. Students may devise their own data sheet, or you may give them the one included with this Teacher Guide.

The experiment should go very quickly, but students may have trouble interpreting the results. The 10 test animals don’t always all choose the same chamber, and repeat tests of the same variables don’t always yield the same results. Encourage students to discuss what such variability might mean. As they do so, help them understand the difference between a preference and a requirement (or limiting factor). For example, the critters'...
preferred temperature range might be narrower than the range in which the animal can survive; moreover, some critters may have an individual preference for a cool enclosure, though most critters prefer a warm one. You might also point out that in wild populations, competition may force some animals to occupy habitats that are less than ideal, and yet they survive. This can also happen in zoo communities.

Students should leave the Explore Lab knowing that the critters generally prefer a warm enclosure and dislike a cool one, but that there is variability in the response. Most students will also understand that while the critters prefer a warm enclosure, they may also be able to survive in a cool enclosure or a hot enclosure. Some students may also appreciate the value of repeating an experimental procedure when the results are ambiguous.

Plan

Next, students write a plan for an experiment that will help them figure out what temperature, humidity, light, and terrain conditions the critters like best. The plan should reflect what the students have learned in the Explore Lab about animal behavior, the critters' temperature preference, and the importance of testing variables systematically.

In the Experiment Lab, students have three new variables to test — moisture, light, and terrain — each with three conditions. In all, there are 81 possible combinations of conditions for the critters' enclosure, 27 if the students think to hold the temperature constant at Warm (as they should). But even 27 combinations is too many to investigate in a haphazard way. Students will need to propose testable questions that address only one variable at a time, and they must devise a procedure that will test each variable in a systematic way; otherwise they may get confusing or misleading results.

It is up to you whether to have students try to determine all the critter preferences or just one or two. Students can always share results after they finish their experiments. In any case, you may wish to make the inclusion of a data table a requirement of the plan.

The plan must include a testable question, a hypothesis, and an experimental procedure. The plan is written offline, and could be completed as homework, but students may wish to return to the lab or consult these online resources:

- **The Briefing Document**, this document is essential for student work at all stages of the Virtual Lab, so you may want to print out copies for your students. It can be accessed through either the Mission tab or the Plan tab in the Virtual Lab.
- **The Plan Resources**, a collection of articles and/or video clips that can be accessed through the Plan tab in the Virtual Lab.
- **The Virtual Labs Student Guide**, which explains how to formulate a good testable question and how to write a plan.
Students will write their plans in their notebooks and bring them to you for approval before they go on to the Experiment Lab. An example of a good plan for Critters is given later in this Teacher Guide. If your students' plans are well conceived, the rest of the Virtual Lab should go smoothly.

Experiment

In the Experiment Lab, students carry out their plan to determine the best conditions for the critters' zoo enclosure. They should make some record of their trials in their notebooks or in a data table as they go along.

Remember that the experiment is designed as a paired trial, and that results for a given set of conditions in one chamber will depend on the conditions available in the other.

For example, when critters are given a choice between Warm, Sand, Dry, Bright, (Chamber 1) or Cool, Sand, Dry, Bright, (Chamber 2), 90% of the animals choose Chamber 1. But when the conditions offered in Chamber 2 are changed to Warm, Sand, Moderate, Bright, 90% the animals choose Chamber 2, even though the conditions in Chamber 1 are unchanged. (Results will vary from test to test; but in all cases 80-100% of the animals choose Chamber 1 on the first test, and 80-100% of the animals choose Chamber 2 on the second test.)

Not even a 100% result guarantees the “best” habitat, only the better of two choices. Only by exploring one variable at a time and working systematically through a process of comparison and elimination can the students be assured that they have the critters’ favorite habitat: Warm, Grass, Moderate Moisture, Moderate Light. Students may come to the above understandings — or they may not. At the conclusion of the Experiment Lab, students are asked to write a brief summary of their findings. You may have to remind them to do so. A sample summary is given later in this Teacher Guide.

The teacher's role in the Experiment Lab should be minimal. You should make sure students know how to work the lab, and you can head off any wildly wrong efforts, but otherwise let the experiments run their course. Failure in the lab is OK.

The Science Behind the Lab: Testing Multiple Independent Variables

In many scientific explorations, there are a number of independent variables that could affect the outcome (or dependent variable) of interest to the scientist. The scientist must predict which variables may have an effect and design the experiment so that only one is changed at a time. For example, if a team of scientists wants to measure the effects of diet on longevity in mice, they will try to keep other independent variables such as water, type of enclosure, and competition the same for all test subjects while they feed the mice different foods. If more than one variable is changed at the same time, there is no way to know which variable is responsible for the outcome.

In this lab, students are asked to determine the best possible habitat for an imaginary creature. They have four variables to test: temperature, light, humidity, and terrain. They must work systematically as scientists do, keeping the conditions for three variables constant while they change the fourth variable. They must also run two trials for each variable, as there are three conditions to test and they must determine the best of the three. Remembering to test just one variable at a time, holding all others constant, is the most challenging part of this lab.

Collaboration

The Virtual Lab can be done successfully by students working alone or in pairs or small groups. If they collaborate, the students can divide the work according to their skills and interests. One student may feel more comfortable interacting with the screen while another may want to record data. One student may want to lead the small-group discussion while another may want to present the group's results to the class. Of course, the social interaction involved in teamwork has its own value. If your students collaborate in the Virtual Lab, it is up to you to decide whether they should write their experiment plans and summaries separately or together.
Sharing Results

One goal of the Virtual Lab is for students to act as a community of scientists working together toward the solution of a problem. For this reason, students are asked to share their plans and summaries with their classmates. You may wish to direct this class discussion in one of these ways:

- Discuss any differences in the students’ experimental procedures. Ask them what kinds of thinking led to their different approaches.
- Discuss any differences in the students' findings. If students investigated only one or two variables in their groups, have them combine their results and decide the best habitat.
- Discuss any differences in students’ interpretation of results. Did everyone assume that the habitat with the most critters in each trial was better, or did some students think that either habitat would be acceptable, so long as there were some critters on each side?
- Have students explain in their own words why a 100% result after one trial does not guarantee the best habitat. Use the following example, and have students explain the fault in the procedure. Ask, “Which of the two inferences in ‘Observations’ is valid? Which is not valid? Why not?”

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<thead>
<tr>
<th>Left Chamber</th>
<th>Trial</th>
<th>Temp</th>
<th>Terrain</th>
<th>Moisture</th>
<th>Light</th>
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Observations

- Ask students if they know which habitat(s) the critters like least.
- Compare and contrast the critters with an organism the class has already studied. What abiotic limiting factors do they have in common? Which ones are different?
- Review world biomes and decide which biome is most like the imaginary critters’ preferred habitat. Then find out what real animals and plants live in that biome and how they are housed in zoos.
- Take a field trip to a local zoo. Have each student or group of students research the abiotic limiting factors for one organism and evaluate how well the zoo enclosure meets its needs.
Inquiry and Sample Outcomes

The Virtual Lab gives students the opportunity to use genuine inquiry skills to solve a real-world problem. Students are asked to think of a testable question and a hypothesis, which is a possible answer to that question.

Here are examples of testable questions your students might decide to explore in this Virtual Lab. Of course, your students may think of others.

- Do critters like more than one kind of terrain?
- What level of moisture do most critters prefer?
- How much light do the critters like best?

Here is an example of a fully formed experiment plan:

**Testable Question:** Do critters have more than one kind of terrain they like?

**Hypothesis:** We think that the critters might have more than one kind of terrain they will use, because in the wild there are some animals that can live in different kinds of terrain.

**Procedure:**
1. Select Grass for terrain in the left enclosure and Rocks for the right.
2. Select Warm for temperature on both sides, because we already know they like Warm best.
3. Select Moderate humidity for both sides, because we don’t know yet what humidity they like best.
4. Select Moderate light for both sides, because we don’t know yet what light they like best.
5. Run the test and record results.
6. If there is a winner between Grass and Rocks, leave that choice on one side and put Sand on the other side. Run the test and record results.
7. If there was no winner between Grass and Rocks, leave Grass on one side and put Sand on the other side. Run the test and record results. Then, put Rocks on one side and Sand on the other. Run the test and record results.
8. Decide the winner.

Notice that the summary does not include the testable question, the hypothesis, or a detailed description of the student’s experimental procedure. Those are in the plan. But the summary should include any conclusions the students have reached.

We found that the critters liked grass the best, but we saw one critter went to the side with rocks. Also, when we tested rocks and sand, the critters liked sand better but two went to rocks. So, it seems like they like grass best but they could live with any of them. We would recommend to the Zoo that they try to put grass in the enclosure and they should keep it warm inside. But maybe the critters would be OK with any kind of floor.
<table>
<thead>
<tr>
<th>Trial #</th>
<th>Temp</th>
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<th>Moisture</th>
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<th># Observations</th>
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# = the number of animals choosing the chamber
You may wish to circle the variable you are testing in each trial.
Intro

The Hillsdale Zoo wants to update its collection to bring in more visitors. It locates an interesting creature, *Critterius hirsutus*, that might do the trick. But these “critters” are rarely seen in captivity because they are so difficult to keep. The Zoo has asked your team of zoologists for help.

Can you determine the best conditions for this creature’s enclosure?

Mission

The Problem: The Zoo’s new animals require special living conditions, but you don’t know exactly what they are.

Your Mission: Figure out what temperature, humidity, light, and terrain conditions the Zoo’s new critters like best.

Explore

First go to the Explore Lab. Here you will find a test enclosure, two thermostats, and a colony of critters. Set the thermostats and observe how the critters behave under different temperature conditions. Your goal is to find out whether the critters prefer a hot enclosure, a warm enclosure, or a cool enclosure.

Here’s how to use the Lab:

- **Critter Enclosure** The test enclosure has two chambers with separate environmental controls. Critters can move from one chamber to the other to find the environment they like best.
- **Temperature** This is the only variable you can test in the Explore Lab. Use the pull-down menu to select Hot, Warm, or Cool. Later you can test the other variables: Moisture, Light, and Terrain.
- **Critters** The animals are housed in the cylinder on the shelf until the test environments are ready. When you have chosen your environmental variables, drag the cylinder to the center of the test enclosure.
- **GO** Click GO to start the simulation.
- **Reset** Click the arrow button to start over.
Suggested Explorations

Start by asking a testable question about the critters and temperature that you can explore in the Explore Lab.

Here’s a sample question:

Do critters prefer hot temperatures or cool temperatures in the test enclosure?

Here’s a procedure you could use to explore that question:
1. Select Hot from the Temperature menu for the left chamber.
2. Select Cool from the Temperature menu for the right chamber.
3. Bring the critters to the test enclosure and click GO.
4. After the animals are settled, record the number of critters on each side of the enclosure. Reset.

Continue exploring until you know what temperature the critters seem to prefer. As you investigate, think about how to define a clear preference, and whether there might be more than one combination of temperature, moisture, terrain, and light conditions that would be comfortable for the critters.

If you do your explorations systematically and record your results carefully, you should be able to help the Zoo figure out how to take good care of its new furry friends.

Plan

Now it is time to plan an experiment that will help you figure out what environmental conditions the Zoo’s new critters like best.

In the Experiment Lab, you will be able to set levels for all four variables: Temperature, Moisture, Light, and Terrain.

- The settings for Temperature are: Hot, Warm, and Cool.
- The settings for Moisture are: Dry, Moderate, and Humid.
- The settings for Light are: Dim, Moderate, and Bright.
- The settings for Terrain are: Sand, Grass, and Rocks.

If you need help writing the plan, consult the Virtual Labs Student Guide. Remember, you can use everything you learned in the Explore Lab, along with information in this Briefing Document and in the Plan Resources, which you will find in the Virtual Lab under “Plan.”

Write your plan in your notebook. Have your teacher approve it before you go to the Experiment Lab.

Experiment

Go to the Experiment Lab and conduct your experiment. Record everything that happens at each step. You may need to make a chart to keep track of all the data. When you are finished, write a short summary of your experiment, including your results and conclusions.

Did any of your results surprise you? If so, describe them in your summary. Scientists often learn more from unexpected results than from experiments that go exactly “according to plan.”

When you have finished your summary, share your plan and your results with your classmates. Did you all use the same procedure? Did you get the same results? Is there more than one way to make the critters comfortable? Do you think the animals' behavior in the zoo enclosure will be the same as in the test enclosure? Why or why not?

Whatever the outcome of your individual efforts, together you will have learned some things about how abiotic environmental factors affect animal behavior and how to test variables in a systematic way. And that is exactly how science gets done: by exploring, asking questions, planning, experimenting, and sharing information with other curious people - like you!