

ScienceNews

IN HIGH SCHOOLS | EDUCATOR GUIDE



Chasing BREATH



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About the article

The *Science News* article “Chasing Breath” explores how new information is challenging the widely held scientific view that birds are the only animals with one-way airflow loops inside their lungs. Recent research shows that, like birds, some reptiles have one-way airflow, a discovery that deepens our understanding of the evolutionary forces shaping lungs in these and other animals, including possibly dinosaurs.

“Chasing Breath” can be used across a wide range of curricula, with a focus on biology. The activities, questions and discussions in this educator guide can be used to support the following education standards:

Next Generation Science	Common Core
From Molecules to Organisms: Structures and Processes: HS-LS1-2	ELA Standards in Reading Informational Text (RI): 1, 4, 5, 6, 10
Biological Evolution: Unity and Diversity: HS-LS4-1	ELA Standards in Writing (W): 1, 3, 4, 6, 7, 8, 9, 10
	ELA Standards in Speaking and Listening (SL): 1, 3, 4, 5
	ELA Standards in Language (L): 1, 2, 3, 4, 5, 6
	ELA Standards in Reading for Literacy in History/Social Studies (RH): 3, 8
	ELA Standards in Reading for Literacy in Science and Technical Subjects (RST): 1, 2, 4, 5, 6, 8, 9
	ELA Standards in Writing Literacy in Historical/Social Studies and Science and Technical Subjects (WHST): 1, 4, 7, 9

Prior to reading

Guide student reading by pointing out connections between this article and what students are learning in class. Here, find ideas for standard-aligned paths to follow while reading:

- Strong readers make predictions about what they will read based on titles, headings and images. Have students make predictions about what they will read using the Making Predictions organizer provided ([Blackline Master #1](#)). When they read, students should note evidence from the text that either supports their predictions or shows why the predictions are incorrect.
- Ask students what they already know about how animals breathe. They might describe how their lungs work and then expand to include ideas about how fish use gills. Listen for whether students realize that different animals have different types of lung structures. Ask students what factors may influence the structure or function of respiratory systems (*size of the animal, energy demands, habitat, for example*).
- Readers come to a story with ideas based on prior experiences. Have students create an image of a biologist. This might be a sketch or a descriptive paragraph. Ask students to think about the characteristics of a scientist, how scientists approach their work and how they make advances. Then have students read the article with the purpose of describing Colleen Farmer, the biologist highlighted in the story. What can students learn about her career path? What can her story reveal about how scientific knowledge advances?
- “Chasing Breath” includes challenging words and phrases to express scientific ideas. Give students a few minutes to scan the article and circle any words they don’t understand. Provide the students with Post-its and have them write each word (or phrase) on a Post-it and bring it to the board where all students can see the collection. Sort the Post-its to determine high-priority words and eliminate duplicates. Ask students to define the words they can based on their current knowledge. Then distribute the remaining Post-its and have teams define the words using available resources and context clues within the text. After the exercise, you can ask the students to present their findings.

After reading: Comprehend

You can adapt and print these questions ([Blackline Master #2](#)) to check for comprehension and analysis before or after discussion:

1. **What is the main topic of the article?**
(Recent research suggests that alligators and some other reptiles have one-way airflow deep in their lungs, a breathing strategy similar to that used by birds. Scientists are still trying to understand the implications.)
2. **How do bird lungs differ from human lungs?**
(In the portion of the bird lung where blood picks up oxygen, the flow of air is one-way.)

3. **Did breathing air evolve as ancient aquatic organisms adapted to dry land?**
(No. Many aquatic organisms have various methods of getting air in order to survive. Some fish can gulp air from the surface when waters are stagnant.)
4. **Name one reptile other than the alligator with unidirectional airflow?**
(Monitor lizard, green iguana)
5. **Why is the article's finding about the structure of reptile lungs important?**
(Scientists had made assumptions about the relationship between the size of an animal, its activity and its respiratory system that turned out to be false. When scientists are presented with new information, they must consider it and change previously held beliefs.)

After reading: Analyze

1. **Why is it important to understand how organ systems work in different animals?**
(Answers will vary, but could include: the field of comparative anatomy examines how organisms are similar and different; studying lungs in various animals helps scientists understand how lungs evolved; understanding organ systems offers clues to how animals survive in their environments; many modern technological advances come from ideas in the natural world. For example, vertical takeoff and backward flying airplanes were inspired by the study of birds such as hummingbirds.)
2. **What does it take to make a sound argument in science?**
(In science, hypotheses testing and data collection are required to make statements about how or why things work. Students may refer to some ideas that were tested and found to be wrong, like cold fusion, mentioned in the article.)
3. **What personal attributes did Colleen Farmer draw on to make this discovery?**
(Answers will vary but might include: she had extensive training in physics and a deep understanding of how air and fluids flow; she had a different perspective because she came from outside the community, so she wasn't tied to one specific way of thinking about how alligator lungs work; she was eager and excited to test her own ideas; she was persistent in getting data and submitting grants.)
4. **According to the article, the new findings have implications for longtime comparisons with dinosaurs. How can data from animals living today help scientists better understand the past?**
(Answers will vary, but might include: animals living today give us a sense of the range of characteristics common in different environments; by comparing the physical appearance of animals and their genetic relationships, scientists can start to construct a story about how the animals evolved; scientists can look to existing animals to understand the basic principles of biology and physiology; scientists studying fossils can look for features similar to those that exist today, for example, feathers.)
5. **A lot of people mistakenly think that evolution has a direction, or a purpose. Why do you think this misconception persists? How does evolution really work?**
(Answers might include: because feathers seem so perfectly suited for flying and legs perfectly suited for walking; people aren't always careful to distinguish how something is used today and how it came to be; because there is a lot of misinformation. Evolution is dependent on random mutations that end up offering an advantage to survival in a given environment at a given time. Through natural selection, individuals with traits that boost their survival and reproductive success are more likely pass on those traits.)

Discuss and Assess

After students read the article independently, return as a group to the concepts outlined prior to reading. Invite students to share their answers and observations from the article and lead a class discussion that further underscores your current curriculum. The discussion can serve as an informal assessment. Ideas for further reading discussion or writing prompts include:

- How has the classification system of organisms changed overtime? Students may want to trace the ways scientists organize information more generally, from the Greeks (*earth, fire, water, air*), to the hierarchical system inspired by Linnaeus, and now using DNA analysis for classification. How might the reliance on DNA, rather than body form or other physical characteristics, change how organisms are classified or change our understanding of evolutionary trends?
- Discuss the evidence from the article that students used to create their image of this biologist and compare this work to how students learn about a character from literature using context and inference. Discuss differences between the imagined generic biologist and this real one. This may lead to a discussion on stereotypes, the low percentages of women in certain STEM fields and the importance of diversity in science, and may open students to the possibility that they can become biologists.
- The development and testing of hypotheses is essential to science. What are some long-standing scientific ideas that later turned out to be wrong (*the Earth is flat, the universe is static, spontaneous generation*)? How did scientists go about changing these ideas? What tests and equipment did they invent to gather new evidence? How did they convince their colleagues?

- Authors create the voice of the article by carefully selecting words and phrases that convey meaning, emotion and style. Use the “What did you say?” chart ([Blackline Master #3](#)) to explore some interesting phrases used by the author in “Chasing Breath.”

Extend

Offer students other ways to explore the content of the article as it relates to your curriculum, such as:

BUILDING A MODEL LUNG

Models are simplified versions of concepts that scientists and engineers use to test out ideas. By creating models, ideas can be visualized and communicated, errors can be uncovered and new thinking emerges. Students should know how to build models based on the NGSS for Middle School ([MS-ETS1-4](#)), yet with the recent adoption of the NGSS, students may not have worked in this area previously. Therefore, this lesson is provided to scaffold toward the [HS ETS standards](#).

- **Purpose:** Students will build a model of a human lung and a lung with one-way airflow to compare and contrast how they function.
- **Prior knowledge:** Students have learned that many organisms have a system of interacting subsystems and that each subsystem is made of a set of specialized organs that work together and across subsystems to accomplish a task. In this case, we are looking at the respiratory system interacting with the circulatory system ([MS-LS1.3](#)).
- **Potential misconceptions:** Students often think that the lungs inflate because air rushing in forces them to do so. In fact, air enters the lungs because extra space is created there and “nature abhors a vacuum.” The key is the action of the diaphragm (no wonder our “sides” hurt after we’ve been breathing hard or coughing a lot!). The human lung model is an opportunity to address this misconception. There is a direct relationship between pulling down on the diaphragm and inflation of the balloon in this exercise. This can lead to a rich discussion of pressure and gas laws, as well as a variety of health topics.
- **Note to the teacher:** This experience is designed to differentiate instruction and encourage sharing of ideas. However, you can have all your students build both models rather than having the two activities happening simultaneously, if you prefer.
- **Materials:**

Human lung model	One-way lung model
Plastic water bottle, small balloon, 6 to 8 inch balloon, rubber band, masking tape, scissors, X-Acto knife or scalpel	Funnel, tubing that fits over or inside the mouth of the funnel, tape, thumbtack, nail, basin or bucket, water source, pitcher

- **Procedure:**
 1. Explain that engineers design models to help them understand how systems work and interact. The article “Chasing Breath” introduces how human and bird lungs work and how an alligator’s lungs operate akin to a bird’s.
 2. Divide the class into teams. Decide which teams will build the human lung and which will build the one-way lung*. Tell students that their task is to build the model lung and then use it to explain the exchange of gases that takes place during respiration.
 3. Give students their set of directions ([Blackline Master #4](#) and [#5](#)), materials and time to work.
 4. Once students have made their models, have teams use the information provided and do additional research to prepare a short presentation to the class explaining how the model works. They can discuss the model itself as well as the limitations of the model. (*Note, in particular, that the one-way lung is a very imperfect and simplified model of an alligator’s lung. While air flows in one direction deep within the lung, it still must enter and leave the body through the mouth.*)

* The human lung is a bit more challenging to build than the one-way lung model, so assign the appropriate model to students based on their skill level (differentiating instruction).

This activity was inspired by an image provided by [Eastern Kentucky University](#).

CLADOGRAMS EXPERIMENT

Cladograms are tools scientists use to share their understanding of how organisms are related to each other and thus how they evolved. These models are an opportunity for students to use evidence and logical reasoning to explain their decision-making process. The concept of mapping the evolution of species has a long history. If you want to infuse the lesson with some history, consider showing some images of the work of Maria Sibylla Merian. Merian was a naturalist and illustrator in 17th century Germany, and her work was consulted by Carl Linnaeus, the Swedish botanist and doctor who created the framework for our modern system of binomial nomenclature.

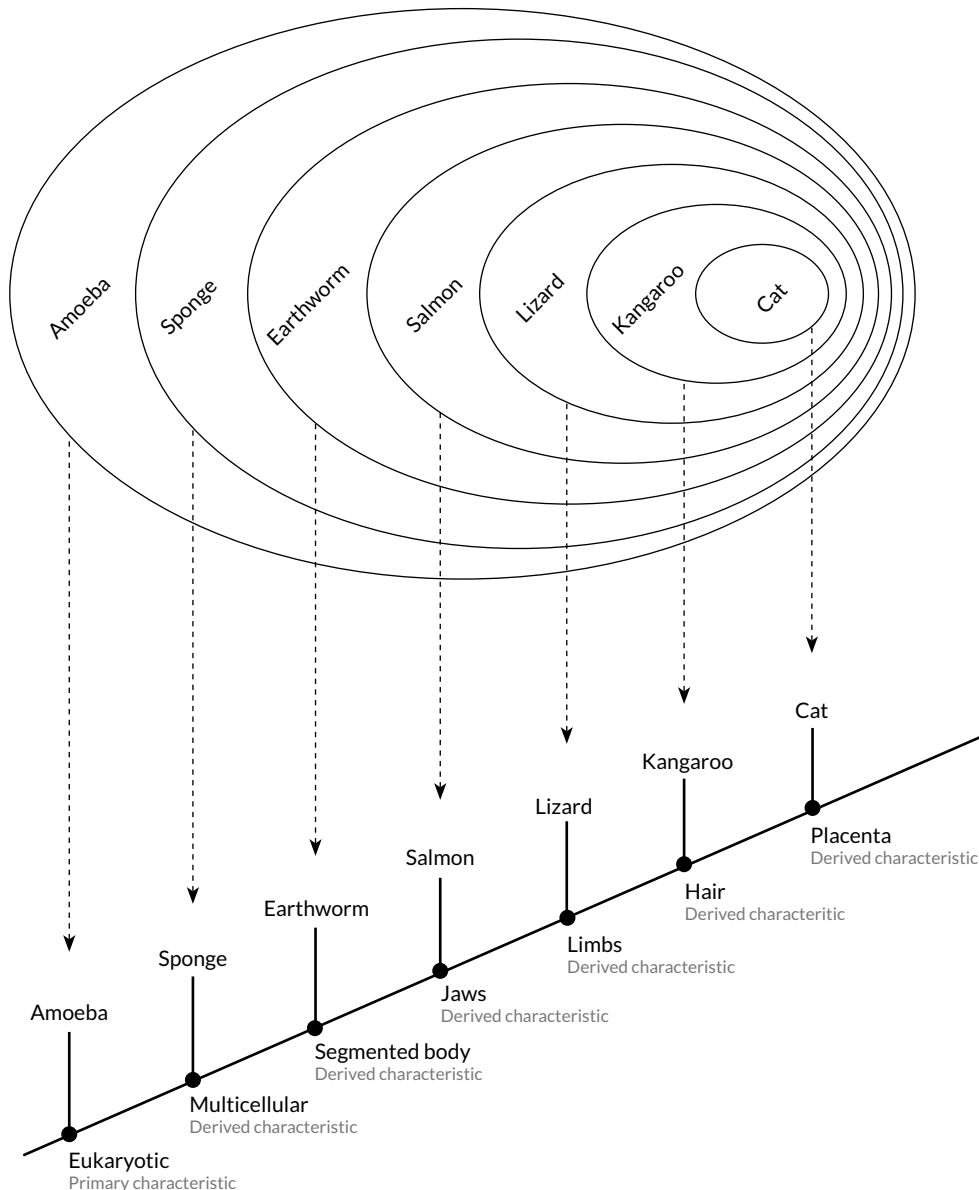
- **Purpose:** Students will create and read a model of an evolutionary tree, known as a cladogram.
- **Time:** This lesson includes multiple strategies to choose from based on the prior knowledge of your students. If using all the activities, this lesson may take more than one class session.

Activity 1: Hardware cladograms

■ **Materials:** 1 of each in a bag (Barrel Nut 5/16 x 18, Cap Screw M8x60, Carriage Bolt ¼ x 1-1/2, Driver Screw #10, Machine Screw FHP 1/4x20x2, PHP #14x2, Slotted PHS 4x1/2, Wood Screw #4), yarn, scissors, Post-its

■ **Procedures:**

1. Give each team a bag of hardware. Let them examine each piece carefully. Explain that these represent different species of organisms.
2. Give teams a copy of the hardware handout ([Blackline Master #6](#)) or you can project one copy for all to view. Have students match the hardware to their descriptions/images to make sure their set is complete.
3. Explain that scientists want to understand species and how they change by looking at how they are similar and different. Have students make a table or chart (or use [Blackline Master #7](#)) to list all the characteristics in the hardware, marking which possesses each characteristic. For example, all have a shaft, but some are smooth, some are threaded and some are partially threaded. If students need help brainstorming characteristics of the hardware, they might create a master list together and chart responses for the class.
4. Based on the completed chart, students will create a series of concentric circles by cutting yarn to form a circle and placing the hardware within it. This will look like a math practice in set theory. The outer circle reflects a characteristic all hardware have in common (all have a shaft). You can model this by placing a ring of yarn around all the hardware and labeling the circle with a Post-it. Tell students that the next layer in is the next most common, continuing until there is a circle with only one piece of hardware in it. Give students time to complete their process.
5. Looking at the concentric circles, show students how to use the concentric circles to create a cladogram format. A simplified version is demonstrated below, but their cladograms may have more secondary branches.



6. Have teams display their cladograms and explain their reasoning for the placement of the “organisms.” What did students agree/disagree on? If you think about these as organisms, did the nail evolve before or after the screw? Let students argue this out. You might also point out that cladograms change as new information is discovered.

Activity 2: Looking at cladograms

1. Have students look at the cladogram in the article (“Breather’s family tree”). Ask students to explain the relationship between the groups of organisms and how they are related based on the diagram.
2. Next pass out the practice cladogram, [Blackline Master #8](#). Have students decide where each characteristic should be placed on the cladogram. You can ask them to justify their responses. (A - *segmented body*, B - *legs*, C - *six legs*, D - *grasping pincers*, E - *jumping legs*, F-*wings*, G - *double set of wings*, H - *curly antennae*)

Activity 3: Kitchen utensil cladograms

- **Materials:** paper, a variety of household or kitchen items (salt shaker, small bowl, ladle, spoon, teaspoon, strainer, salad tongs), a cloth big enough to cover the items from view
- **Procedures:**
 1. Place all the household items, which in this case represent organisms, on a table and cover them with a cloth so students can’t see them. Tell students that they are going to view some “fossils” and will create a cladogram based on careful observation and collaboration.
 2. Divide the students up into teams and tell them that each team will analyze one organism.
 3. Ask each team to create a table of characteristics. Remind students that rather than naming the spoon, the goal is to describe it. What is the shape, for example? Encourage the students to describe the potential uses for those features.
 4. When the class comes back together, have the students create a cladogram from their table of characteristics. (This activity is designed to move a step beyond Activity #1, with students creating the concentric circles of characteristics in their heads rather than with yarn. But, depending on the level of your students, you could include the concentric-circle creation in this activity, too.)
 5. Ask the teams to defend their cladograms using reasoning and logic.

This activity is based on [an education guide](#) created by PBS NOVA. In preparing for this lessons, teachers might want to watch [this video](#) to see how one teacher orchestrated the experiment.

Making predictions

Directions: Scan the article, focusing on the titles, subheadings and images. What do you think this article will be about? Form at least three predictions and write them where indicated. As you read the article, note any evidence that either supports or refutes your prediction.

	Evidence for	Evidence against
Prediction 1		
Prediction 2		
Prediction 3		

Conclusion: How accurate were your predictions? Why do you think so?

Comprehend

After reading the article,
"Chasing Breath," answer
these questions:

1. What is the main topic of the article?
2. How do bird lungs differ from human lungs?
3. Did breathing air evolve as ancient aquatic organisms adapted to dry land?
4. Name one reptile other than the alligator with unidirectional airflow?
5. Why is the article's finding about the structure of reptile lungs important?

Analyze

Use what you already know about the topic, as well as what you learned in the article "Chasing Breath," and answer these questions:

1. **Why is it important to understand how organ systems work in different animals?**
2. **What does it take to make a sound argument in science?**
3. **What personal attributes did Colleen Farmer draw on to make this discovery?**
4. **According to the article, the new findings have implications for longtime comparisons with dinosaurs. How can data from animals living today help scientists better understand the past?**
5. **A lot of people mistakenly think that evolution has a direction, or a purpose. Why do you think this misconception persists? How does evolution really work?**

What did you say?

Writers use figurative language (metaphor, symbolism, simile, for example) to add meaning, emotion and style to their text. Examine how the author uses language to engage the reader while conveying meaning. A few examples are provided. Once you've filled in the chart, you can find more of your own to add to it.

Phrase	Location of excerpt	Type of figurative language	Why did the author choose this language?	What is another way to say it?
"through an intricacy of loopy tubes in the crucial zones"	p. 22, column 1, paragraph 4			
"just a waste gas of a hypothesis"	p. 22, column 2, paragraph 2			
"an aerodynamically smooth whoosh"	p. 22, column 2, paragraph 4			
"speech bubbles of merriment"	p. 22, column 2, paragraph 6			

Now it's your turn:

Phrase	Location of excerpt	Type of figurative language	Why did the author choose this language?	What is another way to say it?

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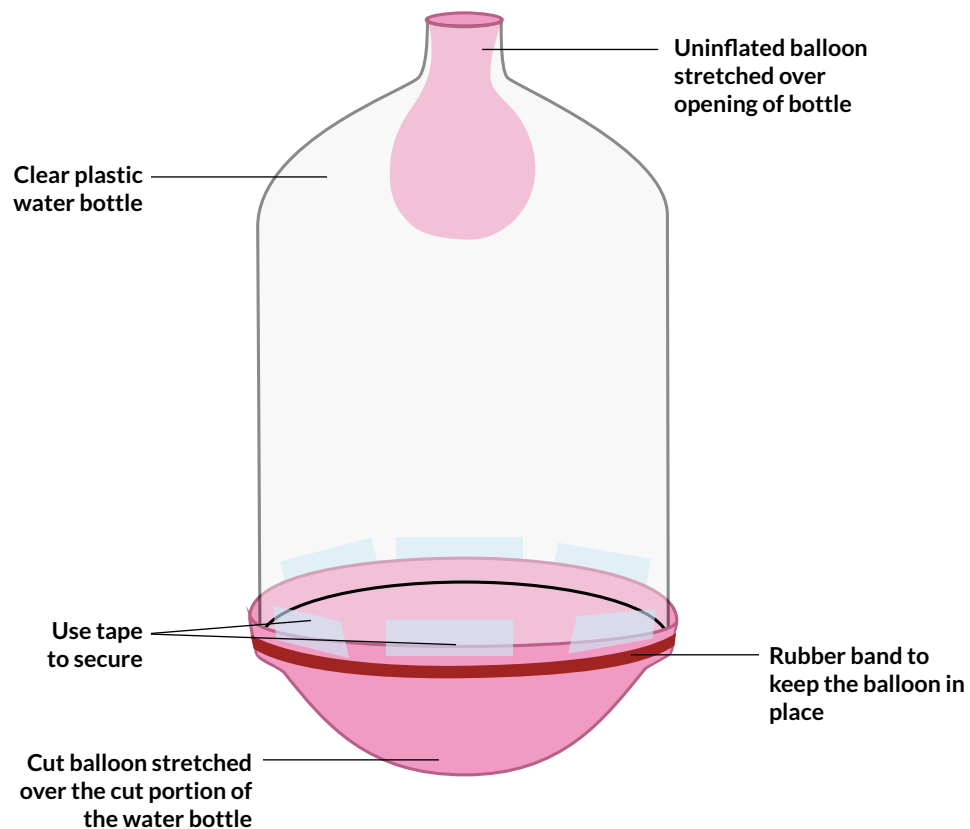
Building a Human Lung Model

Materials

- Plastic water bottle
- Small balloon
- 6 to 8 inch balloon
- Rubber band
- Masking tape
- Scissors
- X-Acto blade or scalpel

Procedures

1. Take a deep breath and exhale. Do this again while placing one hand on your collarbone and the other along the bottom of your ribs. Think about the parts of your body that you are using to get the air into and out of your lungs.
2. Think of the water bottle as your chest cavity. Cut off the bottom of the bottle (make a small puncture with the X-Acto blade or scalpel, then use the scissors for a clean cut).
3. Cut off the neck of the larger balloon and stretch the rubber over the opening you just created. Secure it in place with a rubber band and tape.
4. Insert the small balloon into the mouth of the bottle. Depending on the sizes, you may need to secure it.
5. Think about what the two balloons represent as you pull on the stretched balloon and watch what's happening inside the bottle.
6. Think about it: In this model, where is your heart and the blood vessels that exchange gases with your lungs? Look at the diagram to help you visualize what is happening as you inhale and exhale. Use your existing knowledge and do a bit of research to find out more.
7. Prepare a short oral presentation using your model to explain how human lungs exchange gases with the circulatory system. Include information on the limits of this model to show the details of lung function.



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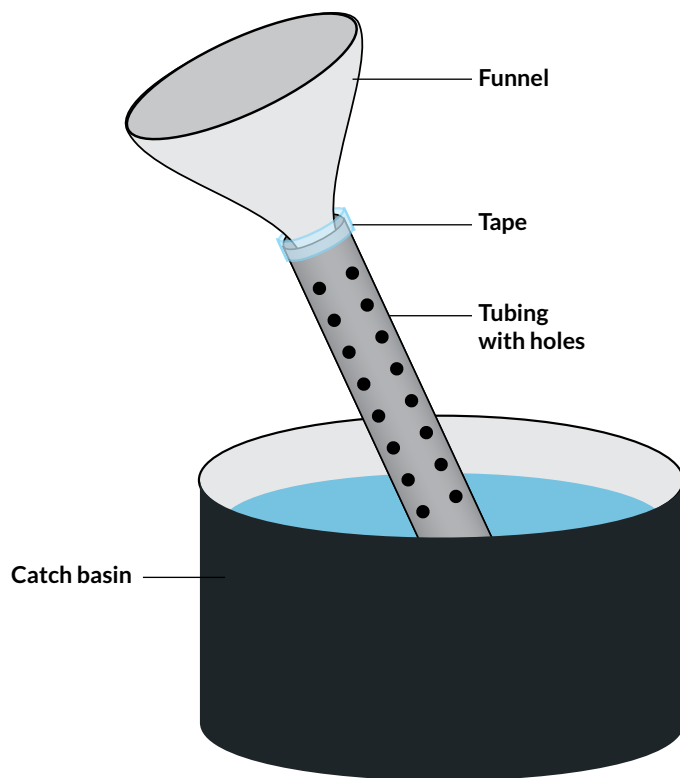
Building a One-Way Lung Model

Materials

- Funnel
- Tubing that fits over or inside the mouth of the funnel
- Tape
- Thumbtack
- Nail
- Basin or bucket
- Source of water
- Pitcher

Procedures

1. To represent the sites of gas exchange, create a series of small holes in your tubing. Use the thumbtack to make a hole, then enlarge it using the nail.
2. Attach the tubing to the narrow end to the funnel, using tape.
3. Water flowing through this system symbolizes air. Practice running water into the funnel and through the tube, over an empty basin or bucket.
4. Consider the animals known to have one-way airflow. How does this model represent their lungs? How could you improve it? Try putting some loops in your tubing to better represent the structure deep inside an alligator's lungs.
5. Place one hand under the open end of the tube. Move your hand, symbolizing a one-way valve, letting the fluid (water and air are fluids) pass through the system with a constant rhythm.
6. Think about how an alligator moves. When would the rhythm quicken and when might it slow down?
7. Use information from the article to prepare a presentation showing your model and how it represents the one-way airflow of an alligator's lungs. Include information on the limits of this model to show the details of lung function.



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Hardware

Wood Screw #4



Slotted PHS 4x1/2



Cap Screw M8x60



Machine Screw FHP 1/4x20x2



PHP #14x2



Barrel Nut 5/16x18



Driver Screw #10



Carriage Bolt 1/4x1-1/2



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Organization Chart

Directions: Use this chart to organize observations related to your set of hardware. Describe the characteristics in each column and record whether each type of hardware has the characteristic described. The first one is done for you.

Characteristics						
Organism	Cylindrical object with head					
Wood Screw	Yes					
Slotted PHS	Yes					
Cap Screw	Yes					
Machine Screw	Yes					
PHP	Yes					
Barrel Nut	Yes					
Driver Screw	Yes					
Carriage Bolt	Yes					

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Practice Cladogram

At what lettered position would you put the following developments?

- | | |
|--|---|
| <input type="checkbox"/> Curly antennae | <input type="checkbox"/> Grasping pincers |
| <input type="checkbox"/> Wings | <input type="checkbox"/> Segmented body |
| <input type="checkbox"/> Double set of wings | <input type="checkbox"/> Legs |
| <input type="checkbox"/> Jumping legs | <input type="checkbox"/> Six legs |

