HELLBENDERS

A SCIENCE 3D ADVENTURE

MIDDLE SCHOOL

By MIKE HEITHAUS Ph.D

symbio education™

KEY WORDS

ANOXIC

BUDDING

CANNIBALISM

DEPOSITION

EROSION

GAMETES

MEIOSIS

METAMORPHOSIS

MITOSIS

NICHE

OSMOSIS

SEDIMENT

SPECIALISTS

WEATHERING

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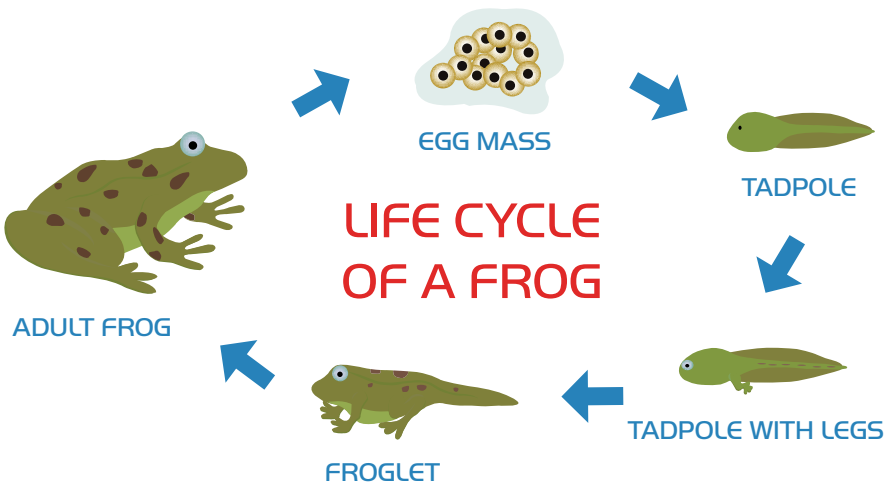
LASAGNA LIZARD
SNOT OTTER
ALLEGHENY ALLIGATOR
MUD DOG

A CREATURE OF MANY NAMES

What on Earth is a lasagna lizard? Believe it or not, it's not even a lizard at all! Lasagna lizard is another name for a giant salamander that lives in rivers of the United States. The most common name for this amphibian is hellbender. Its scientific name is *Chryptobranchus alleganiensis*. People have given them crazy nicknames, though, including Allegheny alligators, water dogs, old lasagna sides, devil dogs, and even snot otters.

Hellbenders share many traits with other amphibians, including frogs, salamanders, and newts. All amphibians have thin skin that needs to stay moist. They lay eggs that do not have shells. That means the eggs need to be laid in water or somewhere very damp, so they don't dry out. If the eggs dry out, they die. The hellbender life cycle is similar to the life cycles of other amphibians. Unlike tadpoles, that look nothing like an adult frog, baby hellbenders look much like adults aside from their gills and stubbier legs.



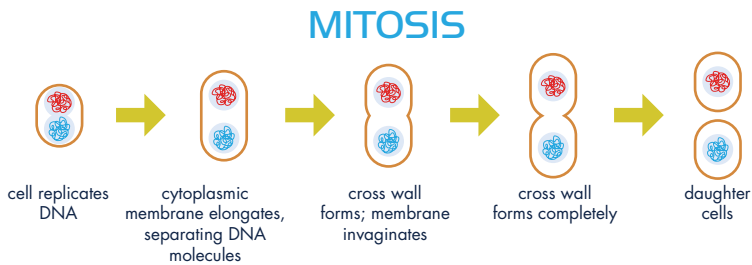
Amphibians lay eggs in water or wet areas. The young that hatch may not look like their parents. As they grow, the young change to look like their parents. This is called metamorphosis.

SEXUAL AND ASEXUAL REPRODUCTION

Most animals, including hellbenders, reproduce using sexual reproduction. Every species needs to reproduce to survive! In the simplest form, asexual reproduction, the genetic make-up of parent and offspring are virtually unchanged. In bacteria, genetic material gets replicated, and then the cell divides. Each daughter cell is identical to the parent. This form of cell division is called **mitosis**. Another form of asexual reproduction is called budding. In budding, an entire animal, like a flatworm, may split into pieces, and each piece regrows into an entire adult animal!

There are advantages to asexual reproduction. If an individual is well adapted to its environment, then its offspring will be well adapted too. Also, species that use asexual reproduction don't have to worry about finding a mate, getting hurt competing for a mate, or possibly getting a disease from mating.

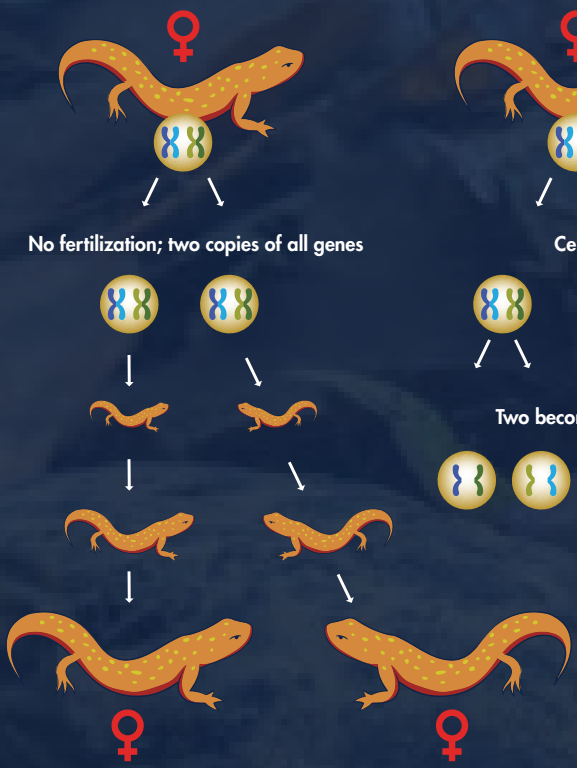
However, asexual reproduction isn't always beneficial. If the environment changes or a new disease enters the population, all the offspring that are genetically identical are likely to struggle. In sexual reproduction, reproductive cells known as **gametes** undergo meiosis. In meiosis, one cell duplicates its genetic material then divides into two cells. Then, each of these cells divides without duplicating its genetic material. That creates four cells (either four eggs or four sperm) with half the genetic material as the original. When the sperm fertilizes the eggs, each offspring has the same amount of genetic material as the parents, but a different combination of traits. This means every offspring is a bit different. Can you think of reasons that sexual reproduction might be beneficial?



DID YOU KNOW?

Some salamanders can use asexual reproduction!

ASEXUAL REPRODUCTION



SEXUAL REPRODUCTION

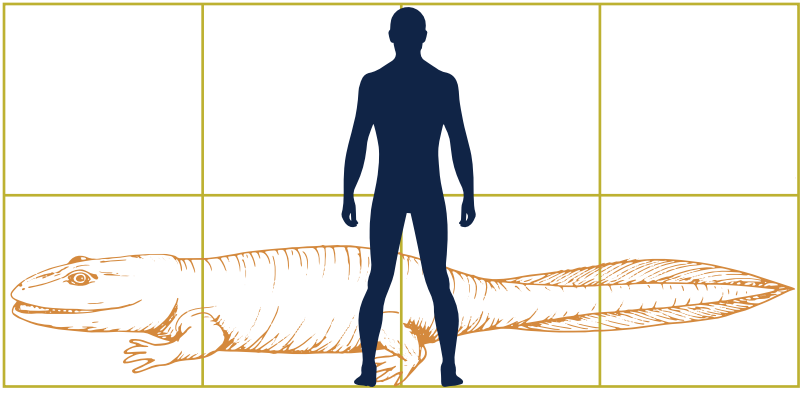
THE BIGGEST OF THEM ALL?

Hellbenders are the largest amphibian in North America. For salamanders, they are huge! They grow to 74 cm, which is almost 2.5 ft long! They can weigh up to 2.5 kg or 5.5 lbs. That is more than some cats! Hellbenders also can live a long time. In captivity one lived 30 years, and scientists think that they could be able to live to 50 years old.

Hellbenders may seem huge, but they are pretty small compared to their relatives in Japan and China. Chinese giant salamanders (*Andrias davidianus*) grow to about 1.1 m (3.7 ft) and weigh around 25 kg (55 lbs). Some may reach 1.8 m (5.9 ft) and 50 kg (110 lbs)! The Chinese giant salamander is the largest amphibian in the world today, but they are small compared to some of the amphibians that lived hundreds of millions of years ago in the Carboniferous period (354 to 290 million years ago). *Anthracosaurus* and *Pholiderpeton* amphibians grew to 3.5-4.5 m (12-15 ft) long. These huge amphibians are extinct today (lived around 300 million years ago), but some of them were once the top predators in their habitats.

This Japanese giant salamander is one of the largest in the world. Chinese giant salamanders are even bigger!

Pholiderpeton **compared with a 1.8 m (6 ft) tall person**



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Meters

Fossils, including those of amphibians, help scientists study ancient environments and the organisms that lived in them. For example, some types of plants can only live near water while others are adapted to drier conditions. Some animals are only found in oceans, while others, like amphibians, need freshwater habitats. Why have amphibians never lived in oceans? It has to do with their moist skin and a process called **osmosis**. Through osmosis, water moves from areas with little salt to areas with a lot of salt. Since an amphibian's body has a lower concentration of salt than ocean water, osmosis would cause the water to be sucked out of amphibians in the ocean. Amphibians would die if they entered saltwater.

Thin, moist skin of amphibians allows water to move across it easily through the process of osmosis.

FRESHWATER ECOSYSTEMS

There are several types of freshwater habitats. Ponds are small, and have calm, stationary water. Like ponds, lakes also have water that doesn't flow, but lakes are bigger than ponds. Some are so big they can even seem like oceans. Some lakes are shallow, but others are very deep. Lake Superior, near Michigan, has depths of more than 400 m (1,300 ft). Ponds and lakes form in depressions in the land where the underlying rock and **sediment** keep water from flowing downwards.

Wetlands are freshwater habitats that have shallow water and lots of vegetation. Water levels of wetlands rise and fall during the year. That means that some areas are wet during parts of the year and dry during other parts. Some animals, like frogs and other amphibians, have to choose the right time to lay their eggs. If they don't choose wisely, the places they lay their eggs could dry up! Ponds can turn into wetlands over time as sediment flows into them. Also, when organisms such as aquatic plants, algae, and animals die, they settle to the bottom. Some of the matter is consumed by decomposers, but much of it builds the sediment on the bottom of the wetlands.

In streams and rivers, the water flows. Streams are smaller than rivers, and flow into each other to create bigger streams and rivers. Rivers come together to form larger rivers. Rivers are classified by how many rivers came together to form them. For example, when two first order rivers (the smallest river with flowing water) come together, they form a second order river. When two second order rivers come together, they form a third order river. However, when a first and a second order river come together, the new river is still a second order river. The Amazon River is the widest river in the world. At the point it flows into the ocean, it is a twelfth order river. In the dry season it is more than 10 km (6 mi) wide. When it rains a lot, it can grow to 40 km (25 mi) wide. The deepest river in the world is the Congo River. It can be deeper than 200 m (700 ft).

FLOWING FRESH WATER

Streams and rivers are shaped by destructive and constructive processes like **weathering**, **erosion**, and **deposition**. Where water moves quickly or flows downhill, it can pick up sediment and soil and carry them away, which is called erosion. Weathering is when water takes away particles from rocks. When the water slows down, the soil or rock fragments fall and remain at the bottom. This is called deposition. Erosion and weathering can cause rivers to cut deep into the land, forming canyons and gorges.

Streams and rivers have different habitats which are inhabited by different types of amphibians. Pools are areas in which the water moves slowly, and are usually deeper and wider than other habitats. The bottom is often covered in mud because sediment in the water sinks to the bottom, rather than getting carried away, when the speed of the water slows down. Sometimes this deposition eventually causes sandbars to form as pools fill with sediment. Since the bottom is muddy, there are not many places for amphibians to hide. But the slow currents allow for even weak swimmers to live in these habitats. Some tadpoles and frogs live in the pools of rivers and streams.

Wetland

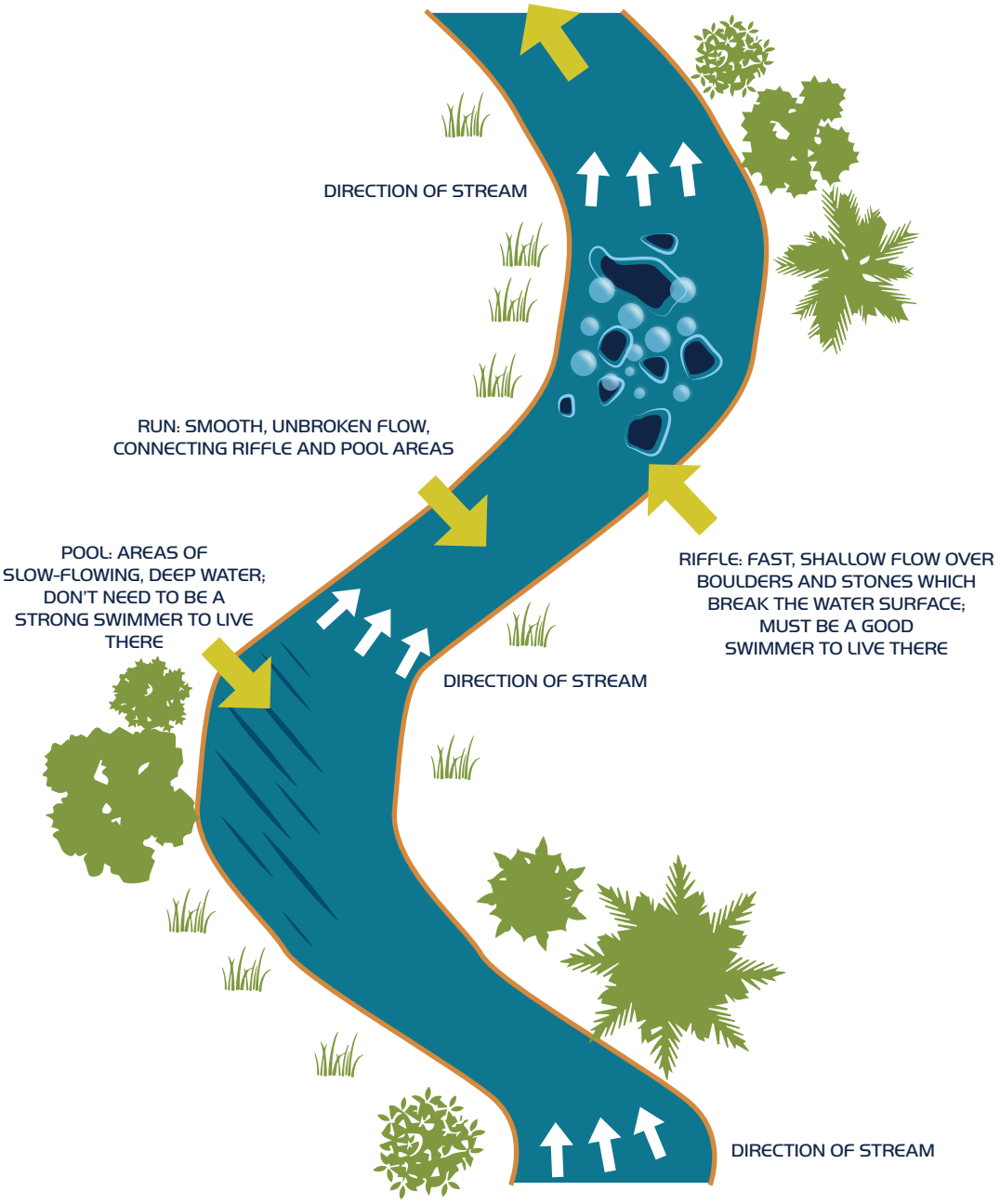
Pond

River

Riffles and rapids are areas where the water moves very fast. To live here, an amphibian needs to be a really strong swimmer or able to crawl around and hold onto the rocks on the bottom! The surface of the water bubbles and helps the level of oxygen in the water. Riffles and rapids are usually shallower and narrower than pools. The bottom has a lot of rocks because mud and small pebbles are swept away by the current. Sometimes there are even big boulders. Hellbenders are well equipped for riffles and rapids.

Runs are areas where the water moves fast, but the surface doesn't bubble. The bottom usually is not muddy. The fast-moving water can erode the mud along the bank and carry it downstream.

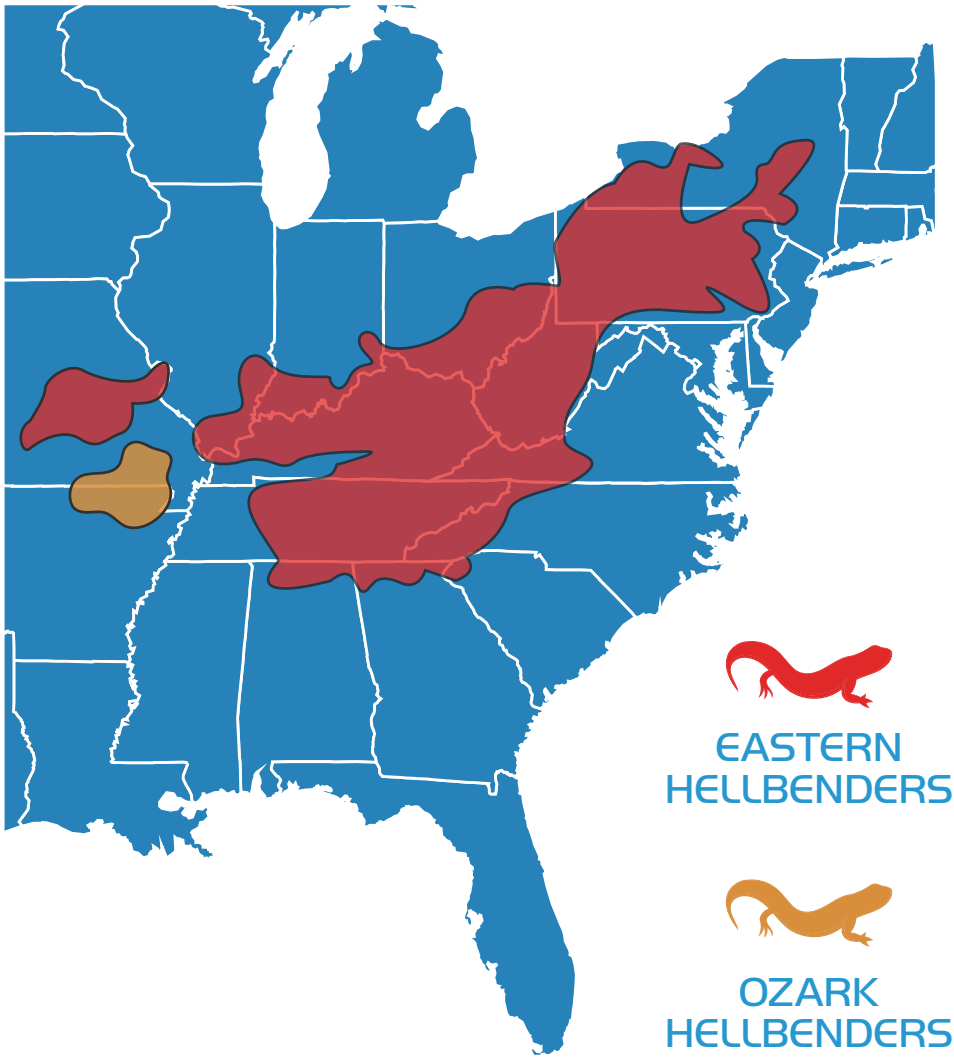
DIFFERENT CURRENT SPEEDS AND WATER DEPTHS CREATE DIFFERENT HABITATS



The habitats of streams and rivers are shaped by how water flows and carries sediment.

WHERE DO HELLBENDERS LIVE?

Hellbenders are aquatic. They live in rivers and streams of eastern North America. There are two types of hellbenders, the Ozark hellbender and the Eastern hellbender. They are both the same species but are different enough to get different names. The Ozark hellbender is found mainly in Missouri and Oklahoma. The Eastern hellbender is found in places like New York, Pennsylvania, Ohio, Kentucky, Tennessee, Georgia, North Carolina, West Virginia, and Virginia.



THE LIFE OF A HELLBENDER

Hellbenders hatch from eggs laid underwater. When they are small, they have gills and small limbs. They get their energy from a yolk sac. After a year and a half, they undergo metamorphosis.

Hellbenders spend most of their time living under rocks. They are mostly nocturnal, which means they are mainly active at night. That is when they come out to look for prey. They also will spend time with their heads peeking out from a rock looking for prey to ambush. Animals that use this hunting tactic are called sit-and-wait predators.

Hellbenders' favorite prey is crayfish, but they will also eat small fish and invertebrates. Sometimes they will eat the eggs of other hellbenders! Some scientists think that hellbender **cannibalism** may limit their populations. Hellbenders have an excellent sense of smell. They can move up scent trails in a river the way that sharks can move up scent trails in the ocean. This helps them find food and makes up for not having very good vision.

Hellbenders need just the right conditions to survive and reproduce. They need clean water with high levels of oxygen. They need big rocks to live and hide under. They need enough prey, like crayfish.

One reason hellbenders hide under rocks is to stay safe from their predators. Raccoons, mink, otters, fish, turtles, and snakes all eat hellbenders. Some scientists think that the "snot" that hellbenders secrete from their skin and gives them the nickname "snot otters," tastes bad to predators. The snot may be used for defense, prevent them from getting scraped when they squeeze under rocks, or help prevent bacterial infections. But scientists don't know what the actual function of the snot is yet.

Raccoons are one of the main predators of hellbenders. Is their snot an anti-predator defense?

DO HELLBENDERS HAVE SOCIAL LIVES?

Hellbenders are solitary. They live alone most of the time. Usually a single hellbender lives under a particular rock. Hellbenders are also territorial. They defend their rocks and the areas near them from other hellbenders, especially during the mating season.

Male hellbenders create a nest under their rocks by digging out depressions in the sediment. Each male waits for a female to come lay eggs in the nest. The female lays between 150 and 200 eggs over several days. When she lays her eggs, the male fertilizes them.

This is external fertilization, which is the most common method of fertilization in amphibians and bony fish. Sharks, reptiles, birds, and mammals use internal fertilization, in which the eggs are fertilized inside the female.

After the female hellbender lays eggs, the male chases her away and waits for another female to add eggs to the nest. More than 1,000 eggs have been found in some nests! The male guards the eggs to keep them safe from fish or other hellbenders that might eat them. This is one reason that hellbenders probably prefer rocks that only have one entrance to the area underneath. It makes it easier to defend the entrance. To get more oxygen to the eggs, the male fans them with his tail to keep water flowing.

MALE HELLBENDERS FIGHT FOR TERRITORY

HELLBENDER HABITATS

Hellbenders are habitat **specialists**. That means they have a narrow **niche** and can't survive if conditions change too much. They need streams and rivers that have the right temperature, high oxygen levels in the water, and fast currents. They also need big rocks that have spaces underneath them, so they can hide and reproduce. The flattened bodies of hellbenders help them move through fast-moving currents, squeeze under rocks, and live in their environment. Hellbenders have impressive camouflage. Their color pattern helps them blend into their surroundings. Some scientists can tell what rivers hellbenders are from based on their colors, which are adapted to the local conditions!

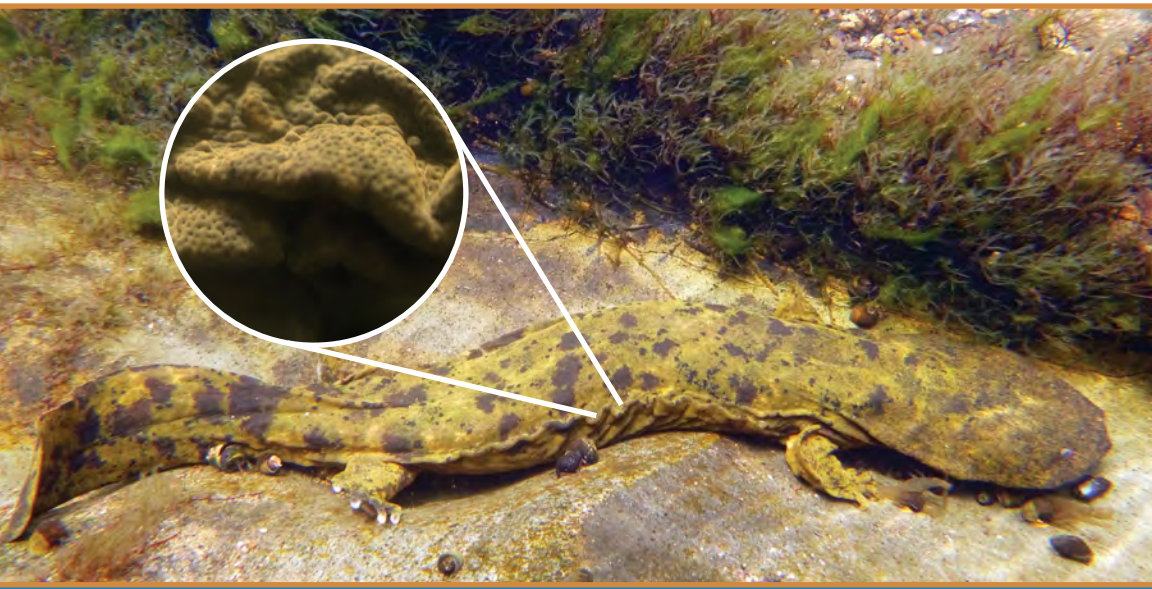
Hellbenders are adapted to their environments. They need the right kind of rocks and the right water quality to thrive.

WHO NEEDS LUNGS ANYWAY?

Most frogs and salamanders breathe through their lungs. Hellbenders barely use their lungs at all! They have thin skin and small blood vessels called capillaries near the surface of their skin. Oxygen passes easily from the water through their skin and into their capillaries. Hellbenders get more than 90% of their oxygen through their skin.

Hellbenders have thin, wavy folds of skin along their sides. These folds give them a couple of their nicknames – "old lasagna sides" and "lasagna lizard."

Because they breathe through their skin, hellbenders need to live in water with a lot of oxygen. There are some negative effects to breathing through the skin. Having permeable skin and blood vessels near the surface means that toxic chemicals can easily move into a hellbender's body. That is one reason why hellbenders need clean water.



Hellbenders breathe through their skin. Most of their oxygen enters their body through folds of skin along their sides. Breathing through skin may sound awesome, but it isn't always a good thing. If there is pollution in the water, it can enter a hellbender's body through its skin. That means hellbenders need clean water!

DIFFERENT SHADES OF SALAMANDER

Look at the pictures below. What differences do you notice?

If you said the colors were different, you are right! Hellbenders don't move very far, even when they are young. That means that hellbenders in one river aren't known to travel to other rivers to mate. Even though sexual reproduction results in some variation from parents to offspring, offspring mostly look similar to their parents. Through generations, the colors of hellbenders become matched to the conditions in their home stream so they are more difficult for predators to spot.

HELLBENDERS IN TROUBLE

Hellbenders thrive in the specialized conditions to which they are adapted. However, they are in trouble. First, they are very sensitive to the quality of the water in their habitat. In many places, the quality of water has declined in streams. There are many causes of this reduction in water quality.

For example, people often want to live or farm near rivers. They have cleared the forests right up to the edge of rivers and streams. This means that when it rains, soil runs into the rivers. This reduces the clarity of the water and can cover the rocks hellbenders need. Farming near the edge of streams can also cause dirt or sediment to flow into the water. Another potential problem occurs when fertilizer runs into waters. If there is too much fertilizer on land, rain can carry it into fresh waters. This gives algae the nutrients they need to reproduce. Algae reproduce using asexual reproduction, so their populations can grow very, very quickly. The algae can choke waterways. When the algae die and are decomposed, a lot of oxygen is removed from the water. This can create **anoxic** waters, with almost no oxygen. This means animals like fish and hellbenders that get their oxygen from the water cannot survive.

Chemicals and toxins are other threats that can flow into rivers. These may be from factories, farms, or the streets of cities and towns. Dredging streams and rivers to be deeper or digging them to be wider also can destroy the habitats in streams that many organisms, including hellbenders, need. This changes how fast the waters flow, can add mud to the bottom, and removes habitats that many organisms need. If people remove rocks from rivers to build walls, it can make a perfect habitat unlivable for hellbenders. In some areas too many hellbenders have been collected for pets, and their populations have declined. Diseases also threaten hellbender populations. Skin diseases are common, but scientists still don't know what causes them.

Hellbenders have disappeared from many streams where they used to be found. Existing populations are much smaller. Hellbenders are still doing well in areas with healthy forests. Forests prevent soil from eroding and clogging streams. There are not many places where hellbender streams are near intact forests. If people don't do something, hellbenders could disappear forever. Ozark hellbenders are an endangered species. Their populations are about 75% less than they were during the 1980s. Only a couple hundred are alive in the wild today.

LOST VARIATION

Genetic variation is important to healthy populations. If there are many genetic variations, it is more likely that a population can survive in a changing world. For example, if there is a new disease, a population with more genetic variation is more likely to have some individuals that are immune to the disease. The offspring of these individuals will ensure that the population survives. When populations get too small, they lose genetic variation and become more likely to go extinct.

Japanese giant salamander
(Andrias japonicus)

Hellbenders have lost a lot of genetic variation. Because they don't move between streams, usually each stream has its own population. As populations have declined, their genetic variation has decreased. Scientists are worried this could make it easier for hellbenders to go extinct. Would moving hellbenders from one population to another help? Maybe not. It also might cause problems, like introducing new diseases.

Because each population is adapted to its environment, mixing populations could result in hellbenders not being adapted to any environment. Scientists are worried that this is happening to giant salamanders in Asia. They are bred on farms, but the farmers didn't know that they shouldn't mix salamanders from different populations. Now the hellbenders that have been raised from mixed populations may not be able to survive if they are released into streams in the wild. They won't have the right adaptations for the streams.

SAVING HELLBENDERS

Some people are working hard to save hellbenders. There are several things that need to happen to save them. Their habitats need to be protected and improved. In many places, people are working to restore rivers. They are replanting trees along the banks of rivers and building wetlands that can help absorb fertilizers and trap pollutants before they run into rivers. Farmers are working to use less fertilizer and applying it in ways so it's less likely to flow into the water. People are making sure toxins are not flowing into rivers. Governments are also protecting hellbenders from being removed from streams. Scientists are investigating what may be causing diseases.

Improving rivers for hellbenders also makes them better for other species and people. Better river conditions help hellbenders survive and their populations grow. Better rivers also provide better habitats for fish, some of which people like to catch. Clean rivers are also nicer for people to enjoy.

Dr. Stephen Spear studies hellbenders and helps protect them in their natural habitat.

STUDYING HELLBENDERS

Because they live under big rocks in areas of rivers where the currents are strong, it can be difficult to study hellbenders. Wading through rivers and turning over rocks takes a long time, can disturb the habitat, and doesn't work if rivers are murky after rains.

Engineering and technology have helped scientists overcome some of these challenges. Camera technology, for instance, has helped scientists observe hellbenders. Instead of turning over rocks, scientists can slide a small camera under the rock and watch what it captures on a small screen. This allows scientists to survey more rocks quickly without having to disturb them. It can still take a long time, especially when murky waters and swift currents makes the recordings more difficult to capture.

A new technology is helping scientists find out more quickly if hellbenders are in an area. It's called environmental DNA, or eDNA for short. All animals have DNA in their cells. DNA has the genetic information that codes for traits in organisms. When skin cells fall off an animal or when an animal eliminates waste, DNA enters the water. Although the complete DNA code of individuals is unique, individuals of each species share many similarities in their DNA. Scientists can use chemical reactions and a small machine to read pieces of DNA to see if it is from a hellbender. With about a liter of water, scientists can tell whether or not hellbenders are present in an area.

HELLBENDER HEAD START

In some places, healthy rivers are not the only thing that hellbenders need to survive. Scientists know this because hellbenders did not return to rivers in which conditions had been restored. In other areas, there are not enough hellbenders to ensure the population will increase. How can people help ensure hellbender survival? What do they need to do to be sure that they succeed?

Now that you have learned about hellbenders, you are ready to join a team of scientists trying to save snot otters in Ohio!

Baby hellbenders have gills and get energy from a yolk sac until they can feed themselves.

At The Wilds hellbender headstart program, babies are reared until they are big enough to be released back into the wild. Researchers also study how hellbenders respond to target training with food.

GLOSSARY

ANOXIC
conditions with very little or no oxygen

BUDDING
asexual reproduction in which an organism splits into two, and both parts grow into new individuals

CANNIBALISM
eating others of the same species

DEPOSITION
the settling of soil or rocks in an area after being moved by wind or water

EROSION
the gradual wearing away of soil, rock, or land by wind or water

GAMETES
male or female reproductive cells with half the normal amount of nuclear DNA

MEIOSIS
cell division that creates four daughter cells with half the amount of genetic material

METAMORPHOSIS
a change in an organism from one form to another

MITOSIS
cell division that results in two genetically identical daughter cells

NICHE
the role and environmental needs of species

OSMOSIS
the movement of water across a membrane from an area of low salt concentration to high salt concentration

SEDIMENT
matter that settles to the bottom of a liquid

SPECIALIST
an organism that is only found in a specific set of conditions

WEATHERING
the breaking down of rocks by water, wind, ice, organisms, or chemicals

PHOTO CREDITS

Abbreviation Key: FI = Freshwater Illustrated; SS = Shutterstock.com

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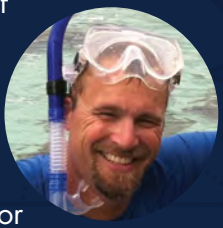
SCIENCE 3D

Thanks for learning about hellbenders with us. Our science adventures take us to remote corners of the planet to uncover secrets of the most amazing animals and places. Our mission and passion is to share the excitement of scientific discoveries with you. There are so many cool things to see out there, even in your own backyard, so get outside and explore!

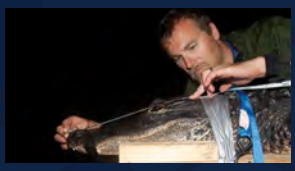
MIKE HEITHAUS, Ph.D.



Dr. Mike Heithaus is an explorer, author, educator, and television host. He is a professor of biology and Dean of the College of Arts, Sciences & Education at Florida International University. Mike and his students study sharks, whales, sea turtles, and other large marine animals around the world. They also work with people to help protect these species. Mike loves sharing his work with others. He has written textbooks and helped create programs for students in elementary, middle, and high school. He has been on television programs on PBS, National Geographic, and Discovery Channel's Shark Week.

PATRICK GREENE

As a wildlife filmmaker, Patrick has always had a passion for animals. He started to draw pictures of sharks and whales when he was just five years old. Later he went to college to become a marine biologist and learned a lot about science. Then he got a job in television and learned how to make videos too. Since then he's gone all over the world studying and filming wild animals. He's made shows for National Geographic, PBS, and ABC, and even won an Emmy Award. He loves making videos to teach students about science and about the many creatures that share our world.



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