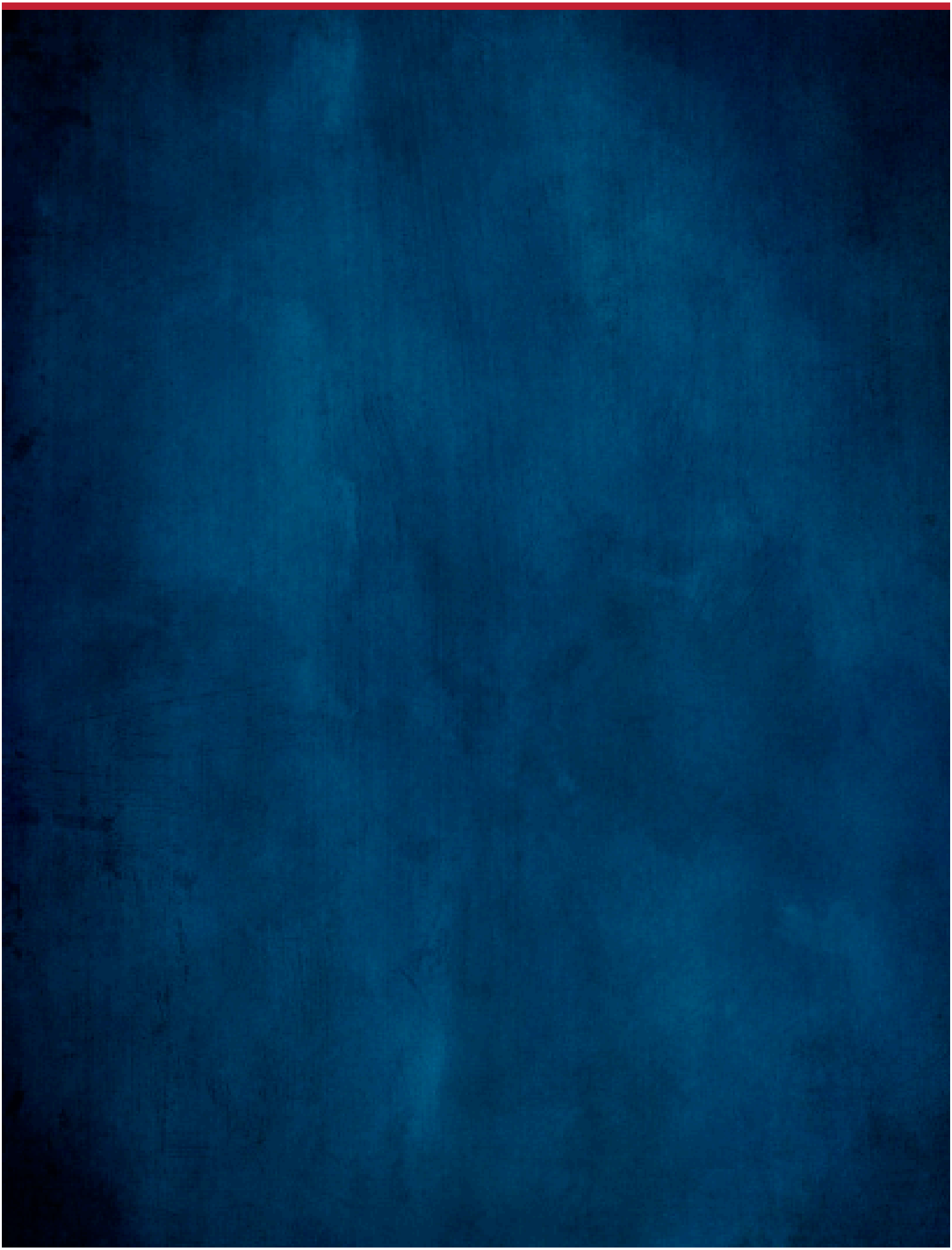
museum in a box



MOLLUSKS



MUSEUM IN A BOX CONTENTS

Mollusks

About Us
Virginia Science Standards of Learning

SECTION 1: RESEARCH
This educational plan covers the following sections:
1- What are Mollusks?
2- Classes of Molulsks
3- Evolution of Mollusks
4- Habitats and Coral Reefs
5- Human Use and Impact

SECTION 2: ACTIVITIES
1. Filter Feeder
2. Mollusks and Math
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4. Stuffed Shells
5. Classroom Coral Reef

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ABOUT US

University of Richmond Museums comprises the Joel and Lila Harnett Museum of Art, the Joel and Lila Harnett Print Study Center, and the Lora Robins Gallery of Design from Nature. The museums are home to diverse and fascinating collections and exhibitions of art, artifacts, and natural history specimens.

Admission is always free and all are welcome. The museums regularly present exhibitions, lectures, openings, gallery talks, workshops, concerts, symposia, and other programs. Guided tours can be arranged to accommodate school groups or special interest groups. Visit *museums.richmond.edu* or call 804-289-8276 for information about hours, programs and exhibitions.



Museum in a Box

The Museum in a Box program brings University Museums' collections to a wide variety of locations including K-12 classrooms, community centers, and places of worship. Each box includes lesson plans based on the Virginia Standards of Learning, relevant activities, and touchable. Boxes are available for two-week periods, free of charge.

Subjects include:

- Virginia Rocks and Geology
- Mollusks and Coral Reefs
- *Growing Up in Civil Rights Richmond*
- Prints and Printmaking
- Mineralogy

For more information about guided tours and Museum in a Box, contact Martha Wright, Assistant Curator of Academic and Public Engagement, University Museums, *mwright3@richmond.edu* or 804-287-1258.

VIRGINIA STANDARDS OF LEARNING, SCIENCE

Kindergarten:

K.4 The student will investigate and understand that the position, motion, and physical properties of an object can be described. Key concepts include

a) colors of objects;

b) shapes and forms of objects;

c) te xtures and feel of objects;

d) relative sizes and weights of objects; and

e) relative positions and speed of objects.

K.7 The student will investigate and understand basic needs and life processes of plants and animals. Key concepts include

a) animals need adequate food, water, shelter, air, and space to survive;

First Grade:

1.5 The student will investigate and understand that animals, including humans, have basic needs and certain distinguishing characteristics. Key concepts include

a) basic needs include adequate air, food, water, shelter, and space (habitat);

b) animals, including humans, have many different physical characteristics; and

c) animals can be classified according to a variety of characteristics.

Second Grade:

2.5 The student will investigate and understand that living things are part of a system. Key concepts include

a) living organisms are interdependent with their living and nonliving surroundings;

b) an animal's habitat includes adequate food, water, shelter or cover, and space;

c) habitats change over time due to many influences; and

d) fossils provide information about living systems that were on Earth years ago.

Third Grade:

3.5 The student will investigate and understand relationships among organisms in aquatic and terrestrial food chains. Key concepts include

c) predator and prey.

3.6 The student will investigate and understand that ecosystems support a diversity of plants and animals that share limited resources. Key concepts include

a) aquatic ecosystems;

b) terrestrial ecosystems;

VIRGINIA STANDARDS OF LEARNING, SCIENCE

Third Grade (continued):

3.9 The student will investigate and understand the water cycle and its relationship to life on Earth. Key concepts include

a) there are many sources of water on Earth;

d) water is essential for living things;

Fifth Grade:

5.7 The student will investigate and understand how Earth's surface is constantly changing. Key concepts include

c) Earth history and fossil evidence

e) changes in Earth's crust due to plate tectonics

Seventh Grade: Life Science:

LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include

b) the relationship between predators and prey;

9th Grade: Earth Science

ES.9 The student will investigate and understand that many aspects of the history and evolution of Earth and life can be inferred by studying rocks and fossils. Key concepts include

a) traces and remains of ancient, often extinct, life are preserved by various means in many sedimentary rocks;

d) rocks and fossils from many different geologic periods and epochs are found in Virginia.

Tenth Grade: Biology

BIO.7 The student will investigate and understand how populations change through time. Key concepts include

a) evidence found in fossil records;

b) how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations;

1

What is a Mollusk

WHAT IS A MOLLUSK

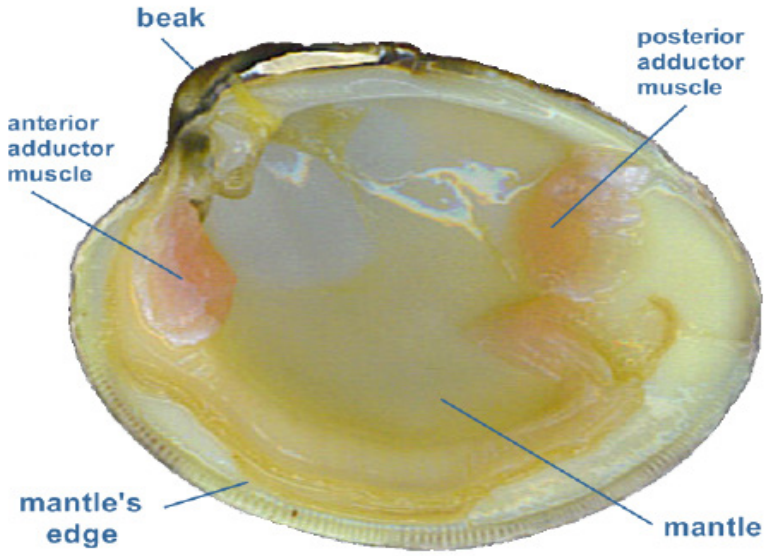
Mollusk derives from the Latin root for “soft” – which seems strange since we associate strong and hard seashells with mollusks. But those shells are the exoskeleton, providing the mollusks with shape, protection, and even camouflage.

In the scientific classification, mollusks are members of the group Lophotrochozoa due to their tentacle mouths. A mollusk family can hold an unlimited number of species and members of one species will share characteristics. Here, we will look at some popular classes (or genres) of Mollusks:

Gastropods (Gastropoda)
Tusks (Scaphopoda)
Chitons (Polyplacophora)
Cephalopods (Cephalopoda)
Bivalves (Bivalvia)

A quick note about Mantles:

The Mantle is a membranous projection of the mollusks body, creating a wall that encloses and protects the organs. The mantle does open to allow air and water to circulate inside the space within. This allows the mollusk to breathe and circulate fresh water in order to stay clean (pumping out grit, waste, or even eggs for reproduction). While all groups have a mantle, they do differ in physical layout per class. For instance, the mantle also creates the shells outer surrounding environment. Most Cephalopods don’t have an outer shell (with the exception of Nautlius), but their mantle makes up the tough tissue that surrounds and protects their inner organs. As such, the mantle can be different colors to communicate (see Octopus below). Their mantle also creates a siphon (siphons can also be found in gastropods, and bivalves) that pumps water into the main cavity for respiration, eating, and to propel themselves underwater.



Civil Rights Richmond

A quick note about Radulas:

Radulas are sharp tooth like appendages that scrape and pierce the food that the mollusk will consumer. The only group that does not have a radula are the bi-valves and some aplacophorans (not discussed in this box). The shape does vary among different mollusks based on the diet.



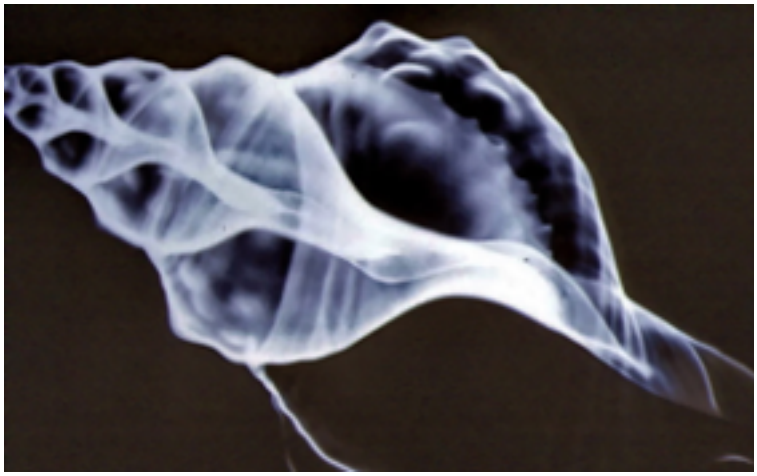
A quick note about shells:

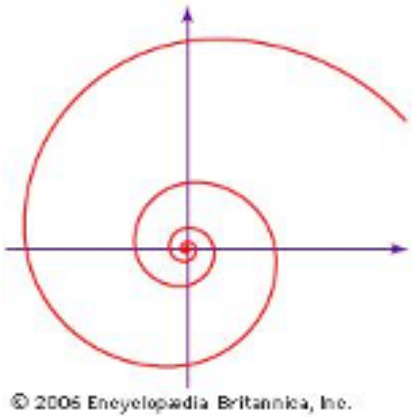
Mollusk shells are a mix of chitin (a fibrous substance that makes up exoskeleton of crustaceans), protein, and calcium carbonate. Shells are found in a variety of shapes and sizes based on the environment, predators, and mollusk. They can be coiled flatly, globe like, triangular, in a long plane, and can be spiked.



Nonetheless, most all shells grown in the logarithmic spiral. First studied by René Descartes in 1638, the equation for this spiral is $r = ae^{\theta \cot b}$, in which r is the radius of each turn of the spiral, a and b are constants that depend on the particular spiral, θ is the angle of rotation as the curve spirals, and e is the base of the natural logarithm. Also known as the Fibonacci sequence or the golden ratio, this mathematical equation is found frequently in nature – from acorns, shells, and florets of flowers, to the scales of a pinecone or pineapple!

Here you can see a scan of a Triton shell – giving a horizontal view to the construct of a shell that grows according to the logarithmic spiral





2

Classes of Mollusks

GASTROPODS

Gastropod- a soft bodied type of mollusk that is protected by a singular hard shell. They can be found on land, in the ocean, and in freshwater – pretty much everywhere except for extreme Polar Regions or deserts (anywhere they could dry out or freeze).

Gastropods vary in their diet. Some are scavengers, eating dead plant and animal matter, and others are predators, eating smaller mollusks and coral, and lastly, the herbivores eat algae and land plant material.

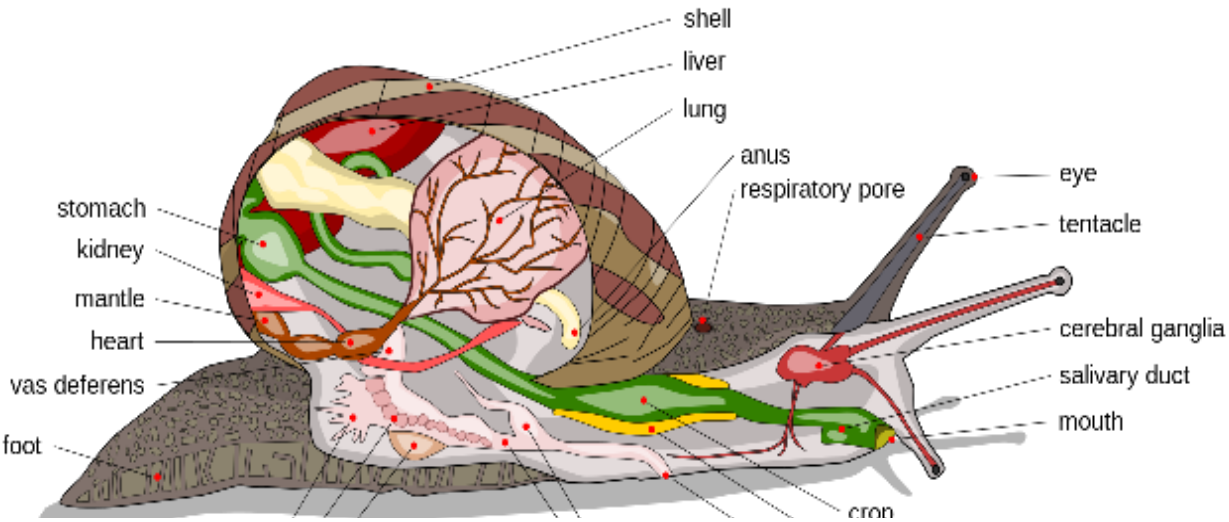


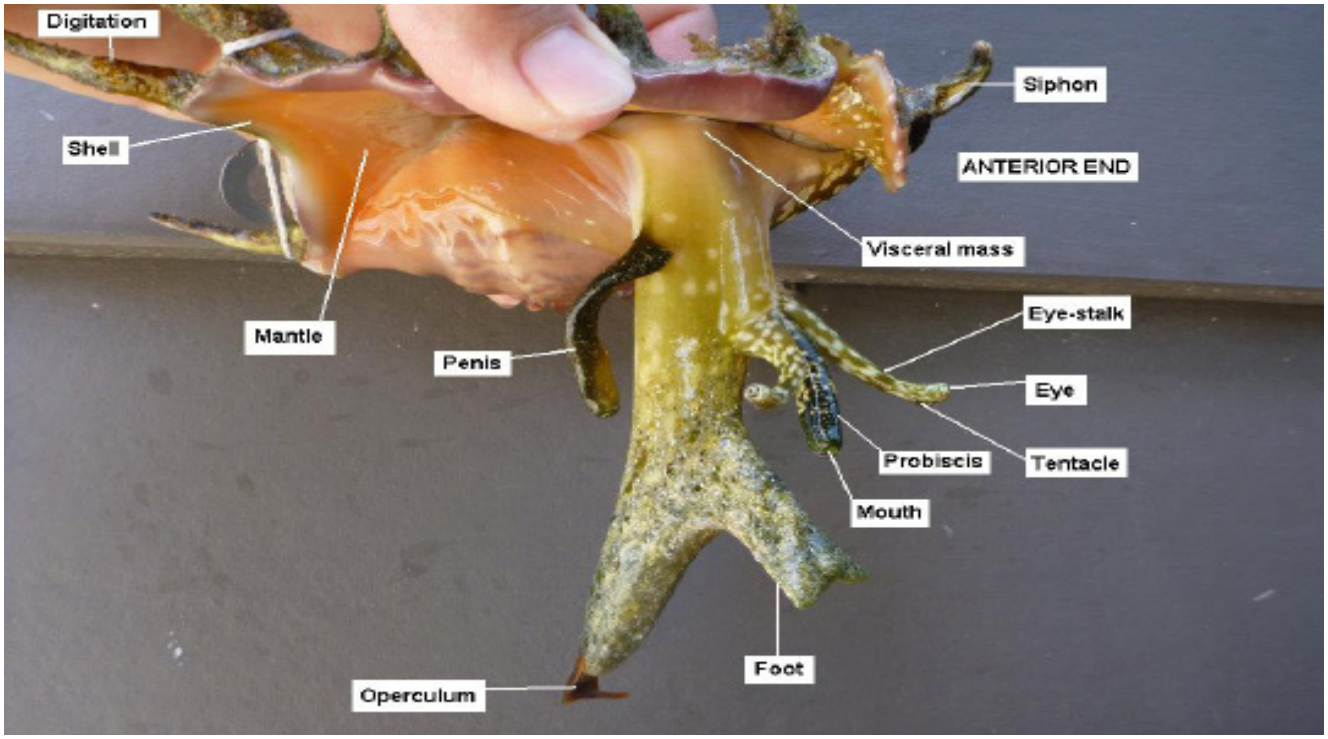
Gastropods are a voluminous group of mollusks. This group includes conch, murex, tritons, limpets, nudibranchs, land snails and more! Even though they are known for having a singular shell, this group also includes a series of non-shelled bodies such as slugs and nudibranchs (more below). Regardless, all gastropods have the same physical design.

There are three major parts of a gastropod: the head, the foot, and the visceral mass (stomach). In fact, gastropoda translates from Greek as stomach (gastro) foot (poda). The head contains the sense organs and the brain. The sense organs typically include eyes at the tip of two long tentacles that visually and physically “feels” the immediate space. These tentacles can move around to see around the animal and can retract to protect the eyes from any danger. Some land and marine gastropods have two sets of tentacles; one long set for its eyes, and the second shorter set to smell/sense the surrounding area.

The visceral mass is where the internal organs are located – digesting food, etc. The foot helps push forward, either by rippling or swimming. The foot can also be used to anchor to the ground to prevent predators from flipping the shell upside down and eating the gastropod. Additionally, they have an operculum –a tough plate that closes the opening of

the shell, which acts as another line of defense.
Here is an anatomical drawing of a land snail:





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Conch's are among the better-known families within Gastropoda. The Queen Conch is a herbivorous conch is a large sea snail that lives within a iconic pink pearly shell that has a pointy top and a fluted lip. These mollusks can be found in the Caribbean, Bahamas, and the Florida keys. This family also includes the Giant Horse Conch, which happens to be carnivorous and can grow up to two feet in size and lives off the coast of Florida.

The Muricidae family includes the famous Murex mollusk. The mollusk shell is popular for its numerous spikes as a form of protection from predators. The spikes are sharp and force distance from the main cavity. Found in rocky shallow waters around the world, this predator will use a long proboscis to drill a hole into smaller bivalves and eat the mollusk inside. Murex also have a significant place in human



One Gastropoda family has mythological ties! This family is also known as Tritons and is comprised of some of the largest living gastropods in the world. The name Triton refers to the broad lip and column like fold that gives the shell a prominent flared opening. Some of these shells have been used as trumpets, and according to Roman legend, Triton (the son of Neptune – god of the Sea caused tremendous waves in the ocean by blowing a trumpet shell. Members of this family, such as the Distorsio clathrata can be found in areas worldwide including the mid-Atlantic waters. These large mollusks range from 4-20 inches long. Because of their sheer size, they also have a large carnivorous appetite. Giant Tritons are known to eat large portions of coral with their radula and sea stars. Below you see a Triton consuming a star fish and to the right is the operculum keeping the mollusk inside and secure.



There is another kind of marine gastropods named limpets. They do not have a spiral shell, but a triangular cone shell that perfectly covers their soft bodies. They live on rocky shores of the ocean of Western Europe. Because they do not have a curved shell to retreat into, they have a particularly strong foot that can suction cup to the surface of the rock to make it very hard for predators (crabs, star fish, birds, etc) to grasp and turn over. The shell also gives them a low profile protecting them from strong waves and currents, and during the low tide they can seal against the wet rock to keep them from drying out.

They use their foot to ripple across rocks as they are herbivores and eat algae using their radula. A fun fact - they always return to the same spot every night to rest!



There are also gastropods without shells, such as slugs and nudibranchs. Nudibranchs translates as “naked gills” and are a class made up of soft body sea slugs. With 3,000 known species, they are found in shallow and deep waters of the ocean where they usually eat algae, anemones, corals, and smaller nudibranchs. These carnivores vary in size from as large as foot long to as flat as .25 in (6 mm). They use their super sensitive tentacles to find their food, and actually get their bright vibrant colors from the food they eat. They retain any chemical defenses from prey and incorporate it into their tissue to make themselves inedible. Furthermore, they assume the colors of their prey to act as camouflage. This is important as they use their foot to ripple amongst rocks and coral. Crazy fact – some of the algae that nudibranchs eat can be stored in their outer tissues to continue photosynthesis and provide additional energy to the mollusk.





After learning about those water-faring gastropods, what about the land snails who are also classified as Gastropoda? These creatures evolved over different periods of times from their marine relatives to live on land, swamps, and fresh water habitats, such as lakes and rivers. Because of their varied habitats, land snails are actually divided into two major groups – those with gills and those with lungs. The biggest challenge these land snails face is evaporation. They evolved with a thicker mantle tissue inside the shell that has a hole to allow air in and out with a muscle that acts as a duct to prevent evaporation. Land snails also produce incredible mucus that helps prevent evaporation by keeping a layer of water around its skin. This mucus can also dry on a surface holding the snail into place. Ever notice that snails and slugs are found in the moist areas of gardens and after a heavy rain? That's because they are attracted to that water to stay hydrated. A very significant function of mucus is for digestion. Strands of mucus start at the mouth and push food through the digestive organs through the anus to be excreted. Like their marine relatives, land snails range in diet from herbivores to carnivores (eating smaller snails). Slugs are the terrestrial version of nudibranchs, but do not display the same amazing bright colors.



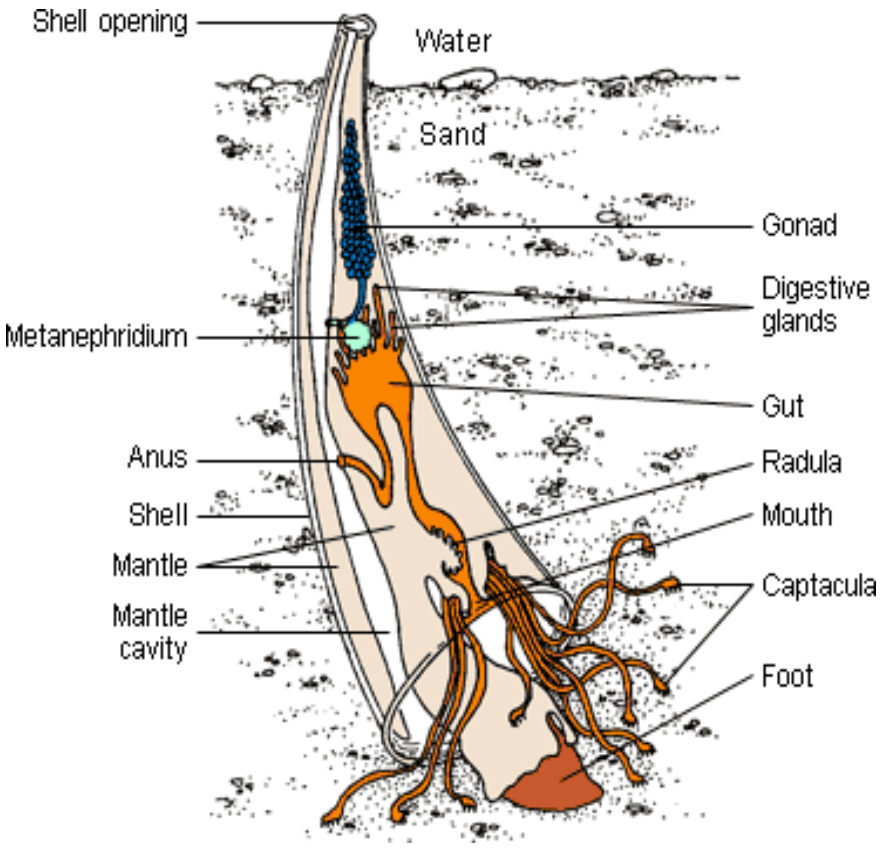
TUSKS (SCAPHOPODA)

Translated from Greek for Boat (scaph) and foot (poda), Tusks shells are long, tubular, and curved like an elephant tusk living in deep waters (around 13,000 feet). These shells can range from as small as 1 inch to about 6 inches long – though some fossil records show foot-long Tusks. Inside, the mollusk's mantle wraps around its visceral mass. Because they have adapted to not need gills, the mantle absorbs oxygen from the water so it breathes through its shell!

The shell is open on both ends to letting water in and out through the two sides of the shell (to carry out waste). What is different about this mollusk is that they usually bury their wider side into the sand – so their heads point downwards into the sand and the narrow side is at the top letting in water down towards the mouth.

They do move through the sand by anchoring their foot ahead of them and pulling themselves forward. While they do that, their small arms known as captacula will grab food. These mollusks are carnivorous, eating zooplankton and young bivalves that are buried in the sand.





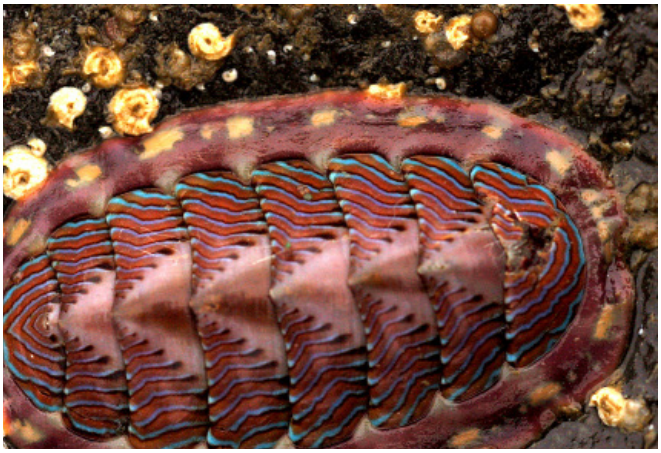
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CHITONS (POLYPLACOPHORA)

With eight overlapping shell plates, Chitons rightly earned their Greek name as it translates as Poly (many) plac (plate/surface) and poda (foot). Their plates protect the mollusk from above while allowing for flexibility since they crawl over rocks, sea floor, and even other mollusks. Chitons scrape algae, bacteria, and small animals such as sponges, with their sharp radula. They tend to graze slowly and are most active during twilight hours.

We know of 800 species of Chitons, with the largest growing up to a foot long. While the majority is found in the shallow water around rocks, some can be found as deep at 5,000 feet. As you see below on the right, some Chitons have spikes emerging from the underside of their shell to offer further protection from predators.

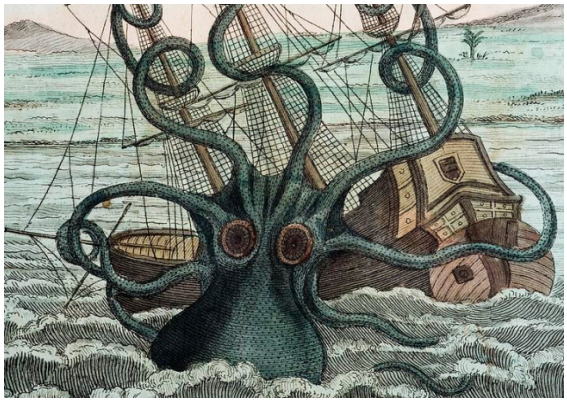




CEPHALOPOD (CEPHALOPODA)

The name translates from Greek as ceph (head) and poda (foot) because their tentacles are attached directly to the head. These head-foot creatures don't much resemble their gastropod, tusk, or chiton cousins. So how are they mollusks? The answer is in their body – they are invertebrates, have a mantle, and the body is separated into three parts: head, visceral mass, and foot.

Cephalopds are best known for having tentacles and big eyes. This group includes octopus, squid and cuttlefish (in the sub group Coleoidea) and nautilus (in the sub group Nautiloid). Giant squid, and large octopus have been known predators in the ocean, infamous in folklore. None seems better known than the legendary Kraken. The Kraken (rendered on the left) was rumored to be over a mile long and could destroy a ship mid-sail in the ocean, eating and killing all sailors aboard. While this monster has its roots in Norse mythology, similar sea monsters are found in other mythologies and mentioned in popular stories such as Moby Dick.



Cephalopods are a very old group of mollusks, with a direct ancestor Ammonite being present as early as the Devonian period (419 million years ago), and fossils with cephalopod characteristics being found in the Cambrian period (500-530 mya). As such, cephalopods today have impressive adaptations such as camouflage, camera sharp eyesight, and are intelligent enough to learn behavior of prey and their own predators. The invertebrate physicality allows them to shrink to tiny sizes for protection or expand wide with suction cup arms to fight and hunt with speed and finesse. Furthermore, they are famous for their quick swimming speeds. Due to their longevity as a class, they have left behind numerous fossils that scientists can study and learn about extinction events and evolutionary patterns (see more below).

Octopuses are distinct within the cephalopods class because of its eight arms

(octo = eight) and bulbous head. Octopuses have incredible eyesight, close in composition to vertebrates, with iris, pupil, lens and cornea. The octopus pupil is shaped like a horizontal rectangle, or card slot. As one of the most intelligent invertebrates, octopus can learn behavior of others such as opening a jar of crustaceans (check out the YouTube videos!)

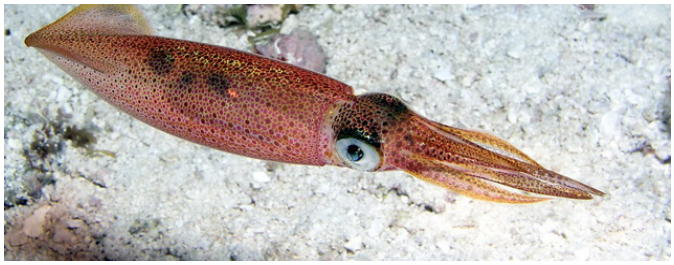
The eight arms have suckers, cirri (a tassel like appendage) and sometimes hooks. These arms enable octopus to be very adept to hunting. They can shove their flexible long arms into coral holes to find small fish and crustaceans to eat. They will use suckers and cirri to hold onto their prey. If they catch a larger fish, they will use their arms to quickly pull in the prey and bite it to release venom that stuns and subdues its meal. However, if the octopus being hunted by a shark or large fish, it has options to defend itself. First, it can release black ink that is visually distracting but also numbs the predator's sense of smell – helping the octopus escape faster. Furthermore, it can lose an arm to get away and then regrow it later.

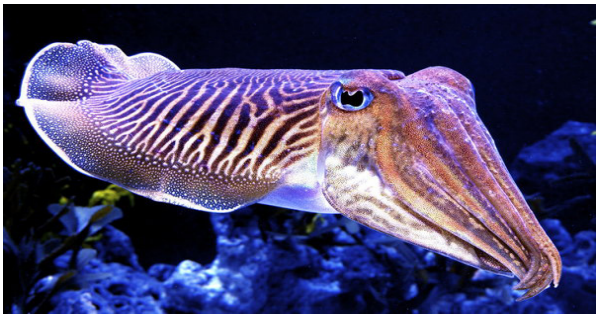




They do not have an internal or external shell, but have an amazing to change their skin color. This is made possible by chromatophores, small pigment filled bags (see photo below) that expand and contract, both found in their skin. Octopuses use these elements to rapidly change color based on mood, mating, and camouflage for protection and hunting. For example, octopus will turn pale if scared or red if angry. The largest octopus is the North Pacific Giant Octopus that can grow 9-16 feet long and weigh up to 110 pounds.

Like octopus, squid have eight arms, but also two tentacles. Their arms also have suckers and cirri, but their tentacles are long, retractable, and have a flat wide tip covered in suckers, called a club. They hunt while they swim using the club on their tentacles to grab their prey and pull it in using the tentacles and arms. Then it smacks the prey against its beak (mouth) and either kills, breaks, or stuns it enough to eat using its radula. Living out in the ocean sea, squid are popular food for whales. Squid's eyes are also quite large for their body size. The giant squid, which can be up to 32 feet long have eyes about 1 foot in diameter. Their eyes are also well equipped with an round pupil, iris, and lens. They do not have corneas.





The internal shell is located in the head, giving squid that dagger like shape. The fins on either side of its tail (the long pointy side, not the mouth with the arms) help with swimming and changing direction. Their fast speed is due to the strength at which they shoot water out of their siphon. These cephalopods are extremely fast, but only swim backwards. Like octopus, squid use chromatophores to change color. Squid that live in "schools" or packs, will often use their skin color to communicate with each other. They also use it as camouflage from predators. Akin to other cephalopods, squids do use ink to evade predators but theirs is a blue-black color.

Cuttlefish are almost like small squid because they share so many characteristics. They range from a few inches to 20 inches long. They have an internal shell, fins on the side of their tail that help them swim, two tentacles and eight arms. Similarly, cuttlefish use their tentacles to capture their prey, usually crabs and other smaller mollusks. To help them, cuttlefish use venom that will stun and paralyze the meal. Their eyes also have iris, pupil, and lens. However, what makes them different from squid is that their pupils are w-shaped, they are not very fast swimmers, and have a wider flatter body shape. Additionally, they tend to live near the ocean floor rather than out in the open sea.

Finally, nautiluses are cephalopods, but have some distinct differences from its other class members. Primarily, nautilus has an outer shell. Their shell has chambers inside of it, contributing to its buoyancy. The largest chamber at the opening of the shell is where the physical mollusk lives. Young nautilus start with 4 chambers and some of the oldest nautilus have been found with up to 30 chambers. The nautilus will add water to the chambers to give it weight so it can sink lower, or release gas into the chambers to help it float higher.

The nautilus also has rudimentary eyesight with very tiny round pupils, and no lens. During the day it will sink lower to the floor to evade predators such as octopus, and at night float up to coral reefs to eat.

Nautiluses do also have a beak they stun prey with, but the tentacles they use to pull in the prey only have ridges and no suckers or cirra. What also separates them from other cephalopods is that they are not limited to 10 arm/tentacles – they have around 90 tentacles. Using these tentacles, nautilus will eat dead animals and feed on live crabs, shrimp and other small fish.





BI-VALVES (BIVALVIA)

With around 500 species of living in freshwater and 15,000 in the ocean, bivalves are a very important class of mollusk. Bivalves are best known for being a source of food, as this class includes clams, scallops, mussels, oysters, etc.

Bivalves differ from the above mollusks because they have not one, but two shells. Like other gastropods, the mantle grows outward to create the shells. This allows the shell to grow larger as the mollusk ages. The two shells are hinged at one point (usually at the narrow side) with an adductor muscle. This muscle allows the shells to open wide and close very tightly. This adductor muscle is strong enough to provide protection from larger predators.

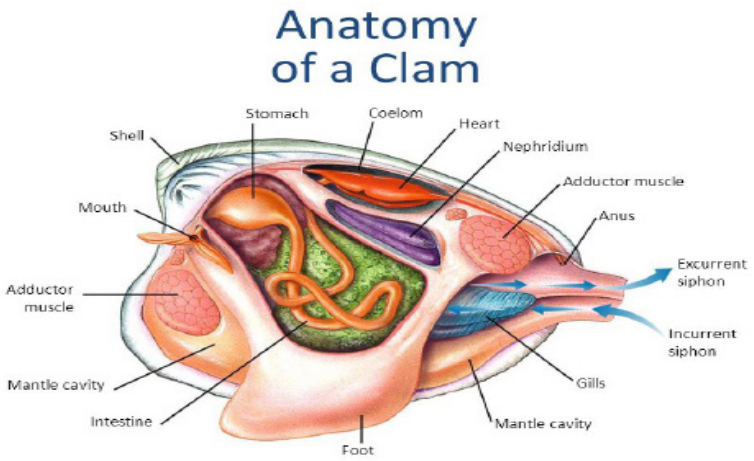
Bivalves are also famous for creating pearls. How does this happen? Because bivalves have their shells open to filter water for food and to breath, and they are usually located on or near the seafloor, sand grains do tend to get into their shells. Mantles are very soft and smooth, and sand is very gritty and irritating to the organs inside. Therefore, the mantle will grow layers on top of that sand grit to protect itself from the abrasive sand. Growing layer after layer on top of the sand particle eventually creates a rounded circular shape that is a pearl!



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Similar to the gastropoda class, these mollusks have a foot and visceral mass, however lack a head and radula. Instead of eyes reaching at the end of a tentacle, some bivalves will have small rudimentary eyes on the edge of their mantle. They do have tentacles, but these are quite small and float to sense the surrounding environment rather than act as hunting tools with the cephalopod class. Bivalves also have two siphons – one inhalant, one exhalant. They filter watert hrough their digestive track to filter out food particles – making them very important to their habitats for cleaning the water. The siphon also brings in water for the gills to breathe.

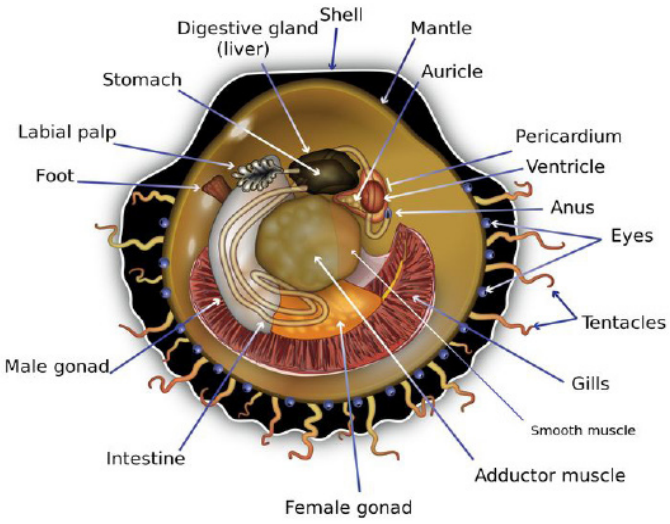
The visceral mass is connected to the retractable foot, as the foot wraps around the front of the mass inside of the two shells. The foot is a very powerful appendage for the bivalves, as it functions as both an anchor and locomotive. For some clams, the foot kicks the seafloor to help move the mollusk. For oysters, the foot helps anchor them in place (and they don't move their whole lives!) Mussels will use byssal threads to glue themselves to rocks so they do not move.

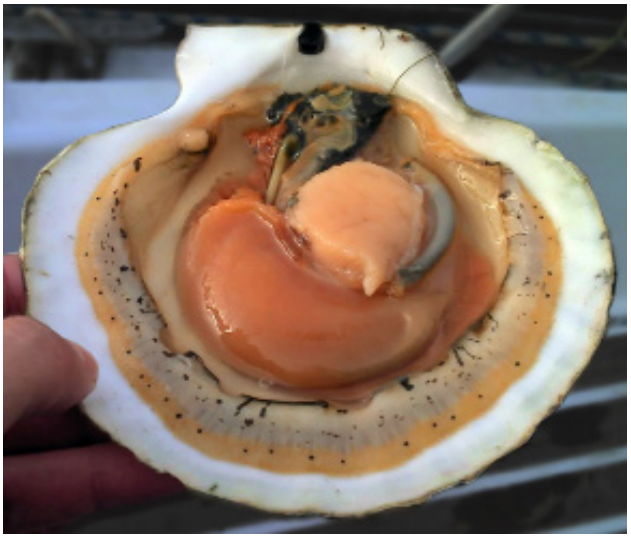


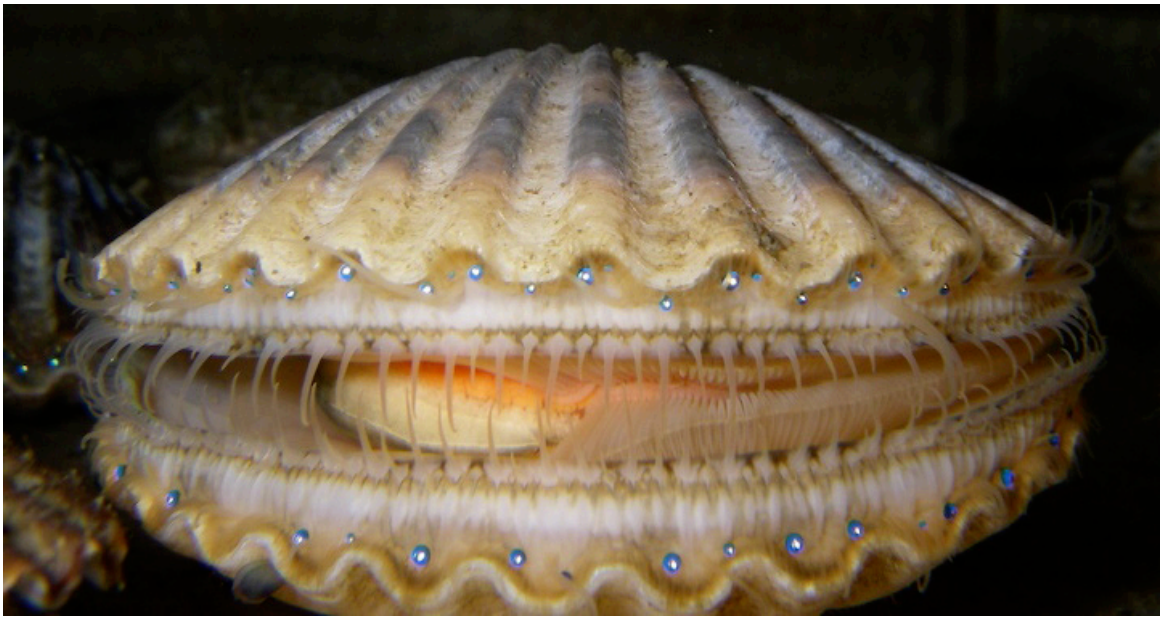
Above we see the anatomy of clams. While all clams are built the same, they do range in size and location. They also use their foot to burrow into the seafloor. Giant clams (bottom right) burrow into the seafloor and stay in the same spot their whole lives. Found in the Pacific and Indian oceans, these clams can grow up to weight 500 pounds. These clams are filter feeders, too, but will also have algae like protozoans that live on them, which helps give extra sugar through photosynthesis – helping them to be so big.



Scallops are shaped akin to a fan, usually with ridges or ruffles on the outer sides of the shell. Scallops are free-floating bivalves – slamming their shells shut to eject water and propel themselves around the seafloor. Here we see what a freshly opened scallop shell looks like with an intact mollusk compared to what a scallop looks like in the ocean. Scallops have about 100 eyes on the outside of their mantle to help them detect changes in light and basic movements. This helps them know when to shut their shells in order to defend themselves from predators.







2

Evolution of Mollusks

WHAT CAN WE LEARN FROM FOSSILS?

What is a fossil? A fossil is the remains or impression of a prehistoric organism preserved in petrified form or as a mold or cast in rock. Fossils help prove the existence of life prior to our written record. Due to mass extinctions, global climate change, and other phenomena, thousands of species that once roamed this planet no longer exist. We study those species by the fossils that their physical body left behind.

Fossils may occur because the remains of plants and animals are covered rapidly by sediment, such as layers of mud, silt, or sand. Fossils are found most commonly in areas where swamps, lakes, seas and oceans occurred– in other words, in places where water was present. In these areas, plant and animal remains are more likely to be buried in a layer of sediment. These anaerobic (without oxygen) environments allow the organic material to become preserved. The layers eventually get so heavy that the mix of pressure and heat radiating from the earths core compresses the figure into the rock. Sedimentary rock is the only rock type with fossils. Metamorphic and igneous rocks heat to such an extremely high temperature that the fossils would melt with the rock.

For millions of years, mollusks have lived on Earth. We have found fossil evidence of mollusks living since the Precambrian period (540 million years ago). Early examples show that the mantle had not hardened into a shell – but rather was just a protective layer (albeit soft).

The cephalopod family has their roots with the ammonite, an organism that is squid like and lived in a coiled nautilus-like shell. Cephalopod fossils can be dated back to the Cambrian period (490 mya), whereas Ammonites (pre-historic nautilus) are found between the start of the Devonian period (416 mya) and end of the Cretaceous period (145 mya). They had beaks and tentacles and grew as large as three feet across. Like modern nautilus, they lived in the first chamber, floated and jetted around shallow seas. Many fossils of ammonites are found from the time of the Western Interior Seaway. The WIS existed from the Gulf of Mexico to north of Canada, laying over the Midwest states, bisecting the continental US into two parts.



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Over time with plate tectonics the seabed rose higher, elevating, what is now, the Mid-West states. Additionally, because the Earth was in a period of global cooling, many animals and fish died. However, a small percentage of ammonite species were able to descend to lower depths. These ammonites evolved over time to handle cooler temps and consume plankton and smaller debris to survive. Those species are related to the nautilus we know today.

During that same time we see other species of cephalopods such as orthoconic (straight shells), and planispiral (shells coiled in a single plain instead of in an circle). Overall, there are about 800 species of cephalopods living today compared to the17,000 species that existed before the Cretaceous-Tertiary extinction (a mass extinction that happened around 66 mya and is responsible for the loss of 75% of organisms).

Here is an artistic rendering of the Cambrian period from the Smithsonian Institute:



Gastropods and bivalves also have fossils dating to the Early Cambrian period (541-485 mya). However, mollusk diversity dramatically increased in the Ordovician period (485-443 mya). Gastropods likely evolved to have their single shell wrap around the soft body of the mollusk, rather than

having a singular top shell protecting itself (akin to a limpet).

One group of bivalves that became extinct during the CT extinction was rudists. They were very large and dominated reefs during the cretaceous period, found across tropical waters. One valve would stay attached to the rock or sea floor while the other valve would be free to float open. However, the top valve had teeth to essentially close the bivalve since the two valves were not symmetrical.

The Chesapectin Jeffersonius is a part of the bivalve family pectinidae, which have been present on earth since the Middle Triassic period (240 mya). In 1687, chesapecten became the first fossil from North America to be illustrated in a scientific publication. The chesapecten lineage of scallops flourished in VA and elsewhere from the Miocene epoch into the Pliocene epoch, from 8 to 3 million years ago. These scallops and other shelled mollusks were periodically deposited when high temperatures melted the polar ice caps and caused the Atlantic Ocean to surge inland. Named for Thomas Jefferson in honor of his interest in natural history, these fossils were designated the state fossil of VA in 1993. Today, the fossils of this extinct mollusk are often found along VA James River between Richmond and Williamsburg.

Tusk fossils can be found in rock as early as the Devonian period (416-358 mya). Tusk fossils tend to lack the curvature that we see in present day examples.





Chitons also range from the Devonian period, it is hypothesized that chitons evolved from a singular shelled mollusk that may have had a mutation to grow overlapping plates – and in doing so,

3

Habitats + Coral

HABITATS

Habitats are defined as "the natural home or environment of an animal, plant, or other organism." This definition includes woodlands, forests, grasslands, bogs, wetlands, etc. For this box, the most applicable habitats would be freshwater habitats (lakes and ponds, marshes, swamps, etc) and marine habitats (deep ocean, rock pools, coral reefs, shallow seas, and seabeds).

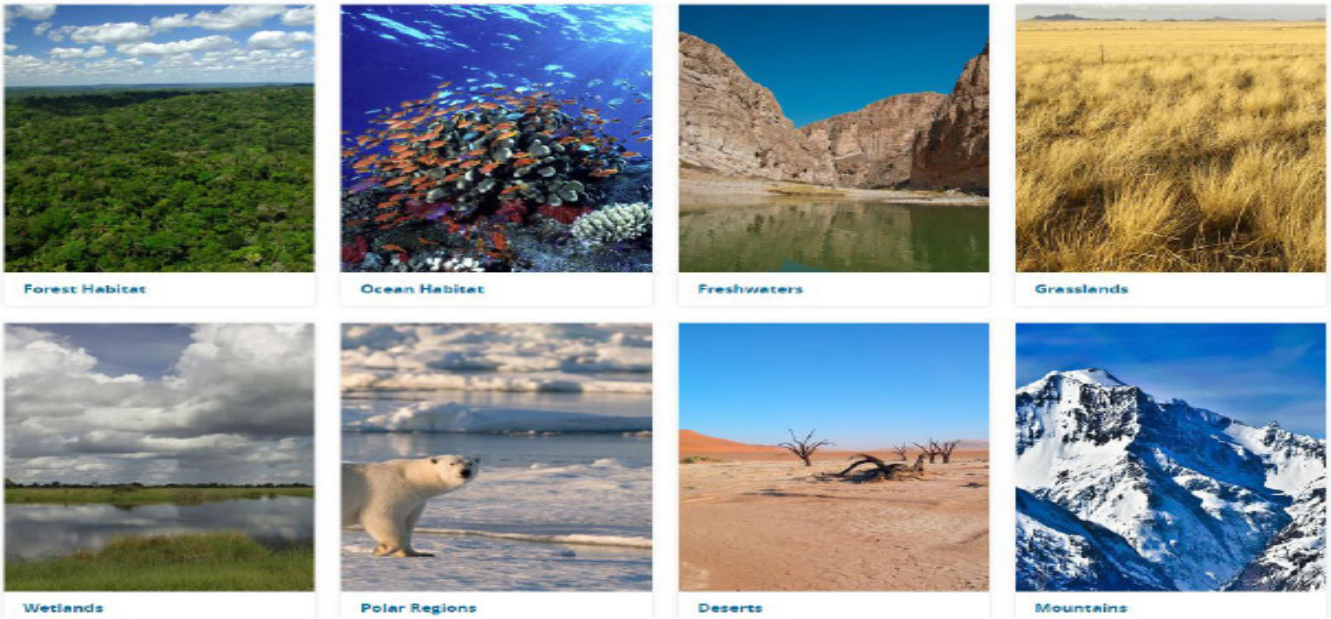
Mollusks play important roles in marine and freshwater ecosystems acting as filters, food, and decomposers.

Bivalves can be found from shallow to very deep water, both fresh and marine. There have also been bivalves found in mud, sand, and rocky watery areas. They are very important for multiple reasons. First, they act as food for larger mollusks and other predators such as starfish. Second, they also are filters – pulling water through their system to gather food. The water they return has been, essentially, cleansed.

Gastropods are found in terrestrial and marine, temperate, tropical, or marsh-like habitats. They live in swamps, thermal vents in sea floor, rocky shores, rivers, lakes and on land. They offer multiple values to their habitats. Their most significant role in these environments are acting as decomposers. This means they feed on dead plant matter or dead animals for food. Second, marine gastropods leave behind their shells (after being eaten or dying) and hermit crabs scoop them up. Hermit crabs do not grow their own shells and as such depend on gastropod shells to grow larger (they will swap out smaller shells for larger ones).

Nautilus are also decomposers. They will use their hundred arms/tentacles to pull the organic material to their mouths. All cephalopods are found in marine environments

Mollusks of all kinds are food for larger predators. Squid and octopus are consumed by such as sharks and whales. Triton gastropods can be eaten by octopus, and smaller mollusks such as scallops and can be eaten by larger gastropods and cephalopods. Birds and other larger marine creatures eat limpets, chitons, and terrestrial gastropods.



CORAL REEFS

Sedimentary rocks can often tells us a lot about the fauna and flora, i.e. plants and animals of the remote past in the area where they were found. Metamorphic and igneous rocks heat to such an extremely high temperature that the fossils would melt with the rock. A fossil is naturally preserved remains or traces of a once living organism from the remote past (generally one that lived prior to the last glacial period 10,000 years ago)

Coral Reefs are hotbeds of marine life with many organisms from the food chain living among one another, using symbiotic relationships exist. Mollusks and cephalopods are very much an important part of coral reef habitats, using reefs to live and hunt. Coral reefs support around 25% of marine life.

First and foremost, coral are living animals. Found in both Deep Ocean as well as shallow tropical waters, coral are colonial organisms with hundreds of to thousands of polyps. At the base is their hard protective limestone skeleton and once that skeleton has attached itself to a reef, sea floor, or rocks, polyps begin to grow by dividing, growing, or cloning itself. These polyps are soft-bodied organisms related to jellyfish.

As they expand, the reef takes one of three types of structures:



Fringing – most common, which project seaward from the shore creating a border along the shoreline;

Barrier – also surround shorelines but at a greater distance and are separated by the land by a deep open water; and

Polyps are actually clear and get their vibrant colors from zooxanthellae (zoo – zan - the - lee), algae that grows on the coral. Stressed coral will push off the zooxanthellae and cause phenomena called "coral bleaching" which can kill an entire coral colony. Additionally, when coral is broken off and removed from the ocean, the animal ceases to live and what is left is the hard skeleton. Human factors such as global warming, pollution, boat anchors, land soil erosion, overfishing (nets and boxes break and scratch coral), and oil drilling could stress coral reefs to the point of potentially losing 30% of all reefs in the next few decades. Unfortunately, coral grows very slowly, about 2 cm a year. Therefore it is important to preserve reefs and coral as much as possible, because without reefs the marine ecosystem would be compromised.

Coral exist through symbiotic relationships with fish and internal algae (the algae produces an organic material of which 90% is used by the coral for growth and energy), keeping them safe and healthy. The coral that hunt us their tentacles, which have stinging cells called "nematocysts" that help them capture small organisms. Coral eats by waving tentacles out of the polyp's mouth – at which point the fish or plankton are brought into the mouth, digested, and expelled back out the same hole. These polyps also clean up much of the debris, which is another reason that coral is absolutely important to preserve for the ocean's health. This is just one way human impact has affected the ocean and its inhabitants. Below are some other elements of human impact with mollusks.





4

Human Use and Impact

HOW DO HUMANS USE/IMPACT MOLLUSK POPULATIONS

Humans have depended on mollusks since the primitive man for various reasons including nourishment, currency, the arts, and potential health benefits.

Primitive men would eat mollusks for nourishment and nutrition. They would then use the leftover shells as utensils and tools. While we don't use shells for tools anymore, we certainly have mollusks of all kinds as part of our general diet. Scallops, clams, mussels can all be found in soups, rice dishes, pastas, and more. Escargot is a famous French appetizer (land snails cooked in garlic butter). Oysters are very popular to be consumed raw and straight from the shell. Fried octopus, squid salads, and conch are also found on many seafood restaurant menus.

Gastronomically, the adductor muscle of the giant clam is considered a delicacy. Furthermore, their shells have been a most popular collectors item, and they are oftentimes pulled out of the ocean to be purchased for large aquariums. However, due to over fishing, these clams are now endangered.

A major concern, though, is the risk of population decline due to over-fishing. As noted above, there are also habitat concerns as reefs are damaged from overfishing. By over-fishing, mollusks are not as capable to filter the water, which affects the overall ecology for other species.

Cuttlefish have a similar use with their ink. Their ink has a brown color, which is known as sepia. Instead of being used for clothing, this brown color was used for painting. Today it is used in cosmetics. Squid ink, being black in color, is used in foods such as spaghetti nero (mixed with the dough to glean the dark color).

Pictured below: Escargot (land snails served with butter and herbs) and Squid ink pasta





Shells have also been used by many cultures for currency. Native Americans used tusk shells as money, and it is said that 25 tusk shells could buy a canoe. Western African cultures used cowrie shells as currency. Both these groups would also be seen using these shells as jewelry and in clothing or as a hair accessory – this just shows to everyone how rich they were! Cowries were first used as a form of currency around 1200 bce in China. In fact, Chinese rulers in 1000 bce decided to model their new bronze and copper currency after the cowrie's shape.



Some shamans in the past (and the tradition continues today) would also use shells to scry (to predict the future). During the middle ages, the scallop shell became associated with St. James in Europe. Today, shells such as the great spotted cowrie are used as decorations, talismans, and charms.

Murex brandaris release a yellow fluid that turns to a deep purple when exposed to sunlight. The dye was used to transform linens to a vibrant purple, known as Tyrian purple, after the Phoenician city of Tyre, which perfected its manufacture. This color was also known as royal purple because it was very costly and laborious to produce (approximately 12,000 murex were needed to produce enough dye to make one roman toga). Therefore it was very expensive to produce, and as such was prized by the Roman elite who used the cloth in ceremonies.



Helmet shells are best recognized as the shells that are used for making cameos. These shells can be found in arm waters all over the world, from North America to Africa and East Asia. Since the Roman Empire, people have used these shells to make jewelry and musical instruments. Abalones are also used in jewelry for their mother-of-pearl mantle. We also see this shell-lining used in beads, buttons, and inlays in furniture. Japan also highly prizes this mollusk in their cuisine. Due to overharvesting, abalones have become quite scarce.



One mollusk that is actually dangerous to handle is the gastropod known as Cones. There are around 500-600 species of cones – some of which produce venom powerful enough to be lethal to humans. The venom is under testing to be used for medicinal purposes to help treat strokes and heart disease issues. Another cone that is considerably safer is the Glory of the Sea cone. This was probably the most famous shell among private collectors due to its initial scarcity. First described in 1777 it was the most valuable and coveted shell in the world for more than two centuries. Because of its immense rarity, the British naturalist and collector Hugh Cuming who had collected thousands of shells, was said "to faint with delight" when he serendipitously uncovered two juvenile specimens on Bohol in the Philippines. During the twentieth century, the




Activities

1

FILTER FEEDER

This activity will demonstrate how some mollusks, such as bivlaves, filter their food. Activity created by Douglas Island Pink and Chum, Inc.

What you will need for this activity

- Sand
- Water
- Tray or tub
- Coffee filter

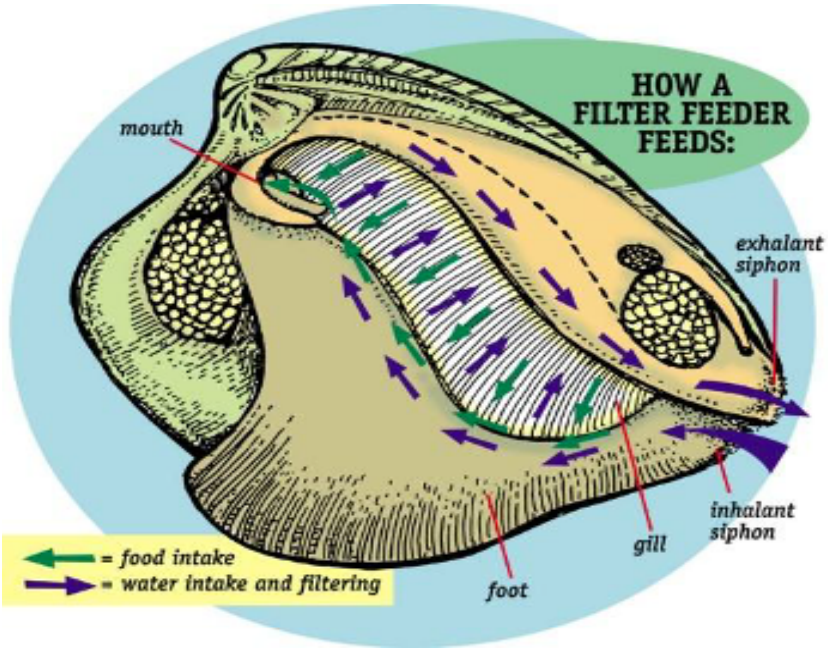
Instructions

1. Show the anatomy illustration of a bivalve and explain: These animals, mainly clams, depend on sucking in large amounts of seawater and filtering out the organisms or debris material for their food. Clams use their tube-like siphon to suck in water which is filtered by hair-like cilia. Collected food is passed into the stomach and seawater or waste is expelled back out the siphon. Let's see how it's done...

2. Mix some sand with water (sand represents food bits).

3. Hold the coffee filter over the tray or tub.

4. Pour the sand water through the filter to demonstrate the clam's feeding process.



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2

MOLLUSK AND MATH

This activity is meant to get students thinking about the mathematical principals of shells.

What you will need for this activity:

- Measuring Tape
- Collection of shells in various sizes and shapes
- Pencils and paper
- Compasses (optional)

Instructions:

1. Distribute shells of different sizes and shapes to groups of students
2. Have students measure the dimensions of the shells reinforcing fractions as measurements
3. Ask the students to make notes of the measurements and then align the shells in ascending or descending order.

Add-On:

Depending on the level of your students, you could have them:

- predict the ages between smaller and larger shells with a standard growth of 1/8 in per year.
- Measure one bi-valve shell, and then mathematically deduce the circumference of the full bivalve (both shells together).
- Estimate the differing sizes of space within the gastropod shell using the Fibonacci sequence, beginning by measuring the opening of the shell. To cultivate this exercise using art, the students can recreate the coil of the inner shell using glue, pipe cleaners, and paper.
- Weigh the difference between the marine mollusk shell and a terrestrial mollusk shell, and deduce the difference in volume of the shell.

Any other ideas? Feel free to include your own activity (be sure to put your name and school!) in this manual.

3

IDENTIFICATION OF MOLLUSKS

This activity allows you to learn how to classify mollusk shells based on appearances.

What you will need for this activity

- 4 bags of shells (five shells in each bag) - or will need to provide a mixed collection of shells
- Anatomical drawings of Mollusks (see next page)

Instructions:

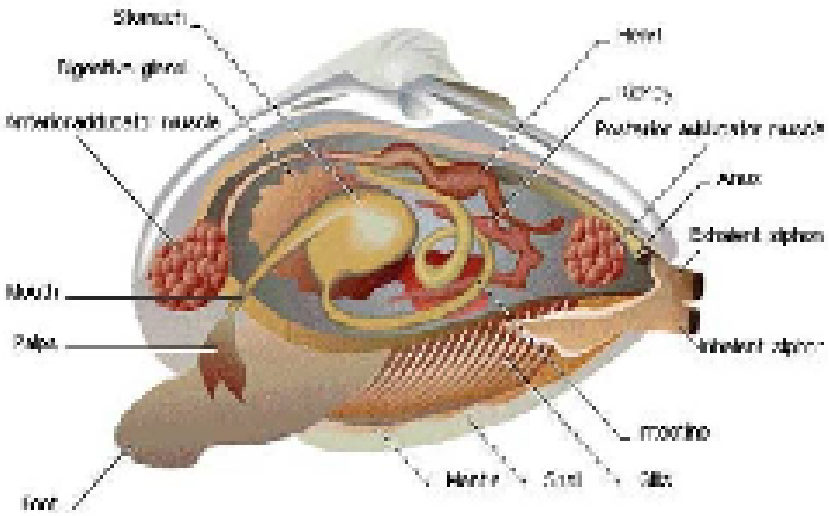
1. Choose one shell from the bag, working with only one shell at a time.
2. Write down 3-5 descriptors about the shell on a sheet of paper
3. Using those descriptors, refer to the anatomical drawings from the bag and discuss what possible type of mollusk lived within the shell.
4. Write down your guess (the mollusk type) on the sheet of paper
5. Trace or draw the shell next to the name of the mollusk, and the descriptions

Add-on:

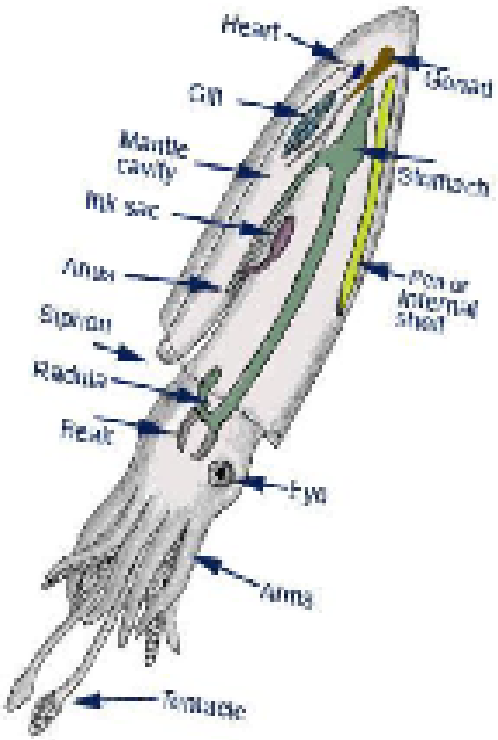
Ask your students to compare and contrast two sets of shells. What makes them similar, and what makes them different? What about the insides versus the outsides? Do you think the animal was predator or prey? Etc.

At the end, groups can turn in their drawings. A fun idea would be to have each group present one or two shells to the class with explanations on how they arrived to their decision as to what kind of mollusk shell they have.

Left: Anatomy of a bivalve

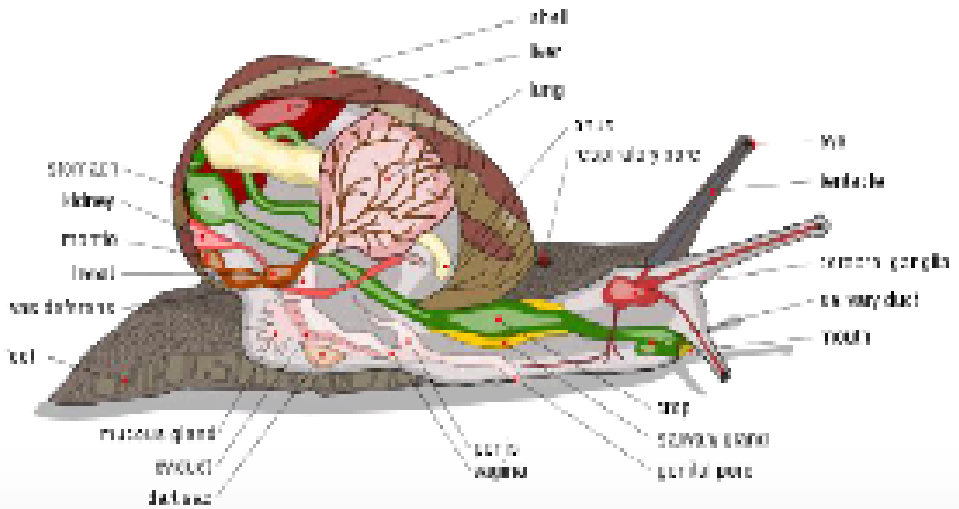


Right: Anatomy of a cephalopod



Below: Anatomy of a Gastropod (aka univalve)

Note: gastropods contain eyes & tentacles which are not present in the anatomy of a bivalve.



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4

STUFFED SHELLS

This activity will familiarize students with the variety of bivalves through art. Activity created by Douglas Island Pink and Chum, Inc.

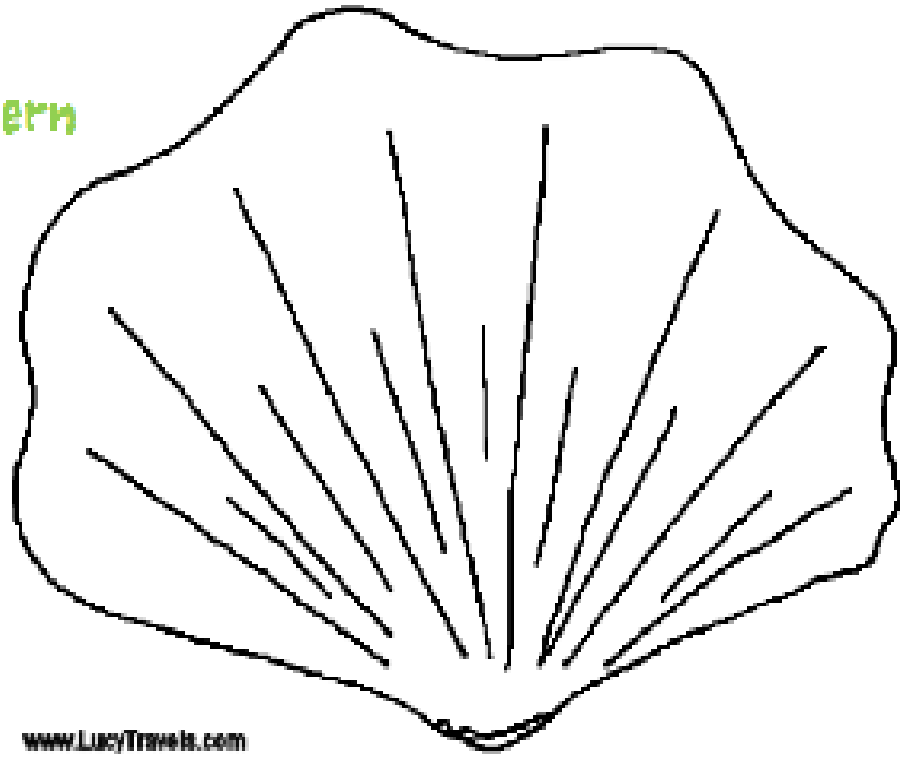
What you will need for this activity:

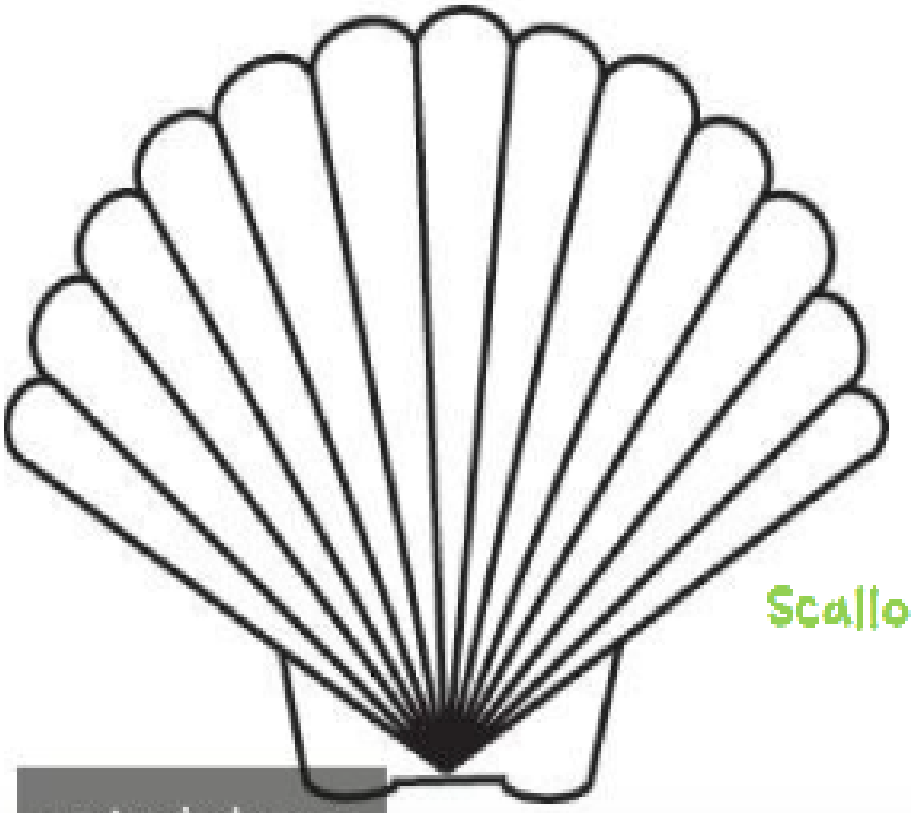
- Newspaper or recycle paper
- Staples
- Scissors
- Cardboard
- Popsicle sticks
- String
- Coloring supplies (markers, crayons, paint, etc)
- Bivalve Patterns, included in the next pages

Instructions:

1. Make cardboard patterns for the different bivalves, such as scallops, clams, cockles, & mussels.
2. Have students trace two copies of one pattern of their choice.
3. Once the pattern is cut out, staple the pattern around the outside or punch holes around the outside and lace the halves together. Leave an open space so you can fill the pattern with stuffing.
4. Paint, color or design outside of the shells.
5. Crumple newspaper or paper scraps to stuff inside the shells. Once stuffed, staple shut the opening.
6. Label the shells by name. You can hang them around class OR gather several together and create a mobile.

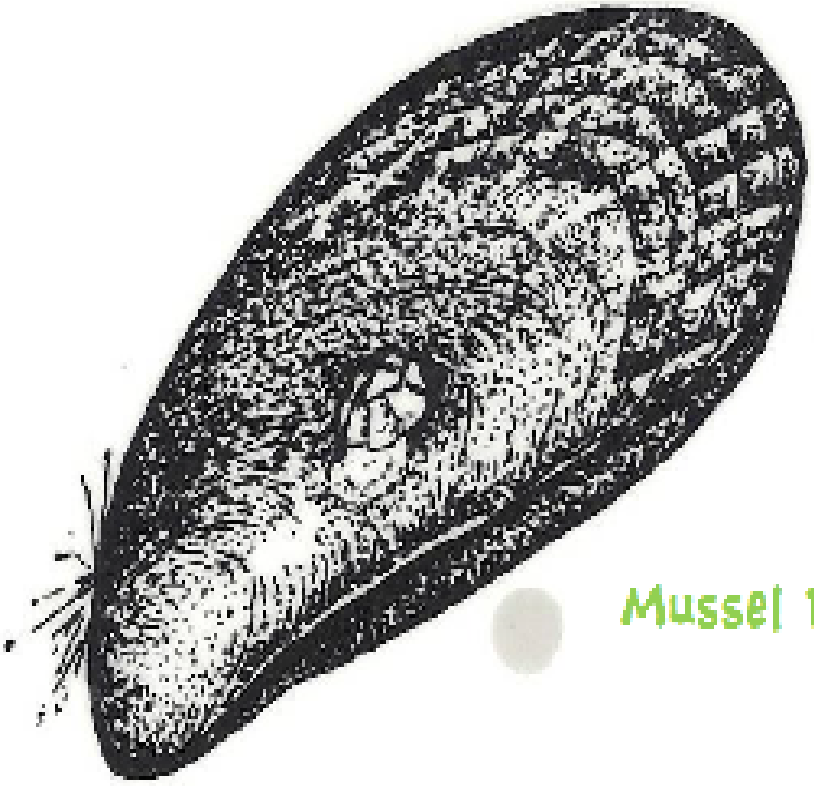
Cockle Pattern





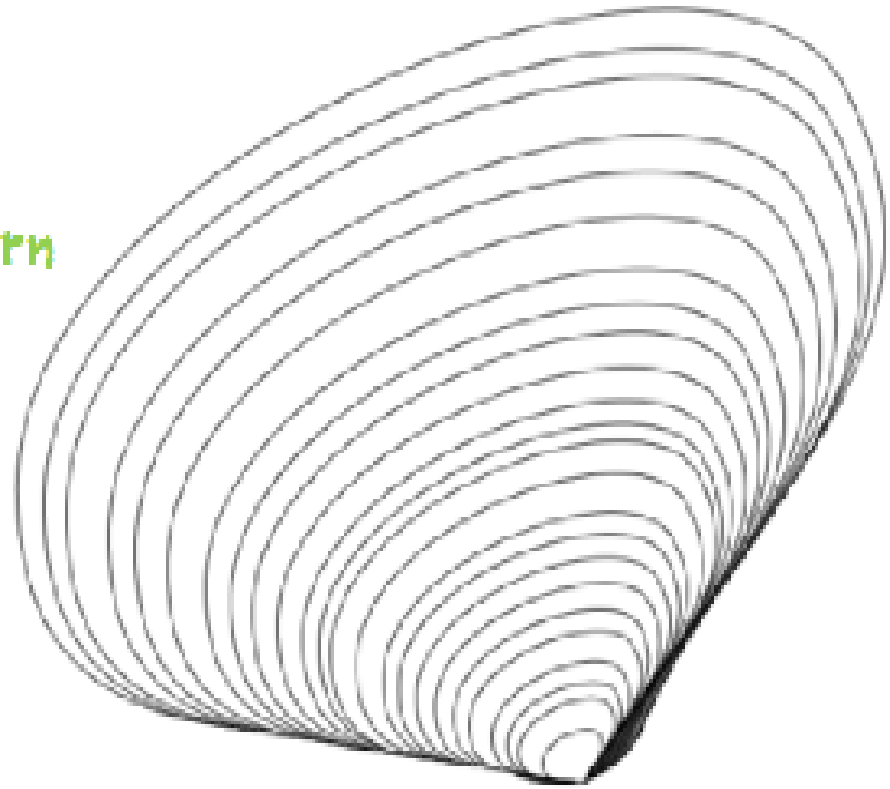
Scallop Pattern

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Mussel Pattern

Clam Pattern



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5

CLASSROOM CORAL REEF

This activity reinforces how coral connect to one another to create a reef.

What you will need for this activity:

- Old Egg Cartons
- Scissors
- Strips of extra string, cloth material, and/or paper
- Crayons, color pencils or markers
- Tape

Instructions:

1- Cut the bottom part of the egg carton off and separate each cubby piercing the top with an X mark

2- Hand out 1-4 cubbies per student giving them access to the strips (you can limit the amount of strips if you prefer).

3- Let students use materials to color and decorate the paper strips and the cubbies however they like – perhaps draw circles around the cubbies, lines on the paper, or color in full...

4- Then take those strips and pull them through the X mark with the cubby being inverted (standing like a mountain, not like a crater). Use tape the secure strips in place.

5- Here is where the fun begins! Have a student, one at a time, put their "corals" on a main ta-ble. As each student joins, there will be a visual example how reefs are created. To make this more dynamic, use bowls or crates to give some variety of height and depth to the "reef".

Specimens included in the box





WHELKS





TOP SHELLS

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CONCHS

HELMETS/BONNETS



TUSKS



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CORAL

MUREX





CHESAPECTIN

CONES





CERITHS

TURBANS



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COWRIES





CHITON

NAUTILUS FOSSILS



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TERRESTRIAL





LIMPETS

OLIVES



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MOONS



OYSTER



SCALLOPS



CLAMS

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