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The Crusty Fossils

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Stop! Look! Listen! These three basic commands can be associated with any adventure that a person wishes to undertake. As this unit is being presented those three little words will play a significant role.

The changes which occur on this earth are so gradual that we don't notice them immediately. However, if we were to ignore our surroundings for a few days or weeks, we would be able to recognize a difference of some kind almost instantly. When we finally notice the changes we are quick to say, "It happened overnight!"

Scientists are constantly recording the changes which are occurring on this earth. For centuries man has theorized why, when, where, who, what, and how something is done. Ever so often new evidence is presented and he is forced to change his explanations when results contradict his previous understanding.

This unit deals with the results of a chain of events which is believed to have started 4-1/2 billion years ago. We are going to take a look at a species of animals which is found in the Arthropoda Kingdom—"The Crab". You will find that these little creatures are quite fascinating in their developmental and behavior patterns.

After studying this unit the students will be able to:

1. identify the Phylum Arthropoda.
2. discuss the Class Crustacea.
3. discuss the evolution of the crabs.
4. discuss the stages of development of crabs.
5. Identify some of the different species of crabs and tell how they adapt themselves to their environment.
6. distinguish the male and female of some species of crabs.

This unit is designed to be used in a science class of grades 5-8. The activities provided should enable you to correlate the information with other subject areas, especially mathematics and reading. This unit can be completed in 2-3 weeks.

Origin of Arthropods

All animals that inhabit the earth are classified as vertebrates or invertebrates. Vertebrates are animals with a row of bones along the middle of their back as well as some appendicular bones. Invertebrates are animals without a backbone.

The arthropoda are considered the most advanced of invertebrates. There is evidence that the arthropods began their development during the pre-Cambrian period which is the first era defined in the geological time. By the Cambrian period, which began about 600 million years ago, arthropods were well established and had found their place on earth.

The most abundant fossils of the Cambrian period are those of the trilobites. These animals are the ancestors of modern day crabs. It is believed that one of the reasons trilobites are so plentiful is that they frequently molted and discarded exoskeletons in large numbers. These exoskeletons are mineralized tissues which contain large amounts of calcium carbonate (CaCO3) which enhanced their capacity to remain unaffected over this vast time interval. The name trilobite means “three-lobed” and makes reference to the fact that the dorsal surface of the body is divided into three lobes. This dorsal surface is the part of the body we normally see on today’s crabs. The three body segments can be identified as: 1) a head; 2) the thorax, which is the middle flexible portion; and 3) the abdomen, the posterior region which consists of a number of fused segments. In some trilobites, this fused segment extends into a spine. On the head there is a pair of similar jointed, two-branched appendages. These projections were modified and may have enabled the arthropods to hold their food. Similarities can be seen on the horseshoe crabs of today. The function of these appendages vary according to the habitat of each species. The protruding legs of some trilobites show segments as well. The outer branches of legs are flat with a row of bristles along the back edge. These flat branches are believed to have been used for respiration and swimming. It is also believed that the inner branches were probably used for walking. At the base of each appendage there are inward projections which probably also aided the arthropod’s movement.

The habits of trilobites can only be inferred. However, it is believed that they lived in the sea because their remains are always found with corals, crinoids, brachiopods, and other exclusively marine animals. [1] Most trilobites probably frequented the shallow waters and crawled on the bottom of the floor of the sea. It is believed that they fed on various seaweeds, sponges, brachiopods, and mollusks which are known to inhabit the same places. They probably scavenged organic matter by plowing through the mud. The analogy of the modern crabs makes these projections seem plausible.

The trilobites were the dominant invertebrates during the Cambrian period. They continued to flourish during the Ordovician period but then began to decline. The last of the trilobites died out in the Permian period which was about 275 million years ago. The trilobites did not directly give rise to any other group of arthropods, however, their morphology and habitat seem to be closely related to the animals which are found in the crustacean class of arthropods of today. (See Diagram Below)

Arthropods—Past and Present

(figure available in print form)

Today's Arthropoda Kingdom

One of the very large phylum in the invertebrate animal kingdom is called the arthropoda. The animals found in this phylum are called arthropods. Arthropods of today have very close evolutionary links to the annelids or worms which is a group of segmented animals. If we take a close look at the diagram of the first arthropods, we can definitely see this relationship. We could turn an annelid into an arthropod with only a few basic structural changes. Arthropods are animals with six or more jointed legs. There is no other group of animals that includes so many different kinds of animals as the arthropods. There are over 800,000 species in the phylum arthropoda. Insects crustaceans, and spiders are all members of the arthropoda kingdom. All have a jointed, chitinous procuticle, serving both as a protective armor and an exoskeleton. [2] The animals in this group range in size from very tiny mites to the giant crabs, which may be about eleven and a half feet from leg tip to leg tip. Arthropods can be found almost everywhere—in the sea, in fresh water, in the ocean and on land. Many arthropods can fly such as the dragon fly and the grasshopper. The arthropods are referred to as armored animals. This means that they have an external covering which provides both protection and support. This protective covering, called the exoskeleton, is discussed later on in this unit.

General Characteristics

Arthropods with a rigid exoskeleton and jointed limbs have internal muscles arranged as flexors and extensors of each joint. The arthropods can propel themselves through the environment, whatever the medium, by interaction of a systems of levers which are its jointed appendages. [3]

On the basis of the mechanical functions and of inferred phylogeny from the characteristic features, arthropods can be divided into two distinct lines. The first group are the animals with characteristics closely similar to those of the phylum annelid showing parallel aspects of development and metamerism. The second group are those that possess an exoskeleton composed of chitin and an epicuticle. By examining these invertebrates more closely you will find that the cuticle forms a series of heavy, skeletal plates or rings (exoskeleton), connected by a thin flexible membrane (cuticle) which permits the animal to move freely.

Growth of the Arthropods: Molting

The growth of animals usually means a gradual increase in size, accompanied by a gradual change in shape, if necessary, until the form of the fully grown adult is reached. This process is difficult in the arthropods because of their exoskeleton. Once an arthropod's exoskeleton has hardened which is caused by sclerotization and calcification, growth in arthropods must proceed through a series of molts. The arthropods have a natural source of calcium (Ca) which is quite useful during this phase of development. The molting process involves the secretion of a new cuticle and shedding of the old exoskeleton. Actually the new carapace or shell is made inside and before the old one is discarded. During this short period, the arthropod shows a rapid increase in bulk, which usually involves the intake of water or air into internal spaces. The arthropod must now grow new tissues to fill the new armor.

During the molting cycle, the behavior of all arthropods change. Once the old shell has been shed the arthropod is vulnerable to attack by predators. Most of them go into hiding when they are unprotected by their usual exoskeleton. Due to the fact that the reproduction has a cycle similar to the molting cycle, the population growth of these animals is affected during the molting process.

The Molting Cycle of Crabs

(figure available in print form)

Physiology of Arthropods

The circulatory system of arthropods is very simple. Although the animal has a heart it functions somewhat differently from those found in humans. The heart is a muscle but in the form of a pulsating tube which lies in a dorsal pericardial sinus. The blood circulates and fills cavities which are found throughout the body. Within these cavities, the blood bathes the various organs. The blood is not necessarily confined within blood vessels at all times creating an open circulatory system.

Most terrestrial arthropods have a system of branching air tubes which make up the respiratory system. These air tubes are formed through in-growths of the surface ectoderm. The ectoderm which contain specialized cells secretes an inner lining of cuticle which strengthens the walls of the delicate tubes and prevents them from collapsing. Openings on the sides of the body permits air to enter and leave the tubes. The air is piped directly from tubes to the tissues almost completely replacing the respiratory function of the circulatory system as we know it from higher animals. [4] Most aquatic arthropods breathe by means of gills which are thin walled extensions of the body wall. These gills allow the gases, carbon dioxide and oxygen, to pass readily.

The nervous system of the arthropods consists of a brain which is connected to the nerve cord by a ring of nervous tissue which circles the digestive tract.

The cuticle of the arthropods also forms an important part of the digestive system. During growth and development, the ectoderm turns in at the mouth and anus and lines the anterior and posterior areas of the digestive tube with the cuticle it secretes. In the anterior region the cuticle may produce hard teeth for grinding up the food. In many of the arthropods the anus serves as a means of expelling nitrogenous wastes since the excretory organs are directly connected to the digestive tube.

Like most invertebrates, arthropods lay large numbers of small size eggs. The eggs are richly supplied with yolk, and few show traces of spiral cleavage or mesoderm stem cell. The body typically forms from a primitive streak that serves as the growth center of the embryo. [5] The young hatch from the egg in an immature state and must be able to move to obtain the necessary materials for further growth.

Exoskeleton

The typical arthropod’s body is a series of segments that have movement through the action of muscles. Each segment is provided with a pair of jointed legs. This body structure allows the arthropods segments and jointed legs to perform many varied functions and no doubt this characteristic has contributed to their evolutionary divergence into various environments.

One of the most unique features of arthropods is their exoskeleton. This rigid structure has been the concern of scientists for extensive investigation. Due to the fact that the skeleton occupies the outside of the body and is heavy and bulky, this has limited the size of arthropods.

Arthropods often display a range of color patterns typifying the different groups. This is especially true of insects and crustaceans.

The true pigments and structural colors are represented: The brilliant yellow, orange, and red colors found among these animals are due to a variety of nitrogen-free, lipochrome pigments found in the tissues, while

shades of blue, green, and some other colors are the results of the effects of light interference on the original chromatic materials. [6] Combinations of two kinds of color might produce many shades resulting from the interaction of both coloring agencies. This color interaction, a characteristics of arthropods, gives them an opportunity for camouflage thus creating a protective environment.

Crustacea

Crustaceans include the lobsters, crabs, shrimps, and sea dwellers which are well known as food for humans. Although they are quite familiar to us, there are other varieties that are unknown to most persons. Many crustaceans are land animals such as the millipedes, centipedes, spiders, and most adult insects. However, most crustaceans have remained marine animals. Their habits and shapes make it easy for them to adapt to the waters.

The major characteristics of the crustacea are:

1. They live predominantly in water and use gills for respiration.
2. They have five pairs of appendages.
3. The body is divided into segments but usually has a recognizable head, thorax, and abdomen region.
4. The posterior region contains an anus but has no appendages.
5. The circulatory system is that typical of the arthropod, an open circulatory system.
6. The excretory system contains either antennal or maxillary glands or both.
7. There is a median eye and usually a pair of lateral eyes.
8. The sexes are usually separable, with indirect development and larva stages.

Crustacea does not contain many species. About 26,000 are known, however, those that exist are abundant and many of them are relatively large. These animals are just as prevalent in the water as they are on land. Let us take a look at one of the crustaceans which we can readily find along the Atlantic coast and, even closer to home, along the coast of Connecticut and other New England states.

The Crab

The crab is an animal which belongs to the phylum arthropoda because it has an exoskeleton and jointed legs. It belongs to the class crustacea because its body is segmented. Due to the fact that it has ten legs it belongs to the group called the decapods.

The crab is a curious creature. Man has become interested in them because of the large variety and also

because they are edible. Anyone who has visited the seashore has seen crabs. They live all over the world from the tropics to the arctic. They make their homes on land, in trees, in shallow water and the deep waters of the ocean. Some crabs live in burrows and even inside other sea animals. These strange creatures have different manners in which they move around from place to place. These maneuvers are characteristic of their environment, shape, and appendages. They can move fast or slow, walk, run, and swim depending on their traits, physiology, environment, and habits.

The largest of this class of animals is the imaginary crab which is found in the sky. This crab is the constellation and the astrological sign, Cancer, which is made up of eight stars. It is so named, the crab, because it appears to move backwards and forward equally as well. This imaginary crab can be seen by studying the stars toward the south on spring nights.

Crabs use many methods of protecting themselves from their enemies. One of the best ways is through camouflage. There is a wide variety of colors and textures of the crab and this enable them to naturally blend in well with the environment in which they live. Some are able to make disguises out of the material around them. If this fascinating creature is unable to hide or disguise himself to avoid a predator, he uses his claws or pinchers as a weapon to ward off his enemy. Some of the crabs that live in the ocean may even use sea anemones for protection. Although sea anemones have a stinging poison in their tentacles, they are not harmful to the crab because of their hard protective shell. However, predators usually keep their distances because of their innate avoidance of this poisonous animal.

Although crabs use all means to protect themselves sometimes they are not fortunate to escape unharmed, especially during the molting cycle. They may lose one of their appendages, however, the crab has the ability to regenerate a lost limb. This biological process is not available to vertebrate orders. If the claw or leg is injured, the crab can make it drop off in a definite place which is called a breaking plane. After molting the crab has a new, usable leg, but much smaller. It takes two or more molting cycles to form a leg or a claw of normal size. Once a crab is old, it can no longer molt and therefore does not regenerate a lost limb. (See Diagram Below)*

(figure available in print form)

All animals must reproduce in order not to become extinct. The sex cells of male and female must unite in order for new life to begin. Believe it or not many shore crabs go through special courtship ceremonies to start the process. The males will begin by waving their claws to attract females of their species. Some males will use their claws to tap on rocks which produce a drumming sound to attract the females. Once a male finds a willing female, the two will mate. Shortly after mating, most female shore crabs are ready to lay their eggs. Depending on the species, a female crab may carry her eggs around in the abdomen for as short as two weeks to as long as several months. The individual eggs are smaller than the period at the end of this sentence. While the eggs are being carried by the female, she stays near the water because the eggs must be kept moist during their development. The female ghost crab has a problem during this period because she lives on the dry beaches. After she has deposited her eggs in her abdomen, she constantly runs into the water to wet them. When the time comes for the thousands of eggs to hatch, the female enters the shallow water near the shore. The eggs leave the female’s body through an opening which is found near the end of the thorax and are covered with a transparent jelly-like substance. After the female has entered the water she moves her abdomen rapidly from side to side. This movement causes the eggs to break open and the little creatures or larvae lmerge. This is the first stage of development of a crab and they do not resemble adult crabs at all. The crab larva must go through a series of changes before it becomes an adult. (See Diagram on the following page)*

Stages of Development

(figure available in print form)

The crab larva has two main stages of development, the zoea and the megalops. In the first part of the stage the crab looks like a shrimp and is called a zoea. [7] This small animal feeds mainly on the larvae of other sea animals such as oysters and starfish and will molt about four to fives times. Each time it molts, more appendages are added to its body. The second stage of the larva crab is known as the megalops which means "large eyes". [8] It is during this stage that the animal acquires the claws and other appendages of an adult crab. After the larvae have reached the megalops stage they molt one more time. All ocean dwelling crabs complete this stage on the ocean floor. The land and shore crabs usually come out of the water at the beginning or at the end of this stage. This is very important to them because it is at this time that they adapt themselves to their environment. [9] When the megalops molt all the basic parts of an adult crab are obvious. Although the larvae development is complete, the new little crab will continue to molt through its life.

Some Shapes of Crab*

(figure available in print form)

The respiratory system of the crab is similar to that of the fish. Crabs breathe by means of gills. The number of gills found on crabs vary with the species. For instance, the blue crabs have eight gills on each side of their bodies while the small pea crabs have only three. Oxygen which is essential to the living crab is extracted from the water as it passes over the myriads of blood vessels in the crab's gills. A current of water is produced by small paddles called gill bailers. Within the gills there are brushes or hair-like appendages, which are used to remove dirt from the gills. (See Diagram)*

Respiratory System

(figure available in print form)

The gills of the terrestrial crabs are smaller than those of the marine crabs, however, the blood vessels are larger to maximize the absorption of oxygen. The crabs that move back and forth from water to land fill their gill chambers with water. While they are on land, a current of air set up by the gill bailers adds oxygen to the water that is being carried in their gills.

The circulatory system of the crab is relatively simple. As the blood flows through the gills, oxygen is taken out and carbon dioxide is released. Crabs have blue blood which is caused by a copper chemical that carries the oxygen. As the blood moves from the gills it enters the heart, goes around the body and back to the gills. This process takes about 40 to 60 seconds in a large crab.

Circulatory system*

(figure available in print form)

The digestive system of the crab appears complex, but it is very simple. They use their pinchers or claws to catch their food. The pinchers pass the food to the mouth which has three pairs of hard jaws. The first pair of jaws helps to hold the food while the other pairs cut and tear it into smaller pieces. The food then passes into a double stomach where 1) a grinding action takes place and 2) digestive juices aid in breaking down food so that it can be digested. All food that is not digested passes through the intestine and out through the anus.

*Digestive System

(figure available in print form)

Crabs have a small, limited brain. It is connected to the nerves that go to sense organs and to all parts of the body of the crab. The eyes are important to the crab. They are usually found on stalks and can make a complete revolution of 360 degrees. They can also be pulled down into eye sockets. These eyestalks also make messenger chemicals which, when combined with the nerve cells, signal changes in the color of the crab's shell. This color change helps the crab to blend better into his environment. The red and yellow colors seem to be more controlled by the messenger chemical while the black and white colors are under the control of the nerves. (See Diagram Below) Scientists are mystified by these color adaptive mechanism as well as the daily activities of the crab. They suspect that these changes are due to a biological change but it is still being studied.

*Nervous System

(figure available in print form)

Hormones produced by the crab are responsible for its size, growth, as well as color change. These hormones also control the amount of salt and water that is found within the body of crabs. If a crab changes from salt water to fresh water too rapidly, it will die. The crabs that move back and forth from salt water to fresh water and vice versa depend on their gills to make the adjustment. The gills respond to hormone signal to let in more or less salt water. An adjustment period of several hours to several days is needed for crabs that move to and from the salt water. (See Diagram Below)*

Color Influenced by Hormones from Eye Stalks

(figure available in print form)

Species of Crabs

Plants and animals are divided into groups within each phylum. The species name follows immediately after the name of the genus or category of that plant or animal. There are about 4,500 different kinds of crabs found all over the world. Many of these species are valued to man because they are used for food. Below you will find the names and habits of some common crabs.

Spider Crab (Libinia emarginata)

Another name for the spider crab is the sea spider. This is a large species and the shell of this animal measures about 2 to 3 inches. Its shell is rough and has a dark olive brown grayish brown color. This crab has a slow sluggish movement and makes its home in harbors, bays, sounds, and on muddy or rocky bottoms. The great sea spider which is found from Massachusetts to Texas has a shell which measures about 5 inches long. The largest of this species is the giant spider crab which lives in the deep waters from the coast of Japan to Alaska. It measures about 10 to 12 feet from leg tip to leg tip. Tie body itself can measure about 12 by 18 inches across.

Green Crab (Carcinides marnas)

The green crab is one of the most common crabs found on the North Atlantic coast. Its shell is greenish in color with yellow spots and is about 1 to 2 inches long. It makes its home under stones and large shells, in wet sand and mud, and in rocky tidal pools. They even hide in crevices and holes along the shore. These little creatures are very active and energetic and can move very rapidly when disturbed.

Rock Crab (Pachygrapsus)

The rock crab is light brown with darker shades of brown spots. The shell is about 2 to 3 inches long and about 3 to 4 inches broad. They make their homes on sandy, rocky shores and in tidal pools where they bury themselves leaving only the eyes and antennae exposed. They are extremely common along the New England coast. The jonah crab or northern crab is a similar species and is excellent for food.

Lady Crab (Ovalipes ocellatus)

The lady crab is one of the most beautiful species found. Its shell is white or pale yellow and covered with spotted rings of violet, purple, and red. It is about 2 inches long and makes its home in the sand in shallow waters. It likes to bury itself up to its eyes. The lady crab, also known as the sand crab or speckled crab, is an expert swimmer.

Ghost Crab (Ocypoda albicans)

The ghost crab gets its name because of its white or light gray coloring. The ghost crab moves sideways and stops and starts so quickly that an observer has difficulty seeing the movements. This quick action makes the observer think that the crab has just disappeared. This animal almost always come out only at night. It makes its home in holes near or well above the high-tide line.

Pea Crab (Pinnixia)

The pea crab is a small round little fellow. He measures only about 1/4 inch in diameter. It is brown or yellowish in color. These little creatures make their homes within the tube of various worms. Some live in the burrows of the mud shrimp, gill baskets of sea squirts, and the cavity of bivalves. Each species of pea crabs prefers its host as a home. Not only are homes provided for the pea crab but also safety, food, and oxygen. Although they live on other animals, they are not considered parasites.

Fiddler Crab (Uca)

The fiddler crab gets its name because of the size of the claws on the male. One of its claws is much larger than the other. When he waves them through the air it appears as if he is holding a bow and playing the fiddle. The mud fiddler is black or deep olive. The red jointed fiddler is brown or dark gray with red patches at the joints of the large claw. These two types of crabs usually make their homes in mudbanks. The sand fiddler is violet gray or olive. Its claws are lighter in color. It loves a sandier environment as his home.

Blue Crab (Callinected sapidus)

The blue crab is the most edible crab. The shell is about 5 to 6 inches broad. The upper side of the blue crab is dark green while the underside is white. Its feet are blue. The tips of the spine is reddish or orange in color. The blue crab makes its home in the mouths of estuaries and small tidal creeks, small bays, and shallow muddy shores. This species is plentiful along the New England coast.

Horseshoe Crab (Limulus Polyphemus)

Another name for the horseshoe crab is the horsefish. This particular animal is more related to the spider and therefore is not considered a true crab. If you were to walk along the beaches from Main to Mexico you are likely to find shells belonging to this species. The young horseshoe is usually light yellow or natural in color. As it gets older its color changes to olive, brown, or almost black. The female horseshoe crawls along the sandy beaches between May and July to deposit her eggs. Although the meat of the horseshoe crab is tasty, it is not too inviting as a meal because of its gruesome looks.

Hermit Crab (Pagurus)

The rear parts of the hermit crab are soft and there is no hard shell to protect this region. He solves this problem by finding an empty shell of a snail and backing into it to make his home. This is how it gets its name. When the shell is too small to serve its purpose the crab simply finds a bigger shell. The hermit crab is found everywhere: on sandy and muddy bottoms, in rock pools, behind sand bars, and in shallow water. Their coloring is a yellowish brown and when the body is extended it is only about 1 inch in length. A much larger species of hermit crabs is found in the deeper water from the coast of Maine extending down to coast of Florida. Some groups of people consider this crab as a delicacy when cooked in oil.

Mole Crab (Emerita-Analoga)

The mole crab is another crab with a peculiar habit. When it’s full grown it is only about 1 inch long and looks like a tiny lobster. He keeps his legs and claws tucked securely under his body even when he is moving. What’s so strange about this crab? He does everything backwards. He swims backwards. He walks backwards. He likes to bury himself in the wet sand and he even digs his hole backwards and enters tail first. This species

can be found abundantly along most coasts.

Jonah Crab (Cancer barealis)

The jonah crab is a member of the red crab species. This species which is caught occasionally by lobstermen, is sometimes sold commercially. It is rarely seen along the shore but inhabits deepwater areas, where it construct mud burrows on the sea floor. Many of these burrows are found in the mud substrate of the Long Island Sound. Its coloring is red and it is a slow-moving animal. Reproduction occurs in early winter, and its entire life cycle is spent offshore.

Coconut Crab (Pagurus)

The coconut crab is one of the largest of the hermit crabs. It has dispensed its mollusk shell, having succeeded in rehardening its own skin, and taken to land. This species is an interesting creature. The coconut crab, also known as the robber crab, climbs coconut palm trees and eats the nut. It has very sharp claws that are used to drill holes in the nut and eat the meat. This species is about 18 inches long and make their homes in the crevices of coral reefs or other safe places. They are found in the tropics.

Box Crab (Calappidae)

The box crab has enormous claws and he uses them to open the shells of mollusks. Once the box crab has caught the mollusk, he chips the shell until he has made a hole large enough to pull the animal out of its protective home. These large claws are also used to push sand forward to make a shelter. The box crab is also known as the bashful or shamefaced crab because when he wraps his claws around his body for protection it appears that he is hiding or being bashful. This particular species can sometimes be found in the deep waters of bays and sounds. They are plentiful along the Atlantic coast.

Male vs Female

It is very difficult to distinguish the male crab from the female crab because they look so much alike. If you were to examine them closely you will note that there is a difference in the shape of the shell, in the structure of their bodies, and in some cases the coloring. The abdomen of the female is usually larger and more oval or round shape while the male is a narrow triangular shape. This difference allows the female to protect her eggs. Among the green crabs, hermit crabs, and others, the male is larger than the female. The horseshoe crab is just the opposite wherein the female is usually larger than the male. The male blue crab has blue and white tips at the end of its claws while there are red tips found on the female. male fiddler crabs have one small and one large claw, however, both claws of the female are small. If you are ever able to watch the courting ceremonies of some crabs, you will note that the male is more aggressive than the female. (See Diagram Below)*

Male

(figure available in print form)

Female
(figure available in print form)

Life Span of Crabs

Although crabs have been around for millions of years, there is very little known about the age of crabs. However, it is believed that most crabs have a life span of about 1 to 2 years. Blue crabs are known to live for three years, mole crabs for two years, and the small pea crabs for two to three years. Dungeness crabs, caught and, sold along the Pacific coast, are reported to live for eight years. The king crab is believed to have a life span of about 10 to 14 years. [10] There is evidence that these apecies who make their homes in the deep waters of the ocean have a tendency to live longer because they are better protected from man and other predators.

Conclusion

This unit has covered only the basic information concerning the physical characteristics, biological function, environmental behavior, and habits of crabs found throughout the world. There is no doubt in my mind that hundreds of years will go by before scientists are able to solve the mysteries surrounding these animals. This is conceived by the fact that their life span is too short for man to study their traits for any length of time. Also I have concluded that those deep ocean dwellers are too remote for man to study. I also perceive that the crabs will fall into the same category as so many other animals have been placed. That is that when and if they ever become extinct or an endangered species, their fossils will reveal to man what he has always questioned. Until that time we must continue to watch these animals and do what we can to extend their lives during this period in history.

Sample Lesson

The Origin of Crabs

Objectives The students will be able to:

1. identify the characteristics of arthropods.
2. tell how the class crustacea got its name.
3. identify the period when arthropods first appeared on earth.

Vocabulary invertebrate, arthropods, trilobites, fossils, preserve, crustacean

Materials Needed Pencil, paper, geological time chart, diagram of arthropods

Procedures Introduce the terms above. Discuss the geological time zones and the pre-Cambrian period with emphasis on how long ago this era was. Point out the first arthropods were the

relatives to the lobsters, shrimps, and crabs. Use diagram 1 -Arthropods, Present and Past, to show the similarity in shape. Using the time line point out the rise of the modern day arthropods.

Questions for Discussion

1. How old is the earth?
2. What types of plant and animal live were present during the beginning of time?
3. Why do you think trilobites became extinct?

Related Activities

1. Have the students to use their reference skills to research trilobites, centipedes, and millipedes.
2. Use molding clay and/or plaster of paris to make imprints of leaves or shells to show how fossils are formed.

Field Trips

Arrange a field trip to the Peabody Museum for a talk on fossils and to learn about the ones which are abundant in the New England area. Also the students will be able to see the display of fossils they have there.

Sample Lesson

The Life Cycle of Crabs

Objectives The students will be able:

1. to discuss the reproduction of crabs.
2. to identify the stages of development of crabs.
3. to identify marine crabs and terrestrial crabs.

Vocabulary marine, terrestrial, environment, cycle, larva, molting, exoskeleton

Materials Needed Paper, pencil, crayolas or colored pencils

Procedures Introduce the vocabulary. Discuss the mating process of crabs and the early stages of development of the crab stressing the rerelationship of the molting process with growth. Point out the fact that crabs are invertebrates and they have an exoskeleton. Make sure the students understand when the terrestrial crabs leave the waters after birth to make their home on land. Discuss the systems of the crabs and compare them with the human system.

Questions for Discussion

1. How long do crabs live?
2. How much of the shell of crabs is shed at molting?
3. How often does a crab shed its shell?
4. Do crabs eat while in soft-shell condition?

Related Activities

1. Collect articles from newspaper and magazines related to crabs.
2. Using papier mache, make the various stages of the crab and write a brief description of each for display purposes.
3. Make a chart and have the students to graph the life span of crabs. They could also research to find out the oldest crab the largest crab, and where was it found.

Field Trip

Arrange for a visit to a local fish market to learn more about crabs, lobsters, and shrimps of the area.

Sample Lesson

The Species of Crabs

Objectives The students will be able to:

1. identify some of the species of crabs.
2. identify the crabs which are found in the New Haven Harbor.
3. identify the edible crabs in the area.

Vocabulary species, habitat, environment

Materials Needed Pencil, paper, outline map of the world, colored pencils

Procedures Explain the terms above. Discuss the crabs listed in the section "Species of Crabs". Have the students to chart on their outline maps where various species of crabs are found. The student can use their colored pencils to code the species.

Questions for Discussions

1. What are the most common crabs found in the New England States?
2. What are the most common crabs found in Connecticut?
3. Are all crabs edible?
4. How do marine crabs adjust to land?
5. How long can marine crabs remain on land before returning to their natural environment?

Related Activities

1. Have the students to choose one species and make up a story about his visit to another environment. Explain the problems that they would have in adapting to the new environment.
2. Have the students to categorize the species as land and water crabs.

Field Trip

Arrange a trip to The Lighthouse to observe the shells left behind by various crabs during molting. If they are lucky they may find a few specimen to take home.

Glossary

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appendage—any part joined to or diverging from the trunk such as a limb, tail, hair, etc.
calcification—conversion into chalk, or into stony or bony substance, by the deposition of lime salts.
chitin—a colorless, horny hard material that makes up most of a crab's shell and the other covering of its body.

crinoid—having to do with the class of echinoderms having jointed stems attached by stalks to the sea bottom.
cuticle—the outer layer of the skin of vertebrates.
dorsal—of or pertaining to, on, or near the back.
echinoderm—any of a phylum of marine animals usually with a spiny process, body cavities, and a well-developed digestive system.
ectoderm—the outer layer of skin of a multicellular organism; the outer germ layer of the embryo.
evolution—the slow stages of development or growth from simpler form to those which are more complex.
flextors—the muscles that operate to bend a joint.
fossil—the actual remains of plants and animals, preserved in the rocks of the earth's crust.
invertebrate—the group of animals without a backbone.
marine—having to do with the sea or matters connected with the sea.
mesoderm—the middle germ layer of the embryo, from which the muscular and vascular system are developed.
metamerism—one of the series of homologous segments that form the body of animals such as the worm.
phylogeny—the history of the evolution of a species or group.
sclerotization—the process by which organic tissues such as the skin of animals and shells of nuts become hard.
segment—one of the serial divisions of an animal; the portion of a limb between two joints.
terrestrial—living on or growing in the earth or land.

Notes

1. Hickman, Cleveland P. *Biology of the Invertebrates.* The C. V. Mosby Company. St. Louis. 1967. p. 286.
2. Russell-Hunter, W. D. *A Biology of Higher Invertebrates* . The Macmillan Company. New York. 1968. p. 8.
3. *Ibid* . p. 9.
4. *Ibid.* p. 38.
5. Buchsbaum, Ralph. *Animals Without Backbones* . University of Chicago Press. Chicago. 1948. p. 251.
6. Megalitsch, Paul. *Invertebrate Zoology* . Oxford University Press. New York. 1972. p. 451.
7. Berrill, N. J. and Michael Berrill. *The Life of Sea Islands* . McGraw-Hill Book Company. New York. 1969. p. 41.
8. *Ibid* . p. 41.
9. *Ibid* . p. 42
10. Zim, Herbert S. and Lucretia Kratz. *Crabs* . William Morrow and Company. New York. 1974.

*The diagrams in this unit are after Zim, Herbert S. and Lucretia Kratz. *Crabs* . 1974.

The Molting Cycle—pp. 18-20

Regeneration of Crab Claw—pg. 24

Stages of Development—pp. 16-17

Shapes of Crabs—pg. 44

Respiration System—pg. 33

Circulatory System—pg. 36

Digestive System—pg. 30.

Nervous System—pg. 38

Color Hormones—pg. 39

Male Female—pg. 12

Suggested Readings for Students

Adrian, Mary. *Fiddler Crab* . E. M. Hale Company. Wisconsin. 1953.

This book fives an account of the life cycle of the fiddler crab. It describes in detail, from the very beginning of this crab's birth—step by step, the changes that he encounters until he is fully grown. It also tells of his struggle to exist on earth.

Cox, Victoria. *The Knight In Crusty Armor* . Western Publishing Company, Inc. Chicago. 1574.

This is an easy reading book which gives an account of the life cycle of several crabs and what they are up against in order to survive.

Johnson, Sylvia A. *Crabs.* Lerner Publications Company. Minneapolis. 1982.

This book which won the Children's Science Book Award discusses the physical characteristics, behavior, and life cycle of crabs.

McClung, Robert M. *Horseshoe Crab* . William Morrow and Company. New York. 1967.

This book gives a detail account of the life cycle of the horseshoe crab. This book is beautifully illustrated and with detailed information.

Russell, Salveig Paulson. *The Crusty One* . Henry Z. Walch, Inc. New York. 1974.

This book surveys the class of animals called crustaceans, describing their characteristics, habits, structure, development, and importance in the food cycle.

Waters, John F. *The Crab From Yesterday* . Frederick Warne and company, Inc. New York. 1970.

This is a book which gives an account of the life of a horseshoe crab who is about to be abused because of its old age. The story ends happily in that a caring boy finds her and places her back into the environment which would prolong her life a little more.

Zim, Herbert S. and Lucretia Krantz. *Crabs* . William Morrow and Company. New York. 1974.

This book describes the characteristics of the many species of crabs and briefly discusses their commercial importance.

Teacher's Bibliography

Berrill, N. J. and Jacquelyn Berrill. *1001 Questions Answered About The Seashore* . Dodd, Mead and Company. New York. 1957.

This book is a guide to help a person to identify animals and plants of the seashore using a question and answer technique.

Buchsbaum, Ralph. *Animals Without Backbones* . The University of Chicago Press. Chicago. 1976.

This book presents the main groups of invertebrate animals, describing their basic structure and habits.

Hausman, Leon. *Seashore Life* . G. P. Putnam's Sons. New York. 1949.

This book gives an account of the sea creatures which are found as you explore the shores of America.

Hay, John and Peter Farb. *The Atlantic Shore* . Harper and Row. New York. 1966.

This book gives a description of the human and natural history which exist from Long Island to Labrador.

Hickman, Cleceland P. *Biology of Invertebrates* . The C. V. Mosby Co. Saint Louis. 1967.

This book deals with major groups of invertebrates describing their characteristics through the evolutionary development.

Kane, Henry B. *The Tale of a Pond.* Alfred A. Knopf. New York. 1960.

This book lets you see the full year's cycle in the life of a pond, from frozen weeks of winter, through the burgeoning of spring, the hot stillness of summer, and the colorful days of fall.

Meglitsch, Paul A. *Invertebrate Zoology* . Oxford University Press. New York. 1972.

This book gives a comprehensive account of some of the reasons why the form and functions of animals are so adaptive for the habitats they occupy.

Morgan, Ann Haven. *Field Book of Ponds and Streams* . G. P. Putnam's Press. New York. 1930.

This book gives an account of the range of life in ponds and streams.

Reid, George K. and George S. Fichter. *Pond Life.* Golden Press. New York. 1967.

This book describes and illustrates some of the most common of the thousands of species of plants and animals found in or near the water.

Russell-Hunter, W. D. *A Biology of Higher Invertebrates* . The MacMillan Company. London. 1969.

This book deals with biological aspects of the whole animal discussing its functional morphology, behavior, and evolution.