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Shells

Curriculum Unit 85.07.01
by Nancy Wyskiel

This unit will be used to teach sixth grade students about the phylum Mollusca. I suggest teaching this unit during the spring for approximately three weeks. The primary objective will be to concentrate on marine mollusks in the New Haven area. I will use my personal collection as a teaching aid. Through this unit I hope to spark an interest in shell collecting among my students. I will try to guide students in an organized manner on how to begin to collect and to enhance their powers of observation by identification of the many different varieties of shells that can be found in our area.

Introduction—Background

Mollusks are an important group of invertebrates in the animal kingdom. They are classified in the phylum Mollusca, and are divided into 6 classes and subdivided based on differences in anatomical features such as the foot, mouth, and breathing organs. The classes are gastropoda, pelecypoda (bivalves), amphineura (chitons), cephalopoda, scaphopoda (tusk shells), and monoplacophora. The major concentration in this unit will be on the classes gastropoda and pelecypoda because of the occurrence in the New Haven region.

To increase students' awareness of the shells and the living organisms that once inhabited them I have provided information on growth, feeding, locomotion, and reproduction. Body parts will be studied through diagrams and explanations of the physiology of these animals. To aid in this study I have included a separate glossary* for uncommon terms such as *radula,* byssus, and *carnivorous.*

*Terms underlined will be found in the glossary.

The name "mollusk" means soft body which is the reason they have a shell for protection. Most of the mollusks live in the water, this is an advantage for food gathering since most do not move easily. They have a similar anatomy and physiology to humans that is each animal has a head, heart, blood, and nervous system and as with most animals oxygen is essential for life. In mollusks *gills* are the structure that extract oxygen from the water. Four interesting areas of the mollusks' life include growth, feeding, locomotion, and reproduction.

Growth of Shell —The shape or structure of a shell is predestined by inheritance, that is, the mineralized outer structure is species specific. The *mantle* which covers the body of the mollusc with a thin sheet of tissue is the specialized part of the body which builds the shell. The *mantle* contains cells which produce an external organic matrix that is rapidly mineralized with calcium carbonate. It is the presence of calcium carbonate that

makes the shells hard. There is a variation in degree of mineralization. Daily increments of matrix with mineral are formed, the thickness and rate is controlled by a variety of physiological and environmental factors. The shells can grow and repair fairly quickly. A shell with a crack can be repaired within a few days. Shells reach their adult size within 1 to 6 years, other species grow throughout their lifetime. Each shell species continues to add shell depending on the nutrients in the environment. Some shells grow with a steady process while others grow at intervals. The end product is a unique and beautiful structure often with external patterns and different colors.

Feeding —Mollusks eat a variety of minute animals and plants. Most bivalves and chitons are *herbivorous.* All cephalopods and more than half of the gastropods are *carnivorous.*

The *gills* of bivalves are important filters in the feeding process. Small food particles stick to the mucous film that covers the gills and slowly passes to the mouth of the clam. Single shelled molluscs, gastropods for example, have teeth or *radulae* which enable the animal to rasp or grind algae from rock surfaces and digest food other than that from the sea water surrounding the animal. *Radulae* are present in all types of mollusks except in the bivalves. There can be from 20 to more than 300 rows of teeth.

Locomotion— There are a variety of ways that mollusk move about such as crawling, swimming, or digging. A snail moves about by using its *foot* . The motion is accomplished through a series of muscular waves that begin at the forward end and move towards the opposite end. Clams use their muscular *foot* to dig through mud or sand. Some bivalves can change their location by rapidly opening and closing the *valves* ; pushing out a jet of water while others are immobile or sessile and attach themselves to rocks. The anchor is by means of *byssus* threads that extend from the animal to the substrate with a form of glue.

Reproduction —Many mollusks such as the whelk and the octopus lay eggs in protective capsules but all produce a great number of egg cells to offset losses of progeny through dips in water temperature, currents, or predators. An octopus may lay 200,000 eggs with only 1 or 2 surviving into adulthood. The eggs may be fertilized in the ocean or in the female depending on the species. Some eggs are laid freely into the sea water depending on the water temperature, moon position, and season. The eggs may be attached to the surface of the ocean floor, rocks, seaweed, or have buoyancy and float to the surface. Some eggs are laid in the sand and have sand collars for protection. Eggs are either abandoned by the parent or shepherded carefully as in the case of the octopus. There is a variation in the size of the eggs: larger eggs contain more nutrients permitting more complete development of the hatchling inside the capsule, and smaller eggs hatch sooner and become free-swimming larvae. The whelks eat their way out of the capsule by eating the other eggs until only one large whelk is left.

Most species have separate sexes but some like the scallop and cockle are *hermaphroditic* , containing both female and male reproduction organs. The slipper shells sex is determined by a hormone produced constantly by the female. When the female becomes too old or dies and stops producing the hormone, the neighboring males will develop ovaries and become female within a week. The octopus and snail have a period of courtship, an octopus may even change color during this time. The packets of male sperm is placed into the female oviduct by the tip of the third arm.

(Univalves) Gastropoda (Fig. I A,B)

This class is the largest containing 3/4 of all the living species of mollusks. It includes snails, whelks, limpets, and slipper shells. It is the only class which contains species living on land. Most gastropods have shells usually in a single coiled structure which are composed of calcium carbonate. Exceptions are the limpets and slipper shell which are flat and flared. Females usually have a slightly larger shell than the males.

Eyes and *tentacles* are contained in the head region to aid in guiding movements. (Fig. IA) Gastropoda means “stomach-footed”, because they eat through their *foot* . They have a single *foot* attached to their body. They move on their foot slowly over rocks and plants. The *spire* faces backward as the snail moves in a forward direction. The *operculum* is a hard disc attached to a portion of the foot that fits tightly into the *aperture* of the shell after the animal retracts itself. It is used for protection from enemies and the sun.

The *radula* is used with a pulling action to scrape and shred food. Some gastropods use their *radulae* to drill through the shells of clams and other mollusks and may also excrete acid to dissolve the calcium carbonate. They may be either *carnivorous* or *herbivorous* .

A. Animal in shell

(figure available in print form)
B. View of exterior of a univalve
(figure available in print form)

(Bivalves) Pelecypoda (Fig. II A,B,C)
Bivalves always have 2 shells, they may be equivalent in size, equilateral, or not equilateral. Quahogs have equilateral *valves* while oysters and jingle shells have distinctly different or inequilateral *valves* . The *valves* are held together by two internal strong muscles and flexible *ligaments* which occur at the hinge or head. (Fig. IIA) The *valves* must be open for feeding or moving. Muscle action is used in closing the *valves* , when *valves* are closed they are in a relaxed position. The *cardinal* and *lateral* teeth make sure that the *valves* are properly aligned when closed. The *pallial line* is the point of attachment to the mantle . The *pallial sinus* is where the muscle operating the siphons was attached, it is an identation showing the size and strength of the siphonal muscle. (See Below) Unlike the univalves the head region is not well defined and they do not contain a *radula* . Sometimes they have rows of tiny eyes along the edge of the *mantle* , as in the scallop.

Most pelecypods move slowly through the sand and water with the aid of a hatchet-shaped *foot* . Some such as scallops move by quickly opening and closing their *valves* . When the *valve* is open the space fills with water, when it closes the water shoots out behind and advances the animal. Others such as oysters and mussels permanently attach themselves to rocks or other objects by secreting strands of *byssus* by a gland in the *foot* .

To obtain food, *siphons* or tubular extensions are used to bring water inside the body. The *gills* strain the water to remove food particles as well as function in respiration. Another *siphon* gets rid of water and wastes. Bivalves generally are herbivorous, feeding on plankton and debris.

A. View of interior of one of the bivalves

(figure available in print form)
B. View of bivalve from umbo
(figure available in print form)
C. Dorsal view Axis of maximum growth
(figure available in print form)

(Chitons) Amphieura (Fig. III A,B)
These animal shells are a series of eight arched hard overlapping valves inside the mantle of the organism. There are 3 types of valves, the anterior valve near the head end, 6 intermediate valves, and the posterior

valve at the hind end. The pieces are held together with a band, or *girdle* , around the outside edge. The valves give them the ability to attach to rocks or to irregular surfaces. When they are removed from the surface with a sharp knife they curl into a ball to protect their fleshy undersurface. Chitons wander at night and return to their hiding place during daylight hours.

Most chitons have a simple head in the anterior position, which lacks eyes and *tentacles* and an *anus* posteriorly. A strong set of *radulae* teeth rasps off food. Chitons have a wide, flat *foot* which is used for slowly creeping along and as a sucking unit. Most chitons are *herbivorous* and eat algae, but a few eat shrimp.

Fig. IIIA. Side view

(figure available in print form)
Fig. IIIB. Ventral view
(figure available in print form)

Cephalopoda (Fig. IV)
The squid and octopus belong to this group which do not have an outside shell. The squid is the fastest swimming and the largest invertebrate ranging from 1 inch to 65 feet in length. The *tentacles* in some species may be 5 to 10 times the length of the body. As example, of a giant squid species, the body of the giant could be 20 feet with *tentacles* 35 feet long. “Cephalopoda” means “head foot” because the *tentacles* are attached to their heads. They have 1 or 2 rows of *suction cups* on their *tentacles* or arms that function for grabbing and holding onto other animals as well as locomotion. The octopus has strong *radula* teeth, well-developed eyes, and 8 long arms. The squid is similar except it has small *radula* teeth. The nervous system is so well-developed that they have great strength, speed, and mobility.

They are *carnivorous* mollusks which prey on fish and crustacea, the octopus concentrates on snails and clams. For defense they secrete an inky substance or they may change color.

(figure available in print form)
Fig. IV. Dorsal view

(Tusk Shells) Scaphopoda (Fig. V)
The tusk shell is a gently curved, elongated, and tublar shell which is open at both ends, the *mantle* completely surrounds the animal. The shell grows from the larger anterior end. They live partially buried in the mud from shallow to very deep sea waters. Their location is worldwide with approximately 200 species found in the United States.

The body does not have a defined head, heart, eyes, or *gills* present. *Gills* are not needed because the circulatory system is so efficient. A muscular, cylindrical, and pointed *foot* at the larger end aids in locomotion, feeding, and keeps water flowing through the *mantle* cavity. A set of *radular* teeth is used to obtain the food and pass it to the intestines.

(figure available in print form)
Fig. V. Side view

Monoplacophora (Fig. VI)
This class today is represented by only 5 living deep-sea species, all have single, oval, spoon-shaped shells. They were thought to be extinct until a discovery in 1952 off the Pacific Coast of Costa Rica. They resemble

the chiton because they have a row of *radular* teeth, and lack eyes or *tentacles* . Also they have a thin, flattened, disc shaped *foot* used for moving slowly but not for sucking. *Gills* and 5-6 pairs of muscle scars are present on the inside of the shell.

(figure available in print form)
Fig. VI. Ventral view

Mollusks—New Haven

Mollusks found on the New Haven area beaches are primarily from either the gastropoda class or pelecypoda class. I will concentrate on 8 shells, 4 from each class, typically found on the beach. For each shell I have included information on characteristics such as body size, food, movement, and eggs produced. For the beginner it is easier to remember common names, scientific names can always be learned at a later time. After reviewing the shells and explaining different characteristics students should be able to collect and identify them easily.

Gastropoda

1. Moon Snail—The Common Moon Snail that lives along the Atlantic coast has a shell size from 2-4 1/2 inches and color ranging from gray to a light brown. The adult shell is usually a globular shape with 5 *whorls* .

It looks for clams and shellfish just below the surface of the sand to prey on. The moon snail eats its victim by drilling a hole through the shell with its *radula* and sucks out the flesh. A large *foot* helps hold the prey in place.

The eggs are laid in a continuous ribbon with a mucous covering that attracts sand to them making a leathery, protective case. The moon snail leaves them to hatch on their own.

2. Whelk—Common whelks along the Atlantic coast are either The Knobbed or The Channeled Whelk. The color in a single specimen may vary from a grayish tan body *whorl* to a yellow, brown, or orange *aperture.* The length of whelks in general range from 3-16 inches. The body is large with a broad *foot* for locomotion.

Whelks eat clams by pulling the shell apart with their muscular *foot* and putting the whelk shell between the *valves.* The whelk shell is stronger than the clam muscle. An average whelk eats one clam per month, but they also feed on other shellfish.

Whelks lay leathery egg capsules containing many eggs. The capsules are a different shape depending on the species. Strings of round dark greenish brown egg capsules can be found on the beach during the summer months containing hundreds of baby whelks.

3. Slipper Shell—The size of the Common Atlantic Slipper Shell, or Boat Shell, ranges from 3/4-2 inches long. The color is a dirty white with brownish purple markings. They have a shelve, or platform, on the inside to protect the digestive gland. They become stationary and secrete a mucous from the *mantle* to catch food particles.

When they are young, the larval stage, they swim for the first 2-3 weeks, then they look for a place to settle down. To attach to a permanent location the *foot* is used as a sucker to attach to a rock, empty shell, or a fellow slipper shell. They often anchor on top of one another with only the bottom shell attached to a rock, usually the females settle down first. Eggs are

produced in thin capsules having 70-100 eggs within. The capsules are attached to a rock until they hatch.
4. Periwinkles—They are the common conical and small shells in shallow waters off New England coasts. They range in size from 3/4-1 inch and color from grayish brown to black. Some periwinkles have different color speckles or bands. The head has a pair of *tentacles* with eyes at the base. They are *herbivorous* , they eat algae with their coiled *radula* . Movement is made by raising one side of the foot and then the other as it slides forward. Some lay egg capsules that float on top of the water, other species lay eggs that attach to algae.

Pelecypoda

5. Mussel—The mussel is the common dock encrusting shell. They range in size form 1-5 inches long. The *valves* are black, relatively thin, long, and strong. Common Blue Mussels and Atlantic Ribbed Mussels are edible and abundant in New Haven. They prefer cool or cold water, but species are found in all waters.

A *siphon* is used to bring water into the mussel. *Gills* strain the food from the water and expel the waste. The *foot* is not used for movement because it is small and weak. *Byssal* threads are used to attach the animal to any surface. Threads are made in a new direction while old ones are broken to make small changes in position. The eggs are released and hatched in the water.
6. Scallop—The Atlantic Bay Scallop is a familiar shell form (Shell Gasoline). The rounded fan shaped shell is found in a variety of color such as white, gray, orange, or calico. The fan is accentuated by the 17-20 strong ribs on an animal ranging up to 3 inches long. The *valves* are not well mineralized and offer little protection. They do not have *siphons* like clams. 30-40 blue eyes along the *mantle* and the ability to move quickly makes them distinctive amongst the bivalves. Scallops move by opening and closing their valves rapidly. Also, the animal can control the direction it travels by moving sideways or backwards. Their great speed is used for protection.
7. Jingle Shell—These translucent bivalves are very common around New Haven. The very thin rounded shells come in a variety of colors such as yellow, orange, and black and up to 2 inches in size. The Atlantic Jingle Shell has 2 different shaped *valves* , the top *valve* is cupped. The bottom *valve* is flat with a hole in it, the hole is the site of threads used to attach the animal to rocks with *byssal* threads.
8. Clam—A bivalve with equal sized *valves* the abundant Northern Quahog ranges form 3-5 inches in size. The thick, dull white, ridged shell indicates that clams grow throughout their life and the ridges or growth lines found on the outside of the shell indicates the age of the shell. During winter months the growth slows down. They live just below the surface of the sand in a vertical

position. Usually clams have 3 *cardinal teeth* . On the interior of the *valve* 2 *muscle scars* can be found. The scars show as purple in color due to the deposition of a distinctive chemical at that site. *Siphon* tubes carry water into the clam and also expel it. The *gills* filter water for food.

Razor clams have thin, narrow, and fragile shells unlike the quahog. Razor clams can quickly burrow deeper into the sand because of their streamlined shells. Razor clams can move by opening and closing their *valves* but when it is about 2 years old it loses its ability to move and stays buried in the sand for protection.

During the summer the adult female clams produce eggs and the adult male clams produce sperm, both eggs and sperm are released into the water. When sperm comes in contact with the egg fertilization takes place. Within a few hours the fertilized egg becomes a minute creature living near the surface of the water, where unfortunately it becomes the prey of the marine life.

Common Shells—New Haven Area—Actual Size

(figure available in print form)

Ideas for Beginning a Student Shell Collection

To prepare for collecting shells one should wear old clothes and shoes. A container such as a pail or sack is needed to carry the collected specimens. Also, small jars or containers are recommended to carry small specimens to avoid loss or breakage. A shovel is helpful to carry along to uncover shells below the mud or sandy surface. Many dead shells can be found, but often they have broken edges and *spires* . Living specimens are excellent to add to a collection, but need proper attention in preparing them. (See Below)

Shells can be found in numerous places along the shoreline even under rocks or pieces of driftwood. Many mollusks can be found in dark places, some are nocturnal. Caution should be used to return stones and logs that have been overturned while searching for shells to prevent unnecessary harm to the remaining organisms. An excellent time to look for shells is at low tide, but take advantage of searching immediately after a violent storm expecting the best shell gathering. The times of low tide are published in the local newspaper, with low tide approximately 1 hour later each day. For a change of pace looking in the evening with a strong flashlight may produce interestingly different results. Some shells have a preference for the type of marine life they enjoy, therefore, you have to check all aspects of the shoreline including rocky areas, tidal pools, sandy flats, muddy bottoms, as well as the near shore waters. A location which is usually not a prosperous place to look is the upper shore line even though a strand line may be found. It is a remnant of the highest tide during the month.

Cleaning and preserving the shells must be done properly, so don't collect more specimens than necessary. Anything which is a living organism will have a terrible odor if not cleaned promptly and effectively. The following are different options to clean and preserve the shells.

1. For both bivalves and univalves that are alive boil for 5-15 minutes. Use cool water to begin with to avoid dulling the shell. Heat slowly and when the time is up remove shells to cool. Bivalves will open during this process themselves, but gastropods will have to be picked out with a sharp, pointed instrument. If some of the animal remains in the shell soak it in 70% solution of alcohol or chlorine for a few hours to remove the odor.
2. Shells can be buried in the ground, after a few days the ants will have eaten the living organisms.
3. Use warm soapy water with an old soft toothbrush.
4. Laundry bleach for a few hours or overnight, if left too long the colors will bleach out. (Mix 1 cup of bleach with 1 quart of water.)

Now that the shells are cleaned, in order to understand some of the biological relationships a shell collection should be clearly identified. Samples of the same species are helpful in demonstrating growth developments. The shells should be stored in a simple, organized, inexpensive way in order to add new specimens without much effort. The collection should be kept out of the sunlight to avoid fading. Each specimen should be catalogued properly to avoid confusion and to retain accurate collection data. The collection can be stotes in egg crates, cardboard boxes with dividers, cigar boxes or any similar container. Small shells can be stored in glass vials and plugged with cotton or small containers such as matchboxes.

Each shell has a Latin name regardless of the common name it may have been given. The scientific nomenclature should be used in cataloguing to avoid confusion with common names. Every species has 3 names. The first word is the genus, or group, the specimen belongs to and is always capitalized. The second word is the species that describes that particular animal alone and is never capitalized. The last name is usually that of the person who first described the species. Example:Crepidula, fornicata, Linne (Common Atlantic Slipper Shell)

Each shell should be numbered with a permanent marker and a card catalogue kept of the number, common name, scientific name, place, date, time of collection, and general remarks. The remarks should include such information asthe weather, tide, type of day, living of dead, and any other information you believe to be pertinent. The records can be kept in an inexpensive notebook.

Lesson Plans

Lesson I

Objective Students will be able to label diagrams of the 6 different classes of mollusks and understand the meaning of the labeled terms.

Lesson Outline:

1. Explain and discuss the anatomy of the 6 different classes of mollusks.
2. Stress the glossary words and ghose words which are on the labeled diagrams.
3. Use the glossary words as class vocabulary or spelling words. Practice the words by writing sentences and defining them.
4. Explain the function and placement of body parts on the diagrams.
5. Distribute unlabeled diagrams for the students to practice and study.
6. Quiz students by distributing blank diagrams to label.

Lesson II

Objective Students will be able to identify 8 common New Haven shells.

Lesson Outline:

1. Review the chart of the 8 common New Haven shells.
2. Practice identification through labeling a blank chart and drawing each shell.
3. Explain and discuss the anatomy of the 8 shells from the information enclosed in the unit.
4. Quiz students by distributing a blank chart to label.
5. Each individual student should choose 1 or more shells to research and write a short report.

Lesson III

Objective Students will be able to begin and organize their own shell collection.

Lesson Outline:

1. Review information enclosed in the unit on ideas for beginning a student shell collection.
2. Take a field trip to a New Haven area beach, for example Lighthouse Park.
3. Search for the 8 common shells that were learned in Lesson II and any other interesting or different shells.
4. The class should display their shells and discuss where the shells were located such as under a log or buried in the sand.
5. Identify and label the shells.
6. Organize the shells into trays in a convenient way in order to accept new shells in an easy manner.
7. Use the duplicate or damaged shells in a creative design display or in a craft project.
8. Allow the students to shell swap for New Haven shells or for shells from Florida, California, etc.

Glossary

Anus — opening for waste removal, final structure in digestive system

Aperture — opening in gastropoda shell through which foot protrudes

Byssus — threads secreted by animal and used for attachment to separate (other animal, dock, rock, etc.)

Cardinal Tooth — central tooth in the hinge of a pelecypoda used for accurately positioning shell on closure

Carnivorous — meat eating organisms

Foot — muscular part of the body of a mollusc used for locomotion

Gills — soft tissue structures typical of invertebrate that aide in taking oxygen out of the water expelling CO2 and in some species feeding

Girdle — mineralized tissue structure that encloses the 8 internal shell valves of chitons

Herbivorous — plant eating organisms

Hermaphroditic — containing both male and female reproductive organs

Lateral Tooth — teeth on either side of cardinal tooth

Ligament — holds the valves open or closed, relaxes when the valves are closed, under tension when open

Mantle — portion of animal that has specialized functions related to shell formation

Muscle Scar — the visible depressions in bivalves that show where the muscles attach

Operculum — covers the large opening of gastropod shells, attached

Pallial Line — scar line showing where the mantle was attached

Pallial Sinus — the indentation in the pallial line where siphonal muscles were attached

Radula — many rows of teeth on a ribbon-like structure

Siphon — tube-like structure to take in or expel water

Spire — the whorls at the apex excluding the body whorl

Suction Cup — structure used for grasping objects, part of squid tentacles

Tentacles — used for grabbing, guidance, holding on, or movement, squiod has 2 long tentacles and 8 arms, octopus has 8 arms

Umbo — beak of the shell, in pelecypoda, an obvious projection near the hinge line

Valve — one of the 2 shells of a bivalve

Whorl — one turn or coil in a gastropoda shell, body whorl is the largest and the last one made, animal lives in latest whorl, may seal it off, previously made sections aids in bouyancy

Notes

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1. General references for this and subsequent sections will be found in the annotated bibliography.

Annotated Bibliography for Teachers

Abbott, R. Tucker. *A Guide to Field Identification: Seashells of North America* . New York: Golden Press, 1968. Excellent phoyos and identification, very clear organization.

Abbott, R. Tucker. *Sea Shells of the World* . New York: Golden Press, 1962. Handy size to carry to the beach for immediate field identification, excellent photos with brief explanations.

Abbott, R. Tucker. *Kingdom of the Seashell* . New York: Crown Pub., Inc., 1972. Excellent colorfuf photos, excellent general knowledge of shell classes, reproduction, location, and collecting.

Campbell, Andrew. *Nature Library* : *Seashore Life* . New York: Exeter Books, 1983. Beautiful photos, diagrams, information on general marine life.

Gordon, Julius and Townsend,E. Weeks. *Seashells of the Northeast Coast from Cape Hatteras to Newfoundland* . Washington: Hancock House Pub., 1982. Excellent identification of the classes gstropoda and pelecypoda.

Morris, Percy A. *A Field Guide to Shells of the Atlantic and Gulf Coasts and the West Indie* s. Boston: Houghton Mifflin Co., 1973. Excellent identfication with mainly noncolor photos.

Purchon, R. D. *The Biology of the Mollusca* . Oxford: Pergamon Press, 1968. Excellent informationon the different classes of mollusks, very scientific with excellent diagrams.

Rhoads, Donald C. and Lutz, Richard A. *Skeletal Growth of Aquatic Organisms* . New York: Plenum Press, 1980. Excellent information on shell minerology, growth, and form scientific, includes environmental factors.

Sterling, Dorothy. *The Outer Lands* . New York: Anchor Press/ Doubleday, 1974. An excellent natural history guide including the Long Island Sound region, very readable.

Wilbur, K. M. and Yonge, C. M. *Physiology of Mollusca* . Vol. I, II. New York: Academy Press, 1964. Excellent information on the physiology of mollusca in both volumes, excellent diagrams.

Zim, Herbert S. *Seashores* . New York: Golden Press, 1955. Handy size to carry for immediate field identification, excellent photos with brief explanations.

Zinn, Donald J. *The Handbook for Beach Strollers from Maine to Cape Hatteras* . Conn.: The Pequot Press, 1975. An excellent natural history guide with recipes of mollusks included.

Annotated Bibliography for Students

Cavanna, Betty. *The First Book of Seashells.* New York: Franklin Watts, Inc., 1955. In contains elementary information, good pictures and diagrams, and a glossary.

Clemons, Elizabeth. *Shells Are Where You Find Them.* New York: Alfred □A, Knopf, Inc., 1960. Good information on how to collect shells and maintain accurate records.

Dudley, Ruth H. *Collecting Sea Shells and Coral* . New York: Hart Book Co., Inc. 1955. A good student reference for identifying with Photos and scientific names.

Dudley, Ruth. *Sea Shells.* New York: Thomas Y. Crowell Co., 1953. Easy reading, a story about shells of a select group, not good for identification.

Goudey, Alice E. *Houses From the Sea* . New York: Charles Scribner's Sons, 1959, Elementary reading, story form, excellent pictures for identification with common names.

Kohn, Bernice. *The Beachcomber's Book* . New York: The Viking Press, 1970. Elementary approach to collecting and organizing shells, ideas for craft projects with shells.

Saunders, John R. *The Golden Stamp Book of Seashells* . Wisconsin: Golden Press, 1974. Good ideas for organizing shells, excellent photos.

Verrill, A. Hyatt. *The Shell Collector's Handbook.* New York: G. P. Putnam's Sons, 1950. For the advanced student, information on physiology and identification of shells.