

THE LOWLY INVERTEBRATES: AN HISTORICAL PERSPECTIVE^{1, 2}

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One of the most awesome things about being President of The Ohio Academy of Science is that you are expected to address the Annual Meeting. What makes it almost frightening is that we have Journal Editors like Dr. Milton Lessler who keep reminding you that the address must be published in *The Ohio Journal of Science*. Herein lies the problem. As President of the Academy, I want to appear scholarly--at least to those who do not know me very well. Those who do know me are aware that whatever reputation I have as a zoologist is probably based upon my work on crustacean larval development. In fact, if I had indeed elected to summarize my work here, many of you except for the most stout-hearted would be asleep by the time I got to my magnificent tangential sections of the third zoeal stage of larval *Palaemonetes*--or described in detail the extracts of the sinus gland.

I decided instead to develop an his-

torical perspective of invertebrate biology. I felt that we should go back as far as I possibly could. I did, however, promise myself that I would not start with, "In the beginning there was darkness . . .".

The earliest reference to invertebrates considered worthy of record by ancient peoples was a biological survey sponsored by Queen Hatshepsut of Egypt about 1493-1492 BC (Landstrom 1964). A bit of background on Queen Hatshepsut: her father was Thutmose I, who became the third king of the XVIII dynasty of ancient Egypt. He had 3 children who succeeded him (he probably had many others). There were Thutmose II, Thutmose III and Hatshepsut. Only Hatshepsut had a royal mother, through whom Thutmose I claimed the throne. Hatshepsut eventually married her brother Thutmose III, who in 1501 BC seized the throne from his aged father. Hatshepsut was an assertive girl and soon pushed her brother/husband aside to take power and call herself "King". Her reign for the next 20 years was peaceful and prosperous. She pursued her interests in developing Egypt's resources--much building, agricultural development and mining in the Sinai (fig. 1).

In those days, enormous quantities of incense and myrrh were burnt each year for the gratification of Egyptian gods. These sweet-smelling gums came from somewhere in the South of Africa through middlemen, from the so-called land of Punt. Hatshepsut wanted to grow her own myrrh trees in Egypt, but no Egyptian ship had sailed to Punt in 300 years. In fact, apparently no one any longer knew the way to get there. Consequently, the queen announced that the route to Punt was to be re-explored.

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FIGURE 1. Queen Hatshepsut of Egypt, 1493-1492 BC (reprinted from Landstrom 1964, with permission).

We do not know where the land of Punt was, but the region was probably somewhere beyond the horn of East Africa, possibly as far south as the delta of the Zambezi.

Timbers were brought from Lebanon to the shore of the Red Sea where the ships were built. Preserved relief carvings show 5 ships, but this may have been just pictorial license because there may have been more. Upon arrival in Punt, the queen's ambassadors presented gifts to the rulers, King Perahu and his wife Eti, and the Egyptians were able to acquire many goods for the return passage. Archaeological restorations of the reliefs portraying the expedition are far from complete, but they have established that the ships returned with many kinds of woods, quantities of incense, trees, monkeys, dogs, and leopard skins as well as fish and crustaceans. Decorations in the walls of the temple at Deir-el-Bahari are in adequate detail for modern species designations to be assigned to some of the pictures (the lobster *Panulirus pencilatus* for example). Relief pictures of Queen Eti herself show enlarged areas suggesting that the queen suffered from

elephantiasis. This disease, you will recall, is caused by an invertebrate filarial worm--a nematode (fig. 2).

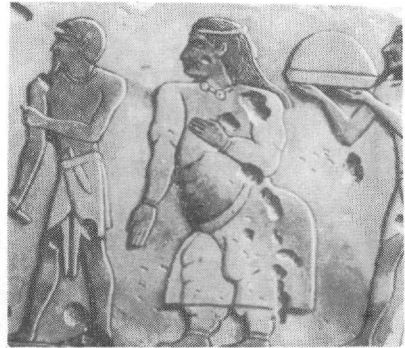


FIGURE 2. Queen Eti of Punt from a restored relief (reprinted from Landstrom 1964, with permission).

While explorations were carried on in Egypt, the Phoenicians were busy building an empire to the North. Certainly by 1400 BC, the city of Tyre was over 1000 years old and the center of maritime supremacy on the Eastern Mediterranean. At that time, the cities of Tyre, Sidon and Laconia were famous centers of textile manufacture and dying. They were especially famous for the dye that became known as Tyrian purple, which comes from a group of marine snails of the genus *Murex*. Murex dying was practiced in other Mediterranean locations, but there is little question that Tyrians were supreme in the development of dying techniques as well as in the quality of their dyed goods. The colors were bright, the tints various, and the dyes colorfast. Accounts vary, but apparently the reputation for quality was a result of the rather precise techniques practiced by Tyrian workers.

This purple dye was extracted from a small hypobranchial gland that had to be removed from the living snail. Only a drop or two of extract could be obtained from each snail, and the extract was darkened by photo-oxidation. After a week or two of slow chemical change in sunlight, usually in lead vessels, the extract was concentrated to about $\frac{1}{16}$ its original volume. The cost of this dye may be realized by the estimate that it

required about 60,000 snails to produce one pound of dye. Two species of *Murex* (*M. brandaris* and *M. trunculus*) were required to produce the typical brilliant purple that was most sought after. By varying the mixture of these (with pigments from other snails) as well as the length of exposure to light, the resultant dye could be varied from bright purple to pale pink (fig. 3).

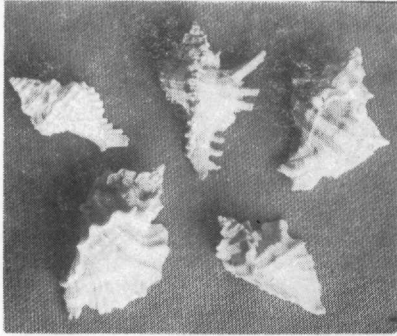


FIGURE 3. Examples of Muricid snails from which purple dye is extracted.

About 64 BC, Tyre came under the control of Rome. Originally, any rich citizen could wear fabrics dyed purple. The prestige associated with the dye was emphasized in the New Testament (Luke 16: 19): "there was a certain rich man, which was clothed in purple and fine linen, and fared sumptuously everyday." Gradually, however, the privilege of wearing purple was restricted to senators and eventually only to the Emperor. About that time, the dye industry suffered an irreversible down-slide. It is not clear to me if the legal limitation on usage was a consequence or cause of the decline. It may have been, as was the case with so many things that came under Roman exploitation, that quality went downhill because the subtle details became neglected and were eventually lost. An account attributed to Pliny the Elder (23-79 AD) suggests a process for dye preparation less sophisticated than that used by the Tyrians, but Pliny was notorious for providing secondhand accounts and it may be that his recipe was simply recorded in very general terms.

At any rate, the practice of dye-making

from snails died out completely during the Middle Ages. With the Renaissance, some of the techniques were rediscovered and practiced again, but later modern chemistry intervened and provided us with access to a wide array of brilliant dyes. It is apparent that, except for the occasional gourmet, *Murex* has been saved from the hammer and simmering vessel of the dye maker, but until this day, the color purple remains the symbol of royalty and wealth.

On our side of the Atlantic, North American Indians also were extracting purple dyes from mollusks. What is even more interesting is that Indians of both the East and West coasts were using mollusk shells for decorative and trading purposes. Some used whole shells, while others used bits and pieces. The coastal Indians from Maine to Texas made wampum by cutting and grinding beads from the heavy shells of the hard clam and drilling and stringing them. Blue and white areas of the shell provided blue and white beads. For such purposes, the northern tribes obviously had the advantage since the northern clam *Mercenaria mercenaria* possesses a distinct blue region of the nacreous layer of the shell. This blue area is absent in the southern species *M. campechiensis*.

On the West coast of North America, another mollusk was favored. This was a small non-obtrusive group of burrowing forms called Scaphopods--the tooth shells or tusk shells. *Dentalium* is the common genus of this class of mollusk on our western North American beaches. Already in a tube-form, these shells also were used whole or were cut into sections that served as beads from which items of value were fashioned. Strung end-to-end and fashioned into cords or mats, they were used as treaty belts or coin-of-the-realm, so to speak. It is reported that a slave was valued at a fathom-cord which amounted to 25-40 shells strung lengthwise. Until the Hudson Bay Company substituted blankets, these shell objects served as the standard of trade among Indians of the Northwest.

On the East coast, and long before the northern Indians had given up wampum in favor of blankets and hatchets, the Spanish forces were building Castillo de

San Marcos at what is now St. Augustine, Florida. This was Spain's northernmost military fortification on the Atlantic Coast and is the oldest masonry fort in the U.S. A symmetrical 4-sided structure with moat and drawbridge, it was built with coquina blocks and cemented with lime burned from oyster shells (fig. 4).



FIGURE 4. Coquina rock was used as the primary building material for Castillo de San Marcos, St. Augustine, Florida.

Here lies the basis for inclusion in tonight's story--not the oysters, but the coquina rock. Oyster lime has provided a necessary ingredient for the mortar used in many of our historic buildings, but at this time, I want to direct your attention to the rock from which the fort was constructed. Coquina is a loosely cemented, easily quarried deposit of fossil shells. For thousands of years before modern Florida existed as a land mass, large populations of mollusks lived in the warm shallow seas that covered the area. In time, millions of shells from small bivalve mollusks accumulated and became incorporated in the characteristic deposit we call coquina rock. An example of the small bivalve producing these shells is the Butterfly clam or Coquina clam of the genus *Donax*. The habitat of *Donax* is the open ocean beach, and these little clams are very well adapted to their habitat. They are extremely mobile and often locally abundant. If dislodged from their place in the open beach, they right themselves and burrow beneath the surface of the sand before the next wave moves ashore. They move up and down the beach with the rising and falling tide.

I also would like to call your attention to one group of marine invertebrates that

has been a nuisance during all of historical time. I am referring to the ship worms (common genus *Teredo* in Europe and *Bankia* in North America) that are not worms at all but bivalve mollusks related to clams and oysters. These highly specialized animals begin life as larvae in the plankton, and if one is lucky enough to settle on a piece of wood, metamorphosis begins. The larval shell ceases to function as protective covering and is converted into a cutting tool with rows of sharp ridges that are continually added during life. With this device, the mollusk rasps its way into the wood, digesting much of what it removes in the way of chips. With growth, the body elongates and becomes worm-like with the cutting confined to the leading tip. The mantle tissue covering the body secretes a porcelaine-like lining to the burrow in the wood. Since their structure is so specialized and their habitat so unusual, it is not surprising that they were not even identified as mollusks until 1733 when they were first carefully studied by the Dutch zoologist Gotfren Snellius (Lambert 1971). See figure 5.

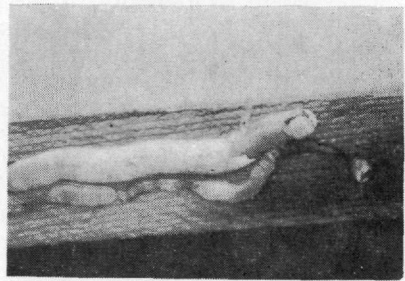


FIGURE 5. A living shipworm exposed from submerged wood.

In Holland, up to 1730, dikes of earth and wood served as the country's sea defenses. In 1730 an outbreak of what they called pileworm infested the wood piling of their dike system. By 1731, the organism had destroyed 50 km of the Westfrisian dike system and had seriously weakened another 20 km. The Dutch were faced with the prospect of their country being flooded, and this possibility had a serious impact on the Dutch economic stability. This situation was potentially as significant as the

later results of the Irish Potato Famine when a fungus disease changed the socio-economic future of both Ireland and America. You may recall that the outbreak of potato blight in Ireland (1845-47) resulted in about one million deaths by starvation--and subsequent emigration of about one half of the population (Moody and Martin 1967).

Damage to the dikes combined with rising sea level and reckless turf (peat) cutting drove many peasants off their farms to the towns, swelling the unemployed masses in Holland. Restrictions on peat harvesting helped somewhat, but the dike problem was much more difficult. The Dutch tried tropical hardwoods, arsenical solutions and covering the dikes with iron plates and nails, but the only real answer was a change in the mode of dike construction. Dikes were reconstructed at great expense (and taxes) of imported stone that took the form of gently sloping revetments.

The notorious borers, the pileworms and shipworms, have been known and dreaded since ancient times when they destroyed the planking of Greek and Roman ships. In fact, an early name given by Linnaeus, *Calmitas navium*, suggests their impact on maritime history. We can be quite certain that these animals destroyed Drake's *Golden Hind*, and it has been suggested that the anxiety attributed to Columbus's sailors might well have been due to ship worm damage rather than to fear of the unknown. It has likewise been suggested that the failure of many Spanish Armada ships to successfully return via the long voyage around Scotland and Ireland was due to shipworm damage.

Over the centuries, various methods from coatings of tar and pitch to sheathing in copper have been tried to prevent the penetration of shipworm into wooden vessels. Abrasion usually nullified the first and electrolysis took care of the latter. The British navy took to "Scupper nailing" the wooden portions of their mooring tackle to take advantage of the

observed sensitivity to iron by the worms. We now recognize that an important ecological limitation to their distribution is freshwater. In fact, the damage to the Dutch dikes was apparently a consequence of several seasons of low rain fall that usually diluted the local seawater, resulting in increased salinity of the Zider Zee, thereby providing a more hospitable habitat for the destructive mollusks. A similar situation occurred in the San Francisco Bay between 1914 and 1920 during which millions of dollars of damage was done to piers and wharfs by boring mollusks.

In closing, I want to repeat why my colleagues in Liberal Arts keep telling their students, "History is not dead." I want to assure you that the lowly invertebrates are continuing to play their role in the dynamic process of cultural evolution. In fact, there is a struggle going on right now. The geographic boundaries are indistinct, but the impact is real. The zone of confrontation is somewhere North of Montauk Point and South of Cape Cod. We are told by the tourist booklets that the widow walks of Nantucket had something to do with the whale oil trade or clipper ships; the fact is that these were the frontier lookout posts that enabled the hard-core resistance to keep an eye out for the intruder. By now, you have probably suspected the identity of the insidious threat, that's right--Manhattan Clam Chowder --The endangered species then--New England Clam Chowder. As scientists, we all demand objectivity. I suggest, therefore, that before you take sides, you try both. I have prepared the following recipes for your experimentation.

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NEW ENGLAND CLAM CHOWDER

3 doz. soft-shell clams	3 cups boiling water
$\frac{1}{8}$ lb. salt pork	4 cups scalded milk
$1\frac{1}{2}$ cups sliced onion	2 cups light cream
6 cups cubed potatoes	3 cups clam liquor
$4\frac{1}{2}$ teaspoons salt	3 tablespoons butter
$\frac{1}{2}$ teaspoon pepper	2 tablespoons flour
2 small bay leaves	

Pick over clams, removing any bits of shell. Drain and strain liquor. Dice salt pork and cook in saucepan until golden brown. Add onions, potatoes, salt, pepper, bay leaves (some New England chefs say no seasoning should be used), the hard part of the clam chopped fine and water. Bring to a boil, reduce heat, cover and cook gently until potatoes are tender (15 to 20 minutes). Add scalded milk, cream, the soft part of the clams coarsely chopped and clam liquor. Blend the butter with the flour, add to mixture. Simmer 15 to 20 minutes. Serves 8.

MANHATTAN CLAM CHOWDER

2 doz. hard-shell clams	1 cup drained canned tomatoes, broken up
1 2-inch cube salt pork	$1\frac{1}{2}$ teaspoons thyme
1 clove minced garlic	$\frac{1}{4}$ teaspoon pepper
$\frac{1}{2}$ cup finely chopped onion	$\frac{1}{3}$ cup chopped parsley
$\frac{1}{2}$ cup thinly sliced leeks	1 bay leaf, 4 cloves
$\frac{1}{2}$ cup chopped green pepper	$\frac{1}{4}$ cup tomato catsup
$\frac{1}{2}$ cup diced carrots	3 cups clam liquor
$\frac{1}{4}$ cup chopped celery	1 tablespoon butter
3 cups diced potatoes	1 tablespoon flour
2 teaspoons salt	
6 cups boiling water	

Sauté the garlic, onions and leeks in salt pork until they are tender. Add the green pepper, carrots, celery, potatoes, salt and boiling water. Cover and bring to a boil. Reduce heat and cook gently for 10 minutes. Add the hard part of the clams chopped fine. Continue cooking until potatoes are nearly tender (about 10 minutes). Add tomatoes, thyme, pepper, parsley, bay leaf, cloves, catsup, the soft part of clams coarsely chopped and the clam liquor. Blend the butter with the flour and add to mixture. Simmer 15 to 20 minutes. Serves 8.