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The Pink Mouth Murex: Seek and You Shell Find

When you look at the pink mouth murex, you see wealth. Sitting in a glass case located in the Orma J. Smith Museum, surrounded by other mollusks, the pink mouth murex bears little description: *hexaplex erythrostomus*, Indo-Pacific. Its pink interior is a pop of color among the earth tones of the other dozens of shells in the case, which is what caught my eye. I knew some shells were used in the past to make purple dye, and I was delighted to learn this shell was a part of that family. With this in mind, I began researching the pink mouth murex, but quickly found trouble: there is very little information available about this species. As a result, I had to look more broadly; therefore, most of my research is on the *muricidae* family of gastropods, which all have similar—though not identical—characteristics and uses. Through all of my research, I was presented with a recurring idea of wealth, but this wealth took on a variety of meanings: material wealth, wealth of knowledge, and symbolic wealth. In these situations, there was also an underlying dichotomy in the acquisition of said wealth. In some cases, it is a wealth of knowledge given to us by the shell's mere existence. Through observation and analysis, we seek to learn more about and to celebrate the shell. In other cases, we acquired wealth through exploitation; no care was given to the shell or gastropod. Rather, it was entirely disregarded for the sole intent of material gains. For all of these gastropods, including the pink mouth murex, there is a distinct change in history that took them from an object used for material exploitation to one studied for scientific celebration.

Shells have been a part of cultures for millennia, where they took on various uses and meanings. In Greek mythology, purple dye was discovered by the dog of Heracles when he bit into a shell on the beach. This event is depicted in a Peter Paul Rubens painting, though he paints a nautilus shell instead of the accurate murex shell (Grovier). There is some debate on the exact origins of this purple dye, but it is generally agreed that it began in the Mediterranean region by 1750 BC, likely on the island of Crete by the Minoans (Stieglitz). This is supported by archeological evidence in the form of large deposits of murex shells. Based on texts from this time and place, we can also conclude that the production of this dye spread to other sites along the Mediterranean, including Troy, Cyprus, and its namesake Tyre. Within these ancient texts are the process of creating the dye, along with some of its unfathomable prices (Stieglitz).

The only recipe for creating this purple was recorded by Pliny the Elder in the first century AD, centuries after this process had been created and fiercely guarded. The recipe is specifically for wool, which would have been one of the only available textiles at the time. To dye 1000 pounds of wool, it was necessary to use over 300 pounds of shellfish, including murex (Stieglitz). The actual pigment for the dye is found in the hypobranchial gland, which is used as a predatory mechanism in living *muricidae*. Due to the size of the gland, it was only removed from larger mollusks, while the smaller ones were crushed in their entirety to get the pigment. After extracting this gland or crushing the shellfish, water and salt were added and the entire mixture was boiled for several days. The boiling and exposure to sunlight developed the color, which could range from red to purple, but generally, the darker colors were more desirable (Cartwright). This process created a horrible stench, but the color was still held in high regard. Unlike other dyes, this purple did not fade, which meant that it would never need to be redyed, as was the case with most other dyes made from plant matter. As described in the boiling process, sunlight develops this color rather than fading it. The thousands of shells required to produce even a few grams of dye created mountainous piles of discarded shells and shell fragments, at one point reported as over 40 meters high (Cartwright). The purple-producing mollusks in this region were hunted to near extinction, evidence of man's commitment to exploitation for monetary gain. Due to the resources and labor required to produce this purple, its price meant that it was available to very few. One Roman tablet reports one pound of dye costing three pounds of gold, which is equivalent to about $20,000 in today's money. For perspective, this amount could be used to dye about twelve yards of cotton, which is enough fabric to make about six shirts, putting the price at over $3300 per shirt.

The exorbitant prices meant that very few could afford to wear purple, and so it became a color that symbolized wealth. In Greece during the fifth century, purple was seen as the color of the barbarous Persians, and it was frowned upon to wear such expensive clothing (Cooksey). By the fourth century BC, this hate of the color was overwhelmed by the desire to look extravagant, and so the popularity of purple among people began to rise. There were few laws regarding who could and couldn't wear purple at this time and place, but this was changed by the Romans, who created laws that permitted only the elite to wear purple. This could take the form of a purple border on the edge of the toga, or for the emperor, a garment that was entirely purple (Cartwright). This historical use of purple is fairly well documented, and it is even mentioned in the Bible. In Acts, the Apostles travel to Philippi, a city in eastern Macedonia, where they meet Lydia, a seller of purple cloth.

While this information provides us with many answers about its origin, production, and legacy, we are still left with one question: how did they manage to create such a reliable process of making this dye when so little pigment can be found in each individual shell? Perhaps there is some truth to the mythology. In 1685, William Cole of Bristol was investigating a part of the linen industry in Ireland, which involved marking directly on the cloth with shellfish (Cooksey). Intrigued, he went to a beach to find the dog whelk, or, at the time, *Purpura capillus*. He opened a shell to expose the mollusk's hypobranchial gland, which he applied to a piece of cloth. He detailed the changes of the pigment when exposed to sunlight, noting a transition from light green, to deep green, to a "dull sea green," to blue, to a purplish red, and finally to a dark red-purple, the most desired shade (Cole). It isn't too unrealistic to theorize that a shell ended up cracked, and some early people observed this deep, purple color. From there, a purposeful process could be developed, resulting in one of the most legendary color to ever exist. Unfortunately, we will probably never know the exact circumstances that led to its discovery.

Centuries later, the Scientific Revolution was an era when people began to learn about and understand the natural world using precision and deductive thought. The sciences began to flourish, making an impact felt to this day. Within this "revolution" was a greater interest in chemistry, based on ancient Islamic studies. William Henry Perkin was an eighteen-year-old chemist working on creating a synthetic quinine. At this time, the English were trying to colonize Africa, but were deterred by the malaria-carrying mosquitoes. Quinine was able to cure malaria, but it was not easily accessible, hence the need for a synthetic solution (Schultz). His experiments with coal tar were resulting in a black, sticky goo that, when dissolved in alcohol, revealed a purple liquid. Purely by accident, he had just created the first synthetic dye (Schultz). He named his color "mauvine," and its creation made purple accessible to more than just royalty. This color was especially popular in France, and it is from a French flower that it was named. Based on his work with coal tar, more colors soon followed (The birth of (synthetic) dying). His work with coal tar provided more than just color. Many pharmaceuticals are based on the chemical compound of this substance, which was plentiful during this time of industry in England. It was a fortunate time for shellfish, whose numbers had dwindled significantly in man's quest for purple. Nowadays, it is unlikely that a dye made from animals would be considered ethical enough to have widespread use, and probably would not be created in the first place.

While Perkin's work was not with shells, it is from the same Scientific Revolution that we now have modern technology capable of helping us learn about shells. There is, unfortunately, so much that we do not know about mollusks. This has begun to change, but in-depth research is still very new, and we are learning more every day. Molecular data analysis is one method of learning about shells (Salisbury). With such a process, classification is able to become more and more precise, and reveals hundreds more species that we knew existed. Even with molecular data analysis, there are still questions we cannot answer. We are not sure the exact ways that so many different shells evolved to have similar structures, we do not know exactly why or how they are colored the way they are, and we have absolutely no idea how many distinct species there are (Salisbury). There are of course theories to try to answer some of these questions.

For color, there are both visual and non-visual theories to describe the reasons for specific shell colors and patterns (Rosenburg). Visual explanations for shell color examine the purpose or reason a shell would have a specific color. For example, some theorize the colors are for camouflage so the mollusk can protect itself from predators. In same cases, the color comes from other creatures the mollusk consumes (Rosenburg) and this pigment gets deposited in the layers of shell growth. Like many other animals, bright colors on the shell can be a warning for other predators to stay away. On the other hand, non-visual explanations for shell color propose the idea that the color of the shells is irrelevant and accidental. Overall, there is much less research to support some of these theories, but we will explore them either way. Most of these theories follow the idea that structure supports function. Perhaps pigment can create structural support to strengthen the shell; this could be the case for certain clams with pigment on the inside, where it is only observable from the outside right where the two valves come together, and would structurally be the weakest point (Rosenburg). Other nonvisual theories propose that for mollusks without predators, (which are few and far between) “anything goes” (Rosenburg). Regardless of the theories for why shells create the colors they do, it has been observed that mollusks in warmer climates produce much brighter shell colors than those in cold climates (Gillespie), which points towards the wider availability of prey and the pigments within those prey.

Due to the daily growth of its shell, mollusks provide us with a detailed record of ocean cycles (MacClintock and Pannella). Most of MacClintock’s and Pannella’s research was done on bivalves (the murex is a univalve), but similar patterns of information occur with most shells. Shells are created by secretions of calcium carbonate from the mantle of the mollusk. The mantle sits between the body and shell, and it absorbs minerals from its environment (Gillespie). The shell is built throughout the mollusk’s lifetime, and the growth lines that appear can be individually analyzed, like tree rings, to learn about ocean conditions or breeding cycles. Seasonal growth is easiest to observe. In summer, increments of 10 to 60 µm of growth can be seen, while in winter, increments of 1 to 7 µm are common (MacClintock and Pannella). These distinctions are more visible in regions further from the equator. Besides seasonal patterns, breeding has an impact on shell growth. During spawning, growth slows down significantly and suddenly, which can help distinguish it from weather changes. These are usually seen after about two to three years of the mollusk's life (MacClintock and Pannella). Fossilized shells can provide similar information, but this is more difficult to study because they must be very well preserved. The greatest benefit of studying fossils is learning about extinct species and what may have contributed to their deaths (Vermeij).

By observing the murex shell, we can theorize the evolutionary reasons for its specific shape and structure. There are questions regarding why shells evolved into so many different varieties and shapes, and how shells in different parts of the world evolved similar characteristics (Vermeij). Evidence shows that 200 million years ago, many marine shell structures were similar to freshwater species, with minimal defensive features (Vermeij). An increase of predation in post-Cambrian times created a need for shells to develop more defenses. Predators were developing jaws and teeth capable of crushing shells. Other predatory techniques included drilling, anesthesia and invasion, and suffocation. *Muricids*, like the pink mouth murex, were notable for their use of drilling to kill prey (Vermeij). Another early defense was the operculum, or "trap door," which is a calcified growth on the bottom of the foot that can be used to block off the entrance to the shell to protect the animal inside. Many species developed these defenses along with narrow apertures, or openings, and a high spire to allow the gastropod to completely enter its shell in response to the predators in their environment. Mollusks play the part of both prey and predator, cementing their vital role in their ecosystems while they are alive. Even after death, they are able to contribute. Hermit crabs rely on the discarded shells of mollusks for protection. These shells are always in high demand for both animals and humans alike.

Collections of shells, when properly catalogued, can be extensively studied and appreciated. Harry Lee is thought to have the largest private collection of shells, estimated at one million shells. He has spent the last several years donating and identifying them for the Florida Museum of Natural History Invertebrate Paleontology Division (Ramey and Ruiz). As of 2018, he had spent over 2,000 hours cataloguing mollusks. His collection features rare shells like a left-spiraling Indian chank; nearly all shells feature right-spiraling structures. Much of his time spent volunteering at the museum is examining fossil micromollusks, which are mollusks with shells measuring less than 5.5 mm (Ramey and Ruiz). This is exceptionally tedious, but invaluable, work. Fossil micromollusks can teach us a lot about prehistoric times, further emphasizing the wealth of knowledge we are capable of learning from these shells. One difficulty is the time it takes to characterize each shell. Both the Florida and Orma J. Smith Natural History Museums are full of cabinet after cabinet of unmarked shells waiting their turn to be identified. As a starting place, the scientific names of species often gives a good idea of their visual identity, and their most noticeable characteristic.

The pink mouth murex's scientific name, *hexaplex erythrostomus*, tells us quite a bit. *Hexa* is our root word for six, and *plex* is our root for fold. This describes part of the structure of the shell, the varix, which is a thickened protrusion around the whorl, or spiral. "Six" can be a little misleading because species within this genus can have between five and eight varices. *Erytho* means red, and *stomus* can refer to a mouth or opening; the pink mouth murex is named for its lovely pink interior. The exact source or reason for this color is unknown, but it is likely a result of diet and circumstance more so than camouflage because the pink is not very visible in a living animal. Its initial name was *murex erythrostomus* and was identified in 1831. *Hexaplex* was added to its name after determining its genus, while *erythrostomus* remained as a visual descriptor.

The pink mouth murex is native to the Pacific Ocean along the coast of Central and South America from Baja California to Peru. It was used by local people as a food source, much like the delicacy *escargot* in France (Salisbury). The pink mouth murex is not very prevalent in any of countries where it is found, but other shells are. In Teotihuacan, a part of the Aztec empire, a painted shell was found depicting symbols related to a ritual calendar (Mursell). Many more were found on *ofrendas* in Tenochtitlan, the capital of the Aztec empire. Conches in particular were held in high regard due to their association with the wind god, Quetzalcoatl. They were used as instruments by cutting and sanding one end of it so it could be blown into like a horn (Kriebel). Tools were also created from shells. From all of the above uses, we can conclude that shells were extremely important to coastal societies for both practical and ritual purposes. Local use of these shells does not have the same exploitive nature as their use in the Mediterranean region. There, species were hunted to near extinction in the pursuit of monetary gains, while in Mexico, they were used for more personal or cultural reasons. Most of their shells were likely acquired after they had washed up on beaches, rather than purposefully being caught and killed. It is interesting to see how different coastal cultures viewed shells and their importance. They were a part of everyone's daily life, and were valuable, but they were valuable in different ways for different cultures. The were more important as a symbol for the Aztecs, while for the Greeks, they were more important for how they could be used to gain wealth.

"Wealth" can be simply defined as an excess of something. In most connotations, this is an excess of money or other material possessions. However, this is a very limiting—and understandably negative—point of view. A wealth of some things is a reason to celebrate. Our world is filled with a wealth of knowledge, of biodiversity, of cultural significance, and these can all be seen in one little shell. By virtue of its mere existence, it can teach us about years, or even millennium, past. The pink mouth murex is classified as a mollusk, the second-largest phylum of invertebrates with some one-hundred-thousand distinct species currently known, and with molecular data analysis, this number is growing. Shells have been significant in Mexican, Greek, and Roman societies, and likely a play a role in nearly every culture by the sea. This role varies. Sometimes the shell is used and appreciated simply as a shell, and sometimes the shell is used as a source of another material. It is primarily here that the dichotomy in the acquisition of wealth exists. Wealth is something that can be freely given or forcefully taken. When given, it takes the role of a teacher and shows us history and life. When taken, it becomes a commodity, no longer having value by virtue of its existence, but by how it can be used.

In a glass case in the Orma J. Smith Natural History Museum lays a shell. A pink shell that stands out among the other browns and earthen colors. It doesn't have much detail: Pink Mouth Murex, *hexaplex erythrostomus,* Indo-Pacific. Many would see that shell as simply a shell, unaware of everything else it can be. It is a source of unfathomable riches, exploited for its rare purple pigment. It is a record, teaching us all about the ocean throughout its lifetime. It is a predator, ready to break down defenses it too has built. It is a meal, consumed by marine and terrestrial life alike. It is a skeleton, the only remnant of the gastropod that once created and inhabited it. It is a home, used by others as a means of protection to survive a harsh world. It is a symbol, representing everything from power to a god. It is something that begs to be seen, to be heard. Nature can be the greatest teacher if only we know how to listen. When you look at the pink mouth murex, you see wealth in every sense of the word; you see more than just a shell if you just take the time to look closer.

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