Systematics and Ecology

There are hundreds of thousands of species living in our oceans. How do scientists group these creatures into a logical order? There are two main classification schemes used by biologists today. The most commonly used system is based on the evolutionary history of an organism, and is known as systematics. Another method used to classify organisms is known as functional classification, based on how an organism interacts with its environment. The laboratory exercise this week will explore these classification systems and examine the ecological role of organisms in the benthic environment.

SYSTEMATIC CLASSIFICATION

This type of classification is based on an organism's evolutionary history. When the system began, in the 1700s, it was based on morphological characteristics. Basically, the shape and structure of an organism is used to determine the relationship between different organisms. For example, the bone structure in the feet of animals can be examined for similarities and differences to infer how closely related organisms are. With the discovery of DNA, and the advancement of molecular technologies in the late 1900s, scientists are now able to determine how closely related different species are based on DNA. This technique is used to calculate the genetic distance between organisms. We will go into greater detail of these techniques in the microplankton lab.

Currently systematics classifies all life on earth into three different domains. Each domain is further broken down to organize the organisms within it using the following scheme: Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species. The domain is the most broad grouping and the species is the most specific. In this week's lab, we will look at specimens from the kingdom Animalia, found in the domain Eukarya. There are seven different phyla represented in the lab exercise, and a brief description of each phylum is given on the following pages. Also shown below is a hierarchy of the terms used.

- **Domain**: Eukarya
  - **Kingdom**: Animalia
    - **Phylum**: Porifera
    - **Phylum**: Cnidaria
    - **Phylum**: Annelida
    - **Phylum**: Mollusca
    - **Phylum**: Arthropoda
    - **Phylum**: Echinodermata
    - **Phylum**: Chordata
      - **Class**: Mammalia
        - **Order**: Primates
          - **Family**: Hominidae
            - **Genus**: Homo
              - **Species**: sapiens (This is YOU!!)
Porifera

Phylum Porifera includes sponges in either encrusting or vase-shaped masses that live on hard substrates. A sponge is a suspension feeder that strains plankton and small food particles from the water using the small pores covering its body. A large sponge may filter 1,500 liters of water each day. Sponges are simple organisms with no circulatory, respiratory, or nervous systems but do have individual digestive cells to process food particles. Sponges contain a network of spicules, or sharp needles and spines composed of either silica or calcium carbonate located within their tissue which helps deter predators. (Photo: encrusting sponge)

Cnidaria

Organisms in phylum Cnidaria have stinging cells called nematocysts and exhibit radial symmetry, a body form that radiates from a central disc. Cnidarians have two body forms. Jellyfish and portuguese-man-of-wars are examples of the mobile medusa form, while sea anemones and corals are sedentary polyps. Some corals, sea anemones, and zoanthids contain endosymbiotic algae also known as zooxanthellae. The symbiotic relationship between the coral and zooxanthellae is mutualistic because the zooxanthellae photosynthesize to provide oxygen and carbohydrates for the coral, while the coral provides a house for the zooxanthellae as well as the carbon dioxide and nutrients necessary for photosynthesis. (Photo: Pocillopora meandrina, coral)

Annelida

Phylum Annelida includes segmented worms of the class Polychaeta, the most abundant marine worms. Polychaetes are often brightly colored and can have bristly projections extending from segments or feather duster tops, useful in both gas exchange and prey capture. Polychates are usually found in the sediment and can produce calcareous tubes that allow only their heads to emerge. Many are suspension and deposit feeders. (Photo: Eurythoe complanata, fire worm)

Mollusca

Organisms in phylum Mollusca have a soft-body, internal or external shell, and foot. Common mollusks include snails, bivalves, squid, and octopus. External shells help protect their soft tissue that predators find especially tasty. Those without shells have other adaptations including sea slugs that secrete poison, octopus that change pigmentation for camouflage, or squid that secrete ink to fool their predator while they make a fast escape. (Photo: Hexabranchus sanguineus, spanish dancer slug)
**Arthropoda**

Phylum *Arthropoda* includes an abundance of organisms including crabs, shrimp, lobsters, barnacles, pycnogonids, and copepods. Arthropods are characterized by hard exoskeletons that fit so snugly that they must **molt** their exoskeleton during periods of growth. Arthropods have **articulated joints** that are able to bend at specific points and allow a full range of motion.

(Photo: *Carpilus maculates*, crab)

**Echinodermata**

*Spiny-skinned* organisms including sea stars, brittle stars, crinoids, sea urchins, and sea cucumbers are classified into phylum *Echinodermata*. Echinoderms have **radially symmetric bodies** based on five sections, and reside on hard substrates, sandy bottoms, and sediments. Echinoderms use a water vascular system, very similar to the hydraulic brake line on your car, to power little tube feet which are used for movement and prey capture.

Photos: (top) Phylum *Echinodermata*, *Heterocentrotus mammillatus* (pencil slate urchin) and (bottom) *Actinopyga mauritiana* (speckled sea cucumber)

**Chordata**

Phylum *Chordata* includes several invertebrates as well as all vertebrates. During development, some invertebrates including tunicates (sea squirts) display several features characteristic of vertebrates and are therefore included in this phylum. About 95% of chordates are true vertebrates that possess backbones. Vertebrate chordates present in Hawai‘i include fish, mammals (humpback whale, spinner dolphin, monk seal), reptiles (turtles), and seabirds. (Photo: Phylum *Chordata*, tunicate)
<table>
<thead>
<tr>
<th>Phylum</th>
<th>Characteristics</th>
<th>Marine examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porifera</td>
<td>Asymmetry in body shape, absence of a digestive system, pores, spicules forming endoskeleton, suspension feeders, produce chemicals against grazers</td>
<td>sponge</td>
</tr>
<tr>
<td>Cnidaria</td>
<td>Radial symmetry, primitive digestive system (only one cavity), nematocyst cells as defense- and capturing prey mechanism, feed on suspended particles, some bare endosymbionts</td>
<td>coral, jellyfish, sea anemones</td>
</tr>
<tr>
<td>Annelida</td>
<td>Bilateral symmetry, Protostomes (mouth originates before than anus), segmented bodies containing each a set of internal organs, buried in sediments or hard substrates, deposit-, filter feeding or carnivores</td>
<td>polychaetes</td>
</tr>
<tr>
<td>Mollusca</td>
<td>Bilaterally symmetrical, Protostomes, soft-body, external or internal shell (protection against predators), well developed nervous system</td>
<td>snails, bivalves, squid, octopus</td>
</tr>
<tr>
<td>Arthropoda</td>
<td>Bilateral symmetry, Protostomes, hard exoskeleton (molts) which work as protection for predators, articulated joints</td>
<td>crabs, shrimp, lobsters, barnacles, copepods, pycnogonids, amphipods</td>
</tr>
<tr>
<td>Echinodermata</td>
<td>Bilateral symmetry (on larval stages), Deuterostomes (anus originates before than mouth), spiny skin which serves as hard armor against predators, radial symmetry with 5 sections in most adults symmetry</td>
<td>sea stars, sea urchins, sea cucumbers, crinoids,</td>
</tr>
<tr>
<td>Chordata (invertebrates)</td>
<td>Bilateral symmetry, Deuterostomes notochord, primitive nervous system</td>
<td>sea squirts</td>
</tr>
<tr>
<td>Chordata (vertebrates)</td>
<td>Bilateral symmetry, deuterostomes, spinal chord, well developed nervous system</td>
<td>fish, mammals (whale, dolphin, monk seal), birds, reptiles</td>
</tr>
</tbody>
</table>
FUNCTIONAL CLASSIFICATION

The second classification scheme scientists use is based on how an organism relates with its environment - rather than its evolutionary history. This organization allows scientists to group organisms based on their lifestyle.

Location

Organisms can be grouped according to many functional schemes. First, where does it live? Benthic organisms live on the bottom of the ocean, while pelagic ones live up in the water column. Most of the animals in this lab activity are benthic. Benthic organisms can further be classified as living on top of the sediment, epifauna, or in the sediment, infauna.

Locomotion

Does the organism move? Those that can move are considered motile (think of a crab crawling on the bottom). Organisms that do not move around are called sessile (think of a coral polyp).

Feeding

How does the animal feed? Suspension feeders are specially adapted to filter food particles out of the water column. Some, such as barnacles, have specialized appendages that can be passed through the water column like sieves to collect particles.

Some soft-sediment benthos feed directly on the sediments themselves. This type of food-gathering is known as deposit feeding. Much of the nutrition available in the sediments is in the form of detritus, or organic debris from fecal material or plant and animal remains that has settled to the bottom. Deposit feeders ingest bulk sediment, and digest any organic material or bacteria contained on the sediment as it passes through their digestive system. Some sea cucumbers are deposit feeders.

Predatory animals, those that prey on other animals, are also common in the benthos. Sea stars are particularly effective predators, with eversible stomachs that they can insert into the shells of other organisms to digest them whole.

Scavenging is a common form of nutrition in the extremely food-poor deep-sea habitats. Scavengers such as hagfish can smell carcasses of dead animals that have fallen to the sea floor, and will congregate to feed on them. Many scavenging animals have the ability to eat huge amounts of food at one time, an adaptation that allows them to take advantage of relatively rare feeding opportunities.
Reproduction

Many different reproductive techniques have evolved in the ocean; we will focus on two. Some organisms carry their developing eggs and larvae around with them, a behavior known as brooding. The majority, however, produce free-swimming larvae which drift in the water and are known as plankton. Spawning occurs when adults release eggs and sperm into the water column, where they must come into contact with one another for fertilization to occur. The fertilized egg then develops in the water column until a free-swimming larva hatches from it. The larva must eventually find a suitable substrate on which to settle, and undergo metamorphosis into an adult. This reproductive strategy provides many benefits.

For organisms that are not free-swimming, planktonic larvae are an important means of dispersal that helps the species to colonize new habitats. Some larvae can spend months in the plankton and travel across entire ocean basins! In addition, by producing larvae that will travel to a different area before developing into feeding adults, competition among members of the same species is reduced. There is also some relief from predation on larvae as they develop in the water column, but of course they are subject to predation by pelagic organisms.