SPONGES - THE FIRST INVERTEBRATE

Sponges are kind of like the exception to the rules of invertebrates. They are so basic that they have not developed many of the characteristics you might think of when you think of animals. Most sponges are found in seawater, only a few in fresh water. You may have even seen a couple around your bathtub! The ones around your bathtub might look like sponges but they are usually man made. When we talk about sponge structure, remember all the holes. They are very important.

STAGES OF LIFE

There are two basic forms in the life cycle of a sponge. Most sponges live their lives attached to a reef. They don't move around. There was a time in their lives when they were little **larvae** that they were swimming around the water all by themselves. The word larva is another way to describe them when they are babies. Baby sponges don't look like adult sponges, so scientists use another word. Once the larvae land on a piece of rock, they take root (so to speak) and that's that, forever anchored.

Sponges are really just a bunch of specialized cells working together to help the entire organism survive. Sponges do not have nervous systems, so they don't react to the world around them. Sponges are in the shape of a big "U." On the outside of the U are protective cells, but on the inside are these very special cells with little **flagella** (wildly whipping tail structures). Those flagella are constantly moving and keeping the water circulating inside of the sponge. Water is sucked in through holes/**pores** in the side of the sponge. We told you to remember the holes. When the water moves through the sponge, tiny food particles are **filtered** out of the water by the flagella. Then the water gets pushed out of the sponge through a hole called an osculum. That's basically

the life of a sponge. Suck the water in, filter out the food, and send the water out.

THE CHOANOCYTE

The entire life of a sponge revolves around one type of cell. We already told you about flagella. Those flagella are part of a cell called a **choanocyte**. It's a cell that has three basic parts: flagella, collar, and cell body. Sponges use the flagella to move when they are larvae. The flagella and collar work together to gather food. Sponges even use the choanocyte when it's time to reproduce. Wow! It's a really busy cell.

ARTHROPODS - INVERTEBRATE POWERHOUSES

We'll start with the big numbers. About 75% of all animal species are **arthropods**. There may be more individual worms in the world, but there are more different types of arthropod than any other group on the plant. You'll find insects, spiders, crabs, lobsters, barnacles, centipedes, and even hundreds of extinct species in fossils.

BASIC STRUCTURE STUFF

You know the first one. Arthropods all have **exoskeletons**. Exoskeletons are hard outer shells made of **chitin**. While you have an endoskeleton, a crab has a tough shell that protects it from the outside world. You might be wondering how an arthropod can get bigger if it has a hard outer skeleton. Doesn't it outgrow the shell? Yes. It has to shake off the shell and let a new one grow every now and then. When an arthropod loses one exoskeleton to grow bigger, it's called molting. Not all exoskeletons are the same. While they may all have chitin, a shell created by the epidermis, crustaceans have an extra layer that is **calcified**. That calcification makes it much sturdier and much heavier.

Next on the list are the arms and legs. They have jointed **appendages**. That's what the name arthropod means. jointed leg. They usually have several legs, more than the four that mammals have. Inside those joints and exoskeletons are muscles that help the organisms move. Arthropods also have very advanced sense organs.

You are probably familiar with the faceted eyes of flies and **antennae** on insects. Those are great examples of how arthropods are prepared to interact with the world. They even have groups of neurons that think and help the organism hunt, move around, and find a mate. They also have open circulatory systems. These systems circulate

nutrients throughout the inside of that exoskeleton so the muscles receive all the energy needed to move quickly.

MAJOR CATEGORIES

There are three major types of arthropod. **Chelicerates** include species such as spiders and horseshoe crabs. **Uniramians** include centipedes, millipedes and the biggest group of arthropods. Insects. **Crustaceans** are the last category of arthropod. Crustaceans include crabs and lobsters. They are mainly aquatic species.

METAMORPHOSIS

We have one more big idea to introduce about arthropod development. **Metamorphosis** is a process where you change your body shape as you grow.

You may have learned about caterpillars changing into butterflies. That is a complete metamorphosis. **Complete metamorphosis** means that the entire body shape has changed (wormlike into insect with wings).

The other type of metamorphosis is called **gradual metamorphosis**. Grasshoppers are a good example of a gradual one. They start off as small odd-shaped grasshoppers with no wings. As time passes, they molt their exoskeletons and grow wings. It's not a big change like a butterfly.

MOLLUSKS – DIVERSE INVERTEBRATES

From the Latin *Molluscus* meaning soft of body.

Mollusks (Phylum Mollusca) are a highly diverse group of animals that include cephalopods (squid, octopuses, cuttlefish), gastropods (nudibranchs, snails, slugs, limpets, sea hares), bivalves (mussels, clams, oysters, scallops) and many other groups of organisms. There are an estimated total of more than 250,000 species of molluscs.

Mollusks are a large group of invertebrate animals. Mollusks have soft bodies, and their bodies are not divided into rings like the segmented worms called annelids. Mollusks don't have legs, though some have flexible tentacles for sensing their environment or grabbing things. Most mollusk species grow a hard shell for protection, but their shell grows in only one or two pieces. It doesn't have joints like the exoskeletons of insects and crustaceans.

Characteristics of Mollusca:

1)Bilaterally symmetrical.
2)Body has more than two cell layers, tissues and organs.
3)Body without cavity.
4)Body possesses a through gut with mouth and anus.
5)Body monomeric and highly variable in form, may possess a dorsal or lateral shells of protein and calcareous spicules.
6)Has a nervous system with a circum-oesophagal ring, ganglia and paired nerve chords.
7)Has an open circulatory system with a heart and an aorta.
8)Has gaseous exchange organs called ctenidial gills.
9)Has a pair of kidneys.
10)Reproduction normally sexual and gonochoristic.
11)Feed a wide range of material.
12)Live in most environments.

There are almost 100,000 species of mollusks around the world, and many tens of thousands more undiscovered. Most mollusk species only live in the ocean, but some live in freshwater or on land. In Michigan there are about 300 species of mollusks known, with more to be found.

BASIC STRUCTURES

They also exhibit an enormous range in size, from species which are almost microscopic to the largest of all invertebrates the giant squid which can weighs 270 kg and measures up to 12 metres long in the body, with tentacles as much as another 50 metres in length. Many species are common and many more beautiful. Most species secrete a shell of some sort, these shells are long lasting and have been collected by human beings for thousands of years, some of these shells, and the pearls which come from oysters, which are also molluscs may be among the earliest forms of money.

Most molluscs are marine. Molluscs are very ancient organisms believed to have evolved from a flatworm like ancestor during the Precambrium about 650 million years ago. Because many species secrete a shell of some sort the fossil record is good.

ANNELIDS - WORMS WITH SEGMENTS

From the Latin *Annellus* a little ring.

The Annelida are a medium sized phylum of more than 9,000 species. Most species prefer aquatic environments, but there are also a number of well know terrestrial species. Earthworms and leeches are most famous. The basic Annelids normally have long thin bodies composed of a series of identical segments. The segments each contain elements of such body systems as circulatory, nervous, and excretory tracts. If one segment is damaged, some annelids can go on living. You are not segmented. You have one of everything. If you lose something... Too bad.

Growth occurs both laterally, by enlargement of the segments during the juvenile stages, and through the addition of new segments. In some species they are produced throughout the animals life but in many species production stops once a certain set number of segments has been achieved.

Annelids are able to move around by contracting their little segments. They have parts called **setae** attached to each body segment. Setae are two pairs of hairs on each segment. Those hairs help some annelids (earthworms) get a grip on the soil. They are able to move through the soil easier with those setae.

NEMATODES - WORMS THAT ARE ROUND

Nematodes are also called round worms. You might not know (but now you do) that there are more roundworms in the world than any other creature. They are small and they are all over the place. If you are having problems imagining that, remember that there is an entire bottom of the ocean where insects and fish can't live. Guess who can?

We like telling you what makes each type of animal special. Nematodes are also special. While you may see a small smooth worm, scientists see creatures that have a gut that is complete. Mouth, lips, **gut**, and a hole when basic digestion is done. That complete gut was one of the first steps to organizing physiological **systems**.

They do not have specialized circulatory systems like annelids. Nematodes have **bilateral symmetry** (both halves look the same). They also have special muscles that move down the length of that entire round body. Annelids (segmented worms) are different in that their muscles just work in each segment.

Nematodes act like predators, hunting down other creatures. They are parasites, surviving at the expense of a host. The best example of nematodes as parasites is a disease called **Trichinosis**. Some are also herbivores, eating plant material and algae. How do they get so many places? It helps that so many species of nematode are very small. You need a microscope to see most of them. Hookworms and Pinworms are examples of roundworms.

FLATWORMS - UMMM. THEY'RE FLAT

There are over 20,000 known species. Most of the species are **parasitic**. The big things you should remember is that they are flat and they are found in every environment that has water.

Tapeworms are always a nasty example. They live in intestinal tracts of many species. Cats, dogs, and even you could wind up with tapeworms. You'll also hear about **flukes**. It's another parasitic species that has a close relationship with man and other mammals. They are suckers in the flatworm family. **Planaria** are harmless flatworms that are

often used in your biology labs. They are freshwater flatworms that have a head like an arrow.

Most are very small and not obvious immediately. There are species in many freshwater and saltwater environments as well as inside larger organisms. Since many flatworms are parasites, they have lifecycles in different hosts. Eggs may be deposited in the feces of one species. Another organism might eat those eggs and development begins in the digestive system. The flatworm might then mature in the muscle tissue. Flatworms can get around.

Although really simple, flatworms have some advanced structures compared to some other animals. They were the first species to develop **mesoderm**. That mesoderm tissue develops into organs and muscles as the organism grows. They also have simple nervous systems and sensory organs.

While they don't have a respiratory system or circulatory system to speak of, they do have a neat little digestive system. Most species of flatworms have no **anus** and a cavity with only one opening. While not all species do, many flatworm species use a mouth to eat. The only problem with no anus is that the stuff you don't digest has to go out the mouth when you're done. Other materials that need to be removed from the system can be excreted through specialized cells called **flame cells**. Flame cells are the first appearance of excretory ducts in organisms. Flame cells have cilia that beat and filter out materials that the flatworm wants to get rid of.

BIRDS

Common name for any member of the vertebrate class Aves. Diagnosis of the class is simple: Any animal with feathers is a bird, because feathers are unique to birds. All adult birds have feathers, although some kinds, such as pelicans, kingfishers, woodpeckers, and jays, are completely naked when hatched.

Birds share certain features with mammals, such as warm-bloodedness and a four-chambered heart. Nevertheless, birds are distinct, believed to have evolved from dinosaurs long after the mammalian and reptilian groups diverged. All birds, like most reptiles and a few primitive mammals, develop from embryos in eggs outside the mother's body. Unlike most reptile eggs, those of birds have hard shells, which are very strong in large birds and rather brittle in small birds.

Anatomy and Physiology

Most living birds can fly; all are descended from ancestors that could fly. The bodies of birds are therefore highly modified for efficiency in flight. The digital and wrist bones of the forelimb are extensively fused to form a rigid support for the large flight feathers of the wing. Fusing of bones for strength and lightness is also found in the skull and pelvic girdle. Many bones of adult birds are hollow rather than filled with marrow and are connected to a system of air sacs dispersed throughout the body. The sternum, or breast bone, of most birds is huge relative to the rest of the anatomy and bears a central ridge, or keel, known as the carina. The sternum and carina support some of the major muscles used in flying. In the ratite birds--including the ostrich (*Struthio camelus*), the kiwis (genus *Apteryx*), and their relatives--which

have lost the power of flight, the carina has been lost, and the sternum is reduced in size.

The jaws of modern birds are extended as toothless bills or beaks, covered with a layer called the ramphotheca, which may be hard, as in most birds, or leathery, as in sandpipers and ducks. Toothlessness lightens the weight of the skull.

Birds have no sweat glands and cannot cool the body by perspiring. When birds are in flight, excess heat is dispersed by the passage of air through the air sacs. When they are at rest, they rid themselves of heat by panting.

A winter survival technique well known in mammals but rare in birds is a slowing of the physiological processes, including reduction of body temperature, resulting in extreme cases in hibernation. Hibernation in birds was long thought to be a myth. Recent research has shown, however, that several species of nightjars, swifts, and hummingbirds that live in desert or high mountain areas, where winter nights are very cold, can enter a hibernation-like condition of torpor to conserve energy.

MAMMALS

Common name for any warm-blooded animal belonging to the class Mammalia, including humans and all other animals that nourish their young with milk, that are covered with varying amounts of hair, and that possess a muscular diaphragm. Mammals have the most highly developed nervous systems of all animals. Most members of the group have four appendages, usually legs. These may be adapted for use as swimming appendages, as in seals, or as wings, as in bats. Some types, however, have two limbs that have been reduced to small vestiges beneath the skin, as in whales, or have been lost altogether, as in sea cows. All mammals, except the egg-laying monotremes, produce live young that undergo the early stages of development within the body of the mother . Mammalians are helpless at birth. The largest mammal, the blue whale, often exceeds 30 m (100 ft) in length, and the smallest shrews, mice, and bats are often less than 5 cm (less than 2 in) in length, excluding the tail.

Anatomy

The outer layer of the mammalian body, called the integument, consists of the skin and its derivatives. The skin, equipped with varying amounts of hair, serves as a protective layer against mechanical injury or invasion by germs, and prevents excessive loss or gain of body heat and moisture. In many mammals the color of the skin or fur blends with the animal's natural surroundings. The skin also functions as a sensory, excretory, and respiratory organ and contains specialized glands.

The internal organs of mammals are essentially the same from the most primitive to the most complex. The internal features that distinguish mammals from lower vertebrates

are the presence of two to four optic lobes in the brain, the presence of a muscular diaphragm separating the heart and lungs from the abdominal cavity, the presence of a single aortic arch located on the left side of the body, the possession of a **four-chambered heart**, including two auricles and two ventricles, and the absence of nuclei in red blood corpuscles after birth. All mammals except sea cows and certain sloths have seven cervical (neck) vertebrae; this characteristic is possessed by the long-necked giraffe and the largest whales as well as by mice and other tiny mammals.

Reproduction

All mammals reproduce sexually, and two types of reproductive acts are used to bring about sexual conjugation. After fertilization, development of offspring takes place entirely within the body of the mother in all mammals except the monotremes, which produce leathery-shelled eggs with large yolks. After birth, mammalian young are not prepared to pursue an independent existence but must be taken care of during infancy.

Classification

Mammals are classified differently by many zoologists. The class Mammalia, which is represented by about 4500 living species, is usually divided into three subclasses: the Monotremata (Platypus) or egg-laying mammals , the Marsupialia (Kangaroo) or marsupial mammals , and the Placentalia (Humans) or placental mammals.

AMPHIBIANS

Common name for any animal of the vertebrate class Amphibia, lying between fishes and reptiles on the evolutionary scale. Emerging from the oceans almost 400 million years ago, amphibians were the first vertebrates (animals with a backbone) to live on land. The class, with about 4400 existing species, includes three living orders:

1. Caudata, or tailed amphibians, consisting of the salamanders, including newts and sirens;
2. Anura (or Salientia), or tailless amphibians, which includes frogs and toads;
3. Gymnophiona, or caecilians, which are worm- like amphibians that are limbless and blind.

With their slender bodies and long tails, some amphibians, such as the salamanders, may be mistaken for lizards and other reptiles. Unlike reptiles, however, amphibians have no scales, and most must stay close to water to survive.

Physical Characteristics

The skin of many vertebrates is protected by fur, feathers, or scales, but most amphibians have no skin covering. They are generally smooth and moist, except for the caecilians, which have small scales in the outer folds of the body. The inner skin has many blood vessels, which aid respiration, and numerous glands that secrete a fluid that is often irritating and poisonous. Color cells in the skin can, by contraction or expansion, cause skin color changes, as seen in some tree frogs. The outer skin is continually being renewed, and is sometimes shed in large patches that may be eaten by the amphibian. Besides growing new skin, some salamanders can regenerate whole limbs. Male and female

amphibians often differ in size and color, and males may have vocal sacs, swollen thumbs, and skin frills.

Internal structure

The skeletal, muscular, digestive, nervous, and other systems of the typical amphibian are similar to those of higher animals. The amphibian brain, however, is notable in that the cerebellum is a mere connecting band. The adult heart consists of a muscular ventricle and two auricles, but during the gill-breathing larval stage the circulation resembles that of fishes. The teeth and tongue vary in form and are sometimes absent altogether.

Body temperature

Like reptiles, amphibians are described as cold-blooded; body temperature varies with the temperature of the environment and is generally much lower than that of birds and mammals. Because they rely on external sources of warmth, amphibians in cool regions hibernate through the winter.

Behavior and Habitat

In mating and feeding, amphibians are quite active at night. Most spend at least part of their lives in moist surroundings, and their fragile, jellylike eggs are usually laid in water. The eggs of most species hatch into larvae called tadpoles. These gill-breathing tadpoles commonly metamorphose, that is, their bodies change and they grow into air-breathing adults. Some amphibians, however, become sexually mature in the larval stage and never metamorphose, and some have both gills and lungs. Adult amphibians are carnivorous, eating mainly insects, slugs, and worms; tadpoles are mainly herbivorous.

REPTILES

Millions of years ago, during the Mesozoic era, dinosaurs and other reptiles were the most numerous vertebrate animals on the earth. Reptiles have since been reduced from 17 recognized orders to just four:

1. Squamata, with about 3000 species of lizards, 2500 of snakes,
2. Chelonia, or Testudines, comprised of about 250 species of turtles,
3. Crocodylia, including 21 species of crocodiles, alligators,
4. Rhynchocephalia, which flourished during the Jurassic period but today is represented only by the tuatara, which lives on several islands off the coast of New Zealand.

Like most classes of vertebrates (animals that have a backbone) reptiles vary in size. The increasingly rare Indian gavial may reach a length of 9 m (30 ft) and weigh 540 kg (1200 lb). The gecko lizard, by contrast, is typically 3 cm (1.2 in) long. Reptiles also include a fascinating range in behavior and appearance; yet, from the timid box turtle to the savage Komodo dragon, all share certain traits that set them apart as reptiles.

Physical Characteristics

All reptiles have scaly, thick, waterproof skin that is dry to the touch. Turtles and tortoises have wide, flat ribs over which is laid the "shell" of horny or leathery scales that serves as protective armor. Snakes and many other species molt: As they grow, they periodically shed the outer skin, revealing a new layer that has grown under the old. Turtles and tortoises gain new shells in much the same way.

All reptiles, even aquatic species, breathe through lungs. In most snakes and some lizards only one lung is functional; in

crocodiles and other reptiles both lungs are equally developed. The thorax and abdomen in reptiles are not separated by a diaphragm, and breathing is accomplished by muscles of the body wall. The reptilian heart generally consists of three chambers, two auricles and one ventricle. In the crocodilian heart, however, the ventricle is almost completely divided into two chambers by a septum, or partition. Blood is pumped from the heart to the rest of the reptile's body through arteries. Carnivorous reptiles frequently have fairly simple digestive systems; those that are herbivorous have a more complicated arrangement. All have an intestine for excretion; the urinary bladder is present only in turtles and lizards.

Body temperature

Reptiles are commonly described as cold-blooded, although the term can be misleading. When active, some reptiles maintain their bodies at a higher temperature than do most mammals. The important difference in temperature physiology is that reptiles rely on external sources of heat, whereas birds (which may be descended from ancient reptiles) and mammals generate internal heat. Reptiles regulate their body temperatures by taking advantage of sources of outside warmth, such as direct sunlight, warm surfaces, and the earth itself. Often the body temperature of a reptile is well above that of the surrounding air. Only when the animal is inactive or dormant is body temperature approximately the same as that of the environment.

Eating Habits

Crocodiles, snakes, and lizards are meat-eaters, as is the tuatara. Turtles and tortoises can be categorized as omnivorous; those that live on land generally eat vegetable

matter, but aquatic species are largely carnivorous.

Reproduction

Most reptiles reproduce sexually, and most mate in the spring. Female turtles, crocodilians, and the tuatara are primitively oviparous--that is, they lay eggs. Most snakes and lizards lay eggs as well. Other reptiles, such as the anaconda, are viviparous--that is, they give birth to living young; and some, such as vipers, are ovoviparous--that is, they give birth to living young from eggs hatched inside the mother's body. Some large sea turtles may lay as many as 200 eggs in a clutch; the tiny geckos generally lay two eggs at a time. In many species the eggs are left to develop by themselves in a sheltered area, where they may draw heat from the sun or the overall environment and be protected from predators. Many, however, are lost to birds, mammals, and other reptiles.

Habitat

Reptiles inhabit most parts of the world, but because of their need to obtain warmth from the environment, they do not live or develop in colder regions. Most are found between 40°N and 40°S lat. In temperate regions they may hibernate during the winter, and in hot climates they frequently estivate--lie motionless, in a state of torpor, during periods of intense heat. Thus, reptiles in the Tropics generally are more active at night than during the day, when they tend to lie in the shade. Water-dwelling turtles and tortoises are adapted to the ambient temperature of the environment where they live, but none are found in the Arctic or Antarctic regions.

FISH

Fish have been around for 500 million years. There are about 25,000 different species of fish alive today. They are an aquatic vertebrate animal, usually possessing gills in the adult stage and having limbs, when present, in the forms of fins. Unlike other commonly recognized groups of animals, the fishes are a heterogeneous assemblage of groups that cannot be recognized by any defining trait (as mammals, for example, can be recognized by the presence of mammary glands or hair). Consequently, there are exceptions to the definition given here. Fishes are usually understood to include the jawless vertebrates such as the lamprey and hagfish, and the shark, ray, chimaera, lungfish, and bony fishes. The latter group includes the forms most commonly known as fish.

Anatomy

In general, fishes are somewhat torpedo-shaped, with bodies that are moderately compressed at the sides and taper more markedly at the tail than at the head. The fundamental feature is the serially repeated set of vertebrae and segmented muscles, readily seen in a filet or skin specimen, that enable the fish to propel itself by moving from side to side. Typically, the body carries a number of fins, which are membranes supported by rays or spines, that function in propulsion or orientation. Great diversity exists in the shape and anatomical details of fishes, ranging from the string-like eel to the globe-shaped puffer or greatly flattened fluke. Fins are often much modified or absent in accord with the diverse modes of life. Fish are also cold-blooded, which means their body temperature changes or adjusts based on its habitat. In cold water, they are cold.

The bodies of most fishes are covered with a layer of scales,

which are bony or horny plates arranged in overlapping rows, with the free posterior end of one scale overlapping the attached anterior end of the scale behind it. A thin epidermis usually covers the scales. In a number of species the scales develop into bony plates. In some species, such as the eel, the scales are minute. In others, such as the catfish, they are almost absent.

The respiratory apparatus of jawed fishes consists of a series of slits, the gill clefts, which open from the pharynx to the gill chambers at either side of the back of the head. These chambers open to the water outside, but can be covered by a series of bones called the gill cover. Inside the gill chamber and in the gill clefts are the gills themselves, which assume the form of thin sheets or filaments through which the blood circulates. When the fish takes in water and expels it through the gills, dissolved oxygen passes across the thin gill membranes into the blood, and carbon dioxide waste passes out of the blood into the water.

Reproduction

Fishes exhibit diverse means of producing young. Oviparous fishes are those that lay eggs that are fertilized outside the female's body. In such species, development of the young is also external. Species that scatter eggs in open water often produce eggs in prodigious quantities. A single cod, for example, may produce in excess of 3 million eggs. Other egg-layers, such as the Pacific salmon, may undertake remarkable homing migrations in association with spawning activity. Parental care after hatching may be absent or elaborate, often involving the defense of a nest or territory.

Habitat Diversity

Fishes occupy almost every conceivable aquatic habitat. Some fishes live in almost pure fresh water, while a killifish in Hispaniola tolerates salinity as high as four times that of the sea. Cave fishes may pass their lives in complete darkness, while fishes in desert marshes experience record levels of solar radiation.

Classification

Fishes are classified differently by different zoologists. They are mainly divided into three superclasses: **Agnatha**, which includes the lamprey and other fishes without jaws; the **Chondrichthyes**--the cartilaginous fishes such as the shark, ray, and chimaera, and the class **Osteichthyes**--the bony fishes such as salmon, minnow, tuna, pike, etc...