-2.3 billion years and all their is a large diversity of aerobic bacteria, and some anaerobic bacteria.

Paleozoic consists of the Cambrian and Ordovician, Silurian and Devonian, Carboniferous and Permian. Each pair shows a massive change in the planet. In the first part, multicellular heterotrophs make their appearance on the planet, and are invertebrates. Soft bodied animals dominate. In the second part, the first algal cells make multicellular structures and come up on land and become effective. Ex mosses, ferns, first plants. When they come up on land, insects also come up, as they feed on the vegetation of plants. Age of plants. In the oceans, an invertebrate form develops a new supporting structure called the notochord, and develops two sets of paired fins, which results in fishes.

-Plants come up on land and have developed a vascular system of cells aligned end to end, with openings, and create drinking straws. Plants are challenged by bacteria. Cellulose is a ready nutrient for bacteria, so they need to make their cell walls bacterial resistant. Make a compound called lignin, and line their cells. So antibacterial, that nothing can digest the plants. Results in carboniferous age. Trees and plants fall over and don't decompose, but rather fossilize as coal etc. Large amounts of CO2. During this time, some finned organisms will remove their fins and come up on land. Vertebrates today. This all ends at the permian, which is one of the biggest mass extinctions on the planet. 90-95% removal. Series of mass extinctions which have occurred.

-Cambrian is unusual: Land masses are lined up near equator. Continental shelves are most productive places. Light penetrates, fairly shallow, and slightly warmer, nutrient rich water temperatures.
-Invertebrates were sinking to bottoms of oceans, and currents would move them over edges of cliffs where there was no oxygen. In these locations, there is no bacterial breakdown, so they maintain their structure. More sediments and more invertebrates would be swept over, and they get compressed and turned into shale. Fine sediment heavily layered type of rock. Makes flattened plates. Shale has shown as a huge variety in odd organisms. These shales are located in Yoho national park. Leading paleontologist climbed the burgess slope until the fossils stopped making an appearance. This meant where the erosion was, was where the fossils are coming from. Created a quarry here. Originally thought these were worms and arthropods. Two grad students discovered these fossils weren't arthropods, but were rather things we have never seen. Complete inversion of how we think diversity appears. Showed that there was an explosion. So many fossils that they are able to be dissected.

-Fungi and animals are united by a single celled organism called a choanocyte. Single celled organism settles on the ground, and has a series of microvilli, which create a collar where the base of the flagellum is positioned. As it's flagellum beats, it creates a water current, and brings water in across the surface where the microvilli are. Filtering food. They can form colonies, either stock or matts. Can pump more water as a group, and gives them an advantage

Certain Autapomorphies which define animalia. Tissues, Symmetry, Embryology, Body Cavities. (refer to written notes).

Tissues: Cell to cell communications: Some have no tissues, some are diploblastic, others are triploblastic (mesoderm, muscles, etc… results in new symmetry (bilateral)).

Body cavities: Fluid filled mesoderm, has many benefits/uses.

-Porifera are the sponges, and contain all the above autapomorphies. Early relative. Uses choanocytes to pump water through their bodies. Puts them together in a layer and pumps large amount of water, which is referred to as an aquiferous system. Sponges have no cell communication between other cells. Cells are arranged in layers, not tissues. Porifera have an asymmetric body plan.
-Typically in animal development, the very early cells can turn into any type of cell. Eg when you get a nerve cell, it is a nerve cell for the left of it's life. A stem cell can turn into any type of cell, but once it has development into something like a muscle cell, it cannot revert back. Stem cells come from placental tissue.
-Sponges however do not have this "lock" for their tissues. For example if you blended red and green sponges, the red amoeboid cells would crawl back to other red ones, and green with green etc. Totipotent.
-Choanoderm is a layer that lines the inner surface.
-Flagella propel water out of the body of the sponge. As it is going out, it is pulled into the wall/cavity (spongocoel) of the cell by choanocytes which gets food. There is a porocyte, which controls how fast it flows. Outer body of the sponge has Pinacocytes which form a layer called the pinacoderm which defines the outer body. In between the pinacocytes and the choanocytes are the mesohyal which is the jelly which holds all the cells together. Porocyte and pinacocyte receive excess food from the choanocyte which passes its food to a travelling amoebocyte, and then passes the food along.
-Entire structure is help up by spicules, which are mineralized needles of calcium salts and salts etc, and are laid down by sclerocytes. Effective filter feeding.

-Sponge Sex: Only one cell has a flagellum, which differentiates into sperm. Choanocytes undergo meiosis (diploid), and meiotic products go under hundreds of mitotic divisions, and turn into lots of sperm. Not all choanocytes turn to sperm. Releases sperm into the water. “Smoking sponge”. Archaeocytes are cells that are wandering around, which undergo meiosis, and becomes an egg. Sperm is picked up in the water by choanocytes, and passes this to the eggs. Only sperm of the same species can fertilize the egg. Becomes fertilized, undergoes cell division, and new sponges are formed.

NEXT STEP ON THE CLADOGRAM

-Gap (Septate) junctions are the cell to cell communication structures. Formed from proteins called connexons, which are imbedded between the walls of two cells. Opens or closes a pore between two cells. Now there is chemical signaling between cells, and there can be hormone between cells that continue development, etc.. Connexons are found all the way through the animal kingdom. Choanocyte is lost. Only sponges. However, microvilli on the surface of absorptive tissues, which is identical to the ones in the choanocyte.
-True tissues with all components. Cells are sitting on a basement membrane. At the very end of the cells, there are tight junctions which bind sells to each other so nothing can seep in between.
-Internal digestive epithelium is developed. All first organisms will have two (diploblastic), and there will be symmetry in the groups. Obtain diploblastic, radial symmetry. Diploblast there is ectoderm and endoderm. Triploblast has mesoderm aswell, which is for muscle.

Zygote divides, undergoes cell divisions, and forms a hollow ball of cells, which is one cell layer thick, called a blastula. A signal is received in development, and some of the cells in this outer layer grow, and invaginate inwards. Results in two layers, ectoderm and endoderm. Both are epithelial, endoderm is digestive, and has a cavity called the archenteron. Has an opening to this cavity called the blastopore. Whole process is called gastrulation, and a gastrula is created.

Symmetry: Draw a line/plane from mouth to the other end, and you can get multiple identical halves by moving this axis, you have radial symmetry. Typical of animals that are floating in the oceans (must sense in all directions) or organisms which sit on the bottom of the oceans. Once muscles are acquired, and movement, animals move in one direction. The part of the body that is moving ahead first is where the sensory

information is. Cephalization (a head), there is multiple types of reception. Symmetry changes, and bilateral symmetry occurs. Sponge is asymmetric because it does not have a mouth.

-NEXT GROUP ON CLADOGRAM
-Cnidaria (jellyfish): Predator and feeds on small invertebrates. Contains a cnidocytes which discharges to sting and capture food. Have a sessile body plan called a polyp. Body surrounding a mouth, with tentacles around this opening, and it sits on the ground. No mesoderm, but there is still movement. Unique cell which allows this movement called epitheliomuscular cells.
-Cnidocytes: Cell which has a unique organelle in it called a nematocyst. As this cell develops, a spring coiled structure develops under tension/pressure, so if it pops open it fires out. Trigger called a cnidocil, which fires when it has contacted prey. Must be organic, not mechanical, and this coiled structure uncoils out at extreme speed, and this punctures through the prey and injects toxins to immobilize it.

-This prey is placed into the digestive tract, (gastrula is an incomplete gut). Gastrula specialized and becomes a polyp. Lining the digestive tract and is the gastrodermis, and there is a whole series of cells that will do things such as release digestive enzymes into the cavity, food will be broken down small enough to be absorbed. Outside of the body there is an epidermis. Some cells in here have started to differentiate. Key thing is cnidocytes, but nerve cells are also produced. Nerve tissue is ectodermal in origin. When this polyp is moving it's tentacles around, there is a net of nerve cells coordinating everything, but since it must sense in all directions there is no concentration of nerve cells in one location, just a net. Food enters digestive tract, mouth is sealed, enzymes are released, etc, but when the undigested residue needs to be removed, it must go back out through the mouth.
-There are muscle strands within the nutritive cells, referred to as myonemes. They are oriented in two distinct directions. Digestive are circular, and there is a set in the epidermis running longitudinally. Together they form a skeleton in the organism.

Primary role of a skeleton:
-Provide the mechanical mechanism to stretch muscles back to their original length.

-Cnidaria have a hydrostatic skeleton, where the longitudinal and circular muscles can contract to either flatten and stretch it.
-Can also exist as a medusa, not just a polyp. Umbrella like, think of a regular jellyfish.
-Mesoglea is the jelly like matrix that sits between the gastrodermis and the epidermis, and it has enlarged in the medusa. Only circular muscle cells used, and when it wants

to swim, it contracts the circular muscles and pulls the bell in, but must get back to original length. Does this with a hydrostatic skeleton based on elasticity.

Jellyfish reproduction:
Polyp develops and branches, and divisions of labour can occur. Some responsible for feeding, some for production. Reproductive polyp shoots off a medusa which swim away and grow and mature. The sexs are sperate, male and female. Has a mechanisms to release gametes away from where its living. They then release eggs and sperm into the water. Some fuse with each other, and a zygote is formed. Settles onto the ground and undergoes cell divisions. Becomes a planula larva, and crawls across the substrate. Moves in one direction, facing forward (like a bilateral organism. Either stopped moving and went to a polyp, or kept moving and was the origin of bilateral symmetry.

-This group is famous for its colonies. On a seapin is branches of polyps connected to each other, which create the organism. There are fossils which resemble these sea pens, which are 650 million years old, but we said cambrian life started 550 million years ago. Possibility of multicellular life starting before cambrian, or sponges and corals predate it.

-Corals: Found around the world, typically along the equator, with lot's of sunlight and high productivity zones to feed herbivores which the coral polyps capture. A coral reef consists of a little organism which makes a calcium based cup where it lives. Sticks out its tentacles to feed and capture prey, and crawls back in. All connected to each other. As the reef grows, this mineralized material is deposited, and more corals grow on top of it. Important group as they modify the ocean environment in the continental shelves by building reefs. Drivers of biodiversity. Times when these reefs entirely disappear.
-Endangered as most corals live with a symbiosis with an algae. They internalize inside their cells an algal cell, to provide them with nutrients. As temperatures of oceans are going up, algal cells are dying. Corals are losing their symbionts, and this process is called coral bleaching.

NEXT POINT ON THE CLADOGRAM (Triploblastic, Bilateral Symmetry)

During cell division and cleavage, when the cells are in 4 cell stage, there is a division across the equator. Top cells either rotate and put their bottoms in the grooves underneath (spiral cleavage), or they sit perfectly balanced on top (radial cleavage). Can divide the whole animal stage into these two groups.

-Gastrulation occurs, but there is also another opening on the opposite side. Have a gut with a mouth and an anus. The original opening can be the mouth and opposite the anus, or vice versa. Protostome and deuterostome. Proto = first opening, deuto = second opening.
-How is mesoderm produced? Two ways.

1. Ectoderm and endoderm cells receive a signal and multiply and being to fill the cavity between them. In development the mesoderm splits, and there is a cavity inside the mesodermal block, and is referred to as schizocoely (splitting of the mesoderm to make the coelom) **from the lip
2. Cells at the gut multiply and results in a mesodermally lined cavity, and is referred to as enterocoely, as it came from the gut.

RECAP
Protostomes: Blastopore mouth, Spiral cleavage, Schizocoely.
Deuterostomes: Blastopore anus, Radial cleavage, Enterocoely