--Phanerozoic Eon

Phylum Porifera:

- **Sponges**
- They contain an opening called the spongocoel.
- They use choanocytes to pump water through the spongocoel and trap particulate matter which they then feed on.
- Sponges have no actual tissue and rely on three different regions called the choanoderm, pinacoderm and a region in between these two holding amoeboid cells.
- All cells are held together by prions and collagen.
- Sponge cells are totipotent and can become any type of cell.
- To reproduce choanocytes become sperm, get launched through the spongocoel enter another sponge and get phagocytosed and brought to an archeocyte with will then fertilize to produce a zygote.
- Autapomorphies:
    - **Totipotent cells**: All of the cells can differentiate into basic archaeocyte cells and then turn into a whole new type of cell. It's a way sponges respond to the changes in their environment and why asymmetric shapes occur
    - **Aquiferous System**: Combines pumping and food capturing choanocytes with a variety of canals, chambers, and spaces through which water flows; it is arranged into three different architecture: asconoid (water is drawn through the porocytes in the body wall and leaves through a single osculum after passing through the choanocyte lined spongoecoel), syconoid (choanocytes are found in smaller radial canals that empty into central spongocoel with single osculum; better at trapping than asconoid), and leuconoid (narrow tubes through which water flows widen into chambers, where choanocytes are located)
    - **Asymmetric Body Plan:** Since a sponge does not have a mouth or digestive tract, it doesn't have an oral to aboral axis to define any form of symmetry

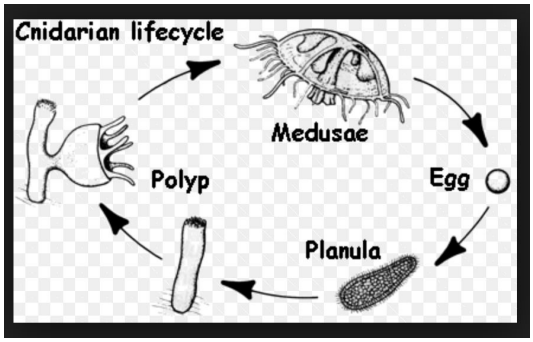
Phylum Cnidaria:

- **Jellyfish**
- **Autapomorphies:**
    - **Polyp body plan:**
        - The sessile, asexual stage in the cnidarian life cycle.
        - In some species they are independent organisms; in others, they form colonies where some polyps are involved in food gathering (gastrozooids) and other polyps (gonozooids) produce the reproductive stage
    - **Epitheliomusculature:**
        - An autapomorphy of the cnidaria
        - Are cells that form part of the epithelium, but extend their bases to form muscle fibres

        - Fibres of the outward layer are perpendicular to the fibres of the inward layer.
        - Cell allowing for movement to occur within the organism since they don't contain a mesoderm

Cnidocytes:

- Specialized cells found only in the Cnidaria. When these cells evert, a nematocyst is discharged. The nematocyst may act as a stinger or a sticky thread to entangle and capture prey.
- Explosive armed with stinging nematocyst. Coiled up nematocyst is shot out with a for of 100's of G force
- Has a venom at tip to incapacitate prey, barbs to latch on as it bring in its prey
    - Planula Larva:



In the keywords he uses Medusa (the singular version I think), so be warned. The trick below uses the singular version, to be more compatible with the keywords. GAPA → Jellyfish love **G**reen **A**pples and **P**ine**A**pples.

Phylum Platyhelminthes:

- **Flatworms.**
- This group loss their coelom
- They are acoelomate and so they have no secondary body cavity. Instead they ingest their food, break it down and then excrete the food through that same opening.
- They have no circulatory and respiratory system and instead rely on the circulatory and respiratory system of a host organism (parasitic)
- They are flat meaning that all nutrients that enter this organism do so by diffusion and they can do this without blocking fluid flow in the organism.
- Flatworms lodge themselves on to other organisms with glue.
- They are ciliated so that they can walk and swim within an organism.
- **Autapomorphies**
    - **Incomplete gut**
        - Mouth is located on the ventral surface
        - Whole column is hermaphrodite
        - Complex reproductive system associated with hermaphroditism
        - A digestive system that has only a mouth and no anal opening. Both ingested food and the undigested food must pass through the same opening to the alimentary tract.

        - Both ingested and undigested food pass through the same opening
    - **Multiciliated Epidermis**
        - Epidermal cells can have either one or multiple cilia. It was originally thought that because Cnidaria and other phyla at the base of the evolutionary tree were all monocellate, this condition was ancestral. But like so many of the traditional characters used in the past, this, too, is coming into question. A case in point: the ciliation on the trochophore larva is multiciliated, making the trochozoans all multiciliated organisms. Multiple cilia have been detected in sponges and are found in Ctenophora. There are even organisms that have monociliate larval stages and multiciliated adults.
    - **Hermaphrodite Reproductive System**
        - An animal that has the reproductive structures capable of producing both the sperm and the egg.
        - Hermaphrodites do not reproduce asexually as that reduces genetic variability, but instead, they allow for both organisms in a sexual encounter to become fertilized (2 zygotes from one event).
        - This also eliminates the possibility for a same sex encounter between two organisms of the same species.
        - Many invertebrates display hermaphroditism, such as Porifera, Cnidaria and namely Platyhelminthes (who will hook together and exchange sperm).
        - Both male and female reproductive organs
- **Platyzoa:**
    - A clade of protostomes that have lost their coeloms (become acoelomate/pseudocoelomate).
    - These organisms have an incomplete gut.
    - Many of these organisms are also quite flat.
    - An example of this type of organism is the Platyhelminthes.
    - Lack a respiration or circulation system due to small size and have a parasitic lifestyle

Phylum Nematoda:

- **Pseudocoelomates worms**
- Bilaterally symmetry
- Sexes separate they show dimorphism
    - ·Female has a paired reproductive tract, males have single. When they mate they couple together so theres direct sperm transfer. The sperm is an amoeboyte movement to find the egg and fertilize them, no flagella involved in sperm crawls by amoeboyte movement.
- Spiders have 7 and insects have 6 articulating limbs. If you are covered in plates you have no use of circular/longitudinal muscles because you cant expand those plates
- **Autapmorphies:**

- **Epitheliomuscular pharynx:** They've developed a double valve pharynx. You lock down the one connected to the gut while opening one at front and propel it partially way along, then you close the one at the front open then one at the bottom to propel the food to the digestive tract. It is essentially a set of alternating valves to get food in (unusual about this)
- **Triradiate pharynx:** The muscle of the pharynx. Normally there's mesoderm, circular and longitudinal in normal digestive tract lining it would be an epithelium. However, that's not there. They've stolen a trick from the cnidarian, they have epithelial musculature associated with their pharynx. They have one cell layer instead of a epidermal, circular and longitudinal layer. That pharynx when it contracts, there's the three lips, as the epithelial muscular cells contract it opens to 3 different positions. Once realized it closes. Doing this by conserving tissue again by having epithelial musculature which was something we saw way back in the cnidarians.

- **Pharynx:** The region of the digestive tract between the mouth and esophagus. In most animals it is muscular and forces food into the digestive tract that lies behind it. In vertebrates it is part of both the digestive and respiratory tracts

Phylum Annelida:

- Annelids include polychaetes, earthworms, leeches, spoonworms, and beardworms. They're bilaterally symmetric. Found in the moist soils of the terrestrial environment and freshwater or marine environments where they may burrow into or swim across the substrate.
- **Trochophore:**This free-swimming ciliated larval stage is found in a number of animal phyla including the Mollusca and Annelida. The larvae has a unique circle of preoral cilia around the middle of the body. Trochophores are often considered an ancestral characteristic of protostomes
- **Schizocoel:** A coelom that originated from mesoderm that originated from the gap between the ectoderm and endoderm near the blastopore. When the mesoderm completely formed, it formed a cavity (a blastocoel) known as the schizocoel. All organisms that are schizocoely are also protostomes
- **Complete Digestive Tract:** A digestive tract that has an anal and oral opening. This adaptation allowed for a linear processing of ingested food with specialized regions in the gut for grinding, mixing, and digesting food under different conditions.
- Annelids burrow through substrate (sediments) and feed on it, tapping into a new food source. They are both terrestrial and marine annelids; diversity occurs and they develop alternative methods of locomotion, but it all began with the burrowing. One of their distinguishing features is metamerism with serially homologous segments that repeat down the length of the animal
- **Autapomorphies:**
  - **Metamerism and Mesoderm**: The division of the body into a series of identical units, metameres, repeated down the longitudinal axis of the animal. Each metamere contains identical structures to the adjacent metameres.
  - Increase their size by repeating their fundamental body unit sequentially down the length of the worm; metamerism; each metamere is a unique hydrostatic skeleton; independent closed fluid filled space

- No exchange of fluid between independent segments
- Circular and longitudinal muscles in the body wall allow the metamere to change its shape resulting in the different forms of locomotion (accordion-like) that annelids use
- **Four beta-chitin setal bundles:** Chitinous bristles found in annelids that help in their movement. These bristles come out when a particular segment's longitudinal muscles contract and cause the diameter of the segment to be at its largest. The bristles bind to the substrate and hold the segment in place so that an adjacent segment whose circular muscles have contracted, will push the annelid forward.

Phylum Mollusca:

Autapomorphies

- **Radula**
  - This unique feeding structure is an ancestral characteristic of all animals in the phylum Mollusca. It looks like a tongue covered with teeth and works like a file to rasp food off the substrate. This unique feeding structure was advantageous for animals in the phylum mollusca b/c they were going to feed on food materials that no other animals have mastered at this particular point in time.
- **Dorsal mantile**
  - Example of convergent evolution... secreted by an underlying mantle epithelium
  - Dorsal mantle that secreted the shell, muscles attach the mantel to the food. This early mollusc could retract those muscles and contract the shell over its entire body to protect itself against predators. It clamps itself down tight against the substrate hide inside waiting for the whatever coming after will go away
  - Mantle that they use to form a mantle shell, for respiration and for excretion as an anus
  - When it clamped down onto the substrate the feeding structure was still there...Molluscas could clamp down their shells and still feed on particulates
  - There was a cavity underneath a space known as the mental cavity b/c it is the mental overhangs it and there was silia all over the gills that was creating a water current.
  - So you could clamp this structure, hide from predators, continue to feed, and breathe by allowing gaps of water to enter as the shell was clamped down
- **Ventral ciliated muscular foot**
  - The ventral surface of the foot is ciliated and glandular, with a high density of mucous-secreting glands that help the animal glide more easily over a substrate.
- **Calcareous spircules or shells**
  - Layer of tissue on dorsal surface that is capable of secreting mineralized calcium. In early ones it will be little needles of calcium to protect them. However, once the evolve those needles will fuse to become a shell that is typical of a mollusc that is sitting on top of a muscular foot that is used to move around.

Class Bivalvia-Mollusca

- Mollusc(muscles, clams), Related to octopus
- Filter feeders that can hide in the sediments and escape predation by sitting inside its shell, it is basically a shell folded in half surrounded by the sides of the laterally compressed foot and visceral mass
- Can be found in shallow marine environments or up to 5km deep of the marine; sessile organisms
- B/c they are filter feeders they don't need a radula to make particles because the particles are already suspended in the water column
- The walls of the demibranch are porous, and cilia on the surface pump water from the mantle cavity into the centre of the demibranch. Once water is inside it flows to a suprabranchial chamber above the ctenidia before leaving through the excurrent opening. Most bivalves are filter feeders, and other clia on the surface of the demibranch can trap particulate food, passing it along the surface to the edge and from there to the palps and mouth.
- Secretions of the salivary gland create a mucus string of food wound in the stomach by the crystalline style that releases digestive enzymes embedded in it to start the digestive process
- Taking ability of a digestive system that specializes in using particulate material and instead of generating itself it just pulls it out of the water. Therefore, there is no radula
- NO head, no cephalization, anterior end, but we don't have a whole sense of sensory structure around it b/c this is a sedimentary brewing animal
- Main point: capable of closing shell, and 2 big muscles they rely on to close the blocks. So what the muscles do is that when they are relaxed the muscle opens, and when the muscle needs to feed it contracts to close & snaps the muscle shut. This is part of how they borrow into the sediments, they push their foot forward they expand the shell to push the dirt away and they pull themselves down and they wiggle the shell to be able to borrow into the particulate.

Class Gastropoda-Mollusca

- This is the group that is the most abundant of all the mollusc b/c theyre one of the conquer of the terrestrial environment. They had the ability to protect themselves from predators inside a shell and not suffer from defication. Ex: Snails
- Hermaphrodites(they have both types of organ systems)
    - Advantageous why?...: B/c if you have an organism that is infrequent to run into another organism of the same species what's going to happen is that when you mate both organisms, at the end of mating they are going to separate from eachother and they're going to be fertilized. Instead of just one organism passing sperm to every single hermaphrodite... when they meet with each other you end up with both organisms producing offspring, so you are doubling the chance of offspring by doubling out of the mating pair that occurs.
    - Unique feature-the calcareous spircules:
        - So within the snail you have the phenomenom and for this snail when they do mate they have a distinct reproductive behavior to ensure that they actually engaged in mating, each snail has a dart a calcareous spircule that they use to impede it on the side of their mating partner in that they are mating with, and the other partner does the same in order to simulate the behavior necessary to bring about mating.
- A class of molluscs that includes snails, whelks, limpets, land and sea slugs, and conches
- Have a large visceral (organ) mass that is coiled up in the exoskeleton shell (which they can retract into)

Phylum Echinodermata:

- Mutable connective tissues
- They returned to radial symmetry triploblastic, unusual
- However,that radial symmetry is a secondary derived event, their larval stages involves bilateral symmetry and they then develop a radial symmetry b/c of the unique way they fed
- They have a unique internal water system that is part of the coelom. Important: a water vascular system is not equivalent to the aquiferous system, one is only found in sponge and one is only found in an echinoderm. This water system is key to their locomotion and how they move around
- The other thing they have is a unique form of connective tissues
    - o Internal skeleton made of plates, and the connective tissues that exist b/t the plates can exist in either inflexible or flexible form
        - A starfish/seareacher can either be flexible and move its appendages or it can lock the connective tissues in rigid form and be totally inflexible and under nervous control. They can basically change as to whether they can flex or move under nervous control

Starfish and relatives

- Adult radial symmetry
    - o The larva stage is bilaterally symmetric
    - o How did and why did this group of organism genistein in all the advantages of bilateral symmetry. All the advantages of cephalization, being able to look for prey, knowing where you're going, and look for predators… and take on an existence that we associate with sedentary organism. That is the secret
    - o So what we have is an organism that is adapted to a sedentary existence and made itself radial symmetric to capture food everywhere.
    - o Unique: they are trapping organic food and detritus that's falling through the water column falling through b4 it hits the bottom. Where the flatworms and everyone else are waiting on the food to land on the substrates

Larva bilateral symmetry

Water vascular system of a starfish

- Water vascular system is sea water, there's an opening call the madreporite and the water goes down and through the end of these water vascular systems where there are hydrostatic skeletons(tube feet).
- **Hydrostatic skeletons:**a fluid-filled and closed cavity surrounded by a body wall containing muscles oriented in different directions, it changes in order to allow movement within animals. comprised of a set of muscles inside them that are fluid filled.There's a valve that shuts them off
- There is also a suction cup structure on the under surface, you can take that to the foot and stick it to the substrate and hold in place and then contract the muscles beside to two foots to act like leaver that's going to move the organism around.
- Ancestrally the system was facing up and as the food particles came down the two feet basically passed the foot down the lengths of the arm to the mouth, but when all the modern starfishes came along they flipped in such a way that two feet are now being used to walk across the substrate.

- This becomes their major locomotory structure, and a food acquisition structure, by using these and coordinating their movement the starfish can move and work its way across the substrate

· Starfish are predators, they actively seek out and kill other animals(clams)
- How to capture prey: They wrap their arms around the clam, contract their muscles and stretch and lock their cuticle connective tissues so they don't have to use any muscles energy to hold the stretch on the clam, this opens up the clam a crack, then the starfish takes its stomach, turns it inside out and it pushes it into the clam. So now the inner lining where all the enzymes are being secreted are now outer surface inside the clam and it digest its meal externally. This is a process called extracorporeal digestion. Iit sits there, throws its stomach inside, liquefies the clam until it's a clam slurpy, and then uses the cilia lining the digestive tract to pull the nutrients back into its own body to feed.
    - o That brings us to the end of the cambrian

Autapomorphies

- **Water Vascular System:**
    - A characteristic of echinoderms. It is a modification of the coelom, and this closed, water-filled system forms canals and branches throughout the body. In one part, the tube feet, it acts as hydrostatic skeleton permitting locomotion.
- **Pentaradite Symmetry:**
    - Radial symmetry based on five. This type of symmetry is unique to the Echinodermata.
- **Endoskeleton:**
    - Supporting structures of the skeleton surrounded by the body tissues. As a consequence, there is living tissue on all sides of endoskeletal structures. Endoskeletons are found, for example, in echinoderms and chordates

Phylum Arthropoda:

- **Class arachnida, subphylum crustacea, class insects**
- Most abundant phylum on face of planet. Over a million of the 1.3 million of organisms and named to date are arthropoda.
- The first animal colonizers of the land mass. They feed on plants mostly but will eat each other if the predator is large enough and if there is a lack in other food sources.
- **Autapomorphies:**
    - **Articulated exoskeleton**
        - Biggest thing is that the cuticle now is in solid plates. And still articulation and flexibility in those plates so they can move relative to one another. Arnecoferan, an **enterocoely** that is covered in the flexible type of cuticle you ultimately get plates. So we get these exoskeletal plates articulating with one another. The limbs(legs and appendages) have a cylindrical cuticle, it has to be able to articulate to the adjacent piece of cylindrical cuticle. Usually you get an extension on each side a twitch other piece attaches and they bend at right angles to one another. This is the articulation of the poda, the legs or limbs that give the group their name. The arthropoda, the articulating leg or footed animals. Articulating, it can only bend in one angle. Which means you need a number of them down the limb. Spiders have 7 and insects have 6 articulating limbs. If you are covered in plates you have no use of circular/longitudinal muscles because you can't expand those plates.The muscles are fibres that run between the joints and the plates. All of the musculature is going to be in bands and not in sheets anymore.

- **Banded Muscles**
  - **Cuticle:** The nonliving, noncellular outer layer of an organism secreted by the underlying epidermis. Cuticles are common in a variety of animals including nematodes, annelids, and arthropods. The presence of a cuticle precludes the presence of cilia. The cuticle of an arthropod is solid which does not allow it to have an hydrostatic skeleton
  - The sheets of muscles are replaced by bands of muscle embedded in solid **cuticle**
  - This type of muscular arrangement, in combination with the tubular **exoskeleton**, creates the unique jointed limbs and feet that give the phylum its name, the Arthropoda - jointed foot animals.
- **Compound eye**
  - The characteristic eye of the Arthropoda. It consists of many ommatidia, the basic optical unit of the compound eye, grouped together to form the compound eye. With the exception of crustaceans, the compound eyes are usually found in combination with much simpler single lens ocelli.
- **Preoral Antennae**
  - Sensory appendages found on the head of a variety of animals, although we commonly associate them with uniramians and crustaceans
  - The first two segments are reflected in the tripartite brain of all arthropods

Class arachnida:

Ex: Spiders, scorpions, and Ticks

- Basically the predators of insects, so as to say most arachnids are predators of other arthropods, although some harvestmen feed on dead organic matter. Ticks are obligate blood feeders (parasites) of vertebrates.
- Arachnids are an ancient lineage: the earliest known fossils are of 420 million-year-old scorpions. All major living groups had originated by the end of the Devonian age, 360 million years ago.
- Arachnids have 2 body parts, the prosoma (cephalothorax) and opisthosoma (abdomen).
  - The prosoma (head and thorax combined) has 2 pairs of mouthparts, 4 pairs of legs, and 2-8 simple eyes that are located above the second pair of legs.
  - The opisthosoma (abdomen) contains the better part of the organs, and genital and anal openings.

Subphylum crustacea-marine arthropods

- Still here in cambrian is the crustacea
  - Shrimp, crab, lobster
  - Body plan having a set of appendages arranged linearly down the animal
  - Grows by molting
  - The crustations have taken the appendages and modified them for different functions and grouped them together based on those modified functions.
  - Example
    - Appendages stiched together that propel food to mouth

- Used for walking
- Defensive appendage in crab

Body takes on regional appearance based on appendages attached to it

They have formed tagma-segments fused together to carry out specialized functions seen in all modern crustacean

This did not occur in the Cambrian. All legs looked similar to one another. There's an appendage it articulates up and down, when we do a power stroke we get a stroke against the water, and recovery stroke folds back in on itself. This occurs as a metachronal wave down the body so you get a nice swimming motion propelling the organism down the water.

Were in the early Cambrian ocean where all primary productivity is being carried out by single celled algae

- On the surface we are trapping the primary productivity of the ocean. We have a way of doing it t concentrate it out of the dilute waste by using a sieve.
- Moving down power stroke, recovery stroke they come together and pulling forward. It scrapes all the algae trapped on sive to move it into its mouth to be consumed. Organism can go anywhere in water column to collect algae and efficiently doing it with a set of sieves that are also apart of its locomotion and taking that concentration material and ingesting it as a food
- Secret to crustacia they are the first primary herbivores and first to figure out how to efficiently capture large amounts food from the primary productivity of a water column. 500 million years later they are still the primary herbivores of the ocean only they can do it this way. They are swimming through water but they are not sessile filter feeders like sponges, the first crustacean become to mobile swimming or paleologic filter feeders

Phylum Chordata:

- Animalia (Invertebrate)
- The chordates are usually divided into two groups: the invertebrate and vertebrates. The chordates include three subphyla: Cephalochordata, which includes the Amphixous; Urochordata, which includes the sessile tunicates; and Vertebrata.
- **Autapamorphies:**
  - **Pharyngeal slits**: Lateral openings in the wall of the pharynx that allow water to enter into the mouth and exit through the pharynx. This ancestral characteristic of the phylum Chordata is also found in Hemichordata and Enteropneusta. Pharyngeal slits allow water to be removed from ingested food before it is passed back into the digestive system
  - **Endostyle**: A ciliated groove on the ventral surface the pharynx in early chordates and related taxa. Mucous produced by the endostyle traps particulate food, and the cilia propel it into the digestive tract
  - **Subphylum Vertebrata**: Vertebrate animals that have a brain case of either cartilage or bone

Phylum Onychophora

- Oral papillae with slime glands: Body wall musculature continuous sheet *uses hydrostatic skeleton to change shape, this group has thin, flexible cuticle

Unarticulated limbs

- Going to have limbs that work by hydrostatic skeleton. No hinges and joints, they are going to be fleshy enough to extend them and move them around as fleshy structures

Cuticle of chitin: organism that has a cuticle but its intermediate on its way to the arthropod b/c still has a cuticle flexible enough to be able to use circular and longitudinal muscles to work like a worm.

- Manipulation of food by limbs; in burgess shale, therefore were marine animals; onychophora still look similar today eventually come on land; living in moist environments.Only difference is that they come up and live on land in moist conditions, b/c no way of waterproofing themselves.

Protostomes:

- A clade of organisms that is incredibly diverse.
- A group of triploblastic organisms that arose during the Cambrian period.
- They have a blastopore mouth (the first opening in the embryo for the endoderm is a mouth)
- Schizocoely and spiral cleavage was an innovation for these organisms but is not characteristic of all protostomes.
- An example of a protostome is the arthropods.

Spiral Cleavage:

- Pattern of cell division in the developing embryo where the products of the cell divisions shift by rotating either clockwise or counterclockwise so that the resulting daughter cells lie in the furrow of the underlying pair of cell. The opposite of radial cleavage

Radial Cleavage:

- Present in some protostomes and al deuterostomes
- Radial cleavage is when the four-cell embryo divides such that the new cells are directly stacked on top of the previous four cells.

Ray Finned Fish:

- Actinopterygii
- Class of bony fishes which have swim bladder to maintain neutral buoyancy
- Fins are supported by bony spikes called rays

Lophotrochozoa

- A new taxon supported by molecular evidence and includes all the animals with a lophophore or a trochophore larval stage. Lophotrochozoans and ecdysozoans, animals with a cuticle, no epidermal ciliature, and who molt, are

combined as the protostomes in traditional evolutionary classification of animals.

- A phylum of invertebrates that either contains lophophores (a feeding structure) or a trochophore (a larval stage of the organism).
- This phylum, unlike most other phyla, contains either of these structures meaning all of its members do not contain a common morphology
- Bilateral Symmetry
- **Presence of Trochophore(a larval stage of the organism):**
  - This ciliated band around the central portion spins like a little top and looks like one, that is stabilized by these two toughs of cilia. It is using cilia to trap food and place it inside its stomach to nourish itself. From that nourishment it will undergo development to become anyone of those four animal phyla.
- **Presence of Lophophore(feeding structure):**
  - Suspension feeding, and lateral cilia on the sides of the tentacles pull water down into the center of the ring of tentacles and out at the base of the ring. In general, particles of food pass between the tentacles, are trapped by cilia, and are passed to the food groove that runs the length of the tentacle to the mouth.

Moss animals (Bryozoa)

- **Lophophore feeding structure:**
  - Lateral cilia create the current, and when they contact food, it is passed down and toward the frontal cilia, which it back to the lateral cilia. They continue to bat the particle of food back and forth until it reaches the mouth.
- **Lophophore respiratory structure:**
  - The coelomic fluid is the main circulatory fluid. In the larger, burrowing phoronids, a closed circulatory system is present with vessels extending into the lophophore, where blood is oxygenated before flowing down the efferent vessel to the stomach at the distal end of the U-shaped gut
- **U-shaped Gut:** The mouth and anus located close to each other. The trick is to position the anus so that its wastes can't mistakenly enter the mouth. In lophophorate animals, the anus is located outside the lophophore ring and wastes are flushed away from the animal as water passes between the tentacles and out of the lophophore.
- **Budding colonies:**
  - Asexual reproduction occurs by budding off new zooids as the colony grows, and is this the main way by which a colony expands in size. If a piece of a bryozoan colony breaks off, the piece can continue to grow and will form a new colony.

Trochozoa

- Trochophore larva:
  - Three distinct regions can be identified in trochophore larva:
    - the pretrochal region from the apical tuft to the mouth;
    - the pygidium(posterior part housing the anal opening), including the anus and telotroch(ciliated tuft surrounding the anus opening);
    - and the middle growth zone.

- This can be distinguished by a band of prototroch surrounding the equatorial position just around the mouth
- A free swimming larva stage. There is a distinct band of prototroch surrounding the equatorial portion of the larva just above the mouth. In some trochozoans, there is a second ring of cilia, the metatroch, around the middle of the larva. Regardless of whether there is one or two of these ciliated bands, they are important in locomotion and feeding by trapping food and passing it along the food groove toward the mouth.

- **Shizocoel**
  - **Mesoderm** forms from cells near the blastopore that proliferate between the endoderm that forms during gastrulation and the outer ectoderm. As the mesoderm expands, it splits, and the opening in the mesoderm becomes the coelom. Schizocoely gets its name from the splitting of the mesoderm.
  - The counterpart to schizocoely is **enterocoely**, where the mesodermal cells form from the endoderm of the primitive gut that forms during gastrulation, and was once considered a synapomorphy for the deuterostomes.

  - ## Deuterostomes

    Deuterostome development

    - Animal embryos undergo a series of transformations taking them from the single cell of the fertilized egg to their final triploblastic(organisms formed from 3 cell layers mesoderm,ectoderm, and endoderm).
    - Deuterostome developmental patterns

      1) Radial cleavage of the embryonic cells; the blastopore became the anal opening to the digestive tract and the tripartite coelom formed by enterocoelic pouching(mesendoderm develops outpocketings

      2)Embryonic cells demonstrated regulative development (also called indeterminate cleavage).
    - These changes denote the development of a single tissue layer

      1)Ectoderm, in the blastula stage;

      the formation of two epithelial layers of ectoderm and endoderm during gastrulation; and the

      2)The mesoderm between the two to complete the triploblastic condition. In coelomate animals, a body cavity forms in the block of mesoderm.

  - **Vertebrates with an axial skelton**
    - The bones, or cartilage, that make up the skeleton of the main body axis of vertebrates. It includes the cranium, vertebral column, and the rib cages, although not all of these may be present in each of the vertebrate groups.
    - the ancestral **axial skeleton** of the **notochord** is replaced with a series of vertebrae
    - The earliest vertebrates, the lampreys, have small cartilaginous rudiments – called arcualia – that extend from the **notochord** on

either side of the nerve cord, and these are assumed to be the precursors of the neural arch.
    - role of the **notochord** diminishes in the cartilaginous fishes, and the vertebrae become the main component of the **axial skeleton**: cartilaginous elements surround the centrum of the **notochord**, extend above it, and surround the nerve cord, forming the neural arch.
- In the sharks the **notochord** is reduced to rounded discs; each one fits into a hollow on either side of the cartilaginous centrum, to create a ball-and-socket type of joint between the cartilaginous vertebrae.
- NO longer assumed that the hagfish that vertebrae evolved in the hagfish, however there's evidence that they may have: pieces of cartilage associated with the **notochord** in the tail may be remnants of vertebrae that were lost in the hagfish, which relied on a flexible **notochord** as the **axial skeleton**. Loss of the
- With that being said the arculia of the lamprey may not be the precursors of vertebrae but what remained after the vertebrae were reduced.

<u>Agnathan fishes</u> (greek for *No Jaw):*

Include Lampreys (a true vertebrate) and Hagfish (not a true Vertebrate):

- Some distinguishing characteristics:
    - Jawless
    - Have not developed scales
    - Considered to mainly be parasites → they are called fluid feeders (because the ingest the fluid of other animals)
    - No paired fins→ Imagine a mermaid without arms.
    - Have light sensitive pineal eyes
    - Agnathans were prominent among the early fish in the early Paleozoic
    - The earliest jawless fishes were the ostracoderms, which had bony scales as body armor.
    - No stomach
    - A Circular mouth that has teeth all around.
    - Hagfish are able to secrete slime through the gland in their skin to help avoid predation.
    - Have a mineral reinforced cartilaginous skeletons to help make them stronger but not so rigid that they lose mobility. They are actually so flexible that they can make knots of their bodies.
- Came around during the late Cambrian, and are still around today.

- **<u>Sharks (Chondrichtyes)</u>**
  - The presence of cartilage in the axial and appendicular skeleton, rather than mineralized bone as found in the agnatha and jawed vertebrates. The perichondrium, which is the superficial layer of the skeleton, may be mineralized with calcium phosphate in some places; this is called prismatic calcification. The skeletal layer beneath the perichondrium has blocks of calcified cartilage that surround a non-calcified cartilaginous core.
- **Heterocercal tail;**
  - The heterocercal tail is flexible, and intrinsic muscles twist the tail from side to side in a sculling-type movement in which the top of the tail leads and the bottom trails. As well as generating a forward propulsive force, the tail's leading edge on the dorsal side pushes down on the water, giving the shark some lift that helps to counteract sinking.
- **Claspers in the male**
  - Claspers on the male transfer sperm directly to the female, which produces a few, well-provisioned eggs.
- **Upper jaw formed from Paleoquadrate cartilage, but not fused to the cranium.**
  - Can be extended forward by movement of the hyoid arch
  - Since there teeth are weakly attached to their jaws lamping onto their prey with their teeth and powerful jaw muscles. They violently thrash and roll to tear the animal that's locked in the grip of their jaws into small pieces. Even though some teeth may be dislodged in the process, this isn't a problem because sharks can replace their teeth. Behind the front row of teeth there is a second row ready to migrate to the front of the mouth

- **Boney fishes (Actinopyerygii)**
- **Autapomorphies**
  - **Fins supported by bony rays,**
    - Extend like the ribs of a hand-held fan from a central base, where they are attached to the body. The early ray-finned fishes had a heterocercal tail, and their fins, formed from modified scales, consisted mostly of the supporting bones of the rays rather than membranous tissues between the rays
  - **Digestive Ceca:**
    - Blind-ended pouch that extends from the main digestive tract. Digestive ceca may be the sites for final digestion of ingested food or may be regions of the gut with specialized enzymes or conditions required for digestion
  - **Modifications of the Jaw for Suction Feeding,**
    - The jaws of the ancient ray-finned fishes were hinged at the back they opened like scissors – and snapped shut on prey, but their grip was weak. The changes associated with various bones and musculature, new articulations between the modified bones of the skull resulted in a jaw that opened much wider. But more changed than the wider opening; the mouth could snap open at remarkable speeds and, as it did so, it sucked water into the cavity of the mouth and the branchial chamber – suction feeding.
  - **Swim Bladder:**
    - Gas-filled chamber is used as the main neutral buoyancy. Oxygen in the blood is added or removed as required. The swim bladder in some fishes opens in the digestive system allowing these fish to swallow air instead.
  - **Cerebral Hemispheres formed by Eversion:**
    - equilibrium data associated with living in a three-dimensional world has resulted in a large cerebellum in the hind brain of fishes.
    - In all vertebrates except than actinopterygians, the tissue of the cerebral hemispheres grows and inverts, curling in on itself along the midline of the brain. In the actinopterygians the opposite occurs and the tissue of the cerebral hemispheres grows and everts, curling outwards from the midline of the brain.

Keywords:

Keywords	Definitions
Acoelomate	• Multicellular eukaryotic invertebrates that lack a body cavity or coelom • Represented by flatworms, they were the ancestors to the whole protestrone lineage • Characterized by a bilateral symmetry with moderate cephalization • Triploblastic (develop three-layered embryos: ectoderm, mesoderm, and endoderm) • Have a gastrovascular cavity (Digestive) • Don't have a body cavity within their mesoderm Example: Flat worms, contains a solid mass of mesoderm no space, the cavity is the digestive tract. To accommodate a flatworm's large size, the gut becomes highly branched, and **diverticula** extend throughout the body. Movements of the body wall and **cilia** lining the gut ensure adequate mixing and the distribution of nutrients to all parts of the body
Pseudocoelomate	• Only partially lined with mesoderm • Group of invertebrates with a three-layered body that has a fluid-filled body cavity (pseudocoelom) between the endoderm and mesoderm • Lack a circulatory system • Has a hydrostatic pressure in the pseudocoelem which gives the body support and acts as a skeleton
coelomate	The gut is lined with mesoderm • Fluid filled body cavity that is called a coelom • Complete lining called peritoneum derived from mesoderm
Amebocyte/Archeocyte	• Mobile cell that is in the body of invertebrates • Carry out several special functions such as delivering nutrients from choanocytes to other cells, give rise to eggs for sexual reproduction, deliver phagocytize sperm from choanocytes to eggs, and transform into other cell types
Archentron	• Name given to the primitive gut The first tube that runs through the developing embryo and is open/exposed to the external environment

	● It is formed during gastrulation(when the blastula is converted into a grastula), it is surrounded by the new endoderm and it will develop into the digestive system of the organism
Assymetrical body plan	● A body plan where there is no axis of symmetry that runs through the body and creates identical parts. ● No oral access ● Example: Conifera(sponge), is assymetrical because it doesn't have a mouth all water comes in through the sides and comes out the top. No oral aboral acess, therefore no symmetry. Sponge is assymetric due to the fact that there is no oral aboral access.
Bilateral Symmetry	· Mirror symmetry; dividing the body vertically into left and right halves with each sense of organ and limb on either side · A characteristic of animals that are capable of moving freely and sensing through the environment · Leading edge animal, often contains sensory structures located about the head. · Increased sensory structures require an increase in the nervous tissue to process the information being collected and this results in the anterior brain of the bilaterally symmetric animals. Of the two architectures bilateral symmetry is the most common suggesting that this active approach was advantageous to the more passive lifestyles of the radially symmetric forms. · E.g. arthropod(spiders)
Radial Symmetry	● When an organism's body parts are arranged around the oral-aboral axis so that any plane passing through this axis results in two identical halves. ● Often associated with sessile animals attached to their substrate, or types that float around in the aquatic systems ● React to their surroundings/environment equally in all directions rection is of equal importance as food or foe and as a result their sensory systems are often diffuse and netlike collecting information from every direction. Example: Jelly fish(cnidarian)
Bivalve (Clams)	Refer to
Blastopore	● The opening to the primitive gut(archenteron), that will develop into either a mouth(protostomes) or anus(deuterostomes), which make the digestive tubes ● Forms during grastulation
Phylum Bryozoa	Refer to

Burgess shale fossils	Soft bodied fossils from the Cambrian Invertebrates of the Cambrian were fossilized in layersof the shales that formed in the ancient Cambrian seas Flattened between layers of the sediments Included fossilized worm-like burrowing animals Believed that before the Cambrian, ocean bottom was covered by inpenetrable algal mats and one of the innovative feeding strategies of the Cambrian was able to penetrate the mats and feed on the substate underneath The explosion of these soft bodied burrowers suggest that the explosion may have been real Found there was a complexity present that has since been lost(extinctions), this idea was completely new at the time
Blastula	
Cambria Burrowers	-Example burrowing worm animals -They burrowed into the nutrient rich substate underneath the algal mats. This was advantageous since no other animal could do this at the time -Food source with little competition, provides protection and they can anchor themselves into the mats and briefly come out to hunt
Cambrian Explosion	Fossils appear in large numbers in the Cambrian rocks Cambrian fossils with shells biologist reffered this as the appearance of shelly animals Increased amounts of calcium and silica fossilized shelly animals Burgess shale fossils(soft bodied) revealed invertebrates that existed This explosion reveals that multicellular animals may have appeared before 542 million years ago
Cambrian Period	
Cambrian Shelled Arms Race	-Race between predator and prey is a major selective force in evolutionary organisms Operates through decent with modification Example: - Faster predator begets faster prey stealthier prey begets better scent and sight in the predator, that begets, in turn, better scent and sight in the prey.
Cambrian Swimmers	● Are mobile, descended from sessile(immobile) ancestors ○ Highest trophic level in oceans ○ Ex: Jelly fish, medusa and other cnidarian ● When this animal wants to swim it will contract the circular muscles and pull the bell margin in and that will squeeze water out and push it out to the water column. To get muscles back to original length, this organism has a hydrostatic skeleton based on elasticity. That mesolia when it compresses it will spring back into its original position and stretch its circular muscle. It changes the

	water volume of the cavity underneath the belle which shoots water out. It opens where there's less resistance than the push
Carnivore	Animals that consume other animals as a source of food Ingestive heterotrophes that eat animal tissues Consumes organisms for nutrients Ex: Crabs
Cephalization	Evolution of a distinct anterior region of the body, the head, with specialized sensory structures Nervous tissue becomes concentrated in one end or an organism(head) with sensory structures Associated simlultaneously with development of bilateral symmetry and mesoderm is present Ex: Squids
Cephalopod	Most complex of the molluscs and includes squids, octopods, cuttlefish and nautiloids Mollusc body plan altered to accomade the demands of their active, predatory existence They have elongated their dorsoventral axis, and they wim on their sides with the ventral surface directed bhind them and the dorsal side pointing forward. To this day only nautiloids have retained the ancestral shells, while other have reduced, internalized or it has disappeared. Loss/reduction of shell were essential if cephalopods were to be agile rapid predators They've expanded their mantle to pull water into the mantle cavity, and contraction forces it out of the full and jet propels the animal forward. The foot forming the funnel, is adjacent to the head surrounded by arms and tentacles, a modified part of the head is used to capture prey The proximity of the head and foot is the origin of their formal name Cephalopoda--head-foot animals. Bilaterally symmetric, large head, tentacles,ink squirters Ex: Squids, octopods
Chitin	A complex carbohydrate composed of linearly arranged N-acetyl-glucosamine units. Chitin is a characteristic of the cell wall of fungi and the outer cuticle of arthropods. Main component of exoskeleton in arthropods, such as shells in the crustaceans and outer coverings of insects
Choanocyte (Choanoflagellate)	Unicellular eukaryotes, closest living relatives to animals The protozoans that resemble the choanocyte cells found in sponges. They have a collar of microvilli that surround a central flagellum. When the flagellum beats, food is trapped against the collar and consumed by phagocytosis. Surrounded by a collar of 30-40 microvilli, which traps food and

	phagocytoses it Some are mobile, however most are sessile(attached to a surface by a stalk)
Choanoderm	The layer of choanocyte cells lining the different parts of the aquiferous system in a sponge: in the asconoid architecture, the spongocoel; in syconoid, the radial canals; and in leuconoid sponges, the choanocyte chambers Layer beats flagella, propels water out of sponge, then water comes back in through the pores, where food is trapped in the microvilli, and then phagocytosed in the sponge Derm b/c no tissue for it in the epithelium, instead its just a layer of cells
Ciliated Ventral Muscular Foot	Refer to Mollusca
Circular Muscle	
Cnidaria	Refer to phylum definition
Cnidocil	A modified flagellum on the cnidocyte that causes the nematocyst inside to fire. The stimulus involves some sort of chemical cue; touching the cnidocil doesn't fire the nematocyst. Triggers nematocyst(stinger) to fire, when stimulated by touch, vibarations, or chemically Is a modified cilia Located on the surface beside the cnidocyte
Cnidocyte	Specialized cells found only in the Cnidaria. When these cells evert, a nematocyst is discharged. The nematocyst may act as a stinger or a sticky thread to entangle and capture prey. Explossive armed with stingin nematocyst Coiled up nematocyst is shot out with a for of 100's of G force Has a venom at tip to incapacitate prey, barbs to latch on as it bring in its prey
Collagen	Tough fibrous protein found in the connective tissue of vertebrates and the cuticles of some invertebrates. The protein is flexible but doesn't stretch or compress
Colonial Choanoflagellate	
Corals	-Reef builders and the most important type of cnidarians -Found around the equator in the tropics o High productivity zone lots of sunlight lots of primary productivity to feed the small little herbivores that their coral polyps are going to capture. B/c a huge coral reef consist of a little organism that makes a little calkarius of a calcium based cup in which it lives. It steps out

	with its tenticles to feed and capture prey and crawls back in. All connected to eachoterh to exchange nutrients b/t one another. As it grows the mineralized material is deposited and more corals grow on top of it. -Are colonies of identical polyps o Sea pin, a foot high, all it on branches are all kinds of little polyps, they're all connected to one another. All working together to create this large organism o Fossil that resemble primitive sea pins o What's happened is that those fossils are very old 600 and 50 million years old o Yet Cambrian life started 550 million years ago o So Beginning to realize that multicellular life started earlier than Cambrian o Maybe sponges and corals pre-date the Cambrian. As temperature of oceans are going up, the algae cells are dying can't handle the extra 2 degrees or so, as a consequence the corals are losing their symbionts. Process known as coral bleaching, this is killing coral reefs. Over 25% of reefs are dead, 60-70%+ are threatened, only 15% are surviving southern most part of the reef is the ones that are immune to coral bleaching
Crustacean	
Cuticle	The nonliving, noncellular outer layer of an organism secreted by the underlying epidermis. Cuticles are common in a variety of animals including nematodes, annelids, and arthropods. The presence of a cuticle precludes the presence of cilia
Deposit (Substrate) Feeders	Obtain energy and nutrients from soil particles Must burrow into soild to do this Ex: Annelids(worms) were the first t0 burrow into the soil
Deuterostome	Organisms whose blastopore becomes an anus Mouth develops on other end, and the two connect to from a digestive tract Ex: vertebrates, echinoderms(starfish)
Diploblastic	Organisms formed from only the two primitive cell layers--endoderm and ectoderm. Although there may be some type of a matrix between the two cell layers, often referred to as mesoglea or mesenchyme, it is not a true tissue layer
Triploblastic	Organism that contains three types of tissues in the blastula: the extoderm, the endoderm, and the mesoderm Tripoblasty is an apomorphy that define the two clades of protostomes and deutostomes
Duoshantuo Fossils	• Dated from 580 – 542 Ma (50 Ma before the Cambrian),

	found in China • Small, spherical, looks like there is 2, 4, 8, 16 cell division going on • Are suspected to be fossilized embryos of the cell divisions of the first multicellular organisms • Likely all filter feeders (tiny sponges and embryos)
Ecdysis	• The process of moulting the cuticle in invertebrates • Defining features of the Ecdysozoa • Occurs in insects, crustaceans • Shedding the old skin or casting the outer cuticle
Ecdysozoa	• Group whose defining feature is ecdysis – moulting of the cuticle • Are protostomes, invertebrates • Ex. insects, crustaceans
Lophotrochozoa	• A phylum of invertebrates that either contains lophophores (a feeding structure) or a trochophore (a larval stage of the organism). • This phylum, unlike most other phyla, contains either of these structures meaning all of its members do not contain a common morphology • Bilateral Symmetry
Platyzoa	Refer to Phylum
Ediacaran Fossils	• Dated from 580 – 542 Ma, slightly younger than the Doushantuo fossils, found in Mistaken Point, Newfoundland • Ediacaran biota shows fractal (repeating) branching • Combined with Doushantuo fossils, it's shown that multicellular life appeared before the Cambrian but was slowed down because of Snowball Earth
Ediacaran Period	• Last period of the Proterozoic Eon (right before the Cambrian) • Ediacaran biota–show fractal branching and were likely sessile • First known multicellular organisms appeared here • All life in the Ediacaran was soft-bodied - there were no bones, shells, teeth or other hard parts
End Ordovician Extinction	• 450 to 440 Ma, second largest extinction in history • Gondwana moved towards the South Pole, causing global cooling, glaciation, and decrease in sea levels • Life was only in oceans at the time, and more than half of

	all marine invertebrates died
Ectoderm	• Outer covering which will form the skin, nails, hair and nervous system. • Develops into epidermis and nervous tissue • Is found in coelomate, acoelomate, and pseudocoelomate animals alike
Mesoderm	The third cell layer that develops in the gastrula between the ectoderm and endoderm in triploblastic animals. Mesoderm develops into muscle, connective tissues, and bones, as well as blood and other components of the vascular system. Innovation occurred after the cnidarian in the phylogenetic tree with the tripoblastic organisms Mesoderm is also crucial for the formation of a coelom or another blastocoel that allows for a more effective hydrostatic skeleton and circulatory system
Endoderm	• Innermost of the 3 primary germ layers in a developing embryo • Forms the lining of the gut in the embryo • Also makes up special epithelial cells of polyps with contractile elements • Linings of the digestive and respiratory tracts and part of the urinary system. The human liver, pancreas, gall bladder, thyroid gland, parathyroid glands, and thymus
Endoskeleton	• Is not unique to echinoderms; vertebrates have one • The skeleton formed from spicules (needle like structure) of calcite micro-crystals • An internal support structure of an animal, composed of mineralized tissue (formed from calcium carbonate) • Endoskeleton develops within the skin or in the deeper body tissues
Enterocoel	• Coelom that develops from the wall of the archenteron • Associated with radial cleavage, and the blastopore becomes the anus • Present in deuterostomes
Epidermis	
Epitheliomusculature	
Exoskeleton	• A hard outer structure that provides protection or support for an organism

	• External skeleton that supports and protects an animal's body, in contrast to the internal skeleton (endoskeleton) • In popular usage, some of the larger kinds of exoskeletons are known as “shells” • E.g. shells of an insect or crustacean
Filter Feeding	• Feeding by filtering out plankton or nutrients suspended in the water. • This is done by many of the simpler animals, like sponges, echinoderms, and most crustacea.
Fluke Life-Cycle	**Ex. Chinese (-_-) liver fluke** - Parasitic flatworm - Flukes, parasitic flatworms, live as an adult in the liver. - In the liver, they mate and produce eggs in the digestive tract that are voided in fecal material. Eggs contain ciliated larva that emerges when egg is exposed to water. - Miracidium, a free living flatworm, emerges and looks for a snail to penetrate and complete its life cycle with - Miracidium grow, enlarges, takes little cell buds of itself and in body cavity, they differentiate into next larval stage, the sporocyst -sporocyst bursts to produce hundreds of Redia - Redia burst to produce hundreds of Cercaria - Cercaria dig out of snail body back into water to penetrate another organism - In organism Cercaria becomes dormant and are called Metacercaria
Gap Junctions (Septae)	Anchoring junctions use transmembrane proteins and intracellular anchors to hold adjacent cells together. Occluding barriers prevent material from slipping between cells, and gap junctions form cytoplasmic connections between adjacent cells.
Gastrodermis	The name given to the endodermal cells that line the gastrovascular cavity (coelenteron) of cnidarians.
Gastropod (Snails)	Refer to mollusc
Gastrula	• Stage in embryonic development where the embryo consists of two cell layers, an outer ectoderm and an

	inner endoderm, surrounding the primitive gut (archenteron) opening to the outside through the blastopore
Gastrulation	● During embryological development this stage results in the blastula is converted into a gastrula ● Cells migrate toward the inside of the embryo from the region where the blastopore will form to create the second germ layer (endoderm) ● The embryo changes from having only one cell layer to having two cell layers
Gastrozoid	● A zooid with a mouth and digestive organs ● Carry out digestive functions ● A zooid is a single animal that is part of a colonial animal
Gonozoid	● Polyp in colonial hydrozoans specialized for producing medusa, the reproductive stage in the life cycle. ● They contain medusa buds which will asexually reproduce to produce mobile medusas which can then reproduce via meiosis. ● An example of this is in the life cycle of Obelia which has both the medusa stage and the polyp stages in its life.
Herbivores	● An animal (ingestive heterotroph) that obtains the nutrients it needs for its metabolic processes by ingesting plants. ● It will not ingest other ingestive heterotrophs and these animals were the first to appear during the Cambrian explosion. ● E.g. Porifera and Bivalves
Hermaphrodite	Refer to Playthelminthes
Homeotic Genes	
Homeotic Mutants	
Hox Genes	
Pinacoderm	● It is the outer body wall of a sponge ● It consists of cells called pinacocytes ● This is not actually a tissue since sponges do not have actual tissue. ● Pinacocytes cannot obtain nutrition on their own and must obtain it from choanocytes via the amoeboid cells.
Playthelminthes	Refer to phylum def

Polyp	The sessile, asexual stage in the cnidarian life cycle. In some species they are independent organisms; in others, they form colonies where some polyps are involved in food gathering (gastrozooids) and other polyps (gonozooids) produce the reproductive stage.
Porifera	Refer to phylum definition
Primary Consumers	● Herbivore – feeds on autotrophs (plants)
Primary Producers	● Organisms in an ecosystem that produce biomass from inorganic compounds(autotrophs) ● E.g. plants
Protosomes	Refer to Onychophora
Radula	● A colony of polyps that feed on particulate matter in the environment. ● Coral reefs are those in which the polyps have learned how to crystallize calcium into cups. ● The polyp can emerge from these calcium cups for feeding and then retract inside these cups for protection. ● The polyps can also build additional cups as the colony grows
Radial Cleavage	● During development as the cells of the zygote divide, the products of the cell division remain stacked directly on top of each other ● Opposite of spiral cleavage Characteristic of deuterostomes
Reefs	● Calcium carbonate skeletons built by corals that accumulate underwater to form gigantic reefs
Schizocoel	● A coelom that originated from mesoderm that originated from the gap between the ectoderm and endoderm near the blastopore. ● When the mesoderm completely formed, it formed a cavity (a blastocoel) known as the schizocoel. ● All organisms that are schizocoely are also protostomes
Segmentation	● Separation of an organism into segments or subunits. ● In arthropods these segments are called tagma and each subunit has a specific function. ● The division of the body into a series of identical segments, metameres, that are repeated down the longitudinal axis of the animal. Each metamere contains

	identical structures to the metameres adjacen
Seminal Receptacle	• The region of an organism that receives and stores the seminal fluid or spermatozoa from another organism for later fertilization. • This structure is only present in female or hermaphroditic organisms since they are the only ones to contain an egg. • Examples of these organisms include Platyhelminthes and annelids (which are both hermaphroditic) as well as arthropods.
Seminal Vesicle	• The region of an organism that secretes and stores the seminal fluid and spermatozoa that is created by the organism. • This structure is only present in male or hermaphroditic organisms since they are the only ones to produce sperm. • E.g. Platyhelminthes, annelids, and arthropods
Setae (Setal Hairs)	• Bristles, or hairlike structures, that extend from the body. Usually made of chitin, they are common in annelids and arthropods • Usually made of chitin • Common in annelids and arthropods Anchor the worm against a substrate, providing traction
Slush-ball Earth/ Snowball Earth	• Modification of snowball earth theory • The ice of the glaciers got very close to the earth's equator but there was still some open near frozen ocean that surrounded the earth at the equator • Provided a place for the new formed eukaryote protists a refuge and possible place to survive
Sponges	• Organisms with the Porifera phylum • Possess asymmetrical body plan • Organized at the cellular grade (division of labour between different sponge cells) but do not have tissue • Because a sponge doesn't have a mouth or digestive tract, it doesn't have an oral to aboral axis to define any form of symmetry and is technically asymmetric
Spongocoel	• Sponges regarded as sacs with a cavity (spongocoel) opening to the environment • The internal cavity of asconoid and syconoid sponges that opens to the outside through the osculum. • There is no spongocoel in a leuconoid sponge

Tagma (Tagmatization)	• Distinct body regions resulting when different segments of a metameric animal become involved in specific functions • Segments modified to carry out that function and the appearance changes
Totipotent Cells	• When a differentiated cell can change into any one of a variety of different specialized cells found in an organism. These changes will result in the cell carrying out new functions.
Trilobite	• Fossil group of extinct marine arthropods Dissapeared during the devonian extinction
Triradiate Pharynx	• Refer to phylum
Trochozoa	• Refer to phyum
Tube Feet	• Hollow and fluid-filled tubes that are part of the water vascular system in Echinoderms. Muscles associated with the tube feet allow them to be hydraulically controlled and function in locomotion, attachment, food gathering, and gas exchange.
U-shaped Gut	Sessile animals that live in burrows or shells by necessity have a U-shaped gut with the mouth and anus located close to each other. The trick is to position the anus so that its wastes can't mistakenly enter the mouth. In **lophophorate** animals, the anus is located outside the **lophophore** ring and wastes are flushed away from the animal as water passes between the tentacles and out of the **lophophore**.
Water Vascular System	• Characteristic of Echinoderms • Modification of the coelom and this closed water-filled system forms canals and branches throughout the body • In one part the tube feet acts as hydrostatic skeleton permitting locomotion • Cilia lining the walls slowly mix the water throughout the system, no pumping system
Yolk Sac	• An extension of the endoderm and mesoderm of an embryo that surrounds the yolk(provides the nutrients that and embryo needs) • Nutrients do not enter the gut through the stalk connecting the yolk sac and the endoderm, but instead

	moves through the blood present in the cell membrane
Zooplankton	Microscoptic organisms drifting in the oceans, seas, and bodies of fresh water

Silurian and Devonian

Keyword	Definition
Agnatha	Refer to def
Alternation of Generations	• The basic pattern of the plant life cycle • Alternates between haploid and diploid states • Each generation gives rise to the other (spores (haploid) to gametophytes (haploid) via mitosis which produce gametes (haploid) via mitosis, gametes (haploid) fuse to form sporophytes (diploid) which produce spores (haploid) via meiosis) • Diploid generation creates haploid generation and vice versa
Antheridia	• Haploid male sexual organ in bryophytes that produces male gametes • Rounded gametangia that forms flagellated sperm • Produced at the tip of male gametophytes
Apoplastic Transport Pathway	• In apoplastic transport, water and minerals flow in an upward direction via the apoplast to the xylem in the root. The concentration of solutes transported in aboveground organs is established through a combination of import from the xylem, absorption by cells, and export by the phloem.
Archegonia	is a multicellular structure or organ of the gametophyte phase of certain plants, producing and containing the ovum or female gamete.
Axial Skeleton	Refer to def
Bony Fish	
Buccal Force Respiration	
Cartilaginous Fish	• refers to the presence of cartilage in the axial and appendicular skeleton, rather than mineralized bone • presence of cartilage rather than bone makes the fish more buoyant • upper jaw not attached to cranium can extend their jaws forward by movement of the hyoid arch lack dermal bone (form teeth with roots) ex. sharks • high levels of urea found in their blood making them a bit hypertonic and causes water to constantly diffuse into the shark across the gills

Cell Plate	A cell plate is a cell divider and the beginning stage of a new cell wall, which develops during the last phase of mitosis known as telophase.
Cellulase Rosettes	
Cellulose Fibril and Microfibril	Microfibril: a small fibril in the cytoplasm or wall of a cell, visible only under an electron microscope, and typically aggregated into coarser fibrils or structures.
Chordata	
Companion Cell	• Found in phloem cells in plants • Are associated with a sieve element • Manage the flow of nutrients through sieve tubes (specifically sugar)
Craniata	• Vertebrate animals that have a brain case of either cartilage or bone
Devonian Period	• The Devonian Period occurred from 416 million to 358 million years ago. • It was the fourth period of the Paleozoic Era; was preceded by the Silurian Period and followed by the Carboniferous Period. • It is often known as the “Age of Fishes,” although significant events also happened in the evolution of plants, the first insects and other animals.
Dorsal Hollow Nerve Cord	• One of the embryonic features unique to chordates, along with a notochord, a post-anal tail, an endostyle, and pharyngeal slits. • The dorsal nerve cord is a hollow cord dorsal to the notochord. It is formed from a part of the ectoderm that rolls, forming the hollow tube, compared to other animal phyla, which have solid, ventral tubes
Endostyle	• A ciliated groove on the ventral surface the pharynx in early chordates and related taxa • Mucous produced by the endostyle traps particulate food, and the cilia propel it into the digestive tract
Gametangia	• A haploid structure that does not go through meiosis • Gametes are produced in it • Females: archegonia • Males: Antheridia
Gametophyte	• A haploid structure (occurring during part of a plant’s life cycle) that produces haploid gametes • Produces male gametes (sperm cell) or female gametes (egg cells) by mitosis • Occurs in land plants and algae

Gemma (Gemma cups)	● Asexual reproduction used by liverworts, mosses ● Small cell masses that form cup-like growths on a thallus ● Can grow into new thalli when rainwater splashes them out of the cups and onto an appropriately moist substrate ● Produced at the surface of rhizoids and on above-ground parts of moss
Genome duplication	● Mechanism for increasing genome size increase in genetic material that could undergo changes such as mutation, drift, and selection ● These changes can potentially create increased diversity or complexity within a population, which could ultimately lead to speciation ● As a result of genome duplication there is two of every functional gene duplicated genome guarantees continued functioning, and any changes in the second copy can be subject to selection ● If a mutation renders a gene nonfunctional in an organism that has undergone genome duplication it would not be detrimental because the original gene is still functional Protects against extinction
Gill arches	● Supports for the gills in chordates ● Form from the tissue between the pharyngeal slits and may include additional support from cartilage or bone One pair of ancestral gill arches formed bones in the upper and lower jaws
Gill slits	● Lateral openings in the wall of the pharynx that allow water to enter into the mouth and exit through the pharynx ● Ancestral characteristic of phylum Chordata ● Allows water to be removed from ingested food before it is passed back into the digestive system Characteristic of cartilaginous fish i.e. sharks
Gnathostomata	● First ones were jawed fish Sharks, rays and their descendants Jawed vertebrates ● All lineages have lateral fins – stabilizes the movement of fish in all three dimensions
Guard cells	● Specialized cells which control the opening and closing of the stomata in a green plant's leaves ● Surround the stomata and aid in the transpiration rate ● Take up water by osmosis and become turgid
Heterocercal Tail	● Autapomorphy of the Chrondricthyes Type of tail fin in a fish where the dorsal lobe is larger than the ventral lobe and the vertebrae of the axial skeleton form part of the dorsal lobe ● Flexible, intrinsic muscles twist the tail from side to side in a sculling-type movement in which the top of the tail leads and the bottom trails ● Generates a forward propulsive force tail's leading edge on the dorsal side pushes down on the water, giving the shark some lift that helps to counteract sinking
Heterosporous	● Gymnosperms and angiosperms

	Produce two types of spores (one is smaller than the other) in two different types of sporangia ● Smaller spores – microspores, develop into male gametophytes ● Larger spores – megaspores, develop into female gametophytes ● Important in the evolution of the seed
Homeotic Hox genes	● Genes which regulate the development of anatomical structures in various organisms such as insects, mammals, and plants; this regulation is done via the programming of various transcription factors by the homeotic genes, and these factors affect genes through regulatory genetic pathways
Homosporous	● When a plant makes only one type of spore ● Gametophytes that develop from such a spore are bisexual (can produce both egg and sperm)
Internal fertilization	● The process in which sperm are released by the male close to or inside the entrance of the reproductive tract of the female ● Involves copulation – when a male's accessory sex organ is inserted into a female's accessory sex organ ● Makes terrestrial life possible because the female's body provides the aquatic medium required for fertilization without the danger of gametes drying out when exposed to air
Jaw	● Made of either cartilage or bone modified gill arch used for feeding ● May be armed with teeth or hardened plates ● forms a part of the vertebrate mouth ● modification for an improved respiratory mechanism that also improved feeding mechanism – allowed early vertebrates to trap and hold onto large prey
Lignase	● Enzyme that breaks down lignin ● Found in basidiomycete fungi – can also break down other environmental pollutants i.e. DDT which are similar in structure to lignin
Lignin	● A polymer of phenylpropanoids (absorb UV) ● changes in earth's atmosphere and climate altered certain biochemical pathways in plants, resulting in excess formation of lignin ● deposited in cell walls, particularly water conducting cells, providing support and rigidity to those tissues and allowing the plant to grow upright ● lignified water-conducting cells make up xylem ● vascular plants contain lignin, mosses lack it, stems grew larger and branched extensively after its evolution
Lobe Finned Fishes	● Sarcopterygii ● Have a central appendage in their fins containing many bones and muscles ● The fins are very flexible and potentially useful for supporting the body on land, as in lungfish and **tetrapods** (vertebrates with four limbs)
Megasporangium (Megaspore)	● A spore produced in heterosporous plants that produce a female gametophyte.

	● In angiosperms (ovary) and gymnosperms (pollen cone) it comes from the ovule – but in gymnosperms the megaspore undergoes meiosis and one of the four products will be used. ● In gymnosperms it specialized two eggs to become the archegonium which resides within a female cone. In angiosperms the same two are specialized but only seeds that are fertilized become megaspores. It is part of the plant's alternation of generations
Meristem (Determinate & Indeterminate)	● Determinate is when the growth of a plant stops when the element reaches a particular size ● Indeterminate have the potential to continue growing throughout a plant's life
Mermaid's Purse	● Protects the young shark developing inside it ● Protected by being wedged into sand or crevices between rocks or by becoming entangled in the aquatic vegetation
Neutral buoyancy	● When the density of the organism is the same as the surrounding water ● Body tissue is denser than water, air and oils may be used to achieve neutral buoyancy
Notochord	● This ancestral characteristic of the Chordata consists of a stiff cartilaginous rod near the dorsal surface of the animal. It is skeletal and helps support the body
Opercular gill	● Moveable flap (operculum) that covers a fishes' gills helps to pump water over the gills ● Opercular gill attached to mandible in teleosts created a larger mouth and branchial cavity when the mouth opened which improved suction feeding
Pectoral fin	● The posterior set of paired fins ● Assist fish in going up or down in water, turning sharply or stopping quickly
Pectoral girdle	● Bones in vertebrates that connect the appendages on the left and right side of the anterior appendicular skeleton to each other ● Also attached to axial skeleton in amphibians, reptiles, birds and mammals
Pharyngeal gill slits	● Lateral openings in the wall of the pharynx that allow water to enter into the mouth and exit through the pharynx. ● This ancestral characteristic of the phylum Chordata is also found in Hemichordata and Enteropneusta. ● Pharyngeal slits allow water to be removed from ingested food before it is passed back into the digestive system
Placental nutrition	● Placenta plays a key role in the nutrition of the fetus ● It mediates the active transport of nutrients and metabolic wastes across the barrier separating maternal and fetal compartments, as well as modifying the composition of some nutrients through its own metabolic activity ● The function of the placenta is essential to the growth of a healthy fetus

Placoid scale	● cover the body surface of Chondricythes formed in the epidermal layer from dentine and covered in enamel ● The spine of the placoid scale, directed toward the back of the shark, creates a layer of microturbulance close to the surface of the body as the shark swims; this decreases the friction between the shark's body and the water ● Characteristic of cartilaginous fish
Plasmodesmata	● Are small channels that directly connect the cytoplasm of neighbouring plant cells to each other, establishing living bridges between cells. ● Similar to the gap junctions found in animal cells, the plasmodesmata, which penetrate both the primary and secondary cell walls, allow certain molecules to pass directly from one cell to another and are important in cellular communication
Primary cell wall	Present in all plant tissue, surrounds the plasma membrane and cell contents Acts as the "skeleton" of the plant, serving as support Made of cellulose – gives it strength and flexibility
Ray finned fish	● Actinopterygii ● Class of bony fishes which have swim bladder to maintain neutral buoyancy ● Fins are supported by bony spikes called rays
Rhizoids	● A hair-like structure that functions as a root in lower organisms, such as certain fungi and mosses ● Rhizoids are important in penetrating a substance, giving anchorage and absorbing nutrients
Root	● The part of a plant that usually grows below ground. ● The root provides anchorage for aerial parts, absorbs water and mineral salts from the soil, conducts water and nutrients to other parts of the plant, and often stores food materials over winter.
Secondary cell wall	● formed from the deposition of additional cellulose from different types of cells ● usually contain lignin – makes cell wall very strong, rigid and impermeable to water, makes cells more resistant to attack by microbes
Sieve elements	● Found in flowering plants; it is an elongated living cell of the phloem (lack a nucleus at maturity) ● Consists of sieve elements which make up the sieve tube ● Main function is to transport carbohydrates (primarily sugars) in plants (from leaves to the fruits and roots)
Sieve plates	● Sieve plates are the connection sites between sieve elements. During early development of young sieve tubes, sieve plates resemble normal cell walls. As in other cell walls, plasmodesmata connect the cytoplast of adjacent sieve elements. Later in development however, plasmodesmata in

	sieve plates undergo a significant structural alteration.
Silurian period	● 443 (end of Ordivician) – 416 Ma (beginning of Devonian) ● Major extinction event ● Appearance of jawed and bony fish Small moss-like vascular plants appear on land
● **Splash fertilization**	
● **Sporangia**	● Spore-producing chambers (capsules) of a sporophyte ● Produce spores by meiosis
● **Spores**	● Produced by diploid generation (sporophyte) ● Produced by meiosis ● Single haploid cells with fairly thick cell walls ● When it germinates it divides by mitosis to produce a gametophyte
● **Sporophyte**	● Diploid structure that produces spores Haploid spores produced by meiosis
● **Stomata**	● Pores in the cuticle-covered surfaces of plants ● Open and close to regulate water loss ● Main route for carbon dioxide to enter leaves Bordered by guard cells that control the size of the openings
● **Suction feeding,**	● Pulls food into the mouth along with water ● Food is large and targeted powerful suction of the mouth guaranteed that water and the prey would be ingested and not be swept aside ● ray-finned fish use this mechanisn ● The combination of modifications of the jaw and the use of a suction-feeding mechanism was a major event in the evolution of the ray-finned fishes
● **Swim bladder**	● Found in bony fish ● Gas-filled chamber used to maintain neutral buoyancy ● Oxygen in the blood is added or removed as required ● In some fishes it opens into the digestive system allowing these fish to swallow air instead bladder is located on the dorsal side of the body cavity above the midline of the fish; because it's in this position the air in the bladder keeps the fish upright in the water without any expenditure of energy
● **Symplastic transport pathway,**	The symplast pathway is where water moves between cytoplasm/vacuoles of adjacent cells.
● **Tail**	The **tail** is the section at the rear end of an animal's body; in general, the term refers to a distinct, flexible appendage to the torso Provides locomotion (aids fishes with swimming), social signaling (deers use it to warn other deers from danger; beavers use it; others use it for balance) move away predators (lizards detach their tail for predators to be distracted from)

• **Tetrapod**	• Vertebrates that have four limbs, or appendages. • The forward pair is attached to the pectoral girdle, and the posterior pair to the pelvic girdles. Tetrapods include amphibians, reptiles, birds and mammals.
• **Tracheids**	• Tracheids are elongated cells in the xylem of vascular plants that serve in the transport of water and mineral salts. Tracheids are one of two types of tracheary elements, vessel elements being the other. Tracheids, unlike vessel elements, do not have perforation plates
• **Transition to land (plants)**	
• **Vessel elements.**	• Cells joined end to end in tube-like columns called vessels • Shorter and wider than tracheids Have pits (since lignin is hydrophobic water doesn't escape) • As they mature enzymes break down portions of their end walls producing perforations that enhance water flow

Phanerozoic-Mesozoic

○ Albumen – the white of the egg containing protein. When it gets broken down it releases metabolic water which is the water source for the embryo. It also helps get toxins out of the embryonic environment by allantois.

○ Amniote animals – Animal that develops an amnion during its embryonic stage; e.g. birds, reptiles and mammals. Allowed them to live on dry land à waterproofing the skin (via keratin and lipids) and their eggs. Produced 3 radiations: synapsids, diapsids and anapsids.

○ Anapsid - Member of the group of amniote vertebrate; No temporal arches; No spaces on the sides of the skull (two holes of the diapsid got FILLED IN); Turtles are the living representatives of this group; strategy is to fuse the bone together.

○ Angiosperm - Flowering plant; Its egg-containing ovules mature into seeds within protected chambers called ovaries. Arised after gymnosperms, which had inefficient fertilization. Flowers in flowering plants have female and male counterparts that resolve this issue and make it more efficient. Also get animals to carry pollen for them to other plants rather than only relying on the wind à main ones include bees and butterflies.

○ Anther - Pollen-bearing part of a stamen

○ Allantois – the fetal membrane lying below the chorion in many vertebrates, formed as an outgrowth of the embryo's gut. In birds and reptiles, it grows to surround the embryo; in eutherian mammals it forms part of the placenta.

○ Central cell – diploid cells of the angiosperm life cycle.

○ Carpel - Reproductive organ of a flower that houses an ovule and its associated structures

- Co-evolution - - 2 or more species that adapt to each other's changes and affect each other's evolution. Ex. pollinators (bees) and flowering plants – pollinators consume nectar, pollen hops on, pollinator flies away and deposits pollen somewhere else so that it can successfully reproduce. Evidence: nectar has no use for the plant itself, it makes it only for its pollinators
- Cretaceous – extinction: top predators starting to diminish from Triassic extinction until the cretaceous extinction. Whole system of organisms crashed. This was sufficient since all the big specialist animals got wiped out. Finished the Mesozoic period and started the Cenozoic period until today.
- Diapsid - Member of a group within the amniote vertebrates; Skull with two temporal arches; Their descendants include lizards/snakes, crocodilians and birds, dinosaurs. Have powerful jaws.
- Double fertilization - Characteristic feature of sexual reproduction in flowering plants; In the embryo sac, one sperm nucleus unites with the egg to form a diploid zygote from which the embryo develops, and another unites with two polar nuclei to form the primary endosperm nucleus à which divides to form endosperm, a tissue which nourishes the embryo (the seedling in monocots) until it leaves and begins Photosynth.
- End Triassic extinction - - Occurred 201 Ma and nearly half of all species became extinct. Due to flood basalts, asteroid impact, climate change. Loss of many marine reptiles, amphibians, cephalopods but the plants didn't do too badly
- Endosperm - Nutritive tissue inside the seeds of flowering plants, including starch, oils and protein.
- Endosprory – the development of a gametophyte within the confines of the spore. Essential innovation toward the evolution of seeds but also arose in seedless plants.
- Extant – a taxa that is still existint, opposite of extinction. E.g. cephalopods, looking at all that have ever existed, more are extinct than currently extant.
- Extinct - The death of the last individual in a species of the last species in a lineage
- Fruit - Seed-bearing structure of angiosperms formed from the ovary after flowering. Offspring from a sexual union. Evolutionary adaptation to increase spread of seeds across wider distances. (eaten by animals, can't digest the seed and it gets spread).
- Jurasic – Period from 201-145 Ma ago, birds evolved in the late Jurassic era. Pangea began drifting off into two landmasses (more coastlines). Late Tithonian even is a MASS extinction in this era.
- K/T (K/P) boundary – Geological signature (usually a thin band) defining end of Mesozoic era and beginning of Paleogene period. 66 Ma à mass extinction.
- Keratin (Beta and Alpha) – Alpha à protein that is a large constituent of hair, nails and skin. Fibrous and rich in alpha helical proteins. Beta à same as alpha but have beta pleated sheets in protein folding. Found in reptiles. Impregnated into their outer layers resulting in waterproofing and prevention of dehydration.
- Keratinized (Cornified) skin
- Megasporangium – sporangia that produces megaspores (female). In gymnosperms à cone. Angiosperms à ovary.

- Megaspore - Plant spore that develops into a female gametophyte; Usually larger than microspore. Produced in heterosporous plant.
- Mesozoic – Between Paleozoic and Cenozoic, age of reptiles, 246-65 Ma. Large reptiles are dominant on land and appearance of first mammals, birds and flowering plants. Began after Permian mass extinction.
- Microsporangium – part of sporophyte that makes microspores (male), a type of sporangium. Takes place in anther/pollen tube of plant in angiosperms.
- Microspore - Plant spore from which a male gametophyte develops; Usually smaller than a megaspore
- Micropyle – small opening in the ovule of a seed plant through which the pollen tube usually enters. A pore in the membrane covering the ovum of some animals through which a sperm can enter.
- Nectar – sweet sugar laden substance produced by plants to attract insects to land, and pollenate plants.
- Ornithischia – extinct order of beaked herbivore dinosaurs.
- Oviparous - Animals that lay eggs containing the nutrietns needed for development of the embryo outside the mother's body
- Ovary (plant) – female reproductive organ of the flower. Part of the pistil which holds the ovules and is located below the sepals and petals of the flower.
- Ovule – structure that arose in gymnosperm plants. It arises from a megasporangium producing a megaspore which then proliferates to form a female gametocyte within the megaspore wall and inside the megasporangium. The ovule contains an egg developing inside a female gametophyte which is inside megasporangial tissue. When fertilized this ovule becomes a seed.
- Pangea – supercontinent that existed during the late Paleozoic and early Mesozoic eras. When divided = more coastlines.
- Pericarp – the part of a fruit formed from the wall of the ripened ovary.
- Plesiosaurs – an order of reptiles that lived during the Mesozoic era. These reptiles were marine-dwelling and had four flippers and long neck with tiny heads and large bodies.
- Pole cell,
- Pollen - Grain; Male gemetophyte of a seed plant
- Pollen tube - Tube that grows from a germinating pollen grain through the tissues of a carpel and carries the sperm cells to the ovary
- Pollination - Transfer of pollen to a flower's reproductive parts by air currents or on the bodies of animal pollinators. Pollination does not always result in fertilization if the two individuals cannot reproduce. Pollination only occurs through the wind (in gymnosperms and angiosperms) or through animals (angiosmperms).

- Pterosaurs – like tetrapods in that they could walk normally. However they were one of the four organisms that developed the ability to fly (along with arthropods, birds and bats). Since tehya re so large, able to get lift they would have to jump off a cliff or take headwind. Extinct in cretaceous extinction.
- Saurischian – large reptiles. Moved up their pelvic girdle such that they wouldn't compress their ribcage when they moved. Could also become bipedal. Unlike ornithischians, their pubis bone pointed forward. Extinct in cretaceous.
- Sauropods – large herbivorous saurischians. Dinosaurs were quadrupedal with a REALLY long neck. Appearing in late Triassic period of the Mesozoic era.
- Sperm nucleus,
- Stamen - "Male" reproductive organ in flowers, consisting of an anther pollen producer and a slender filament
- Stigma – receptive tip of a carpel in the flower. Receives pollen and it is on the stigma that the pollen grain germinates.
- Synapsid - One of a group of vertebrate amniotes; One temporal arch on each side of the head; Mammals are their living descendants
- Synergid – part of the egg apparatus and are thought to help the pollen nucleus reach the egg cell for fertilization.
- Temporal fenestra – a hole in the skull of an animal. Allows for the animal to move its jaw muscle without interfering with the cranial capacity of the organism à stronger and larger jaw movements. None = anapsid (turtles). One = synapsid (mammals). Two = diapsid (birds + reptiles)
- Theropods – large carnivorous saurischians. Dinosaurs were bipedal. Thought that aves (birds) descended from this group of saurischians. E.g. T-Rex.
- Tube nucleus – one of the two nuclei formed by mitotic division of a microspore during the formation of a pollen grain that is held to control subsequent growth of the pollen tube and that does not divide again – contrasts with generative nucleus.
- Vertebrate - Member of the monophyletic group of tetrapod animals that possess a vertebral colum

Phanerozoic-Cenozoic

- Alpha keratin - an amino acid with a coil shape that is found in different types of hair, fur, wool, horns and tails. Their structure is maintained with hydrophobic bonds between apolar residues. Synapsids have them (humans).
- Amniote animals - Animal that develops an amnion during its embryonic stage; Ex. Birds, reptiles and mammals. In pair with the placenta, it delivers all the nutrients necessary to grow the young inside the womb.
- Apocrine sweat gland - type of merocrine sweat gland (=) that are small tubular structures of the skin that produce sweat… Found in the armpit, areola (nipples), perineum (between anus and genitals), ear and in the eyelids. Secretory portion is larger and puts off a scent.. Inactive before puberty of the mammal. In

mammals, apocrine sweat contains pheromone like compounds to attract other organisms within their species.

- Barb - furry part of the feather that forms its shape. Fused to the rachis or stem of the feather.
- Barbule - branches off from the barbs of a feather.
- Deciduous teeth - aka primary teeth. First set of teeth in the growth development of humans and other mammals. Develop during the embryonic stage of development and erupt during infancy. Lost and replaced by permanent teeth. A.k.a baby teeth.
- Eccrine sweat gland - type of merocrine sweat gland (=) that are small tubular structures of the skin that produce sweat. Smaller than apocrine sweat glands and don't extend into the dermis. Excrete directly onto the surface of the skin. Mainly produces sweat and acts as a cooling mechanism.
- Endothermy - characteristic of an animal that obtains most of its body heat from internal physiological sources
- Glandular skin – skin has glands to produce things. Modified to be able to produce nourishment to feed young with (mammary gland) à lactation.
- Great apes
- Heterodont dentition - an animal which possesses more than a single tooth morphology. In contrast à homodont have only a single tooth. Along with deciduous teeth.
- Macroevolution - evolution of species and their INTERACTIONS with everything else. Includes: Adaptive radiations of taxa, paleontology, extinctions, speciation, origins of novel structures. Autapomorphies that UNIQUELY define the group from others and the addition of them to diversify organisms (forming cladograms). The stories of the xtinciton of species.
- Mammary gland - specialized organs of female mammals that produce energy-rich milk a watery mixture of fats, sugars, proteins, vitamins and minerals
- Oviparous - animals that lay eggs containing the nutrients needed for development of the embryo OUTSIDE the mother's body. E.g. in mammalia include monotoremes (platypus). Apocrine glands produce milk to nourish young.
- Parental care – new trait first found in reptiles. Usually, eggs were laid and left to see who would survive, but parental care involves incubating the eggs (by sitting on top of them or keeping them somewhere warm) and then taking care of the offspring once they hatch. This allows them to produce less offspring that have a higher chance of survival. Better reproductive strategy than before.
- Placenta - specialized temporary organ that connects the embryo and fetus with the uterus in mammals, mediating the delivery of oxygen and nutrients; analogous structures occur in other animals. In the eutherian type of viviparous mammal (humans and most mammals). Way of perfecting the blood brain barrier, keeping the two independent.
- Pneumatized bone - presence of air spaces within bones. Produced during the development by excavation of bone by pneumatic diverticula (air sacs) from the lungs or nasal cavity.
- Sebaceous gland - small glands in the skin which secretes a lubricating oily matter (sebum) into the hair follicles to lubricate the skin and hair.
- Sternal keel - extension of the sternum which runs axially along the midline of the sternum and extends outward, in bird anatomy. Provides an anchor to which a bird's wing muscles attach, thereby providing adequate leverage for flight. Flightless birds lack keels.
- Viviparous - animals that retain the embryo within the mother's body and nourish it during at least the embryonic development stage, early on.

Crossword Answers

Highlight to see them

Phanerozoic: Cambrian and Ordovician Periods:

Clams are an example of the mollusc body plan specialized for this type of feeding:

These large tubes help supply air to insect tissues that require oxygen:

Cnidarians remove undigested food from the gastrovascular cavity through this opening:

Extensions of these cells connect the nervous and muscular systems of a nematode:

Ancestrally, the mouth of an echinoderm faced in this direction relative to the substrate to which it was attached:

This fluid filled cavity forms the hydrostatic skeleton of a nematode:

Planaria feeds by using this structure to get food into its digestive tract:

These flatworm parasites always have a mollusk, usually a snail, as a part of their complex life cycle:

The ancestral echinoderms tube feet were originally used for this:

Specialized sponge cells can, if required differentiate and become amoebocytes once again and after that specialize once again for different functions. The cells are referred to as having this characteristic:

These cover the surface of a bryozoan's tentacles:

Echinoderms have this special type of symmetry:

Crustacea, very important in marine environments because of what they feed on, are described as being this:

This type of skeleton is found in Ecdysozoans:

The sponge stem cell is an amoebocyte, and may have this more specialized term:

The type of symmetry characteristic of cnidarians:

Annelids always have setae to help anchor them in their burrows or as they crawl across the substrate. How many bundles are they arranged in?

In an echinoderm the tip of the tube foot uses this to help it attach to the the substrate:

Like corals, these animals also built reefs in the ordovician oceans:

The side of the medusa opposite the mouth is referred to as this surface or side:

Some of the animals in the Lophotrochozoa have a unique feeding structure, what is the name of this structure (this one's a freebie):

Even though onychophora have a chitinous cuticle they have this type of skeleton:

A free living flatworm's mouth is located on this side of the animal:

The number of muscle layers in a nematode:

Most echinoderms have this number of arms:

The tremendous array of molluscan body plans is an excellent example of this type of radiation: →

The type of movement used by nematode sperm:

With two different body types, we refer to the life cycle of cnidarians as being this:

Because onychophorans are active at this time of day they are considered to be:

This fluid provides the hydro in the hydrostatic fluid in worms:

Metameres in a worm are also called these:

This arthropod was abundant in the Cambrian and although it survived into the Ordovician it in now extinct:

The main locomotory structures used by echinoderm's:

There are thousands of these on the surface of the radula, and they can scrape, peirce, tear, or cut at a mollusk’s food:

These filter feeding, and the simplest of architectures, appear prior to the the Cambrian period: →

Burrowing worms consume what they burrow through, and that makes them this type of feeder: →

The bristles, or hairs of annelids:

Sponges are organized at the cellular grade and don’t have cells organized as these:

In a mollusk, the edge of this tissue secretes the shell and creates the cavity that bears its name: →

The stage of the fluke life cycle that swims to either its vertebrate host or another vertebrate host where it encysts:

A cnidarian gastrovascular cavity is described as incomplete because it lacks this:

Bryozoans get their common name from these plants, which they look like (this plant is referred to as a bryophyte) :

The name of the ciliated larval stage of the cnidarian life-cycle:

The sperm duct transports gametes from this organ to the seminal vesicle:

This is the mobile or floating stage in the cnidarian life cycle:

Silurian and Devonian Eras;

This is trapped on the inner surface of the mucus net that lines the pharyngeal cavity of early chordates:

In non vascular plants these assist the sperm in getting to the egg:

Gemma in primitive plants like liverworts are an example of this type of reproduction:

The ray finned fish perfected this unique form of feeding to capture their prey:

The composition of their skeleton and the use of this substance help the Chondrichthyes achieve neutral buoyancy:

These structures on a the surface of a fish create microturbulence and help reduce drag as the fish swims:

As a bony fish swims deeper, air is ____ _____ to the swim bladder:

What an arch***eg***onium produces:

Microtubular structure that directs cell division in plants:

Cellulose is a polymer of which sugar molecule:

The sarcopterygian fishes are commonly called the ____ ____- finned fishes.

The addition of this mineral to the skeleton occurs in all gnathostomes except the sharks and rays:

The waterproof layer of a leaf:

The cells that swell to close the opening and shrink to allow air to pass through to the photosynthetic tissue:

The name for the part of the skeleton that runs the length of the body of a vertebrate:

These plant tissues are missing in mosses:

This type of skeleton is the least dense of the skeletons found in fishes and its use is an adaptation attempting to achieve neutral buoyancy:

Parasite that lives on the surface of the host is what type of parasite:

This pathway for moving materials in plants uses the cell wall:
Chordates slits that help separate food from ingested water prior to passing the food to the digestive system:

Number of flagella on the moss sperm cell:

Unlike the sharks, the pectoral and pelvic fins are __ ___ and allow for much better maneuverability.

This part of the vertebrate skeleton induces the two sets of paired fins:

Together, bundles of the living cells that move sugar in plant are referred to as this type of plant tissue:

Bones and what other tissue extends into the lobed finned fishes fin:

Another way of describing post anal segmentation:

Bundles of dead plant cells move water in which direction in a plant (The dead go ***UP*** to heaven…) :

The sheet of mucus covers the inner surface of the pharyngeal cavity of chordates is produced by this structure on the ventral surface of the cavity:

When the fate of the undifferentiated cells in a plant is fixed; it becomes only one structure, we refer to the undifferentiated tissue as being this:

Early chordates, like the lancelet, were this type of feeder;

In addition to chlorophylls, this plant pigment is also shared with algae, indicating that these are the ancestors to plants:

Lampreys are best described as this type of feeder:

There isn't agreement as to whether Vertebrae are an autapomorphy for the Vertebrata. If they aren't, what would the chordate subclass be called:

These dead plant cells transport water and dissolved nutrients:

This gamete is produced inside mosses antheridia head:
Actinopterygian fish are commonly called the __ __-finned fishes.

The early bony fish were covered in protective bony plates and were referred to as being this type of fish:

The unique shape of a shark's tail which has a dorsal lobe that is much larger than the ventral lobe:

During the transport of sugar in plants, sugar is added to the vascular cells at the source and it is removed in the root or developing fruit. What is the term used to describe the structures where the sugar is removed:

As a bony fish rises in the water and swims nearer the surface air is ____ ____ from the swim bladder.

Unlike all the other gnathostomes the upper jaw of the shark is not attached to this:

The evolution of the jaw was originally an enhancement to this function:

Terrestrial plants evolved from this type of algae:

During aseual reproduction, these are launched from cup like structures on liverworts to produce new plants:

Food is trapped in sheets of this material covering the inner surface of the pharynx of the first chordates:

During *this* geological time the earth was warm and dry and there was an advantage to be able to move between bodies of water. It's one of the reasons amphibians appeared.:

In early plants, sperm had to do this to get to the egg:

Bundles of dead plant cells that move water are collectively called this plant tissue:

Compared to the other fish, this is missing in an agnathan:

The spine of a shark's scale points in this direction:

This biopolymer on the surface of leaves helps prevent water loss:
Most bony fish have this number of copies of the genome:

Cytoplasm and this cellular component are connected between plant cells (Abbreviation):

Plant spores are produced inside this structure:

Individual cellulase molecules are grouped together into a smaller complex structure and six of these form the large final cellulase complex. How many cellulases are in the smaller complex:

Phanerozoic: Carboniferous and Permian periods

---A trick for the Three Musketeers: "Xylem up and Phloem down"---

A strand of fungal cells aligned end to end:

In the gymnosperms the spores differ in appearance from each other and the two are described as this:

Chromosomal complement of fungal hyphae before plasmogamy occurs:

This kingdom is the sister group to the fungi:

Crustaceans dominate this environment:

The type of cell division that the spore mother cell in a moss sporangium undergoes when it produces spores:

In conifers (gymnosperms), pollen is dispersed using this:

Germinating fern spores form this structure with antheridia and archegonia on its surface:
→

These plates separate the phloem cells:

One of the two main vascular tissues in vascular plants that moves water down the plant:

Structural carbohydrate in a fungal cell wall:

Lignin's original form or appearance in the first vascular plant cells:

An amphibian can breath through these when its mouth is shut:

Insects protect the egg from drying out by covering it with this:

The feeding strategy of fungi that obtain their carbon from non-living material:

These glands in an amphibian are defensive:

Because fungi spend most of their life cycle in the haploid stage, we refer to them as having this type of life cycle:

An immature larval amphibian:

Fungal hyphae are wound together to form this filamentous stand:

The photosynthetic partner in a lichen is most often green algae but can also be this type of single celled organism:

A folded fern frond:

In female sporangium of a pine (gymnosperm) how many products of meiosis survive and fuse with the sperm? →

Wings are only found in this stage of the insect life cycle:

In vascular plants the cellulose cell wall is the ___ ___cell wall.

To be able to keep amphibian skin moist you'll find many of these in the skin:

One of the main roles of Fungi is in this important part of the carbon cycle:

The cytoplasm of fungal cells flows freely from one cell to the next because either these structures are missing or perforated with small openings:

Number of nuclei in a dikaryotic fungal cell:

Usual name for a fern leaf:

What were the first vascular plants reaching up for? →

The photosynthetic part of a lichen is given this name:

The female cones a pine tree are located on this part of the tree:

What lichens do to rock to get their nutrients:

The storage carbohydrate of terrestrial plants and their algal ancestor:

This part of the cuticle contains waxes that waterproof the cuticle of an insect:

Pollen contains which gamete:

Like the plants that follow, ferns have vascular tissues, but they still lack this plant innovation: →

The spore forming structures in a fern are protected by a covering and the whole resulting structure is called this:

The male embryonic protective device of gymnosperms and angiosperms:

Transpiration occurs with these plant structures:

This structure gives the Basidiomata fungi their name:

The first terrestrial plants were made entirely out of this plant part:

Probable food for the first amphibians on land:

Although almost all insects have them not for locomotion, ancestrally they didn't:

Unlike other multicellular organisms the nuclei of the mating types remain separate and the cell is referred to as being a __ ___ mycelium.

Insects have this many pairs of legs:

The main respiratory surface in most amphibians:

In the relationship between plant roots and fungi the plant provides this as part of their relationship:

Unlike most multicellular eukaryotes these haploid cell type are rarely…:

To survive, all amphibians have to lay their eggs in this:

Unique cyanobacterial fungal association:

Phanerozoic: Phylogeny and Extinction:

These genes control pattern in multicellular organisms:

These geological events are too small and infrequent to result in any change in greenhouse gasses to cause a mass extinction:

This tissue is missing from the gut wall of a pseudocoelomate:

The Parazoa, without cell-to-cell communication, are sister group to these animals which have this form of cellular communication:

Although there is increasing evidence to the contrary it is still generally believed that This form of life appears at the start of the Cambrian period:

The ancestral cell type of animals and fungi:

These fossils found in Australia and Newfoundland predate the Cambrian and appear to be multicellular organisms:

An explosion in different types of multicellular animals identifies this era starting approximately 540 MYA:

One of a skeleton's functions is to do this to contracted muscles:

When oxygen in the atmosphere destroyed this greenhouse gas and the less insulative carbon dioxide replaced it the earth cooled; it may have been one of the causes for the entire freeze of the planet 600 MYA:

Unlike all other animals, ecdysozoan surface epithelium is missing these structures:

Although it was thought to be the most primitive of the three protostome lineages or clades, it is now considered to be the most derived. Which clade is it? →

A good rule of thumb for how long a species normally survives is this many million years:

The change from a larval to an adult (Hint for friends: the same word for the process by which a caterpillar becomes a butterfly)

Endodermal cells that appear at the start of gastrulation invaginate to form a new cavity in the developing embryo. What is the name of this cavity? →

To assess the symmetry of an animal, a plane (or division through) this axis of the body is used to determine of multiple planes or only one result in identical halves (two words):

Nerve cells form from this tissue layer:

This type of movement allowed the Cambrian fauna to tap into a rich unused food source of the marine sediments:

In a deuterostome animal the blastopore becomes which part of the digestive tract:

Animals with this type of body rarely fossilize:

This type of geothermal discharge was probably the source of the greenhouse gasses that melted the frozen planet earth prior to the Cambrian:

The Precambrian ocean bottom was covered in these and they prevented the earliest animals from burrowing into the sediments:

The development of this type of egg protected the developing embryo from water loss and allowed the invasion of land by vertebrates:

The protostome animals are divided into lineages, or clades. How many clades are there? →

This cavity is missing in an acoelomate animal (this one's as easy as you think it is):

As water temperatures rise the solubility of this gas in it decreases. If it decreases enough a mass extinction may occur:

To optimize their surface to volume ratio, animals that have no body cavity usually have this shape:

Decreased dissolved oxygen in the water makes the water…

The levels of this greenhouse gas fluctuate dramatically near the end of the Proterozoic Eon alternating between low levels and a frozen planet and high levels (two words):

The type of stone that the Cambrian fossils are found in:

During the eight cell stage in the developing embryo, when the cells above the equatorial plane where cleavage occurs remain in place, and aligned perfectly with the cells underneath the cleavage pattern is this type:

In addition to cell-to-cell communication the presence of this structure ***under*** the layer of cells is also when distinguishing between cell layers and tissues (Two words):

In a protostome animal the blastopore becomes which part of the digestive tract? →

If the Doushantuo fossils are aren't animals they may be this type of organism, only very large: →

These shales are famous for the fossilization of soft boned Cambrian animals:

One of the two terms describing the type of junction that appear early in animal evolution that allows for cell-to-cell communication:

The number of tissue layers in a diploblast:

Prior to the Cambrian the earth is believed to be completely frozen which gives the theory explaining the phenomenon its name:

The name given to the types of animal with cells that work together but haven't formed tissues:
→

*____*_____*____*_____*____*

A few practice tests for la fam:

----Number 1 (Randomized)

This type of skeleton is the least dense of the skeletons found in fishes and its use is an adaptation attempting to achieve neutral buoyancy:

Parasite that lives on the surface of the host is what type of parasite:

This pathway for moving materials in plants uses the cell wall:
Chordates slits that help separate food from ingested water prior to passing the food to the digestive system:

To optimize their surface to volume ratio, animals that have no body cavity usually have this shape:

Decreased dissolved oxygen in the water makes the water…

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Animals with this type of body rarely fossilize:

The bristles, or hairs of annelids:

Sponges are organized at the cellular grade and don't have cells organized as these:

In a mollusk, the edge of this tissue secretes the shell and creates the cavity that bears its name:
→

The stage of the fluke life cycle that swims to either its vertebrate host or another vertebrate host where it encysts:

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Compared to the other fish, this is missing in an agnathan:

The waterproof layer of a leaf:

The cells that swell to close the opening and shrink to allow air to pass through to the photosynthetic tissue:

The name for the part of the skeleton that runs the length of the body of a vertebrate:

These plant tissues are missing in mosses:

The spine of a shark's scale points in this direction:

This biopolymer on the surface of leaves helps prevent water loss:
Most bony fish have this number of copies of the genome:

Clams are an example of the mollusc body plan specialized for this type of feeding:

These large tubes help supply air to insect tissues that require oxygen:

Cnidarians remove undigested food from the gastrovascular cavity through this opening:

Extensions of these cells connect the nervous and muscular systems of a nematode:

These plates separate the phloem cells:

One of the two main vascular tissues in vascular plants that moves water down the plant:

Structural carbohydrate in a fungal cell wall:

A folded fern frond:

In female sporangium of a pine (gymnosperm) how many products of meiosis survive and fuse with the sperm? →

Wings are only found in this stage of the insect life cycle:

In vascular plants the cellulose cell wall is the ___ ___cell wall.
In an echinoderm the tip of the tube foot uses this to help it attach to the the substrate:

Like corals, these animals also built reefs in the ordovician oceans:

The side of the medusa opposite the mouth is referred to as this surface or side:

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Like corals, these animals also built reefs in the ordovician oceans:

The side of the medusa opposite the mouth is referred to as this surface or side:

----Number 2 (Randomized)

Ancestrally, the mouth of an echinoderm faced in this direction relative to the substrate to which it was attached:

This fluid filled cavity forms the hydrostatic skeleton of a nematode:

Planaria feeds by using this structure to get food into its digestive tract:

These flatworm parasites always have a mollusk, usually a snail, as a part of their complex life cycle:

In a protostome animal the blastopore becomes which part of the digestive tract? →

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Terrestrial plants evolved from this type of algae:

During aseual reproduction, these are launched from cup like structures on liverworts to produce new plants:

Food is trapped in sheets of this material covering the inner surface of the pharynx of the first chordates:

This is trapped on the inner surface of the mucus net that lines the pharyngeal cavity of early chordates:

In non vascular plants these assist the sperm in getting to the egg:

Gemma in primitive plants like liverworts are an example of this type of reproduction:

The ray finned fish perfected this unique form of feeding to capture their prey:

The composition of their skeleton and the use of this substance help the Chondrichthyes achieve neutral buoyancy:

These structures on a the surface of a fish create microturbulence and help reduce drag as the fish swims:

Crustacea, very important in marine environments because of what they feed on, are described as being this:

This type of skeleton is found in Ecdysozoans:

The sponge stem cell is an amoebocyte, and may have this more specialized term:

The type of symmetry characteristic of cnidarians:

Annelids always have setae to help anchor them in their burrows or as they crawl across the substrate. How many bundles are they arranged in?

Although almost all insects have them not for locomotion, ancestrally they didn't:

Unlike other multicellular organisms the nuclei of the mating types remain separate and the cell is referred to as being a __ ___ mycelium.

Insects have this many pairs of legs:

A strand of fungal cells aligned end to end:

In the gymnosperms the spores differ in appearance from each other and the two are described as this:

Chromosomal complement of fungal hyphae before plasmogamy occurs:

Number of flagella on the moss sperm cell:

Unlike the sharks, the pectoral and pelvic fins are __ ___ and allow for much better maneuverability.

This part of the vertebrate skeleton induces the two sets of paired fins:

Together, bundles of the living cells that move sugar in plant are referred to as this type of plant tissue:

----Number 3 (Randomized)

The levels of this greenhouse gas fluctuate dramatically near the end of the Proterozoic Eon alternating between low levels and a frozen planet and high levels (two words):

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Unique cyanobacterial fungal association:

Usual name for a fern leaf:

What were the first vascular plants reaching up for? →

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The storage carbohydrate of terrestrial plants and their algal ancestor:

Because fungi spend most of their life cycle in the haploid stage, we refer to them as having this type of life cycle:

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Fungal hyphae are wound together to form this filamentous stand:

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Cytoplasm and this cellular component are connected between plant cells (Abbreviation):

Plant spores are produced inside this structure:

Individual cellulase molecules are grouped together into a smaller complex structure and six of these form the large final cellulase complex. How many cellulases are in the smaller complex:

During *this* geological time the earth was warm and dry and there was an advantage to be able to move between bodies of water. It's one of the reasons amphibians appeared.:

In early plants, sperm had to do this to get to the egg:

Bundles of dead plant cells that move water are collectively called this plant tissue:

A cnidarian gastrovascular cavity is described as incomplete because it lacks this:

Bryozoans get their common name from these plants, which they look like (this plant is referred to as a bryophyte) :

The name of the ciliated larval stage of the cnidarian life-cycle:

The sperm duct transports gametes from this organ to the seminal vesicle:

This is the mobile or floating stage in the cnidarian life cycle:

Early chordates, like the lancelet, were this type of feeder;

In addition to chlorophylls, this plant pigment is also shared with algae, indicating that these are the ancestors to plants:

Lampreys are best described as this type of feeder:

Cellulose is a polymer of which sugar molecule:

The sarcopterygian fishes are commonly called the ____ ____- finned fishes.

The addition of this mineral to the skeleton occurs in all gnathostomes except the sharks and rays:

Some of the animals in the Lophotrochozoa have a unique feeding structure, what is the name of this structure (this one's a freebie):

Even though onychophora have a chitinous cuticle they have this type of skeleton:

A free living flatworm's mouth is located on this side of the animal:

The number of muscle layers in a nematode:

Most echinoderms have this number of arms:

The ancestral echinoderms tube feet were originally used for this:

Specialized sponge cells can, if required differentiate and become amoebocytes once again and after that specialize once again for different functions. The cells are referred to as having this characteristic:

These cover the surface of a bryozoan’s tentacles:

-----Number 4 (Randomized):

Echinoderms have this special type of symmetry:

The tremendous array of molluscan body plans is an excellent example of this type of radiation: →

The type of movement used by nematode sperm:

With two different body types, we refer to the life cycle of cnidarians as being this:

Because onychophorans are active at this time of day they are considered to be:

This fluid provides the hydro in the hydrostatic fluid in worms:

Metameres in a worm are also called these:

This arthropod was abundant in the Cambrian and although it survived into the Ordovician it in now extinct:

The main locomotory structures used by echinoderm's:

There are thousands of these on the surface of the radula, and they can scrape, peirce, tear, or cut at a mollusk’s food:

These filter feeding, and the simplest of architectures, appear prior to the the Cambrian period: →

Burrowing worms consume what they burrow through, and that makes them this type of feeder: →

The Precambrian ocean bottom was covered in these and they prevented the earliest animals from burrowing into the sediments:

The development of this type of egg protected the developing embryo from water loss and allowed the invasion of land by vertebrates:

The protostome animals are divided into lineages, or clades. How many clades are there?
→

This cavity is missing in an acoelomate animal (this one's as easy as you think it is):

As water temperatures rise the solubility of this gas in it decreases. If it decreases enough a mass extinction may occur:

As a bony fish swims deeper, air is ____ _____ to the swim bladder:

What an arch***eg***onium produces:

Microtubular structure that directs cell division in plants:

To assess the symmetry of an animal, a plane (or division through) this axis of the body is used to determine of multiple planes or only one result in identical halves (two words):

Nerve cells form from this tissue layer:

This type of geothermal discharge was probably the source of the greenhouse gasses that melted the frozen planet earth prior to the Cambrian:

This kingdom is the sister group to the fungi:

Crustaceans dominate this environment:

The type of cell division that the spore mother cell in a moss sporangium undergoes when it produces spores:

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Although there is increasing evidence to the contrary it is still generally believed that This form of life appears at the start of the Cambrian period:

The ancestral cell type of animals and fungi:

These fossils found in Australia and Newfoundland predate the Cambrian and appear to be multicellular organisms:
Bones and what other tissue extends into the lobed finned fishes fin:

Another way of describing post anal segmentation:

Bundles of dead plant cells move water in which direction in a plant (The dead go ***UP*** to heaven…) :

The sheet of mucus covers the inner surface of the pharyngeal cavity of chordates is produced by this structure on the ventral surface of the cavity:

When the fate of the undifferentiated cells in a plant is fixed; it becomes only one structure, we refer to the undifferentiated tissue as being this:

To be able to keep amphibian skin moist you'll find many of these in the skin:

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The cytoplasm of fungal cells flows freely from one cell to the next because either these structures are missing or perforated with small openings:

Number of nuclei in a dikaryotic fungal cell:

The unique shape of a shark's tail which has a dorsal lobe that is much larger than the ventral lobe:

During the transport of sugar in plants, sugar is added to the vascular cells at the source and it is removed in the root or developing fruit. What is the term used to describe the structures where the sugar is removed:

As a bony fish rises in the water and swims nearer the surface air is ____ ____ from the swim bladder.

All the keywords I've done so far, how are we doing this?

Cambrian Explosion

- Explosion of invertebrates on planet
- Occurs in shallow water around Laurentia (continental Blob)
  - Shallow water allowed for penetration of light, lots of photosynthesis and food
  - Water was warming in this area, incubator of life
- Short period of time all phyla today appeared (ancestors to all organisms today)
- Phyla that don't exist today appeared too -> means diversity exploded and diminishes over time

Burgress Shale Fossils

- Layers of sediment that when split reveal impressions of invertebrate animals of the Cambrian period (ancestors of animals today)
- Found in Yoho National Park
- Invertebrates of Cambrian were fossilized in layers of shale that formed in ancient Cambrian sea
- Fossils in rocks were pushed to Rocky Mountains

- Evidence of Cambrian explosion

Choanocyte (Choanoflagellate)
- Cell with a collar of microvilli surrounding a central flagellum (unicont)
- When flagellum beats, food particles in water are trapped against microvilli collar and consumed by phagocytosis
- in structure of sponges (Porifera), cells become sperm of sponges (do not have committed differentiation, sponge cells)
- cells come together to form colonial choanocyte (cluster of choanocyte cells), filters water faster that individual cells, advantage of forming clusters
- choanocyte is unifying ancestor of fungi and animals

Sponges (Porifera)
- use of choanocytes in an aquiferous system
- cells but no tissues
- totipotent cells
- asymmetric body plan *b/c no mouth

*hollow structure filters huge volume of water - Use choanocytes in aquiferous system to pump water and feed cells
*cells are arranged in layers, NO TISSUES (no cell communication)
*Sponge cells are totipotent, do not have fixed developmental fate (uncommitted differentiation)
*Sex – choanocytes become sperm, archeocytes become eggs -> sperm is released, sucked in by female sponge of same type, eggs are fertilized//sucked in by different type, sperm is food

Aquiferious System
This type of system is found in sponges. Consists of the canals (pores) and chambers (spongocoel) through which water flows. Water pumped through the system by the choanocytes.

<u>Structure of Sponge:</u>
Spongocoel: large central cavity of sponge, water enters cavity through pores (porocytes) of sponge and exits through large opening (osculum)

Choanoderm: The layer of choanocyte cells lining the different parts of the aquiferious system in a sponge; different sponges have lining of cells in different areas of the system;

cell layer composed of flagellated collar cells (choanocytes), cells lock together to form cover on surface

Pinacoderm (Pinacocyte): Outer layer of pinacocyte cells in a sponge. It is not a tissue, only a layer of cells. Pinacocytes are flattened cells that cover the surface of the sponge.

Mesohyl: gelatinous matrix between the two layers of cells in the body wall of the sponge (fills space between external pinacoderm and inner choanoderm). Contains spicules and amoebocyte (moves through it to transport).

Amoebocyte (Archeocyte): A cell in a multicellular organism that moves using amoeboid movement and has a variety of functions. Amoebocytes often are involves in transporting materials, defending against invading organisms and cleaning up dead debris and materials
Can differentiate into different cell types with different functions
- Moves in mesohyl of sponge, fed by choanocyte cells, transport cell that can take food and give it to pore cells, form eggs of sponge (sponge stem cell)

Spicules: calcium glass needles, form skeleton of mineralized material, holds structure up/together

Gap (Septate) junctions
- Formed by connexon (series of 6 specialized proteins, rosette structure)
- Channel in the center that permeates through cell membranes (connects cells)
  - Allows for communication, can open and close (open and closed communication)
- Holds cells together, forming tissues (communicating cells)

Blastula
During the development of the embryo, single cells divide and form a hollow ball of epithelial cells one cell layer thick; this is the blastula. The cavity inside this hollow ball is the blastocoel.

Gastrulation
The stage of embryonic development where the blastula turns into a gastrula. Cells invaginate towards the inside of the embryo from the region where the blastopore will form to create the second germ layer (endoderm). The embryo changes from having only one layer to having two cell layers; the ectoderm and endoderm.

Gastrula
Stage in embryonic development where the embryo consists of two cell layers, an outer ectoderm and an inner endoderm, surrounding a primitive gut (archenteron) opening to the outside through the blastopore.

Archenteron (Enteron)
The primitive gut formed during gastrulation. Surrounded by the endoderm and will develop into the digestive system of the organism. Open to environment through blastopore.

Blastopore
The opening to the primitive gut (archenteron) and entry point for external material into the gut. Develops into the mouth or the anus of the organism. Forms during gastrulation.

Diploblastic
Organisms formed from only the two primitive cell layers (endoderm and ectoderm).
· Although there may be some kind of matix btw. layers (ex. mesoglea) it is not a true tissue layer
- Body having 2 germ layers (ectoderm and endoderm, but no mesoderm)

Ectoderm
The outermost cell layer that forms the epithelium and nervous systems of an animal. A primary germ layer.

Endoderm
The innermost layer of cells that form the digestive tract and the other associated organs. A primary germ layer.

<u>Symmetry</u>
Asymmetric Body Plan
A body plan where there is no axis of symmetry that runs through the body and results in identical parts.
- No symmetry

Bilateral Symmetry
- Symmetry where you can draw a line (drawn through the side with the mouth, to the opposite side of the animal, the location of the anus if there is one) in only one way and get identical halves

- Bilaterally symmetric animals travel in one direction and sense where they are going, special sensory structure concentrated on leading end of bi. animal (anterior) and head forms, results in anterior brain (Cephalization)

Cephalization

- The concentration of sense organs, nervous control etc. at anterior end of the body, occurs in bilaterally symmetric animals
- Evolution of a distinct anterior region on the body, the head; specialized sensory structure concentrate in this area

Radial Symmetry

- Symmetry where you can draw a line (drawn through the side with the mouth, to the opposite side of the animal, the location of the anus if there is one) in a number of different angles and get identical halves
- When an organism's body parts are arranged around the oral-aboral axis so that any plane passing through this axis results in identical halves
- Associated with sessile animals living attached to substrate
- Radially symmetric animals react equally in all directions to surrounding environments, sensory system can collect info in every direction

Oral-Aboral Axis

(Phylum) Cnidaria

Ex. Jellyfish, coral, sea anemones, hydroids

- Cnidocytes
- Polyp body plan
- Epitheliomusculature

*Phylum contains species in exclusively aquatic and marine environments
*Exist in 2 forms; polyp and medusa
*prey on primary herbivores for food
*diploblastic
*Few are herbivores, mostly carnivores that sting, entangle or poison prey using nematocysts

- *Dimorphic life cycle (exception of Anthozoa), Cnidarians live first as polyp (sedentary) and then as motile, sexual medusa

Cnidocyte
Specialized cells and predatory tools found in Cnidaria. When these cells evert, nematocyst is discharged. The nematocyst may act as a stinger or a sticky thread to entangle and capture prey.
- Cells contains Nematocyst (organelle) that grows into coiled structure with tension (spring) used to capture prey (small invertebrates, primary herbivores)
- Barbs on surface of coil break through skeleton of prey into soft tissue underneath, toxin release and prey is consumed

Nematocyst
An organelle in cnidocyte cell unique to Cnidarians. It is the stinging tool of the cell that can drill into, entangle, or stick to potential prey. Spring like structure; coil with tension.

Cnidocil
A modified flagellum on the cnidocyte cell that causes the nematocyst inside the cnidocyte cell to fire. The stimulus involves some sort of chemical cue; touching the cnidocil doesn't fire the nematocyst.
- On surface of cell, rod like structure, awaiting contact on proteinaceous prey
- when cnidocil is in contact with prey, nematocyst opens up, releasing pressure, springs out

Polyp
- Tentacles surrounding a central mouth; when prey is captured, tentacles put food in cavity
- Diploblastic (has endoderm and ectoderm)

A sessile/sedentary, asexual stage in the cnidarian life cycle. In some species, they are independent organisms, in others, they form colonies where some polyps are involved in food gathering (**gastrozoids**) and other polyps (**gonozooids**) produce the reproductive stage.
Ex. Sea anemone and freshwater hydra

Gastrozoids
Polyps in colonial hydrozoans specialized for feeding; also, referred to as hydraths.

Gonozooids

Polyp in colonial hydrozoans specialized for producing reproductive structures, medusa, the reproductive stage in the life cycle. Also, referred to as gonangia.

Medusa
The free swimming, mobile stage of the cnidarian life cycle. This stage, when present, is reproductive and mature gonads form on either male or female medusa.
Ex. Jellyfish

Gastrodermis
The name given to the inner layer of endodermal cells that line the gastrovascular cavity of cnidarians.
- This layer contains gland cells (release digestive enzymes) and nutritive cells (undergoes phagocytosis to absorb nutrients from food)

Hydrostatic Skeleton
Formed from a fluid filled and closed cavity surrounded by a body wall containing muscles oriented in different directions. Muscular contractions (myonenes) maintain the rigid form or change the shape of the organism allowing movement.
- In polyp: fluid filled gut and longitudinal and circular myonenes (strands of muscle)
- In Medusa: uses elasticity of mesoglea in the bell and circular myonemes around its margin to increasing and decreasing diameter of medusa forces water in and out of bell

*Primary and most important role of a skeleton – mechanical device in combination with antagonistic muscles that stretches muscles (cells) back to original length after contraction has taken place

Mesoglea
The jelly-like layer found between the ectodermal and endodermal cell layers of diploblastic organisms. It acts as a type of cement holding the two layers, but has few, if any cells.
- Used in hydrostatic skeleton of Medusa, elasticity of this structure stretches muscle cells after they have been contracted in Medusa
- Also present in Polyp, but thinner layer

Corals
- Consist of colonies of polyps on branches
- Reef Builders

- Most live in symbiotic relationships, coral animals in symbiotic relationship with contained algal cell, algal cell provides animal with sugars and nutrients from photosynthesis and algal cell is protected from predation b/c polyp can retract in skeleton/casing
- Change in ocean temperature increase, as a result algal cells die in coral cells, and coral dies too without symbiotic relationship (coral bleaching)

*Fossil similar to structure of coral (branches of polyps) may represent early fossil cnidarian, fossil and older than the beginning of the Cambrian, suggesting multicellular life came before the Cambrian

Reefs
- Structure made from hard coral animals that and/or polyp colonies
- Coral reefs are huge productivity engines in oceans
- build reefs in warm water, found in tropical zones, consist of little polyps living inside harden cases made from calcium from water

Triploblastic
Organisms formed from the three layers: ectoderm, mesoderm, endoderm

Mesoderm
The third cell layer that develops in the gastrula between the ectoderm and endoderm in triploblastic animals. Mesoderm develops into muscle, connective tissues, and bones as well as blood and other components of the vascular system.
- Chemical signaling between ectoderm and endoderm make mesoderm

Protostome
Phyla that share common characteristics of the blastopore forming the mouth and second opening becoming the anus.

Not autapomorphies of Protostomes and Deuterostome:
*these characters did not stick to the lineage

Spiral cleavage (Spiralia)
Pattern of cell division in the developing embryo where the products of cell division shifts by rotating either clockwise or counterclockwise so that the resulting daughter cells

lie in the furrow or groove of the underlying pair of cell. Stable structure. The opposite of radial cleavage. Occurs in 8 cell stage of animals.

Radial cleavage
During the development as the cell of the zygote divide, the products of the cell division remain stacked directly on the top of each other. Remain in original position after division, rounded end on rounded end. Occurs in 8 cell stage of animals.

Body Cavities
Coelomate (Eucoelomate)
Animals that have a true coelom entirely lined by mesoderm.
Coeloms are formed in two ways:
1) By splitting a block of mesoderm, schizocoely, to create the coelom inside
2) Enterocoelic pouches
*more primitive group of animals in comparison to Acoelomates

Schizocoel
A coelom produced within the mass of embryonic mesoderm by splitting or cleavage.

Enterocoel
A coelom produced by primitive gut (Archenteron), forms from pouches "pinched" off the gut. Cells proliferate separately on two sides in pouches and meet up at the top of the cell.

Acoelomate
Triploblatic animals that do not have an internal body cavity. This includes the flatworms and ribbon worms. Although the term could be applied to other lower phylum, it is the most accurately used with the triploblasts rather than diploblasts.
- Assumed to be the most primitive of all animals b/c they do not have body cavity; this was wrong
- Sit at more advance end of protostomia lineage after examining DNA sequence
- Acoelomates are a highly derived group and lost coeloms for the way they lived; coeloms are primitive, not having coeloms is a the more derived state

Pseudocoelomate
Animals that have a body cavity that is not completely lined by mesoderm (partially lined). In the past these organisms were referred to as the phylum Aschelminthes but this

is no longer considered acceptable because there is no apparent common ancestor to the group.

- There is mesoderm (muscle) associated with outer ectodermal layer, but no muscle associated with gut; this forms Pseudocoelom space (space not entirely lined with mesoderm)
- Pseudocoelomate are intermediate between Acoelomates (not having coelom) and Coelomate (true coelom lined with mesoderm).
- Pseudocelomate condition is found in organisms that specialize to miniaturization (100- 300 cells)

Miniaturization: extremely small size in order to keep volume or weight to a minimum

- Miniaturization is associated with the the getting rid of surplus structure (ex. One structure they get rid of is mesoderm -> are partially lined with mesoderm)
- Most often optimal surface to volume ratio, diffusion meets need b/c of small size
- Allow invasion of microhabitats

Three Main Protostome Groups (Taxa)

Ecdysozoa

- Moulted protein cuticle *always jelly-like matrix of protein with reinforcing fibers that have to moult to allow growth
- No surface cilia *cilia are common on epithelial lining except in this group

Taxon of animals that have a chitinous or collagenous cuticle (exoskeleton) and no epithelia cilia. These animals must undergo ecdysis or molting of the cuticle grow.

Cuticle: The nonliving, noncellular outer layer of an organism secreted by the underlying epidermis. Cuticles are common in a variety of animals including arthropods. The presence of a cuticle precludes the presence of cilia.

Exoskeleton: supporting structure of the skeleton not surrounded by the body. Endoskeleton elements are secreted by underlying epidermis and one side of the skeletal structures is exposed outside the body

Ecdysis: The periodic molting, or shedding, of the outer exoskeleton of an arthropod.

Platyzoa

- Loss of coelom
- Acoelomate or pseudocoelom (*loss of a true coelom)
- Loss of mentanephridia and circulatory system

Taxon of animals that have three tissue layers but lack a coelom. Classic example of acoelomate body plan. Lost their coeloms.

- Ex. flatworm

Lophotrochozoa

Taxon of animals supported by molecular evidence (evident that animals of this group are molecularly related). But, morphology of animals in group were very different, no single unifying character. Therefore, animals in this group fall into 1 of 2 categories based on morphology (organisms in this group are either:):

1) Presence of **Lophophore** (feed with a locophore)

OR

2) Presence of **Trochophore** larval stage. (trochophore larva in larva stage)

Lophophore

A unique double ring of hollow ciliated tentacles that surround the oral opening in a number of animal phyla.

- Tentacular feeding structure that is projected into water creating current and trapping food. Filter feeding.
- U shaped gut

Trochophore

Free-swimming ciliated larval stage found in a number of animal phyla including Mollusca and Annelida.

- Spinning top with a ciliated band around the middle, stabilizers so it can swim through the water, band collects food for larval stage to grow

(Phylum) Nematoda (Round worm)

- Collagenous cuticle without microvilli
- Longitudinal but no circular muscles
- Epitheliomuscular pharynx

* Phylum

- Triploblastic
- Bilaterally symmetric
- Protostome

- pseudocoelomate *partially lined coelom with mesoderm
  - pseudocoelomate is linked to this groups specialization in miniaturization
  - miniaturization allows them to move through substrate and feed on bacteria

Miniaturization involves the simplification of trait:

- Muscles are directly stimulated by central nervous system without peripheral nervous system
- Males - only have 1 teste, females – paired coil tubular reproductive system
- Only group of animals where sperm is amoeboid and does not move by flagellum
- Epitheliomuscular pharynx (consists of 2 bulbs, when back in squeezes front open to allow food in, no food escapes because back pharynx is closed), solves issue with pressure forcing food out every time trying to get food in)

Epitheliomusculature

- Cells with two functions: form the outer body covering the animal and movement by contraction of myoneme portion of the cell. In other words, epithelial and contractile cells.
- In Cnidarians (and in Nematoda, Nematoda stole this from them)
- In Nematoda, contraction of cells allow pharynx to open and close
- Nematodes have Epitheliomuscular pharynx (consists of 2 bulbs, when back in squeezes front open to allow food in, no food escapes because back pharynx is closed), solves issue with pressure forcing food out every time trying to get food in)

Pharynx

The region of the digestive tract between the mouth and esophagus. In most animals, it is muscular and forces food into the digestive tract that lies behind it. In vertebrates, it is part of both the digestive and respiratory tracts.

Triradiate pharynx

Crossed pharynx that is radially symmetric, appears triangular when seen in cross section. Present in Nematoda.

- In this structure epitheliomuscular contraction cause pharynx to open, relaxed pharynx closes.

Longitudinal muscle

(Phylum) Arthropod (Arthropoda)

Ex. Insects, Crustacean

- Articulated exoskeleton of plates *cuticle become solid rigid plates, articulation where cuticle is soft
- Muscles arranged in bands
- Compound eyes

*Largest and most dominant vertebrates
- cuticle of chitin
- Manipulation of food by limbs

Trilobites

- In phylum arthropod
- Ecdysozoa
- Large arthropod
- Predator in oceans
- Major arthropod group
- Goes extinct over time, do not exist today

Crustacean

- Ecdysozoa
- First arthropods to figure out a way to filter food particles from water
- Primary herbivores and food source for most marine animals in oceans
- Abundant in oceans, dominate; large marine animals like whales can feed exclusively on these for a time
- Grow by molting
- Body plan consists of tagmata
- Filter feeder

*cuticle of chitin
*Manipulation of food by limbs

Tagma (Tagmatization)

Ex. In Crustacea, for example Lobster, they have different appendages have different functions, claws are defensive and legs are for walking

The distinct body regions, tagmata, resulting when different segments of a metameric animal become involved in specific functions. These segments are modified to carry out that function and their appearance changes.

- Group of appendages taking on unique functions

Filter feeding
Common among crustaceans.
- Organisms that take water to filter out the food and then releases the extra water
- Swimming motion through water allows them to collect food and feed
- Limbs contain articulation point with 2 flaps, as they move, movement of water in and out allows for locomotion
- Unidirectional flow of water down length of organism
- Algae from water is filtered, caught on side of legs by hairs
- Trapping food on sides, movement of legs move food to mouth

Phytoplankton
Primary producers, that are food for herbivore primary consumers

(Phylum) Onychophoran (Velvet worm)
- Oral papillae with slime glands
- Body wall musculature continuous sheet *uses hydrostatic skeleton to change shape, this group has thin, flexible cuticle
- Unarticulated limbs

*cuticle of chitin
*Manipulation of food by limbs

* in burgess shale, therefore were marine animals; onycophora still look similar today
*eventually come on land; living in moist environments

Oral Papillae
Structure where slime exits, used as predatory tool in Onychophoran to immobilize prey.

Bryozoa
- Filter feeder
- Triploblastic
- Sessile
- U-shaped gut