Geology 2051 Assignment 3

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Part A: Short Answer Questions

1. As Laurentia and Baltica moved toward each other, plate convergence would have been taking place. The Iapetus Plate subducted beneath Laurentia (oceanic-continental plate convergence) forming the Appalachian mobile belt (Taconic orogeny). Rising magma from the subduction zone rose to begin volcanic activity and mountain formation. Between the two plates divergence would also have been taking place, causing seafloor spreading and the narrowing of the Iapetus Ocean.
2. During the early Paleozoic, the subduction of an oceanic plate off the East Coast of Laurentia caused Volcanism, forming volcanic islands and eventually the micro continent of Avalonia. The Pearya Terrane then collided with the North Coast of Laurentia which deforms and uplifts the existing sediments. The six major Paleozoic continents are Baltica, China, Gondwana, Kazakhstania, Laurentia, and Sibera. The Paleozoic began after the breakup of a supercontinent called Pannotia. Plate movement had a major part in changing the world geography. During the Ordovician period, Gondwana moved southward and began to cross the South Pole. During the Early Ordovician, microcontinent Avalonia separated from Gondwana, moved northeastward, and finally collided with Baltica in the Late Ordovician. A convergent plate boundary formed on the East Coast of Laurentia during the Ordovician. Baltica (attached to Avalonia) then moved northwestward of Laurentia and collided with it to form Laurasia (during the Silurian). After this collision, an ocean called the Iapteus Ocean was closed off in its northern region. Previously, the subduction of the Iapetus plate subducted beneath Laurentia (oceanic-continental convergent plate boundary) formed the Appalachain mobile belt (Taconic orogeny) Siberia and Kazakhstania moved northward from their south equatorial location starting in the Cambrian and ending in the Silurian period.

3.

Organism	Phylum	Ecosystem position	Feeding style
Ottoia	Priapulida	Benthos-mobile-infauna	Carnivore, used hook like spines to capture prey, then swallowed it headfirst. Ate snail like molluscs.
Anomalocaris	Lobopodia Stem group: Arthropoda	Nekton, thought to be predator	Carnivore-soft prey like worms or plankton, hard-bodied animals – trilobites have been found with anomalocaris mouth shaped "bite marks"on them. Debated as to whether or not they ate hard or soft bodies prey (a weak jaw is debatable)
Vauxia	Porifera (demosponge"calcareous")	Epiflora (sessile benthos)	Extracted nutrients from the water
Marella	Arthropoda/Lobopodia	Epifauna bottom dweller-mobile benthos	Scavenger-detrital and particulate matter, carnivore

4. A Cambrian reef was dominated by trilobites, brachiopods, and archaeocyathids (the skeletonized portion). Trilobites made up about half of the total fauna. They crawled or swam along the seafloor. There were also floating jellyfish, sponges, and swimming arthropods. An Ordovician reef had brachiopods and invertebrate phyla like bryozoans and colonial coral. There would also have been acritarchs (phytoplankton), cephalopods, stromatoporoids, with the reef containing mainly suspension feeding organisms, graptolites, and eel-like creatures. A Devonian reef was a massive sized reef with predominately tabulate and colonial corals, and stromatoporoids. There were also bryozoans,

cephalopods, trilobites, crinoids, and brachiopods. This reef looked the most like present day reefs, so would appear very familiar. There was also an abundance of pincered, scorpion like creatures called euryptids. Ammonoids were also plentiful. A Carboniferous reef contained brachiopods and ammonoids, lacy bryozoans and crinoids. The once large reefs were now small and patchy.

5. The **lungfish** is the present day fish closes to the immediate ancestor of the first amphibians. They are known for retaining primitive characteristics of bony fish (Osteichthyes) including the ability to breathe air. They have lobed fins, internal skeleton, and a specialized respiratory system with lungs. These lungs are divided into smaller air sacs which maximize surface area available for the exchange of gas. There are six known lungfish species living specifically in Africa, South America, and Australia.
6. For plants in particular, the transitional freshwater environment helped to overcome differences in osmotic pressures between saltwater and freshwater. Both plants and animals had to overcome the transition from water to land, and freshwater was a natural transition between the two. Both needed a source of water to reproduce.
7. The development of vascular tissues in plants was important because it allowed transportation of nutrients and water within the plant while living on land. Nonvascular plants could only live in low moist areas because they did not have these special tissues. Vascular tissues also provided support for the plant's body. The first known vascular plants were small Y-shaped stems from the genus Cooksonia. They were seedless (did not produce seeds) and had simple leafless stalks that produced spores at the tips. There was no root system either. Instead there was a rhizome (underground part of the stem) that transferred water from the soil to the stem and held the plant in the soil. They lived in low, wet marshy areas like the first amphibians.
8. The massive extinction at the end of the Permean came from climatic and geologic changes resulting from tectonic events. The formation of Pangaea after many continental collisions caused new arid and semi-arid conditions instead of the previous tropical moisture. Mountain ranges produced by orogenies created a rainshadow effect that blocked moist, subtropical easterly winds.

Scientists think that there was deep-sea anoxia and increased oceanic carbon dioxide levels, reducing oxygen-rich surface waters that could be circulated to the deep ocean. There was also stagnant water in the shelf regions that affected shallow water marine fauna. Global warming during this time may have also brought on the extinction. It would have played a part in making a stratified global ocean: warming of higher latitudes would have decreased or eliminated downwelling of cold and dense oxygenated water from polar regions to lower latitude oceans. The oceans would have been more stratified (layered) and stagnant rather than well mixed and oxygenated. Another contributing factor may have been volcanic and continental fissure eruptions releasing additional carbon dioxide into the atmosphere, as well as ozone-destroying fluorine and chlorine. A final factor may have been the Siberian Traps Basalt that also affected the ozone layer, increasing UVB radiation at the end of The Permean.

Part B: Accumulation of Sediments in Canada during the Paleozoic

There are four major regions where Paleozoic sedimentary rocks exist in what is now Canada: The Franklin Mobile Belt, The Cordilleran Mobile Belt, the Appalachian Mobile Belt, and some inland areas from when the continent Laurentia was below sea level.

"Canada" was part of the continent Laurentia during the early Paleozoic. Sediments were accumulating along its eastern and western coastlines, as well as the north coast. The northern coast of present day Canada has sedimentary accumulation in a region known as the Franklin Mobile Belt. This particular area is the result of a convergent plate boundary when Pangaea was formed. By about 450 million years ago, sea levels were higher so part of the continent was under water, eventually creating inland areas of sedimentary deposit on shallow continental shelves.

The sedimentary rocks of the **Franklin Belt**, along Canada's northern coast were the result of forces from a convergent plate boundary as the supercontinent Pangaea was formed. There are two overlapping basins, the Franklin and the Sverdrup, which make up the Innuitian Orogen.

Sedimentary. Plates from further north deposited sediment into these basins as plates converged and collided. The Pearya Terrane collided with the north coast and uplifted existing sediment.

The **Williston Basin** is an area known for deposits of petroleum and potash (potassium bearing minerals, most commonly potassium chloride). It is a structural basin formed by tectonic deformation of previously flat strata, a geological depression. This basin crosses the area of present southern Saskatchewan. It lies on top of the Trans-Hudson Orogenic Belt. A weak zone probably produced this basin when the belt sagged, and it is approximately 764 km north-south and 480 km east-west. Sediments began in Cambrian and were most intense during the Ordovician, Silurian and Devonian when there were sedimentary accumulations of thick limestone and dolomite, with thinner sandstones, siltstones, shales, and evaporites. Dinosaurs leaving fossil deposits may also have been responsible for sediment in this area, covering regions of NE British Columbia, Alberta, and Saskatchewan.

The **Athabasca Basin** covers approximately 100,000 square kilometers in Saskatchewan and a small piece of Alberta, bordering lake Athabasca. It is a fluvial basin containing sediments from the Hudsonian mountains and occasional marine sediments. Sandstone is the main deposit of the basin (100-1000 metres deep) and uranium ore is found at the bottom point where the sediment meets the basement. It currently supplies about 20% of world uranium.

The two above basins are also related to Western Canada reef formation from the middle and late Devonian. The reefs began forming as the Kaskaskia Sea transgressed southward into Western Canada. By the end of the middle Devonian, the flow of ocean water was restricted which caused evaporate precipitation conditions. There is about 300 meters of evaporates in the back-reef area. More than half of the worlds potash (see Williston Basin section) comes from these particular Devonian evaporates.

The Coal Basins of North America/Canada began in the Carboniferous (late Paleozoic) period, 318-299 million years ago, when southern Gondwana moved over the south pole, causing extensive glaciation. It began colliding with Laurasia in a clockwise direction resulting in deformation along the Appalachian and Ouichita mobile belts. Thrust faulting created mountain belts in these areas. The coal basins of eastern North America all occur in the equatorial zone of this continental area where there was high rainfall and warm temperatures. During the Carboniferous Period, sediments varied between shallow marine and continental in a strata form called cyclotherms. The initial layer is from delta and fluvial deposits (sandstone) while the layer above is an underclay containing root casts from plants and trees. The coal bed is the result of accumulations of plant matter overlain by marine deposits of alternating limestone, shale, and invertebrate fauna. It is the later Carboniferous period (the Pennsylvanian) that shows the frequent coal swamps in the northern hemisphere. The southern hemisphere was experiencing continental glaciations.

Related to:

The Cordilleran Mobile Belt started as a passive continental margin with continental shelf sediments. There were thick marine sediment deposits graded into thin cratonic units when the Sauk Sea transgressed (advanced) onto the craton. Mantle upwelling formed an island arc to the west of this craton, which moved eastward to collide with the western border of the craton. This produced a highland area and the orogenic event was called the Antler Orogeny: Deep-water continental deposits were forced eastward over shallow water continental shelf carbonates. Porphyry copper and molybdenum deposits occur in this belt, associated with subduction zones at continental plate margins. The Canadian Cordillera has such deposits in the Intermontane Belt region:

<u>The Eastern Coast: The Acadian Orogeny</u> is the third of four orogenies that made the Appalachian orogeny and basin. Fragments of the continent Avalonia collided with Laurasia. It extends from the Canadian Maritime provinces, then southwest to Alabama in the USA. The northern region was the most affected by this collision, which eventually closed the Iapetus ocean to form a mountain belt. There was a major movement along a strike-slip fault (southeasterly). Avalonian terranes attached to the eastern side of Laurentia during the late-middle Devonian. This continent-continent collision caused Baltica/Avalonia to subduct below eastern Laurentia.

Red beds are a sedimentary feature of this area, resulting from sandstone and other sediment (siltstone, shale) being coloured red by hematite (ferric oxides). There are excellent examples in Nova Scotia, Canada.


Canadian Shield
Michigan Basin
Appalachian Basin
Acadian Highlands
Iapetus Ocean


Paleozoic North America
• Platform
Franklin mobile belt
Canadian Shield
Cordilleran mobile belt
Williston Basin
Appalachian Basin
Michigan Basin
Cincinnati Arch
Platform
Illinois Basin
Nemaha Ridge
Ozark Dome
Appalachian mobile belt
Nashville Dome
Permian Basin
Ouachita mobile belt
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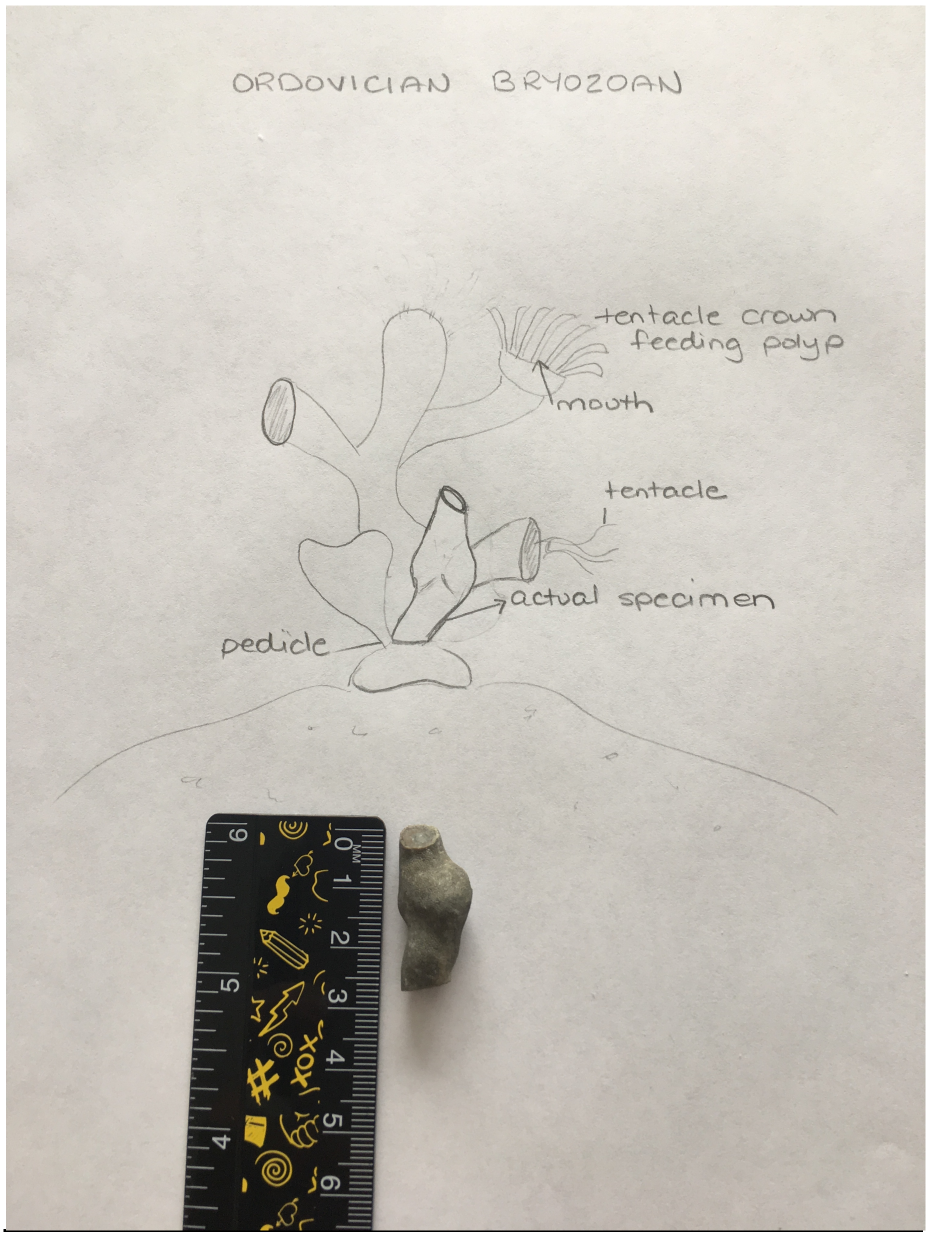
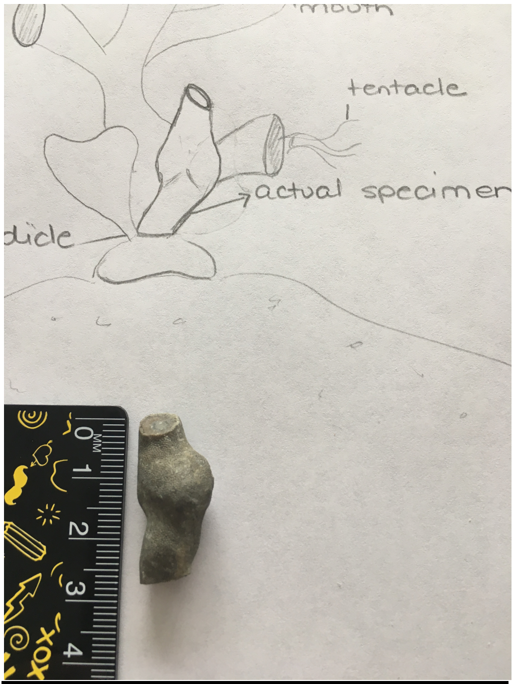
PART C: Brachiopods of the Paleozoic

Group	History (time range)	Morphology (valve shape, symmetry, hinge type and pedicle)
Orthida	Early Cambrian-Mid Permean (542 mA-between 298-251 mA)	Strophic (elongated, well defined hinge line) Brachial valve is flatter than pedicular valve Valves are usually sub-circular to elliptical, typically biconvex (both sides convex), bilateral symmetry
Pentamerida	Mid Cambrian-Upper Devonian (between 542-488 mA and 359 mA)	Biconvex, articulate, impunctate (lacking pores), short hinge line (astrophic), bilateral symmetry, well developed spondylium (curved median plate for muscle attachment) on pedical valve, looped brachidia to hold feeding arms
Lingulata	Cambrian-recent (542mA – present)	Tongue shaped valves, long fleshy pedicle, inarticulate, both valves basically symmetrical,
Strophomenida	Ordovician-Early Jurassic (488mA – 200-146mA)	Articulate, included largest and heaviest brachiopod shell, not attached by stalk in adult specimens so lay free, attached to ventral valve, or balanced with spines sunken into soft substance, dorsal valve concave or flat (occasionally convex) while ventral valve was convex. Shape was wider than it was long, tiny hole for stalk, interior of valve covered with bumps, symmetry bilateral
Spiriferida	Late Ordovician (nearing 444mA – Jurassic (middle Jurrasic known as Bathonian, 168.3-166.1 mA)	Articulate, known for long hinge line at widest part of shell, shell has wide, winged appearance, sulcus (deep fold down centre of shell), spiral, coiled support for lophophore (feeding organ) that is coiled tightly in shell and often preserved in the fossils, bilateral
Rhynchonellida	Upper Ordovician – recent (488mA – present)	Articulate, strongly ribbed, wedge shaped or nut-like shells, astrophic/non strophic(short hinge line), first with internal articulation (teeth sockets), strong radiating ribs, accordion-like folds on sulcus, biconvex, (bulbous shell) distinguishing zig-zag line between the two shells (fold in brachial valve) functioning pedicle with prominent break of pedicle valve that usually overlaps brachial valve,
Terebratulida	Silurian/Devonian – recent (444mA – present)	Inarticulate, shells resemble oil-lamps, called "lamp shell", biconvex shells, oval-circular outline shape, smooth or ribbed, looped

		shaped lophophore, astrophic, circular pedicle opening in beak, microstructure of shell is punctate (with tiny holes), plicate (corrugated) shells

Part D: Describe the Paleozoic Fossils




mouth
tentacle
actual specimen
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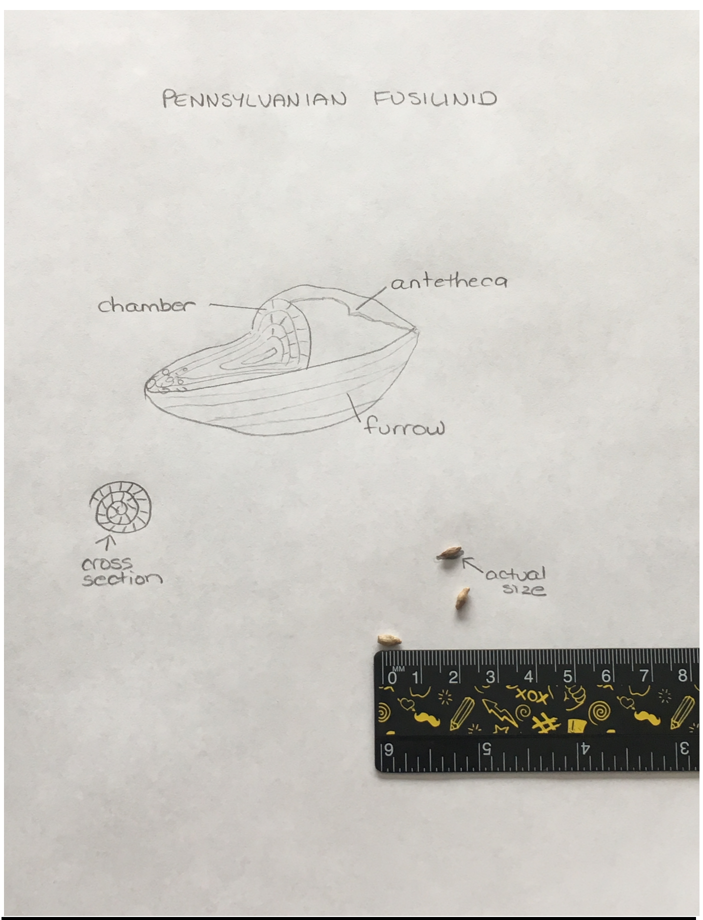
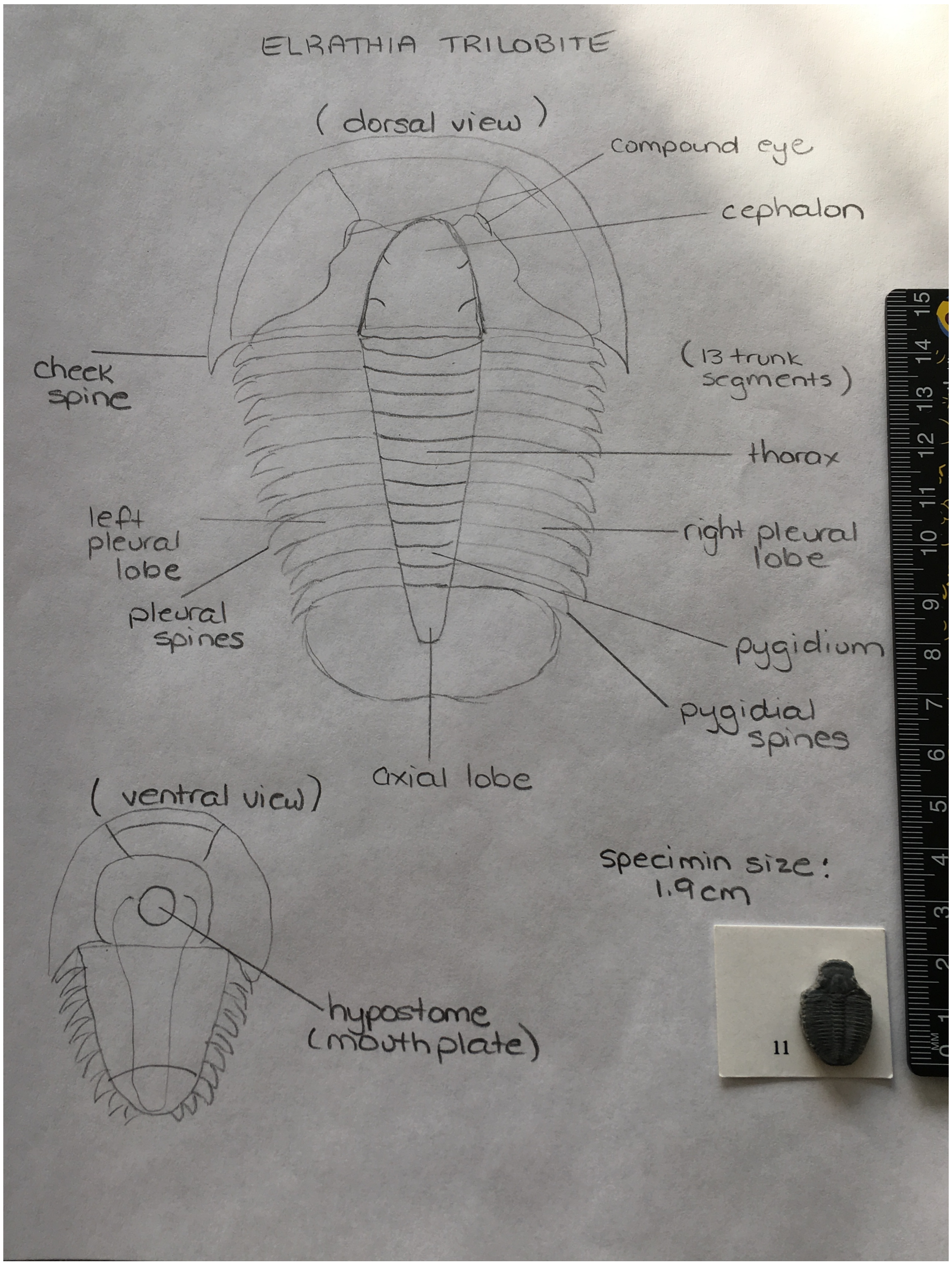

PENNSYLVANIAN FUSILINID
chamber
antetheca
furrow
cross section
actual size

Written Component: (pictures follow each description)

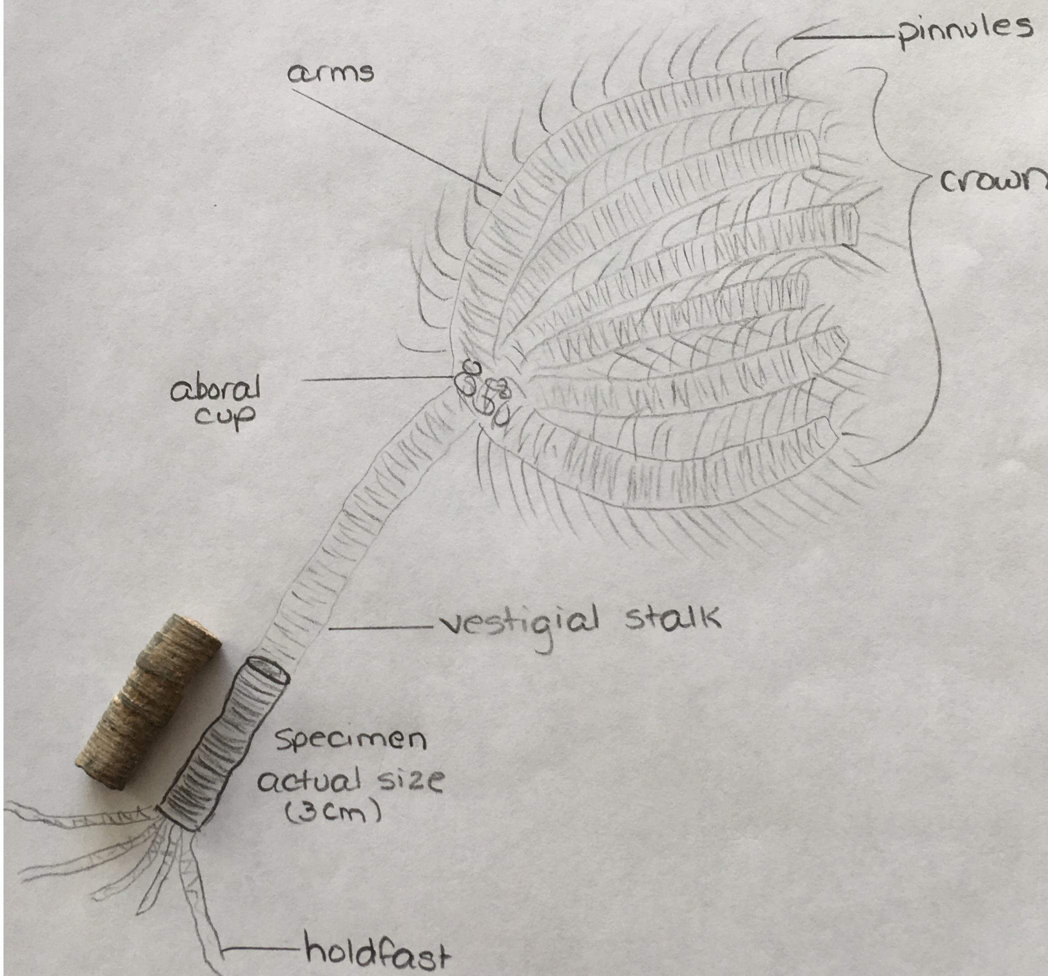
1. The specimen in the fossil sample appears to be a molt, as it is not a complete animal. During moulting, the exoskeleton usually splits between the head and the thorax. The Elrathia trilobite existed in the middle Cambrian (approximately 505 million years ago). It is a genus of ptychopariid trilobite (type species Conocoryphe kingii) and lived in the areas of Utah and British Columbia in the Phyllopod bed of the Burgess Shale.   They are commonly found rolled up into a ball because this is the method they used for self-defense to avoid being eaten or to avoid danger. They curled their tails under their heads. The Elrathia has similar body structures to the other trilobites, such as the three main

body parts, although they have varying trunk segments (some have 12 instead of 13 like the Elrathia).

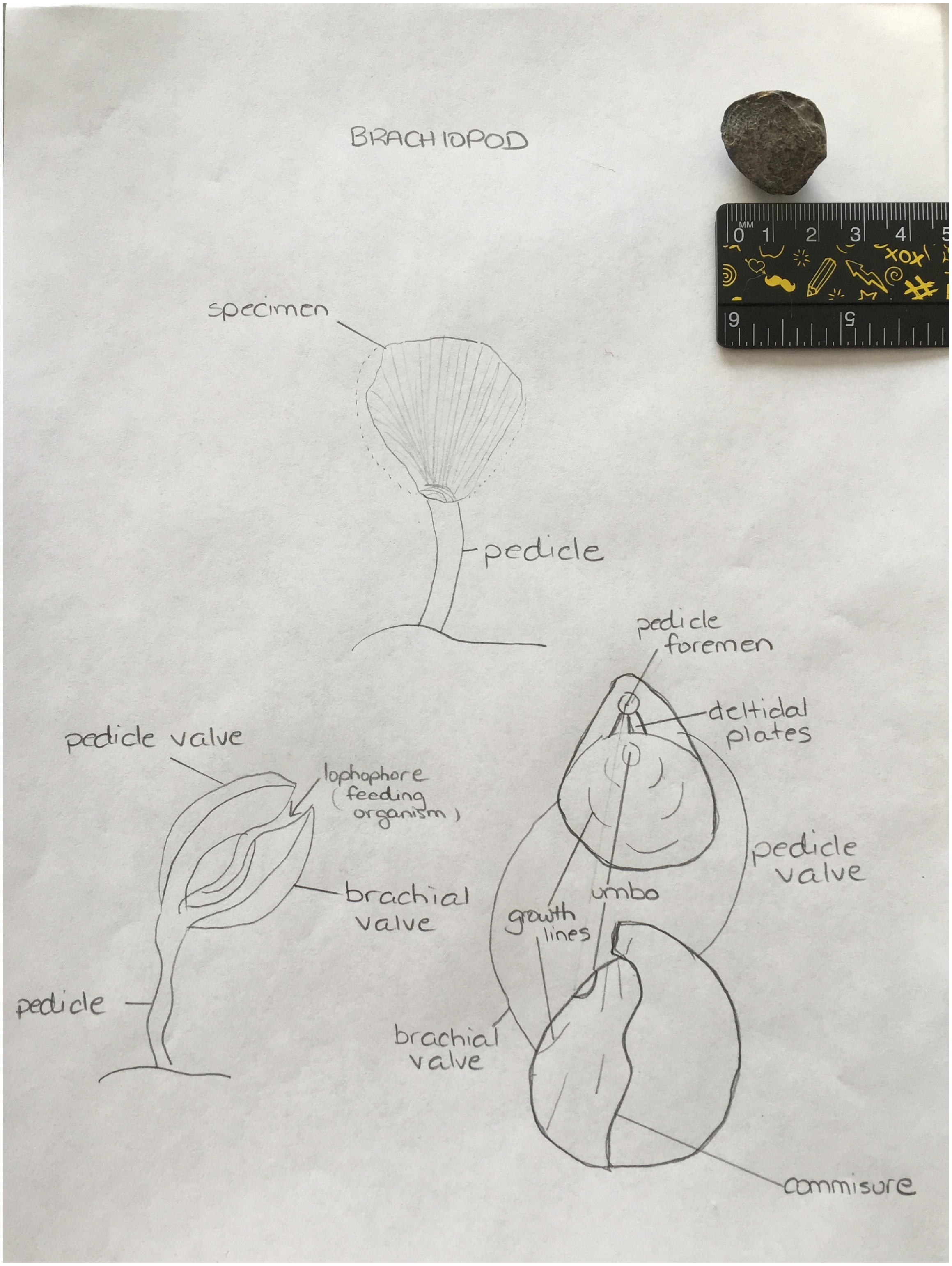


2. Crinoids feed by way of the “calyx”, which contains the crinoid’s digestive (and reproductive) system. The mouth is located at the top of the dorsal cup. The arms are made of smaller ossicles than the stem, and have cilia that commence feeding by moving the food down the arm and into the mouth. The crinoids feed by filtering small particles of food from sea water with their arms. The tube feet then flick the food into the ambulacral groove where cilia propel a stream of mucus toward the mouth. The mouth descends into a short esophagus. There is no actual stomach so this esophagus connects to an intestine (which includes diverticulae, long or branched) that opens into a short rectum, and then the anus. The pinnules of crinoids are not usually preserved because they are delicate compared to the stem and would have been easily broken off during the fossilization process. The stem is a more rigid material, the soft parts of the animal would decay.

PENNSYLVANIAN CRINOID



3. Brachiopods are biconvex, with both valves being convex, but the pedicular valve is large than the brachial valve. They have bilateral symmetry. The valves are hinged at the rear end, the front can open for feeding or close for protection. They live only in the sea, away from strong currents or waves. Young brachiopods will often attach to the shells of older ones. The lophophore (feeding organism) captures food particles like phytoplankton and gets them to the mouth via brachial grooves that are on the base of the tentacles. The mouth is located at the base of the lophophore. Food goes from the mouth to the pharynx (throat) and esophagus. They are all lined with cilia and cells that secret mucus and digestive enzymes. The stomach wall is lined with branched ceca pouches where food is digested mostly within the cells.


BRACHIOPOD
specimen
pedicle
pedicle foremen
deltidal plates
pedicle valve
lophophore (feeding organism)
brachial valve
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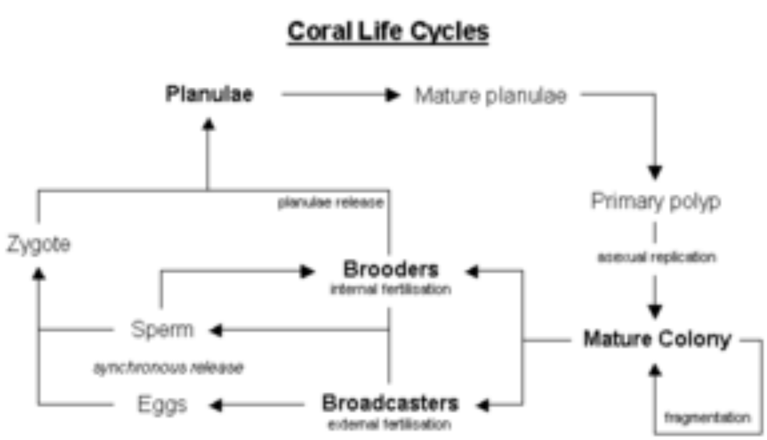
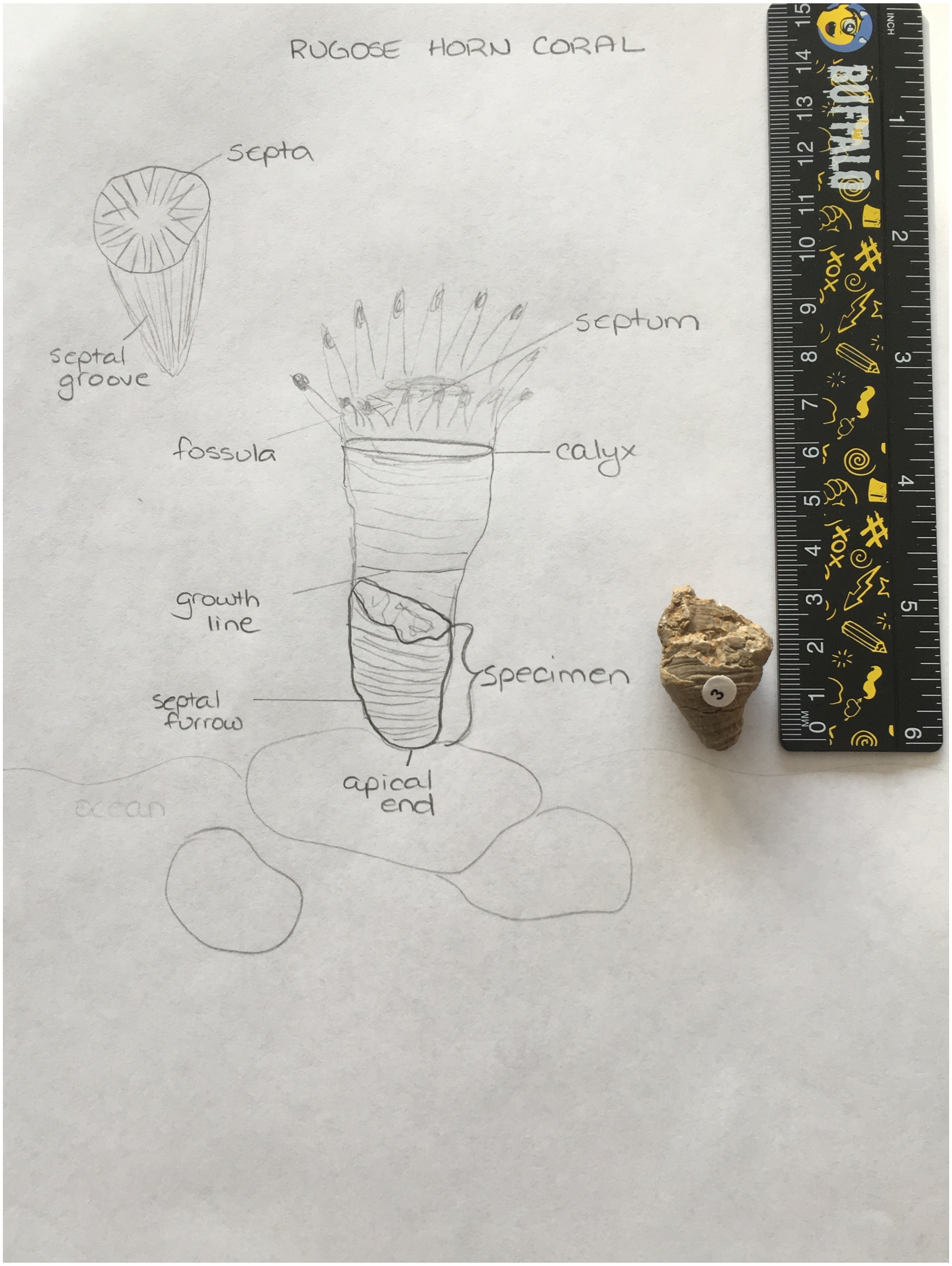
4. Coral reproduces either asexually by budding or sexually via gametes. Some corals can take up to eight years to reach sexual maturity.



Usually, corals reproduce sexually. They release egg and sperm into the water in order to spread colonies over great distances. This is called broadcast spawning. Gametes join during fertilization and form microscopic larvae called planula, which is pink and elliptically shaped. Coral colonies form great numbers of these larvae to defend against hazards. If corals don't broadcast spawn they are called brooders. (The non-stony corals usually do this). They release sperm but keep eggs and allow larger planulae to form. They are released later when they are ready to settle. This planula swims to surface water and drifts for a while, then swims back down to find a surface on which to settle. This often takes three days. The larva grows into a coral polyp that then becomes a coral head by asexual budding and growth to create new polyps. Often there is synchronous spawning on a coral reef, where multiple species spawn at the same time. This has been known to produce hybrid species of corals. Within one head of coral the polyps are genetically identical and reproduce asexually to help the colony to grow. Colonies can also reproduce asexually by fragmentation, which occurs when a coral piece breaks off a coral head, is moved by waves, and then grows in a new location.

Rugose corals became extinct at the end of the Permean, most likely caused by deep-sea anoxia and increased carbon dioxide levels in the ocean. This would make the ocean stratified without much circulation, thus reducing oxygen levels. Stagnant water would affect coral survival. Global warming in the late Permean would also have caused ocean stratification. Warming of high latitudes would reduce downwelling of oxygenated water from polar areas into oceans at lower latitudes, as well as creating stagnant water instead of a well-mixed ocean. Another contributing factor (alongside increased carbon dioxide levels) would have been volcanic and continental fissure eruptions, which also released carbon dioxide into the atmosphere. This also released fluorine and chlorine which may have damaged the ozone layer, also contributing to climatic unrest and extinction for species such as corals.


RUGOSE HORN CORAL
septa
septal groove
septum
fossula
calyx
growth line
specimen
septal furrow
apical end
ocean
BUFFALO


MM
0
1
2
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4
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3