Geology 2051 Geologic Time: Assignment 4
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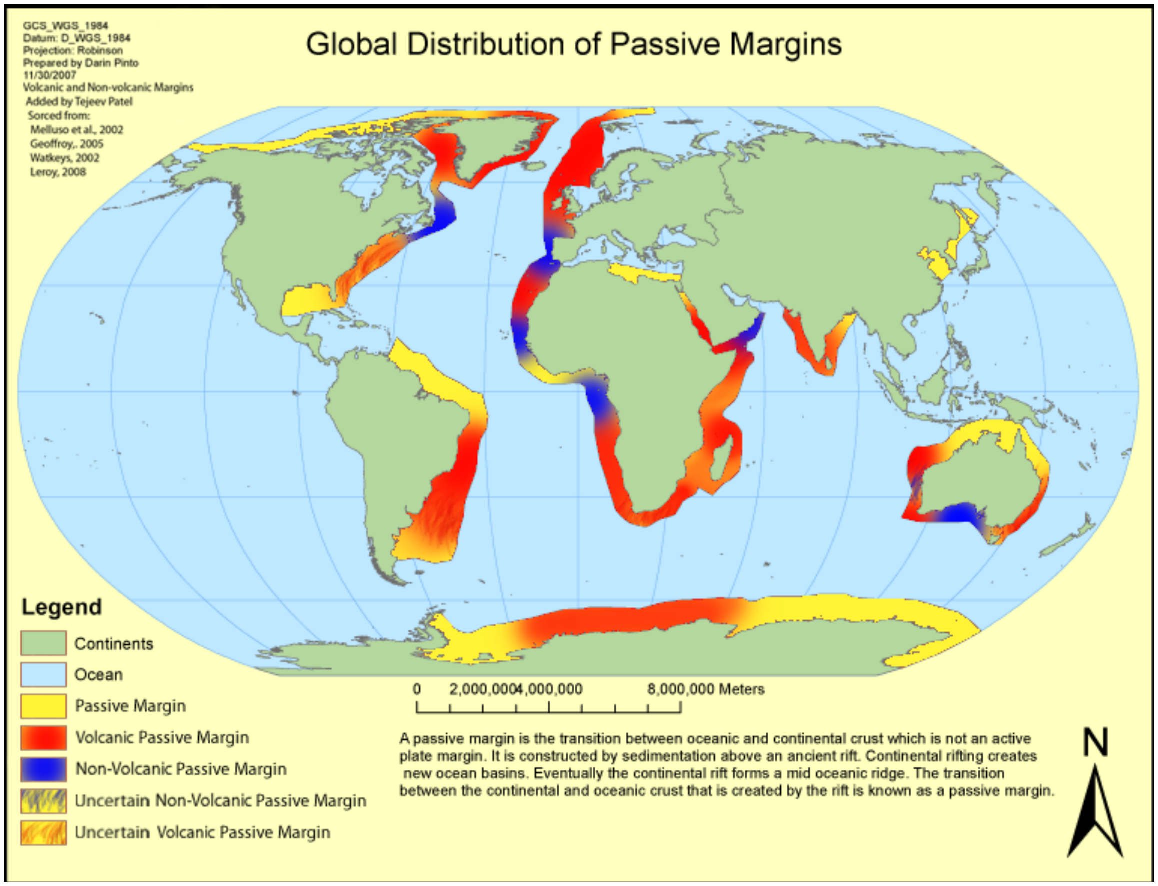
Part A: Short Answer Questions

1. The oldest sea floor located in the Atlantic basin was formed as Pangaea began rifting between Laurasia and Gondwana. The newly formed (and spreading) Atlantic ocean (north-eastern) existed at the end of the Triassic, about 200 million years old. This sea floor is far from the mid ocean ridge that created it. It is found in the north-Eastern Atlantic ocean and the North Eastern Pacific ocean.
2. Pre-cursor: Pangaea extended from pole to pole by the end of the Permean (25% of Earth's surface) and was surrounded by the Panthalassa Ocean that covered about 300 degrees of longitude. This caused typical arid conditions over the interior of Pangaea's large landmass. Temperature gradient between tropics and the poles affects oceanic and atmospheric circulation (greater difference causes greater circulation). When Pangaea broke up, the global temperature differential increased because the Northern Hemisphere continents moved northward and displaced higher latitude ocean water. The high latitude temperatures decreased and the continents' positions changed to increase oceanic and atmospheric circulation patterns. The temperature gradient increased. During the Jurassic and Cretaceous, the seasonal differences did increase but the higher and middle latitude oceans were still warm from Tethys Sea water circulating to higher latitudes. This kept the climate in reasonable equilibrium.
3. A passive margin is the transitional area between oceanic and continental lithosphere. A passive margin forms from sedimentation above ancient rifts. Continents have rifted apart and are now separated by an ocean. Continental rifting makes new ocean basins, with the rift eventually forming a mid-oceanic ridge. The passive margins taper sea-ward, and are a wedge of continental crust dissected by faults with overlying sediment where erosion and weathering often take place. Some examples (besides North America) are: The northeast Coast of South America, and the entire coasts of Greenland, India, Africa, and Australia. The southwest boundary of the Indian Ocean is also an example. This area contains tilted crustal blocks that are covered with sediment.



4. The Rocky Mountain system contains accreted lithospheric blocks (terranes) that were not formed in that area. Geologists speculate that the terranes were carried huge distances as parts of other plates until they collided with other terranes or a continent. The Rocky Mountains are part of the Eastern System of British Columbia, created from the Omineca and Foreland Belts. The Omineca belt is a metamorphosed near-craton terrane, containing fragments of North America that are from 2 billion to 180 million years old. The Foreland Belt is composed of metamorphosed sedimentary rocks that are 1.4 billion to 33 million years old. There was a repeating rift sequence followed by a passive margin that turned into arc fold and a thrust belt with synorogenic sedimentation (deformation that happens simultaneously with formation). **Terranes began to collide with the West Coast of North American in the Mississippian (approx 350 Ma) to cause the Antler orogeny, and during the late Mesozoic, much of today's British Columbia (as well as Oregon, California, and Washington) were accreted to North America. This West Coast was repeatedly collided with as the Kula and Farallon plates sank beneath the North American continent. The present-day Rocky Mountains were officially "raised" between 80 and 55 million years ago during the

Laramide orogeny, as the Kula plate subducted and terranes collided with the continent.

5. Carbon has two stable isotopes, 12 (lighter) and 13 (heavier), (usually existing in a ratio of 99:1). High C-13 levels in the late Permean likely meant that C-12 was being stored in deep water of stratified oceans. Plants use the C-12 for photosynthesis, and C-12 is incorporated into seawater from the atmosphere. Plankton also absorbed C-12 from the oceans. When the oceans do not mix and become stratified, plankton dies, taking the C-12 away to the bottom and leaving the surface waters heavy with C-13. This does not happen if the oceans mix properly with colder water upwelling, bringing C-12 back to the surface. This stratified ocean/carbon situation was likely caused by factors such as the Siberian traps basalt lava eruption and release of carbon dioxide and other greenhouse gases into the atmosphere. This would have created a global warming affect and higher ocean temperatures that slowed down circulation. Without ocean mixing, anoxia occurs and oxygen in bottom water gets used up in chemical reactions, leaving most ocean dwellers, except maybe those at the very surface without enough oxygen to survive, thus bringing about (over approximately 1 million years) the Permean-Triassic extinction event.
6. Angiosperms (flowering plants) are seed producing, having seeds enclosed within an ovary (a fruit). The seeds have evolved to become more protected, giving a better chance and survival through reproduction. During the Paleozoic, most land plants reproduced by spores, not seeds. Spores are small and contain little stored energy, while seeds are larger, containing stored energy for the new plant to develop and grow. The pollination of seeds can take place without the restriction of needing water, giving them a more diverse ability to reproduce and survive. The early gymnosperms had "naked seeds" where the pollen needed to land on a "naked" ovule, but angiosperms, pollen lands on a stigma, grows a pollen tube and extends down a style to a enclosed, more protected ovule (as opposed to a "naked" ovule). Angiosperms and insects have also developed a co-evolutionary relationship where insects depend on plants for food and plants depend on insects for pollination. Flowering and fruit bearing plants have evolved in such a way that their seeds are protected and their pollination system is efficient and safe, creating many flowers and fruits in order to ensure each species carries on.
7. Two living types of archosaurs are:
   Crocodilia

   Kingdom: Animalia
   Phylum: Chordata
   Class: Reptilia
   Clade: Eusuchia
   Order: Crocodilia

Specific example: African Dwarf Crocodile (osteolaemus tetraspis)
order: crocodilian

**dwarf crocodile**

And,
Birds (Aves)

Kingdom: Animalia
Phylum: Chordata
Class: Aves
Clade: Ornithurae
Order: **there are 27 orders of birds

Example of order: Great Blue Heron

Classification as above, except specific order is: **Pelecaniformes**

**Blue Heron, Burnaby Lake**

The above two groups are the only known survivors of archosaurs, and the crocodilia are the closest living relative to the birds.

***Extinct examples, next page:**

Two examples of extinct archosaurs are:

<u>Archaeopteryx</u>

Kingdom: Animalia
Phylum: Chordata
Clade: Dinosauria
Order: Saurischia

Archeopteryx fossil, showing feathers

simulated Archeopteryx bird

And,

<u>Triceratops</u>

Kingdom: Animalia
Phylum: Chordata
Clade: Dinosauria
Order: Ornithischia

Triceratops skeleton (top) simulated body (lower)

8.

Endothermic Dinosaurs (Evidence)	Exothermic Dinosaurs (Evidence)
Bone structure contained Haversian canals. These canals contained blood vessels and are similar to bones of living endotherms. Some dinosaurs had large brains, which requires a fairly constant body temperature, implying endothermy. Dinosaurs are related to birds, and dinosaur remains have been found with feathers or feather-like coverings, implying endothermy since birds are endothermic. Even though the dinosaurs with feathers were flightless, some were short and insulating, again supporting endothermy (keeping a constant body temperature) Some duck-billed dinosaurs are reported to have grown at a faster rate than ectothermic examples, and also an ornithopod fossil has been found to have a four chambered heart like living mammals and birds, implying that it was endothermic.	Some ectotherms also have canals in their bone structure, like crocodiles (current descendants of dinosaurs, archosaurs) Some small mammals also have this bone structure so endothermic properties may be related to body size Dinosaur bones contain growth lines that are thought to be driven by changes in seasonal temperature (fast and slow growth rings). This has been used as a sign of slow metabolism and ectothermy Larger dinosaurs heat up and cooled down more slowly than smaller ones because they have a small surface area compared to volume, so they may have retained heat more efficiently than smaller ones and could have been ectothermic.

Much of the evidence points to the idea that many dinosaurs were endothermic and those, like the crocodilian were ectothermic (and still are today). Since birds are related to dinosaurs and are endothermic, it appears that warm-bloodedness definitely evolved along with the dinosaurs.

9. By the late Jurassic, Laurasia had begun to rift (by the opening North Atlantic) as Pangaea began to separate. By the Late Cretaceous, the North Atlantic had opened further completely separating Africa and South America. Faunas began to become different on each continent and some animals were able to reach Australia from South America by way of Antarctica. Some never reached Australia. Climates became more directed by latitude, some becoming more seasonal and cooler, however it remained fairly warm and balanced till the end of the period. These factors may have had influence on

why there was less diversity among the dinosaurs during this time. Although dinosaur fossils have shown there was still travel between the continents, they may have been more limited and difficult as to where they could reach. Since other animals, specifically dinosaur prey, may not have been able to relocate, dinosaur diet may have been affected, thus affecting health and population. Also, while they may have survived the initial climate change, their internal systems may have been thrown off, slowing down reproduction and survival rates. Just like with any current species of animal, some may have been more resilient to these changes.

Scientist James Fassett discovered 34 bones from the same hydrosaur fossil at the San Juan Basin. His thought is that is it possible dinosaurs from the farthest north of North America (farthest from the meteor impact site) could have migrated south afterward. He supports that this dinosaur lived in the Paleogene Era. After time, this group (or one) may have suffered from different soil, prey, climate, air pollution content (from volcanism and meteor impact) and water, eventually dying out as they were unable to adapt to a new habitat.

Referring back to the separation of the continents, tectonic activity, changes in seas, and mountain building would have initiated an impact on the animals (dinosaurs). Those plant eaters, being lower on the food chain and more common, may have seen the first trouble as their food source declined. Location seems to have had an impact on which dinosaurs declined. For example, hadrosaurs declined in North American but increased in Asia during the late Cretaceous. Different groups would have evolved in different ways: some for the better and some, worse.

It took approximately 100 million years for decline and finally extinction to happen. All of the above may have begun the process, followed by increased volcanism, climate change, and finally the impact from a meteor collision that blasted about 60 times its mass into the atmosphere, blocking sunlight (preventing photosynthesis), starting forest fires, filling the air with particulates, and causing acid rain from vaporized rock and atmospheric gas (sulphuric and nitric acid).

Even at that it is possible that some dinosaurs could have survived the catastrophe and lived into the Paleogene. Usually and entire species doesn't vanish in an instant, and there is no reason why small groups or individuals couldn't have defied the odds and survived a little longer than the rest.

Citation for question 9 on following page:

Citation:

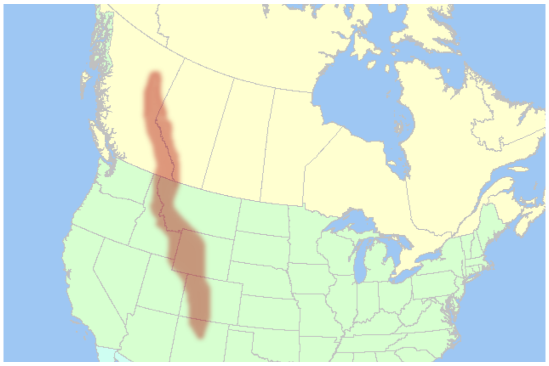
"Lost World" of Dinosaurs Survived Mass Extinction?
https://news.nationalgeographic.com/news/2009/05/090501-dinosaur-lost-world.html

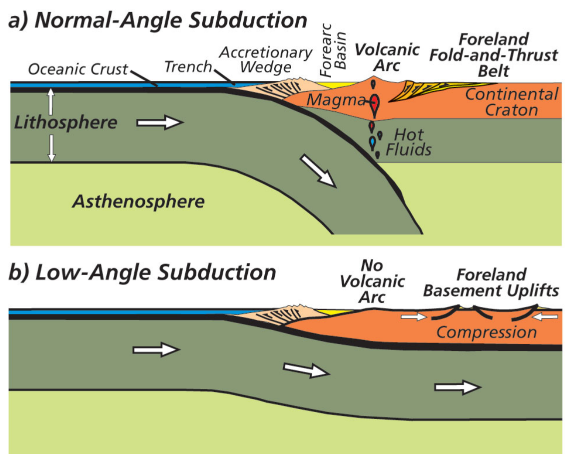
Some Dinosaurs Were Dealt a Slow Death | Mass Extinction
https://www.livescience.com › Animals

Part B: Comparing the Rockies and the Coast Range

The **Rocky Mountains** are a series of mountain ranges that reach from Northern British Columbia down to central New Mexico. They are included in the Eastern Geologic System of British Columbia, which is composed two belts, the Omineca and Foreland. The Omineca contains metamorphosed near-craton terranes and fragments of continental North America, ranging in age from 2 billion to 180 million years old. The Foreland belt is made of metamorphosed sedimentary rocks from 1.4 billion to 33 million years old. There was a repetitive rift sequence followed by a passive margin that turned it into arc folds and a thrust belt with synorgenic sedimentation. The oldest rock is metamorphic rock from the Precambrian, which forms the core of the North American continent. There is Precambrian sedimentary argillite, as well as kilometers of limestone and dolomite deposited during the Paleozoic, when North America was transgressed by a shallow sea.

Approximately 350 million years ago, during the Mississippian, terranes (containing island arcs, ocean crust fragments) collided with western North America to cause the Antler orogeny. There were repeated collisions as the Kula and Farallon plates subducted under the continent. This continued for about 270 million years but the present day Rockies were not affected until about 80 million years ago. The Laramide orogeny was responsible for raising the Rocky Mountains. The Kula plate and terranes pushed into the continent, the older rocks got pushed along the "floor base" of the Canadian Shield. The angle of the subducting plate is thought to have been less than typical, which moved the mass farther inland. There would have been more friction with tremendous thrusts that built the incredible high and wide Rocky Mountain Range. The present day Rockies have risen above Pennsylvanian and Permian sedimentary layers, and the marks of the steep folds are visible in some places. Periods of glaciation and erosion over the last 60 million years have formed U valleys and cirques within the Mountains, as well as exposing some of the ancient parent rocks beneath.





Rocky Mountain Range

Low angle subduction pushed Rocky Mountains further Inland

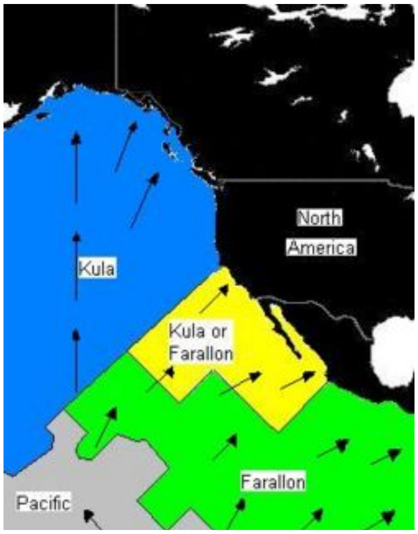
image showing folds of Rocky Moutain Range (Mt. Robson, BC)

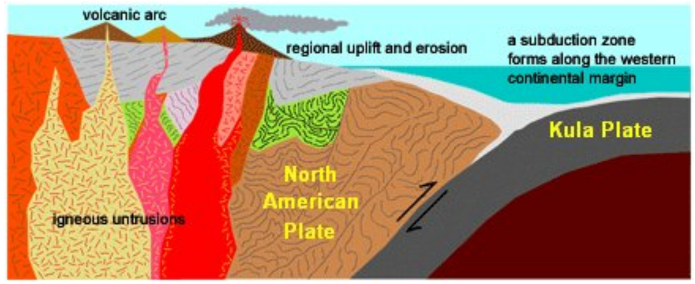
The **Coast Mountains** are a mountain range in North America that reaches from the southwest Yukon, through the Alaskan Panhandle, and down the Coast of British Columbia to the Fraser River. They, along with the Cascade Mountains, are part of the Coast Belt Geologic Zone of British Columbia. The rocks are mainly granitic, deformed igneous and metamorphosed complex pre-Tertiary rocks. These came from various locations, as the region is made up of random-aged terranes from various tectonic processes. The oceanic crust below the Pacific Ocean is subducting under the southern part of the range to form the Garibaldi Volcanic Belt (which is a northward extending part of the Cascade Volcanoes in the United States).

Tectonic activity began approximately 130 million years ago when a group of volcanic islands, the Insular Islands approached the North American coast line. The Insular Islands were formed on the Insular Plate when the Farallon Plate subducted under it during the early Paleozoic. There was also a twin subduction zone between the Insular and North America called the Bridge River Ocean. The Insular plate moved closer to the North America Coast by subducting under this Bridge River Ocean. This process stopped about 115 million years ago and formed what is called the Insular Belt (which is the western most geologic region of British Columbia) and is now accreted onto the continent. The final event to form the Coast Range occurred when the Farallon Plate continued to subduct under the new continental margin (after the previously described accretion). The Coast Range Arc was formed about 100 Million years ago during the Late Cretaceous. Magma from the subducting Farallon Plate rose up through the Insular Belt inserting large amounts of granite into the older igneous rocks. This was an area of major volcanism. About 85 million years ago the Kula Plate (north piece of the Farallon plate) broke off and formed a mid ocean ridge, bringing on more Coast Range volcanism. Molten granite also intruded deformed ocean rocks and remnants of the Bridge River Ocean. This made a metamorphic rock called schist. Older Coast range arc also deformed, becoming layered metamorphic rock called gneiss. Migmatite was formed in swirl patterns from the original ocean rocks being nearly melted. Volcanism began to decline around 60 million years ago and many of the volcanoes have been eroded away.

These two mountain ranges both began with plate subduction, yet ended up as quite differently formed mountain ranges. The low angle of subduction pushed the Rocky Mountains far inland, creating the chain of fold mountains, while the Coast Range followed with plate subduction, this time including volcanic arcs to produce a highly volcanic mountain range.


Coast Mountain Range (green)

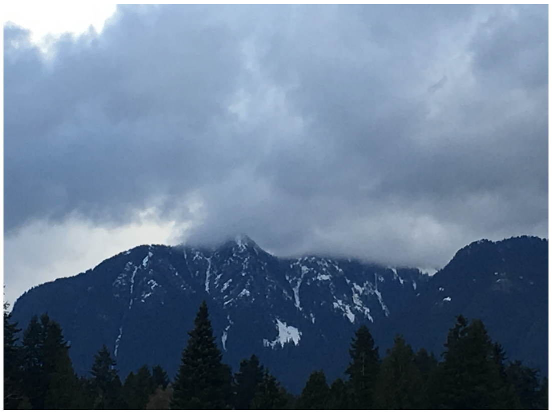




Tectonics of Coast range: 75 million years ago

Coast Mountain range (North Vancouver, BC) showing volcanic formation

***Photo comparison on next page:**

The Coast mountain range (above), formed by volcanic activity does not show the distinctive fold lines that are shown by the sharper angles of the Canadian Rocky Mountain Range (below)

Part C: The Dinosaurs (URL link chart follows first chart)

Sub-order	Example dinosaur with image (URL)	Lifestyle characteristics	Age-range
Theropoda		Most are known to have bipedal stance with shorter forelimbs Modern birds: body is quite upright with the upper leg (femur) parallel to the spine. The knee creates forward locomotion force. The group, as a whole, are carnivors, but variance exists with some being insectivores or herbivores. Fossils show sharp teeth with serrated edges (for cutting meat) and some fossils have been found with evidence of predator behaviour: one fossil was found with a lizard in its stomach, and two fossils were found locked together in battle formation. Diet for this group is figured by the teeth, tooth marks on prey, and stomach contents. An example of a herbivore for this group are the segnosaurs. They had large abdomens to process plants, small heads, beaks, and leaf shaped teeth. Some groups had teeth with folds, thought to help against breakage while the animal attacked its prey. Judging by the teeth and stomach contents of fossils, Theropoda appear to have been a predatory dinosaur. Their bones are found with little inury (mostly only in ribs and tail) which could further support that they were mostly predator, not prey. Evidence shows that this dinosaur became smaller over time (the past 50 Ma) and eventually evolved into modern birds, like the common ostrich. Their skeletons changed four times as fast as other species.	Late-Triassic to Present (231- 0 Ma)
Sauropoda		Sauropods have a quadrupedal stance, tiny heads, large bodies and long tails. Hind legs were straight, sturdy, and powerful and front legs were also straight but more slender with "hands" for supporting weight. They included the largest land group of animals. Their necks are extremely long. (some were 50 feet) Sauropods were herbivores and their teeth were broad at the tip and narrow at the back. Since their head was small, it was basically a tool to get the food down the long neck to the body. Some Sauropods are thought to be able to rear up, using the tail as additional balance. With their long necks this would not have been for feeding, but maybe territorial arguments with another dinosaur? Herbivores would not hunt prey, and something so large wouldn't be hunted by many other animals. A few also had armour such as small clubs on the tails and small bony coverings on parts of the body. Their teeth are thought to be replaced often (from every 14-62	Late Triassic-Late Cretaceous (210-66 Ma)

		days) due to their large appetites and eating of rugged plants. Different varieties of Sauropods ate plants at different heights which allowed them to co-exist with each other. The different teeth are the key to knowing that the different groups ate different varieties of plants.	
Ornithopoda		Ornithopods began as running, grazing dinosaurs with a bipedal stance. They are herbivores and were dominant in North America because of their evolutionary development of a chewing mechanism. They used their stiff tails for balance like the theropods and later on adapted to grazing in a quadripedal stance. Their spines evolved so they stood like modern day bison or cows. They would still assume a bipedal stance though. A group of hadrosaurs, (iguanodonts), crested and duck-billed dinosaurs had special sinus regions on their skulls and webbed feet, suggesting a life on land but near water. As plant eaters, they would not have hunted other dinosaurs, but the crest on their heads is thought to have been used to make loud noises, perhaps for mating, or warning or other predators. This suggests that some varieties were prey for other carnivores. Since they began as bipedal running animals, they would have probably been able to run as escape from predators, as well as use their strong beaks as weapons. They also had bird like feet, which could have assist in defense to some degree.	Mid Jurassic-Late Cretaceous (169-66Ma)
Ankylosauria		These dinosaurs were mostly herbivores, with a bulky build and quadrupedal stance. Their limbs were short but strong and could only run about 10km/hr. They had bony armour on their bodies, in the shape of nodules, plates, and spines, probably a defense mechanism to compensate for their slow speed. Since they were only about one foot high, they ate vegetation from that height, and they had a second palate so they could breathe while chewing. They probably ate ferms, cycads, and angiosperms, using fermentation to digest their food (suggested from their expanded gut area). A distinguishing feature of the Ankylosauridae was a bony club at the end of the tail, (used for defense or mating), domed snouts and plates on the side of their skull. The tail clubs were made of plates of bone with soft tissue that acted as a shock absorber. The other family, the Nodosauridae, had predominant spikes and longer snouts, with no clubbed tail.	Mid Jurassic-Late Cretaceous (167-66 Ma)
Stegosauria		This group is also an armoured dinosaur with scutes (bony plates) as well as an evolved spiked tail (thagomizers) which was used as a defensive weapon. This was necessary because certain groups became larger with long hindlimbs that prevented running. They are quadrupedal. The thagomizers were positioned high enough to defend against even larger predators. Their neck became longer and their heads narrow in order to eat the good parts of cycads (they were herbivores), and their beaks were horn covered. These dinosaurs declined when the cycads declined, becoming extinct in the early Cretaceous.	Mid Jurassic-Early Cretaceous (169-125 Ma)
Ceratopsia		This group started out as small and bipedal, evolving into larger quadrupeds with facial horns. It is speculated that the horns protected the neck area from predators, was used for mating display, thermoregulation (oxygen isotopes have	Late Jurassic-Late Cretaceous (158-66 Ma)

		been inside the horns, supporting the fact they were head radiators) , or connected a large neck to chewing muscles. Some predators may have been Saurischian, like the Tyrannosaurus (lived at the same time and area of the Ceratopsia). The Triceratops is the most well known of the Ceratopsia. They were herbivores, and had grinding cheek teeth that would imply they ate rough vegetataion. Fossils finds have found groups of these animals together, implying that they grouped together to defend from predators.	

Example Dinosaur URL Chart

Dinosaur	URL
Theropoda	http://images.dinosaurpictures.org/Eoraptor_sketch5_2e86.jpg (link to Eoraptor, Theropoda example)
Sauropoda	https://www.google.ca/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwih64esoZ_aAhUNiIMKHYSxB7oQjRx6BAgAEAQ&url=http%3A%2F%2Fzt2downloadlibrary.wikia.com%2Fwiki%2FAmpelosaurus_(Royboy407)&psig=AOvVaw2qAH0dfhaUITuD__ggiUn2&ust=1522884563238695 (link to Ampelosaurus, Sauropoda example)
Ornithopoda	https://upload.wikimedia.org/wikipedia/commons/7/7e/Muttaburrasaurus_skel_QM_email.jpg (link to Muttaburrasaurus skeletal image)
Ankylosaurus	http://images.dinosaurpictures.org/Ankylosaurus-Papo_815d.jpg (link to Ankylosaurus image example)
Stegosauria	https://lh3.googleusercontent.com/-fT-Cx_35H8c/TYKHOfpfUTI/AAAAAAAAADY/JN3XgmgZh2Q/s1600/DSC_0266.JPG (link to Hesperosaurus skeletal image) https://upload.wikimedia.org/wikipedia/comm

	ons/thumb/2/27/Thagomizer_01.jpg/800px-Thagomizer_01.jpg link to skeletal image of Thagomizer (mounted to Stegosaurus tail)
Ceratopsia	https://upload.wikimedia.org/wikipedia/commons/thumb/6/6f/Spinops_NT.jpg/220px-Spinops_NT.jpg (link to Spinops recreation image)

Citations (Part C)

Theropoda - Wikipedia
https://en.wikipedia.org/wiki/Theropoda

Sauropoda - Wikipedia
https://en.wikipedia.org/wiki/Sauropoda

Is there any evolutionary advantage to gigantism? Did sauropods ...
https://www.scientificamerican.com/article/is-there-any-evolutionary/

Ornithopod - Wikipedia
https://en.wikipedia.org/wiki/Ornithopod

Ornithopoda - UCMP
www.ucmp.berkeley.edu/taxa/verts/dinosauria/ornithopoda.php

Ankylosauria - Wikipedia
https://en.wikipedia.org/wiki/Ankylosauria

Palaeos Vertebrates: Ornithischia: Ankylosauria
palaeos.com/vertebrates/ornithischia/ankylosauria.html

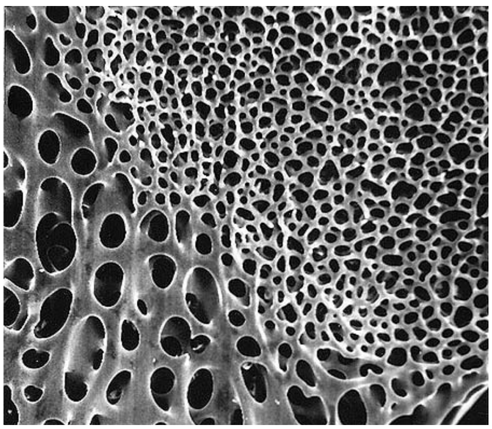
Ceratopsia - Wikipedia
https://en.wikipedia.org/wiki/Ceratopsia

Introduction to the Ceratopsians
www.ucmp.berkeley.edu/diapsids/ornithischia/ceratopsia.html

Part D: Describe the Mesozoic Fossils in the Kit

****Sketches/Photographs follow written component**

1. Another Paleozoic fossil (from the kit) that is also from the phylum Echinodermata is the Pennsylvanian Crinoid Stem (318-299 Ma). One of the key morphological features of this phylum is that their (exo)skeletons are made of interlocking calcium carbonate plates and spines. Whether these plates fit tightly or loosely, they are not solid, rather they are fine structures of calcium carbonate making a structure called stereom. Each "piece" of an echinoderm's skeletal element is actually a finely branched and structured single crystal of calcium carbonate.


stereom

There are structures that protrude from the Echinoderm skeleton (tube feet, pedicellaria, and gills) which are used for breathing, moving, and defense. All echinoderms have a water vascular system that consists of a set of water-filled canals that extend from one round canal that surrounds the gut. These canals lead to the tube feet (podia) that move by hydraulic pressure. The Pedicellaria are located on the skeleton to keep small organisms from landing on its body. This water vascular system takes on functions of respiratory and circulatory systems because the Echinoderms have a primitive circulatory system and usually lack a respiratory system. The Aristotle's Lantern (labeled in diagram) is an arrangement of five large teeth arranged in a pattern that Echinoderms used to scrape algae from rocks.

An example of a modern Echinoid is the "flower urchin" Toxopneustes pileolus.
Phylum: Echinodermata
Order: Camarodonta
Family: Toxopneustidae
Species: T. Pileolus

Flower urchin from Okinawa, Japan

The flower urchin is a common sea urchin found in the Indo-West pacific, and is dangerous due to extremely strong stings if touched. It lives in coral reefs, sea grass areas, or rocky/sandy areas up to 90 metre depths. It feeds on algae (like the primitive Echinoderms), bryozoans, and organic matter.

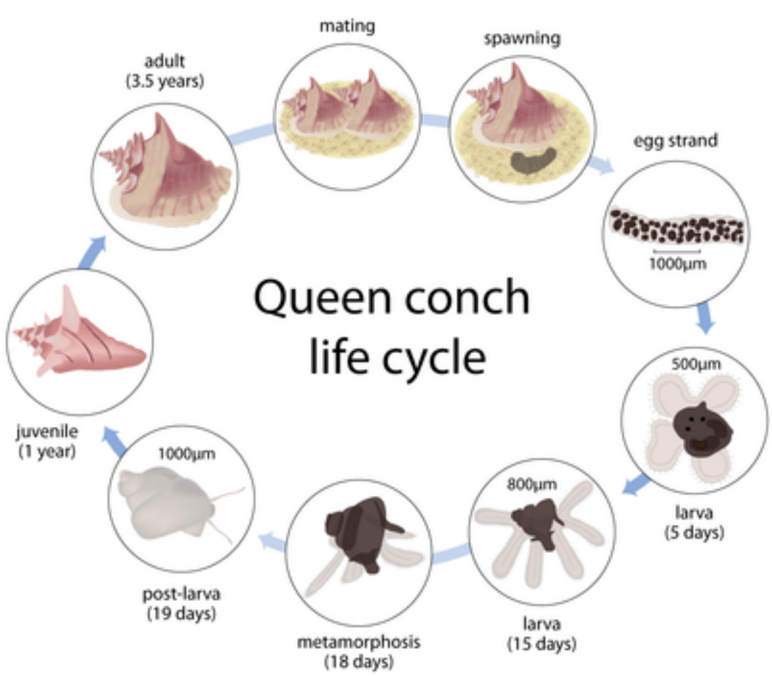
2. It has been suggested that the ammonite **septa** was for strength and support, but is more currently supported that the septa were important in the attachment of the adductor muscles of the animal as well as control buoyancy. Muscle relocation during growth happened by the release of muscle attachment and rapid forward movement of the ammonite inside its shell. The muscle would reattach along a narrow area of a freshly formed septum (and an enlarged attachment surface). The location and morphology of the siphuncle (tissue "strand" passing through the shell to "empty water from new chambers as the shell grows", reducing density like a "floatation device"). This hypothesis is further supported by the study of microscopic "fabric" structure of Cretaceous Ammonite shells. The suture lines are contact lines between the septa and the inner shell wall. In early ammonites these were simple lines, able to tolerate great pressure but had poor buoyancy. As ammonites evolved, the **suture lines became more complex**, but could tolerate less pressure. These were however more buoyant, and indicated a life in shallow waters as opposed to the less buoyant simple ammonites that were most likely slower, deeper water dwellers. ****The septa in the assignment diagram have a wavy shape,** which can form if the rear mantle (labeled in drawing) has a wavy/complex shape. The mantle is a flexible membrane and can be formed into a particular shape by an outside force. It acts like a template as to what shape the septum will become.

Suture pattern formation in ammonites and the unknown rear ... - Nature
www.nature.com/articles/srep33689

A muscle attachment proposal for septal function in Mesozoic ammonites
https://www.palass.org/publications/palaeontology-journal/.../27/.../article_pp461-486

3. The Cretaceous gastropod has an elongated (oblong) shell with a swirled appearance. The fossil sample appears to be the spire piece of the gastropod, from the apex to the shoulder. The whole gastropod would be longer, with a continued swirl appearance, followed by a slight bulge called the body whorl (where the main mass of the animal is found), until the end of the animal where the canal is, between the inner and outer lip. This is a one-piece shell, not a bivalve. The opening is usually on the right hand side (if viewed with the apex pointing upward as in the diagram). The shell serves as an exoskeleton for protection against damage, predators, dehydration, it is also for muscle attachment and calcium storage.

Modern marine gastropods (eg: snails) produce eggs that hatch into larvae that are able to swim. These gastropods will mate with other gastropods but many of them contain both male and female reproductive organs. Some can fertilize their own eggs if no mate is available. The larvae are called veliger larvae. Mating usually occurs in the summer months. Using a conch snail as an example gastropod (queen conch: Lobatus gigas), egg cases may house up to four thousand embryos. The eggs will hatch after about four to six days once the egg case is in shallow water. Once the larvae hatch, they descend to the ocean floor and twist themselves into a nonsymmetrical shape. After this, they burrow under the sand to avoid predators. These larvae grow in the sand and become sexually mature between three and five years old.



Conceptual diagram illustrating the life cycle of the queen conch (µm = micron [1/1000th of a millimeter]).
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L., and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

Queen Conch Snail

Detailed Life Cycle of Queen Conch snail: (after internal fertilization)

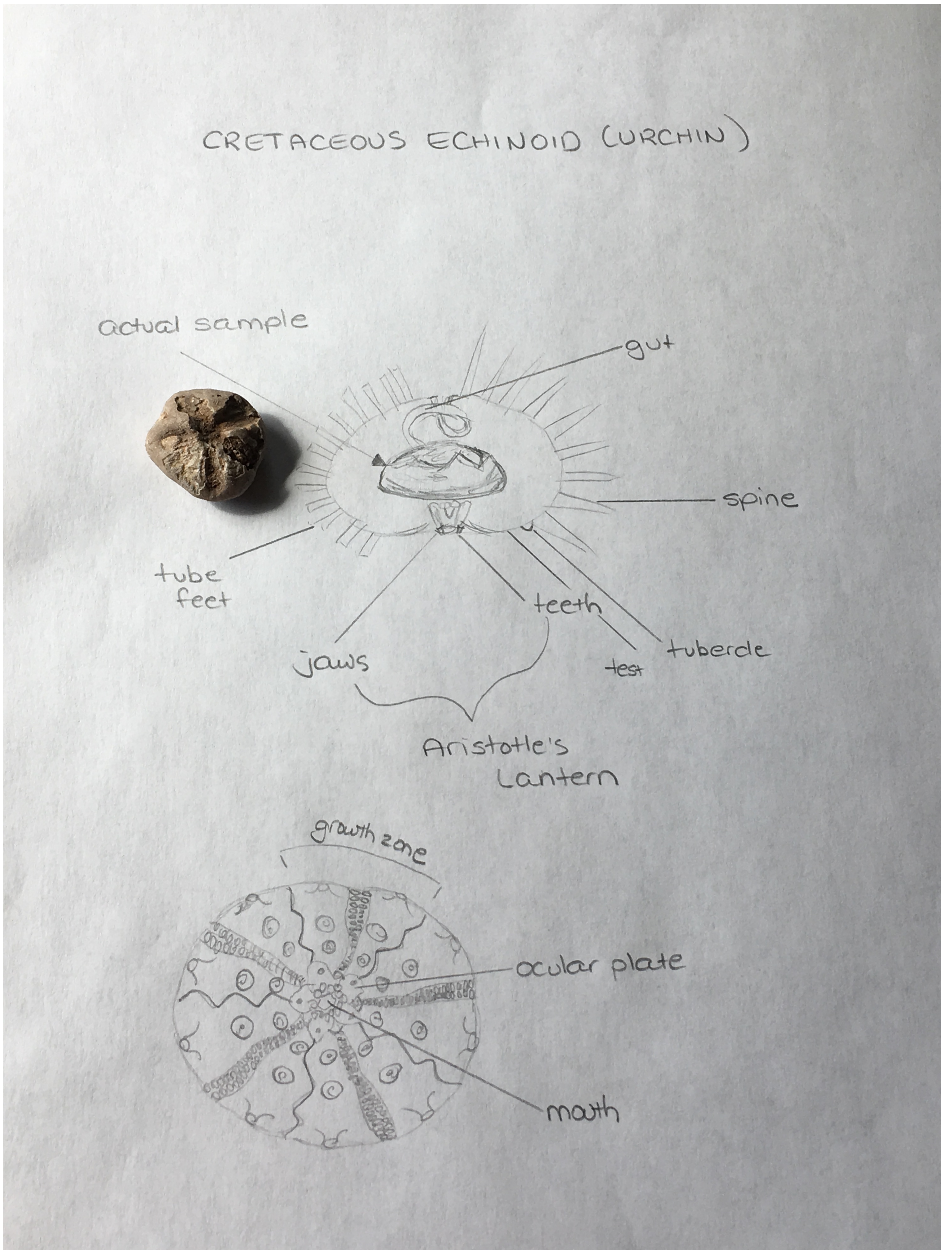
The female will lay eggs in gelatinous strings that may be up to 23 meters long, usually on sea grass or bare sand. The long sticky strings become coiled and mix with the sand to form egg cases (number of eggs in cases depends on environmental factors such as diet and temperature). Females will produce between 8 and 9 egg cases per mating season (March through October). Each of these egg cases can contain between 180,000 – 460,000 eggs, but some have contained as many as 750,000 eggs. The embryos hatch in about 3-5 days and become veliger larvae, and then spend the next days developing and feeding on plankton. After 16-40 days, a change occurs and the fully developed conch is now about 1.2 mm high. Once this change occurs, the queen conch snail spends the rest of its life in the sediment (usually remaining buried for about the first year, being protected from predators). The Queen Conch shell becomes sexually mature at around 3-4 years of age. The shells can weigh up to 5 pounds. The life span is 7 years on average but some can live between 30-40 years in deeper, more protected waters.

Conch Shell from Kauai, Hawaii, USA

4. The shell shape of the cretaceous gastropod is coiled/spiraled, and all once piece. It is not a bivalve like the cretaceous oyster. The gastropod has a “door” that is used to “close” the shell. This is often made of calcareous material. The shell is of medium thickness. The Cretaceous oyster shell is a bivalve, and quite thick. It too is spiraled but the right valve has a snail like coil that protrudes out from the shell, like a swirl. The left valve is more cupped and does not have a swirl. The oyster is usually attached to the rock or reef by this left valve. The Cretaceous oyster actually had adductor muscles to close the shell.

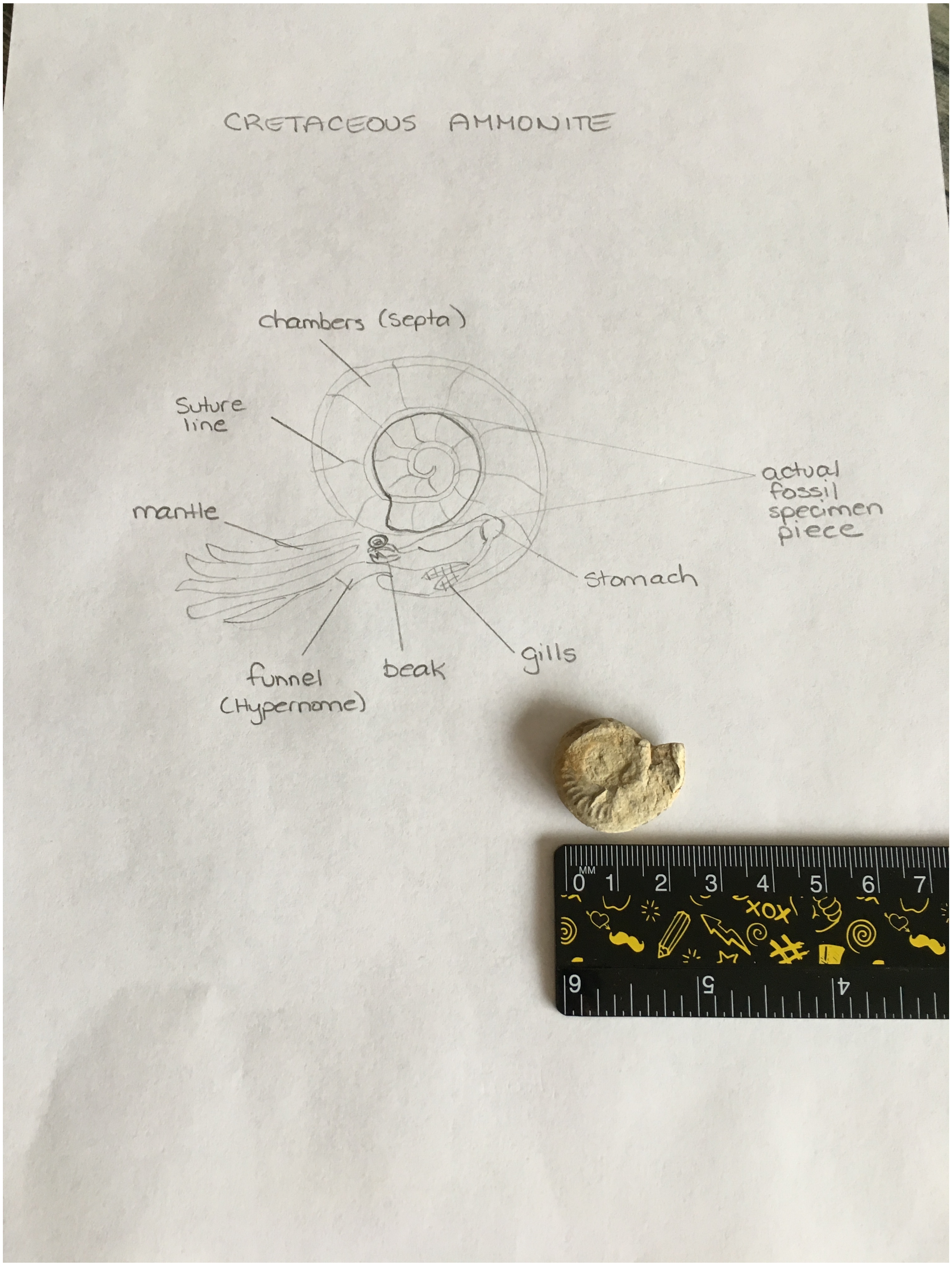
   Both Cretaceous and modern oysters built enormous reefs and grew attaching themselves together in groups. Today the oyster reefs are also called oyster beds. Cretaceous oysters had one flat valve and one (as in the fossil example) curved or spiraled “snail shaped”. Oysters provide habitats for other marine species as well, such as sea anemones, barnacles and mussels. Many species can live in the nooks between the shells and seek refuge from predators like larger fish. Even in modern oysters, one valve is cupped and the other is flat, but the outer flared shell is the outer one, being attached by the cupped valve, like the Cretaceous oysters. Oysters usually reach maturity in about one year and are protandric (able to change sex). They spawn as males for the first year, grow over the next two to three years and then spawn as females to release eggs. The eggs are fertilized in the water and become larvae and can settle on another oyster’s shell. These attached larvae are called “spat”. Oysters filter water to eat and breathe, but shut their valves to rest. This behavior follows sun and moon positions. Oysters are also known to have a positive affect on water quality: since they are filter feeders they remove plankton and organic particles from the water, up to 50 gallons of water a day. The oyster reefs can improve water quality as well as clarity. They “eat” nitrates, ammonia (nitrogen containing compounds) phosphates, plankton, detritus, bacteria and dissolved organic matter. Oysters are a benefit to the present ecosystem: by nutrient cycling, filtering water, forming habitats and habitat biodiversity. If “historic” populations could be restored (maybe those of the Cretaceous era?) shallow costal ecosystems could become balanced again.

<u>FOSSIL SKETCHES </u>(begin next page)

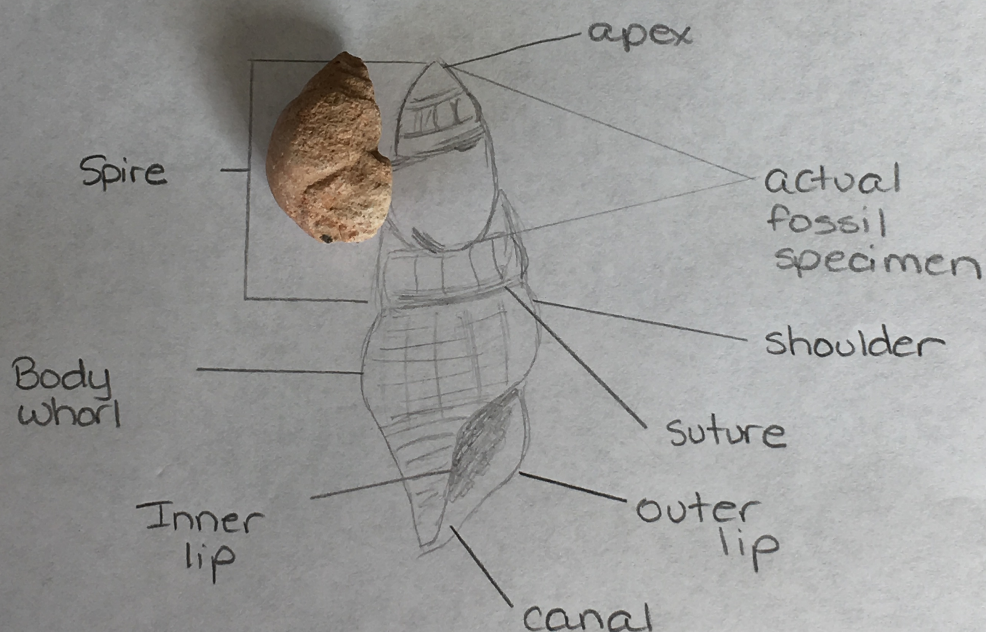

CRETACEOUS ECHINOID (URCHIN)
actual sample
gut
spine
tube feet
teeth
jaws
test
tubercle
Aristotle's Lantern
growth zone
ocular plate
mouth

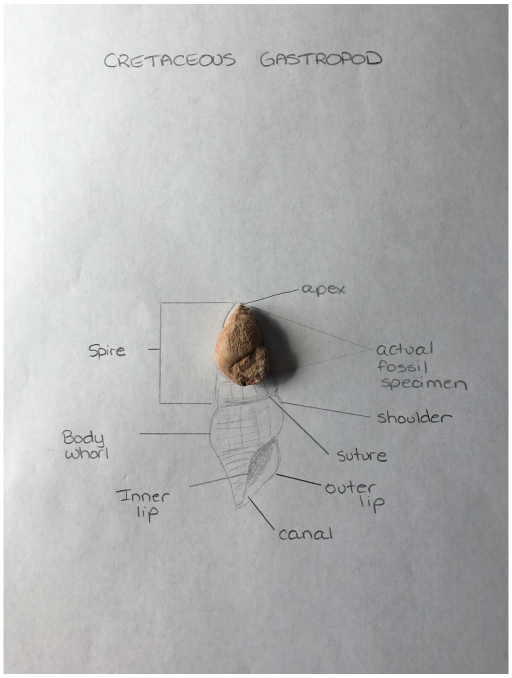
Cretaceous Echinoid fossil beside modern urchin shell (found near Tofino, British Columbia)

Cretaceous Ammonite fossil from kit, showing measurement (sketch on next page)


CRETACEOUS AMMONITE
chambers (septa)
Suture line
mantle
funnel (Hypernome)
beak
gills
stomach
actual fossil specimen piece

CRETACEOUS GASTROPOD





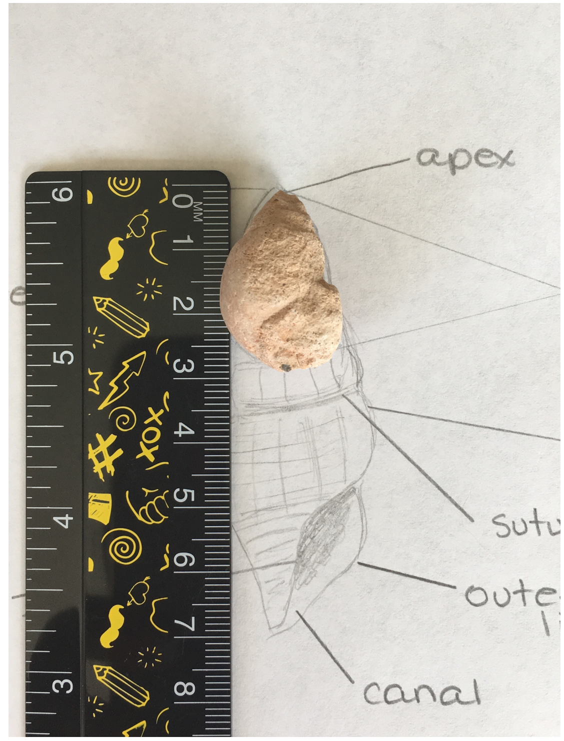


diagram showing relative position of fossil to whole animal (Cretaceous gastropod)

Cretaceous oyster (sketch next page)

CRETACEOUS OYSTER

"Honeycomb oyster"