FOUNDATIONS

1. **Homology:** similar structures with different functions. Theropod dinosaurs, whales, and humans have the same arm bone structures. The upper arm has one bone (humerus), lower arm has two bones (radius and ulna), wrist bones (carpals), and finger bones (metacarpals and phalanges). These bones have been modified through evolution to serve different functions.

   Biogeography: closely related organisms inhabit similar geographic areas. Coyotes are found in North America with their relatives, the North American wolf, while thylacines (Tasmanian tigers) were found in Australia with their relatives, kangaroos and koalas. Similarly, related tyrannosaurid dinosaurs like *Albertosaurus* and *Tyrannosaurus* are found in North America, while *Carnotaurus*, only distantly related to tyrannosaurids, is found in South America along with its relative *Aucasaurus*.

   Vestigial structures: remnants of anatomy that have been reshaped by evolution, removing old traits that are no longer useful. The human coccyx (tailbone) is a vestigial structure left over from when our ancestors had tails. Birds have remnants of a first digit in the hand similar to their reptilian ancestors.

   Transitional forms: these bridge anatomical gaps between major groups and show the development of modern forms and structures. Fossil horse limbs show the transition between short limbs with three to four toes, to longer limbs with a single enlarged toe in modern horses.

   Extinction: the end of a species or many species can open opportunities for others to evolve and diversify. Mass extinctions can cause a spike in diversification in their aftermath. Ammonites, marine reptiles, and non-avian dinosaurs went extinct at the end of the Cretaceous Period, allowing mammals to diversify.

2. There are many fossils in the *Foundations* gallery preserved in many different ways. This question presents an exercise in forming informed ideas about fossils, and answers may vary. However, here is further information to help in marking:

   Fossilization occurs when a dead organism (plant or animal) is buried by sediment. This usually happens very soon after death as scavengers, bacteria, and other decomposers will break down the organism, preventing it from fossilizing. There are many different types of fossils; each one is dependent on the conditions in which the organism is buried and what conditions it experiences over time.

   Articulated skeletons (like the *Gorgosaurus libratus*) occur when animals are buried almost immediately after death preventing scavengers and other forces from disturbing the carcass; this can occur in a riverbed, during large floods, the sea floor, or even in a landslide.

   Bonebeds occur when carcasses are disturbed during the organisms' decay; they can form when scavengers eat the carcass, or when it is transported by water in either a river or flood mixing up the bones and scattering them. Another aspect of bonebeds is that widely scattered remains can become concentrated into a small space. For example, the *Centrosaurus* bonebeds in Dinosaur Provincial Park are concentrations of remains that were initially widely scattered over a large flood plain.

KINDS OF FOSSILS

Colour patterns: Some fossils can still have pigment showing patterns present on the organism during life (i.e., fossil seashells, insects, feathers, skin).

Skin impressions: Pattern left behind in the rock from the skin of an animal. They show the texture of the skin and arrangement of scales (i.e., dinosaur skin impressions).

Mold: a void left in the rock after the organism has dissolved/decayed.

Cast: a copy of the interior of an organism cause by sediment infilling (i.e., *Pleuroceras spinatum* shell).

Unaltered organic material: This type can be seen in areas were permafrost is common or where conditions are very dry. The organism is preserved by desiccation (the process of extreme drying) or freezing; exposure to atmospheric conditions can cause them to decay (i.e., plant shells, Siberian mammals).

Permineralization: The replacement of organic material by minerals. The minerals slowly fill the pores within the object being fossilized and the original organic material disappears leaving a three-dimensional copy. Unlike a cast fossil, detailed internal structures will remain (i.e., petrified wood, dinosaur bones, *Centrosaurus apertus* tibia).

Carbonization: When organic material is compressed, it can leave a film of carbon behind. This preservation often has excellent fine detail (i.e., plant fossils like *Ginkgo* sp.).

Trace fossils: These are fossils created by organisms rather than fossils of the organisms themselves (i.e., footprints, burrows, coprolites).

Replacement: When ground water dissolves part of an organism and minerals take its place as it is dissolved. The slower this occurs, the more detail is preserved (i.e., plant fossils like *Cunninghamia* sp.).

Amber: Tree resin that has been exposed to heat and pressure due to burial in sediments, which causes polymerization (a chemical reaction) and the hardening of the resin (i.e., insects like *Atriculicoides globosus*).

GROUNDS FOR DISCOVERY

3. *Borealopelta* was fossilized in seafloor sediments despite being a land animal. Shortly after death, it was washed out to sea after ending up in a river. Gasses building up in its body cavity allowed it to float and eventually the pressure from these gasses burst the body cavity allowing it to fill with water causing *Borealopelta* to sink to the seafloor.

   Once it hit the sea floor, it sank into the sediments, and fine mud allowed it to be preserved in exquisite detail and in three dimensions. The skin has been fossilized in such detail that analysis of pigments left in the specimen tell us that it may have been reddish-brown in life. The remains of its last meal are preserved, as are the keratin sheaths covering its armour.

   Borealopelta is Alberta's oldest dinosaur fossil, 30 million years older than those found in the south of the province.

4. **Dinosaur Trackway:** These tracks reveal three theropods were taking shorter steps than expected due to the mud. Dinosaur trackways can tell us about extinct animals' gaits and behaviour.

   Mosasaurus missouriensis: A mosasaur tooth was left embedded under one eye in the skull. Analysis of the tooth suggests the mosasaur was attacked by another mosasaur of similar size that probably came from below to attack. This indicates a skirmish for territorial or mating reasons, rather than a predatory attack intended to kill and eat this *Mosasaurus*.

   The embedded tooth likely caused this animal pain. Healed wounds like these can give researchers clues into a mosasaur's social behaviour.

DEVONIAN REEF

5. Here are some examples. Answers will vary.

   Shark: gills, fins, streamlined body, special scales to reduce drag, oily liver for buoyancy, different teeth in different species for eating different foods

   Ammonite: 'propulsion jet' (hyponome), gills, septa (chambered shell) used for buoyancy, image forming eyes

   Nautiloid: 'propulsion jet' (hyponome), gills, septa (chambered shell) used for buoyancy, image forming eyes

   Fish: gills, fins, streamlined body, swim bladder for buoyancy, lateral lines for sensing

   Trilobite: gills, compound eyes, ability to enrol for protection, long antennae for sensing their environment

   Brachiopods: brachidium, a hard internal structure (used to feed and breathe), filter feeding, articulated shell for protection

   Clams: gills, ability to burrow, siphon for more effective transport of water through ctenidia (a soft, comb-like structure) for respiration and feeding

   Corals: dissolved oxygen absorption through skin (breathing), stinging cells (nematocysts), secretion of an external skeleton for support and protection, colonial growth, development of symbiosis with oxygen-producing algae

Crinoids: arms for filter feeding, oxygen absorbing organs (breathing), water vascular system, exoskeleton for support; calyx (the flower-like top of the crinoid) supported on long stalk to get it up and out of the boundary layer close to the seabed and up into better food-supplying currents

Snails: gills, radulae (a series of tiny tooth-like structures) for feeding, coiled shells and the ability to retract into it for protection, simple eyes

Sponges: regional specialization in a single individual via different cells: some for food acquisition, some for moving water through the body, some for growing skeletons (e.g., glass sponges), some for reproduction

PERMIAN

6. **The amphibian egg**, like that of the earliest fish, lacks a protective shell. Embryo and yolk are surrounded by a jelly and the egg is laid in water so it does not dry out. A continuous exchange of gas and fluids occurs between the egg and surrounding water.

   The reptilian egg, laid on dry land, carries water within it. A liquid-filled sac, or amnion, encases the developing embryo. Other protective structures include the allantois, which acts as a breathing organ, and the shell-like chorion, which protects the entire egg.

   In short, amphibian eggs must be laid in the water, whereas reptilian eggs have protective structures and amnion that allow them to be laid on land.

DINOSAUR HALL

7. Compared/contrasted physical features are based on student observation and may vary.

Ornithischians:

Albertaceratops nesmoi
Anchiceratops ornatus
Ankylosaurus magniventris
Brachylophosaurus canadensis
Camptosaurus dispar
Centrosaurus apertus
Chasmosaurus belli
Chasmosaurus russelli
Coronosaurus brinkmani
Corythosaurus casuarius
Edmontonia rugosidens
Edmontosaurus annectens
Edmontosaurus regalis
Euoplocephalus tutus
Gryposaurus notabilis
Hypacrosaurus altispinus
Lambeosaurus clavinitialis
Lambeosaurus lambei
Lambeosaurus magnicristatus
Leptoceratops gracilis
Maiasaura peeblesorum
Montanaceratops cerorhynchus
Pachyrhinosaurus lakustai
Prosaurolophus maximus
Psittacosaurus mongoliensis
Regaliceratops peterhewsi
Stegoceras validum
Stegosaurus armatus
Styracosaurus albertensis
Triceratops horridus

Saurischians:

Allosaurus fragilis
Camarasaurus supremus
Dromaeosaurus albertensis
Gorgosaurus libratus
Ornitholestes hermanni
Ornithomimus brevitertius
Ornithomimus edmontonicus
Struthiomimus altus
Tyrannosaurus rex

PALAEO ART

8. Mark for completion.

PLEISTOCENE

9. The only constant in life on Earth is **change**.