Cover photo © Fresh Air Photograph by Janis Morrison

Mosquitoes are well known vectors (transmitters of diseases).

Cold sores are caused by a type of Herpes virus.

Our primary defense against any infection is our skin.

C.4 EFFECTS OF VIRUSES

Viruses kill living cells. Outbreaks of world epidemic -threatening viruses such as HIV, West Nile, SARS, Ebola, and more recently Zika keep them in the news and have promoted ongoing research to manage their presence. It is not too bold to suggest that cells of any organism could be affected by some sort of virus, and there is no shortage of varieties of them. Humans, fish, frogs, dogs, cats, plants (like tobacco) and so on are all subject to viral invasion. If viruses are present, and they come in contact with cells in a way that accommodates the injection of the viral nucleic acid, replication and lysis causing cell death can follow. There is no escaping it.

Viruses can be passed between organisms in a number of ways. Insect **vectors**, such as mosquitoes are common culprits. Other viruses are airborne and are spread simply by coughs and sneezes. Still others are transmitted by the transfer of body fluids. The norovirus, which affects millions of people every year causing internal discomfort and severe bouts of vomiting, can be transmitted by direct contact with an infected person or contaminated surface, ingesting contaminated food, or even by inhaling airborne viruses.

The key to any viral infection is that the proteins of the viral capsid and the surface proteins of the cell's membrane must match up before penetration is possible. Cells and organisms have a number of features that help prevent this from occurring. Plant and fungal cells have cell walls; animals often have hardened exteriors, shells, scales, feathers and so on that cover the otherwise vulnerable membranes. Once a viral nucleic acid gets through this barrier—like into the sap of a plant or the blood of an animal —cell infection can occur over and over again.

Of fundamental importance for humans is skin—a layer of dead cells, which are not prone to viral attack. Even the openings through our skin into our body's interior are protected with chemical secretions, have **mucus** membranes, **sphincter** muscles, etc. to prevent the entry of pathogens into the body and their passage into blood and other tissues. Our skin and its specializations are known as the **primary line of defense**.

Should a pathogen get past these defense mechanisms, certain **white blood cells** that are capable of ingesting and destroying the pathogens are activated. This is called the **secondary line of defense** (AKA cell-mediated immunity). These white blood cells travel about the body primarily in the blood identifying pathogens by the presence of certain **antigens** on their surfaces. Many times this is all that is required. Sometimes, however, pathogens do establish themselves in tissues and cannot be destroyed by this activity alone.

The **third line of defense** (AKA antibody-mediated immunity) requires the activity of a different type of white blood cell called a **lymphocyte**. Lymphocytes respond in a number of very specific ways that involve the recognition of the pathogen and the subsequent release of proteins to isolate and destroy it. One such reaction is the production and release of **antibodies**. Antibodies are protein complexes that attach to specific antigens on foreign entities in blood plasma and form inactive aggregates (clumps) out of them, which can be later destroyed. Another protein that is produced and released is **interferon**, which will coat non-infected cells, masking the proteins in their cell membranes so viruses cannot "recognize" them. This prevents further infection of host cells, making the viruses easier to eliminate.

change, chemicals and radiation, are called **mutagens**. When replication is affected by mutagens, daughter cells may inherit altered DNA.

Typically, **mutations** are thought of as "bad" because the changed DNA could be unable to produce a required protein that the cells normally produce. At the organism level, an individual may have some metabolic deficiency due to the lack of an enzyme, for example. In nature, an organism with a metabolic deficiency may not survive. Another possibility exists, however. The changed DNA may allow the cell and, by extension, the organism to make a new protein or have a new characteristic that is otherwise unknown in the population giving that individual a survival advantage. In time, individuals with this new genetic trait would survive better than their counterparts. A change in the gene pool would result, which is evolution.

The genetic composition of a species can also undergo **genetic drift**, namely random changes in the gene pool that do not have any major identifiable cause. It is easiest to recognize these changes by considering a small, isolated population —on an island for example, where mate selection and breeding occurs only among the members of the population on the island. In this type of situation, factors such as the sexual activities and viability of individuals, and the gender ratio in the population take on a new significance. Consider the effect of one male that fathers twenty surviving offspring, where another male has half of that number. Obviously, the more offspring an individual has, the more that individual's alleles will become represented in the gene pool. Related to this is a phenomenon known as the **bottleneck effect**. What if, continuing with the island example, there was a particularly harsh winter and only a few members of the species survived. The variation of alleles in the gene pool of subsequent generations would be significantly reduced as those generations would be propagated by the few that survived the intense selective pressure of the harsh winter.

The concept of **gene flow** can be used to explain changes in the gene frequencies of isolated populations of species with their own particular genetics. Suppose that a member of a different population immigrates and joins a given population. He or she may introduce unique alleles into the population. The result is a passage of genetic information into the gene pool of one population from another. Over time, the **genetic distance** between the two populations may become lessened.

Another pattern is the **founder effect**, namely when a small group of individuals becomes isolated and starts a new population. Without being able to share genes with the larger population, the new population can evolve rather quickly with its limited gene pool.

White lions exist because of a rare genetic mutation.

Genetic research to improve the quality of individuals' lives is occurring in many centres all over the world.

the quality of life are all worthwhile pursuits. Others might argue that it is immoral to alter the genetics of organisms. To what extent should scientists today be allowed to alter the gene pools of organisms? Is enabling people with genetic deficiencies to lead more normal and productive lives going to affect the gene pool of the human populations in the future? Will these techniques be allowed to go one step further and allow the selection of human characteristics for the people that will populate Earth in the future? These are all questions that can be asked, though they are probably unanswerable with certainty.

D.6 CONCEPT CHECK-UP QUESTIONS

1. State three ways that human activities affect natural populations.
2. a. How has human activities promoted an evolution of the *Culex* mosquito?
   b. How might current human activities be causing the evolution of the *Culex* mosquito in North America?
3. What are genetically modified organisms?
4. a. What is the purpose of gene therapy?
   b. Briefly describe a gene therapy technique.

D.6 DISCUSSION QUESTIONS

1. Research your own example of speciation caused by humans and be prepared to comment.
2. What are the pros and cons of producing genetically modified organisms?
3. (Research) Describe Kristopher Boesen's recovery story.
4. What might be the long term effects of gene therapy on the human population?

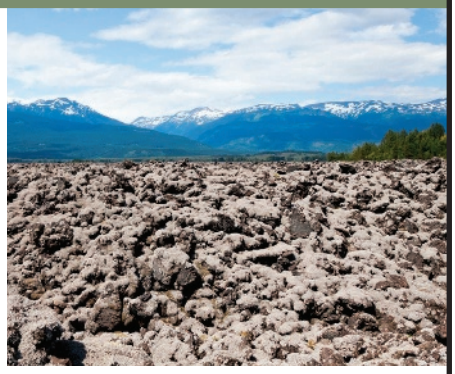
FIRST NATIONS' PERSPECTIVE

Nisga'a Memorial Park

Speciation occurs when a population of organisms is reproductively isolated from the rest of its species. Generation after generation of not sharing a common gene pool can result in enough genetic differences that the two groups are no longer able to interbreed and produce viable offspring.

The oral records of the Nisga'a Nation describe the time when the Tseax Cone in the Nass Valley of Northwestern BC erupted. The extensive lava flow dammed the Nass River flooding two villages and killing an estimated 2000 Nisga'a people. The area is now a Provincial Park. It is sacred ground as it is a burial site.

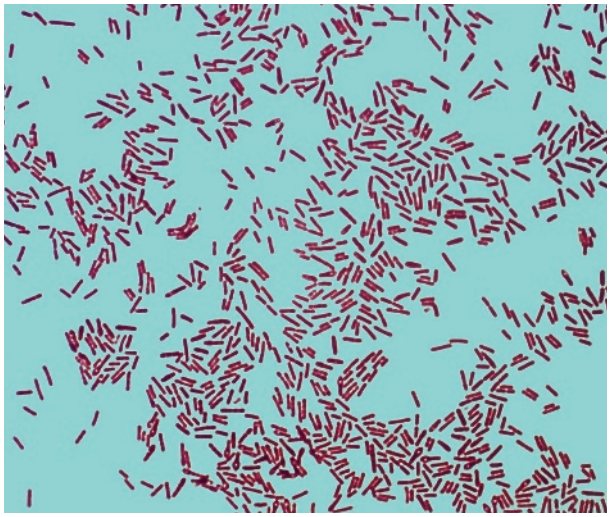
There were no written records of this event, which occurred about 1700. It is Canada's most recent volcanic eruption and lava flow. This is the type of catastrophic event that can cause speciation and is a driving force of evolution. The oral records of the eruption and its aftermath do not include the topic of speciation, but it is highly possible that a singular population of animals (or plants) was isolated by the lava flows and is currently evolving on its own. Only time will tell.



This "moonscape" is a 300 year old lava flow in BC's Nass Valley, home of the Nisga'a Nation. There is still very little life thriving here.

TAKE A CLOSER LOOK AT:
NISGA'A MEMORIAL PARK

Bacteria colonies growing on agar. Each colony is comprised of millions of cells.



E.coli is a common gram positive bacillus bacterium.

bottom of a petri dish where it will harden quickly to produce a thin, gel-like layer of food. Objects suspect of having bacteria can then be used as a source from which to transfer and attempt to grow the bacteria. It is important that these procedures be done with proper laboratory techniques because bacteria cannot be seen with the unaided eye and there is no telling what is being transferred for growth.

Once transferred, the bacteria should start to metabolize the nutrients in the agar. If the conditions are ideal, they will reproduce rapidly so that in a few days they can form **colonies** large enough to see without a microscope. Different bacteria form colonies with distinctive characteristics like colour, sheen and texture. The most common bacterial colonies are round, whitish, shiny and smooth on top. Cultures of bacteria can be used to prepare microscope slides for viewing and identification. If a slide is well prepared, a colony is broken apart to reveal the shape and size of the individual bacteria cells. Staining with Gram's stain will allow one to determine the nature of their cell wall, which is an important step to their identification.

Bacteria can be separated into two nutritional types. They are either heterotrophic or autotrophic. The heterotrophic ones are the types that have been described already (grown on agar in Petri dishes). They require a carbon-based (organic) food source such as sugar, which is provided by the agar. Autotrophic bacteria are ether photosynthetic or chemosynthetic. The **photosynthetic** ones utilize sunlight energy along with carbon dioxide and water to manufacture organic compounds. **Chemosynthetic** bacteria harness the energy from inorganic chemicals to produce organic compounds. All bacteria metabolize organic molecules for energy by the processes of cellular respiration. Because they are prokaryotic and lack mitochondria, these processes do not produce as much ATP as they do in eukaryotic cells.

Bacteria have other requirements for growth besides nutrients. They are either **aerobic** (requiring oxygen) or **anaerobic** (requiring the absence of oxygen). *Escherichia coli*, the common intestinal bacterium is a facultative anaerobe. As such, it can survive in oxygen depleted environments.

Temperature is also critical for bacterial growth. As with all organisms their metabolic activities will increase as temperature increases. Bacterial cultures can be refrigerated and stored for periods of time because their metabolism slows right down. At higher temperatures, still much lower than that of boiling water, they cease to carry out metabolic activities and die because proteins and enzymes get destroyed. Somewhere between these two extremes is a temperature that bacteria are the most metabolically active. This is their optimum temperature. For pathogenic bacteria, the **optimum** temperature will be very close (or the same as) that of their host's.

that was owned by the British. Potatoes were a valuable crop as they grew well, were nutritious and their demand was very high. It became a food staple for the Irish, and an important export to England. Unfortunately, water molds got in the soils of rural Ireland and infected the plants. Repeated crop failures resulted in wide-spread famine, economic disaster, emigration of hoards of people to other countries like Canada and United States, and hundreds of thousands of deaths.

Even today, with current knowledge of plant diseases, human enterprises are still affected by crop-destroying water molds. One in particular is known as **downy mildew**, which primarily affects grape leaves. It has been known to destroy entire grape orchards. Grape growers spray **fungicides** to prevent this from happening.

G.4 CONCEPT CHECK-UP QUESTIONS

1. a. Describe the body forms of the phyla of slime molds.
   b. Why are they classified as protists?
2. What is a fruiting body?
3. Why would a cellular slime mold release cAMP?
4. Consider Acrasiomycota and Sarcodina. In what ways do they have similar body forms?
5. a. Why are water molds (oomycetes) also called egg fungi?
   b. Describe two instances where water molds have affected human endeavors.

G.4 DISCUSSION QUESTIONS

1. Think about cAMP as well as ATP. What is the relationship between these two molecules.
2. Describe a human body cell that has amoeboid capabilities?
3. Use the description of the life cycle of *Ulva* to draw a life cycle for a water mold.
4. The majority of protists are aquatic, but many of the fungus-like ones are terrestrial. What characteristics must they have to allow them to survive on land?

A grape leaf infected with a water mold. If left alone, a mold like this could spread and destroy an entire vineyard.

Fungicides are sprayed in grape orchards to prevent the growth of crop-destroying molds.

Ascomycetes are commonly called "cup fungi" because of the reproductive structure they produce.

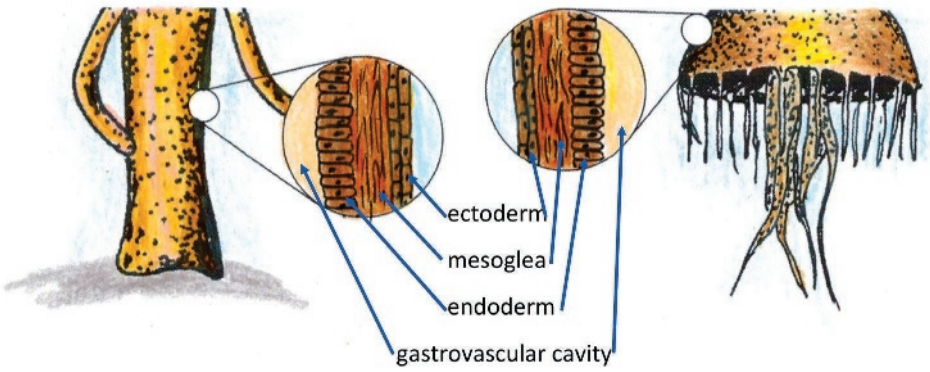
hyphae specialize and develop into haploid **conidiophores**, which vegetatively produce spores of their own, called **conidiospores**, or simply **conidia**. They germinate to add to the mycelium. The term "conidio" comes from the Greek word meaning "dust", which describes the very small size of these spores. Yeast is a unicellular ascomycete that typically reproduces asexually by budding. Yeast also produces ascospores under extreme conditions.

Members of Phylum **Deuteromycota**, commonly known as imperfect fungi, are only known to reproduce asexually in a method that greatly resembles the ascomycetes. Their spores are also called conidiospores. In a few cases a fungus has been reclassified from this phylum into one of the other phyla when its sexual reproduction method was identified.

Perhaps the most complex life cycles belong to members of Phylum **Basidiocycota**, commonly called "club fungi". The fruiting bodies of these fungi are quite obvious, and sometimes highly pigmented, though they are not photosynthetic. The hyphae forming the mycelium of these fungi can extend throughout decaying organic matter in the substrate, whether it be a rotting log, or the ground itself. Basidiomycetes often produce a primary mycelium comprised of haploid, acoenocytic + and – hyphae. These hyphae can fuse and form a secondary mycelium (also acoenocytic, but **binucleate**. Like the hyphae of ascomycetes, the nuclei have not fused.) In good growing and feeding conditions, the tips of hyphae form an entirely different mycelium, called a **secondary mycelium**. Portions of this mycelium develop into bulb-like structures, which further develop into the reproductive fruiting bodies. Fertilization occurs when the two hyphal nuclei in these strands finally fuse in specialized cells called **basidia**. Basidia are located in the gills of the fruiting body. A single mushroom can contain thousands of basidia. The nucleus in each basidium undergoes meiosis to produce four haploid **basidiospores**. When mature, these spores are released and can germinate

Morels are ascomycetes.

Mushrooms and bracket fungi are members of Phylum Deuteromycota.



Cnidarians have two true tissue layers, an inner endoderm and an outer ectoderm, which are separated by an undifferentiated layer of cells known as mesoglea.

TAKE A CLOSER LOOK AT:
SOUTH AMERICAN JELLYFISH

Genus ***Hydra*** is a well-known fresh water example. In addition to being broadcasters, hydrozoans, like *Hydra* reproduce asexually by budding. They generally lead simple and solitary existences, however some colonial members do exist, such as Genus ***Obelia*** and the **Portuguese Man-o-War**.

Scyphozoans are motile with a medusa body form for the majority of their polymorphic life cycle. These individuals are commonly called **jellyfish**. The adult jellyfish are typically male or female. Their gametes are released into the water where fertilization occurs. The resulting zygotes develop into larvae, which attach to surfaces and develop into polyps. These polyps reproduce **vegetatively** to produce medusas once again. Members of the third class, the Anthozoans, are primarily sessile and have more complex tissue structures. There are many colonial and solitary examples including sea anemones and coral-forming anthozoans. **Anthozoans** are not usually polymorphic.

Today, coral reefs are protected places. It takes thousands of years for a coral reef to develop, yet they can be damaged easily. They are ecologically sensitive areas where a tremendous number of species of animals and algae can be found. Cnidarians are also of pharmaceutical interest because of the chemicals they produce.

J.3 CONCEPT CHECK-UP QUESTIONS

1. What is the distinguishing feature of a cnidarians? How does this feature function?
2. Compare and contrast the two body forms of cnidarians.
3. What differences are there between the ectoderm and the endoderm of a typical jellyfish?
4. Do jellyfish have a brain? Explain.
5. Describe the polymorphic life cycle of a jellyfish.
6. List three significant differences between a typical anthozoan and a typical schyphozoan.

J.3 DISCUSSION QUESTIONS

1. a. Which three life functions are managed by the cells in the mesoglea of a jellyfish?
   b. How do these life functions occur in a sponge?
2. Design and complete a chart similar to Table J.1 to summarize the seven life functions in a typical cnidarians. Be sure to identify the type of cnidarians your chart refers to.

Sea anemones are members of Class Anthozoa. The sea anemone on the left is relaxed with its delicate tentacles extended for respiration and potentially feeding. The one on the right has been disturbed and has withdrawn its tentacles to protect them.

33. Which class of arthropods has branching appendages?

A. Insecta
B. Crustacea
C. Chilopoda
D. Diplopoda

34. Which system does the green gland of a crayfish belong to?

A. Digestive
B. Excretory
C. Circulatory
D. Reproductive

35. What is the function of the uropods and telson?

A. Digestion
B. Excretion
C. Locomotion
D. Reproduction

36. People who enjoy eating lobster are actually eating muscles of the lobster's

A. uropods and telson.
B. carapace and abdomen.
C. chelipeds and abdomen.
D. cephalothorax and chelipeds.

Build your understanding of concepts

1. What advantages does an earthworm have over worms in other phyla as a result of the coelom?

2. Discuss the advantages and disadvantages of broadcasting as a means of gamete distribution.

3. a. The higher invertebrates display a number of unique features or structures. Consider the location and function of each of the following: clitellum, radula, mantle, pedicellaria, and pedipalps.

b. Make your own list of ten more and identify the location and function of each.

4. How could one distinguish between the sexes of grasshoppers? Spiders? Lobsters?

5. Can a clam produce a pearl? Why or why not?

6. Copy and complete the following table to identify the key features of each of the seven life functions in the four phyla in this unit.

	ANNELIDA	MOLLUSCA	ECHINODERMATA	ARTHROPODA
Feeding and Digestion				
Gas exchange/ Respiration				
Excretion				
Skeleton and Support				
Responses/ Nevous System				
Internal Circulation				
Reproduction				

ANIMALS: PHYLUM CHORDATA

This unit will enable you to:

- Distinguish between chordates and other phyla of animals
- Evaluate characteristics shared by vertebrates that contribute to their success
- Identify specific specializations and contrast structures of different classes of fish
- Appraise characteristics of amphibians in the transition from aquatic to terrestrial life
- Recognize and evaluate trends in the continued development of organs systems of animals
- Appreciate the significant of the amniotic egg
- Identify and describe specific vertebrate adaptations and specializations
- Critique the position of mammals as the most advanced members of the Anima Kingdom

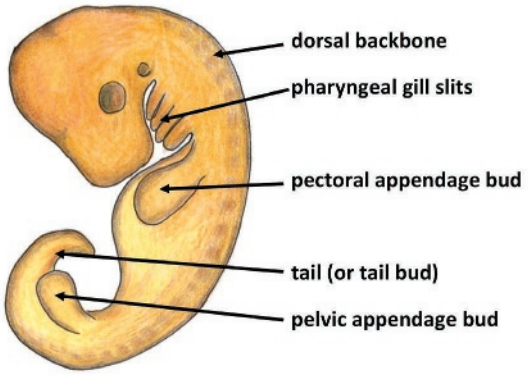
L.1 CHORDATE CHARACTERISTICS

Most of the animals people are very familiar with are members of Phylum **Chordata**. Generally speaking, chordates are physically the largest members of the Animal Kingdom. Humans are mammals, one of the classes of chordates—so are our pets like dogs and cats. Much of our meat, such as beef, poultry and fish comes from chordates.

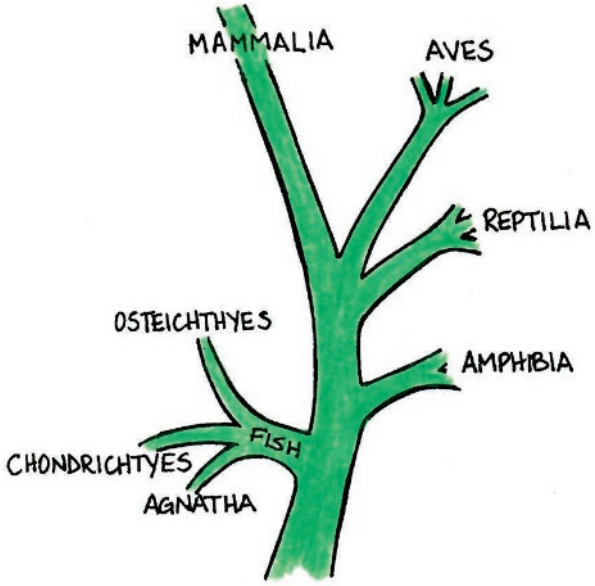
Three characteristics unite members of Phylum Chordata. All chordates have **pharyngeal gill slits** at least at some stage in their development. The **pharynx** is the region behind the mouth before the start of the trachea and esophagus. The embryonic pharyngeal tissues of some animals, like fish, continue to specialize and develop into gills. For the majority of chordates, however, the gill slits only exist as a developmental phase before respiratory systems with lungs become specialized. Chordates also have a **notochord** at some stage in

their development. A notochord is a stiff supportive tissue along the inner dorsal surface. In a few chordates, again, this feature remains in the adult, but in most it simply marks an early developmental stage prior to the specialization and development of a true internal skeletal system. Most chordate skeletons are made out of bone but, in the class where sharks are classified, the skeletons are constructed out of cartilage instead. The final unifying feature of all chordates is a **dorsal tubular nerve cord**. This is in contrast to the paired ventral nerve cords of the invertebrates.

There are four subphyla of Phylum Chordata. Three of these subphyla are groups of simple animals that possess chordate features. One is a worm-like creature that shares the essential features of the Phylum Chordata at its anterior end. This is the **acorn worm** of Subphylum **Hemichordata**. It is named after the shape of its snout, which it uses to gather food. Members of Subphylum **Tunicata** (AKA Urochordata) are the "**sea squirts**", which at first glance could be mistaken for sponges. These jelly-like sessile creatures are small marine-filter feeders noted for their characteristic contracting action, which forcibly pumps water through their interiors. The third subphylum, Subphylum **Cephalochordata**, includes small fish-like creatures like amphioxus, another marine filter feeder that is only a few centimeters long. Subphylum **Vertebrata**, the focus of this unit, includes the animals we are most familiar with. The phylogenetic tree illustrated below arranges the seven classes of vertebrates in a possible evolutionary sequence.



All chordates have similar embryonic features including pharyngeal gill slits, a notochord, and a dorsal tubular nerve cord that usually becomes surrounded by cartilage and then bone as the embryo develops.



This phylogenetic tree shows a sequence of complexity among seven classes of Subphylum Vertebrata.

At first glance, sea squirts may resemble sponges.

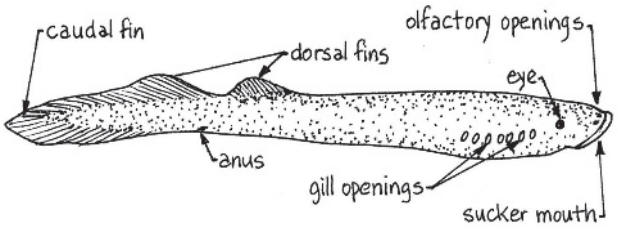
L.1 CONCEPT CHECK-UP QUESTIONS

1. What are the three defining characteristics of members of Phylum Chordata?
2. List the four subphyla of Phylum Chordata and comment on the relative biological success of each.

L.1 DISCUSSION QUESTIONS

1. In what ways do sea squirts resemble sponges?

Agnathans are jawless parasitic fish.



External anatomy of a lamprey.

L.2 FISH

The term "**fish**" is not a taxonomic term. Like "tree", it is a term of convenience used to describe a certain type of organism. Fish are aquatic vertebrates with gills. There are three classes of fish in Subphylum Vertebrata—Class **Agnatha** (jawless fish), Class **Chondrichthyes** (cartilaginous fish) and Class **Osteichthyes** (bony fish).

Agnathans are primitive, parasitic fish. This nature of their lifestyle is immediately apparent by examination of their structures. Most obvious is the lack of jaws in their mouths. Unable to chew, agnathans, such as the **lamprey**, have toothed mouths with suckers specialized to attach to the surface of another aquatic animal, bore a hole into the soft tissue and, in a manner reminiscent of a leech, suck out body fluids. Another agnathan, the **hagfish** actually bores a hole and crawls into a host, such as a dead fish, and sucks up nutrients while inside!

Lampreys and hagfish have similar body plans. Their embryonic notochord has been replaced by a flexible cartilaginous rod that supports their body. They have seven pairs of exposed gills, are long and eel-like without scales or fins other than reduced **dorsal** and **caudal** (tail) fins. The absence of paired fins also coincides with their parasitic lifestyle as they are often attached to, or are inside of a host and have little need of their own means of locomotion. As could be expected from an understanding of the lifestyle of these primitive fish, the nervous systems lack specialization. Sensory organs are poorly developed or are completely absent. Their life cycles are characterized by larval stages, a pattern common in parasites as a means of increasing the distribution of their offspring. Hagfish are distinct from lampreys not only by their feeding styles, but also by their incredible ability to produce slime to facilitate their movement through the tissues once inside a host. When caught, a hagfish can release over two liters of slime, which also helps them escape. These fish, lampreys in particular, have historically caused large-scale destruction of the fish populations in the Great Lakes thus adversely affecting the economy of that industry.

The **cartilaginous fish** (members of Class Chondrichthyes) are made famous by the ancient predatory carnivores of this class—the sharks. Rays and skates are other members of this group. Besides their skeleton, the most obvious unifying feature of chondrichthyes is their body shape. All are **dorso-ventrally flattened**, as are the members

Sharks and skates are members of Class Chondrichthyes. They are dorso-ventrally flattened and have cartilaginous skeletons.

TAKE A CLOSER LOOK AT:
LAMPREYS

This taxonomic guide provides an organization and description for the names of organisms mentioned in this study guide.

DOMAIN ARCHAEA

Kingdom Archaea – Domain and Kingdom Archaea are relatively new groupings. Since it was decided that archaea are significantly different than bacteria, they have been classified as their own domain. The differences are biochemical difference in their cell membranes. So far, all archaea are considered to be in the same kingdom and no phyla have been named. In time, as scientists continue to learn more about these organisms, this will likely change.

All members of Kingdom Archaea are prokaryotic and have membranes containing bipolar phospholipids bonded to glycerol with ether bonds. These membranes are fundamentally more durable than their alternative allowing archaea to inhabit environments not previously known to be livable.

DOMAIN BACTERIA

Kingdom Bacteria – The subdivision of the historic "Kingdom Monera" into two separate groups of organisms, each designated as a domain (Domain Archaea and Domain Bacteria) leaves what was previously known as the "true bacteria" in a grouping by themselves. Domain Bacteria contains only one kingdom. The classification of bacteria is an active study.

These organisms are unicellular prokaryotes. Bacteria can be identified by a number of features, such as cell shape (coccus, bacillus, or spirillus), staining effects, which reveal the chemical nature of their cell walls, etc. There are many well-known bacteria such as:

Escherichia coli – a common bacillus bacterium. One strain of *E. coli* lives symbiotically in human intestines, metabolizing some components of feces. *E. coli* manufactures some vitamins and releases minerals from the feces that our systems absorb from feces along with water. Another strain of *E. coli* causes food poisoning, if ingested. *E. coli* is also used in the lab for experimental purposes and for recombinant DNA procedures because of its availability and ease of culture.
Helicobacter pylori – this bacterium was discovered in the mucous lining of the human stomach a long time ago, but it wasn't until relatively recently that it was identify as the cause of ulcers.
Treponema pallidum – a spirillus bacterium that causes syphilis, an STD.
Pneumococcus – the coccus bacterium that causes pneumonia.
Streptococcus – the coccus bacterium that causes strepthroat.

DOMAIN EUKARYA

All members of Domain Eukarya have eukaryotic cell structure. The domain is subdivided into four Kingdoms: Protists, Fungi, Plants and Animals.

Kingdom Protista – The Protist Kingdom includes the unicellular eukaryotes (and their nearest relatives). Protists are easily clustered according to their nutritional pattern; some are ingestive (and called animal-like); others are photosynthetic (plant-like); and the rest are absorptive (fungus-like)

Ingestive (Animal-like) Protists

Phylum Ciliophora – The ciliates all have cilia, which are short protein strands that enable movement. The ciliates either use them to move food towards an oral opening or to more through their environment (or both). Ciliates tend to be free-living and hot harmful. A common example is Genus *Paramecium*.

Phylum Sarcodina – The sarcodines have amoeboid body forms. As such their extend portions of their cell membranes and "flow into them" in order to move or to surround food. Their process of food engulfment is called phagocytosis. Some sarcodines are pathogenic, like *Entamoeba histolytica*.

Phylum Sporozoa – The sporozoans reproduce by spores. Many of them, like *Plasmodium vivax*, have a polymorphic life cycle where one stage is specialized for reproducing and the other is specialized for feeding and relocating. Unfortunately, *Plasmodium vivax* is parasitic and invades red blood cells, causing malaria.

Phylum Zoomastigina – Many of these flagellated protists swim through their watery environments. There are well-known parasitic members of this phylum, like *Girardia*, which causes beaver fever, and *Trypanosoma*, which causes sleeping sickness. There are also symbiotic zoomastiginans, like *Trichonympha*, which lives in termite intestines enabling it to digest wood fibres.

separate do the ova mature. Fertilization of the ova follows using the sperm that are being held in a sperm receptacle.
c. Trochophore larvae are tiny larvae that have bands of cilia for locomotion through fluids (water). They are weak swimmers and would be considered planktonic.

7. Oligochaetes are free-living and ingestive. They consume nutrient-rich detritus. Polychaetes are predators, though their predatory nature ranges from aggressive to passive (as in some filter-feeders). Leeches are blood-sucking parasites.

8. Hirudin is a chemical with both anti-coagulant and anaesthetic qualities. It is secreted by leeches as part of its parasitic life style.

K.2 CONCEPT CHECK-UP QUESTIONS

1. All mollusks share three main characteristics: foot (used for locomotion), mantle (secretes shell-producing material), and a visceral mass (soft inner tissues, which are used by humans and other animals as food).

2. The fact that both of these groups of animals have trochophore larvae is considered by many to be an evolutionary link. A trochophore larva is almost spherical and equipped with cilia for locomotion.

3. The class names of mollusks are based on obvious physical characteristics related to their foot ("poda" = foot). Clams, members of Class Pelecypoda, are so named because their foot becomes hatchet-shaped when the blood sinus fills to move them through the sand. ("pelecy" comes from the Greek word for hatchet). Similarly, Gastropoda means "stomach–foot", and Cephalopoda means "head-foot".

4. a. A closed circulatory system is one where the blood circulates the body tissues contained in blood vessels. This system relies on diffusion and osmosis occurring through the walls of the blood vessel (capillaries) to exchange substances with the tissues and maintain a suitable blood pressure. In contrast, an open circulatory system allows the blood to soak within the tissues, exchanging materials as it does. Open circulatory systems have a few blood vessels designed to collect up blood for delivery to the heart and deliver blood to tissues once the heart pumps it. Open systems are not as efficient as closed systems.
b. Insects have an open circulatory system and all chordates, including us, have a closed circulatory system.

5. Pearls form as a result of an irritation inside the shell of an oyster. The irritation, often a grain of sand, is covered with a chemical secretion called nacre to smooth it out. This hardens and more nacre is deposited and a pearl starts to form. Continuous layers of nacre are secreted and harden in place forming a commercially valuable pearl.

6. A radual is a rasping mouthpart in gastropods. It consists of tiny carbohydrate plates (chitin) that the gastropod uses to grind food material off surfaces.

7. a. A wide range of ingestive or feeding styles exists in Phylum Mollusca. The most active hunters are the Cephalopods like squids and octopi. These relatively quick moving invertebrates have tentacles, well developed eyes, and closed circulatory systems. Their brain is also well developed and they are capable of some learning activities. Less active, with different specializations are mollusks like the snail, which has a radula (much like a file) used for scraping off vegetation that it crawls over. Slower moving, it has less need of a highly developed nervous system than cephalopods. These mollusks also have an open circulatory system and a single tissue called a foot (rather than tentacles). Even less active are clams, which have siphons for filter feeding. Similarly, their other systems are modified to complement their almost sessile existence.
b. Nervous systems are designed to respond to environmental stimuli. The faster moving, more interactive the animal is, the more specialized the nervous system has to be. An octopus, therefore, has the most developed nervous system of the three animals listed. A clam has the least.

8. Edible mollusks include: clams, oysters, snails, octopi, mussels, scallops, squid etc. The soft body masses of the members of this phylum are quite edible.

K.3 CONCEPT CHECK-UP QUESTIONS

1. Placement of animals on a phylogenetic tree is determined by the physical similarity that the phylum being considered has to other phyla. Echinoderms are difficult to place because they are radially symmetrical, which is a low level feature, yet they have an endoskeleton, which is a high level feature. They also have a unique system of hydraulics called the water vascular system, which cannot fairly be compared to any other system in the animal kingdom.

2. The endoskeleton is present in both echinoderms and chordates. Its presence requires a particular sequence of embryonic cell specializations that only occurs in these two phyla.

3. a. The water vascular system starts with the madreporite (also called the sieve plate). From here, water is conduced down the stone canal to the circular canal that encircles the central region of a sea star. Branching out from this are radial canals that extend down each ray (leg). Lateral canals extending from the radial canal conduct the water to the tube feet, which are the terminal ends of the water vascular system.
b. Three functions of the water vascular system are:
Locomotion – this set of tubes (canals) is fluid-filled and has muscular endings called tube feet. Valves exist to isolate the tube feet from the rest of the tubes. By using the muscles and valves, water pressure in the tube feet can be increased or decreased causing elongation or shortening of the tube feet (respectively). The tube feet have suction ends, which are used to adhere to surfaces. Used by the hundreds, the tube feet make a very strong locomotory device.
Circulation & Respiration – sea stars lack a heart and blood vessels. The water vascular system doubles as a system of internal transport because gases and excretory wastes travel in the fluids. The tube feet serve as a gas exchange surface (in addition to the main respiratory surfaces called skin gills) and a surface for the excretion of nitrogenous wastes as well.
Feeding – sea stars take advantage of the combined strength of hundreds of tube feet and used their rays to pull open bivalves exposing their soft inner tissues that are ingested by evertable stomachs.

4. Evertible means much the same as invertable, only here it is inside-out (not upside-down). Their stomach is said to be evertible as it drops out of the mouth for ingestion purposes.
Pedicellaria – refer to the small appendages that exist on the aboral surface, particularly around the skin gills. The function of the pedicellaria is to keep the surface free of debris, which could clog up the skin gills.

green algae – common name of members of Phylum Chlorophyta. Green algae are of particular interest in biology because of the similarities of their photosynthetic processes and that some species live in fresh water. It is thought that the first land plants may be descendent from green algae.
green gland – excretory structure of crustaceans located in the anterior part of their body.
guard cells – pairs of specialized cells embedded in the epidermal layer of plant leaves. Guard cells bend to open pores called stomata when they are turgid. This allows gas exchange and water evaporation for photosynthesis.
gullet – opening to the esophagus. In the back of a frog's mouth, the gullet is dorsal to the glottis.
gymnosperm – group of plants that produces seeds that are exposed to the air as opposed to contained in some protective structure. Conifers are well known gymnosperms.
hagfish – type of jawless fish (agnathan). Hagfish consume dead tissues of other organisms. They secrete large volumes of slime to avoid entrapment or capture (see Taxonomic Guide).
hair – protein products of particular cells in mammals. Fur is made up of hair.
halophyte – plant specialized to live in mineral-rich soil.
haploid – (AKA monoploid) adjective used to refer to the gene number in a gamete, abbreviated "N" (related vocabulary "diploid").
haustorium (pl. haustoria) – hypha that releases digestive enzymes.
head – body region at the anterior end of an organism that is equipped with a concentration of nerve tissue (brain)
heart – specialized muscular organ of a circulatory system that contracts to pump blood.
heartwood – cellulose impregnated xylem tissue that no longer actively conducts water.
heat capacity – ability of a substance to retain heat as opposed to letting it dissipate into the surroundings. Water has a relatively high heat capacity, which contributes to its moderating effect on climate. In comparison, metals have low heat capacities and will transfer heat readily.
Helicobacter pylori – bacterium that causes ulcers in the soft mucus lining of the digestive system of mammals.
Hemichordata – subphylum of Phylum Chordata (see Taxonomic Guide).
Hemophilia – genetic condition that prevents person's blood from efficiently forming blood clots, which should stop bleeding and bruising.
herbaceous – non-woody.
herd immunity – type of immunity gained without vaccination because the majority of individuals in the population have been vaccinated.
hermaphroditic – organisms which have both genders of reproductive organs. The advantage to the organisms of being hermaphroditic is that during sexual reproduction with another member of their species, both members can carry out both roles, which doubles the reproductive potential.
heterotrophic – organisms that gain their energy (food) from the consumption of other organisms.
hirudin – anti-coagulant chemical substance secreted by leeches that prevents blood from clotting.
Hirudinea – class name of leeches (see Taxonomic Guide).
holdfast – anchoring structure of algae. Holdfasts differ from roots because they do not absorb water and nutrients from soil, which are functions that require vascular tissue.
homeostasis – processes or mechanisms of organisms that maintain a set of constant conditions (e.g., maintaining body temperature). Homeostatic mechanisms are essential for survival.
Homo sapiens – scientific name of humans.
homologous – structures of different organisms that correspond to each other. To be homologous, the structures must have the same types of tissues. An example is human arm and bird wing. Homologous structures are different from analogous structures because analogous structures involve different tissues (related vocabulary "analogous structures").
homology – the study of homologous structures.
hornwort – member of Phylum Bryophyta (see Taxonomic Guide).
host – organism from which others, called parasites obtain their nutrients. For example, humans are hosts to mosquitoes because mosquitoes obtain blood from them.
Hydra – common genera of Class Hydrozoa, Phylum Cnidaria (see Taxonomic Guide).
hydrolytic – from the word hydrolysis, which means the chemical breakdown of a substance. Hydrolytic enzymes conduct digestive processes.
hydrophilic – will mix with water.
hydrophobic – will not mix with water.
hydrophyte – water plant (Phylum Tracheophyta; not an alga). Water lilies are hydrophytes.
Hydrozoa – class name of a type of cnidarian (see Taxonomic Guide).
Hypha – filamentous fungal growth. Individual hyphae may be coenocytic or acoenocytic depending on the type of fungus.
immune system – set of tissues and organs that protects an organism from infection. White blood cells are part of the immune system of humans as they release antibodies.
incomplete metamorphosis – series of changes that some animals go through as they mature from an egg to an adult. Typically, incomplete metamorphosis requires less than the four steps that characterize complete metamorphosis (related vocabulary "complete metamorphosis").
incurrent opening (AKA "ostium") – passageway for water with dissolved gases and small suspended particles through a porocyte (pore cell) into the interior of a sponge.
independent assortment – random separation of chromatids into daughter cells. Independent assortment contributes to genetic variability in sexual reproduction.
industrial melanism – evolutionary change in the predominant colour of organisms brought about by the environmental impact (pollution) of the industrial revolution. The classic example of industrial melanism is the evolution of Biston betularia, a peppered moth in England.
ingestive – eating. To ingest means to eat. Structures that are used for ingestion are called ingestive structures.
injection – insertion. Viral genetic material is injected into host cells during penetration.
ink – dark coloured, foul tasting chemical released by some mollusks as a defense mechanism.
inoculated – treated with a vaccine.
Insecta – class name of insects (see Taxonomic Guide).
interaction – relationship between different organisms. Biologically, there are five major types of interactions (related vocabulary "predation", "parasitism", "mutualism", "competition" and "commensalism").
interferon – protein produced by certain white blood cells to help the body combat viral infection.
interleukin – protein produced by certain white blood cells as part of the immune system's response to infection.
intertidal zone – ocean shoreline region subject to tidal influences. Depending on the height of the tides, some intertidal regions are covered by water twice a day. The ecology of the intertidal regions is both delicate and unique.
intestine – organ of the digestive system that is specialized for the secretion of digestive enzymes and the absorption of nutrients. Organisms with more complex digestive systems have both small and large intestines.
intracellular digestion – digestion that occurs within an individual cell. Lysosomes contain enzymes that digest particles in food vacuoles as well as worn out organelles. The digestion products are molecular and can be used by the cell.
iris – coloured muscular tissue of the eye capable of contracting and relaxing to regulate the amount of light that passes into the eye through the pupil.
jellyfish – common name of members of Class Scyphoza in Phylum Cnidaria (see Taxonomic Guide).
keel – in birds, the extension of the sternum from which the pectoral muscles originate. Birds that are capable of flight have large masses of pectoral muscles and, therefore, large keels.