Biology 40S – Final Exam Review (2016-2017)
Answers to Review Questions

Review Questions and Competencies by Topic:
Classification of Life:

- Be familiar with the order of taxa (from domain to species).
    - Domain -> kingdom -> phylum -> class -> order -> family -> genus -> species
- Be able to recognize and write a binomial name for an organism (*Genus species*; eg: *Homo sapiens*).
- Be familiar with the distinguishing features of the three domains of life (bacteria, archaea, and eukarya)
    - Bacteria and archaea are both ***prokaryotes*** (single-celled, no nucleus in cells, no membrane-bound organelles). Archaea do tend to inhabit extreme environments, though, while bacteria are found more broadly.
    - Eukarya range from single- to multi-cellular. Their cells have nuclei and membrane-bound organelles.

Bacteria, Archaebacteria, and Viruses:

- How are microflora different from other bacteria? What good are they to us?
    - Microflora actually provide health benefits, unlike many other kinds of bacteria, and normally live on and in us. Among other things, they produce important vitamins for us, aid in digestion, and help the skin in the task of keeping invasive microbes out.
- How do prokaryotic cells (like those of bacteria and archaebacteria) differ from eukaryotic cells (like those of plants, animals, and fungi)?
    - As mentioned above, prokaryotic cells lack a nucleus and membrane-bound organelles, while eukaryotic cells have a nucleus and several membrane-bound organelles.
- What is the overall function of the bacterial cell wall? How does the cell wall of Gram-positive bacteria differ from that of Gram-negative bacteria?
    - The cell wall is designed to give bacterial cells shape and to prevent them from swelling and bursting (usually due to osmosis).
    - The Gram-positive cell wall possess a very thick layer of peptidoglycan (a sugar-amino acid polymer), while the Gram-negative cell wall possesses a thin layer with a second membrane beyond that.
- Be familiar with the basic shapes (cocci, bacilli, spirilli) and growth patterns (strepto, diplo, staphylo) of bacteria.
    - Cocci = spherical; bacilli = rod-shaped; spirilli = spiral-shaped
    - Strepto = chains; diplo = pairs; staphylo = clusters
- Know the basic difference between aerobic, facultative anaerobic, and obligate anaerobic bacteria.
    - All vary in their need for oxygen: aerobic bacteria MUST have it. Facultative anaerobic bacteria can survive with or without it, and obligate anaerobic bacteria CANNOT survive with it.
- Be able to define and distinguish between heterotrophic and autotrophic bacteria
    - Heterotrophic bacteria obtain energy ("food") from other organic sources (usually living, but sometimes dead). Autotrophic bacteria use inorganic sources to generate their own energy ("food").

    - Also be able to distinguish between photosynthetic bacteria and chemoautrophic bacteria.
        - Photosynthetic bacteria are autotrophs that use sunlight as their source of energy.
        - Chemoautotrophic bacteria are autotrophs that use inorganic molecules (nitrogen, sulphur, iron, etc.) as an energy source.
    - Know the difference between a parasite and a saprobe.
        - Parasites are heterotrophs that consume other living things for energy; for bacteria, these are usually the ones that cause disease (because they attack a living host).
        - Saprobes are heterotrophs that consume dead, organic matter for energy.
- Distinguish between bacterial asexual reproduction (binary fission) and bacterial sexual reproduction (transformation, transduction, conjugation). What makes these two processes different?
    - Asexual reproduction in bacteria – usually through binary fission – results in offspring that are genetically identical to the parent cell. In short, nothing really changes about the bacteria (assuming no mutations happen).
    - In sexual reproduction, the bacteria will obtain new genetic material – some sources include loose pieces of DNA in the environment, conjugation ("sex") with other bacterial cells, and receiving new genetic material accidentally from a virus. In any of these cases, the bacterial cell affected will have new genes, unlike asexual reproduction which produced identical offspring.
- What, basically, is different about the environments that archaebacteria prefer to inhabit? Name a couple of environments archaebacteria are often found in.
    - They are all extreme environments. Some of these include salt lakes (halophiles), hot springs (thermophiles), and swamps (methanogens). (I know – swamps don't sound extreme, but beneath their surface, they have an extreme lack of oxygen).
- What are the basic structural components of viruses?
    - Viruses all have a ***capsid*** (a coat made out of proteins). This surrounds the other essential component – the ***core***, which houses a genome made out of DNA or RNA, depending on the virus.
- Why aren't viruses generally considered to be alive?
    - Every other living thing we studied was made up of cells that could grow, adapt, and multiply on their own. Viruses are only able to multiply if they invade host cells and hijack their ribosomes and enzymes to recreate their proteins and DNA/RNA for them. Otherwise, in the environment, they are incapable of performing any of the basic functions of life – they do not consume energy in any form, and they have no organelles or cellular structures to perform tasks essential for life.

Protists:

- Generally, how are protists different from bacteria/archaebacteria? Are there any similarities?
    - They are eukaryotic, and thus are made up of cells that posses a nucleus and membrane-bound organelles. Like bacteria, they can be unicellular and can be either heterotrophic or autotrophic. However, some protists (like algae) can be multicellular. Most protists are found in aquatic environments, whereas bacteria are far more widely spread.

- What are the three major types of protists in Kingdom Protista?
    - The animal-like protists (Protozoa), plant-like protists (mainly algae and euglena), and fungus-like protists (slime molds and cellular slime molds)
- On what basis do we classify the 4 different types of protozoans? What are these 4 different types, anyway? List an example of each!
    - We classify protozoans (animal-like protists) by how they move (their method of motility). The 4 types based on this classification method are:
        - Zooflagellates (of phylum mastigophora) – use flagella to move (eg: trypanosomes that cause sleeping sickness)
        - Cilliates (of phylum ciliophora) – use cilia to move (eg: paramecium)
        - Amoeboids (of phulum sarcodina) – use pseudopodia to move (eg: amoeba)
        - Non-motile (of phylum sporozoa) – these do not move on their own (eg: *Plasmodium vivax*, which causes malaria).
- In general terms, describe how the protist responsible for malaria is spread, as well as the general course of its life cycle.
    - Be ***brief*** – it is spread through the bite of certain mosquitoes. When inside the mosquito, it undergoes sexual reproduction. When transferred to the human host through the bite, it undergoes asexual reproduction while invading red blood cells.
- How are algae and euglena similar? How are they different?
    - They are both types of plant-like protists, and thus are both photosynthetic autotrophs. They differ in that euglena are unicellular and motile (using flagella), while algae are multicellular and, like plants, are generally non-motile.
- How are the fungus-like protists, in general, different from the plant-like protists and the protozoa?
    - They largely differ from the other two in their ecological role – they are decomposers. They break down dead, organic material, just as fungi do.
- Why might it be harder to fight a protist infection with antibiotics than it would be to fight a bacterial infection with antibiotics? (Hint: which domain do our cells belong to? Which domain are protists in?)
    - Bacteria are prokaryotes – their cells are quite different from ours, and so we can engineer antibiotics that can target features they have that we do not. Protists, however, are eukaryotes, and thus our cells have quite a bit more in common with them. This makes it trickier to create antibiotics that would attack the protist without affecting our own cells. We both belong to Domain Eukarya and are expected to have some fundamental features in common.

Fungi

- Describe, generally, the composition of fungi. Are they multicellular or unicellular? Prokaryotic or eukaryotic? Are there any distinguishing cell features?
    - Funi are usually multicellular (except for yeasts) eukaryotes. Their cells feature a cell wall made out of chitin and have stores of glycogen for energy. These cells are set up into branched tubes called hyphae. The cells are not totally separate, and share cytoplasm between each other.
- What is the role of hyphae?
    - Hyphae absorb nutrients from the fungus' surroundings.
- How do fungi obtain and digest their food?
    - They release digestive enzymes into the environment, onto their intended food source. Digestion takes place outside of the fungus' cells (it's extracellular). Once

digested, the food is absorbed by the hyphae. Note that this means fungi are heterotrophs.

- Compare and distinguish between sexual and asexual reproduction in fungi. How do they sexually reproduce, and what are the various asexual methods they use?
    - Sexually, fungi reproduce by letting two mycelia merge, forming a zygote that will grow into a new fungus.
    - Asexually, fungi can produce spores, which germinate into mature fungi (but are identical to the parent) or can reproduce by fragmentation, where a piece of a mycelium breaks off and develops into a mature (and identical) fungus.
- What are some of the commercially or industrially important uses for fungi?
    - Yeasts are used to make bread and alcoholic beverages.
    - Penicillium is used to make blue cheese and is a source of the antibiotic penicillin.
    - Many club fungi produce edible (and therefore valuable) mushrooms.
- Mushrooms are delicious. Which phylum contains the majority of the delicious mushrooms we eat?
    - Phylum Basidiomycota
- Define the three types of human fungal infections, and be familiar with the symptoms of histoplasmosis and tineas.
    - Mycoses (fungal infections) can be ***cutaneous*** (affecting the skin), ***subcutaneous*** (affecting deeper layers of skin), and ***systemic*** (where the fungus spreads throughout the body). Please check your notes for the typical symptoms of tineas (which are skin infections) and histoplasmosis. Just remember to brace yourself for gruesome pictures. You've been warned!
- How are fungal diseases treated, and what complicates their treatment?
    - They are treated using drugs (anti-fungals) that target steroid synthesis in fungal cells (this is one the major differences between our own cells and the fungal cells). Like with the protists in an earlier question, treatment is complicated by the fact that fungal cells are more similar to our own cells than, for example, bacterial cells, so it's more complicated to engineer antibiotics that will attack fungal cells and not our own.

Plants

- What features distinguish plants from all of the previous organisms mentioned (bacteria, archaea, protists, and fungi)?
    - They are almost exclusively autotrophic (and photosynthetic); their cells have a cell wall made of cellulose (also unique). They are multicellular and show differentiation (specialized tissues and structures), which sets them apart from the plant-like protists.
- Plants progress through two, alternating generations in their lives. Describe this alternation of generations and describe the two stages/generations.
    - Plants will usually move through the ***sporophyte*** and ***gametophyte*** generations. It's almost as if many plants are two organisms in one because of this. A ***sporophyte*** is a diploid version of a plant (has a full chromosome count) that produces ***spores*** by meiosis; these spores, due to meiosis, will have half as many chromosomes as the parent (so we say they are haploid). When these spores germinate, they will develop into a different form of the plant called the ***gametophyte***. The gametophyte is a haploid organism (half as many chromosomes as you'd expect for the plant), and it will produce male and female ***gametes*** by mitosis. When these gametes fuse, they will merge into a diploid organism – another ***sporophyte***. This cycle continues on

and on until the plant either dies… or until we decide we don't want to study its life cycle anymore ;)

- Into what three broad categories are plants arranged?
    - Non-vascular plants (bryophytes, like the mosses), seedless vascular plants (pteridophytes, like the ferns), and vascular seed plants (the angiosperms and gymnosperms – flowering plants and usually conifers, respectively).
- What is the role of vascular tissue?
    - It carries nutrients and water throughout the body of the vascular plant, just like our circulatory system does, except without a heart to provide pumping force, and obviously without blood.
- What two types of vascular tissue do many plants contain? What is the role of each?
    - Xylem (which carries water throughout the body of the plant) and phloem (which carries nutrients like glucose and minerals throughout the body of the plant).
- How are angiosperms and gymnosperms different? How are they alike?
    - Both are types of vascular seed plants (plants that possess circulatory tissues, and can produce seeds as a means of protecting their offspring until growing conditions are ideal). They differ in a few ways: gymnosperms, according to their name, do not completely enclose their seeds. They often develop in cones (hence "coniferous" plants), which leave the seeds exposed to wind for purposes of pollination and dispersal. They have adaptations which help conserve water (needle-like leaves to lower surface area for evaporation, relying on wind for pollination). Angiosperms produce flowers that encourage animals to carry out pollination for them, can produce fruit that enclose and nourish seeds, and have seeds that are able to spread in a variety of ways aside from simply riding wind currents (such as floating on water, sticking to animals, or "bursting" in a mini-explosion).

Animals

- What are the defining features of animals?
    - Animals are heterotrophs, through and through. They are multicellular (not like those protozoans, being all "single-celled" and obsessively individual. What hipsters!), eukaryotic, and often have systems of tissues and organs. Sexual reproduction is common, as is motility (though some sessile animals do exist, like anemones).
- What are some of the ways by which we can classify animals?
    - We looked at 4 ways this year: classification by body plan, by symmetry, by body cavity, and by segmentation. The next 4 questions deal with each of these in a bit more detail (jeez… it's like I ***planned*** this out! Crazy!)
- What are the two body plans that animals may possess? Give two examples of animals that have each of these plans.
    - They may have the sac body plan or the tube-within-a-tube body plan. The sac body plan features only a single opening in the digestive tract that serves jointly as a mouth and an anus ("***manus***"), while the tube-within-a-tube body plan features two separate openings – a separate mouth for intake an anus for excretion (sometimes called the "***sanus***" by some of you). Members of phylum Cnideria and Platyhelminthes are examples of animals with the sac body plan (so, jellyfish, anemones, corals, flatworms, and tapeworms are all examples). Phylum Porifera (the sponges) technically do to. Members of phylum Nematode, Mollusca, Annelida, Arthropoda, and Chordata have the tube-within-a-tube body plan (so, earthworms, leeches, any insects, spiders, and crustaceans like the crayfish are all examples).

- What types of symmetry may animals possess? Give an example of an animal (or group of animals) that have each type of symmetry.
    - Assymetrical (no symmetry in the body plan of the animal at all) – sponges (Porifera)
    - Radial symmetry (the symmetry is arranged in a circular fashion, so that any cut through the middle of the animal produces a mirror image; like spokes on a wheel) – jellyfish, anemones, corals (Cnideria), starfish (Echinoderms – we only dissected them).
    - Bilateral symmetry (left and right halves that are mirror images) – flatworms, round worms, segmented worms, molluscs, insects, spiders, crustaceans, mammals, reptiles, birds, amphibians… (Phylum Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropoda, and Chordata)
- What types of body cavities can animals have? Again, give an example of an animal or group of animals that has each type of body cavity.
    - Acoelomate – the animal lacks a body cavity (no open space around organs). Flatworms (Platyhelminthes) and jellyfish (Cniderians) are examples.
    - Pseudocoleomate – the animal has a body cavity that is not completely lined, inside, by tissue. Roundworms (Nematoda) were our only example.
    - Coelomates – the animal has a body cavity that is fully lined, inside, by tissue. Phylum Mollusca, Annelida, Arhtropoda, and Chordata all feature animals with this type of cavity, and so there are tons of examples you could give – anything from a squid or octopus right up to a pig or a human being, and everything in between (bees, wasps, spiders, earthworms, snails…).
- What are some examples of segmented animals that we have studied?
    - Anything with obvious repeats in their body structure – earthworms, leeches, grasshoppers, spiders, and crayfish are all examples of ones brought up in the notes.
- What characteristics distinguish animals in Phylum Chordata from the other phyla studied?
    - To be in Phylum Chordata, an animal ***MUST*** possess these 4 characteristics ***at some point in their life*** (some are lost as the animal grows):
        - A hollow, dorsal nerve chord
        - A notochord – a supporting rod-like structure
        - Pharyngeal pouches (pouches lining the pharynx – often called "gill slits")
        - A post-anal tail
- Which phylum first showed animals that had evidence of a nervous system?
    - Phylum Cnideria – it had a simple network of nerves, though it has no brain or spine. This means that ***every phylum we studied has a nervous system EXCEPT Porifera (the sponges***).
- From which phyla did each of the animals we dissected come from (reminder: we dissected an earthworm, a crayfish, a squid, a frog, and a fetal pig)?
    - Earthworm – Phylum Annelida
    - Crayfish – Phylum Arthropoda
    - Squid – Phylum Mollusca
    - Frog and pig – Phylum Chordata
    - (Note: We did dissect a starfish, from Phylum Echinodermata, but did not go through any extensive discussion of that phylum, so do not expect coverage of it).

Understanding Inheritance

- Why do humans have two copies of every gene?
    - Because we receive one full set of genes from each of two parents (one is carried in the mother's egg, and the other is delivered when the father's sperm fuses with the egg).
- What distinguishes a dominant gene from a recessive gene?
    - A dominant gene (more properly a dominant ***allele***) is one that expresses its trait no matter what it is paired with. A recessive allele will only express its trait if it is paired with a second recessive allele. For example, someone can carry the allele for brown eyes and the allele for blue eyes (they'd be Bb). Since brown eyes is dominant, that's the colour that will be expressed. Only individuals with two alleles for blue eyes will appear to have blue eyes.
- Briefly describe Mendel's laws of Segregation and Independent Assortment.
    - Law of Segregation – states that, during meiosis, all pairs of homologous chromosomes will separate, so that gametes receive either a chromosome from the mother OR from the father. NOT from both.
    - Law of Independent Assortment – states that, during meiosis, pairs of homologous chromosomes will separate randomly and independently of each other. So, for example, if a pair of Chromosome 1's separates so that the one from mom goes left and the one from dad goes right, there's nothing stopping the Chromosome 2's from separating so that the maternal chromosome goes right and the paternal chromosome goes left. Every pair separates randomly. This means that each gamete that forms will have a complete set of chromosomes, but each set will be randomly made up of contributions from mom and from dad.
- Distinguish between codominance and incomplete dominance.
    - Both are cases where the recessive allele is not silenced by the dominant allele. In codominance, both alleles end up expressing their respective traits. For example, in blood types, the allele for type A and the allele for type B will both express themselves equally, so that a person will have type AB blood. Incomplete dominance happens when each allele partially expresses itself, causing a "blending" to occur that creates a "middle" version of the trait, such as a red allele and a white allele blending to create a pink flower.
- In humans, how does the inheritance of sex-linked traits compare to the inheritance of autosomal traits? Specifically, how does inheritance differ in men in this case?
    - Sex-linked inheritance differs primarily in that the genes involved are carried on the sex chromosomes, usually the X chromosome specifically. Other traits are carried on the autosomes – the chromosomes that both genders possess equally. For men, this means that you can either possess the dominant version of the trait or the recessive version of the trait. There is no chance of being a carrier (showing the dominant trait, but carrying a hidden copy of the recessive allele). That is, men cannot be X^AX^a. They are either X^AY or X^aY.
- Distinguish between phenotype and genotype.
    - A phenotype is the physical effect that a combination of alleles has on an individual. It is the actual appearance of a trait. For example, saying someone has black hair is describing their phenotype.
    - A genotype is the specific combination of alleles an individual possesses for a certain trait. For example, if they are ***homozygous dominant*** for black hair, that is a genotype (and we can simply write it as BB).

- Briefly describe how a test cross is carried out and how the results are interpreted.
    - In a test cross, we have an individual who shows the dominant phenotype (eg: brown eyes), but we aren't sure if they are homozygous or heterozygous (BB or Bb).
    - We cross-breed the individual with one that has the ***recessive phenotype*** (eg: blue eyes) because we are sure about their genotype (bb).
    - If the offspring all have the dominant phenotype (eg: brown eyes), then the mystery parent had a homozygous dominant genotype (BB). If some of their offspring have the recessive phenotype (eg: blue eyes), then the mystery parent must have had the heterozygous genotype (Bb).
- Be able to solve problems involve a single gene, two genes, codominance, incomplete dominance, blood types, and sex-linked genes.
    - Be sure to check up on the old assignments we did – there are copies of them on the website. If you want to run through some additional problems, let me know!
- Explain how nondisjunction causes genetic disorders and diseases in offspring.
    - All individuals are supposed to have two copies of every gene because we get one complete set of chromosomes from two parents. However, when meiosis is happening, homologous pairs of chromosomes may not properly separate, so instead of having one copy of each chromosome in the pair moving into separate gametes, both members of the pair move together into the same gamete. This creates one gamete with an extra copy of a number of genes, and one gamete that is missing a number of genes altogether. If either of these gametes becomes involved in fertilization during intercourse, the resulting offspring will either have too many chromosomes (and, thus, too many copies of some genes) or too few chromosomes (and, this, will be missing some genes altogether). This leads to disease/disorder, with some examples being Down Syndrome (three copies of Chromosome 21 – trisomy 21), Klinefelter Syndrome (being a male with an extra X – XXY, another trisomy), and Turner Syndrome (being a female with only a single X chromosome – XO, a monosomy).
- Distinguish between monosomy and trisomy. Be able to identify these conditions (as well as gender) on a karyotype.
    - Monosomy refers to a case where an individual has only one copy of a given chromosome, rather than the usual 2 copies. Trisomy refers to a case where an individual has three copies of a given chromosome, rather than the usual 2 copies. On a karyotype, be sure to look over the image carefully to ensure that there are only 2 copies of each chromosome (except the X and Y chromosomes – remember that females are XX and males are XY, so be mindful when you are checking that part of the karyotype image).

Mechanisms of Inheritance

- What are the structural units of DNA and RNA (ie: what are the repeating blocks that make up these moluecules)? What are the three major components of these structural units?
    - DNA and RNA are made up of repeating units called ***nucleotides***. Each nucleotide is made up of a sugar (either deoxyribose or ribose), a phosphate group, and one of four nitrogenous bases.
- What are the nitrogenous bases used in DNA? In RNA?
    - DNA – adenine (A), thymine (T), cytosine (C), guanine (G)
    - RNA – adenine (A), uracil (U), cytosine (C), guanine (G)
- How are DNA and RNA structurally similar? How do they differ?

    - Both are made up of nucleotides (and those nucleotides are still made up of sugar, phosphate, and a nitrogenous base). Both are arranged into strands.
    - RNA is single-stranded, while DNA is made up of two strands linked, at the nitrogenous bases, by hydrogen bonds. DNA is also twisted into a double-helix, while RNA usually isn't. RNA nucleotides use the sugar ribose, while DNA nucleotides use deoxyribose. RNA nucleotides use the nitrogenous base uracil, but not thymine. DNA nucleotides use thymine, but not uracil.
- Where is DNA stored in eukaryotic cells (such as our own cells)?
    - In the nucleus.
- Describe the process of DNA replication, including products of the process and enzymes involved.
    - When DNA is to be replicated, the enzyme ***helicase*** will pry apart (unzip) the two strands so that the nitrogenous bases are exposed.
    - Free-floating DNA nucleotides will begin to bond with the exposed bases on the DNA strands.
    - The enzyme ***DNA polymerase*** will help position the new nucleotides in place (and ensure that the bases are correctly paired).
    - The enzyme ***ligase*** will seal any breaks between the sugars and phosphates of the new nucleotides in order to create one, smooth, uninterrupted strand of DNA.
    - Once this is done, ***two double-stranded*** DNA molecules will exist. Each will be identical to each other, and to the original molecule. Both will be made up of one new strand and one original strand (thus making this semi-conservative).
- Describe the structure of a double-stranded DNA molecule. You may consider using the ladder analogy to structure your answer.
    - A double-stranded DNA molecule is made up of two sugar-phosphate backbones with nitrogenous bases pointed toward each other. This facilitates hydrogen bonding between bases on each strand (base-pairing). The two strands are pointed in opposite directions.
    - In the ladder analogy, the sides of the ladder are the sugar-phosphate backbones of the two strands. The steps (or rungs) of the ladder are the pairs of nitrogenous bases.
- Describe the process of transcription. Be sure to include the product, the enzymes involved, and the template used in this process. As well, include any processing done to the final product after transcription is complete.
    - The enzyme ***RNA polymerase*** will bind to and unzip DNA at a certain location (depending on the gene to be transcribed). Like in DNA replication, this will expose the nitrogenous bases on the DNA strands. ***ONLY the 3' -> 5' strand of DNA will be used, though.***
    - Free RNA nucleotides (NOT DNA nucleotides) will start to pair with the exposed bases of the 3'->5' DNA strand.
    - RNA polymerase will help to position the RNA nucleotides in the correct order according to base-pairing rules. It will also seal any breaks between nucleotides to ensure one, smooth strand of RNA.
    - When completed, RNA polymerase will release a completed strand of mRNA that will be processed. Processing involves cutting out "junk" sections (introns) and splicing together useful segments (exons). It ends with the addition of a poly-adenine (poly-A) tail for protection.
- What is a codon? What does a codon code for?
    - A codon is a triplet of bases on a strand of mRNA. Each codon codes for a specific amino acid to be used in the construction of a specific protein.

- Describe the process of translation at the ribosomes, covering all three major steps (chain initiation, chain elongation, chain termination).
    - Chain initiation: a strand of mRNA leaves the nucleus. The small subunit of a ribosome will attach to a start codon (AUG) on the mRNA. A tRNA carrying methionine will bind to the start codon as well. The large ribosome subunit will attach to the small subunit. At this point, the tRNA with methionine is the the P site of the ribosome, and the A site is empty.
    - Chain elongation: the codon in the A site attracts a tRNA carrying another amino acid. Now both the P and A sites are filled. The two amino acids in these two sites form a bond, and the tRNA in the P site lets go of its amino acid. The tRNA in the P site is kicked out, leaving the P site empty. The ribosome slides over 1 codon, so that the codon and tRNA from the A site is now in the P site, and the A site (now empty) is positioned over the next codon. A new tRNA, carrying an amino acid, is attracted to the A site. A bond is formed between the amino acid it carries and the amino acids held in the P site. The tRNA in the P site lets go of the amino acids, gets kicked out, and the P site is empty again. The ribosome slides over so that the P site is occupied and the A site, now empty, is positioned over the next codon. This continues over and over.
    - Chain termination: when the ribosome shifts over and the A site ends up on top of a ***stop codon*** (UAA, UAG, or UGA), no tRNA comes to the A site. Instead, a ***release factor*** comes to the ribosome, causing the chain of amino acids at the ribosome to be released as a new protein. The ribosome will come apart and will release the mRNA strand that it was reading.
- What constitutes a gene mutation?
    - Any change in the base sequence of a gene (a segment of DNA) can be called a gene mutation.
- What is a point mutation? Distinguish between the three types of point mutations that are possible.
    - A point mutation occurs when any base in a gene changes (this ***does not include additions or deletions***, it only includes changes to individual letters). For example, if an adenine (A) mutates into a guanine (G), this would be a point mutation.
    - The three types of point mutations are:
        - Silent mutations – the bases in the codon change, but it still ends up coding for the same amino acid, so there is no effect on the protein being made.
        - Missense mutations – the bases in the codon change, and the amino acid coded for changes too, so the properties of the final protein will likely change too.
        - Nonsense mutations – the bases in the codon change, turning it into a stop codon. This causes a protein that is too short, and likely non-functional.
- How does a frameshift mutation differ from a point mutation?
    - While point mutations involve changes to individual bases in a gene (usually affecting only a single codon), a frameshift mutation happens when a base is inserted or deleted. It's called a frameshift mutation because the reading frame (the chunks of 3 bases read) moves, affecting every single codon after the point of insertion or deletion. The results can be drastic.
- How do mutations potentially cause cancerous growth (tumors) in our bodies?
    - Mutations, whether inherited or from the effects of mutagens or transposons, can alter the activity of our genes. Certain genes control how quickly our cells divide, and are supposed to help kill off cells that are malfunctioning or harmful. These genes are the oncogenes (which accelerate cell division) and tumor suppressor

genes (which slow or stop cell division, and also trigger cell death if the cell is mutated to dangerous levels). If either or both of these genes become mutated and malfunction, the cell may divide uncontrollably, leading to the formation of tumors (which, in turn, may become invasive and move throughout the body).

- Be able to write DNA sequences that are complementary to a given strand.
- Be able to write mRNA sequences that are complementary to a DNA template strand.
- Be able to translate mRNA codons into a protein (sequence of amino acids) using a codon chart.