AP Biology

21 Must Know Concepts to Ace the Test

Published in the United States of America.

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Introduction

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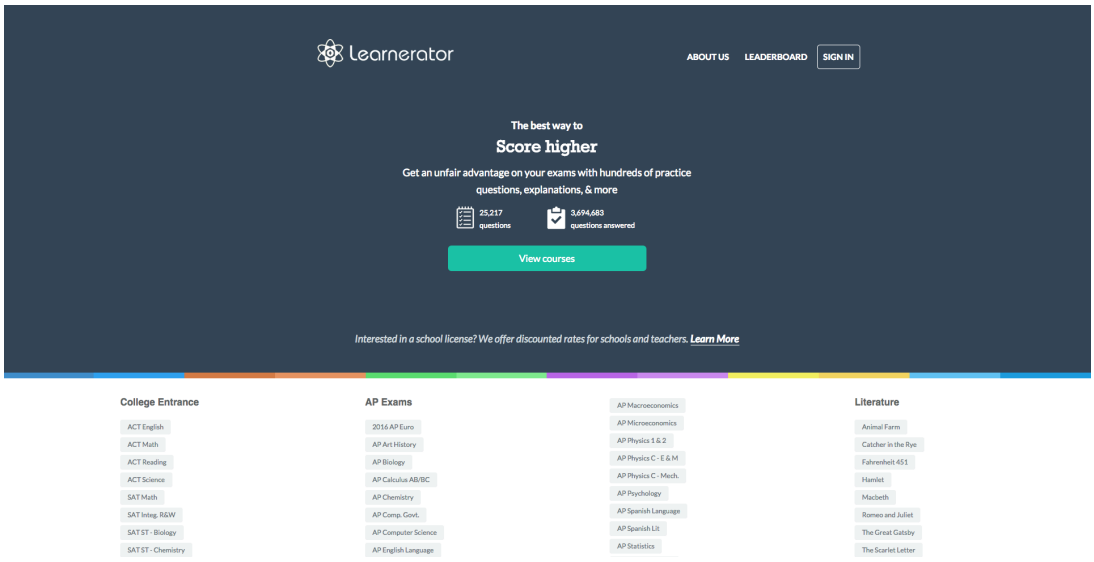

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Abiogenesis

Abiogenesis is a funky sounding word that has a pretty simple definition. If you break down "biogenesis," you might guess it has something to do with the creation of life. Well, abiogenesis is a natural process of life arising from non-living matter. This is different from spontaneous generation, which would mean life came from literal nothingness. Spontaneous generation was tested long ago in an odd way. It was hypothesized bees would arise from the decaying carcass of a dead bull. As it turned out, this did not happen. The general thought goes that life came about in the following manner. First, there was no life. Just chemicals, gases, and the like. From no life, we stepped up to monomers, very simple proteins, and from there progressed to polymers, more complex ones. These appeared as protocells. From protocells came the more complex cells we often find in living things we find today, and then we had life. Natural selection started kicking in from there.

The Earth Oh So Long Ago

About 4.6 billion years ago, the Earth was a pretty inhospitable place. It was in a molten state and constantly being bombarded with explosive objects from outer space, which was later deemed not so pleasant. It was actually called the Hadean Eon, named after Hades, the Greek mythological underworld. There was no noticeable oxygen in the atmosphere and it was a highly reductive environment. No life existed at this point. As life had to somehow come about, we know, a couple pretty smart guys thought they'd recreate this environment to test how life might have started.

Stanley Miller and Harold Urey designed an experiment they could conduct in a vacuum and introduce electricity to (to simulate lightning). What they were testing was a hypothesis put out by Alexander Oparin and J.B.S. Haldane that conditions of the primitive Earth favored the formation of complex organic

compounds from simpler inorganic compounds. Examining sealed vials from the experiment much later, scientists at the University of Chicago found about 25 amino acids present. Not only that, these were the types of amino acids that might have been present LONG ago. So, it was shown possible that we can move from no life, a chemical stage, to one of monomers, simple proteins being present. This is the terrestrial theory, putting forth it was conditions on Earth that supplied all was needed for the first stages of life to begin. There is also the thought it had interstellar origins in the form of scattered organic molecules that had formed in space and landed here. Terrestrially speaking, as far as where this spark of life may have actually occurred, the thought was generally that it was in some sort of soupy, molten environment, or perhaps on a mineral surface like clay of some sort. Haldane, and even Darwin, put forth it happened in some sort of primordial soup.

Next Steps

Next, we had to determine if monomers could somehow help induce the presence of polymers. The thought is that as monomers began to conglomerate in this primordial soup, they began to interact and combine to form more complex structures. Many think that RNA showed up first, others metabolic cycles (Krebs cycles). It's been found that under certain conditions, RNA can somewhat spontaneously appear, and this may have been the case in a hot, wet environment where monomers were binding with each other. As anaerobic organisms use the Krebs cycle for energy production, it may have been one of the early contributors, as well. Now, most agree it's probably some of both.

As far as where life actually made its first appearance, the oldest fossils of life we have found are called stromatolites. This was about 3.5 – 3.8 million years ago during the Eoarchean Era. These are layered biochemical structures, formed in shallow waters, by the trapping and binding of sedimentary grains of biofilms of microorganisms.

So abiogenesis is most likely a very real thing, life beginning in environments where before there was none. Do you believe it's more likely organic compounds first appeared on Earth or elsewhere in space? Did your AP Bio class think it was the primordial soup where life first appeared on the planet?

Anaerobic Respiration

Anaerobic respiration is how cells make energy when, as you may have guessed from the name, there is no available oxygen. In fact, for this process there is neither oxygen nor mitochondria present. The two processes that allow this to work are those of glycolysis and fermentation.

In cellular respiration, what we normally see is glucose breaks down to pyruvate and from this process we net 2 ATP. Next, the pyruvate will go into the mitochondria and enter the Krebs cycle. In the process of being converted to acetyl CoA, CO_2 is given off and another 2 ATP are made. This energy is stored in NADH and $FADH_2$. Their electrons move into the electron transport chain which will move to oxygen to transform the product to water. In this, 23-34 ATP are made.

How can we break this process? If there's no glucose, it falls apart, but we usually have enough food in our bodies. The other things we can take away are the mitochondria or oxygen. A toxin maybe destroyed the mitochondria, or maybe there just aren't enough present to carry out this process. If there's not enough oxygen, the final electron acceptor disappears, and so either way, the process backs up in these cases. As a human, you will start to feel pain if you start running out of oxygen. We'd really be out of luck at that point if it weren't for anaerobic respiration.

Remember in glycolysis, glucose breaks down to pyruvate. The energy goes to NADH so that the NADH becomes reduced. When NADH fills up, no more electrons can be donated after it's been fully reduced, and so now the process hits a wall. There are two solutions biology has found: lactic acid fermentation and alcoholic fermentation.

Animals and bacteria will use lactic acid to allow the process of glycolysis to continue. Through lactic acid fermentation, glycolysis can continue. We've made pyruvate from glycolysis, but we have all this NADH filled up. So now, in lactic acid fermentation, the pyruvate can be broken down to lactate. No ATP is made, but electrons can now move from the NADH to lactate, which frees NAD+ to pick up more electrons. This allows glycolysis to run over and over, and it picks up ATP every time.

You often notice anaerobic respiration during heavy exercise. As you go through oxygen more quickly, the body starts building up lactic acid to allow you to move into anaerobic respiration to provide a bit of a turbo boost. It will not be able to continue forever, but keeps you from simply having to stop at the point the body does not have enough oxygen to continue its normal means of producing energy. Once lactic acid fermentation starts to fail, you simply "hit the wall" and you need more oxygen to break down all the lactate that has built up (at this point you will probably have muscle pain from all the lactic acid present). Bacteria also use this process, such as lactobacillus breaking down milk to make yogurt (so we sort of make use of it, too!).

In alcoholic fermentation, we often see yeast present, as in the making of beer. In this process, glucose is broken down to pyruvate, but then we're stuck. When we have yeast, grain, and sugar put together in a closed environment, cellular respiration can occur. But oxygen will soon be used up, and as no more can enter, what then?

With the alcoholic fermentation process, we find pyruvate with 3 carbons converting to acetylaldehyde with 2 carbons, and CO_2 is released. The acetylaldehide is reduced by NADH to ethanol, which regenerates the NAD+ supply. This continues until the levels of alcohol simply kill off the yeast.

Because the oldest prokaryotes were around before there was sufficient oxygen in the atmosphere, they probably used anaerobic respiration to survive. It is the most widely used metabolic pathway amongst living organisms.

So, now you know how energy can be created without the use of oxygen? Have you ever felt the process at work in your own body? Be sure to understand the chemical process for both types of anaerobic respiration when you take the AP Biology test.

Animal Behavior

Animal behavior is a rather complex topic when you think about the all the movements, mechanisms, and psychological basis for all we and other living things do. If we are to simplify this to a mostly animalistic thing, though, we can look at behavior on a spectrum of innate to complex learned behaviors. It will be helpful to understand this spectrum for the AP Biology test.

Lower Forms of Animal Behavior

Instinct is anything you have from the very first day of existence. Human babies are noted to have a grasping reflex. If you put your finger near one's hand, it will grab on, and believe it or not, if you did this near its toes, you'd find a similar reaction.

Fixed action patterns are a step up from innate behaviors. In this case, there is a stimulus, and this draws out a series of actions to completion. Take a gray goose. It sits on its eggs to incubate them, as many birds do. But scientists picked on the gray goose, at one point, a bit and noticed something interesting. If you take an egg out from the nest and sit it just next to the nest, it will pull the egg back in with its beak. This may not sound so interesting, just a natural reaction to having your egg taken and misplaced if you need to incubate it. But what the scientists did next is place a billiard ball next to the nest to see if it would react to the shape and size, rather than further specifics of the object. Sure enough, the billiard ball served as enough stimuli. It took the ball up in its beak, placed it in the nest, and sat on it. Humans have been noted as having a similar behavior in that when one recognizes another person, but don't really look at them; there may be an almost unconscious nod of the head as acknowledgement. But really this is happening imperceptibly at another level as a simple reaction to a particular stimulus.

Imprinting is a step up from fixed action. It happens at a critical period in a developing organism's life. Geese imprint on their mothers and follow the mother around until they are much older. Konrad Lorenz took a mother goose out of a scenario with young geese, and placed himself in the role of mother. What happened was they began to follow him around much as they would their actual mother if she were in that picture.

Associative learning is what Pavlov was working on. This is where a stimulus is associated with a particular effect. Pavlov is, of course, known for his experiments with dogs' reaction to a bell. He would ring a bell, then give them some meat powder, and then measure the saliva generated. The dogs would start to associate the bell with food, and he would see similar saliva production even if the food wasn't present.

Next on up the spectrum is trial and error learning. This is most associated with B.F. Skinner. He developed something called the Skinner box. This was operant conditioning, where you could basically teach behavior. There were lights and a lever in the box, as well as some rats. A rat could touch the lever and food will come out. There's an example with a crow vending machine, where a man trained crows to place coins into a vending machine, and food would come out. So the crows would fly all over the city looking for loose change and bring it back to the vending machine. The inventor made out okay on this one.

Next on the spectrum is habituation. This is where an organism is exposed to the same stimuli over and over to the point it can learn to ignore it if it poses no threat. Prairie dogs make a horrific scream if they see a snake, and this warns other prairie dogs so they can hide underground. If a prairie dog were to see a human, the same reaction would occur. However, if humans keep coming around the same group repeatedly and never offer any harm, the prairie dogs will habituate at a certain point and know they won't be harmed and so will stay quitter and above ground.

Higher Forms of Animal Behavior

Then there is observational learning, which is essentially watching a behavior and the mimicking it. There was some experimentation done with octopi and food being kept in a container with a lid secured on it. About half of the octopi could unfasten the lid and get to the food. Now, if you had two tanks of octopi next to each other, the octopi in one tank could watch the octopi in the first tank and learn how to unfasten the lid simply through observation. Mirror neurons can be found in humans and are an interesting phenomenon whereby neurons fire based simply on watching someone else doing a movement, replicating the firing of neurons in that other person. Not all neurons will do this, but it is another way that observational learning can influence behavior. If you were to watch someone else touching the nose, about 10% of your neurons are doing the same thing.

Insight is the final level on the spectrum. This can be described with the candle problem, where a participant is given a box full of tacks, with matches, and a candle. The idea is to stick the candle to the wall and light it. Maybe you try to melt some wax and stick it to the wall (doesn't work), maybe try to tack the candle to the wall (also won't hold). At some point you may find the solution is to tack the box to the wall, stand the candle up in it, and then light it. Just like if you were to put a chimp in a room with boxes of various sizes and a banana hanging from the ceiling, it will eventually figure out how to stack the boxes to climb up and reach the fruit.

Wrap-Up on Animal Behavior for AP Biology

That covers the spectrum of animal behavior as far as what you'll have to know for the AP Biology exam. Try to think of some times you've applied insight or observational learning in your own life to better understand these mechanisms for the test.

Cell Organelles

The two main types of cells you'll be concerned with on the AP Biology exam when talking about structure are plant cells and animal cells. We'll first discuss organelles you are more likely to find in plant cells, and then move through the animal cell organelles.
Cell walls are found only in plant cells and are mostly made up of cellulose. It helps protect the cell, as well as maintain it shape. It also prevents excess water uptake that might result in the death of the cell.

Chloroplasts are unique to plants and are a group or organelles referred to as plastids. They serve as sites for carrying out photosynthesis. Chloroplasts have outer and inner membranes, and two distinct regions. There is the stroma, a fluid-filled space between outer and inner membranes. And thykaloid space, which is space within the thykaloid (stacked inner membrane) membrane that contains photosynthetic pigments.

Vacuoles are large membrane-enclosed, fluid-filled sacs. There are several types. Food vacuoles are formed by phagocytosis and serve as the site of intracellular digestion. Contractile vacuoles are found in freshwater protozoans and pump excess water out of the cell. Other vacuoles store waste and toxins.

In most plant cells, you will find a central vacuole that develops through the accumulation of smaller vacuoles derived from the ER and Golgi complexes. The central vacuole may store organic compounds or inorganic ions, can sequester dangerous cell by-products, and can help a cell hold water and elongate.

Both plant and animal cells will have a cytoskeleton. It is a network of fibers that extend through the cytoplasm and provides a dynamic framework for support and movement. It also interacts with specialized proteins involved in movements such as muscle contractions.

The endoplasmic reticulum (ER) is a major manufacturing center of the cell with an extensive membrane network of tubules and sacs which divide internal sac space from cytosol. The lumen is empty space within the ER.

There are two types of endoplasmic reticulum: smooth and rough. Smooth ER has no ribosomes and functions in metabolic processes. It synthesizes lipids, phospholipids, and steroids. It's also key in removing toxins, especially in our liver cells. The rough ER has ribosomes all over its cytoplasmic side, and it manufactures proteins and membrane parts.

The golgi complex packages, processes, and sends out products of the endoplasmic reticulum. It's named after its discoverer, Camillo Golgi. It's made of flattened, stacked membranes. The stacks are referred to as dicytosomes, and the spaces are called cisternae. Vesicles transport materials between the Golgi and other cell structures. It has two distinct sides to it, one which receives materials, and the other which ships products out.

Lysosomes are produced in the Golgi and are membrane-enclosed sacs of hydrolytic enzymes that digest all major types of macromolecules. So basically, unused materials that would just be floating around the cell are disposed of by the lysosomes. If they're not functioning properly, disease can develop from enzyme build-ups or leakage. A specific example is Pompe's disease which can occur when carbohydrase is missing, and so glycogen cannot be converted to glucose.

Mitochondria are found in almost all eukaryotic cells. It converts energy from its surroundings into suable energy by the cell. It's enclosed by two of its own membranes and also has ribosomes and its own DNA for protein synthesis. The outer membrane is smooth and highly permeable to small solutes, but easily blocks macromolecules. The inner membrane contains embedded enzymes used in cellular respiration.

The nucleus is near the center of a cell in eukaryotes. It contains most of the genes that control the entire cell (DNA). It has a nuclear envelope that encloses it and monitors what goes in and out. The nucleolus can also be found here and that assembles the two subunits that make up ribosomes.

Ribosomes have complexes of RNA and protein and is a site of protein synthesis. It is not membrane-bound and can be found free-floating in the cytoplasm or bound to the ER.

All of these organelles are floating around in cytoplasm (cytosol) inside the plasma membrane. The cytoplasm also contains water, salts, and other chemicals, and is jelly-like in its consistency. Hopefully you can diagram the parts of a cell for the AP Biology exam.

Diffusion & Osmosis

Molecules are always moving, and like many people, prefer to be in less concentrated, or crowded, areas. This general principle of molecules moving from areas of high concentration to areas of lower concentration is what is described by diffusion and osmosis. This will generally occur until a state of equilibrium is reach (concentrations are equal on either side of the membrane as far as it's permeable to the molecules in question). It's important to understand the difference between diffusion and osmosis for the AP Biology test.

Diffusion is a passive form of movement as it requires no input of energy to occur. It simply happens. In our own bodies, carbon dioxide and oxygen diffuse across cell membranes, for example. There are cases of facilitated diffusion, when energy is used, but that is generally when molecules need to move from an area of lower concentration to and area of higher concentration. Osmosis is a special type of diffusion where water moves through a selectively permeable membrane from an area of higher water potential to a place of lower water potential. Water potential is the measure of free energy in a solution and is represented by the symbol psi. Water potential is generally affected by two things: osmotic potential and pressure potential. It can be measured by adding those two potentials together.

When discussing selectively permeable membranes, three terms you mostly likely will see on the AP Bio exam are: hypertonic, hypotonic, and isotonic. Hypertonic solutions have a higher solute concentration and lower water potential. A hypotonic solution has a lower solute concentration and higher water potential. Water will move down its concentration gradient. Isotonic solutions have equal concentrations and water potential.

A common diffusion experiment uses a dialysis bag (permeable membrane) filled with water, starch, and glucose placed in a beaker of water and iodine potassium

iodide. If you let that sit, the iodine potassium iodide moves inside. We'll also learn there's glucose in the beaker now. The starch does not move though, because the molecules are too big to fit through membrane. To see if water is moving, you could check the mass of water in each container before and after.

The common experiment used to observe osmosis is a potato and glucose experiment. Semipermeable membrane allows only the water to move, not the solute. If cored potatoes are put in breakers with different concentrations of sugar water and one with distilled water, you can take the mass of the potatoes over time. If potatoes are put in distilled water, they gain mass. Water flows into the potato as there is a lower water concentration in the potato. In sugar waters, the higher concentration of sugars, the water trends towards moving out from the potato as the water concentration actually ends up being lower on the outside (more sugar molecules, fewer water molecules).

Now you have a better idea of what diffusion and osmosis are. Can you think of some everyday examples of diffusion? Ready to get a 5 on the AP Bio test?

Dissolved Oxygen

How is dissolved oxygen different from oxygen? It's not that different except dissolved oxygen refers to the amount of oxygen dissolved in water. We know that water contains oxygen atoms already, aquatic life can't pull that out for respiration, so it's useless to other forms of life. A small amount of oxygen, about ten molecules of oxygen for every million of water, is actually dissolved in the solution of H_2O. It typically enters the water supply through the atmosphere, though possibly through groundwater discharge in places. It's also produced by plant life already in the water as it breathes.

Dissolved oxygen is incredibly important to an aquatic ecosystem. Therefore, its measurement helps scientists monitor the health of these environments. The Winkler test, named after its originator, Ludwig Wilhelm Winkler (later referred to as Lajos Winkler), is used to measure the concentration of dissolved oxygen in a volume of water. This effectively measures the biological activity as microalgae and the like produce oxygen through photosynthesis, and eukaryotic organisms consume it through cellular respiration. The difference between the concentrations of oxygen in the water supposing there were no organisms in it, and the actual concentration, is called the biological demand. The Winkler test is somewhat scrutinized as it has proven to not be 100% accurate, but still serves as a general technique for testing concentrations and overall health of an aquatic ecosystem.

Measurement

The Winkler test is carried out in the following manner. Manganese sulfate is added to the water sample, followed by potassium iodide in a hydroxide solution, to create a pinkish-brown precipitate. Dissolved oxygen oxidizes the manganese and manganese hydroxide is formed as a whitish precipitate. The precipitate is then oxidized by dissolved oxygen into brown manganese precipitate. Next, a

strong acid is added and the precipitate converts the iodide ion to iodine. The amount of dissolved oxygen is directly proportional to the titration of iodine with thiosulfate solution. Determining the number of moles of iodine at the end allow us to determine the moles of oxygen of the original sample.

Now that we have a measurement, we can determine the primary productivity of the system. Primary productivity is the rate at which autotrophs convert light energy into stored chemical energy. An increase in oxygen correlates directly with an increase in primary productivity. Two other terms worth knowing is gross productivity and net productivity. Gross productivity measures the rate at which the primary producer synthesizes oxygen, and net productivity measures the difference in oxygen given off in photosynthesis and the oxygen used up in respiration. There are three main ways primary productivity is typically measured. One is by the amount of carbon dioxide used, the second is measuring the rate of sugar formation, and the third is checking the rate of oxygen production.

A typical experiment to measure effects on dissolved oxygen concentrations is the light/dark bottle test. You have one initial bottle, which is fixed and titrated to serve as a control with the amount of dissolved oxygen present in an original sample. You have one dark bottle, which is covered in foil. This effectively allows for no photosynthesis, so the only biological process occurring will use oxygen rather than contribute further oxygen. The light bottles all have a different number of screens wrapped around them, allowing for varying amounts of light to enter. To calculate the amount of oxygen consumed in respiration, you subtract the amount of dissolved oxygen in the dark bottle from the amount in the initial bottle. This type of experiment has shown up in past AP Bio exams, so it's important to understand how these measurements are made.

To measure the gross productivity, you can first measure net photosynthesis by subtracting the dissolved oxygen of the initial bottle form the dissolved oxygen of the light bottle. Then subtract the dissolved oxygen of the dark bottle from the

initial bottle to measure the respiration. Adding the amount used up back to the amount accumulated in the light bottle tells us how much dissolved oxygen was actually produced. This serves as an indirect measurement of the sugars produced in photosynthesis and lost in respiration. Our net productivity is what we just referred to as net photosynthesis.

Factors

There are several factors that affect how much oxygen may be dissolved in water beyond what we've already discussed. Temperature, photosynthetic activity, decomposition, turbulence, and salinity all play a role. As water becomes warmer, its ability to hold on to oxygen molecules decreases as the molecules being to move about more freely. Light clearly affects the amount as with more sunlight, more oxygen is produced by aquatic plant life. As organic material decays, microbial processes use up oxygen. Waterfalls or rapids stirring up the water allow it to better aerate and so increase the dissolved oxygen concentration. And as water becomes saltier, the increase in salt molecules means less room for oxygen.

Eutrophication is the addition of chemical nutrients, possibly through pollution, to the water supply. This has an effect on the concentration of dissolved oxygen and therefore the health of the ecosystem. The added nutrients generally mean an increase in biomass, which may sound like a great thing, but with a sudden increase in biomass at the scale it may be, this creates a strain on the organisms as there is increased competition which often lowers diversity and survival rates, creating a less healthy ecosystem. The opposite is an oligotrophic system which is generally oxygen rich and nutrient poor.

Now you know a lot more about dissolved oxygen in an aquatic system and how it affects life on the whole. You should understand how to measure dissolved oxygen should you see it on the AP Bio test. Have you ever witnessed algal

blooms and thought about oxygen being such a factor?

DNA Replication

DNA replication is one of the more researched fields in today's labs. Looking into how DNA can and does accomplish such impressive tasks may lead to eradicating genetic defects as well as looking to cure diseases such as HIV/AIDS and various cancers.

The AP Biology exam will have several multiple choice questions and even some open ended questions that deal with the topic of DNA replication. This is because DNA replication, or the duplication of the wealth of genetic material, is vital to life and the upkeep of that life. Your complicated DNA has to replicate perfectly every time, and through some small, nearly impossible miracle, it usually does. This concept is another opportunity to show how amazing your nucleic acids are. DNA is able to duplicate its millions of base pairs in only a few hours!
The DNA strand is a remarkable structure that allows the DNA to function properly, embodying the structure to function concept of biology that dictates that the structure of an organism or a part of that organism allows it to perform a certain function. The hydrogen bonds that are in between nitrogenous pairs within the nucleotides allow the DNA strand to unravel as well as split the double helix down the middle of the DNA's ladder. This allows the strands to separate from the double helix and act as specifically coded templates for the new replicated strands. Because each of the nitrogenous base pairs can only bond with a specific other base pair, this allows the DNA to replicate exactly the same every time. This is important so that genetic mutations do not occur and wreak havoc on the protein synthesis and other genetic information.

Once this happens, then the multitude of free nucleotides that were floating around in the nucleus link up with the templates. After this happens, then enzymes link up with the free nucleotides to form the other side of the ladder in order to create two separate, but still completely identical, daughter DNAs. Please note that there is no gender implied here. Daughter DNA a simply a term that

means that there is identical DNA after it has been copied. This process of replication is referred to as the semiconservative model. This name was chosen, because half of the original strand is conserved in each of the daughter DNAs. While this concept seems simple, DNA replication is actually a complex function that requires countless enzymes that are able to significantly speed up the rate of reactions when connecting fragments of the daughter DNAs. We, as humans, can replicate our DNA that contains forty-six chromosomes, or twenty-three pairs, in a few hours. This process is extremely complicated and fast. It is also surprisingly accurate and barely makes a mistake. This is very lucky, because if the DNA replication goes horribly wrong, then strange mutations may occur.

DNA replication begins when a protein is triggered to tell the DNA to replicate at sites that are called the origin of replication. The origin of replication is a sequence of nitrogenous base pairs that are needed for a certain task, such as protein synthesis. The base pairs are carefully paired up by an enzyme called DNA polymerases with only the base pairs that complement them as well. Therefore, adenine matches up with thymine and guanine matches with cytosine; however, the outside sugar-phosphate backbone must match up as well. One side of the ladder may have a nucleotide with three carbon atoms and on the other the nucleotide that matches must have a five carbon sugar. This is very important in order to ensure that the DNA perfectly matches together.

Once the DNA knows where to replicate, the DNA begins to separate the double helix, working outward in both directions form the origin of replication. This eventually creates two separated strands. There are often many origin of replication sites at a time, causing the DNA to replicate much faster than with just one origin of replication. This allows the process to be much less cumbersome and difficult within the inside of the nucleus and becomes more effective. If time is money, then the nucleus should be making millions with its amazingly quick replication of DNA.

As the DNA separates, the replication fork comes into fruition. Here, the growing daughter strand is synthesized from half of a DNA strand into a full half and small pieces of the mirroring strand. Many scientists often refer to these pieces of

synthesized daughter strands as the Okazaki fragments. These Okazaki fragments were named after the husband and wife Japanese couple that discovered them. An enzyme that is called DNA ligase comes in between the Okazaki fragments and pulls the daughter strand together seamlessly. This allows the daughter strands to become complete more easily. It is also important to note that DNA replication always moves toward the replication fork and the non-split parent strand, so that the daughter strand is synthesized in organized pieces and errors are eradicated.

It is also important to note that every time a DNA replication takes place the telomeres on the forty-six chromosomes are shorted. Telomeres are located at the end of the chromatid in order to protect the chromosome from damage. When these telomeres are shortened by DNA replication, then the telomere cannot grow back. While this is a natural process, this will be damaging to the genetic material eventually. The telomeres are protective measures, and when the telomeres are worn away the genetic material can become damaged. Once this DNA damage occurs, then the cell will no longer go through DNA replication and the cell will not go through mitosis and divide. When this happens your cells will eventually all die off, leaving you cell-less and dead as well. This is why no one can live forever. Our telomeres keep humanity and other organisms from achieving immortality, because our genetic material will eventually become damaged and we will die.

While the replication of DNA is often surprisingly perfect, every once in a while a complication may arise. The DNA strands must remain parallel as it unravels and copies itself. If this does not happen, then the DNA may become muddled and errors may become more common.

Why should I care about deoxyribonucleic acid replication?

Once the strands are separated, then the base pairs join up with the two templates. This ensures that each replicated strand of DNA will be exactly the same as the rest of the DNA. This is important, because if the DNA is not the same in every cell, then there will be confusion within the body. Also, if the replicated DNA replicates incorrectly and the cell divides, then there is an entirely new cell with that strange genetic information. This may kill the cell or cause cancer, which all of us want to avoid.

This replication of DNA could go completely and horribly wrong, but it does not, which is a miracle in itself. The fact that our DNA does not change as it replicates allows us to function as an organism, and that is pretty fantastic.

As for the AP Biology exam, DNA replication is extremely important in life as well as other processes in the body. DNA replication is needed in protein synthesis and mitosis. Protein synthesis involves replicating the DNA into daughter DNA as well as sending those strands through a process that involves RNA transcription, translation, and other processes that will be difficult to understand unless you know the basis of how DNA replicates. Also mitosis, otherwise known as somatic cell duplication or division, needs DNA replication to occur before any cell may divide. Once this DNA replication happens, then the cell may proceed with the stages of mitosis, which allow the cells to replace themselves after others have died. This is vital to the body, because if the cells do not continue to replicate, then you will die.

Therefore, if you do not have DNA replication taking place, then you will eventually die once your cellular functions become impossible to do with dead cells.

So in conclusion, DNA is awesome in that it replicates perfectly and keeps you alive! There are two meters of DNA that replicates and fits inside of each cell. This genetic material, if you wrote it out at two hundred letters per minute, would fill two hundred yellow pages books. This would also take you twenty-nine years. There is so much information that it is amazing that the replication of DNA goes so well within the nucleus. Through more research on the replication of DNA, more thoughts about cloning have erupted. If we understand how we can replicate an individual's DNA, then what is holding us back from manipulating and creating an exact duplicate of the individual? This could be used not only for animals, but for plants as well. DNA could solve world hunger by allowing food to be replicated in countries where food is scarce. The possibilities are endless with genetics and DNA replication.

Endocrine System

In this AP Biology crash course we will be talking about the endocrine system. The endocrine system is a system that regulates the secretion of hormones in order to control the body and mind. This system allows our bodies to do certain functions and have certain emotional states. All over our bodies are glands and vital organs that are controlled by the brain to direct our flow of hormones to allow life to happen.

The Pituitary Gland

One of the most important parts of the endocrine system is the pituitary gland. The pituitary gland is found at the bottom of the brain in humans and this glad contains two parts. These parts are called the anterior lobe and the posterior lobe. Each lobe has a specific function, although both release hormones.

The Anterior Lobe

The anterior lobe has seven hormones that it secretes. One of the most important hormones is the human growth hormone, or otherwise known as somatotropin. This hormone allows regular growth to occur when the pituitary gland releases the correct amount. When the anterior lobe secretes too much of this hormone, then the result is gigantism. Gigantism is often caused by a tumor on the pituitary gland and is often passed genetically through mutated genes. If there is not enough human growth hormone released, then dwarfism occurs. Dwarfism is when the opposite occurs. The individual simply does not grow as expected and the individual ends up below four feet ten inches tall. People with gigantism and dwarfism can lead normal lives with some alterations to their homes and day to day activities as well as medical attention to their different skeletal issues.
The anterior lobe also secretes prolactin. Prolactin, also referred to as the lactogenic hormone, triggers breast development and lactation in females. The third hormone, the adrenocorticotropic hormone, is another hormone secreted by the anterior lobe, and it controls the adrenal glands that secrete adrenaline in

a dangerous situation. Adrenaline is used to trigger the fight or flight response in a scary situation.

The fourth hormone is a thyroid-stimulating hormone that does exactly that. The thyroid is triggered to secrete glands that can affect the weight gain or loss of the individual as well as other factors.

The fifth hormone is the follicle-stimulating hormone, which triggers the ovaries to make egg cells. This is followed later by the luteinizing hormone that matures those egg cells. For men, these two hormones are not present. Instead, the interstitial cell-stimulating hormone stimulates the production of sperm in the testicles.

The final hormone that is secreted by the anterior lobe of the pituitary gland is the melanocyte-stimulating hormone. This hormone allows pigment that colors our skin to be made.

The Posterior Lobe

The posterior lobe to the pituitary gland produces only two hormones. The first one is an anti-diuretic hormone. This means that this hormone, normally called vasopressin, triggers the kidneys to reabsorb water. If this hormone is not sent out, then the body will not save enough water. The water filtered through the kidneys will be sent out of the body as waste when it could be reused. This will make you extremely dehydrated, which may cause complications.

The second hormone is found in women. This hormone is called oxytocin, and oxytocin allows the uterine muscles to contract during labor. This allows child birth to happen naturally. If your posterior area of the pituitary gland does not send out oxytocin, then a Caesarian section must be done, as opposed to a natural birth, in order to remove the unborn baby from the uterus.

The Thyroid Gland

The next portion of the endocrine system is the thyroid gland. This important gland releases a hormone called thyroxine that controls the rate at which your body metabolizes glucose into adenosine triphosphate during cellular respiration. The amount of thyroxine available to the body depends on how much iodine is present. An iodine deficiency is often the main cause for the thyroid to enlarge. This enlargement is often called a goiter and is treatable with iodine supplements.

The thyroid gland also releases another hormone that is called calcitonin. Calcitonin is the hormone that releases calcium into the blood stream, which allows the body to benefit from the vitamin. We need this hormone to keep up good bone health!

Adrenal glands

The next part of the endocrine system is vital to the survival of our species. The adrenal glands are two triangle shaped glands that are located on top of the kidneys within the body. These glands secrete epinephrine, otherwise known as adrenaline. Epinephrine, when triggered to be released by the adrenal glands, elevates your breathing, heart rate, blood pressure, and blood supply to the skeletal muscles. This is because adrenaline is usually triggered in a circumstance that causes you distress. Your body responds by giving you a boost of energy and oxygen to your muscles that it assumes that you will need. Adrenaline is nice when you are actually in a dangerous situation, but unfortunately it is often used most commonly in my body when I need to give a speech. The flight or fight response that is triggered has kept our species alive; however, it can be cumbersome in modern society.

The adrenal glands have another function in the body as well. Corticosteroids are sent out to the body through the adrenal glands. The two steroid hormones that are released are mineralocorticoids and glucocorticoids. Mineralocorticoids are

used to control how fast or slow the body uses up minerals in the body. One example of a mineralocorticoid is aldosterone. Glucocorticoids are steroids that assist with protein synthesis as well as glucose metabolism and anti-inflammatory agents within the body. Some examples of a glucocorticoid are cortisol and cortisone.

Pancreas

The pancreas, an obscure organ that you may have forgotten during an anatomy quiz, is another vital part of the endocrine system. This vital organ is located behind the stomach and is a hormonal powerhouse. While only two hormones are pumped out of the pancreas, these hormones are extremely important. The pancreas sends out the hormones insulin and glucagon.

Insulin is the hormone that regulates the glucose metabolism. Insulin also allows sugar passage into the cells. This can be problematic when the pancreas does not produce enough or produces way too much insulin, which is a condition called diabetes. Diabetes does not allow the cell to have enough access or too much access to sugar, a substance that the cells need to live and thrive. Some types of diabetes can be managed with insulin injections and diet.

Glucagon is another hormone that is necessary in the body. This hormone within the endocrine system releases adipose tissue and other fat cells to be used for energy. Without glucagon the body would just build up fat until the person died from obesity complications. Having the correct glucagon levels are very important for that reason. Sometimes men and women that are trying to lose weight cannot because they are not releasing enough of this hormone.

The Ovaries and Testicles

Believe it or not, the ovaries are also part of the endocrine system. Ovaries give off estrogens, which is also a hormone. This allows women to go through puberty to eventually be able to have a child. In men, testicles give off testosterone, which

triggers puberty in males. This allows men to be ready for sexual reproduction as well as developing secondary sex characteristics like body hair.

The Thymus Gland

The thymus gland is a small gland that is located in the tissues of the neck. The thymus gland has a very important job in that it secretes thymosins. Thymosins regulate the creation of T-lymphocytes in the body, which strengthens the immune system.

The Pineal Gland

This gland is the last major gland in the endocrine system. While most of the pineal gland's functions are shrouded in mystery, scientists can agree that it has something to do with secreting hormones that control behaviors in mating and day-night cycles.

Why is this important to AP Biology?

The endocrine system is important to AP Biology, because of the impact it has on every part of the organism. The endocrine system controls sexual reproduction, which is the point of life for many organisms. It also controls your metabolism, your feelings, and everything in between. The endocrine system is sometimes glossed over, but the fact that you have these chemicals affecting your cells and tissues allows your body to understand what it needs to do. The brain controls your body, but it needs help to get those messages across. The hormones of the endocrine system help the brain do that.

Endosymbiosis

Endosymbiosis is an evolutionary theory that attempts to explain how eukaryotic cells arose from prokaryotes. It states that several key organelles of eukaryotes originated as symbiosis between separate single-celled organisms. Mitochondria and plastids (chloroplasts), and maybe even some other organelles may represent formerly free-living bacteria that were taken inside another organism about 1.5 billion years ago.

When life started some estimated 3.6 billion years ago, there were only prokaryotes. We don't believe eukaryotes appeared until about 2 billion years ago. So there were aerobic bacteria and cyanobacteria that were just were just doing their thing, which were engulfed by larger organisms, and then went on living inside and became the organelles we know today.

The theory was first articulated by the Russian botanist Konstantin Mereschowski. He was familiar with the work of Andreas Schimper who had observed the division of chloroplasts in green plants and thought they resembled free-living cyanobacteria. The idea was further advanced and researched later by Dr. Lynn Margulis (this is a name you may want to know for the AP Bio test). She had a hard time getting this published though, and was generally criticized for a long time as the scientific community had some trouble believing that single-celled creatures eaten up by other single-celled creatures created the organisms we have today. After more work and discussion, though, we arrive today to find it generally accepted as fact.

One place we can easily observe this process occurring in nature today is with certain types of coral. Coral is a living thing that can use the process of photosynthesis to make energy. How is this possible? Symbiodinium is a dynoflagellate that is eaten by the coral. As an algal organism, it has the chloroplasts to carry out photosynthesis. The coral allows it live within, and in

return, it allows the coral to use its photosynthetic process to obtain energy. So the coral feeds itself continually through photosynthesis carried out by the other organism.

There is a fair amount of evidence to point to the organisms that once lived freely and were engulfed becoming organelles as we know them today. There is a type of bacteria that looks an awful lot like the mitochondria we currently have. Both have double-membranes that even look similar under a microscope. They reproduce similarly as well. Eukaryotic cells copy chromosomes, then they line up in the middle, and then they split. Bacteria copy DNA and split in half as well (called binary fission here). Mitochondria can also copy itself asexually much like a bacterium. The fact that a cell cannot form new mitochondria or chloroplasts if they're removed from a cell also serves as a bit of evidence.

Once we could look at DNA, it became even more convincing. Mitochondria have their own DNA that codes its own proteins, and so it really does function almost as a cell living within a cell. The DNA in the mitochondria also relates to a bacterium. Mitochondria are copied from generation to generation in our bodies when sexual reproduction takes place. In an egg cell, there are a lot of mitochondria that get passed down over and over. The sperm does not carry mitochondria.

So, now you should have a good idea of the theory of endosymbiosis and what it means to life today. Can you imagine that pieces of your cells were once living on their own? Keep in mind not only the process, but of the evidence when taking your AP Biology test.

Enzymes

If you've started reviewing for your AP Biology exam, you may have come across enzymes. Enzymes are molecules that catalyze a chemical reaction. Molecules at the beginning of the chemical reactionary process are called substrates, and these are converted into products. Enzyme kinetics, or Michaelis-Menten kinetics, investigates how enzymes bind substrates and turn them into products. The amount of substrate needed to reach a given rate of reaction is the Michaelis-Menten constant. Enzymes are quite necessary to life since almost all metabolic processes require enzymes to occur at the proper rate. Chances are you'd be dead without enzymes.

Some chemical reactions take a lot of energy to start. The amount of energy needed to kick off a chemical reaction is called its activation energy. When a cell wants a little help, it looks to a protein called an enzyme to overcome the amount of energy needed.

French chemist Anselme Payen discovered the first recognized enzyme, diastase, in 1833. Louis Pasteur also noticed when studying a mixture of sugar, alcohol, and yeast, something was happening to ignite the fermentation process. The word "enzyme," itself, was first used by a German physiologist in 1877 named Wilhelm Kuhne.

What do Enzymes Look Like?

As you may have learned in your AP Biology course, an enzyme's primary structure is nothing more than a long sequence of amino acids, but amino acids can bond with one another. Short-range interactions (secondary) between amino acids can be alpha-helix or beta formations. Alphas look like spirals, and betas look like flat, wavy sheets. The long-range interactions (tertiary) are when amino acids interact with other amino acids a long ways down the strand, and as they fold over, it forms a globular structure. The quaternary structure is when one

globular strand interacts with other tertiary pieces. When bonds are formed at this level, they are often hydrogen bonds, but sometimes it's two hydrophobic pieces interacting, or even ionic bonds. Alternatively, when an enzyme is unfolded, it's referred to as being denatured.

Enzymes are quite large relative to their substrates, yet only a small portion of the structure is involved in catalysis. That part is referred to as the catalytic site. This site is located next to a binding site where residues orient the substrates. These two sites together are referred to as the active site. This looks like a donut hole in the folded up globular protein.

How Do Enzymes Work?

Enzymes are very picky about which substrates they'll work with. Typically they have to be very similar to the enzyme to do business together. A few enzymes are very flexible with who they'll bond with. In fact, they're described with the term "enzyme promiscuity," essentially the sluts of the enzyme world. Related to the specificity of enzyme and substrate bonding, Emil Fischer proposed the "lock and key" model where the two would have complementary geometric forms. Daniel Koshland suggested that these complementary geometric pieces can actually shift and can even be reshaped by their interactions. Induced fit means these changes can be occurring the whole time the bonding is taking place so a fit can be obtained. This would imply a far more flexible process.

There are three ways an enzyme can lower activation energy.

- It can stabilize the transition state, essentially by straining the shape of a substrate.
- It can lower the energy of the transition state, but without morphing the shape, this time by creating an opposite charge distribution to that of the transition state.
- It can provide an alternate reactionary path, perhaps by temporarily reacting with the substrate to form an intermediary complex. Or it can

reduce the reactionary entropy change by bringing substrates together in a particular orientation.

Enzymes are like a car in that they have to be turned on to work. The process of activation adds something to an enzyme that makes it get going, but just because it's activated does not mean it has to catalyze a process at that moment. Activators can either be cofactors or coenzymes. Cofactors are small, inorganic chemicals. Coenzymes are organic compounds required by certain enzymes to carry out the catalytic process. They bind to the active site, but are not considered substrates.

Inhibition (no, not losing your clothes)

Inhibitors bind to an enzyme to decrease its activity. There are two types of inhibition, competitive and non-competitive. In competitive inhibition, the inhibitor bonds itself directly to the active site, effectively completely blocking access. Non-competitive inhibition, also known as Allosteric inhibition, is where the inhibitor binds to a different part of the enzyme, and effectively covers the active site without actually stopping it up. The other way to inhibit is to bond at an Allosteric site and change the shape of the active site at that point. These processes all help to regulate rates of enzyme activity.

So, now you know more about enzymes, what turns them on, turns them off, and makes them so sexy. Do you understand how important they are to life and everything in the world?

Hardy Weinberg Equation

The Hardy Weinberg equation helps us to determine the frequency of certain genetic traits within a population. Key terms to know for the AP Biology exam include phenotype and genotype. A phenotype is a physical characteristic. It is therefore evident simply by looking at an individual. For example, if someone has red hair (we'll be using this example throughout this crash course), as you can see this just by looking at them, the physical trait of having red hair would be a phenotype. The genotype is related to the genetics that correlate to the physical appearance. But the genotype is slightly more complicated, as it consists of two separate alleles (types of genes). There are dominant and recessive alleles, and so it is not always straightforward to assume the genetic makeup of an individual based solely on phenotype.

There are three types of genotypes, generally speaking. You can have a homozygous dominant individual. This means both alleles are of a dominant gene. The phenotype will then be that trait. Homozygous recessive means both alleles are the recessive genes, and so the phenotype will be that of the recessive characteristic. Heterozygous dominant means the alleles are different, one dominant and one recessive. The dominant gene will determine the phenotype, but this is a situation where you cannot guess the genotype simply by observing the physical characteristic.

When working with genetic problems, you will see two letters used. A capital letter will represent the dominant gene, a lower case version of the same letter indicated a recessive gene. An example of phenotypes versus genotypes would be looking at a particular disease. If someone has Huntington's Disease, this is a phenotype because it's a physical manifestation of the genetic coding for those traits. However, if someone is said to be a carrier of that disease, it means physical symptoms haven't shown up even though they have a gene of that disease, indicating this to be a genotype (it tells us there is a recessive gene). It is

helpful to know whether you're dealing with a genotype or phenotype when looking at questions on the AP Bio test.

You can think of alleles like socks. Let's say a red sock represents an allele for red hair, and a black sock represents a non-red hair allele. A recessive allele/sock can be tucked into the dominant allele/sock or other one. If both socks are red, you can tuck one into the other and it doesn't matter – both alleles are for red hair so the phenotype will definitely be red hair. If both socks are non-red, again, it doesn't matter; it is clearly a non-red haired phenotype. But if you have a red sock and a black sock, the red sock would be tucked into the back and all you see is the non-red haired phenotype. So that would tell you the physical manifestation of a heterozygous dominant pair is the dominant trait.

Now let's look at a population of ten individuals. Five of these have red hair, and five are non-red haired people. We only know the genotype of those that have both recessive alleles for red hair as non-red haired genotypes could be homozygous dominant or heterozygous dominant. If we mixed up all the alleles into a random collection of the genes present, the collection would be called the gene pool. Looking at the gene pool, we can see the frequency with which certain alleles occur. The frequency can be expressed as a ratio of the allele in question against the total number of alleles in the population.

Let's call p the variable which will represent the frequency of the dominant allele. A q will represent the frequency of the recessive allele. Going back to our group of ten people, p will be 6/20 which can be expressed in decimal form (the form we will use when doing Hardy-Weinberg problems on the AP Biology test) as .3. This can also be said as 30%. Our q in this is 14/20 or .7, also expressed as 70%. In the Hardy-Weinberg equation, $p + q = 1$, always. The Hardy-Weinberg equation in all its splendor is written: $p^2 + 2pq + q^2 = 1$. In this equation, p^2 is our homozygous dominant frequency, 2pq that of the heterozygous dominant, and q^2 homozygous recessive.

Let's look at a practice problem. Let's say 2% of humans have red hair. What percentage of the population is heterozygous recessive for this trait? Let's first see what the problem is telling us. It is giving us the frequency of the homozygous recessive. This will be pretty typical for Hardy-Weinberg word problems, as we can only guess at genotypes of dominant-expressed phenotypes. Also, remember to use a decimal value in these problems.

So, in this problem, we're being told q^2 is 0.2. As we're dealing with a square, and we always want to get our p and q values, we take the square root of both sides to see that q = .14. As p + q = 1, we now know that p = .86. Again, we are looking for the frequency of heterozygous recessive, the same as a heterozygous dominant as we've been referring to it thus far (keep in mind heterozygous just means the alleles are different, so calling it recessive or dominant doesn't really matter). In our equation, this is our term 2pq. So, now that we know p and q, we can plug these in and see 2pq = 2(.86)(.14) = .24. Our decimal of .24 tells us the percentage is 24%. So 24% of the population is heterozygous recessive for this trait.

All the Hardy-Weinberg formulas stay true under an equilibrium assumed to include only diploid organisms undergoing only sexual reproduction. Generations are not overlapping and mating is at random. The population size, really, has to be infinitely large, allele frequencies ought to be equal between the sexes, and there is no mutation, migration, or selection.

So now you know the Hardy-Weinberg equation and how to use it to predict allele frequencies within a population. Mind your p's and q's when taking the AP Bio test!

Heredity

In discussing genetics in AP Biology, no doubt you have heard of Mendel. Mendel is known for crossing pea plants in the early study of genetics. Peas have lots of different characteristics, and there are a lot of peas in one pod, so this made them great for testing. From his experiments, Mendel came up with the law of segregation and the law of independent assortment. We will take a closer look at these laws and other realms of inheritance in genetics as we explore heredity.

Simple Genetics

When Mendel experimented, he also crossed flowers, crossing a purple flower with a white flower. The result was a purple flower. He then crossed two of these new purple flowers and wound up with three purples and white flower. It showed that the gene for a phenotype displaying white petals was passed down the line.

In the law of segregation, you can think about a coin flip scenario. It's either heads or tails, and every time you flip it, the possible outcomes, and the odds for those outcomes, are the same. If heads and tails were alleles, it would be like a 50% of getting either allele from the parent.

The law of independent assortment states that traits don't affect each other. This was somewhat of a convenient matter for Mendel, as he happened to be studying seven different genes on seven different chromosomes. He came to the conclusion that traits don't affect each other. As we will see shortly, that does not actually hold true throughout.

A karyotype is the number and appearance of chromosomes in the nucleus of a eukaryotic cell. It's worth noting that mitochondria have their own sets of DNA and this is passed down from the mother. An egg will contain mitochondria with its DNA, and so this traces down evolutionary history.

Linked Genes

Genes do appear on the same chromosome sometimes in traits that are being passed down, and sometimes these can actually affect each other. These are referred to as linked genes. At times, there can even be multiple genes connected to one particular trait. This is referred to as polygenic inheritance, and height would be an example of this.

Let's take a closer look at height. In reality, there are many alleles connected with this phenotype, but we will say that it is caused by three different types of genes just to simplify this explanation. There are two different types of alleles of that gene in our case. This means if you had all six of these, you would be really tall, none would mean really short, and then there are several scenarios in between.

So, let's look at a boy and girl each with three height genes (of six possible). They have kids. Setting up our Punnett square would mean on each side we have AaBbCc (the capital letters representing the presence of the tall allele). This would lead to eight different possibilities on either side of the square. SO we have a 1 in 64 chance of having an exceptionally short child. There are 6 possibilities of 64 for having one height gene, 15 of having two, 20/64 for three, 15/64 for four, 6 for five, and 1 for all 6. So our distribution of odds for the offspring achieving certain heights looks like a bell curve, with it most likely of being somewhere in the middle, which is typical for the distribution of a polygenic situation. This works for things like eye color and skin color, as well.

Thomas Hunt Morgan crossed fruit flies with different colored eyes at one point and found certain genes exist on the sex chromosomes. In humans, color blindness travels on the gametes. As it is typically on the y chromosome, males are more likely to be colorblind in any scenario where it may be passed from parent to offspring.

There is also nonnuclear inheritance as, remember, the mitochondria have DNA as well. They get passed within mitochondria as they divide, and we already know mitochondria can be passed to offspring through the mother. Plants also have DNA in their chloroplasts, so can exhibit nonnuclear inheritance, as well.

Wrap-Up for Heredity in AP Biology

Now you have a sense of how heredity works and what you'll need for the AP Biology test. Know how to work those Punnett squares and the different types of inheritance, and you'll do great.

Immune Systems

What do you think of when you hear "immune system?" Maybe your body fighting a cold, maybe white blood cells? Your body's immune system is there to protect you, both from inside and outer-body offenses. Animals must defend themselves against viruses, bacteria, and other types of intruders. Our cells have no walls, as we traded in mobility for susceptibility over the course of evolution. So our immune system is there to help keep us safe. Let's take a closer look at the workings of the immune system as far as what you'll want to know for the AP Biology exam.

Attacks on the Immune System

Your body can be attacked from within, whether by mutated cells, or more often, viruses or bacteria. Viruses have been a topic for discussion over a long time as they are rather unique in both their structure and function. Viruses do not have cells. They need energy from their environment, as they can't maintain an internal stable environment on their own. They are no considered to be alive, yet do take great strides to replicate themselves.

Viruses have a capsid (protein code) and inside this is DNA or RNA. Lysogenic virus DNA hides in your chromosomes and generally remains dormant. It does not automatically cause disease. Lytic viruses destroy the cell. To lyse something is essentially to cut it up, or destroy it. There is a lytic phase to many viruses in which they copy themselves and then destroy the host cell before moving on to other cells in the body. The flu is an example of this type of virus. It attached to a host cell, injects its DNA (or if it uses RNA, then it undergoes reverse transcription to have DNA available), and then the lytic cycle turns off the cell's machinery and forces it to make proteins for the virus.

When a virus becomes part of the chromosomes, the virus DNA in there is called prophage. It's dormant, and when the cells divide, the DNA from the virus also

divides and is copied. Occasionally, there may be a stimulus that drives it out of the chromosome and into a lytic cycle. Most viruses are actually a bit of both, part lysogenic, part lytic. They may lean more heavily to one side, as in the flu virus, which exists mostly in a lytic phase. Viruses can generally only be prevented with vaccines, though bacteria can be cured with antibiotics.

General Immune Defenses

There are three general lines of defense the body has against invaders. The first lines of defense are physical barriers such as skin and mucus membranes. The second is non-specific, as well, but internal. This would include phagocytic white blood cells. The third and last line of defense is what's typically referred to as the immune system. This includes lymphocytes and antibodies, more specific to definitive types of invaders.

The first line of defense includes epithelial cells and mucus membranes. This involves the skin, respiratory system, digestive tract, and genito-urinary tract. These are most exposed to the outside world. Sweat has an acidic pH and can help to prevent bacterial infections. Stomach acid also has a low pH. Tears, saliva, and mucus have antimicrobial properties, themselves, and can serve to trap potential invaders and neutralize them. Lysosomes within the saliva digest the cell walls of bacteria and destroy them.

The second line of defense is generally made of the white blood cells, which patrol the body looking for any type of foreign particles. They are phagocytic cells, which is to say they eat other cells. They also have microbial proteins and work with inflammatory responses. There are several types of white blood cells, and these are basophils, eosinophil, neutrophils monocytes, and lymphocytes. Monocytes and neutrophils are phagocytic and digest invaders with enzymes. Monocytes start as cells and become macrophages. Most white blood cells are neutrophils, which are rather short-lived cells, which neutralize invaders.

Eosinophils fight parasites. Basophils are part of an inflammatory response and produce histamine.

Basophil produces histamine, which attract more white blood cells. This makes the blood vessels more leaky, which allows fluids to leave and enter more easily, which allow for the more efficient transport of white blood cells to a site. As they are also involved in inflammatory responses, the temperature in the area may go up then, and swelling will occur.

When a local response is not enough, a fever is a common reaction. This resets the body's thermostat. The higher temperatures are helpful in that they can inhibit the growth of microbes, facilitate phagocytosis, and speed up the repair of tissues.

The lymph system produces leukocytes. Lymph fluid moves throughout the body by way of contractions of muscles and vessel with one-way valves. Lymph nodes are located in certain parts of the body and act as little police stations, all containing a large number of lymphocytes and macrophages.

Lymphocytes

The third line of defense is the lymphocytes, the B and T cells, which develop in the bone marrow. T cells mature in the thymus. They are attracted by chemical signals, the process of which is referred to as positive chemotaxis. In this way, lymphocytes are able to respond to specific toxins, microorganisms, abnormal body cells, and antigens (which in general, is just anything that elicits an immune response). Once the signal triggers a response from them, they move faster and look to destroy invaders. B cells produce antibodies to remember the chemical print of a foreign invader and allow for faster responses in the future. T cells facilitate the production of chemicals used by lymphocytes to kill off the foreign particles.

B cells recognize specific antigens, which each stimulate a unique antibody to be made. B cells are spurned to reproduce clone colonies, clone cells being either plasma cells or memory cells. Plasma cells facilitate the immediate production of antibodies, and release them in the short-term. Memory cells are for long-term immunity. They produce plasma cells to fight off invaders if they recognize the same foreign particle at a later date. These play a big role in vaccines.

Antigens are proteins that elicit a specific response by lymphocytes based on where they're coming from. B cells recognize intact antigens, and T cells recognize antigen fragments.

Antibodies are proteins that bind to a specific antigen. If it's designed to work against e. coli, for example, that is the only invader it works against. They are multi-chain proteins produced by B cells that "tag" invaders as being foreign so other cells can recognize them as invaders.

There are four main ways an antibody will work to rid the body of invaders. In neutralization, it would bind to a locking site on a virus so that it can't take over a cell then. With agglutination, it causes invaders to clump up. The reason this helps is this: think of peas. Is it easier to get one pea off a plate to eat, or use a spoon to eat many at once? When bacteria are clumped up, and a white blood cell finds it, it eats up the entire clump. Precipitation is where antigens are connected together by antibodies and they become dense and separate out the bad parts from the rest of the blood. And in a complement reaction, antibodies bind to a foreign cell, and complement proteins form and encircle the invader, and a hole is put in the ring and the cell dies. Plasma cells are typically involved in this type of attack.

There are millions of types of B cells with all different receptors for all different antigens. An antigen binds with a B cell and then it's triggered to make many, many copies of itself. Clones can become memory cells or plasma cells.

A first invasion usually takes about 10-17 days to mount an effective response. If it happens again, it is much faster. Memory cells stick around after a first attack and the antibody concentration becomes much higher far more quickly if the same invader comes back.

Vaccines work by giving partially destroyed viruses to the recipient so that memory cells can be created without actually harming the host. Vaccines are a form of active immunity. They stimulate the immune system to produce a response of its own. This is most effective against viral diseases.

Passive immunity comes from an outside source and is only short-term. A person receives antibodies only in this case. An example would be a mother making antibodies and passing them to her child by way of breast-feeding. If the child stops breast-feeding, it will no longer have those antibodies. Antivenom works in a similar way. Scientists inject rabbits with snake venom and the rabbits produce antibodies. The antibodies are separated, and now you have an antivenom. Those antibodies will lock up the proteins in venom and serve to neutralize them.

Another concern in immunity is recognizing self from non-self. MHC (major histocompatibility complex) tells the body what is a part of itself, and develops early in life. T cells use this in knowing what to go after.

There are helper T cells and cytotoxic T cells in the body. Helper T cells stimulate immune components while cytotoxic T cells kill off cells. If you have an invading bacterial infection, they would be taken up by a macrophage in response. Now the macrophage becomes APC (antigen present cells) and presents an antigen on the outside of the cell for MHC to recognize. Helper T cells are activated and then activate the cytotoxic T cells to destroy cells with that same antigen mark. Cytotoxic T cells bind to infected cells and produce a protein called perferin which perforates that alien cells to rip them apart.

Wrap-Up for the Immune System in AP Biology

This has been a very complete description of the immune system including everything you need to know for the AP Biology test. Remember all three lines of defenses and the different types of cells that play a role, including B and T cells.

Kingdoms

With so many organisms on the planet, it helps to have reference points for understanding and discussing these forms of life. Scientists have come up with groupings for various types of living things, classifying them into three domains at the top, all the way down to millions upon millions of species. On the AP Biology test, you will need to know some of these subdivisions and their characteristics shown here in this crash course.

Historical Classifications

Historically, living things have been classified as either plant or animal going as far back as Aristotle. Carolus Linnaeus, who devised binomial nomenclature (the system where each organism gets a two-word Latin name used to distinguish it from any and all other living things), would classify things as plant or animal, but also began using a third group for minerals. The mineral group didn't really stick, but in the mid-1800s, Protista was created for things that didn't seem to really fit neatly into either the plant or animal category.

With the advent of the electron microscope, it became apparent prokaryotes and eukaryotes were quite different from each other, and so some bacteria and blue-green algae were put into their own group named Monera. Fungi, while long noticed as being a bit unique, had yet to receive formal recognition as such. Yet around 1969, the kingdom Fungi was added to the growing list. For a brief period in the 1990s, eight kingdoms were being professed with further subdivisions amongst bacteria and simpler organisms, but eventually a six-kingdom system was settled upon.

There are three domains at the very top of the classification system, which are bacteria, archaea, and eukaryota. The kingdom archaebacteria is the only kingdom in the archaea domain. The eubacteria kingdom is in the bacteria domain. And Protista, fungi, plantae, and animalia fall into the eukaryota group.

In a general sense, the classifications get more specific moving from domain to kingdom, and the followed by phylum, class, order, family genus, species. A mnemonic for this is Dear King Philip Came Over For Great Spaghetti, or Dumb Kids Playing Chase On Freeways Get Squahsed. Let's move on to look at some of the characteristics of the kingdoms you'll need for the AP Bio exam.

Archaebacteria

Archaebacteria are unicellular, prokaryotic organisms. The have cell walls, but these walls lack peptidoglycan (which can be found in the eubacteria), and their plasma membranes have rarer fatty acids. The ribosomes resemble those of eukaryotes. There are no membrane-bound organelles, and they reproduce through binary fission (asexually). This group includes extremophiles, such as thermophiles and methanogens.

Eubacteria

Eubacteria are unicellular and prokaryotic. They have a peptidoglycan cell wall, a cell membrane, and ribosomes. There again are no membrane-bound organelles, and their DNA is "naked" (just a singular circular chromosome floating around). They reproduce with binary fission and include heterotrophs, photoautotrophs, and chemoautotrophs.

Protista

There is lots of differentiation within Eukaryota. Let's first look at Protista. These are eukaryotic and may be unicellular or multicellular. The group includes autotrophs, like algae, and heterotrophs. Some have cell walls, others only a cell membrane. Diatoms and forams have silica cell walls. They generally reproduce asexually through binary fission and buddiing, but sometimes use sexual methods.

Fungi

Fungi are multicellular and eukaryotic. These heterotrophs feed themselves through absorption, and have chiten cell walls. Perfect fungi can reproduce both sexually and asexually, while imperfect fungi can only reproduce asexually by mitosis. In both sexual and asexual reproduction, fungi produce spores that are dispersed by wind or another animal (by grabbing on to fur, for example). With asexual reproduction, there can be fragmentation, budding, or spores. Fragments of hyphae can grow entire new colonies. In yeast, some cells can form buds. In budding, a bulge will form on the side of the cell, the nucleus divides as in mitosis. And the bud then detaches itself from the mother cell.

Plantae

In plantae we find multicellular, eukaryotic organisms. They are autotrophs and create energy through photosynthesis. They have a cellulose cell wall and use sexual reproduction with alternation through generations, distributing spores and seeds. They may also reproduce asexually as with cuttings and tubers.

Animalia

In animalia, we find multicellular, eukaryotic organisms. These are heterotrophs that feed themselves through ingestion. There are no cell walls and they use sexual reproduction with gametes. This includes invertebrates and vertebrates. There are MANY further divisions of this kingdom, but that is a sense of its distinctions.

Key Takeaways for Kingdoms in AP Biology

Now you have a breakdown of the kingdoms you'll need to understand for the AP Biology test. Remember the six: plants, animals, protists, fungi, archaebacterial, and eubacteria. Major differences include cell structure and reproductive means. Keep those in mind!

Krebs Cycle

The Krebs cycle is also known as the citric acid cycle, because of citrate being a key component of the beginning of the process. It occurs within the inner matrix of the mitochondria and is generally associated with cellular respiration. We will break down the process in this crash course for the AP Biology exam.

Beginnings of the Krebs Cycle

The Krebs cycle is thought to potentially have originated with anaerobic bacteria. Bacteria were using glycolysis to create energy 3.5 billion years ago before there was sufficient oxygen in the air. Once oxygen became more readily available to organisms on the Earth, somewhere around 2.7 billion years ago, processes like photosynthesis evolved. Eukaryotes began using cellular respiration about 1.5 billion years ago, and it may have been around this time the Krebs cycle had worked its way into the lexicon of organic energy production. Though it does not directly require oxygen, it does use byproducts of oxidation and so would not have occurred earlier in time.

The entire process begins only after glycolysis has taken place. Here, glucose exists as a six-carbon molecule, and this is essentially split in glycolysis to two pyruvates with three carbons each. From this, we get a net gain of 2 ATP and 2 NADH. The pyruvates are then prepared for the Krebs cycle proper by undergoing oxidation and a carbon is cleaved off the end. Now the 2-carbon molecule that exists is Acetyl CoA. It also gives off NADH.

Steps of the Krebs Cycle and Catalyzation

Throughout the Krebs cycle, each step is catalyzed by different enzyme. In past free-response questions, most attention has been paid to the movement of carbons, or creation of ATP. In the first step, Acetyl CoA combines with water and oxaloacetate to form citrate and CoA-SH. This is catalyzed by citrate

synthase. In general, you want to keep the substrates in mind from each step more than anything for the AP Biology test. You'll get a mnemonic device to help you towards the end of this description of the full cycle.

Next, citrate loses some water and becomes cos-Aconitate, which is catalyzed by Aconitase. More water is given off as we move along to D-Isocitrate, and from there we will see NAD+ and NADH with another hydrogen ion coming off, as well as CO_2, with the help of isocitrate dehydrogenase. The next step sees alpha-ketogluterate and an NAD+ and CoA-SH combine to form Succinyl-CoA and NADH with another hydrogen ion and CO_2. The enzyme helping here is alpha-ketograterate dehydrogenase.

From there, the succinyl-CoA mixes with guanosine dihosphate and a phosphate ion to form succinate and CoA-SH. The GDP has become GTP, as well. The enzyme for this step is succinyl-CoA synthetase. Next succinate and ubiquinone combine to make fumarate and ubiquinol. The enzyme in this step is succinate dehydrogenase.

Fumarate mixes with water to form l-malate, catalyzed by fumerase. As we near the end of the cycle, l-malate and NAD+ combine to form oxaloacetate and NADH plus another hydrogen ion, aided by malate dehydrogenase.

Finally, the cycle comes back to the beginning when we again find oxaloacetatea combining with acetyl CoA and water. The cycle generally completes two full revolutions.

As carbons are cleaved off in cycle, CO_2s are given off. All six carbons from glucose are lost over the course of all this cycling, so 6 CO_2s are given off by the end. FAD is also oxidized to $FADH_2$.

Products of the Krebs Cycle

The products of the Krebs cycle at the end of both cycles looks like 6 NADH plus the 2 from that first part, for a total of 8, 2 $FADH_2$, and 2 ATP.

There are 4 ATP, 10 NADH, 2 $FADH_2$ that serve as inputs to the electron transport chain and get oxidized there, and with every NADH producing 3 ATP there, that's 30 ATP total. When $FADH_2$ is oxidized, there are 2 ATP produced, so 4 ATP from that. This is where we get the 38 total ATP, the number you would need to know for the AP Bio test.

This whole process is basically sugar metabolism. It's breaking down sugar, glucose. Humans can metabolize many other things to create energy, as well, but the Krebs cycle is very common as we most often derive energy from food.

Chemiosis is an important process to understand for the AP Biology test. It is responsible for the actual production of ATP in cellular respiration. Chemiosis involves the pumping of protons through channels in mitochondrial membranes, which effectually establish a proton gradient. Loose protons, or hydrogen atoms, diffuse down the gradient through the transport protein, ATP synthase. The flow of hydrogen ions catalyzes the pairing of phosphate with ADP, which forms ATP.

Wrap-Up of the Krebs Cycle for AP Biology

As complicated and layered a process as it is, you should now have a clearer understanding of the Krebs cycle and the role it plays in energy production within the body. Knowing key substrates and catalysts, as well as net ATP production, will help you immensely on the AP Biology exam.

Lipids

The AP biology exam focuses on organic molecules and their functions. In this article, we will focus on the lipid, which has three components that make up the category. Fats are just one subcategory that is often focused on, although it is a category that is often focused on. There are two other categories that will be covered below. Each subcategory of lipids is valuable to the body and its functions, allowing us, as humans, to live and function properly. In this AP Biology crash course we will explore lipids, so grab some lipids out of your refrigerator and get let's get started!

Lipids are a group of molecules that are classified together based on their composition. Lipids, as a group, do not mix with water. This means that lipids are hydrophobic, or that their hydrocarbon chains avoid water. You can test this easily with a glass of water that you pour some oil from salad dressing on. The oils, or lipids, will separate from the water and float on top of the glass. Lipids can function as energy storage, important hormone manufacturers, and cellular membrane components. Lipids are necessary for the human body.

Fats

Fats, or triglycerides, are used for long term storage. They are large compounds that are made from two smaller molecular compounds. These are the glycerol and the fatty acids. Glycerol consists of three carbons combined with hydroxyl groups (-OH). The fatty acids are made up of a carboxyl group (-COOH) as well as a hydrocarbon chain. Complete with sixteen or eighteen carbons, this hydrocarbon chain is attached to two hydrogen atoms. This hydrocarbon bond is hydrophobic, making the overall lipid hydrophobic.

Within the group of fats are several subgroups that are fairly common knowledge in today's society. Saturated fats are one of these subgroups. Saturated fats are when there are no double bonds within the hydrocarbon chain. Therefore, all of

the carbons are “saturated” with hydrogen. These saturated fats pack very tightly together in the body, causing sometimes dangerously high lipid levels in the body.

Unsaturated fats, however, do have these double bonds within the hydrocarbon chain. These double bonds have more energy stored within the bonds; therefore, when your body breaks down this lipid, then your body will receive more energy. Also, the double bonds prevent the fatty acids from packing tightly together in the body and building up unhealthy amounts of fat deposits. Unsaturated fats are often found in fish, which is why you often hear how great fish is for you.

Another type of fats is the trans-fat. Trans-fats have little to no nutritional value for the body, and cause many problems for those who ingest too much of this lipid. Trans-fats are often used to make the fat more solid by adding hydrogen to the lipid. This makes it terrible for you and has moms scanning food labels at the grocery store. Trans-fats in high doses can lead to obesity, heart disease, and more cardiorespiratory issues, so steer clear of these lipids.

Phospholipids

Phospholipids are a lipid bound together with a phosphate group, which creates your body’s membranes. Cells could not exist without these phospholipids, because cellular membranes are important in regulating what comes in and out of the cells. These phospholipids are made up two fatty acids, a glycerol, and a phosphate group that is attached to glycerol’s third carbon atom. By adding in the phosphate group, then the reaction of the molecule’s attitude toward water changes. The phosphate group, or the head of the phospholipid, is hydrophilic. This means that the phosphate group will turn to face the water, and the fatty acid tails will remain hydrophobic and will turn away from the water. This results in a phospholipid bilayer. The phospholipid bilayer is the main component of cellular membranes, allowing the membrane to be selectively permeable and promote overall cellular health.

Because the phospholipid bilayer is used for cellular membranes, this lets the cells utilize osmosis. Osmosis is the movement of water across the concentration gradient, which causes water to move to an area of low concentration. This may be in or out of the cell, and this is regulated by these phospholipids in their bilayer within the cellular membrane.

Steroids

The last lipid group is the steroid, a lipid with a carbon makeup of four fused rings. The most common steroid is cholesterol, which is another main component in cellular membranes. Cholesterol is great in moderation to keep cellular function healthy; however, in high doses cholesterol can cause a variety of health problems. One of these health problems is atherosclerosis, or the build-up of cholesterol in the arteries. This may cause heart disease, heart attacks, or strokes. Other steroids such as the sex hormones are also necessary for regular growth and health of the individual. Estrogen and testosterone allow for primary and secondary sex characteristics to appear in women and men respectively. When a normal amount of sex hormones are in the body, then sexual reproduction is possible and easier than without. However, too many steroids are not a great idea. Excess testosterone can cause muscle mass development as well as liver problems, rage, psychological disturbances, unnaturally fast weight gain, and cancer just to name a few.

If anabolic steroids are taken, then the individual will gain muscle mass as well as masculine characteristics and growth problems. Intense rage is often attributed to anabolic steroid use. An example of this rage is a domestic violence case due to anabolic steroid abuse. Breasts have been known to develop in men when taking anabolic steroids, and in children this steroid wreaks havoc. Anabolic steroids are to be avoided unless directed by a doctor. Although it is illegal, many athletes use anabolic steroids to allow them to have an edge over their competition. These

athletes, however, are often caught and are revealed to have complications like cancer because of the anabolic steroid.

Too much estrogen will cause problems as well. This is often seen in complications in hormonal birth control, which changes the amount of estrogen and progesterone in the woman's body. This causes the body to think that it is pregnant without actually being pregnant. Unfortunately, other problems may result from birth control such as blood clots in the lungs and psychological effects due to an imbalanced estrogen hormone level in a woman's body.

The lesson to be learned here is to carefully moderate your steroid levels. If you keep your cholesterol low, then you will reduce your risk of high cholesterol, heart disease, heart attacks, and strokes. If you keep your estrogen and testosterone levels normal and do not take extra hormonal supplements, then you will avoid any pervasive side effects that may result.

Why is this important to AP Biology?

If you are taking the AP Biology exam, then you need to know about lipids as these are one of the main organic molecules that your body needs in order to function. By understanding lipids you will be able to understand other concepts such as cellular respiration, otherwise known as the breakdown of glucose. Lipids are for prolonged energy because of the glycogen attached to the fatty acids. Because of this cellular respiration will break down this energy slowly. Knowing how lipids function at a cellular level helps you understand how cellular membranes function, which is another vital piece of the AP Biology Exam. The phospholipids create a selectively permeable bilayer that lets diffusion occur to sustain life.

Lipids allow your body to function. Without the long term energy stored in your body, you would have to live on a constantly depleting energy source. People would be in constant danger of quick starvation, and this would destroy the food

supply on Earth. Yes, obesity is a massive problem in many countries; however, lipids are necessary in moderation for life.

So next time you are deciding what to eat, do not discount the lipid. Are there other lipids that you love to eat? Do you have a favorite healthy lipid? Let us know!

Mendelian Genetics

Do you know your classical Mendelian genetics inside and out? If not, then read on, because Mendelian genetics is always a crucial part of the AP Biology Exam. All forms of life are composed of DNAs, which Mendelian genetics can explain, and this crash course can help you out with the studying.

Mendel's famous pea plant experiments have launched the study of genetics into an intense research subject area that has saved lives. So while this man's experiments started with a pea plant, the knowledge gained by many grew to so much more. In this AP Biology crash course we will illustrate Mendel's discoveries.

What is Mendelian Genetics?

Mendelian genetics and characteristic intelligence is a fancy term for the way that genes get information from your parent's sex cells to integrate it into your characteristics. At the very heart of Mendelian genetics is heredity, which is the passing on of genetic traits from parent to offspring. The definitions for Mendelian genetics and heredity are similar, because Mendel based his research off of this idea. He researched what happens genetically when parents mate to form offspring. Mendelian genetics sounds like a complex concept, but it is the foundation of everything that modern science knows about genetics. Genetics is what gives your eyes their color and what makes you tall or short.
Gregor Mendel, in 1865, published a hypothesis about inheritance of the characteristics of the peas in his garden. Mendel did this in order to prove the popular blending hypothesis of the time invalid. Before, it was believed that the traits of both parents blended to produce a hybrid offspring that was a perfect mix of both parents.

An example of this is that a white flower mated with a purple flower would produce a light purple offspring. Mendel disproved this theory, because when he

bred his flowers, the F1 generation, were all the original deep shade of purple. The colors did not mix as what was believed in the blending hypothesis. Mendel claimed that genes will retain their individuality generation after generation as a result of his experiment.

This is also why the human gene for red hair color may skip generations. The red coloring is not blended with the hair color of the other parent. Instead, the red is only masked by another version of the gene within the chromosome.

Chromosomes and Genes

But what are chromosomes? To put it simply, chromosomes are coils and coils of genetic information. Humans have forty-six chromosomes that are combined in pairs, which make it twenty-three pairs all in all. This happens, because humans are diploid organisms, meaning that we gain a chromosome from each parent's haploid sex cells, which contain twenty-three chromosomes in the sperm and another twenty-three in the egg cell. Once they combine, then the forty-six chromosomes come together to create a full genetic code. These chromosomes pairs are homologous, as these encodes for the same traits, and they link up because of the genes housed in their DNA.
Genes housed within the DNA are made up of specific parts of a chromosome and are used to determine the characteristics of an organism. Genes code for specific functions and characteristics in the body.

Within the body, genes sometimes work together to form a trait. This is called a polygenic trait. Other genes, called pleiotropic genes, affect multiple characteristics with only the single genes. Even less genes are encoded to form a single trait. This is the type of trait that Mendel studied with his peas, and we refer to it as a Mendelian Trait.

Determining Traits

Traits are determined by which form, or allele, of the gene is expressed. These alleles can be dominant, meaning they overpower the recessive gene. The expression of the trait is called the phenotype. Therefore, if the purple and white flowers bred together and produced purple flowers, then the purple coloring would be the phenotype.

Through Mendelian genetics, we can also determine that the purple flower is the dominant trait, because it was expressed over the white. The genotype is the combination of alleles within the gene. After gaining a chromosome from Mom and one from Dad you have two alleles. The genotype shows these alleles. This is usually noted as two letters, each representing an allele. Dominant traits are capitalized and the recessive is lowercase (Bb). For example, if your mother has blue eyes, a recessive trait, and your father has blue eyes, then each parent will have a genotype of two recessive alleles for blue eyes, or “bb”. They will pass one of each recessive allele down to you, causing you to also have two recessive alleles for blue eyes. Having two recessive alleles allows the recessive trait to show, causing the genotype to be homozygous recessive.

If your parents have brown eyes, the dominant trait, then it gets a bit more complex. Your parents could either have homozygous dominant, or BB, for brown eyes or heterozygous for brown eyes, or Bb. This is because the brown trait is expressed over the blue trait. This gives the child a fifty percent chance of being heterozygous, or brown-eyed, a twenty-five percent chance of being homozygous dominant, or brown-eyed, and a twenty-five percent chance of being homozygous recessive, or blue-eyed. This can be determined by a Punnett Square, which is a visual representation of trait distributions.

Another example of a trait that can be laid out like this is the ability to curl your tongue. We will say that the ability to curl your tongue is dominant (C) and the inability to curl your tongue is recessive (c). Classical Mendelian genetics dictates

that if your parents are both homozygous dominant, then all offspring will be able to curl their tongues. If the parents are homozygous recessive, then none of the offspring will be able to curl their tongues. If the parents are heterozygous, then the twenty-five percent will not be able to curl their tongues and seventy-five percent will be able to curl their tongues.

Not only did Mendel prove that the blending hypothesis was invalid, but he also provided a method to predict the outcome of the genes of the offspring by utilizing Punnett squares. After Mendel proved this he also proved that allele pairs segregate independently. Because of this, your eye color has no effect on your hair color. This is important, because without this, one faulty gene could alter your entire body composition! Mendel proved this with his peas as well when he simultaneously studied the shape of the pea and the color of the pea. He determined that the alleles for each of these traits did not affect each other. This can be represented in a dihybrid Punnett square as seen to the right. As you can see, the color expressed by the pea does not affect the shape expressed by the pea.

Why is this important to AP Biology?

These Punnett Squares show the variations on the genotypes and the chances of the gene being expressed as a certain phenotype. While this may seem trivial, this ability to predict how offspring will turn out is vital. Mendelian genetics began on a small level of crossing two single traits in a monohybrid Punnett Square. Mendel paved the way for scientists to uncover why certain genetic impairments act the way they do. Deafness, for example is a recessive trait; therefore, through Mendelian genetics scientists could determine why deafness could not be present in the parents but was present in the child. This was because the parents could be heterozygous and both pass on the recessive allele, causing the offspring to be deaf. This is one of the great applications of Mendelian genetics that has truly led to bettering the knowledge of genetics as a whole.

Mendelian genetics is also important to AP Biology and this AP Biology crash course, because knowing how genetic variation works sets the foundation for studying evolution. By understanding Mendel's Laws that state that alleles are individually segregated and that alleles separate as gametes, or sex cells, form, then Charles Darwin's Theory of Evolution is confirmed and even further supported. After all, how could the survival of the fittest come to be so fit without their initial genetic variation? It would not make any sense.

You were created by the ideas that the laws of Gregor Mendel convey. Your body started out as a single cell, a combination of a sperm cell and an egg cell. You not a clone of your parents, but you are your own individual with both the same and unique traits from each parent. This allows for genetic diversity in the population, which allows for each generation to become stronger than the last.

So yes, Mendelian genetics unlocked the study of genes and DNA to the rest of the scientific community. Those pea plants spurred curiosity, and in turn, changed Gregor Mendel into the properly named father of genetics. Did he figure out every aspect of genetics? No, of course not, but Gregor Mendel did build the groundwork for other scientists to build upon his work, which is science at its best.

Do you have a question about Mendelian genetics? Please ask us about it. Do you have a strange trait that has been passed down through your family? Please share!

Mitosis and Meiosis

Mitosis and meiosis are two ways existing cells will create new cells. Mitosis only takes place in eukaryotic cells. This is a method whereby the cell splits into two new cells, each with identical sets of chromosomes and a direct copy of the original cell. This is usually followed by cytokinesis, when the cytoplasm splits. Meiosis is a typical method for creating new sex cells (gametes) and creates four different cells. This helps ensure genetic variation for long-term survival of a species. For the AP Biology exam, it will help to know the stages of each process, and keep in mind the end results of each.

Mitosis

Mitosis has four main phases, though five stages may be recognized. Interphase is always seen as the first phase. It's in interphase that a cell spends most of its life. This is where, if looked at under a microscope, you wouldn't necessarily see anything interesting. The cell is mostly just growing. Interphase is, itself, divided into separate phases, G1 being the longest where the cell grows. In S-Interphase, DNA is duplicated, and in G2, it grows some more. M phase is where nuclei divide.

If you were to watch a cell undergo mitosis under a microscope, you would see the cell membrane quite stationary right up until the point where it suddenly splits. A cleavage furrow forms just before this moment, and then it essentially pinches itself together and apart. The nuclear membrane also does about nothing until the last moment when it fragments and then reforms in each cell.

A key player in mitosis is the centrosome. Centrosomes are made up of microtubules that form spindles during the process to help equally split the cell materials. They also are comprised of centrioles in the middle which help to organize the microtubules. Centrosomes replicate immediately.

The most important thing being split in cell formation is genetic material. In eukaryotic cells, which we'll mostly be discussing, genetic information is diploid. There are two pairs. Some cells are haploid, where only one copy of each exists. But in humans, as you may already know, there are 23 chromosome pairs to make 46 total chromosomes. These pairs are how we know it's diploid.

Chromosomes are basically just genetic information, tightly wound and condensed strands of DNA. This happens to allow for replication more simply. A chromosome is said to be made up of two sister chromatids attached at a centromere in the middle. Kinetochore is a protein at the center of the sister chromatids that will attach to microtubules during mitosis. All the chromosomes will line up before splitting and the sister chromatids are pulled apart, each going into a new nucleus. That is essentially interphase. DNA is copied, centrosomes replicate, and miotic spindles form.

In prophase, the DNA condenses and the microtubules attach. In a half-step called pro-metaphase, the nuclear envelope fragments. Microtubules attach to the kinetochores. In metaphase, all chromosomes have lined up in the middle, which is now called the metaphase plate. It's a very straight line, one of the straightest lines found in nature. One way to remember this step is the M's: meet, middle, and metaphase. In anaphase, chromatids separate. To remember this, you have "A" for "apart" and "anaphase." In telophase, cytokinesis occurs. Cells elongate and new nuclei form on each side of the cell. The cleavage furrow appears and pinches the cell into two. Daughter nuclei form and the microtubules that weren't attached to chromosomes help in this process. New nuclear envelopes are formed from the previously fragmented pieces, and the cycle continues with new cells.

Meiosis

This occurs during sexual reproduction and has four distinct phases: prophase, metaphase, anaphase, and telophase. The products of this process are four

genetically different cells. There are two of each chromosome in the beginning of this process. You have one from the mother and one from the father. There are hundreds of genes on each chromosome. During metaphase, because of the number of possibilities for ways a chromosome can line up (2^{23}), there are over 8 million variations of ways genetic material can end up being passed. When you then consider only one sperm will reach the egg, it makes for over 64 trillion possible outcomes. This is what gives us genetic variation through sexual reproduction.

The acronym for remembering the order of meiosis stages for the AP Bio exam is PMAT times two, because we will go through this twice with each pair of genetic materials. Interphase isn't generally considered to play a role in this process. The DNA is condensing into chromosomes, with two sister chromatids, and from there we move into prophase 1.

In prophase 1, chromosomes undergo synapsis. Sister chromatids from each parent come together and wrap around each other very tightly. They swap parts of their chromosomes. In crossing over, segments of the mother chromosome start sequencing in with the father chromosome.

In metaphase 1, all the chromosomes line up at the metaphase plate, similar to what we saw in mitosis. Spindles attach and centrosomes move to either side of the cell. Spindles then attach themselves to the centromeres of homologous chromosomes. In anaphase 1, we then see them pulled apart and split.

Telophase 1 is where new nuclei form on each side of the existing cell. Cytokinesis then splits the rest of the cell. And that's the first half of the process of meiosis.

In prophase 2, there is no more crossing over of genetic materials. In metaphase 2 the chromosomes have lined up and meet in the middle. Spindles attach to

each centromere, and then in anaphase 2 they are pulled to either side. Then you have telophase 2 and cytokinesis. In the end, four cells have been created.

So, now you know all about how cells replicate within organisms. What are the main differences between mitosis and meiosis? Can you diagram each process for the AP Bio exam?

Nucleic Acids

The scientific method is probably something you've used before AP Biology without realizing it. It's one way to analyze the world around us. The scientific method is known as having five basic parts, which vary slightly depending on your source: observing, questioning, hypothesizing, experimenting, and concluding. Another common way of expressing the method is to first ask a question and do background research, then write a hypothesis, make a specific prediction, test it, and draw a conclusion. Occasionally you'll see sharing the results as a sixth step.

Where did this all start?

The scientific method began, in many ways, in ancient Greece. Socrates began to analyze ideas and the world starting from a hypothesis. In fact, the Ancient Greek word "*hupóthesis"* means "base," as in a foundation. Abu Ali al-Hasan ibn al-Hasan ibn al-Haytham (often referred to as Ibn al-Haytham, or Alhazan) was a Muslim scholar who stressed the importance of forming questions and testing them, which was further advocated much later on by Galileo. Though the process has evolved in its more clear definition, it's been around a while, and now we have our few steps often used.

The Steps

The first step of questioning can refer to a very specific observation, such as "Why is grass green?" or it can more open-ended as in, "How can I cure cancer?" There may also be some research done in this step. Research may include gathering general background information that would be helpful in planning later steps of discovering answers to the question in mind, or perhaps looking over previous experimental data relating to the topic.

With the hypothesis, you are essentially making a guess as to the answer of that question. It can be quite a specific address to the question, or it may be a more broad conjecture. For example, if we're looking into curing cancer, your hypothesis could be something along the lines of, "A plant is going to cure cancer," or "this specific plant, *whatever it's called*, will cure cancer." A couple terms you may hear in the realm of hypotheses are null and alternative hypotheses. A null hypothesis is to guess that the statistical hypothesis (a guess about a population – maybe a test group for curing cancer and how a new drug will affect that group) is false. So if you think the drug will cure 100 of 100 people, the null hypothesis would say it wouldn't. An alternative hypothesis relates to the desired outcome. The drug will cure all participants is an alternative hypothesis.

In the prediction stage of the scientific method, you determine exactly what it is you're going to test. You want something that will be very unlikely to be found correct by simple coincidence. If you predict water will cure cancer, that water may contain trace elements that would affect the outcome. You'd be better taking a look at a particular type of molecule that can be easily isolated (water can be isolated, but you understand).

When you test your hypothesis, you are essentially determining if the real world behaves in the manner you've guessed. Experimentation is the way to figure this out. Experiments must be precise in order to limit variables, as results will

otherwise be inconclusive. By having a control group (a group where the tested scenarios don't apply – perhaps a placebo instead of an actual drug as in the cancer example), and only testing one variable in one experiment, it will be easier to determine how that variable has affected the outcome. As such, you will be able to actually learn something from the experiment.

Once an experiment is complete, the results are analyzed and conclusions are drawn. Typically results aren't considered conclusive until an experiment has been repeated many times. But hopefully all your time will pay off with data that shows a particular trend related to the dependent variable.

Now that you understand how to apply the scientific method, you can do this in many realms of your AP Bio class, as well as more in your own life. Wondering why you have bad luck on dates only on Friday nights? Want to know why the binding on every book but your science book is wearing away? Try it out!

Scientific Method

The scientific method is probably something you've used before AP Biology without realizing it. It's one way to analyze the world around us. The scientific method is known as having five basic parts, which vary slightly depending on your source: observing, questioning, hypothesizing, experimenting, and concluding. Another common way of expressing the method is to first ask a question and do background research, then write a hypothesis, make a specific prediction, test it, and draw a conclusion. Occasionally you'll see sharing the results as a sixth step.

Where did this all start?

The scientific method began, in many ways, in ancient Greece. Socrates began to analyze ideas and the world starting from a hypothesis. In fact, the Ancient Greek word "*hupóthesis"* means "base," as in a foundation. Abu Ali al-Hasan ibn al-Hasan ibn al-Haytham (often referred to as Ibn al-Haytham, or Alhazan) was a Muslim scholar who stressed the importance of forming questions and testing them, which was further advocated much later on by Galileo. Though the process has evolved in its more clear definition, it's been around a while, and now we have our few steps often used.

The Steps

The first step of questioning can refer to a very specific observation, such as "Why is grass green?" or it can more open-ended as in, "How can I cure cancer?" There may also be some research done in this step. Research may include gathering general background information that would be helpful in planning later steps of discovering answers to the question in mind, or perhaps looking over previous experimental data relating to the topic.

With the hypothesis, you are essentially making a guess as to the answer of that question. It can be quite a specific address to the question, or it may be a more

broad conjecture. For example, if we're looking into curing cancer, your hypothesis could be something along the lines of, "A plant is going to cure cancer," or "this specific plant, *whatever it's called*, will cure cancer." A couple terms you may hear in the realm of hypotheses are null and alternative hypotheses. A null hypothesis is to guess that the statistical hypothesis (a guess about a population – maybe a test group for curing cancer and how a new drug will affect that group) is false. So if you think the drug will cure 100 of 100 people, the null hypothesis would say it wouldn't. An alternative hypothesis relates to the desired outcome. The drug will cure all participants is an alternative hypothesis.

In the prediction stage of the scientific method, you determine exactly what it is you're going to test. You want something that will be very unlikely to be found correct by simple coincidence. If you predict water will cure cancer, that water may contain trace elements that would affect the outcome. You'd be better taking a look at a particular type of molecule that can be easily isolated (water can be isolated, but you understand).

When you test your hypothesis, you are essentially determining if the real world behaves in the manner you've guessed. Experimentation is the way to figure this out. Experiments must be precise in order to limit variables, as results will otherwise be inconclusive. By having a control group (a group where the tested scenarios don't apply – perhaps a placebo instead of an actual drug as in the cancer example), and only testing one variable in one experiment, it will be easier to determine how that variable has affected the outcome. As such, you will be able to actually learn something from the experiment.

Once an experiment is complete, the results are analyzed and conclusions are drawn. Typically results aren't considered conclusive until an experiment has been repeated many times. But hopefully all your time will pay off with data that shows a particular trend related to the dependent variable.

Now that you understand how to apply the scientific method, you can do this in many realms of your AP Bio class, as well as more in your own life. Wondering why you have bad luck on dates only on Friday nights? Want to know why the binding on every book but your science book is wearing away? Try it out!

Transcription and Translation

You're probably already familiar with what DNA is. You know, that stuff in your blood with the genes that give you so many of the traits you've come to find about yourself (and some you maybe haven't – just wait until that receding hairline shows up 10 years from now). But what about RNA, DNA's slightly less popular cousin? It's just as important in so many ways, but not quite as discussed.

The major differences between the two are the sugar, of course. Here we see ribose instead of deoxyribose. RNA is also only composed of one strand, not two like in DNA's ever-so-famous double-helix structure, and has uracil (U) instead of thiamine (T). So adenine will bond with uracil in strands of RNA. Lastly, RNA can be found in both the nucleus and cytoplasm of a cell, unlike the DNA which resides only in the nucleus.

Looking at the processes we're about to cover in a big picture, transcription is shifting from DNA to RNA. Translation then moves us from RNA to a protein. These two processes are important to know for the AP Biology exam. You will often see several questions on genetics, and may even find a free response question on the subject.

How Does Transcription Work?

When it comes to transcription, what we're essentially doing is building genetic materials, much like you might build any other complex structure. The DNA is like our instructions, or blueprint. It's hard to build that Lego castle without the instructions (if you want it to look right). The messenger RNA (mRNA) is copied from the DNA and serves as the working copy of that blueprint. The building site is the cytoplasm in a prokaryote, or endoplasmic reticulum (ER) in a eukaryote. Amino acids serve as the building material, and the laborers are ribosomes and transfer RNA molecules.

As DNA is forever caged within the nucleus, the mRNA must copy it to build new proteins. RNA polymerase carries this out, reading a strand of DNA and adding nucleotides in reverse fashion because it can only add nucleotides to one end, the end it reads last. RNA polymerase needs a promoter to get started. The rate of transcription is modified by other proteins referred to as activators, repressors, and possibly coactivators or corepressors.

RNA polymerase and any transcription factors bind to the promoter in the DNA. The promoter is a section of DNA that initiates transcription, near the 5' part of the sense strand. The sense strand is the non-template strand of DNA, also called the coding strand, as it will be sequenced identically to the new mRNA strand. The template strand of DNA may be called the anti-sense strand. The RNA polymerase and transcription factors then unwind and unlink the two strands of DNA. From there, matching begins as complementary nucleotides are brought in to form the copy strand which is becomes the new mRNA. Once it reaches a stop codon, the transcription halts. Introns are cut out, a cap is added to the strand, and a tail of adenines is added to the other end. We now have our mRNA. Would you be able to diagram the process for the AP Bio test?

The process of creating DNA from RNA also occurs at times, and is called reverse transcription. Some viruses, including HIV, operate in this matter. The newly created DNA will insert itself into the host DNA, and in that way can affect the host organism.

OK, so what's Translation?

Translation is the process in which cellular ribosomes create proteins. Ribosomes read the mRNA sequence and translate it to the amino acid sequence of the protein (the amino acid sequences can also be referred to as polypeptides, basically just meaning more than one amino acid). It starts at the amino acid AUG and reads three nucleotides at a time (a codon) until it reaches a stop codon (UAA, UAG, or UGA). Along the way, each mRNA codon is matched against the

tRNA anti-codon. If they match, the amino acid is transferred and added to the growing protein chain.

The ribosome builds around the target mRNA. The first tRNA (transfer RNA) is attached at the start codon. The tRNA then transfers an amino acid to the tRNA corresponding to the next codon. It's basically serving as the middle-man or bridge in the process of bring new nucleotides into the new chain. Peptide bonds attach the new pieces. The ribosome then translocates to the next mRNA codon to continue. The polypeptide (chain) is released after the stop codon is reached. Hopefully you can draw a simple diagram explaining this in preparation for the AP Biology exam.

So now you know a bit about how new proteins are formed from existing DNA within your body and the bodies of other living organisms. How would you metaphorically explain the processes of transcription and translation? Do you understand their importance in how we live?

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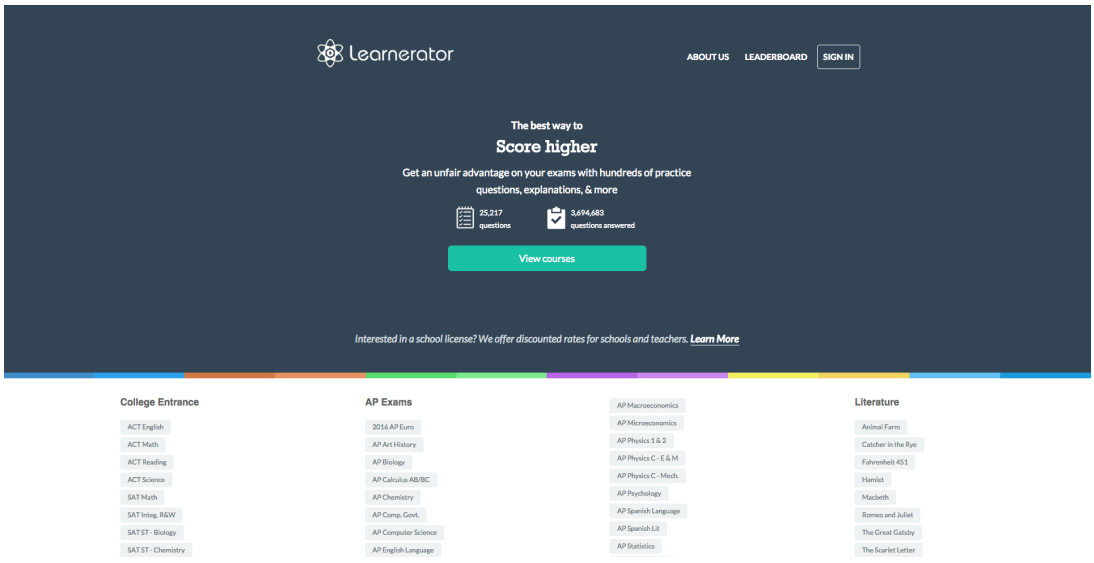

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