Unit Essentials:

1. ☑ 2.1 Unit map
2. ☑ 2.2 Traffic light

2 - Traffic Light

Term	Pre-Assessment	Post-Assessment
aero-	🟩	🟩
an-	🟥	🟩
chlor-	🟩	🟩
-elle	🟩	🟩
hapl-	🟩	🟩
homo-	🟩	🟩
re-	🟩	🟩
-sis	🟩	🟩
zyg-	🟩	🟩
hyper-	🟩	🟩
hypo-	🟩	🟩
endo-	🟩	🟩
exo-	🟩	🟩
osmo-	🟩	🟩
Prokaryotes	🟩	🟩
Eukaryotes	🟩	🟩
Diffusion	🟩	🟩
Osmosis	🟩	🟩
Aquaporin	🟩	🟩
Hypotonic	🟩	🟩
Hypertonic	🟩	🟩
Isotonic	🟩	🟩
Endocytosis	🟩	🟩
Exocytosis	🟩	🟩
Phospholipid	🟩	🟩
Amphipathic	🟩	🟩

3. 2.3 Test topics

3 - Test Topics

Test Topics

- Prokaryotic vs. eukaryotic cells
  - Prokaryotes are thought to be the evolutionary ancestors of the eukaryotes due to their comparative simplicity and lack of certain organelles and a nuclear envelope.
- Why are cells small?
  - To maximize SA:V ratio in order to maximize transfer of molecules in and out of the cell
- Organelles – function and structure
  - They all have different purposes for the cell ranging from breaking down energy to providing protection and structure for the cell
- Where is DNA found?
  - In the nucleolus
- Plant vs. animal cells
  - Plants have additional chloroplasts and a cell wall
- Endosymbiosis theory
  - When cells get incorporated into other cells
- Endomembrane system
  - Consists of the nucleus, rough ER, ribosomes, lysosomes, smooth ER, and the golgi
- Structure of the cell membrane – components and functions and Fluid mosaic model
  - Has a phospholipid bilayer and has many different channels, receptors, and other things that go through the wall
- Membrane responses to cold
  - Cell signalling happens in order to maintain homeostasis
- What does amphipathic mean?
  - Both hydrophobic and hydrophilic
- How do different types of molecules get through the cell membrane?
  - Either through diffusion or with a transport protein or not at all
- Passive transport vs. active transport and types of each
  - passive goes down the gradient without a protein
  - active goes up the gradient with a protein and energy
- Types of bulk transport
  - There are vacuoles and endo/exocytosis
- Specific types of transport – sodium/potassium pump and cotransporters
  - Transports stuff two ways with only specific molecules
- Isotonic/hypotonic/hypertonic and effect on cells – difference in plants and animals

    - iso means equal, hypo means less (pushes water in), hyper = more(sucks water).
- How does water get through the cell membrane
    - Diffuses through
- Water potential – factors that change movement of water
    - Pressure, gravity, concentration, temperature (theres more)
- Lab concepts – diffusion/osmosis
    - moving through a membrane just cuz you can

4. ☑ 2.4 Unit summary

4 - Unit Summary

Objectives:

1. Be able to discuss the evolution of cells including the endosymbiont theory.
    - Slow evolution and modification of dna leads to different cells and cells that adapt better to their environment and those that leard how to defend themselves as well. Endosymbiosis is when cells incorporate other cells as part of themselves to create a megacell.
2. Be able to differentiate between prokaryotic and eukaryotic cells according to the types of organelles are contained in each and in which organisms.
    - check for nuclear envelope
3. Be able to identify the differences between plant and animal cells (organelles).
    - Check for chloroplasts and cell wall
4. Be able to diagram the structure of the cell membrane and discuss its function.
    - Phospholipid bilayer with a bunch of proteins in it
5. Be able to discuss the principles of osmosis and diffusion in plant and animal cells.
    - Flows from high to low concentration (of water)
6. Be able to explain the difference between active and passive transport.
    - Passive is with gradient, active is against and uses a protein and energy
7. Be able to discuss and give examples of endocytosis and exocytosis in cells.
    - When the bilayer folds around molecules to take them into the cell

Essential Questions:

- How do shared conserved cellular processes support the idea that all organisms are linked by lines of descent from common ancestry?
    - It would be practically impossible for two completely independent evolutionary processes to create the same system without sharing something
- How do cells create and maintain internal environments that are different from their external environments?
    - With the cell membrane selectively allowing what can come in the cell. Also sometimes it can expel extra substances.
- How do structure and function of subcellular components and their interactions provide essential cellular processes?

    - No one thing can do everything, so this allows the cell to do complicated things, like how mitochondria cant directly break down glucose, but only pyrivic acid
- How do cells maintain dynamic homeostasis by the movement of molecules across membranes?
    - Allowing or blocking protein channels

5. ☑ 2.5 Official AP Biology unit summary
6. ☑ Topic review guides
    1. ☑ 4.1-4.5 Signal Transduction and Feedback

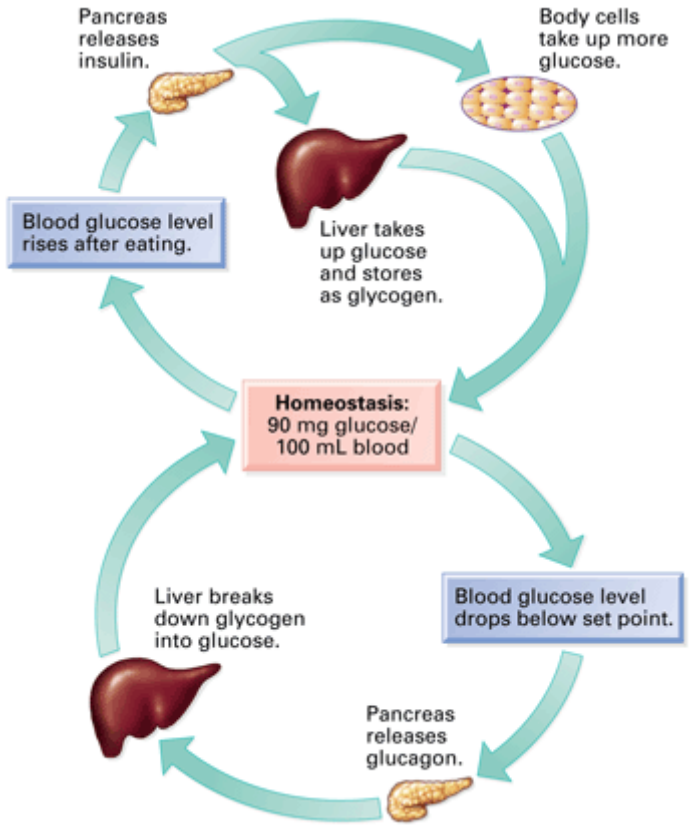
4.1-4.5

1. Describe specific examples of each of the following ways that cells can communicate with each other:
    1. No distance
        - Directly through gap junctions
    2. Short distance
        - Signals can get sent out quickly and into the new cell
    3. Long distance
        - Signals get sent through the bloodstream
    4. Local regulators
        - When signals effect the cells in the vicinity
2. Describe a signal transduction pathway. Create an illustration that represents what one of these might look like, and describe the three major steps that occur in this pathway that allow communication to occur.
    - Reception, Transduction, and Response
3. Explain the relationship between the following components of a signal transduction pathway:
    1. Ligand (first messenger)
        - The thing that gets recepted
    2. Receptor
        - The thing that recieves the receptor and sets something else off
    3. Second messenger
        - The thing that goes and activates later parts of the chain often through oxidative phosphorylation
4. Compare the actions in a signal transduction pathway to making a phone call. How are these two things alike?
    - It goes through so many different steps, and if any of the chain is broken the whole chain is broken
5. Describe how signal information is transduced into cellular responses in the cytoplasm and nucleus.
    - Often proteins are phosphorylated which activated their active site in order to produce something
6. Describe how it is possible for a single molecule of epinephrine to cause a cell to release thousands of molecules of glucose from glycogen during the

fight or flight response

- A protein that has been phosphorylated, which is probably an enzyme can produce many molecules, not just one

7. Explain how a crowd cheering at a football game is like quorum sensing in bacteria.
    - Imagine everyone is blind. If everyone cheers, you can guess the amount of people around you from the volume of the cheers. Same for quorum sensing, everyone emits a certain signal, and when there is enough of that signal you know there are a lot of other people around
8. Explain how mutations can affect signal transduction pathways.
    - A mutation in a secondary messenger could probably mess up the whole chain, making it completely ineffective. Alternatively the mutation may create a different product, having different effects on the cell.
9. Describe how chemicals can inhibit or activate a signal pathway.
    - chemicals can inhibit enzymes and prevent them from doing things, and some enzymes can only be activated when phosphorylated
10. Create a t-chart that compares and contrasts positive and negative feedback loops.
    - negative feedback loops balance out at a certain concentration, while positive ones just keep on going out of control
11. Using the diagram below, explain why the regulation of blood sugar is an example of a negative feedback loop.



    - When its too high, it gets taken out, while when it is too low, more gets put in

2. ☑ 4.6-4.7 Cell Cycle and Regulation

4.6-4.7

1. Write a hashtag that describes the major event of each of the following stages of the cell cycle:
    1. G1 phase
        - Growth
    2. S phase
        - Synthesis
    3. G2 phase
        - Prep
2. Cells can enter a non dividing phase known as G0. Explain how it is possible for a cell to enter and exit this non dividing phase of the cell cycle.
    - When enough of a certain signal is present it will exit. But otherwise it will be in G0 because it is not ready to grow yet
3. Describe what the goal of mitosis is. Identify two instances in which the cells of an organism would undergo this process.
    - Split the cell into two
4. Explain the difference between haploid and diploid chromosome numbers.
    - Haploids only have one of each chromosome while diploids have two
5. Draw a picture to illustrate the difference between a chromatid and a chromosome.
    - chromatid is just one wing of the butterfly
6. Create a Venn Diagram that shows the relationship among these terms: DNA, gene, genome, chromatin, chromosome, chromatid.
    - gene on genome on chromatin on chromatic on chromosome which makes up DNA
7. The term “mitosis” is Greek in origin and means “division of the nucleus.” Explain how the steps of this process fit the definition of the word.
    - PMAT, the cell splits into two
8. Explain how the spindle apparatus ensures that daughter cells receive a full copy of the genetic material of the parent cell.
    - It pulls apart two exact copies of the DNA in chromatids
9. The cell cycle is regulated by several checkpoints as well as a class of specialized protein kinases known as cyclin-dependent kinases. Explain how cyclin and the cyclin-dependent kinase interact to propel a cell through the cell cycle.
    - Different levels of CDKs trigger and begin different stages of the cell cycle
10. The cell cycle is controlled by a multitude of factors. Explain the role of each of the following in ensuring that cells divide appropriately.
    1. G1
        - Cell size
        - Nutrients

    - DNA health
2. S
    - DNA replication
3. G2
    - Cell size
    - DNA
4. M
    - Spindle attachment

11. Compare and contrast healthy cell division with cancer development.
    - Dying when stuff is wrong, stopping cell growth when cell is too small

Activity Log:

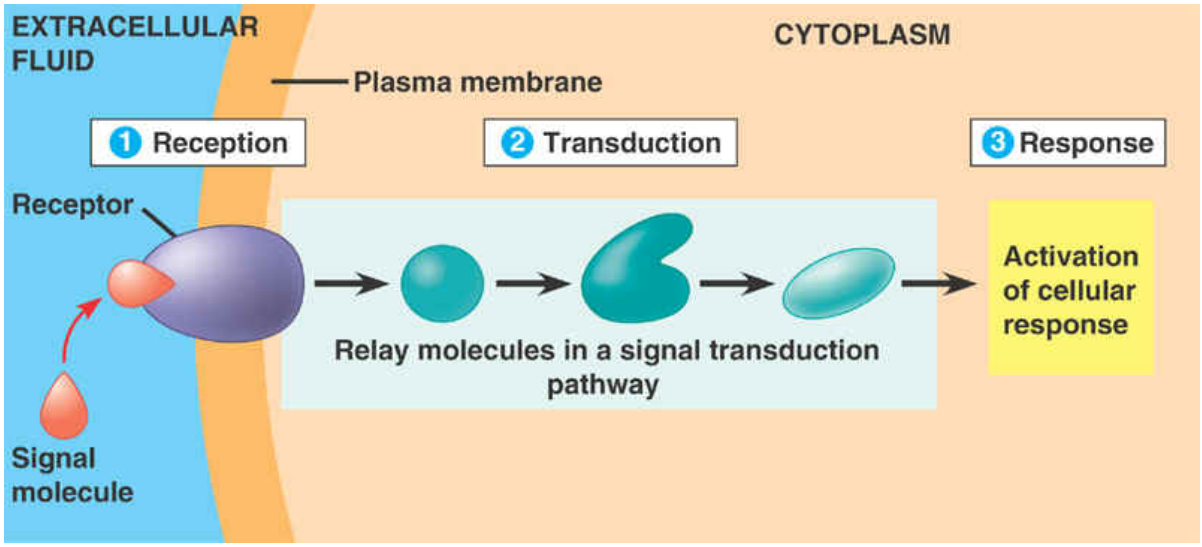
1. ☑ BR: This too shall pass discussion (1-page short response)

1 - This too shall pass - Rube Goldburg Machine

1. He hit it pretty hard
    1. If it was harder it probably would have worked
    2. If it was softer it may have not activated
2. Each step is required to lead to the next thing, if one fails, everything else will fail
3. They would get a lot of paint on them?

2. ☑ BR: Signal Transduction Pathway Diagram

2 - Signal Transduction Pathway Diagram

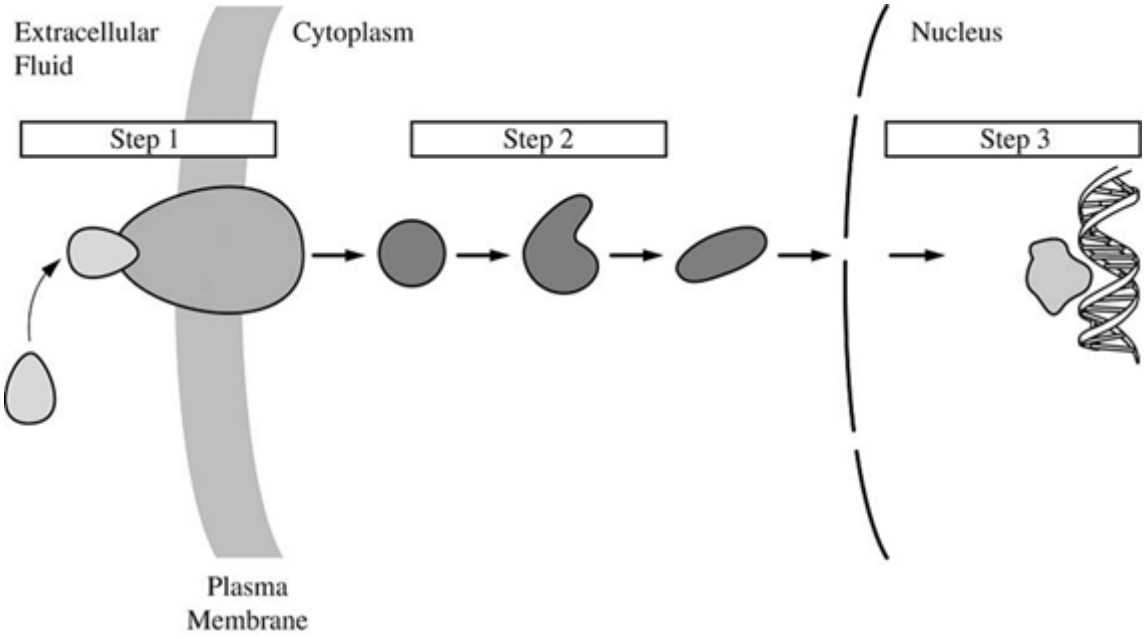


1. **Describe** the type of molecule the receptor in this model most likely is composed of.
    - Proteins
2. **Predict** what would happen if the receptor molecule's shape were to be changed in some way.
    - It would not bind to the signal molecule and the chain would not be activate
3. **Explain** how the transduction process here is like a set of dominoes that fall.
    - If one is missing then the whole chain doesn't work at all

4. **Describe** a cellular response that could be elicited from this type of signaling pathway.
    - Production of glycogen from glucose

3. BR: Practice FRQ - Cell Signaling

3 - Practice FRQ - Cell Signaling

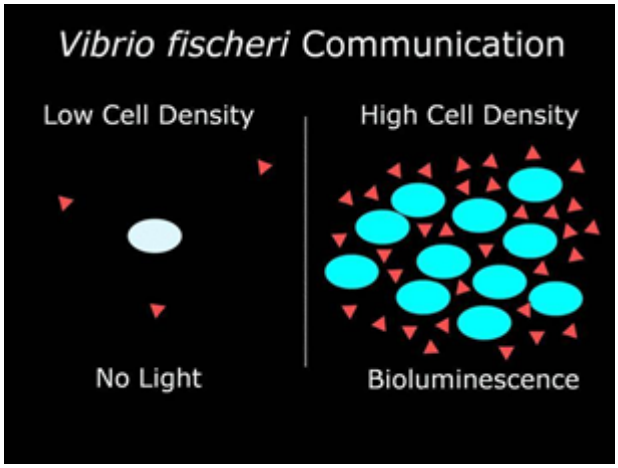


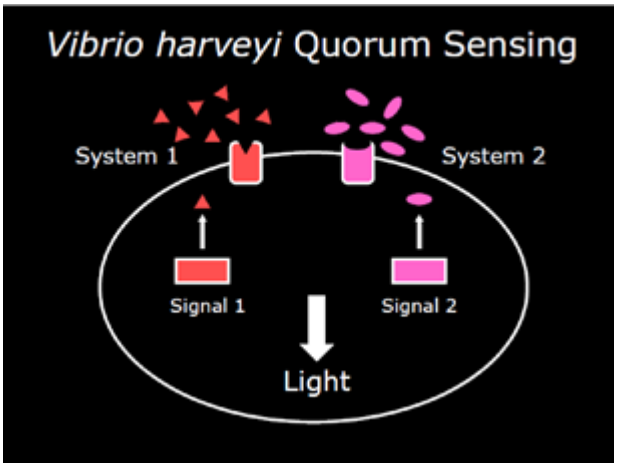
1. The figure above represents a generalized hormone-signaling pathway. Briefly explain the role of each numbered step in regulating target gene expression.
    1. Reception - The signalling molecule is received and the chain propagates
    2. Transduction - The signal gets set down the chain by modifying proteins and enzymes and what they produce by either inhibiting them, phophorylating them, or modifying their characteristics
    3. Response - The end of the chain is carried out (often production or destruction of a certain molecule)

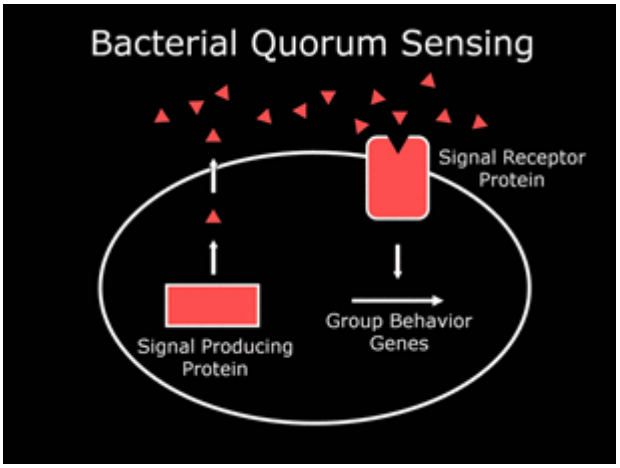
4. BR: Quorum Sensing

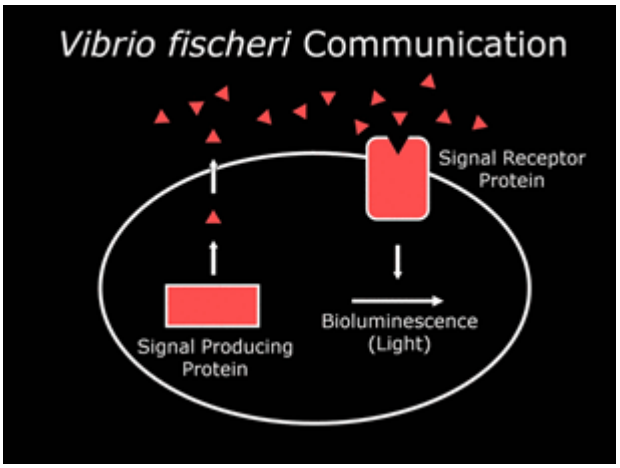
4 - Quorum Sensing

Quorum Sensing Diagrams: Using the diagrams below, write a brief summary of what is happening in each one.









1. Vibrio fischeri is only enacting bioluminecence when there is a high cell density
2. Two separate signalling chemicals being uneffected by each other
3. Quorum sensing through the concentration of a signal chemical
4. Quorum sensing specifically in Vibrio fischeri, creating bioluminescence

5. ☑ BR: Feedback Loop Summary

5 - Feedback Loops

POSITIVE FEEDBACK LOOPS

A feedback mechanism resulting in the amplification or growth of the output signal

NEGATIVE FEEDBACK LOOPS

A feedback mechanism resulting in the inhibition or the slowing down of a process

Breakdown the homeostasis of the system

Less common but, occur in specific situations

Ex: childbirth, blood clotting, and fruit ripening

Always maintain the conditions of homeostasis

Occur more often in the body, helping in maintaining various conditions of the body

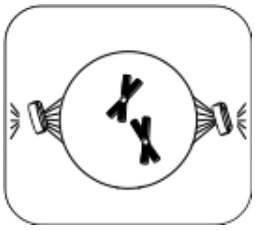
Ex: regulation of body temperature, blood pressure, and fluid content

6. ☑ BR: Stages of Mitosis

6 - Stages of Mitosis

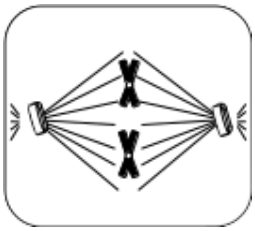
Interphase

- Chromosomes are threadlike as DNA is unwound so that genes can be transcribed.
- Nucleolus is visible
- DNA replicates, making two identical copies of itself.



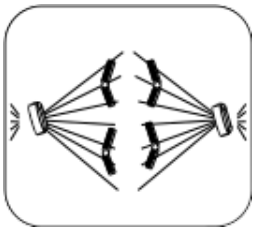
Prophase

- Chromosomes coil up and shorten, becoming visible...
- ... each chromosome consists of two copies called chromatids which are joined at a centromere
- Centrioles move to opposite sides of nucleus and spindle fibres start to form
- Nuclear membrane breaks down at end of prophase.



Metaphase

- Chromosomes line up along the equator of the spindle
- Centromeres attach themselves to the spindle.

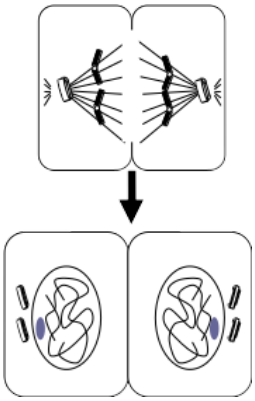


Anaphase

- Daughter chromatids are drawn by the centromeres.
- Chromatids move along the spindle towards opposite ends of the cell.

Telophase & Cytokinesis

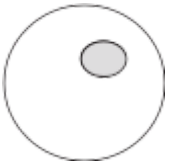
- Spindle breaks down

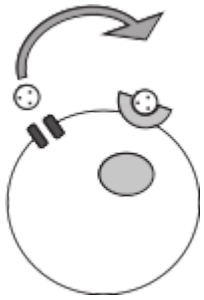


- Nuclear membrane and nucleolus reform in each daughter cell
- Chromosomes unwind
- Cytoplasm constricts to form two separate daughter cells (Cytokinesis).

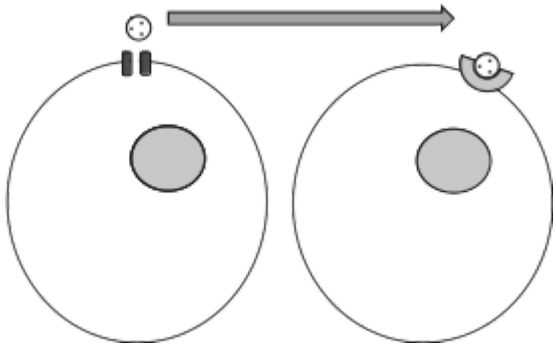
7. POGIL: Cellular Communication

1 - Cellular Communication

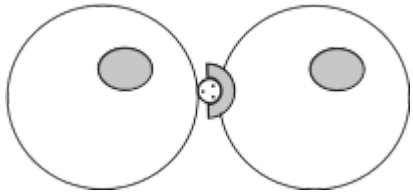
1. Consider the diagrams in Model 1 of four types of cellular communication. Match each of the shapes below with a label at the right.
    1.  Signalling molecule (ligand)
    2.  Cell
    3.  Membrane Channel
    4.  Receptor
2. Describe how the shape of the ligand (signaling molecule) and the shape of the receptor are related.
    - The ligand fits perfectly into the active site of the receptor, binding together. They have inversely matching shapes
3. Which of the cellular communication methods in Model 1 appear to be for signaling between cells that are in close proximity?
    - B or C, C is close proximity while B is touching
4. Which of the cellular communication methods in Model 1 appear to be for signaling between cells in different parts of an organism (long-distance communication)?
    - D, it goes down the bloodstream
5. In which of the cellular communication methods would a ligand (signaling molecule) need to have the longest “life”? Explain your reasoning
    - D, it needs to travel all the way down the bloodstream
6. Use the four terms below to label the diagrams in Model 1. Word-part definitions are given to help you determine the meanings of each term.
    1. Autocrine (auto = self)



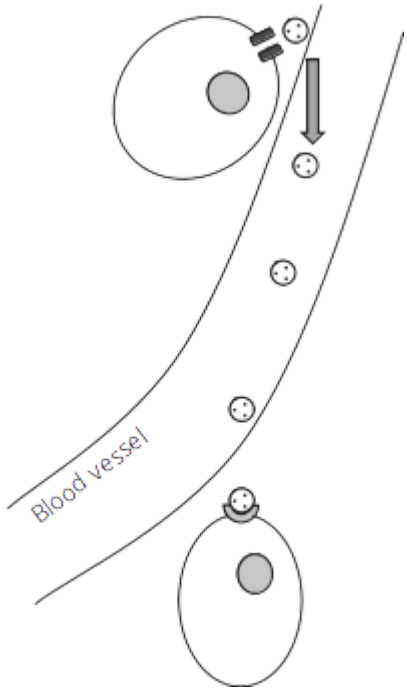
2. Paracrine (para = nearby)



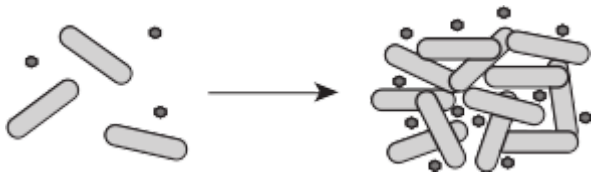
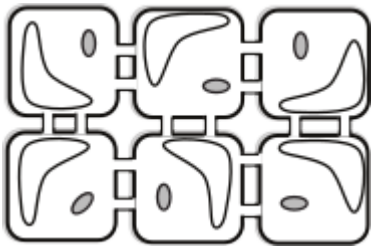
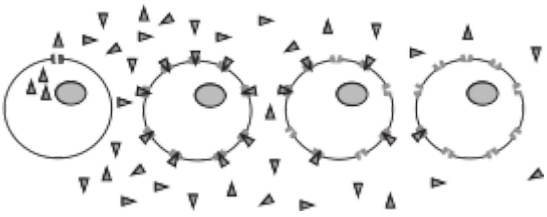
3. Juxtacrine (juxta = beside, next to, touching)



4. Endocrine (endo = within)

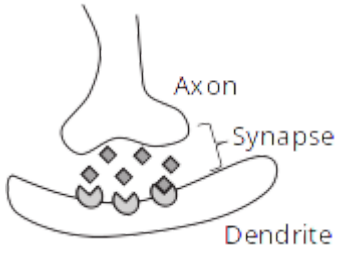


7. Cellular communication takes place for a variety of reasons — mating, defense mechanisms, homeostasis, growth, etc. Discuss the following question with your group and make a prediction: “Do all ligands for cellular communication have the same chemical structure (shape)?” Provide specific reasons or examples to support your prediction.
    - No, if they did then all receptors would receive all signals, which would lead to the same signal signalling everything

8. Consider each of the following cellular communication examples. Divide the work among group members. Have each group member determine which type of signaling is being used in their scenario (autocrine, juxtacrine, paracrine or endocrine), and then present their reasoning to the group
    1. **Quorum sensing** is used by bacteria to determine the population density of their species in a local area. (Many bacterial functions would be ineffective in small numbers—infecting a host organism with a toxin, for example—and would therefore be a waste of energy and resources to the bacteria.) Each bacterium produces a ligand. Once the concentration of that ligand reaches a critical concentration, thus indicating a sufficient population density for the response to be effective, all bacteria will respond simultaneously
        1. 
        - Autocrine and paracrine, as it receives its own signals as well as the ones nearby
    2. Plants construct channels between cells called **plasmodesmata** that allow ligands to move directly from one cell to another throughout the plant structure.
        1. 
        - Paracrine, its going directly to a cell touching the other one
    3. **Morphogens** are produced in embryos from a central source early in development. They diffuse throughout the tissue creating a concentration gradient that provides a spatial reference for developing cells. Cells far from the morphogen production will develop into one type of tissue while cells close to the source will develop into a different type of tissue. This allows for differentiation of cell structure early in embryotic development.
        1. 
        - Paracrine, it only signals nearby cells
    4. Cells in the human pancreas release insulin when blood sugar levels are elevated. The insulin signals cells in the liver to begin absorbing glucose and convert it to glycogen for storage.
        - Endocrine, it sends it across the body through the bloodstreams
9. Consider each of the following cellular communication examples. Divide the work among group members. Have each group member determine which type

of signaling is being used in their scenario (autocrine, juxtacrine, paracrine or endocrine), and then present their reasoning to the group.

1. **Pheromones** released by a female gamete cell (egg) provide a pathway for the male gamete cell (sperm) to travel, increasing the possibility of fertilization.
    - Endocrine, it signals it far away through the bloodstream
2. Some cancer cells release their own growth hormone rather than relying on growth hormones from the host organism or from other cells. This presents challenges to cancer researchers looking for ways to slow the growth of cancer cells.
    - Autocrine, it stimulates itself
3. **Neurotransmitters** are ligands that are released from the axon of one nerve cell to the dendrite of another nerve cell. This helps to propagate the signal across several cells.

    1.
    - Paracrine, because they are nearby
4. Cells in the pituitary gland produce thyroid stimulating hormone (TSH), which is received by cells in the thyroid. The arrival of TSH in the thyroid triggers production of several hormones, which then travel throughout the body to regulate metabolism.
    - Endocrine, it travels through the bloodstream

10. If a medical researcher wanted to prevent communication between cells in order to cure a disease or prevent a malady, how might they achieve that? Propose two or more general methods that could be used to stop a signal transmission from cell to cell.
    - Prevent the signal from being emitted, or destroy the receptors so that it wouldn't be received. Alternatively, you could break the signal transduction chain.
11. If a medical researcher wanted to enhance communication between cells in order to cure a disease or prevent a malady, how might they achieve that? Propose two or more general methods that could be used to enhance signal transmission from cell to cell.
    - Add more receptors to the cells or stimulate cells to emit more signalling molecules
12. The examples of cellular communication used in this activity vary from bacteria to plants to vertebrates. However, the mechanisms of cellular communication are similar among varied species. Explain how scientists might use cellular communication systems to show evolutionary relatedness between species.
    - Show that the signals and receptors used are similar, this shows that they are highly likely to come from the same evolutionary process.

13. Some hormones such as estrogen and testosterone are lipids and are therefore nonpolar. Explain why a receptor protein would not be needed for this type of ligand to activate a response in a cell.
    - They can already diffuse through the phospholipid bilayer into the cell without the help of a receptor or channel.
14. Suggest some stimuli that might cause a cell to release a ligand and begin communication between cells.
    - Heat or cold, high blood sugar

8. ☑ POGIL: Signal Transduction Pathway

2 - Signal Transduction Pathway

1. According to Model 1, does the signal transduction pathway occur inside or outside of a cell?
    - Inside
2. Compare the shape of the ligand in Model 1 to the shape of the receptor protein
    - They match perfectly so that the receptor can properly receive the ligand
3. The four steps in the signal transduction pathway are listed below. Label the diagram above with the Roman numerals to indicate where on the diagram each step is taking place.
    1. Signaling
        - The Ligand outside of the cell
    2. Reception
        - The receptor on the membrane
    3. Transduction
        - The Relay proteins
    4. Response
        - The big stars after the proteins
4. Based on the diagram in Model 1 and your labels, propose a definition for “transduction” in the context of the signal transduction pathway
    - Conversion
5. Amplification often occurs during the transduction step in the signal transduction pathway.
    1. Define “amplification” as it is used in everyday language.
        - Multiplication and Boosting
    2. Explain how the signal in Model 1 was amplified.
        - When it went from relay protein 1, it went to 3 of the relay protein 2
6. List several possible responses that could occur due to a signal being received by a cell. (Hint: There are several listed in the Why? box.)
    - A gene is turned on
    - A protein is manufactured
    - An enzyme is activated
    - Cell divides or dies
7. Once the response is achieved in a cell, what would need to occur to stop the response?

- Stop the signalling and either destroy or inhibit the enzymes that were produced

8. Refer to Model 2. Describe the event that sets off a phosphorylation cascade inside of a cell.
    - Reception of the ligand
9. **Phosphorylation** is a process that adds a phosphate group onto a protein to "activate" it—that is, to change its shape enough that it can function properly.
    1. Which step(s) in the phosphorylation cascade illustrated in Model 2 include phosphorylation?
        - 4 and 5
    2. Where do the phosphate groups come from that are added to the proteins during phosphorylation?
        - From the ATP becoming ADP
10. According to Model 2, what class of enzymes performs phosphorylation?
    - Protein kinases
11. Identify the steps in Model 2 that represent reception, transduction, and response for the phosphorylation pathway
    1. Reception
        - 1
    2. Transduction
        - 2, 3, 4, 5, 6
    3. Response
        - 7
12. What is the cell's response to the signal received in Model 2?
    - Transcribing a part of the DNA
13. In Model 2, steps 3, 4, and 5 are shown as amplification steps. Describe what that means in terms of this signal transduction pathway example.
    - One signal would produce multiple signals, meaning it would increase the effect of a single signal
14. What advantage would there be to an organism if the signal transduction pathway had several amplification steps?
    - It would be harder for a signal to accidentally go unnoticed, it is more likely to be acted upon
15. Describe what would occur in the cell if the activated protein kinase enzymes continued to be active for a long period of time.
    - The signals would be highly concentrated and would activate a lot of other functions
16. What would need to occur in the cell to deactivate the protein kinase enzymes?
    - Dephosphorylation or inhibitors
17. Protein phosphatases are enzymes that remove phosphate groups from proteins. Complete the illustration in Model 2 by adding at least two protein phosphatases (PP) to show how the cell is returned to inactive status.

- The PPs will remove the phosphate group from all activated proteins produced in steps 4 and 5

18. Although signal transduction pathways vary among species, there are several common elements. Explain how a biologist might use details about signal transduction pathways used in different species as evidence for evolutionary relatedness.
    - If they share similar signals and receptors to produce the same cellular response, it is highly unlikely that they evolved separately from each other
19. Consider the signal transduction pathway in Model 3. What event begins the process of producing a cellular response?
    - Reception of the signal
20. Locate the secondary messenger molecules in Model 3.
    1. Describe the type of diffusion that is used to get the secondary messengers into the cell.
        - Facilitated diffusion
    2. What activates or opens the transport protein channel that allows the secondary messengers to enter the cell?
        - The active relay protein from the receptor
21. Within an organism it is critical that signals between cells are very specific. For example, if ligand A is meant to activate immune system cells to reproduce in response to an infection, it should not also cause other cells to grow as if they had received a growth hormone. When a ligand is released, what prevents all of the cells in the body from being affected?
    - Not all cells have the matching receptor for this specific signal

9. ✅ POGIL: Cell Cycle

3 - Cell Cycle

1. Describe what would occur in the cell if the activated protein kinase enzymes continued to be active for a long period of time.
    - It would just produce too many signals and uncontrollable cell growth
2. Starting at the starred cell, what is the order of the stages of a cell's life?
    - Growth
    - Synthesis
    - Growth
    - PMAT (mitosis)
3. During which phase does the size of the cell increase?
    - G1 and G2
4. During which phase does the number of cells increase?
    - Cytokinesis (after mitosis)
5. Considering your answer to Questions 3 and 4, identify two ways that the growth of an organism can be accomplished through the events of the cell cycle.
    - More cells = more growth

6. Cancer, the uncontrolled growth of cells, often results in a tumor, or mass of abnormal cells. Some cancerous tumors consist of many cells that are much smaller than normal. According to Model 1, what part(s) of the cell cycle is (are) most likely being affected?
    - The checkpoints, G1, and G2
7. In Model 1, if the length of the arrow represents time, then for those cancerous cells, what happens to the time that is necessary for the cell cycle? What implication might this have for doctors who are treating cancer patients?
    - G1 and G2 are shortened
8. Model 2 presents cell cycle data for a typical human cell in culture. Use the phase names in Model 2 to label the G, M, and S phases in Model 1.
    - Gap, Mitosis, Synthesis
9. Looking at the third column of Model 2, compare the time spent in mitosis with the time spent in G1 in human cells and describe any difference.
    - G1 takes 11x longer than Mitosis
10. Imagine 100 cells were chosen randomly from a tissue sample and examined under a microscope. In which phase of the cell cycle would you expect to find the largest number of cells? Explain.
    - Gap 1 because it takes the longest
11. Look again at Model 2. Compare the amount of DNA at the beginning and end of synthesis. Why did the amount of DNA change?
    - Half of it went to one cell and the other half to the other
12. Fill in the “Key Process” column for synthesis phase in Model 2.
    - DNA is duplicated from one chromatid to two per chromosome
13. *Cyto = cell*, *kinesis = cutting*. What do you think takes place during cytokinesis?
    - The cell gets split from one into two
14. Other than cytokinesis, what else occurs during the mitosis phase? Hint: Consider the sets of DNA in each cell.
    - DNA gets separated into the two cells
15. Look carefully at information given to you in Model 1 and Model 2. Fill in the key process column in the table for G1.
    - Cell grows and key proteins and enzymes needed for synthesis are made
16. If a culture in the lab starts with one human cell, how many cells will there be after 24 hours?
    - 2
17. The total time for the phases listed in Model 2 is 24 hours. How many human cells will be in the culture after another 24 hours? Explain.
    - 4, both cells become 2 cells, 2×2=4
18. Is the original cell “dead” or does it disappear after mitosis? Explain your answer.
    - No, it split into two
19. If a starfish sustains damage to a limb, it often grows a new one. If a human adult sustains damage to his or her spinal cord, mobility is often impaired. If a

gecko loses its tail, it may grow a new one. Which type of cell is less likely to go through the cell cycle after being damaged— starfish limb, human spinal cord, or gecko tail? Support your answer.

- Human spinal cord, it doesn't get regenerated when it is damaged

20. Occasionally cells stop dividing and enter another phase, G0 . If you damage your liver, new liver cells can be produced to replace up to 75% of the liver. However, if you sustain brain damage, your body does not produce new brain cells. Explain this observation using what you have learned about the cell cycle.
    - Those cells never leave G0 and don't reproduce
21. Keeping in mind the events of each part of the cell cycle, mark with a double arrow on Model 1 where those cells might (either temporarily or permanently) exit the cell cycle to G0. Label this as G0. Why did you choose this location for G0? Hint: Think of a place in the cell cycle where the cell is functioning normally, but not preparing to divide.
    - The middle of G1
22. Consider a cell in G0. Use the information in both Models 1 and 2 to answer the following questions.
    1. In order for this cell to divide normally, what would need to occur?
        - Exit G0 and start growing
    2. What if the phase(s) you identified in part a of this question did not occur? What would be the outcome for the cell in that case?
        - It would never grow and it would die alone
23. According to Model 3, ultraviolet light is affecting a cell in which phase of the cell cycle?
    - G1
24. Ultraviolet light may cause DNA damage, which is known as a mutation. How might such damage affect events taking place during the synthesis phase? Hint: Use information from Model 2.
    - Broken DNA will be replicated and the cell will probably die
25. How might the DNA damage go on to affect the rest of the cell cycle if apoptosis did not occur?
    - The resulting cell would have mutations in the DNA
26. Why might it be beneficial to an organism for damaged cells to enter G0 instead of dividing once they exist?
    - They won't grow and spread across the body
27. What could happen, after several cell cycles, to an organism whose damaged cells did not go through apoptosis? In other words, what if a damaged cell that is supposed to die does not?
    - It is a cancer cell, it keeps growing and forms a tumor
28. For each phase, describe at least one way mistakes during the cell cycle could result in problems.
    - G1: mutated proteins are manufactured and synthesis cannot occur
    - S: DNA is copied incorrectly and the resulting cell has incorrect DNA

- G2: Chemicals needed from Mitosis are not generated, so mitosis will have problems
- M: The cell never splits so it has 2 nuclei

29. Some types of cancers are treated with radiation, similar to ultraviolet light. Why might it be beneficial to irradiate cancer cells?
    - To kill them or to force a mutation that would lead to apoptosis
30. Plasmodial slime mold is an example of a multinucleated cell. It can be referred to as “one huge cytoplasmic mass with many nuclei” as seen to the right. What part of Model 1 is skipped in the formation of such a cell? Explain your answer.
    - Cytokinesis, the cell never splits and just keeps growing
31. Chemotherapy utilizes chemicals that disrupt various parts of the cell cycle, targeting rapidly growing cells. Paclitaxel (Taxol®) is one such drug that prevents the mitosis phase from taking place.
    1. Explain how this drug is useful as a cancer treatment.
        - The cancer cells will be unable to split and form more cancer cells
    2. How might targeting rapidly growing cells explain common chemotherapy side effects such as hair loss and nausea?
        - Things will no longer grow as fast as it should and things will not regenerate as quickly either

10. ☑ POGIL: Meiosis

4 - Meiosis

1. According to Model 1, in what type of organs are the cells that enter meiosis I found?
    - Sex organs
2. Considering what you already know about mitosis in cells, what event must take place during interphase before a cell proceeds to division?
    - DNA replication and cell growth
3. What two structures make up a single replicated chromosome?
    - Chromotids
4. In Model 1, how many replicated chromosomes does the cell contain during prophase?
    - 46
5. At which stage in meiosis I do the pairs of homologous chromosomes come together?
    - Metaphase 1
6. Once the chromosomes have formed a pair, what are they called?
    - homologous chromosomes make tetrad
7. At the end of meiosis I, two cells have been produced. How many replicated chromosomes are in each of these cells?
    - 23 chromosomes
8. Cells with a full set of chromosomes are referred to as diploid or 2n, whereas cells with half the chromosomes are haploid or n. At which stage(s) of meiosis I are the cells diploid and at which stage(s) are they haploid?

- Diploid until cytokinesis 1 when they become haploid

9. Which of the statements below correctly describes the relationship between the cells at the end of telophase I and the original cell?
    - They have half the chromosomes
10. Considering the genetic makeup of the homologous pairs, will the cells at the end of telophase I be genetically identical to each other?
    - No, since crossing over happens they will be different
11. According to Model 2, where did each of the cells come from that started meiosis II?
    - Meiosis I
12. In meiosis I, during anaphase I, which structures separated—homologous chromosomes or sister chromatids?
    - The spindle fibers separate homologous chromosomes
13. In meiosis II, during anaphase II, which structures separated—homologous chromosomes or sister chromatids?
    - The spindle fibers separate the matching chromatids
14. At the end of the meiosis II are four daughter cells. Are they haploid or diploid? Explain your answer in a complete sentence.
    - Haploid they only have 23 chromosomes
15. Which of the statements below correctly describes the relationship between the cells at the end of meiosis II and the original cell?
    - The new cells have one copy of half of the genetic information in the original cell.
16. According to Model 3, what is the name given to the cells produced at the end of meiosis I in males?
    - Spermatids
17. What is the name given to the cells produced at the end of meiosis I in females?
    - Oocyte
18. Refer to Model 3.
    1. At the end of meiosis II in males, what cells are produced?
        - Sperm
    2. What do these cells (from the previous question) eventually become?
        - Part of the Zygote
19. Before fertilization, what happens to the secondary oocyte?
    - Meiosis 1
20. During fertilization which two cells come together? Be specific in your answer.
    - Mature sperm and secondary oocyte
21. During meiosis II, the secondary oocyte divides unevenly, with one cell (the ovum) receiving half of the chromosomes and nearly all the cytoplasm and organelles, while the other cell, the polar body, is much smaller and eventually degenerates. With your group, propose an explanation to explain why the secondary oocyte divides in this way.

- It needs all the organelles from the mother cell, but not all of the genetic information

22. What is the ploidy of the zygote produced by fertilization—haploid or diploid?
    - Diploid, it has a pair of all 23 chromosomes
23. What would the ploidy of the zygote be if egg and sperm were produced by mitosis rather than meiosis? How would this affect the ploidy of each successive generation?
    - Quadroploids, each generation would have double the chromosomes of the previous
24. With your group write a statement to explain the origin of the chromosomes found in the zygote. Your statement must include the term homologous pair.
    - Half from the sperm and the other half from the egg
25. At which stage of meiosis are the chromosomes in Model 4?
    - Crossing over in meiosis 1 (metaphase)
26. When the chromosomes come together as homologous pairs, the arms of the sister chromatids may cross over.
    1. What are these crossover points called?
        - Chiasma
    2. Describe what happens to the chromatids during crossover
        - It swaps genetic information, randomizing its contents
27. What phrase is used to describe the chromatids after crossing over takes place and the homologous chromosomes separate?
    - Recombinant chromatids
28. Compare the recombinant chromatids with the original pair
    1. Are the genes on a recombinant chromatid the same as the original chromatid?
        - No, they are mixed from both
    2. Are the alleles on a recombinant chromatid the same as the original chromatid?
        - No, they are mixed
29. Model 5 is a condensed version of meiosis I. Notice the two possible arrangements of chromosomes in late prophase I. Considering what you know about DNA replication and meiosis, is either arrangement equally likely during the formation of tetrads in late prophase I? Explain.
    - Yes, the order of which the chromosomes line up are completely random.
30. If there were three sets of homologous chromosomes in the cell in Model 5, how many possible arrangements would there be for the tetrads in late prophase I?
    - 4
31. With your group, calculate the number of possible genetic combinations due to independent assortment.
    - 2^22

32. Meiosis and sexual reproduction each lead to variation in the genetic make-up of every person. With your group, explain how meiotic events, as well as the random fertilization of eggs and sperm, together lead to this genetic variation.
    - Crossing over, random assortment, random fertilization

11. ☑ Activity: Signal Transduction Pathway Modeling (G-Drive)

1 - Signal Transduction Pathway Modeling

https://docs.google.com/document/d/1z-b6PsrYkO89Qfkp_0Olg4Y6xU4mfDidb_0i_2FvQbM/edit

12. ☑ Activity: Feedback Loop Examples

2 - Feedback Loop Examples

Regulated Blood Glucose Concentration (Negative feedback)

When Glucose level rises above set point

1. Pancreas is stimulated to secrete insulin from beta cells
2. Insulin levels increase in the bloodstream
3. Cells take up glucose from the blood
4. Liver uses excess glucose to produce glycogen
5. Blood glucose levels out

When Glucose levels drop below set point

1. Pancreas is stimulated to secrete glucagon from alpha cells
2. Glucagon levels in the bloodstream increase
3. Glycogen is broken down by the liver
4. Glucose is released into the bloodstream
5. Blood glucose level rises

Graphs

1. When there is more glucose, more insulin is secreted
2. When there is more glucose, less glucagon is secreted
3. 3
    1. B
    2. A - 90mg/dL
    3. C - below set point

Thermoregulation (Negative feedback)

When Body temperature increases above set point

1. Thermostat in hypothalamus activates cooling mechanism in the brain
2. Blood vessels in your skin dilate, releasing heat
3. Body temperature decreases back to set point

When Body temperature decreases below set point

1. Thermostat in hypothalamus activates warming mechanism in the brain

2. Blood vessels in your skin contract, generating heat and moves heat to the body's core
3. Body temperature increases back to set point

Temperature regulators and conformers

- Regulators maintain homeostatis in their temperature
- Conformers conform to the environment's temperature

Osmoregulation in Marine Fishes vs. Freshwater

1. Saltwater fish will excrete salt because their food and drink contain salt, so to maintain homeostasis in through osmoregulation, salt is excreted in urine to maintain constant salt levels within the fish
2. Freshwater fishes' food does not contain as much salt, so it is not necessary to excrete as much salt to maintain homeostasis in the concentration within the fish. Also, excreting to much salt would make the osmolarity of the fish very low, leading it to have bloated cells.

Fruit Ripening (Positive feedback)

1. Ethylene gas is produced in one fruit by ripening
2. Nearby fruit detect the release of the gas
3. Nearby fruit ripen and release the same gas
4. More nearby fruits detect the gas and release more gas
5. More fruit ripen

Questions

1. What does it mean for a fruit to ripen? Describe what happens when a fruit becomes ripe.
    - Become more palatable for seed dispersion from other organisms
2. Why is it important for a fruit to ripen? What would happen if a fruit's ethylene receptors were mutated?
    - Produce flavor, color, and texture

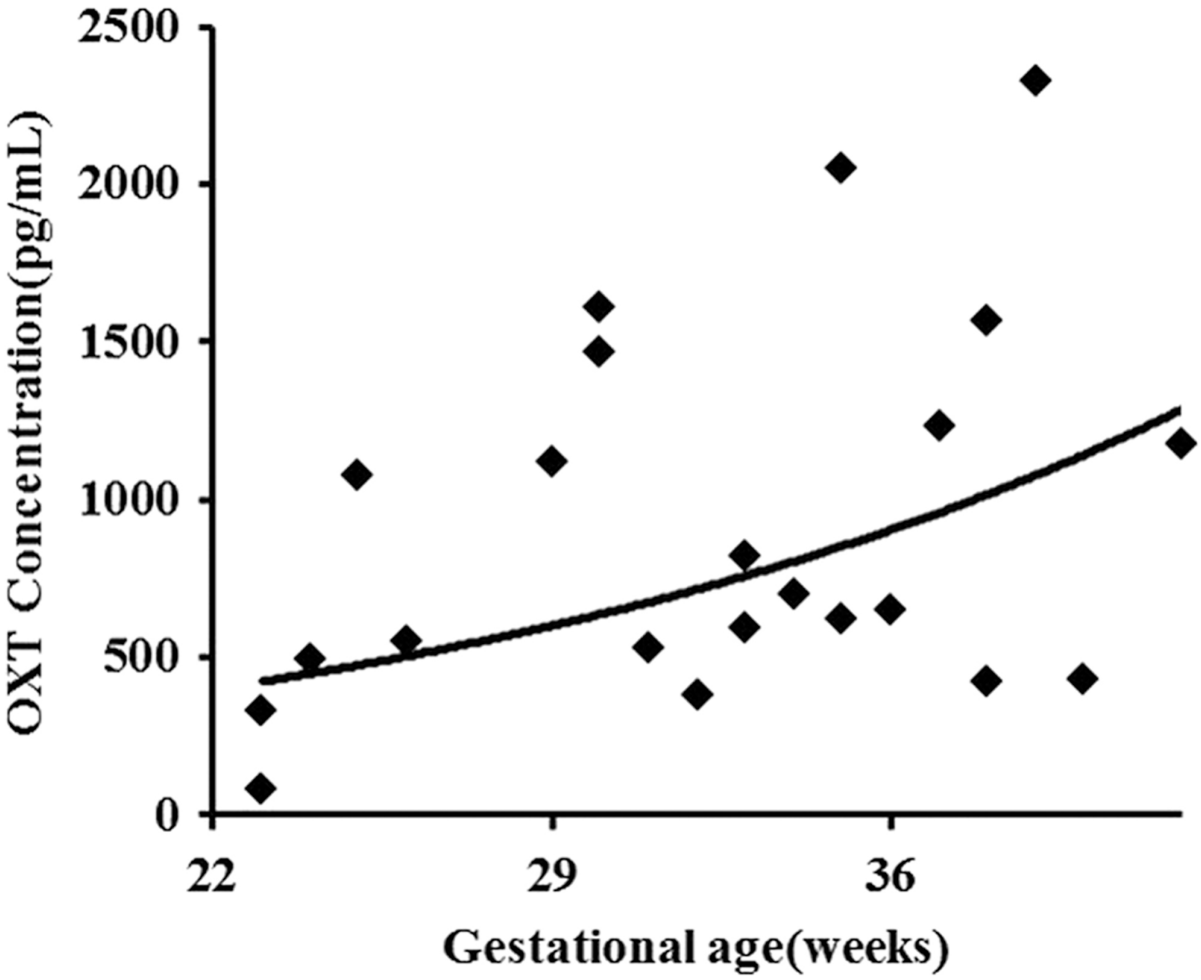
Signal transduction in fruit ripening

1. Phosphorylate the neighboring EIN2 so that it cannot enter the nucleus
2. It provides the phophate group to phosphorylate the EIN2
3. EBF1/2 F-box blocks EIN3/EIL1 from allowing Ethelene from being produced. EIN2 C-end comes and blocks EBF 1/2 F-box, which allows EIN3/EIL1 to produce ethelene gas

Childbirth (Positive feedback)

1. The baby's head pushes on the cervix, applying pressure on it
2. Nerve impulses from the cervix are transmitted to the brain
3. Brain stimulates the pituitary gland to secrete oxytocin
4. Oxytocin is released into the bloodstream and is carried to the uterus
5. Oxytocin stimulated the uterus to contract, moving baby towards cervix

Questions



1. Identify the independent and dependent variables.
    - Gestational age is independent and OXT concentration is dependent
2. Describe the relationship between gestational age and oxytocin concentration.
    - As the fetus grows older, OXT concentration increases to stimulate contraction for childbirth

13. ☑ Investigation: Gymnema Tea Party

1 - Gymnema Tea Party

Data

Candy	Rating (Before)	Rating (After)
Mentos	9	2
Plum Candy	5	2
Ribena Chews	7	1
Peanut MnMs	6	0
Milo Pieces	5	1
Choki choki	8	1

14. ☑ Investigation: Cancer Cells and Mitotic Index

2 - Cancer Cells and the Mitotic Index

Sample	# of cells in Interphase	# cells in any other phase of mitosis	Mitotic Index: # of cells in mitosis / total # of cells	% cells Dividing	Normal or Cancer?
Slide A: Ovary	17	3	3/20	15	Normal
Slide B: Ovary	13	7	7/20	35	Cancer
Slide C: Stomach	15	5	5/20	25	Cancer
Slide D: Stomach	17	3	3/20	15	Normal
Slide E: Brain	20	0	0/20	0	Normal
Slide F: Brain	18	2	2/20	10	Cancer
Slide G: Lung	13	7	7/20	35	Cancer
Slide H: Lung	17	3	3/20	15	Normal
Slide I: Pancreas	18	2	2/20	10	Normal
Slide J: Pancreas	11	9	9/20	45	Cancer
Slide K: Prostate	8	12	12/20	60	Cancer
Slide L: Prostate	11	9	9/20	45	Normal

1. Cancerous tissue has higher % of cells dividing, which leads to more cell divisions than normal
2. Pancreatic cancer, it is the greatest increase in the mitotic index and % of cells dividing

15. Case Study: Eukaryotic Cell Cycle and Cancer

1 - Eukaryotic Cell Cycle and Cancer

Phase	Phase Events	Checkpoint Events	Regulatory Processes

Phase	Phase Events	Checkpoint Events	Regulatory Processes
G1	Grows and preps to replicate DNA	Near the end, checks resources and if ready to replicate DNA	G1-phase CDK-cyclins allow to pass into S, If DNA is damaged, p53 stops the progression to S phase by inhibiting the G1 CDK-cyclin complex
S	Replicates DNA, checks DNA	Checks for DNA errors	CDK-cyclin complexes signal the cell to duplicate its DNA, and breaks in the two DNA strands during replication activate the ataxia telangiectasia mutated (ATM) protein, which halts the cell cycle
G2	Grows and matures, preps for division	Sorts out chromosomes, checks DNA	Concentration of mitotic (M-phase) cyclins rises, and they bind to the appropriate CDKs, and p53 protein will stop cell cycle progression until the damage is repaired
M	Cells stops growing then divides	Chromosomes are connected to spindle fibers	APC/C is activated when all chromosomes are attached to the mitotic spindle during metaphase, and When chromosomes are not properly attached to the mitotic spindle, MAD proteins inhibit the anaphase-promoting complex/cyclosome (APC/C)

1. Compare and contrast the reasons cell division is important for unicellular (single-celled) and multicellular organisms.
    - For single-celled organisms, its the only way they can reproduce.
    - For multi-cellular organisms, cell division is used to replaced broken or damaged pieces, and grow
2. Provide an example of why cell division remains important to an adult organism even after it is fully developed.
    - To renew old and dead cells, as well as damaged cells from cuts or broken things.
3. What is the role of growth factors?
    - A bunch of chemicals that when are concentrated enough, signal cell division
4. Cells divide, differentiate, or die. What is differentiation?
    - When cells undergo a change in gene expression in order to specialize for a particular function like bones or muscles.
5. What is apoptosis? Explain its purpose.
    - Planned cell death, when something goes wrong it will self destruct
6. Organisms maintain the right number of cells by regulating the cell cycle. What are “cell cycle regulators?”

- Signals that start, enhance, or stop cell division and growth, signal to start differentiation or apoptosis

7. Watch the video clip of cells in the small intestine. Name the general location along the villus where the following processes occur:
    1. Cell Division
        - Crypt
    2. Cell Differentiation
        - Lumen
    3. Apoptosis
        - TOp of vilius
8. Name one harmless result of too little cell division
    - Hair loss
9. Name one harmless result of too much cell division.
    - Growth of warts
10. List, in order, the four events we collectively call the “cell cycle.” Next to each event, write the correlating cell cycle phase name.
    - G1, S, G2, M
11. In general, what is the purpose of a checkpoint in the cell cycle?
    - To make sure the cell is ready to progress to the next phase and to make sure there is nothing wrong
12. What is one potential outcome when errors occur in this highly regulated cell cycle process?
    - Cancer
13. What type of protein that regulates the cell cycle is encoded by proto-oncogenes?
    - Stimulating proteins
14. What type of protein that regulates the cell cycle is encoded by tumor suppressor genes?
    - Inhibitory proteins
15. The most important cell cycle regulators are the
    - CDKs
16. What is a kinase, and what does it do?
    - Enzymes that phosphorylate other proteins in order to inhibit or activate them
17. When are CDKs present inside the cell during the cell cycle?
    - Always
18. When are cyclins present inside the cell during the cell cycle?
    - Always increasing but drops back to almost none during mitosis
19. CDKs form molecular complexes with cyclins. What do activated CDK-cyclin complexes do?
    - Stimulate the cell cycle and promote growth
20. Go to “Cell Cycle Phases” and click on “Interphase.” The interphase alternates with mitosis. What happens during interphase and what phases does it include?

- G1, S, G2, the time when growth and DNA replication happens

21. Go to “Cell Cycle Phases” and click on “G0.” The G0 phase is a resting or nondividing stage. What three factors determine if a cell enters G0?
    - Stage in development, type of cell, and resources
22. Provide an example of a fully differentiated cell that is (a) permanently in G0 and (b) one that can leave G0 to progress through the cell cycle and divide again.
    - Neurons
    - Spinal cord
23. Cancer is an improperly regulated cell cycle. Name two reasons why cells can form tumors.
    - Uncontrolled division, uncontrolled death
24. What causes uncontrolled cell division at the genetic level?
    - Mutations breaking the checkpoints
25. Watch the video clip. At the cellular level in this example, explain what occurs if the APC gene is mutated.
    - Makes it unstable and more likely to cause cancer
26. Normally, proto-oncogenes stimulate the cell cycle. What do mutated proto-oncogenes (i.e., oncogenes) cause?
    - More stimulation of the cell cycle
27. Normally, tumor suppressor genes inhibit the cell cycle. What do mutated tumor suppressor genes cause?
    - Uncontrollable cell growth
28. To cause cancer, proto-oncogenes require 1 allele to be mutated and are therefore considered dominant. This results in a gain of function.
29. To cause cancer, tumor suppressor genes require 2 alleles to be mutated and are therefore considered recessive. This results in a decrease of function.
30. Watch the video clip.
    1. Using the gas pedal analogy, explain the impact on the cell cycle of a proto-oncogene versus an oncogene.
        - When broken, the gas pedal gets pressed more, accelerating the cell cycle
    2. Using the brake pedal analogy, explain the impact on the cell cycle of one mutated tumor suppressor gene allele versus two mutated tumor suppressor alleles.
        - When there is a mutation, it breaks the foot and you can no longer press the gas pedal.
31. p53 is a protein that is encoded by a tumor suppressor gene, and some scientists refer to it as “the guardian of the genome.”
    1. Explain its normal role and why scientists would regard it as the “guardian of the genome.”
        - It prevents entering the S stage when there are problems with DNA, so it stops bad DNA from replicating

2. Explain what happens to the cell cycle if both alleles of the gene encoding p53 are mutated.
    - The checkpoint will be broken and broken DNA will not stop the cell cycle.

32. Explain why people who inherit one mutated allele of the BRCA1 gene have a higher likelihood of developing cancer.
    - It normally fixes the errors in DNA, so a broken BRCA1 gene would prevent this from happening if the DNA is broken
33. Predict a potential outcome of a mutated mitotic arrest deficient (MAD) protein.
    - Cells with the incorrect number of chromosomes because they never attached properly and was not detected.
34. Use the model illustrated in the figure below to answer the accompanying questions.
    1. The human gene EGFR located on chromosome 7 is a proto-oncogene that codes for a growth factor cell surface receptor. The binding of growth factors to this receptor can lead to cell proliferation. Hypothesize what potential impact a mutated EGFR allele will have on a cell. Give one possible impact and explain your answer.
        - A modified EGFR would most likely be unable to bind to growth factors, meaning that it would not signal cell proliferation and the cell would probably die
    2. RAS is a G protein that is activated when a growth factor attaches to EGFR. Its activation results in the exchange of GTP for GDP. Once activated, the GTP cannot be hydrolyzed and RAS cannot be deactivated What is one potential outcome of a mutation in one of the two copies of RAS?
        - A mutation in RAS would most likely disable it from performing its function of signalling BRAF and would most likely fail to be phosphrylated by EGFR as well, permanently staying inactive.
    3. Mutations in the genes that code for proteins in this pathway have been linked to various types of cancer (i.e., RAS: pancreatic, BRAF: colorectal, MEK: melanoma, EGFR: lung). If you were developing a new cancer drug, what would be an appropriate target protein for the new drug therapy? Justify your answer.
        - MEK, because it is the last protein in the chain and would ignore all the problems with the rest of the chain

16. ☑ Case Study: HeLa Cells Documentary (Questions on G-Drive)

2 - HeLa Cells Documentary

1. Who was Henrietta Lacks? (You will need to listen to the entire podcast before you will learn all of the information needed to completely answer this question.)
    - A black tobacco farmer with a special mutation in her cells that wouldn't die even after regrowing forever
2. Why did Henrietta seek medical attention at Johns Hopkins Hospital?
    - She felt a lump inside of her

3. Why were Henrietta's cells of interest to tissue culture researchers? Which cells did they take from her body?
    - Her cells wouldn't die even after growing extensively
4. Specifically what did Henrietta die of? How old was she when she died? (You will need to listen to the entire podcast before you will learn all of the information needed to completely answer this question.)
    - Cervical cancer at 31
5. Researchers took cell samples from Henrietta on two occasions. Describe.
    - They took some when she was receiving treatment and some after she died
6. What is HeLa? What's so special about these cells?
    - They are the first undying human cells ever discovered. They can grow and divide unlimitedly.
7. Why have HeLa cells been important to research on polio and other medical conditions?
    - We can study viruses easier with an unlimited supply of human cells
8. What problem did HeLa cells eventually cause for cell biology researchers?
    - HeLa can take over other cells and grow very aggressively, they contaminated many other cells.
9. When did Henrietta's family learn of the importance of her cells? Did her family have a good understanding of what HeLa cells were and why are they important? Do you think the medical establishment did right by Henrietta's family?
    - They only found out a long time after she died. I don't think the family had a good understanding of what was going on because they weren't particularly science oriented. I feel like this is not fair because the family has the right to know what happened to her and why they were taking samples from her and the family as well. They didn't even let them know they were taking samples from her.

Your thoughts

1. Should tissue be removed from a patient without his or her consent for research?
    - No. Their tissue is part of them and without consent, you are just stealing something that is theirs.
2. Put the use of HeLa cells on trial. What is more important: an individual's rights to his/her own body tissues or the medical knowledge gained by studying a patient's tissues?
    - The individual should have the rights to choose what should be done to his or her body. Even though it helped the medical community as a whole, it should have been explained to her and she should have had the chance to agree to it regardless
3. Should Henrietta Lack's family be compensated for the discoveries made by using her cells?

- Yes, or atleast Henrietta atleast. While it was claimed that they sold them at cost, there were many examples where money was made off of her cells. Imagine her cells as intellectual and physical property, of the family and Henrietta herself, it wouldn't be right to use it without permission.

4. Do companies or universities have the right to patent discoveries made using a patient's tissues or genes without consulting the patient?
    - No. The patient should be made aware and have the chance to choose what happens with the discovery as it happened because of her.
5. What other legal and ethical questions does this make you think about?
    - None really
6. What are your thoughts on this topic from a biblical worldview? (You can think about this either from the family's point of view or the researchers').
    - I believe that the family should have known and that it is ethically wrong to operate on patients with false pretenses and without consent.