Cell Communication and its Applications

Mrs. Elizabeth Pelphrey

Paul Laurence Dunbar High School

1600 Man O War Blvd

Lexington, KY 40513

Elizabeth.pelphrey2@fayette.kyschools.us

Acknowledgements

I'd like to thank the following people and programs for this opportunity to learn, "do science," and enhance my teaching:

- Dr. Subbarao Bondada
- Dr. Jacqueline Rivas
- Dr. Sara Alkaheem
- University of Kentucky, College of Medicine, Department of Microbiology, Immunology, and Molecular Genetics
- The American Association of Immunologists

Table of Contents

I. Science Background –

- This unit follows a unit on cellular energy so students should already be familiar with cell parts and certain cell functions.
- The immune system is not a specific content piece for the AP curriculum but it is recommended as an illustrative example so it makes a good fit to use specific immune system examples to teach cell communication and make it easier for students to comprehend.
- Students should have a basic idea of specialized cells and some of the differences between B cells and T cells
- Students should be able to understand the structure of a protein and how structure dictates function as receptors or signals.

https://www.jimmunol.org/content/196/1_Supplement/211.17
https://www.ncbi.nlm.nih.gov/pubmed/29712773

II. Recommended Course Placement

This unit is designed for AP Biology to follow a cell energy unit and come before genetics. Unit placement is appropriate after a unit on Cell Energy and before a unit on Heredity, but could also be taught after Heredity and gene expression. If following the AP suggested curriculum this is Unit 4. Students will model basic cell communication, perform tests to detect communication compounds and observe the effects of communication on cell division, as well as make connections to the implications of "bad" communication. Using the immune system and its interactions with cancer as an illustrative example will help to make this topic applicable to student's lives.

III. Student Outcomes

AP Biology Standards:

- IST-3.A: Describe the ways that cells can communicate with one another
- IST-3.B: Explain how cells communicate with one another over short and long distances
- IST-3.C: Describe the components of a signal transduction pathway
- IST-3.D: Describe the role of a signal transduction pathway in producing a cellular response
- IST-3.E: Describe the role of environment in eliciting a cellular response
- IST-3.F: Describe the different types of cellular responses elicited by a signal transduction pathway
- IST.3-G: Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway
- IST-1.B: Describe the events that occur in the cell cycle
- IST-1.C: Explain how mitosis results in the transmission of chromosomes from one generation to the next
- IST-1.D: Describe the role of checkpoints in regulating the cell cycle
- IST-1.E: Describe the effects of disruption to the cell cycle on the cell or organism

IV. Learning Objectives

- I can describe the process of cell communication from reception, to signal transduction, to cellular response.
- I can explain the role of each component of cell communication.
- I can explain how the cell cycle maintains homeostasis through positive feedback.
- I can describe the role of checkpoints regulating the cell cycle and the effects of a disruption to the cell cycle.

V.Time Requirements

. 7-8 blocks (90 minutes each)

VI.Advance Preparation

- Order Lab kits from BioRad and Carolina
- Make student copies
- Gather materials for Acting Out and Labs
- Prepare solutions, student aliquots, and student workstations

VII.Materials and Equipment

- Props for Acting Out
- Bio-Rad Explorer- ELISA Immuno Explorer Kit (http://www.bio-rad.com/en-us/product/elisa-immuno-explorer-kit?ID=1e3f3100-99f6-49b3-b9a0-2c8aad9d9285)
    - Reagents needed (all supplied in kit)
    - Antigen, primary antibody, secondary antibody, HRP enzyme substrate, 10x phosphate buffered saline (PBS), 10% Tween 20
    - Color-coded microcentrifuge tubes
    - Disposable pipets
    - 12-96 well plates
    - 20-200 µl micropipette with tips
    - Beaker
- Carolina Investigations for AP Biology- Cell Communication (https://www.carolina.com/carolina-investigations-kits/cell-communication-kit-for-ap-biology/FAM_747740.pr)
    - Materials included in the kit
    - Microscope (compound)
    - Incubator (optional)

VIII.Student Prior Knowledge and Skills

- Structure and function of proteins
- Structure and function of cells
- Structure and function of cell membrane
- Structure and function of key organelles

IX.Daily Unit Plans

- Day 1- Cell Communication basic steps- Acting Out, introducing the immune system as an application of communication between and within cells.
- Day 2 - (Maybe finish notes), Diabetes and Insulin Case Study, Introduce the immune system and ELISA testing.
- Day 3- ELISA Lab detecting “IL-10 cytokines” in “patient samples” using the BioRad ImmunoExplorer Kit. (Online alternative: https://www.biointeractive.org/classroom-resources/immunology-virtual-lab
- Day 4- Review communication, Introduce the cell cycle
- Days 5-7- Carolina’s Cell Communication Lab with quorum sensing among yeast to initiate cell division.
    - https://learn.genetics.utah.edu/content/cells/

        - https://www.labster.com/simulations/signal-transduction-how-cells-communicate/ (requires a paid subscription to labster.)
    - Day 8 Cancer and its implications on cell cycle and communication.

X.Student Activities

- Acting Out Cell Communication
- Diabetes and Insulin Case Study
- ELISA Lab
- Mitosis Lab
- Cell Communication Lab
- Cancer Case Study

XI.Summative Assessment

- AP style multiple choice from old, released, but secure AP exams and free response test.

DAILY LESSON PLANS

Day 1- Cell Communication Basic Steps

Learning Objectives:

- IST-3.A: Describe the ways that cells can communicate with one another
- IST-3.B: Explain how cells communicate with one another over short and long distances

Science Practices:

- 1.B- Explain biological concepts and/or processes

Essential Knowledge:

- Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling—
  - Cells communicate by cell-to-cell contact.
- Cells communicate over short distances by using local regulators that target cells in the vicinity of the signal-emitting cell—
  - Signals released by one cell type can travel long distances to target cells of another cell type.

Agenda: (Document Names match agenda item names)

1. Acting Out- student simulation of cell communication
2. Cell Communication Notes- direct instruction lecture with videos

Teacher Instructions:

1. Acting Out:

The Basics:

Adapted from **Pathways with Friends** (https://teach.genetics.utah.edu/content/cells/PathwaysWithFriends.pdf)

1. Make copies from the link above of the 6 cards.
2. Make copies of the attached sheets and gather necessary props. (Post it notes and scrap paper)
3. Divide students into groups of six, each group should have enough space to move around freely. If your class doesn't split evenly into groups of 6, you can have two people share a role.
4. Give each member of a group a card and ask them not to share but to internalize what the card is asking them to do.
5. Students should first follow the instructions on #1 and then #2 in response to another student.
6. Give students the cell communication role explanation sheet and have them decide based on the definitions given, which part of their communication fit each role given. More than one person (one card) may represent a given a role.
7. Have each group share out their decisions and facilitate a discussion if any of them had different answers.

Specific Example

8. Using the same 6 member groups, pass out the roles for the Epinephrine example. For this example to work, students will have to discuss their roles and figure out which order it all goes in.
9. Have each group run through their modeling in front of the other groups.
10. Briefly discuss the consequence of increased glucose in the blood as a part of fight or flight responses.

Extension: (in time allows, this may fit better to be assigned at the end of the unit as a review and a way to make sure they can apply their knowledge to other examples)

11. In these same groups have students research another example of cell communication and create their own script and skit. Some examples below:

a. Mating factor (Shmoos in yeast)
b. Growth Factor

c. Apoptosis
d. Testosterone
e. Long term memory
f. Insulin

2. Notes- see slides, videos embedded to break up the lecture and continue examples focusing on the immune system.

Acting Out Cell Communication:

Cell Communication Roles [1]

Signal- a chemical ligand or signal molecule travels through the extracellular matrix. A controlling cell makes a specific molecule that acts as a signaling molecule to affect the activity of another cell, the target cell.

Reception- binding of a signal molecule with a specific receptor on a target cell. Target cells have receptors that are specific for the signal molecule, with a given shape to recognize and bind the signal specifically.

Transduction- the process of changing the signal into the form necessary to cause the cellular response. Transduction may occur in a single step, although more often it occurs in a cascade of reactions.

Response- the transduction causes a specific cellular response. The specific response depends on the signal and the receptors of the target cell.

Specific Example: [2]

EPINEPHRINE- SIGNAL

In response to stress, a mammal's adrenal glands secrete the hormone epinephrine into the blood stream. Epinephrine binds to a receptor on a liver cell.

Find the liver cell and clasp hands

[1] Russell, P. J., Hertz, P., & McMillan, B. (2011). *Biology: the dynamic science*. Pacific Grove, CA: Brooks/Cole.

[2] http://bcs.whfreeman.com/webpub/biology/sadavalife9e/animated%20tutorials/life9e_0701_script.html

TARGET CELL- LIVER (RECEPTION)

Epinephrine triggers a shape change in the receptor, converting it to an active form. This active form generates a cascade of events (signal transduction), starting with the activation of a G protein. Soon after this activation, the hormone leaves the receptor, and it returns to its inactive form.

Clasp hands with epinephrine, and with the other hand gently "push" the G protein. Once you have "pushed" the G protein you can let go of epinephrine.

G- PROTEIN (Part of transduction)

The G-protein activates an enzyme adenylyl cyclase that converts ATP into signaling molecules known as cAMP. Because cAMP carries the message from the first signal into the cell, it is known as the second messenger.

Help cAMP move around in circles two times.

cAMP

cAMP produced by the enzyme adenylyl cyclase continue the cascade by activating another enzyme known as protein kinase.

Place post-it notes on protein kinase.

PROTEIN KINASE AND PHOSPHORYLASE KINASE

Once activated, protein kinase activates phosphorylase kinase with the addition of phosphate groups. In its activated state, phosphorylase kinase activates on final enzyme, called glycogen phosphorylase.

Remove your post it notes and place them on glycogen phosphorylase.

GLYCOGEN PHOSPHORYLASE

Once activated, this enzyme can finally produce the response elicited by epinephrine. Glycogen phosphorylase can help break down glycogen into glucose so that it can be released into the blood stream.

Remove the post it notes. Rip different pieces of paper into two and throw them into the air.

Day 2 -

Learning Objectives:

- IST-3.C: Describe the components of a signal transduction pathway
- IST-3.D: Describe the role of a signal transduction pathway in producing a cellular response
- IST-3.E: Describe the role of environment in eliciting a cellular response
- IST-3.F: Describe the different types of cellular responses elicited by a signal transduction pathway

Science Practices

- 1.A Describe biological concepts and/or processes
- 6.C- Provide reasoning to justify a claim by connecting evidence to biological theories

Essential Knowledge

- Signal transduction pathways link signal reception with cellular responses.
- Many signal transduction pathways include protein modification and phosphorylation cascades.
- Signaling begins with the recognition of a chemical messenger- a ligand- by a receptor protein in a target cell-
    - The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one to one relationship.
    - G protein-coupled receptors are an example of a receptor protein in eukaryotes.
- Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression.
    - After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.
    - Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.
    - Binding of ligand to ligand gated channels can cause the channel to open or close.
- Signal transduction pathways influence how the cell responds to its environment
- Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis)

Agenda/ Teacher Instructions

1. Finish any lecture slides/videos from Day 1
2. Diabetes and Insulin Case Study
    a. https://sciencecases.lib.buffalo.edu/collection/detail.html?case_id=700&id=700
    b. For a small yearly membership you can get access to teacher notes and answer keys.

c. I like to let the students work through these themselves, but some cases lend themselves to group discussion. Because of the reference materials for this case, it has worked best for me to allow the student's time to work on their own.

3. Present the background information for the ELISA Lab. A popcorn read with modeled annotations works well with this reading. The virtual click through portion of this lab is a great pre-lab. If there is class time left, let the students do this portion in class, if not assign it for homework or allow them to complete it in class before the lab.

Day 3-

Learning Objectives

- IST-3.C: Describe the components of a signal transduction pathway
- IST-3.D: Describe the role of a signal transduction pathway in producing a cellular response
- IST-3.E: Describe the role of environment in eliciting a cellular response
- IST-3.F: Describe the different types of cellular responses elicited by a signal transduction pathway

Science Practices

- 1.A Describe biological concepts and/or processes
- 6.C- Provide reasoning to justify a claim by connecting evidence to biological theories

Essential Knowledge

- Signal transduction pathways link signal reception with cellular responses.
- Many signal transduction pathways include protein modification and phosphorylation cascades.
- Signaling begins with the recognition of a chemical messenger- a ligand- by a receptor protein in a target cell-
  - The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one to one relationship.
  - G protein-coupled receptors are an example of a receptor protein in eukaryotes.
- Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression.
  - After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.
  - Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.
  - Binding of ligand to ligand gated channels can cause the channel to open or close.
- Signal transduction pathways influence how the cell responds to its environment
- Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis)

Agenda

- Introduction of application of ELISA- Chronic Lymphocytic Leukemia
- Brief overview of lab expectations
- ELISA LAB (students will need computer access for the pre-lab)

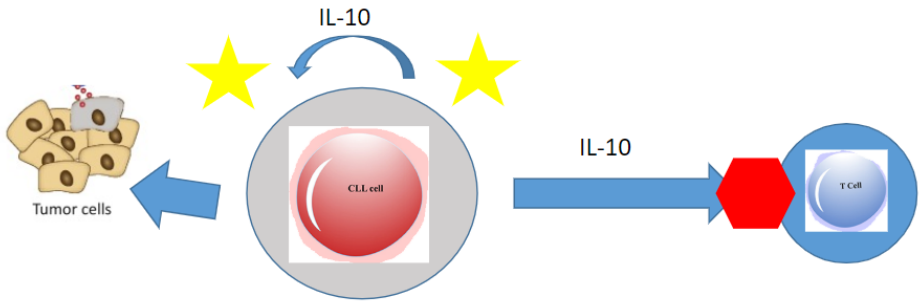
Teacher Instructions

- Use the slide about CLL to explain about cytokines and recognition of particular proteins in the signal transduction pathway in these cells. In the speaker notes of the slide is some more background information about this type of cancer.
- If using the Bio-Rad kit, teacher background information is thorough and detailed. Review the slide below to understand how an ELISA works.

- Set up lab materials per the instructions in the lab kit. If you are only doing the virtual ELISA, it should not take a whole class period.
- Review lab safety, pipette use, and the importance of multiple washes throughout the ELISA.
- Students will answer the questions when they are finished.

• B Cell- Chronic Lymphocytic Leukemia (CLL)

- Most common leukemia (lymphocytic- white blood cell specific)
- Immunosuppression is a major complication
- CLL produces a cytokine Interleukin-10 (IL-10)
- IL-10 stimulates tumor growth and inhibits T-cell effector function
- Can IL-10 be inhibited or blocked in order to return T-cell antitumor function?



---

https://www.ncbi.nlm.nih.gov/pubmed/29712773
https://www.ncbi.nlm.nih.gov/pubmed/11133769
https://www.jimmunol.org/content/196/1_Supplement/211.17
https://ashpublications.org/blood/article/134/Supplement_1/5486/425257/Enhancing-Anti-Tumor-Immunity-and-Responses-to

Enzyme Linked Immunosorbent Assay (ELISA)

- Uses the "attraction" of an antigen to an antibody as means for detection
- Antibodies can be produced and purchased to match with whatever "antigen" you are looking for.
- This makes an ELISA a helpful tool for detecting certain proteins throughout the communication processes
- The microplate used is designed to provide binding sites (hydrophobic interactions) for antigens/antibodies/detergent
- The basic steps for an indirect antibody capture ELISA are as follows:
  - Add antigen or sample that may contain antigen to microplates
  - Wash with a detergent, this removes any part of the sample that did not bind, as well as blocks any empty binding sites to prevent false positives. This is the purpose of all the subsequent washes as well.
  - Add primary antibody- meant to detect antigens that may be in the sample
  - After incubation, any unbound antibodies are washed out
  - Add enzyme linked secondary antibody- will detect primary antibody/antigen pair and provide an enzyme for colorimetric detection. Any unbound secondary antibodies are also washed.
  - A chromogenic (color producing) enzyme substrate is added, if antigen/primary antibodies/enzyme linked secondary antibodies/substrate complexes are present, the well will change colors.

CLL-IL10 ELISA connection

- Cell lines are produced with CLL to be used for research
- Extraction procedures can be done to isolate certain proteins in the cell communication process to understand their purpose, and potentially harness their abilities.
- ELISAs can be used to determine the efficacy of the extraction
- In order to know understand more about how certain messengers like IL-10 affect tumor growth, it's important to understand when and in what quantities they are present.
- ELISAs are a relatively quick and easy way to detect the presence of proteins like IL-10 in a sample
- The color change aspect allows for samples to be quantified using spectrometers.

ELISA LAB Questions (in addition to student and teacher resources provided with lab kit)

1. Chronic Lymphocytic Leukemia (CLL) is the most common form of Leukemia in adults. CLL cells produce a ligand known as Interleukin-10 (IL-10). This ligand also known as a cytokine, serves as both an autocrine growth factor and a paracrine inhibitor to T cells (immune cells capable of recognizing and breaking down foreign/invading cells). Draw a diagram representing the enhancing and inhibiting properties of IL-10 and the CLL cells. Explain what your diagram means.
2. Il-10 can act like an antigen that can be detected by antibodies. How can we use an ELISA to detect for IL-10 and then support a diagnosis?

Day 4-

Learning Objectives

- IST-1.B: Describe the events that occur in the cell cycle
- IST-1.C: Explain how mitosis results in the transmission of chromosomes from one generation to the next
- IST-1.D: Describe the role of checkpoints in regulating the cell cycle
- IST-1.E: Describe the effects of disruption to the cell cycle on the cell or organism

Science Practices

- 4.B.b- Describe data from a table or graph, including describing trends and/or patterns the data
- 5.A.e- Perform mathematical calculations, including percentages
- 6.E.a -Predict the causes or effects of a change in or disruption to, one or more components in a biological system based on biological concepts or processes.

Essential Knowledge

- In eukaryotes, cells divide and transmit genetic information via two highly regulated processes
- The cell cycle is a highly regulated series of events for the growth and reproduction of cells-
  - The cell cycle consists of sequential stages of interphase (G1,S, G2), mitosis, and cytokinesis
  - A cell can enter a stage (GO) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.
- Mitosis is a process that ensures the transfer of a complete genome from a parent cell into two genetically identical daughter cells.
  - Mitosis plays a role in growth, tissue repair, and asexual reproduction
  - Mitosis alternates with interphase in the cell cycle.
  - Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase)
- A number of controls or checkpoints regulate progression through the cycle.
- Interactions between cyclins and cyclin-dependent kinases control the cell cycle.
- Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis)

Agenda

1. Cell Cycle Notes
2. Mitosis under the microscope Lab

Teacher Instructions

1. Cell Cycle notes are set up to focus more on the signaling that occurs to initiate the cell cycle rather than memorization of the phases.
2. The mitosis lab is meant to help students recognize different cell phases, but also to practice with the microscopes before the Yeast cell communication lab.
3. If you are teaching an AP class, this is a good time to assign the Personal Progress Check through AP Classroom as a formative check on current learning.

Day 5 Yeast Cell Communication Lab

Learning Objectives

- IST-1.B: Describe the events that occur in the cell cycle
- IST-1.C: Explain how mitosis results in the transmission of chromosomes from one generation to the next
- IST-1.D: Describe the role of checkpoints in regulating the cell cycle
- IST-1.E: Describe the effects of disruption to the cell cycle on the cell or organism

Science Practices

- 4.B.b- Describe data from a table or graph, including describing trends and/or patterns the data
- 5.A.e- Perform mathematical calculations, including percentages
- 6.E.a - Predict the causes or effects of a change in or disruption to, one or more components in a biological system based on biological concepts or processes.

Essential Knowledge

- In eukaryotes, cells divide and transmit genetic information via two highly regulated processes
- The cell cycle is a highly regulated series of events for the growth and reproduction of cells-
  - The cell cycle consists of sequential stages of interphase (G1,S, G2), mitosis, and cytokinesis
  - A cell can enter a stage (GO) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.
- Mitosis is a process that ensures the transfer of a complete genome from a parent cell into two genetically identical daughter cells.
  - Mitosis plays a role in growth, tissue repair, and asexual reproduction
  - Mitosis alternates with interphase in the cell cycle.
  - Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase)
- A number of controls or checkpoints regulate progression through the cycle.
- Interactions between cyclins and cyclin-dependent kinases control the cell cycle.
- Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis)

Agenda

1. Cell Communication Lab
   a. If you cannot purchase this kit, this would be a good time in the unit to do the extension from Day 1 and allow students time to research and present their modeling of cell communication.

Teacher Instructions

1. Read through the introduction with students and facilitate a discussion for the pre-lab question.
2. The first day is setting up the cultures to grow until the second day, a review of sterile techniques is a good idea at this point. Even though the procedures are minimal, I like to give my students plenty of time to go slow, be methodical, and make mistakes they can learn from.

Day 6 Yeast Cell Communication Lab

Learning Objectives

- IST-1.B: Describe the events that occur in the cell cycle
- IST-1.C: Explain how mitosis results in the transmission of chromosomes from one generation to the next
- IST-1.D: Describe the role of checkpoints in regulating the cell cycle
- IST-1.E: Describe the effects of disruption to the cell cycle on the cell or organism

Science Practices

- 4.B.b- Describe data from a table or graph, including describing trends and/or patterns in the data
- 5.A.e- Perform mathematical calculations, including percentages
- 6.E.a - Predict the causes or effects of a change in or disruption to, one or more components in a biological system based on biological concepts or processes.

Essential Knowledge

- In eukaryotes, cells divide and transmit genetic information via two highly regulated processes
- The cell cycle is a highly regulated series of events for the growth and reproduction of cells-
  - The cell cycle consists of sequential stages of interphase (G1,S, G2), mitosis, and cytokinesis
  - A cell can enter a stage (GO) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.
- Mitosis is a process that ensures the transfer of a complete genome from a parent cell into two genetically identical daughter cells.
  - Mitosis plays a role in growth, tissue repair, and asexual reproduction
  - Mitosis alternates with interphase in the cell cycle.
  - Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase)
- A number of controls or checkpoints regulate progression through the cycle.
- Interactions between cyclins and cyclin-dependent kinases control the cell cycle.
- Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis)

Agenda

1. Cell Communication Lab

Teacher Instructions

1. This second day of the lab can feel very tedious. One recommendation is to have each group do individual counts of their a and α cultures but do a whole class count for the shared culture. Have each group just count one view of the mixed culture and then compile the data.
2. This day is also when students should set up their own experiments. Their driving question is what can impact how these cells communicate and what evidence they will have to prove that communication was or wasn't taking place.

Day 7 Yeast Cell Communication Lab

Learning Objectives

- IST-1.B: Describe the events that occur in the cell cycle
- IST-1.C: Explain how mitosis results in the transmission of chromosomes from one generation to the next
- IST-1.D: Describe the role of checkpoints in regulating the cell cycle
- IST-1.E: Describe the effects of disruption to the cell cycle on the cell or organism

Science Practices

- 4.B.b- Describe data from a table or graph, including describing trends and/or patterns the data
- 5.A.e- Perform mathematical calculations, including percentages
- 6.E.a - Predict the causes or effects of a change in or disruption to, one or more components in a biological system based on biological concepts or processes.

Essential Knowledge

- In eukaryotes, cells divide and transmit genetic information via two highly regulated processes
- The cell cycle is a highly regulated series of events for the growth and reproduction of cells-
  - The cell cycle consists of sequential stages of interphase (G1,S, G2), mitosis, and cytokinesis
  - A cell can enter a stage (GO) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.
- Mitosis is a process that ensures the transfer of a complete genome from a parent cell into two genetically identical daughter cells.
  - Mitosis plays a role in growth, tissue repair, and asexual reproduction
  - Mitosis alternates with interphase in the cell cycle.
  - Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase)
- A number of controls or checkpoints regulate progression through the cycle.
- Interactions between cyclins and cyclin-dependent kinases control the cell cycle.
- Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis)

Agenda

1. Cell Communication Lab

Teacher Instructions

1. Today is about collecting data and finalizing lab reports.

Cell Communication in Yeast Formal Lab Report Section Rubric

Working in a group, you will each be assigned a section. This section will be individually graded as a summative grade. You are expected to know all the information from this lab, regardless of the section you turn in for your summative grade. The content on this lab can and will be on the unit summative exam and the AP exam. Be nice and share your section with your group members. Each time we do a lab you will be assigned a different section to complete.

Introduction and Methodology:

Set the reader up to understand the basis for the experiment. That should include but NOT BE LIMITED to the answers to the following questions: W*hat are the basics of cell communication? What are yeast? What are the two types? How does understanding cell communication help understand how they reproduce?* Make sure you include information that will help understand your design your own experiment too. BRIEFLY explain the methodology used to complete the DESIGN YOUR OWN EXPERIMENT section.

Score	Expectations
5	Background information is thorough, detailed, complete, and shows true understanding of content. Methodology is complete, organized, and easy to understand.
4	Background information is somewhat thorough, detailed, complete, and shows true understanding of content. Methodology is somewhat complete, organized, and easy to understand.
3	One of the following is weak or lacking: Background information is somewhat thorough, detailed, complete, and shows true understanding of content. Methodology is somewhat complete, organized, and easy to understand.
2	Two of the following are weak or lacking: Background information is somewhat thorough, detailed, complete, and shows true understanding of content. Methodology is somewhat complete, organized, and easy to understand.
0.1	You do know this is an AP class right?

****Packet completion- if packet is not completely finished and with enough effort, it will automatically drop the summative grade to the next grade level down.**

Data Collection and Analysis:

Assigned to: _____

Hypothesis statement. Variables outlined. Data collected. Appropriate statistical analysis performed. Neat organized data table with appropriate labels. Neat organized graph with appropriate labels. PICTURES from under the microscope of every different stage.

Score	Expectations
5	Data is collected in a neat and organized way, units and numbers are detailed, calculations are correct and easy to understand, diagrams and drawings are detailed and included when appropriate, graphs are detailed and easy to understand.
4	Data is collected in a somewhat neat and organized way, units and numbers are somewhat detailed, calculations are somewhat correct and easy to understand, diagrams and

	drawings are detailed and included when appropriate, graphs are somewhat detailed and easy to understand.
3	One of the following is weak or lacking: Data is collected in a somewhat neat and organized way, units and numbers are somewhat detailed, calculations are somewhat correct and easy to understand, diagrams and drawings are detailed and included when appropriate, graphs are somewhat detailed and easy to understand.
2	Two of the following are weak or lacking: Data is collected in a somewhat neat and organized way, units and numbers are somewhat detailed, calculations are somewhat correct and easy to understand, diagrams and drawings are detailed and included when appropriate, graphs are somewhat detailed and easy to understand.
0.1	You do know this is an AP class right?

***Packet completion- if packet is not completely finished and with enough effort, it will automatically drop the summative grade to the next grade level down.**

Conclusion

Assigned to: _____

What does your data mean in the context of the background information and content? Make sense of your results using what you know about cell communication. Be specific in discussing the mechanisms of the cell communication that yeast employ to send messages to each other.

What are some sources of human error, how did they affect your data and what are some ways to improve those errors?

Score	Expectations
5	Conclusion is thorough, organized, and shows true understanding of content. Data is explained based on science. Sources of error are detailed, listed separate from explanation of data, and explained. Ways for improvement are noted.
4	Conclusion is somewhat thorough, organized, and shows some understanding of content. Data is explained based on science. Sources of error are somewhat detailed, listed separate from explanation of data, and explained. Ways for improvement are noted.
3	One of the following is weak or lacking: Conclusion is somewhat thorough, organized, and shows some understanding of content. Data is explained based on science. Sources of error are somewhat detailed, listed separate from explanation of data, and explained. Ways for improvement are noted.
2	Two of the following are weak or lacking: Conclusion is somewhat thorough, organized, and shows some understanding of content. Data is explained based on science. Sources of error are somewhat detailed, listed separate from explanation of data, and explained. Ways for improvement are noted.
0.1	You do know this is an AP class right?

****Packet completion- if packet is not completely finished and with enough effort, it will automatically drop the summative grade to the next grade level down.**

Day 8- Wrapping Up the Unit

Learning Objectives

- IST.3-G: Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway

Science Practices

- 6.E.b- Predict the causes or effects of a change in or disruption to one or more components in a biological system based on a visual representation of a biological concept, process, or model

Essential Knowledge

- Changes in signal transduction pathways can alter cellular response-
    - Mutations in any domain of the receptor protein or in any component of the signaling pathway may affect the downstream components by altering the subsequent transduction of the signal.
- Chemicals that interfere with any component of the signaling pathway may activate or inhibit the pathway.

Agenda

1. Group discussion-Cancer, cell cycle, cell communication
2. Case Study
    1. https://sciencecases.lib.buffalo.edu/collection/detail.html?case_id=590&id=590
    2. https://sciencecases.lib.buffalo.edu/collection/detail.html?case_id=1031&id=1031
    3. https://www.hhmi.org/sites/default/files/Biointeractive/Outreach/NABT%20Cancer2.pdf

Teacher Instructions

1. Facilitate a whole class discussion about what cancer is and its connection to cell communication. What do they now know about cell signaling and the importance of it in maintaining homeostasis?
2. There are a lot of resources about cancer. Two good but high level case studies, could be done as a whole group to help with understanding.
3. HHMI also has great resources that could be used here to supplement the class discussion. See folder.

References:

Alhakeem, S. S., McKenna, M. K., Gachuki, B. W., Rangnekar, V. R., Byrd, J. C., Muthusamy, N., & Bondada, S. (2016, May 1). The role of IL-10 in B-cell chronic lymphocytic leukemia cell survival. Retrieved from https://www.jimmunol.org/content/196/1_Supplement/211.17

Alhakeem, S. S., McKenna, M. K., Oben, K. Z., Noothi, S. K., Rivas, J. R., Hildebrandt, G. C., … Bondada, S. (2018, June 15). Chronic Lymphocytic Leukemia-Derived IL-10 Suppresses Antitumor Immunity. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/29712773

Fayad, L., Keating, M. J., Reuben, J. M., O'Brien, S., Lee, B. N., Lerner, S., & Kurzrock, R. (2001, January 1). Interleukin-6 and interleukin-10 levels in chronic lymphocytic leukemia: correlation with phenotypic characteristics and outcome. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/11133769

(n.d.). Retrieved from http://bcs.whfreeman.com/webpub/biology/sadavalife9e/animated tutorials/life9e_0701_script.html.

Rivas, R., J., S., S., Eckenrode, Joseph M., Z., P., J., … Subbarao. (2019, November 13). Enhancing Anti-Tumor Immunity and Responses to Immune Checkpoint Blockade By Suppressing Interleukin-10 in Chronic Lymphocytic Leukemia. Retrieved from https://ashpublications.org/blood/article/134/Supplement_1/5486/425257/Enhancing-Anti-Tumor-Immunity-and-Responses-to

Russell, P.J., Hertz, P., & McMillan, B. (2011). Biology: the dynamic science. Pacific Grove, CA: Brooks/Cole