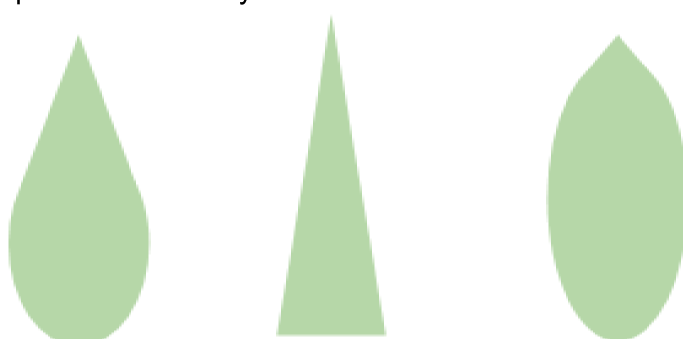
- Why do cells need to communicate with each other? Two reasons.
    - To be able to adjust to changes in the environment
    - To allow multiple cells to coordinate their behavior
- When cells communicate with one another, how does cellular physiology change (what two things in the cell change)?
    - Cell activity is regulated, by physiological changes resulting from regulation of either gene expression and/or protein activities
- What are the two categories of response to hormonal communication?
    - Fast: changes to the function of existing proteins
    - Slow: changes in gene expression and synthesis of new proteins
- How does local communication happen (three ways)?
    - Neighboring cells can pass signals through adjacent cell membranes
        - Depolarizing
        - Through gap junctions
        - Via cell-cell receptors
- How does long-range communication happen (two categories of mechanism)?
    - Fast mechanisms: via neurotransmitters
    - Slow mechanisms: via hormones that diffuse/circulate long distances in the body
- What are the three scales of hormone signalling?
    - Short: autocrine signalling, the hormone binds to receptors on the exact same cell that produced the hormone
    - Medium: paracrine signalling, acts on neighboring cells
    - Long: endocrine signalling, requires that the hormone move through the circulatory system
- Hormones circulate through the entire body. Why do only some cells respond?
    - Only cells with receptor proteins for the hormone respond to the hormone signal
- Describe feedback loops in physiology. What is a feedback loop?
    - A feedback loop occurs when the product of a process regulates its own production
        - Ex: a stimulus causes production of an effector molecule, which then changes the stimulus
- Describe the two types of feedback loops: name, general description of what they are, general effect on the boy, an example.
    - Negative feedback loops: stimulus causes production of an effector molecule; effector molecule reduces levels of the stimulus.
        - Lead the body to return to homeostasis.
        - Example:
            - Thermoregulation: increase in temperature causes sweating, which reduces temperature
        - Negative feedback loops act like thermostats; they return the body to homeostasis and then turn themselves off.
    - Positive feedback loops: stimulus causes production of an effector molecule; effector molecule increases levels of the stimulus.

        - Example:
            - During human birth, the head of the baby pushing on the cervix causes the pituitary to secrete oxytocin, which causes uterine contractions, which push the baby into the cervix even harder, causing more oxytocin to be produced
        - Positive feedback loops act like switches; they get stuck on as soon as they start, increasing in intensity
- Why are negative feedback loops important in hormonal communication?
    - They allow fairly precise control over **timing** of hormonal signalling, producing an oscillating pattern of signalling to maintain homeostasis
- How is time sensed and tracked by the body?
    - Via the circadian rhythm, which is produced by a biochemical oscillator
- How do hormones respond to time of day? What kind of pattern is generally produced?
    - The circadian rhythm influences hormone secretion, causing daily cycles of secretion and negative feedback
- Diagram hormonal communication through the body:
    - Secretory cells
    - Move through circulatory system
    - To cells with hormone receptors
- Only certain kinds of chemicals can be hormones; a hormone is defined by what kind of chemical compound it is. True or false?
    - False
- What are the two big categories of hormones? How are they secreted, circulated, and received?
    - Water-soluble, hydrophillic hormones
        - Secreted by exocytosis into the bloodstream
        - Circulate freely in blood
        - Bind to cell-surface receptors because they can't move through the cell membrane on their own
    - Lipid-soluble hormones
        - They can just diffuse through the membrane, so not secreted by exocytosis
        - Need to bind to a carrier/transport protein because they can't circulate freely on their own,
        - Don't need receptors; diffuse right into cells and then bind to receptors in either the cytoplasm or nucleus
- Give three examples of lipid-soluble hormones:
    - Sex steroids
    - Glucocorticoids
    - Mineralocorticoids
- What are the receptors for lipid-soluble hormones called? Why are they called this (what do they do)?
    - Nuclear receptors

        - Because they go into the nucleus and regulate gene expression
            - They are often transcription factors
- How do water-soluble hormones have their effect, since they don't actually enter the cell themselves?
    - They do this via transduction of the signal, aka signalling cascades.
    - Transducer, aka relay, molecules are released on the inside of the cell and communicate the effect to the nucleus, changing gene expression
- Describe the general steps of a signal transduction/signal cascade:
    - Water-soluble hormone binds to a receptor on the cell membrane
    - The receptor has an enzymatic function, which is now triggered. Either:
        - Production of secondary messenger molecules
        - Modification of existing proteins inside the cell
    - Those secondary messengers/modified proteins impact a target inside the cell
- What do kinases do?
    - They add phosphate groups to proteins
- Describe the activity of a hormone receptor kinase
    - When the hormone ligand binds to the receptor, it turns on the kinase function of the receptor
    - The activated receptor phosphorylates another protein kinase in the cell, activating it.
    - This is repeated two more times (three protein kinases total)
    - Downstream proteins are finally phosphorylated, activating them.
    - This has some cellular effect.
- Why is it important that hormone receptor kinase cascades involve multiple phosphorylation events?
    - Because it allows one signal to be greatly amplified inside the cell
- What are the two parts of a g-protein coupled receptor?
    - A receptor protein
    - A g-protein attached to the receptor on the inside of the cell
- Explain how g-protein coupled receptors work. Explain the steps of the process.
    - When the hormone ligand binds to the receptor, GTP gets bound to the g-protein, activating it
    - This activates enzymes that then synthesize secondary messenger molecules
    - Secondary messenger molecules cause downstream changes in the cell
- What secondary messenger does adenylate cyclase produce?
    - Cyclic AMP
- Explain the steps in hormone-activated calcium signalling pathways
    - Ligand binds
    - G-protein coupled receptor is activated
    - This actives phospholipase C
    - This cleaves PIP2 into IP3 and DAG, which are secondary messengers
    - IP3 causes calcium to be released from the endoplasmic reticulum
    - Increased calcium levels cause various changes in the cells

- Based on it’s name, can you figure out what kind of enzyme **phospholipase** is? What does it break down?
    - It’s a lipase, so it breaks down lipids.
- Why do organisms need transduction pathways that activate more than one molecule during each step of the process?
    - Transduction pathways/ signalling cascades amplify the effects of hormones
    - This allows a hormone to have a major effect even at very very low concentrations
- Why are hormones able to have significant cellular effects even at very low circulating blood concentrations?
    - Because each step of the signal transduction pathway amplifies the signal by activating many molecules.
- If a single cell is exposed to auxin, what happens?
    - That cell will grow and elongate.
- Explain how auxins travel through the body of a plant to regulate plant growth and shape.
    - Auxins cause plant cells to grow and elongate
    - They are produced at the tips of plant shoots and diffuse from there
    - This creates a concentration gradient along the stem
    - This creates differential rates of growth along the stem
- What hormone causes phototropism?
    - Auxin
- How do cells respond to this hormone in a manner that leads to phototropism? How was this experimentally determined?
    - Cells away from the light grow faster and longer than those closer to the light
    - This bends the stem towards the light
        - Auxin is distributed away from the light
        - Away from the light, auxin stimulates proton pumps, acidifying the ECF
        - This activates expansins, enzymes that loosen cellulose
        - This loosening allows turgor pressure to push the cells and make them bigger
    - Experiment:
        - Cut off tip of stem: no phototropism
        - Cover tip of stem: no phototropism
        - Transparent cover: phototropism happens
        - Cover other parts of stem: phototropism happens
            - So light must reach tip for phototropism to happen
        - Cut off tip and block it from stem with impermeable mica: no bending
        - Cut off tip and block it from stem with permeable gelatin: bending
            - So you know you need a signalling molecule produced by the tip for the rest of the stem to grow and cause phototropism
- Describe apical dominance. What does this term mean?

        - Apical dominance means that signals from the top of the growing plant prevent the growth of buds along the stem.
- What causes apical dominance?
    - The shoot apex inhibits axillary buds (lateral buds) from growing
    - This is because auxin has different effects on different tissues at different concentrations:
        - At low levels it stimulates growth
        - At high levels it inhibits growth
        - Lateral buds have a more sensitive threshold to switch between these two effects
        - So at levels that stimulate the apical bud, the lateral buds are inhibited
- Why is apical dominance important to plants?
    - Plants need to grow upwards to access light, so they should generally favor apical growth (growing tall) over lateral growth (growing wide)
- How does auxin signalling translate into the shape of a tree?
    - Lateral buds that are closer to the top experience higher auxin levels, so more inhibition of growth, so trees are usually more triangular in shape
- Match the tree shape to its sensitivity to auxin.



A. B. C.