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Question 1 4 pts



Which of the following is TRUE regarding the passage of charged ions across a cell membrane?



The concentration gradient and the electrical gradient for an ion must always be in the same direction in order for ion transport to be passive

Correct Answer



It is possible for an ion to move passively against its concentration gradient if the electrical driving force is of greater magnitude and in the opposite direction



To move an ion from an area of low to high concentration will always require the input of energy (i.e., active transport)



If the electrical gradient points out of the cell and the concentration gradient points into the cell, there will be no net movement of the ion in all cases



Question 2 4 pts



Match the described biological scenario to the respective type of intercellular signaling:

A cancer cell secretes growth factors to promote its own division

Autocrine

A motor neuron releases a signal causing a nearby muscle cell to contract

Paracrine

The pancreas releases insulin into the bloodstream to bind to peripheral receptors to permit glucose import

Endocrine

The PD-1 receptor of a T-cell binds to the PD-L1 receptor on a tumor cell, reducing the activity of the T-cell

Juxtacrine

A disrupted endothelial cell releases a molecule that leads to the recruitment of platelets in the proximity of the wound site

Paracrine



Question 3 4 pts



You are investigating a novel signaling pathway. You have access to two inhibitors: Inhibitor 1 degrades the SDSU protein, Inhibitor 2 degrades the Aztec protein.

You perform a series of experiments and obtain the following blot showing protein activity. If the protein is active, it will appear with a band; no band will appear if the protein is not active.



What can you conclude about the signaling pathway?

Correct Answer

- ☐ In order for Viejas to be active, Aztec must be active
- ☐ Montezuma activity is dependent on SDSU activity
- ☐ Viejas appears earlier in the signaling pathway than Aztec
- ☐ SDSU appears after Aztec in the signaling pathway



Question 4 4 pts



Match the following disease scenarios to the cytoskeletal component most likely causing the issue:

The mitotic spindle is unable to form during prophase

Microtubules

A muscle cell is unable to contract following calcium release

Actin filaments

A sperm cell has very low motility

Microtubules

A shear stress causes the detachment of a layer of the epithelium

Intermediate Filaments

Telophase is unable to be completed because cytokinesis does not occur

Actin filaments



Question 5 4 pts



Why of the following is a correct description of the "GTP cap" on microtubules?

Correct Answer



The GTP cap is a buffer region formed due to the rate of tubulin heterodimer addition exceeding the rate of GTP hydrolysis



The GTP cap is a protein that protects the "+ end" of microtubules from dynamic instability, similar in function to the 5' cap on mRNA



The GTP cap is a specific type of "+ end" linking protein, a type of MAP that prevents microtubule catastrophe



The GTP cap is formed at the "+ end" of microtubules following a Guanine Exchange Factor (GEF) exchanging GDP for GTP on protofilament tubulin heterodimers



Question 6 4 pts



Taxol is a drug that prevents α - and β -tubulin heterodimers from dissociating from microtubules

Colchicine is a drug that prevents microtubule protofilament formation by binding to α - and β -tubulin heterodimers

Nocodazole is a drug that prevents α - and β -tubulin monomers from dimerizing

Addition of which drug to a normal cell would lead to microtubule catastrophe?

Correct Answer



Colchicine and Nocodazole



Colchicine only



Taxol only



Taxol and Nocodazole



Nocodazole only



Question 7 4 pts



Which of the following is FALSE about kinesin?

Correct Answer



ATP hydrolysis is the mechanism that ensures that kinesin will remain bound to the microtubule track during processive movement



Kinesin is an important part of the endomembrane system, ensuring vesicles are trafficked to the correct destination in the cell



The globular heads of kinesin have a time-dependent affinity for microtubule association when bound to ADP

- ☐ Kinesins can move organelles throughout the cell in addition to cargo vesicles



Question 8 4 pts



Using the following information, determine whether the described organelle is cilia or flagella:

The organelle uses a whip-like motion powered by microtubules.

The organelle leverages dyneins and accessory proteins to power its movement.

The organelle is involved in moving eggs through the fallopian tubes for possible fertilization.

Correct Answer

- ☐ The organelle is cilia
- ☐ The organelle is flagella



Question 9 4 pts



Which of the following is TRUE of actin treadmilling?

Correct Answer



Actin treadmilling leverages the recycling of G-actin monomers to continually polymerize at the "+ end" of the filament and depolymerize at the "- end" of the filament



Actin treadmilling occurs only at the "+ end" of the actin filament, with the relative rate of monomers joining and leaving the filament determining polymerization or depolymerization



Actin treadmilling is the result of differential affinity of G-actin monomers for GTP and GDP



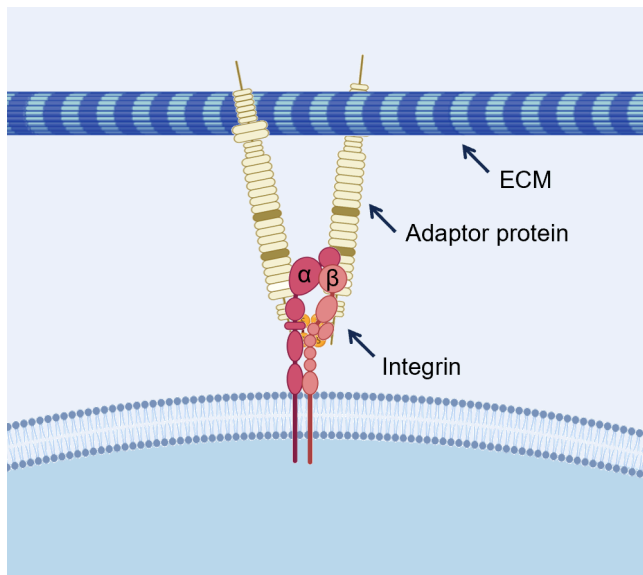
Actin treadmilling can only occur when ATP is unable to hydrolyze to ADP, thus lessening monomer affinity for the filament



Question 10 4 pts



What is the role of actin in the following image?



Correct Answer

- ☐ Integrin connects the ECM to the actin cytoskeleton at focal adhesions, and acto-myosin contractions pull the cell body forward toward the leading edge during cell migration
- ☐ Actin has no relationship to the process depicted in the image
- ☐ Integrin binds to the actin cytoskeleton in the extracellular matrix, forming anchorage points from which to move the cell forward
- ☐ Stress fiber formations from actin and myosin bind to integrin and prevent actin depolymerization, inhibiting cell movement at anchorage sites



Question 11 4 pts



A potent GDI (GDP-dissociation inhibitor) is added to a migratory cell.

Which of the following is FALSE?

Correct Answer

- ☐ The GDI will have no effect on actin remodeling, as this is governed by ATP/ADP not GTP/GDP
- ☐ The GDI will impede the movement of the migratory cell
- ☐ The GDI will impede the ability for GEFs (guanine exchange factors) to perform their normal functions
- ☐ Over time, addition of the GDI will cause stress fibers to break down



Question 12 4 pts



Which of the following correctly defines the roles of ATP and Ca^{2+} in muscle contraction?

Correct Answer



ATP causes the release of myosin from actin, Ca^{2+} causes the movement of tropomyosin to reveal the myosin binding site on actin



ATP causes the binding of myosin to actin, Ca^{2+} causes the release of myosin from actin to reinitiate the cycle



ATP causes the binding of actin to myosin, Ca^{2+} causes the "power stroke" of myosin pulling on actin to contract the muscle



ATP binding causes the "power stroke" of myosin pulling on actin to contract the muscle, Ca^{2+} causes the release of myosin from actin to reinitiate the cycle



Question 13 4 pts



What are the roles of microtubules and actin filaments during anaphase?

Correct Answer



Both microtubules and actin filaments polymerize and depolymerize to result in chromatid separation and spindle pole movement



Microtubules polymerize and depolymerize to separate sister chromatids, actin filaments only polymerize to move the spindle poles apart



Microtubules only depolymerize to separate the sister chromatids, actin filaments polymerize and depolymerize via treadmilling to move the spindle poles apart



Microtubules only depolymerize to separate the sister chromatids, actin filaments are not involved in anaphase, instead forming the contractile ring during telophase for cytokinesis



Question 14 4 pts



Why is P53 referred to as the "Guardian of the Genome" ?

Correct Answer



P53 prevents cell cycle progression in the event of DNA mutations, which may otherwise lead to permanently mutated daughter cells



P53 prevents the separation of improperly aligned chromosomes during metaphase, ensuring daughter cells will not have abnormal karyotypes

- ☐ P53 prevents cyclin binding to Cdk to prevent unregulated cell growth and cancer
- ☐ P53 prevents apoptosis from occurring, thereby ensuring cell survival and genomic integrity



Question 15 4 pts



Which of the following is TRUE of cyclin's role in the cell cycle?

Correct Answer

- ☐ Cyclin concentration is tightly regulated so as to only bind to Cdk and advance the cell cycle at the appropriate time
- ☐ Cyclin concentrations are maintained at elevated rates so that the cell can progress through cell cycle checkpoints upon receiving a growth signal to do so
- ☐ Cyclin alone is responsible for the progression of a cell through a cell cycle checkpoint and therefore must be kept away from the cell until the correct moment
- ☐ Cyclin must be degraded immediately after binding to Cdk because elevated cyclin concentration is the cause of all cancers



Question 16 4 pts



Which of the following is FALSE regarding the similarities and differences between Mitosis and Meiosis I?

Correct Answer

- ☐ In Mitosis, "crossing over" occurs during prometaphase, but during Meiosis I, "crossing over" is completed during prophase I
- ☐ Mitosis involves the production of daughter cells identical to the parent cell, while Meiosis I produces daughter cells that are distinct from the parent cell
- ☐ Both Mitosis and Meiosis I produce two diploid daughter cells
- ☐ Mitosis involves the separation of sister chromatids, Meiosis I involved the separation of homologous chromosomes



Question 17 4 pts



Consider the following nondisjunction events:

- I.** A nondisjunction event occurs during Meiosis II in a spermatozoa that goes on to fertilize an egg
- II.** A nondisjunction event occurs during Meiosis I in a oocyte that remains unfertilized following ovulation
- III.** A nondisjunction event occurs during Mitosis in an epithelial cell lining the stomach
- IV.** A nondisjunction event occurs during Mitosis in an embryonic stem cell

Which **two** of these events would likely cause the most harm to the organisms in question?

Correct Answer

- ☐ I and IV; many daughter cells would be directly affected by the nondisjunction
- ☐ I and II; nondisjunction occurs only in Meiosis, not in Mitosis



II and IV; nondisjunction events during Meiosis I lead to aneuploidy in all gametes, and nondisjunction in a stem cell would impact the entire embryo

- ☐ I and III; these are the situations of most rapid cell division, leading to more daughter cells maintaining the mutation



Question 18 4 pts



Which of the following is TRUE concerning spermatogenesis vs. oogenesis?

Correct Answer



Spermatogenic mitosis and meiosis occur throughout the adult life of a human, while oogenic mitosis only occurs before birth and meiosis ends at menopause

- ☐ Both spermatogenesis and oogenesis produce 4 haploid gametes able to potentially participate in fertilization



In both spermatogenesis and oogenesis, only Meiosis I is completed during puberty; ejaculation and fertilization, respectively, are required for Meiosis II to occur

- ☐ Polar bodies are only formed during Meiosis I of oogenesis, there are no polar bodies in spermatogenesis



Question 19 4 pts



An intrauterine device (IUD) is an effective form of birth control. Which of the following is accurate about IUDs?



Some IUDs release copper into the uterine cavity, which drastically reduces sperm motility, helping prevent pregnancy. These can last up to 10 years without needing a replacement and have a failure rate of less than 1%



Some IUDs release a progesterone analog into the uterus, which breaks down the uterine lining and helps to prevent ovulation. These have a failure rate of less than 1% and help to reduce menstrual bleeding and pain



IUD insertion is an invasive and often painful process, so in spite of its benefits should not be something one is pressured into doing



IUDs do not prevent the transmission of sexually transmitted infections (STIs) and can still lead to pregnancy, so usage of a condom is necessary to avoid pregnancy and STIs if one elects to engage in sexual intercourse

Correct Answer

- ☐ All of the other choices are accurate



Question 20 4 pts



Which of the following is FALSE regarding the stem cell niche?

☐ Cells in the stem cell niche maintain the ability to either self-renew or differentiate

☐

Once out of the stem cell niche, former stem cells have reduced in potency and can no longer return to this undifferentiated state

Correct Answer

☐

The stem cell niche is only found in the developing embryo and in the bone marrow, which gives rise to the blood cell lineages

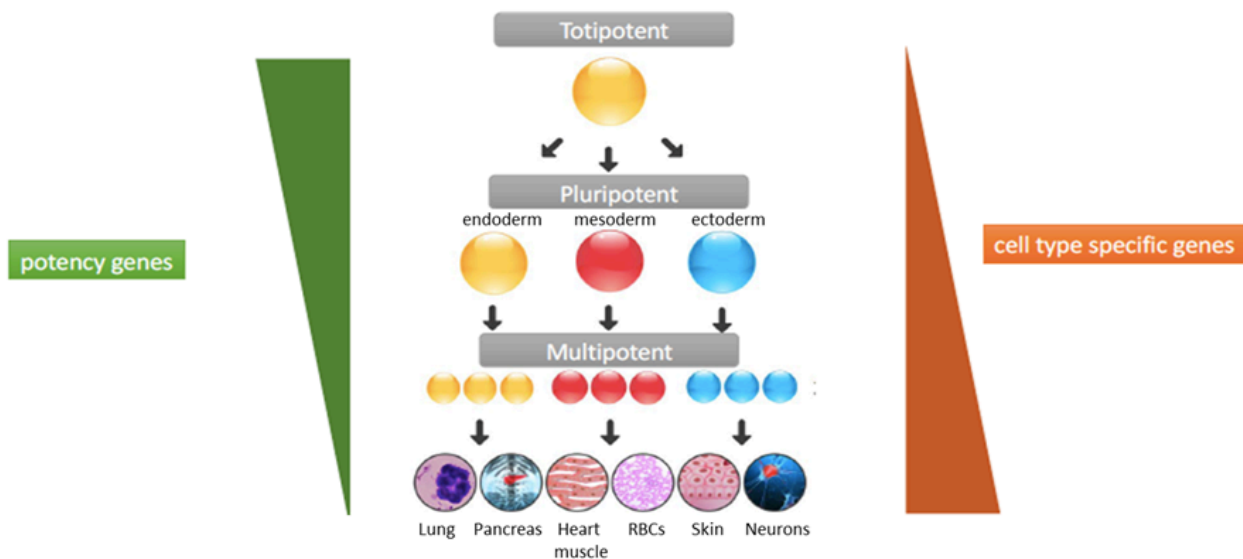
☐ The stem cell niche is maintained by cells that are not themselves stem cells

⋮

Question 21 4 pts

✎ ✕

What is an accurate interpretation of the image below?



Correct Answer

☐ Genes required to maintain a stem cell identity are downregulated as differentiation proceeds

☐

As a multipotent stem cell can become any type of cell in the body, it does not have many cell type specific genes actively expressed

☐

Once a stem cell makes a fate decision and becomes less potent, it no longer contains the genes that promote a stem cell identity

☐ All cells are essentially stem cells, with less and less potency as they become more highly specialized

⋮

Question 22 4 pts

✎ ✕

How can the formation of induced pluripotent stem cells (iPSCs) be possible?

Correct Answer



The same genes are present in all of our cells, specialization occurs through differential gene expression. iPSCs utilize embryonic factors to reverse the developmental clock to transform a differentiated cell into an embryonic-like cell



iPSC formation is possible because they are produced from adult stem cells, and so only a few genes need to be turned on or off to reach an embryonic-like state



iPSCs are formed from cancer cells that display unregulated cell division. Scientists block the harmful cancer pathways but keep the benign pathways active, increasing the cell potency



Although a differentiated cell has lost the genes needed to maintain a stem cell identity, these genes can be reintroduced (i.e., the Yamanaka factors) to transform the cell into an iPSC



Question 23 4 pts



A patient has a mutation in their DNA that leads to the development of dysfunctional liver cells.

The following therapeutic approaches would likely be effective EXCEPT:

Correct Answer



Take fibroblasts from the patient, induce them into iPSCs, differentiate them into liver cells, and transplant the liver cells back into the patient



Take fibroblasts from the patient, induce them into iPSCs, genetically correct the mutation, transplant the corrected iPSCs into the patient



Take fibroblasts from the patient, induce them into iPSCs, differentiate them into liver cells, identify a drug that resolves the issue, give the patient this drug



All of these proposed approaches would be effective



Question 24 4 pts



Select the appropriate intercellular junctional component for the following situations:

A second messenger from one cell travels into another cell

Gap Junctions

Attaches to the actin cytoskeleton for cell-to-cell mechanical integrity

Adherens Junctions

An ionic gradient is disrupted due to leakage of ions across the cell-cell boundary

Tight Junctions

Mediates cellular adhesion and resistance to mechanical disruption via intermediate filaments

Desmosomes



Question 25 4 pts



Which of the following is FALSE regarding the extracellular matrix?

Correct Answer



The extracellular matrix is a collection of structural and gelatinous proteins that, while complex to produce, remain fairly static once fully mature and outside of the cell



The extracellular matrix acts as a depot for growth factors and constant remodeling of the ECM can lead to growth factor release and receptor binding



The extracellular matrix serves as a structural buffer, insulating cells from extreme mechanical disturbances



The extracellular matrix provides communication to the cell through mechanotransduction via integrins

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