Introductory Plant Biology Model Exam II

Name_____*Key to Model Exam*________SSN________________

Grade: Bonus________ Exam Proper______Total_______

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☐ Check here if you wish to **withdraw permission** to have your grade posted by SSN.

☐ Check here if you have written **a detailed explanation** by a question. This is your **only** opportunity to challenge a question if you believe it to have two correct responses with neither substantially better than the other or if you believe that no answer is correct. Start your explanation with "I chose answer 'D' instead of answer 'B' because . . . ." Only challenges started thus will be considered and, in some cases, credit will be given even if you mark an answer that does not correspond to the key. Identify the question that you challenge:________________.

I understand that it is a violation of the Honor Code to refer to **any** information not specifically condoned by the instructor or to receive **any** information from a source that is not specifically authorized during an exam. I also understand that I should report to the instructor any violation of the Honor Code unless the person who violates the code reports himself or herself. In this course, an additional example of a violation of the Honor Code is to divulge information about exam content to anyone who has not taken the exam or to receive unauthorized information about the contents of an exam before taking the exam.

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Signature

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Bonus Section (Optional Reading)

1. (2 pts) Succinctly list some uses of the phloem fibers of flax.

laces, sail cloth, power-transmission belts.

2. (2 pts) Describe in a few words the research interests of Stephen Hales.

water movement in plants

2. (2 pts) Name one commercial use to which auxin or auxin analogs have been put.

herbicide, rooting compound, and others

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Exam Proper

1. Select the statement that best describes the incorporation of CO_2 into organic form by the Calvin Cycle (≡Reductive Pentose Phosphate Pathway).
   a. CO_2 is added to a 2-C compound to produce the 3-C initial product.
   b. CO_2 is added to a 4-C compound to produce the 5-C initial product.
   c. CO_2 is first reduced to formic acid, which then is incorporated into a pentose.
   xxxd. CO_2 is added to a 5-C compound, which subsequently splits to form 2 3-C initial products.

The first step in the Calvin cycle is the formation of a bond between the C in CO_2 and the #2 carbon in RuBP, a doubly phosphorylated 5-C sugar, so answer d is correct.

2. ANY organism that reproduces sexually by alternation of generations forms gametes
   a. by meiosis.
   b. that undergo up to three rounds of mitosis before syngamy.
   c. of four types (2 each for the sporophyte and gametophyte generations).
   xxxd. by mitosis of a nucleus of the haploid generation.

Gametes are formed from the haploid generation in organisms that exhibit alternation of generations, so answer a is incorrect. Gametes have one fate, fusion, so answer b is incorrect. The gametophyte is the gamete-forming generation and the sporophyte is the spore-forming generation, so answer c is incorrect.

3. ANY organism that reproduces sexually by zygotic meiosis
   a. is essentially a diploid organism.
   b. produces gametes by meiosis.
   c. undergoes double fertilization.
   xxxd. forms gametes by mitosis.

In organisms that reproduce by zygotic meiosis, the zygote is the only diploid cell, so answer a is incorrect. In organisms that exhibit zygotic meiosis, the only fate of the zygote is meiosis, so all other cells, including those that produce gametes, are haploid. Therefore, answer b is incorrect. Angiosperms are the only organisms that undergo double fertilization, and all plants have the alternation-of-generations life cycle, so answer c is incorrect.

4. Select the physiological process that is usually associated with gibberellin.
   a. inhibition of seed germination.
   b. inhibition of stomatal opening.
   c. leaf abscission.
   xxxd. cell elongation.

Gibberellin promotes *seed germination, so answer a is incorrect. Although two other plant-growth regulators (auxin and cytokinin) stimulate stomatal opening, and another plant-growth regulator, abscisic acid, inhibits stomatal opening, neither of the other two of the MAJOR FIVE plant-growth regulators (gibberellin and ethylene) affects stomatal aperture size, meaning that answer b is incorrect. Ethylene, and maybe to a limited extent abscisic acid, causes abscission. Again, gibberellin has no role, so answer c is incorrect.*

5. Select the best statement.
   a. All seed plants are heterosporous and only in some taxa is the megaspore retained within the "maternal" sporophyte.
   b. From a theoretical point of view, it is impossible for non-seed plants to be heterosporous.
   xxxc. All seed plants are heterosporous and the megaspore is always retained within the "maternal" sporophytic tissue.
   d. Heterosporous plants produce at least two different kinds of megaspores.

The megaspore MUST *be retained within the maternal sporophyte in order for seeds to form, so answer a is incorrect. Answer b is contrived, and indeed, there are nonseed plants that are heterosporous; answer b is therefore incorrect. Heterosporous plants produce two kinds of spores (microspores and megaspores), but not two kinds of megaspores, so answer d is incorrect.*

6. "Primary cell wall" means
    a. the layer of the wall that is always adjacent to the plasma membrane.
    b. the wall or the layer of the wall in which metabolic activity occurs.
    c. the wall between the primary plasma membrane and the peripheral plasma membrane.
    xxxd. the wall layer that is synthesized first and which permits growth or elongation.

Cell walls are synthesized by the plasma membrane. The most recently synthesized wall is adjacent to the membrane; if the wall has layers additional to the primary wall, those layers are internal to the primary wall, so answer a is incorrect. Metabolic activity occurs in all wall layers, meaning that answer b is incorrect. Plants have only one plasma membrane, so answer c is incorrect. Answer d is correct and you must know that it is correct independently of the other answers. I.e., although you know that answer a and answer c are patently incorrect, you probably have not addressed the contents of answer b in any detail. Although answer b is incorrect, you would choose answer d based on your knowledge that it is correct, and not by elimination as you usually do.

7. Select the phrase that best describes collenchyma cells.
    a. generally found in both roots and shoots, irregularly thickened cell walls, generally found as isolated cells.
    b. generally found only in shoots, regularly thickened cell walls, generally found in bundles near the center of the shoot.
    xxxc. generally found only in shoots, irregularly thickened cell walls, generally found in bundles just beneath the epidermis.
    d. specialized for support after the elongation phase of growth is completed, irregularly thickened walls, generally form a layer just beneath the epidermis.

Collenchyma is not typical of roots, and it serves with other collenchyma cells to provide plastic support during shoot elongation, so answer a is incorrect. Collenchyma walls are irregularly thickened, and collenchyma bundles are typically found just under the epidermis, so answer b is incorrect. Collenchyma is specialized for support during plastic growth, so answer d is incorrect.

8. Select the phrase that best describes sclerenchyma cells.
    a. generally capable of redifferentiation into parenchyma cells, may be photosynthetic, primary wall only.
    xxxb. may or may not be living at maturity, may be elongate or isodiametric, thick secondary walls.
    c. never living at the mature and functional state, elongated cells occurring singly, thick secondary walls but without lignin.
    d. provides flexible support during shoot elongation, isodiametric cells occurring in bundles, walls usually rich in lignin.

Sclerenchyma has elaborate cell walls—primary, secondary, and even tertiary, making answer a wrong (see also other comments in this explanation). Answer c is incorrect because a major wall component is lignin (see also other . . .) and sclerenchyma is sometimes living at the mature and functioning state. Answer d is incorrect because lignified walls are not flexible and because sclerenchyma are often fibers (which do, however, occur in bundles.)

9. Select the MOST COMPLETE LIST of cell structures found in parenchyma cells.
   xxxa. endoplasmic reticulum, mitochondria, nucleus, plasmodesmata, plastids, ribosomes, vacuole.
   b. endoplasmic reticulum, nucleus, plasmodesmata, plastids, ribosomes, vacuole.
   c. endoplasmic reticulum, mitochondria, nucleus, plasmodesmata, ribosomes, vacuole.
   d. endoplasmic reticulum, nucleus, plastids, ribosomes, vacuole.

Selecting the "MOST COMPLETE" of anything is inherently difficult. As usual, treat each sub-response as a true/false question, and then count the number of trues in each response, with the highest number winning. Answer a has seven components, and all are true. Answer b-d contain true responses, but fewer than answer a.

10. Select the statement that differentiates tracheids from vessel elements.
   a. Tracheids are living at maturity, whereas vessel elements are not.
   b. Water movement in tracheids is by diffusion, whereas water movement in vessels is by bulk flow.
   xxxc. Tracheids have a higher resistance to the bulk flow of water than vessels do.
   d. The strength of vessel walls is necessary to support medium and large trees, whereas tracheids alone are only sufficient to support shrubs and small trees.

Answer a is incorrect because tracheids are not living at maturity. Diffusion is an inadequate mechanism to transport substances over long distances, so the solution in all tracheary elements (tracheids and vessels) moves by bulk flow, making answer b incorrect. Tracheids are more specialized for support and are found in all vascular plants, including the tallest (gynmosperms, which lack vessels), so answer d is incorrect.

11. Select the best GENERALITY that describes the distribution of tracheary elements among plant taxa.
   a. All plants contain one or two types of tracheary elements.
   b. Angiosperms contain only vessel elements, whereas gymnosperms contain only tracheids.
   xxxc. Only angiosperms contain both vessel elements and tracheids.
   d. Wood is conservative evolutionarily, which is a statement consistent with the observation that tracheary elements of all seed plants are virtually identical.

Bryophytes do not contain tracheary elements, so answer a is incorrect. Answer b is incorrect because angiosperms contain both vessels and tracheids. Relatively speaking, wood is evolutionarily conservative, but wood is found in a limited number of plant taxa (gymnosperms and dicots), and see plants differ in their tracheary elements (e.g. gymnosperms do not have vessels), so answer d is incorrect.

12. Select the best statement that pertains to the cohesion theory of sap ascent.
   xxxa. Heat, which causes evaporation of water from the cell walls of the leaf, is the main energy source.
   b. Solutes are removed in the shoot as the water moves from cell to cell, so pure water arrives at the evaporating surfaces within the leaf and salt build-up is avoided.
   c. The pressure inside the tracheary elements is somewhat greater than that of most bicycle tires.
   d. The high pressure inside the tracheary elements prevents air bubble formation.

Answer b is incorrect because solutes do move in the transpiration stream (indeed, minerals must, to get from roots to leaves). Under most conditions, the pressure inside tracheary elements is negative, making answers c and d incorrect.

13. Select the best statement that pertains to transport in tracheary elements.
    xxxa. The pressure inside the tracheary elements is less negative in the shoot than in the leaf.
    b. The phloem transports nutrients and hormones, but the xylem transports only water.
    c. Along the transport pathway of functioning tracheary elements, there are many discontinuities in liquid water caused by bubbles across which gaseous water moves by diffusion.
    d. Transport is essentially an osmotic phenomenon caused by the higher solute content of tracheary elements in the leaf as compared with that of the root.

As indicated above, solutes move in the xylem, making answer b incorrect. Functioning tracheary elements do not have bubbles; indeed, could not function with bubbles because, as gases, bubbles do not have a defined volume and could not transmit tension. Answer c is therefore incorrect. As discussed above, xylem transport is via bulk flow, so answer d is incorrect.

14. Identify a primary site of synthesis of auxin.
    a. the parenchyma associated with xylem in the shoot.
    b. tracheary elements that are no longer functioning.
    xxxc. the tips of shoots.
    d. the elongated form of sclerenchyma cells.

Auxin is synthesized in more than one place in a plant, but we emphasized synthesis in the shoot tip, from which it moves downward and inhibits lateral growth, as for answer c. Vascular parenchyma (cf. answer a) does have role in basipetal transport of tip-produced auxin, but is not itself involved in synthesis, making answer a incorrect. Tracheary elements are dead and therefore do not synthesize hormones, making answer b incorrect. Fibers—elongated sclerenchyma—are often dead at maturity, making answer d incorrect.

15. Select the best statement that describes one physiological function of auxin (when it is present at an optimum concentration).
    a. Auxin stimulates lateral bud growth.
    b. Auxin inhibits stomatal opening.
    c. Auxin suppresses fruit formation.
    xxxd. Auxin stimulates formation of adventitious roots.

Auxin inhibits lateral growth (making answer a incorrect), has a mild stimulatory effect on stomatal opening (making answer b incorrect), and is usually required for fruit formation (making answer c incorrect).

16. Select the statement that best describes one mechanism by which auxin stimulates growth in the short term.
    a. Auxin activates the Na^+-K^+ ATPase in the plasma membrane.
    b. Auxin forms a salt bridge between cell-wall components and thus facilitates extension of the wall.
    xxxc. Auxin enhances excretion of protons, which loosen cell walls.
    d. By inhibiting respiration, auxin causes the increase of sugar concentration in the cell.

Auxin is a plant hormone, and plants do not have a Na^+-K^+ ATPase, making answer a incorrect. The concentration of auxin is too low to form abundant salt bridges, which, in any case, would strengthen the wall, so answer b is incorrect. Auxin does not inhibit respiration, making answer d incorrect.

17. Select the three attributes that are typical of sieve-tube elements but not of other plant cells.
    a. presence of plastids, presence of P-protein, absence of nucleus.
    xxxb. absence of nucleus, absence of vacuole, presence of P-protein.
    c. absence of nucleus, absence of plasma membrane, absence of plastids.
    d. presence of cell-to-cell connections, presence of vacuole, absence of nucleus.

Answer a fails the true/false diagnosis because other plant cells have plastids. Sieve tube elements have a plasma membrane (required to explain osmotically generated bulk flow), so answer c is incorrect (see also, above). Other cells have various cell-to-cell connections, but sieve-tube elements are only connected to adjacent companion cells, making answer d incorrect.

18. In the secondary active process of sucrose uptake by companion cells,
a. sucrose moves down a concentration gradient from the companion cell wall into the companion cell.
b. the driving force is the gradient in proton concentration from the outside of the cell to the inside of the cell, but the membrane potential is unimportant.
xxxc. the loss of free energy associated with proton uptake exceeds the gain in free energy associated with the uptake of sucrose.
d. sucrose is taken up by a pump that is fueled by ATP.

Answer a is incorrect because "active" implies movement against an electrochemical potential gradient. This driving force has two components of (membrane potential and (H^+)) so answer b is incorrect. Answer d is incorrect because "secondary" implies the absence of the hydrolysis of ATP or similar.

19. Bulk flow, as in sieve tubes, implies that
xxxa. all molecules regardless of size or charge will move at approximately the same velocity.
b. the difference in charge from cell to cell is the primary energy source that drives the transport.
c. the pressure is the same throughout the system.
d. the membranes of the sieve-tube elements along the pathway are impermeable to water.

Adjacent sieve-tube elements are electrically coupled through the large pores in the shared sieve plate, eliminating answer b. By definition, "bulk flow" results from pressure differences, so answer c is incorrect. Membranes are quite permeable to water (although some may facilitate exchange through abundant water channels). Sieve-tube membranes are not different, and answer d is incorrect.

20. Ultimately, the energy that drives flow in sieve tubes is
a. heat, which causes the water to expand in the sieve tubes of the leaves exposed to light.
b. the active accumulation of sucrose in the sieve-tube element vacuoles.
xxxc. the hydrolysis of ATP by the proton-extruding ATPase on the plasma membrane of the companion cells.
d. used in the conversion of sucrose to starch in the sieve-tube elements of the sink tissue.

If anything, heat would cause the movement of water down from the tip (assuming the tip was in a more sun-exposed position), and we know that phloem feeds the growing point. Answer a is generally foolish, anyhow, because the coefficient of expansion is far too small to drive movement. Sieve-tube elements do not have vacuoles, so answer b is incorrect.

Answers c and d are tougher to discriminate between. The preferable answer is c, because the proton pump ultimately drives sucrose loading, and sucrose accumulation causes osmotic influx of water, which creates the pressure gradient. However, this system would ultimately bog down if sucrose were not removed at the sink and converted to an osmotically inactive substance, like starch. So, I would accept answer d in a challenge if you know the above and indicate that the conversion of sucrose to starch requires energy, but few students taking this course will have that knowledge.

21. According to the mechanism of sucrose translocation taught in this class,
    xxxa. sucrose moves without the input of energy from the mesophyll apoplast to the companion-cell apoplast.
    b. sucrose moves from the interior of the companion cell into the apoplast between the companion cell and the sieve-tube element during phloem loading.
    c. sucrose is shuttled from the interior of mesophyll cells to the interior of companion cells without the expenditure of energy.
    d. the active accumulation of sucrose in the sieve-tubes of the source is done by the sieve-tube elements themselves, and companion cells serve only to provide nutrition to the sieve-tube elements.

Sucrose moves by diffusion (i.e., down an electrochemical potential gradient) from its site of synthesis to the companion cell wall. Answer a is a good answer although we cannot be sure whether the movement of sucrose is symplastic or apoplastic between the mesophyll and phloem parenchyma. Answer b is fundamentally incorrect because sucrose accumulated by the companion cell moves directly into the sieve-tube element. In some plants, sucrose may move symplastically from the mesophyll to the companion cells, but this mechanism, which is under active research now, was not taught in class. (In the class, I taught the widely accepted and well-explained mechanism, but if you know the current state of research, I would, of course, accept a challenge.) Answer d is incorrect because loading (and unloading) is done by companion cells.

22. The INITIAL event in stomatal opening is
    a. osmotic influx of water.
    xxxb. activation of the plasma-membrane proton-extruding ATPase.
    c. the activation of the H^+-sucrose symport.
    d. the movement of K^+ through plasmodesmata from adjacent cells into guard cells.

Osmotic movement of water into guard cells is the penultimate event, and answer a is incorrect. Sucrose uptake does not seem to occur in the early phase of stomatal opening, but answer c is incorrect in any case, as the symport would have to be powered by the ATPase. Answer d is incorrect because guard cells do not have plasmodesmata with adjacent cells, and plasmodesmata only facilitate passive transport.

23. The driving force for K^+ uptake and accumulation by guard cells is
    a. the gradient in proton concentration from the outside to the inside of the guard cells.
    xxxb. the membrane potential of guard cells.
    c. the gradient in potassium concentration from the outside to the inside of the guard cells.
    d. the hydrolysis of ATP by a Na^+-K^+ pump on the guard-cell membrane.

Answer a is incorrect because the concentration of protons is unimportant as they are not involved in transport (cf. sucrose transport). Answer c is incorrect—the membrane potential is the driving force (acting in concert with the ratio of potassium concentration inside and outside the cell). Again, plants do not have the typical Na^+-K^+ pump of animal cells, making answer d incorrect.

24. The short-term effect of ABA on guard cells is to
    a. open channels that permit K^+ influx into guard cells.
    xxxb. close channels that permit K^+ influx into guard cells and open channels that permit K^+ exit from guard cells.
    c. form membrane-spanning pores in the guard-cell membrane.
    d. block ATP synthesis and thus shut down the proton-extruding plasma membrane ATPase.

ABA causes stomatal closure, but K^+ influx causes opening, so answer a is incorrect. Some xenobiotics do insert themselves into membranes and form pores, but ABA is not one of them, and answer c is incorrect. As far as is known, ABA does not block ATP synthesis, so answer d is incorrect.

25. Secondary growth

xxxa. does not result directly from cell division in the growing tips of plants.

b. describes the addition of the secondary and tertiary cell-wall layers.

c. causes elongation of the plant.

d. describes the mobilization of nutrients from older dying leaves to developing leaves near the top of the plant.

Secondary growth results from cell division of the bifacial vascular cambium, not from making each cell have a thicker wall, so answer b is incorrect. Secondary growth is growth in girth; answer c is incorrect. Certain nutrients, like nitrogen, are mobilized from older leaves as they die (which explains their becoming paler as chlorophyll is lost), but this phenomenon is not secondary growth, so say no to answer d.