Introductory Plant Biology Model Exam III

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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Bonus Section (Optional Reading)

1. (2 pts) Summarize Haber's life and contributions.

A *full-credit answer must contain his contributions to commercial nitrogen reduction for fertilizer use, his war effort, his loss of family and home.*

2. (2 pts) What is the waggle dance?

pattern of movement inside hive by scout bee that directs foragers to nectar.

3. (2 pts) Briefly, why does a Gram-negative bacterium not stain whereas a Gram-positive one does?

thin peptidoglycan layer of Gram-negative bacterium does not retain stain. (will also accept alternative explanations that have been published.)

4. (2 pts) What is the mode of action of penicillin?

interferes with cell-wall biosynthesis.

Exam Proper

1. Select the best statement pertaining to photosynthesis.
   a. The ultimate source of electrons for reducing CO_2 is always water, regardless of the organism.
   b. Overall, C reduction occurs when the CO_2-acceptor, ribulose bisphosphate is carboxylated.
   XXXc. The source of electrons for C reduction in photosynthesis is NADPH in all eukaryotes.
   d. Light harvesting occurs in the chloroplast, but C reduction occurs in the cytosol.

Some prokaryotes use alternative electron sources, such as H_2S, making answer a incorrect. Carbon reduction occurs in only one step (reduction of the acid to the aldehyde) of the Calvin cycle, so answer b is incorrect. Both light harvesting and carbon reduction occur in the chloroplast, so answer d is incorrect. (Overall, however, the synthesis of sucrose involves several cellular compartments—the cytosol and the mitochondrion and peroxisome (the latter two in the photosynthetic carbon oxidation pathway, which functions in concert with the Calvin cycle)).

2. Select the best statement pertaining to glycolysis.
   a. The first step in glycolysis is to oxidize the electron carrier NAD^+.
   b. The first step in glycolysis is to oxidize the 6-C sugar glucose before it is phosphorylated.
   c. Glycolysis occurs in the mitochondrion, where it provides NADH for oxidative phosphorylation.
   XXXd. A key regulated step in glycolysis is the phosphorylation of Fru 6 P.

NAD^+ is the oxidized form of NAD. NAD^+ is reduced in glycolysis and not in the first step. Answer a is thus doubly wrong. Six-carbon sugars themselves are not oxidized in glycolysis, and the oxidized sugar is phosphorylated, so answer b is also doubly wrong. Glycolysis does not occur in the mitochondrion, although another energy-yielding pathway, the TCA cycle, does, so answer c is incorrect.

You noted that these review questions are very basic. If you had any difficulty with them whatsoever, be sure to review. These are at or below the level of any questions that you might find on standardized exams that are required for admission to professional or graduate schools.

3. Select the best statement that pertains to plants.
   XXXa. A homosporous species is one in which a spore produces a bisexual gametophyte.
   b. Homospory is a means of asexual reproduction in primitive plants whereby a diploid plant produces a diploid spore that germinates to form a new diploid plant.
   c. Homospory is a means of asexual reproduction in primitive plants whereby a haploid plant produces a haploid spore that germinates to form a new haploid plant.
   d. A heterosporous species is one in which the gametophyte produces two kinds of spores.

Spores are involved in the sexual *reproduction of plants and they are haploid, so answer b is incorrect. Answer c is incorrect as stated above, but also because spores are formed meiotically from diploid sporophytes. Answer d is incorrect because, as mentioned, spores are formed from the sporophyte.*

4. Select the best statement.

XXXa. In an organism that exhibits zygotic meiosis, the zygote is the only diploid cell or nucleus.

b. In the broadest definition, "zygotic meiosis" means that a zygote is formed and that meiosis occurs at some stage of the life cycle.

c. In the narrowest definition, "zygotic meiosis" means that the zygote is formed by meiosis.

d. Zygotic meiosis is the type of life cycle that primitive plants have; the name of this life cycle is conceptually equal to a statement that the gametophyte is the dominant generation in primitive plants.

In zygotic meiosis, the zygote undergoes meiosis; indeed any sexual organism would fit the definition in answer b, which is incorrect. The zygote, by definition, is the fusion product of two gametes and answer c is very wrong. All plants reproduce sexually by alternation of multicellular generations, so answer d is incorrect, although the gametophyte is the dominant generation in plants that first appeared in the fossil record.

5. Select the true statement.

a. All gymnosperms and all angiosperms undergo secondary growth.

XXXb. All gymnosperms and all angiosperms are heterosporous.

c. All gymnosperms and all angiosperms have vessel elements.

d. Angiosperms, but not gymnosperms, have seed coats.

Shoots of monocots do not have secondary growth, gymnosperms do not have vessel elements, and all seeds have a seed coat, meaning that answers a, c, and d, respectively, are incorrect.

6. Select the best statement.

a. The driving force for sucrose movement from the companion cell to the sieve tube element is the proton concentration.

b. The membrane potential, the absolute value of which is set by the activity of the H^+-extruding ATPase, is **not** a component of the driving force for sucrose movement into the companion cells.

c. A special ATPase on the companion cell pumps in one molecule of sucrose per H^+ by a coupled transport mechanism.

XXXd. The movement of sucrose into the companion cell is "fueled" by the proton concentration gradient and the membrane potential.

Sucrose moves passively from the companion cell to the sieve tube element, so answer a is incorrect. The membrane potential and the asymmetric proton distribution are the two components of the driving force for sucrose movement into companion cells in plants that are apoplastic loaders (the only type discussed in class). Answer b is therefore incorrect. Transport of sucrose into companion cells (again, in apoplastic loaders) is a secondary active transport process, and answer c is incorrect.

7. Select the best statement pertaining to the nitrogen cycle.

a. All of the nitrate (NO_3^-) resulting from nitrification (conversion of ammonium to nitrate) is reassimilated by plants.

b. Although certainly a phenomenon, biological nitrogen fixation accounts for only a minor fraction of the dinitrogen reduced on Earth.

XXXc. The amount of nitrogen fixation associated with geological processes (lightening, volcanoes) is very small compared with the amount fixed by biological nitrogen fixation.

d. The largest input of ammonium into the nitrogen cycle results from the use of synthetic fertilizers.

Some nitrate is converted to dinitrogen; answer a is incorrect. Biological nitrogen fixation accounts for about 90% of dinitrogen reduction, so it is not minor and answer b is incorrect. Answer d is incorrect because biological nitrogen fixation > 10x nonbiological synthetic processes.

8. The evolution of sunken stomata as a trait to provide drought-tolerance is explained by
    a. their ability to select water for retention while facilitating carbon dioxide acquisition.
    XXXb. diminution of the water gradient by increasing the pathway for water movement.
    c. Bad premise—sunken stomata are associated with drought-**in**tolerance.
    d. Bad premise—"sunken stomata" is a contrived term; they do not exist.

Stomata are far far larger than molecular dimensions so they cannot select for or against one or another uncharged gas; answer a is thus incorrect. Sunken stomata do exist and are associated with drought tolerance, making answers d and c, respectively, incorrect.

9. Maize, a monocot, was cultured in the extremely dry southwestern U.S. Making this possible, the indigenous peoples selected for an unusual trait:
    XXXa. persistence of the tap root.
    b. arrested fruit development.
    c. abundant secondary growth.
    d. male infertility.

The development of fruit was, of course, the purpose of planting so answer b is incorrect. Because of the diffuse nature of the vascular bundles in a monocot shoot, the cambium cannot form a ring and develop secondary growth, so answer c is incorrect. Male infertility would not have permitted fruit development, so answer d is incorrect.

10. Select the best statement as it pertains to nitrogen fixation.
    a. Nitrogenase, the enzyme that reduces dinitrogen to ammonium, is found only in the kingdom Plantae.
    b. As a means of speeding the metabolism of the prokaryotic symbiont, the plant has evolved a mechanism of maintaining a high concentration of O_2 in the nodule.
    c. Although biological nitrogen fixation is important in some ecological and agricultural systems, its magnitude pales in comparison with nitrogen fixation by geological processes.
    XXXd. In the legume-*Rhizobium* symbiosis, the bacterium supplies the plant with reduced N and the plant provides an oxygen-free environment and reduced C for the bacterium.

Nitrogenase is produced exclusively by prokaryotes, so answer a is incorrect. The concentration of oxygen is clamped to a low level in the nodule to avoid denaturation of nitrogenase; answer b is incorrect. Geological processes fix about 1/20th the amount of nitrogen that biological sources do, so answer c is incorrect.

11. Select the best statement that pertains to C_4 photosynthesis.
    a. Phospho*enol*pyruvate carboxylase (PEPC) is located in the bundle sheath cells.
    b. Although phospho*enol*pyruvate carboxylase (PEPC) is inhibited by O_2, the O_2 in the leaf is maintained at a low concentration by the oxygenase activity of ribulose-1,5-bisphosphate carboxylase oxygenase (rubisco).
    c. C_4 plants have phospho*enol*pyruvate carboxylase (PEPC) instead of ribulose-1,5-bisphosphate carboxylase oxygenase (rubisco).
    XXXd. In C_4 plants, a carbon atom in CO_2 is fixed into organic form, then released, and then fixed again into organic form.

PEPC is located in the mesophyll cells of C_4 plants, making answer a incorrect. Answer b is rubbish from end to end—PEPC is not inhibited by oxygen, the $[O_2]$ is not maintained at a low level, and if rubisco consumed so much oxygen, the plant would burn before your eyes. C_4 plants have an auxiliary pathway that uses PEPC, but they still have the same Calvin cycle as in all plants; answer c is incorrect.

12. Select a statement that describes an advantage of C_4 photosynthesis over C_3 photosynthesis.
    a. The CO_2 fixation pathway is simpler and consumes less energy.
    b. The higher intercellular CO_2 concentration permits smaller stomatal apertures at a constant CO_2 uptake rate.
    XXXc. The lower intercellular CO_2 concentration permits higher stomatal resistance at a constant CO_2 uptake rate.
    d. Because O_2 is not a substrate for phospho*enol*pyruvate carboxylase (PEPC), the oxygen concentration in C_4 plants is never at a low and stressful level.

C_4 photosynthesis is more complicated than the C_3 pathway—the C_4 pathway is an auxiliary pathway that "piggybacks" onto the C_3 pathway. The C_4 pathway consumes 2 more ATPs (there are more steps and a series of steps generally equates to a loss of free energy). Answer a is dead wrong. The $[CO_2]_{inside}$ is lower in a C_4 plant (see answer c) and thus answer b is incorrect. In a ventilated plant organ, such as a leaf with open stomata, the internal oxygen concentration approaches ambient, making answer d wrong.

13. Select the best statement.
    a. All prokaryotic walls contain peptidoglycan.
    b. All walled eukaryotes contain at least some peptidoglycan.
    c. Gram-negative bacteria lack peptidoglycan.
    XXXd. none of the above.

Neither archaeal nor eukaryotic walls contain peptidoglycan, making answers a and b incorrect. (I would accept a challenge, however, re answer a if you know that some archaeal walls contain substances similar to peptidoglycan.) Gram-negative bacteria contain a thin layer of peptidoglycan, so answer c is also wrong.

14. Select the best description that is true of eukaryotes.
    a. DNA organized into several chromosomes, poly-A mRNA absent, DNA amount not reduced during meiosis.
    b. most genes organized into operons, genome size typically approximately 10x that of a typical bacterium, extranuclear DNA present..
    c. membrane lipids mainly diacyl ethers, sterols absent from membranes, introns are typical.
    XXXd. DNA organized into several chromosomes, poly-A mRNA typical, introns typical.

Most mRNA in eukaryotes has a poly-A tail and the DNA content is reduced by half during meiosis (= reduction division), so answer a is doubly wrong. Eukaryotes do have extranuclear DNA (plastids, mitochondria) and genome size (measured as number of genes) is about 10x higher in a higher eukaryote (plant, animal) than in a bacterium (2000–4000), but organization of related genes into operons is a trait of prokaryotes, not eukaryotes, so answer b is incorrect. Introns are typical of eukaryotes, but eukaryotic lipids are esters, not ethers (like some Archaea), and sterols are present in eukaryotic membranes, so answer c is incorrect.

15. Select the response that best explains the size limitation on prokaryotic cells.
    a. Cytoplasmic streaming is too violent to maintain in larger cells.
    b. Prokaryotic cells are incapable of photosynthesis.
    XXXc. Compartmentation is limited in prokaryotic cells.
    d. The building blocks of the lipid bilayer of the cell membrane are too weak to withstand the forces associate with large cells.

Prokaryotic cells do not stream, so answer a is wrong. Many prokaryotes, e.g. cyanobacteria, photosynthesize, so answer b is incorrect. The essential physical nature of all biological membranes is similar, making answer d invalid.

16. Select the phrase describing attributes of a prokaryotic flagellum, but not of a eukaryotic flagellum.
    a. two central microtubules covered by a membrane.
    XXXb. a filament of protein not covered by a membrane.
    c. an arrangement of 9 pairs of microtubules in a circle that surround two central microtubules.
    d. a filament of protein that is surrounded by a membrane made of ether-linked lipids.

The prokaryotic flagellum is a filament of protein that is not covered by a membrane (answer b), which contrasts with all other answers (and with the eukaryotic flagellum).

17. Select the sentence that best describes attributes of a bacterial cell wall, but not a eukaryotic cell wall.
    a. The bacterial wall always has an outer membrane.
    b. The bacterial wall has rods of high tensile strength running through it.
    XXXc. Some of the monomeric units of bacterial cell walls are identical to monomeric units of chitin.
    d. The bacterial wall is mainly cellulose, implying that plants acquired this trait from Bacteria and not from Archaea.

Gram-positive bacteria do not have an outer membrane, making answer a incorrect. The generality is that the bacterial wall does not have rods of high tensile strength (cf. cellulose microfibrils), making answer b incorrect. A few prokaryotes (see footnotes) do make cellulose, but the generality is that bacteria have "exclusively" walls of peptidoglycan, invalidating answer d.

18. Select the sentence that provides the best comparison of archaeal and bacterial ribosomes.
    a. The archaeal, but not the bacterial, ribosome has a 16S or 16S-like rRNA.
    XXXb. The archaeal and bacterial ribosomes are about the same size, as determined by sedimentation in a gravitational field.
    c. The archaeal, but not the bacterial, ribosome has two subunits.
    d. In size and function, as manifested by sensitivity to selected antibiotics, archaeal and bacterial ribosomes do not differ.

The small subunit of the prokaryotic ribosome contains a 16S rRNA, making answer a incorrect. Answer c is incorrect because all ribosomes have two subunits. Bacterial ribosomes differ from those of Archaea, which have properties similar to those of the cytoplasm of Eukarya, making answer d incorrect.

19. Select the best statement that describes glucose metabolism in Bacterial and Archaea.
    a. Glucose is metabolized by glycolysis in both taxa.
    XXXb. Glycolysis operates in Bacteria, but not Archaea.
    c. Glycolysis operates in Archaea, but not Bacteria.
    d. Glycolysis does not operate in either Archaea or Bacteria.

Archaea do not have glycolysis so answer a is incorrect. The taxa are reversed in answer c, which implies that answer d is incorrect also.

20. Select the best statement that describes membrane composition in Bacteria, Archaea, and Eukarya.
    a. The organellar membranes in Bacteria are similar to the cell membranes of Archaea.
    b. Glycerol diesters with linear hydrocarbon chains are basic elements of all biological membranes.
    XXXc. Glycerol diethers with branched hydrocarbon chains are basic elements of archaeal membranes.
    d. The cell membranes of Archaea and Eukarya are similar in lipid constituents.

Bacteria do not have organelles invalidating answer a. Archaea have membranes based on ethers and branched hydrocarbons (= answer b is incorrect) but bacterial and eukaryal membranes are described by answer b (= answer d is incorrect).

21. Select the phrase that describes the most important similarity in photosynthesis between cyanobacteria and all photosynthetic eukaryotes.
    a. extraction of electrons from RuBP in the reduction of O_2 to H_2O.
    b. identical light-harvesting pigment/protein complexes to harvest light.
    c. chloroplast structure.
    XXXd. electron source for reducing CO_2.

Answer a is nonsense, kind of photosynthesis in reverse. There are three basic kinds of peripheral pigment/protein complexes; cyanobacteria have phycobilisomes, and plants use LHCs, so answer b is incorrect.

22. Select the best ***GENERAL*** statement that describes attributes of prokaryotic DNA, but not of eukaryotic DNA. (Of course, "general statements" implies a qualified truth.)
    XXXa. presence of operons, presence of plasmids, absence of poly(A) tails on mRNA.
    b. presence of histone proteins, DNA attached to membrane, diploid.
    c. absence of sexual recombination, presence of introns, absence of sequences for rRNA.
    d. absence of operons, absence of plasmids, absence of poly(A) tails on mRNA.

Prokaryotes are haploid and lack histone proteins, making answer b incorrect. Prokaryotes do not have sex (but do have limited DNA exchange) and, of course, have rRNA sequences, making answer c doubly wrong. Genes are often organized into operons in bacteria, and plasmids are common, making answer d doubly wrong, too.

23. Select the best general description of a virus.
    a. DNA **or** RNA coated by lipid and which can reproduce itself independently.
    b. DNA **or** RNA with a protein coat and which can reproduce itself independently.
    XXXc. DNA **or** RNA with a protein coat and which cannot reproduce itself independently.
    d. DNA **plus** RNA coated by lipid and which cannot reproduce itself independently.

Viruses require a host cell for reproduction, making answers a and b wrong. Viruses are "compact" and do not contain both RNA and DNA, making answer d wrong.

24. Select the best statement.
    a. Immediately after the formation of Earth, the conditions were “perfect” for the evolution and continuation of life.
    b. Photosynthetic prokaryotes, required to produce the reduced carbon on which further life depended, were the first life forms to appear on Earth.
    c. Nonphotosynthetic prokaryotes did not evolve until the oxygen in the atmosphere reached its present level.
    XXXd. Life has been on Earth for about 75% of Earth’s existence.

Earth was inhospitable right after its formation, making answer a incorrect. Although photosynthesis appeared quite early, the first life forms were not photosynthetic. O_2 concentration did not reach its current levels until about 800 million years before present, at which time there was an abundance of diversity, including multicellular eukaryotes, so answer c is wrong.

25. An explanation for the relationship among the most inclusive taxa is
    a. evolution from Bacteria of a progenitor of Archaea and Eukarya.
    b. independent evolution of the three domains.
    XXXc. whole-cell permanent fusion of a bacterial cell and an archaeal cell to form a eukaryotic progenitor.
    d. evolution of Eukarya from Archaea and evolution of Bacteria from Eukarya through loss of function.

Two alternative explanations for the three domains were presented. One, represented by answer c, is shown.