

USABO Open Exam
February 3 to 13, 2015

1. What best describes a nucleosome?

- A. Region in bacterial cells where DNA is located.
- B. DNA wrapped around 8 histone cores.
- C. RNA with protein bound.
- D. A region in the nucleus where ribosomes are assembled.
- E. The space between the layers of the nuclear membrane.

2. You observe fly cells that are undergoing meiosis and treat them with a drug that inhibits the separation of parental homologs. At which stage of meiosis do cells treated with this drug become arrested?

- | | |
|----------------|------------------|
| A. Prophase I | E. Prophase II |
| B. Metaphase I | AB. Metaphase II |
| C. Anaphase I | AC. Anaphase II |
| D. Telophase I | AD. Telophase II |

3. Psoriasis is a skin disorder that is caused by the increased proliferation of skin cells and results in red, itchy skin. Skin cells from a mouse model for this disease are isolated and cultured in a plate containing a drug that promotes the supercoiling of DNA. Which enzyme does this drug inhibit?

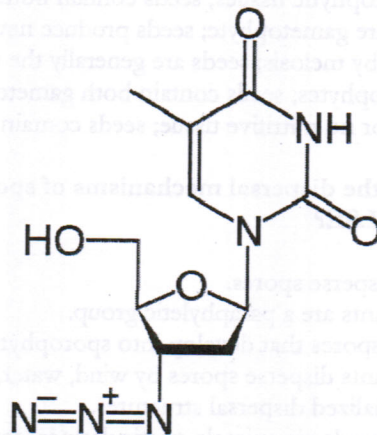
- A. DNA polymerase.
- B. Helicase.
- C. Topoisomerase.
- D. Primase.
- E. DNase.

4. Which phase of the cell cycle do cells treated with the drug specified in Question 3 become arrested?

- A. G₀ phase.
- B. G₁ Phase.
- C. G₂ phase.
- D. M phase.
- E. S phase.

5. A liquid culture of yeast was grown under anaerobic conditions but then had a significant quantity of alcohol dehydrogenase inhibitor added to the medium. Which of the following would best describe the effect on glycolysis due to the presence of the inhibitor?
- A. Glycolysis would continue with no change in catabolic efficiency.
 - B. Glycolysis would continue with higher catabolic efficiency.
 - C. Glycolysis would continue with lower catabolic efficiency and pyruvate would be further broken down through the Krebs cycle.
 - D. Glycolysis would continue with lower catabolic efficiency and the cells would start to excrete pyruvate instead of alcohol.
 - E. The rate of glycolysis would slow to a complete stop.
6. C-Myc is a transcription factor that recognizes DNA bases using hydrophobic interactions. By binding to specific DNA sequences, c-Myc can encourage cell division. In order to halt cell division, what mutations can one make to c-Myc?
- A. Change the nucleotides in the recognition site sequence from GCATTG to CGTAAC.
 - B. Change the nucleotides in the recognition site sequence from GCATTG to TATGGT.
 - C. Change the amino acids in the recognition site sequence from GVVLIA to AFFLLP.
 - D. Change the amino acids in the recognition site sequence from GVVLIA to FAFIIL.
 - E. Change the amino acids in the recognition site sequence from GVVLIA to TRKESE.
7. A replication inhibitor is added to stem cells in the middle of DNA replication. At what phase of the cell cycle would these cells remain?
- A. Mitosis.
 - B. G0 phase.
 - C. G1 phase.
 - D. S phase.
 - E. G2 phase.

8. The chemical structure shown is AZT, also known as Zidovudine, which is often used to treat human immunodeficiency virus (HIV) infection. Based on its chemical structure, how would it work?



- A. By decreasing the amount of DNA synthesized by HIV.
B. By modifying the surface proteins expressed by the host.
C. By decreasing the fidelity of reverse transcriptase of HIV.
D. By directly solubilize and degrade the surface proteins of HIV.
E. By accelerating the degradation of viral DNA synthesized by the host.
9. You have been asked to identify a bacterial culture using a light microscope. In order to examine a single bacterium, you use the technique of oil immersion. Which of the following responses does NOT support your use of this technique?
- A. The numerical aperture of the objective lens is increased.
B. It protects the objective lens from contacting the slide.
C. Resolution is increased to discern an individual bacterium.
D. The refractive index of glass is similar to that of the oil, preventing loss of light to the scope.
E. Refraction at the coverslip - air interface causes the light ray to miss the objective.
10. Which of the following is FALSE about Meiosis II?
- A. Cytoplasmic division occurs.
B. Individual chromosomes line up on the equatorial plate.
C. Sister chromatids separate and move toward opposite poles.
D. The chromosomes replicate.
E. The nuclear envelope disintegrates.

11. Spores and seeds are necessary for reproduction. Which of the following comparisons is FALSE with respect to spores and seeds?
- A. Spores contain gametophytic tissues; seeds contain both gametophytic and sporophytic tissues.
 - B. Spores produce mature gametophyte; seeds produce new sporophytes.
 - C. Spores are produced by meiosis; seeds are generally the result of fertilization.
 - D. Spores produce sporophytes; seeds contain both gametophytic and sporophytic tissues.
 - E. Spores contain little or no nutritive tissue; seeds contain nutritive tissue.
12. If one were to compare the dispersal mechanisms of spores and seeds, which of the following statements would be FALSE?
- A. Seed plants do not disperse spores.
 - B. Non-seed bearing plants are a paraphyletic group.
 - C. Seed plants produce spores that develop into sporophytes that are dispersed.
 - D. Non-seed bearing plants disperse spores by wind, water, active discharge (compression, slingshot, development of specialized dispersal structures).
 - E. Seed plants disperse seeds via animals, particularly insects.
13. Monocots and dicots are angiosperms. There are approximately 200,000 species of dicots on the Earth today and approximately 59,000 monocot species. From the characteristics below, select the statement that is TRUE for dicots. Dicots
- A. Are a paraphyletic group.
 - B. Have a ring shaped vascular bundle, but no pith region in the stem.
 - C. Have stomata in their roots.
 - D. Have the order of plant components from the medial to the lateral direction in the root cross section of phloem -> xylem -> endodermis.
 - E. Include the families Rosaceae, Orchidaceae, and Asteraceae.
14. Angiosperms are dominant in most terrestrial ecosystems. Which of the following traits DOES NOT contribute to their dominance over the specified clade of terrestrial photosynthetic organisms?
- A. Cuticle: compared to ferns.
 - B. Stomata: compared to liverworts.
 - C. Lignin: compared to mosses.
 - D. Seeds: compared to ferns.
 - E. Xylem: compared to conifers.
15. Which of the following statements about long distance transport systems in plants are TRUE?
- A. Phloem requires rigid cell walls to prevent implosion.
 - B. Phloem transport can be multidirectional.
 - C. Phloem transport is dependent upon metabolic activity.
 - D. The driving force that moves water in the xylem is ultimately derived from the energy of the sun.
 - E. Xylem transport occurs through the living xylem conduits.

16. You are given an *Arabidopsis* mutant PIN3, in which an auxin efflux protein is disabled. Which of the following phenotypes would you expect?
- A. Accelerated seed germination.
 - B. Delayed seed germination.
 - C. Diminished phototropic response.
 - D. Increased rate of fruit ripening.
 - E. Reduced stomatal response to soil drying.
17. Chrissie is a Papillon an herbivore who tends to round out her daily serving of “crunchies” with slash palms and grasses found in the yard. Today, she decided to try the new *Dieffenbachia* plant in the living room. Unfortunately, she developed the following symptoms: swollen lips and mouth accompanied by drooling. Which statement BEST describes Chrissie’s reaction to the *Dieffenbachia*? Her symptoms were the result of the effects of:
- A. An organ-level defense mechanism of the *Dieffenbachia*.
 - B. A cellular level defense mechanism of the *Dieffenbachia*.
 - C. The soapy solution applied to the *Dieffenbachia*.
 - D. A tissue-level defense mechanism of the *Dieffenbachia*.
 - E. The trichomes found on the leaves.
18. In which of the following habitats would you expect to find many C4 plants?
- A. Cool temperate grassland and temperate forest canopy.
 - B. Subtropical grassland and tropical rainforest canopy.
 - C. Subtropical grassland and tropical rainforest understory.
 - D. Temperate forest canopy and temperate forest canopy.
 - E. Tropical rainforest understory and tropical rainforest canopy.
19. You hypothesize that reduced caloric intake may increase the lifespan of *C. elegans*. To test your hypothesis, you feed the worms different caloric diets and measure their life span. Which of the following are examples of a positive control experiment you could perform to further support your results:
- A. Knock out a gene that decreases the worm’s ability to eat and provide this strain of worms with the same dietary regimes.
 - B. Provide one group of worms with a drug known to increase their lifespan.
 - C. Provide one group of worms with their ‘normal’ diet and measure the difference between control and treatment groups.
 - D. Provide the worms nothing but sugar water and measure the placebo effect.
 - E. Isolate one group of worms known to have longer life spans determined by genetics and provide them with the treatment diet.

20. You are a summer student at the Marine Biological Laboratory, Woods Hole. Like Hodgkin and Huxley, you want to study the speed of action potential propagation in the squid giant axon and compare it with a cultured neuron isolated from the Central Nervous System of a C57BL/6 mouse. To do this, you apply a stimulus near the squid and mouse axon hillocks and record the speed of action potential propagation downstream of each. You calculate the squid and mouse speeds to be 25m/s and 145m/s respectively. Based on your observations, which of the following is TRUE regarding the properties of your test neurons?

- I. The squid giant axon is myelinated and hence the propagation speed is high even though it is an invertebrate.
 - II. The cultured mouse axon is myelinated. Therefore, the speed is greater because there are voltage gated ion channels throughout the myelination.
 - III. The squid giant axon has a larger diameter which reduces the resistance, thereby increasing the speed of propagation.
 - IV. The cultured mouse axon is myelinated and therefore there is saltatory propagation of action potential.
- A. I and II.
 - B. I and III.
 - C. II and III.
 - D. II and IV.
 - E. III and IV.

21. You are in a developmental biology lab and your professor has asked you to study the effects of manipulating cortical rotations on a fertilized frog embryo. You try a few manipulations and report to your professor. Which of the following is an INCORRECT observation?

- A. You inhibit cortical rotation with UV irradiation and end up with a ventralized embryo.
- B. You permit cortical rotation and end up with a normal embryo.
- C. You create an additional rotation with centrifugation and end up with conjoined twins.
- D. You inhibit cortical rotation and end up with a dorsalized embryo.
- E. You enhance microtubules elongation with D2O treatment and end up with a dorsalized embryo.

22. You are making a fate map of a developing *Xenopus laevis* embryo. Which of the following structures will the archenteron form in the adult animal?

- A. Blood vessel.
- B. Epidermis.
- C. Gonads.
- D. Kidney.
- E. Lumen of the gut.

23. Reptiles differ from amphibians due to:

- A. Eyelids and an external ear openings.
- B. Scaly skin and the cleidoic egg.
- C. Terrestrial life style and the ability to climb.
- D. Scaly skin and an external ear opening.
- E. A three chambered heart and the cleidoic egg.

24. While there are several types of reproduction in single-sex amphibian species, _____ is characterized by offspring that have the exact genome as its mother; this is also true in _____, except that this requires the presence of male gametes.

- A. Parthenogenesis – gynogenesis.
- B. Neogenesis – parthenogenesis.
- C. Gynogenesis – hybridogenesis.
- D. Parthenogenesis – hybridogenesis.
- E. Gynogenesis – parthenogenesis.

25. Which of the following structures of the human nephron is relatively impermeable to water?

- A. Ascending limb of Henle.
- B. Descending limb of Henle.
- C. Glomerulus.
- D. Medullary collecting duct.
- E. Proximal tubule.

26. Vitellogenesis is a very important process in all egg-laying vertebrates. Which of the following statements is FALSE about vitellinogen? It

- A. Can last up to several months.
- B. Cannot be detected in plasma of females.
- C. Is a very large protein.
- D. Is taken up by the developing oocytes.
- E. Produced by the liver of females.

27. If excitatory potentials in the cell body reach the threshold, where do action potentials begin in neurons and how do they propagate?

- A. They begin in the axon hillock and propagate in one direction down the axon toward the axon terminals.
- B. They begin in the dendrite and propagate in one direction down the dendrite toward the dendrite terminals.
- C. They begin in the dendrite and propagate in two directions down the cell body toward the dendrite terminals.
- D. They begin in the axon hillock and propagate in one direction down the cell body toward the dendrite terminals.
- E. They begin in the axon hillock and propagate in two directions down the cell body toward the dendrite terminals.

Questions 28 to 31. Are the following ions found at a higher concentration in the cytoplasm than in the extracellular fluid in a *resting* neuronal axon? Use A for Yes and B for No.

- 28. Calcium.
- 29. Chloride.
- 30. Potassium.
- 31. Sodium.

32. Ellie is a Labradoodle who, as a pup, would quiver at the sight of any tiny leaf that flew near her. She is now a one-year old and will forget everything and bound into the woods to chase a blowing leaf. The learning mode is
- A. Classical conditioning.
 - B. Habituation.
 - C. Imprinting.
 - D. Operant conditioning.
 - E. Reasoning or insight learning.
33. The Homer Spit was selected by the Alaska Department of Fish and Game as an enhancement site due to its accessibility to locals and tourists to fish Chinook. In nature, fish smell the unique odors of soil and trees along the home stream to return to the same site to spawn. Unfortunately, there were no such unique odors at Homer Spit. So the salmon fish managers added a harmless chemical morpholine to the stream when they released the young fish and continued to do so even after the fish left for the ocean. At maturation, the fish swam back to the stream at Homer Spit by using the morpholine odor. In effect, the fish were using
- A. Habituation.
 - B. Higher order reasoning.
 - C. Learning by trial-and-error.
 - D. Its genetic-grounded ability to relocate its own stream via chemotropism.
 - E. Sensitization.
34. The Pallas cat, *Otocolobus manul*, inhabits both the desert and the rocky terrain and woodlands of the mountain steppe environments of Central Asia, and has been observed on rocky plateaus at altitudes of 13,000 feet. One of its major food sources is the rabbit-like pika. Which of the following characteristics of the Pallas cat would be the MOST valuable in hunting the pika?
- A. Flat forehead and low ears.
 - B. Stocky build.
 - C. Thick coat.
 - D. Well developed, nictitating membrane.
 - E. Well furred tail.
35. A farmer purchases F1 hybrid seed. This seed contains four heterozygous loci that give a significant increase in crop yield when compared to either homozygote. Two of these loci are on the same chromosome and show partial linkage. If the farmer allows the F1 plants to self-fertilize, what is the probability that a seed from the resulting F2 generation has *all four* heterozygous loci?
- A. At least 1/2.
 - B. Between 1/2 and 1/4.
 - C. Between 1/4 and 1/8.
 - D. Between 1/8 and 1/16.
 - E. Less than 1/16.

36. For forensic inspection, you only obtained red blood cells from an individual and amplified for the D1S80 locus in chromosome 1. Twenty nine different alleles of D1S80 have been identified, and 435 allelic combinations are theoretically possible. Approximately 86% of the population is heterozygous at this locus. You set up a PCR reaction for this locus and ran a DNA gel electrophoresis. What would your expected results be based on the described protocol?
- A. You would most likely see no bands.
 - B. You would see more than two bands.
 - C. You would see two bands for the heterozygous while one band for the homozygous.
 - D. You would see two bands for the homozygous while two bands for the heterozygous.
37. Some thermophilic organisms can thrive at very high temperatures ($100^{\circ}\text{C} +$). What effect, if any, would natural selection be expected to have on double stranded DNA (dsDNA) composition for survival at high temperatures?
- A. dsDNA would evolve to be rich in AT base pairs.
 - B. dsDNA would evolve to be rich in GC base pairs.
 - C. dsDNA would evolve to be rich in purine bases.
 - D. dsDNA would evolve to be rich in pyrimidine bases.
 - E. dsDNA composition would not need to change to support life at high temperatures.
38. Alcohol Dehydrogenase (ADH) is a critical enzyme for the fruit fly *Drosophila melanogaster*, which lives on rotting fruit. Flies with malfunctioning ADH will mostly die before reproduction. If you sequenced the gene that encodes for ADH in random samples of flies from around the world, which of the following qualitative observations would you anticipate: (Note multiple answers are possible.)
- A. All gene sequences would be identical, or nearly so.
 - B. Sequences from flies in one part of the world would be more similar to each other than to those from other regions.
 - C. The number of mutations which change amino acid structure of ADH is very low when compared to mutations which do not affect amino acid structure.
 - D. ADH does not affect reproductive fitness, so no unique pattern of mutations will be observed in this gene.
 - E. The number of mutations found in ADH is about the same as the number of mutations found in all other fruit fly genes of the same length.
39. You crossed two parental plants with unknown genotypes, while screening for a particular trait for height (T being completely dominant over t). If you obtain offspring that are 50% tall and 50% short, what could be the possible genotypes of the parents?
- A. TT, Tt
 - B. Tt, tT
 - C. Tt, TT
 - D. Tt, tt
 - E. TT, TT

40. Two female worker bees that were offspring of the same drone from another colony and the queen would on average have what fraction of DNA in common?

- A. 1
- B. 1/2
- C. 3/4
- D. 1/3
- E. 1/4

41. Some reptiles have very striking coloration; _____ is thought to provide a visual warning to predators and it's usually found in _____.

- A. Batesian mimicry – cobra snakes.
- B. Mullerian mimicry – skinks.
- C. Aposematic coloration- vipers.
- D. Aposematic coloration – coral snakes.
- E. Batesian mimicry – boas.

42. Fossil evidence suggests that roughly 400 million years ago, fish began exploring the terrestrial environment, eventually evolving into the first four-legged land animals called tetrapods. *Nature* published a study that examines this issue with the organism *Polypterus senegalus* (bichirs), a modern day walking fish. In the journal article, "Developmental plasticity and the origin of tetrapods," Dr. Emily Standen's team from McGill University raised one group of *Polypterus* on land and another group in the water and tested to see if a change in environment caused a change in the behavior or anatomy of the fish.

The study found that fish raised on land walked more effectively; their fins slipped less during the stroke; they planted their fins closer to their body mid-line; and lifted their heads higher off the ground, reducing friction. In addition, the bones at the base of the fin changed shape, becoming more supportive and allowing more freedom of motion of the shoulder and neck. These anatomical changes actually mirror what is found in the fossil record. Given these results are found in a single generation of land-raised fish, select ALL answers that are an accurate description of this study.

- A. Data from this study shows how evolution occurred when fish evolved into tetrapods.
- B. This study shows that a change in environment can induce a plastic response in an organism.
- C. This study proves that *Polypterus* are the common ancestor of tetrapods.
- D. This study made evolution happen.
- E. The offspring of land raised fish would be even better at walking than their parents.

43. Mink and fox both prey upon rabbits, exhibiting resource competition. Which of the following is an example of why the mink and fox may be able to coexist in the face of this competition?

- A. The mink and fox will never coexist due to the competitive exclusion principle.
- B. The mink and fox have a degree of niche separation such that they can coexist.
- C. Interspecific competition is more important than intraspecific competition, so the mink and fox can coexist.
- D. Spatial metapopulation structure can enable competitive species to coexist.
- E. B & D.

44. The size of an amphibian or reptile matters in terms of thermal interactions with the environment. The larger the animal the _____ and the _____.

- A. Lower the surface: volume ratio - lower the heat exchange.
- B. Higher the surface: volume ratio - higher the heat exchange.
- C. Higher the surface: volume ratio - lower the rate of water loss.
- D. Higher the heat exchange - higher the rate of water loss.
- E. Higher the surface: volume ratio - lower the heat exchange.

45. Mangroves tend to grow around the fringes of tropical estuaries and lagoons, as well as in the intertidal regions of tropical coasts. Two key problems for the survival of the mangrove in these areas are waterlogged sediment and increased salinity. Below is the environment condition matched with an adaptation of the mangrove. Which of the adaptations to the problems of waterlogged sediment or increased salt levels is FALSE?

Choice	Problem	Adaptation
A.	Waterlogged sediment	Lenticels
B.	Increased salt levels	High salinity tolerance level
C.	Increased salt levels	Proportion of root/above ground biomass decreases
D.	Waterlogged sediment:	Aerial roots
E.	Increased salt levels	Sheds leaves

46. Below are the parameters for five biomes. Which biome is characterized by warm temperatures year round and a dry season that can last up to nine months?

Biome	Typical plant/plant descriptor	Typical animal
A.	Forests vertically layered.	Animal diversity is higher than other terrestrial environs.
B.	Low, widely scattered vegetation.	Many animal species are nocturnal.
C.	Scattered trees found at different densities.	Large, plant-eating mammals.
D.	Dominated by cone-bearing trees.	Diverse mammals
E.	Forests have distinct vertical layers, closed canopy, understory, shrub and herb layers.	Mammals hibernate in winter.

Questions 47 to 50. Which of the following statements about taxonomy are CORRECT? Use "A" for CORRECT and "B" for NOT CORRECT.

- 47. Diatoms (*Bacillariophyta*) are more closely related to red algae (*Rhodophyta*) than they are to brown algae (*Phaeophyta*).
- 48. Slime molds (*Eumycetozoa*) are more closely related to amoebas (*Lobosea*) than they are to brewer's yeast (*Saccharomyces*).
- 49. Cycads are more closely related to ferns (*Polypodiopsida*) than they are to conifers (*Pinophyta*).
- 50. Insects are more closely related to roundworms (*Nematoda*) than they are to segmented worms (*Oligochaeta*).