

E/M Core Section (Ecological and Molecular)

Directions: Each set of lettered choices below refers to the numbered questions or statements immediately following it. Select the one lettered choice that best answers each question or best fits each statement and then fill in the corresponding circle on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1–2 refer to the following parts of the cell cycle.

- A) Anaphase
- B) Prophase
- C) Cytokinesis
- D) Interphase
- E) Metaphase

1

The point at which chromosomes are replicated to provide a full set of genetic material for both daughter cells

Choice (D) is the correct answer. In order to produce two daughter cells, the complete DNA must be replicated. This occurs during the S (synthesis) phase of interphase. During other stages of interphase, protein synthesis takes place and the centrioles replicate. Interphase is not technically part of mitosis.

2

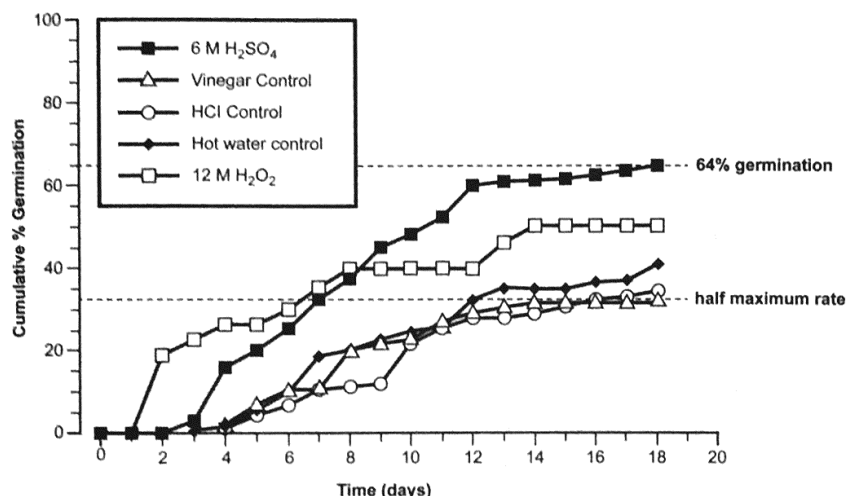
The point at which the cytoplasm divides

Choice (C) is the correct answer. Cytokinesis is the process during which the cell actually divides in two. At this point, the two nuclei of the daughter cells are at opposite poles of the cell, and the cytoplasm separates. In animal cells, a contractile ring of cytoskeleton elements forms; the ring contracts and cleavage occurs to eventually form two daughter cells. In plant cells, a cell plate forms with new cell membranes for each cell. A new cell wall then forms between the two membranes of the cell plate.

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Questions 3–4 refer to the following figure.

The figure below represents the percent germination of gourd seeds after being exposed to various treatments.



Cumulative germination of gourd seeds following various pregermination treatments.
n = 100 seeds per trial.

3

Which treatments reach more than a 30% germination rate by day 8?

- A) 6 M H₂SO₄ only
- B) 6 M H₂SO₄ and 12 M H₂O₂
- C) Hot water control and vinegar control only
- D) Vinegar control only
- E) 6 M H₂SO₄, vinegar control and hot water control

Choice (B) is the correct answer. On day 8, the only treatments that have passed the 30% germination rate mark are 6 M H₂SO₄ and 12 M H₂O₂.

Choice (A) is incorrect because it only includes the 6 M H₂SO₄ treatment.

Choices (C), (D) and (E) are incorrect because they all include treatments that have not passed the 30% germination rate mark by day 8.

4

Which of the following can be inferred from the data?

- A) Gourd seeds that are exposed to the hot water control would grow better if they were also exposed to 6 M H_2SO_4 .
- B) 64% is the highest possible germination rate for any group of gourd seeds.
- C) Strong acids, like H_2SO_4 , have a greater effect on germination than weak acids, like vinegar.
- D) Tomato seeds would have similar responses to the same treatments.
- E) If the experiment continued, the treatment with the highest germination rate would also have the tallest plants.

Choice (C) is the correct answer. According to the data, gourd seeds exposed to 6 M H_2SO_4 had the highest germination rate. H_2SO_4 is considered a strong acid, while vinegar is considered a weak acid. It can be inferred from the graph that strong acids could have a greater effect on germination than weak acids. Choice (A) is incorrect because there is no information on the graph about exposing gourd seeds to both hot water and H_2SO_4 . Choice (B) is incorrect because the graph only provides information for gourd seeds given specific treatments, not any random group of gourd seeds. Choice (D) is incorrect because tomatoes are a different plant species; the effects of these treatments on tomato seeds could be different than those on gourd seeds. Choice (E) is incorrect because the graph only provides information on germination rates, not on the height of the gourd plants.

5

Meiosis is a type of cell division important in human gametogenesis (spermatogenesis and oogenesis). Which of the following statements about human gamete formation is correct?

- A) The final step of gametogenesis results in the formation of two diploid cells.
- B) The result of oogenesis is the formation of four fully functional ova.
- C) Spermatogenesis and oogenesis are both regulated by a monthly cycle.
- D) Oogenesis occurs throughout the lifetime of a female.
- E) Spermatogenesis results in four fully functional sperm cells.

Choice (E) is the correct answer. In sperm production, all four products of meiosis become viable gametes. Choice (A) is incorrect because it describes the results of mitotic action, not meiosis, which results in twice as many nuclear products containing half the number of chromosomes (reduction division). Choice (B) is incorrect because oogenesis produces only one functional ova and three smaller polar bodies. Choice (C) is incorrect because spermatogenesis occurs continuously after puberty while ovulation and completion of oogenesis is regulated by a menstrual cycle. Choice (D) is incorrect because the actual production of viable eggs occurs only after puberty and ends after menopause.

6

In our current classification system, members that belong to the same order also belong to the same

- A) genus
- B) class
- C) species
- D) family
- E) race

Choice (B) is the correct answer. In the Linnaean classification hierarchy, class is above order. Therefore, order members share the same class, phylum, and domain. Order members will not necessarily share the same genus, species name, or family, so choices (A), (C) and (D) are incorrect. Choice (E) is incorrect because race is a subdivision under species; it is defined as "a geographically isolated breeding population that shares certain characteristics in higher frequencies than other populations of that species, but has not become reproductively isolated."

7

The cells of the fruit fly *Drosophila melanogaster* contain 3 pairs of autosomal chromosomes and one pair of sex chromosomes. Upon completion of Meiosis II, how many chromosomes will each fruit fly gamete contain?

- A) 2
- B) 4
- C) 6
- D) 8
- E) 16

Choice (B) is the correct answer. The process of meiosis is a reduction division that produces cells containing the haploid number of chromosomes. A fruit fly cell contains a total of 8 chromosomes arranged into 4 pairs. Replication will occur prior to meiosis, producing 16 chromosomes to be distributed. Upon completion of Meiosis II, four cells will be produced, and each cell will contain 4 chromosomes (half the original number and one from each of the 4 pairs).

8

Huntington's disease is a degenerative disorder of the nervous system that follows an inheritance pattern of autosomal dominance. What is the probability that a child will inherit Huntington's disease if one of the parents has an allele for the disease?

- A) 0%
- B) 25%
- C) 50%
- D) 75%
- E) 100%

Choice (C) is the correct answer. Traits following a pattern of autosomal dominant inheritance do not need to be present in both alleles for expression to occur. If an individual inherits one copy of the Huntington's disease allele, he or she will have the disease. If one parent carries one allele for the disease, there is a 50% chance that the child will inherit the allele and have the disease.

9

Pattern baldness is a sex-linked recessive trait characterized by hair loss near the hairline and at the crown of the head. If a woman whose father is bald and a man who is bald have a son, what is the probability that the son will inherit the allele for pattern baldness? Assume that the woman's mother does not carry the allele for pattern baldness.

- A) 0%
- B) 25%
- C) 50%
- D) 75%
- E) 100%

Choice (C) is the correct answer. Pattern baldness is a sex-linked recessive trait, which indicates that it is carried on the X-linked chromosome. A female inherits one X-linked chromosome from her father. Because the woman's mother does not carry the allele for pattern baldness, the woman only carries one copy of the allele. If the couple has a son, there is a 50% chance that the son will inherit the X-linked allele for pattern baldness from his mother. The father's baldness is irrelevant; he will pass his unaffected Y chromosome to the son.

10

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10

Both avian and mammalian hearts are referred to as double-pump structures. Which of the following explains the anatomical and physiological basis for this description?

- A) Blood always enters into an atrium and then is pumped into a ventricle.
- B) Blood pressure alternates between systolic pressure and diastolic pressure.
- C) The atria provide one pump and the ventricles provide a second pump.
- D) The heart sends blood out through arteries and retrieves blood through veins.
- E) The heart pumps blood simultaneously through a pulmonary circuit and a systemic circuit.

Choice (E) is the correct answer. The first pump sends oxygen-poor blood to the lungs and oxygen-rich blood back to the heart, which is pulmonary circulation. The second pump sends oxygen-rich blood to the rest of the body, which is systemic circulation. Choice (A) is incorrect because one atrium and one ventricle create a single pumping unit. Choice (B) is incorrect because systolic pressure and, together, diastolic pressure are simply measures of the pumping pressure in the systemic circulatory system. Choice (C) is incorrect because atria and ventricles work together to provide pumping pressure. The atria are receiving chambers and are too weak to work alone as pumps. Choice (D) is incorrect because arteries and veins are not pumping structures.

11

All of the following would be true of a population in Hardy-Weinberg equilibrium EXCEPT

- A) There is no migration of individuals either into or out of the population.
- B) The population is not influenced by selective pressures.
- C) Mating occurs randomly within the population.
- D) There is no change in the rate of mutation.
- E) The population is relatively small.

Choice (E) is the correct answer. The Hardy-Weinberg equilibrium is used to determine the shift in allele frequency within a population. The introduction or loss of genes will have a greater effect on a small population than it would on a large population. Choices (A), (B), (C) and (D) are incorrect because they are all requirements for Hardy-Weinberg equilibrium (no occurrence of evolution). The Hardy-Weinberg equilibrium predicts gene flow patterns within a population and assumes alleles will be inherited in similar ratios to those of the parents over several generations. This genetic equilibrium is maintained if few new genes are introduced to the population.

12

There is a high degree of homology in the DNA of dogs and wolves. Which of the following best explains why dogs and wolves show a high degree of similarity in their DNA?

- A) Dogs and wolves have the same number of chromosomes.
- B) The morphologies of dogs and wolves are similar.
- C) Dogs and wolves share the same ecological niche.
- D) Dogs and wolves share a very recent common ancestor.
- E) The high degree of homology is the result of convergent evolution.

Choice (D) is the correct answer. Homology refers to traits that two different organisms inherit from a common ancestor. The best explanation for the high degree of homology in the DNA of dogs and wolves is that dogs and wolves share a very recent common ancestor. Choice (A) is incorrect. Although it is true that dogs and wolves both have 78 chromosomes, chromosome number does not necessarily indicate a close relationship (for example, chickens also have 78 chromosomes). Choice (B) refers only to morphology, which describes the form and structure of an organism but does not discuss its inherited traits; two organisms can share certain morphological features but may not be genetically related. Choice (C) describes the relative position of species within a habitat where organisms live, which does not affect DNA. Choice (E) describes convergent evolution, which means that a similar characteristic evolved within two separate lineages independently, usually due to similar environmental challenges. Since dogs and wolves share a high degree of homology in their DNA, their similarities are genetically based, and not independent of one another.

13

Darwin based his ideas of natural selection based on all of the following observations EXCEPT

- A) Parents pass their successful traits on to their offspring.
- B) Population members exhibit variations in many traits.
- C) All living organisms use the same genetic code.
- D) Environmental pressures can select various traits based on survivability.
- E) Populations that adapt to environmental conditions produce many offspring.

Choice (C) is the correct answer. The structure of DNA was not discovered until the 1950s; Darwin could not possibly have had knowledge of the genetic code. Choices (A), (B), (D) and (E) are incorrect because they do support Darwin's theory of evolution. Darwin conducted direct observations of various species and he noted that parents with the most favorable traits survive to have offspring who receive those favorable traits; that there is variety in traits; that there is relative success or failure based on environmental conditions; and that species seem to overpopulate.

14

Which of

- A) Random
- B) Occur
- C) Develop
- D) Emigr
- E) Forma

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Which of the following is LEAST likely to result in speciation?

- A) Random mating among members of a large population of a species
- B) Occurrence of hybridization between individuals from two different species
- C) Development of different mating behavior by some members of a species
- D) Emigration to a specialized microenvironment by some members of a species
- E) Formation of a physical barrier that blocks gene flow between members of a species

Choice (A) is the correct answer. Random mating is considered to be one of the factors that maintains gene flow within a species and therefore should show no change with time, or evolution of the species. Choice (B) is incorrect because hybridization can be a factor in speciation, especially in some plant species. Choice (C) is incorrect because differences in mating behavior that prevent successful mating are considered reproductive isolating mechanisms and can lead to speciation. Choices (D) and (E) are incorrect because both emigration and the formation of physical barriers lead to isolation of a subpopulation, which can lead to genetic divergence of the subpopulation from the original population, which can lead to speciation.

the major cause of heavy metals in the tissue of fish-eating birds is biomagnification. Choice (B) is incorrect because the high concentration of heavy metal in the tissue of one fish-eating bird does not imply that all birds of that species in the population died. Choice (C) is incorrect because a high concentration of heavy metals is not in any way related to the explosive increase of populations; in fact, it can have the opposite effect. Choice (D) is incorrect because land pollutants would be in the soil. This species eats fish rather than soil organisms or plants, so the heavy metals present in a toxic soil wouldn't make their way into the bird's tissue at such high levels.

M Section (Molecular)

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20

Which of the following statements regarding mitosis is correct?

- A) Mitosis will result in reduction division.
- B) Sister chromatids will separate during metaphase.
- C) Cytokinesis occurs during the process of prophase.
- D) Mitosis occurs continually in the life cycle of all somatic cells.
- E) The final product of mitosis is the formation of two identical nuclei.

Choice (E) is the correct answer. Mitosis is a process that produces two diploid nuclei that are genetically identical to the original. Choice (A) is incorrect because meiosis, not mitosis, reduces the final chromosome number by half. Choice (B) is incorrect because sister chromatids separate during anaphase. Choice (C) is incorrect because cytokinesis occurs at the end of telophase, not during prophase. Choice (D) is incorrect because some somatic cells, such as certain neurons and skeletal muscle cells, do not divide once they are fully differentiated.

21

The process of photosynthesis occurs in two steps. One step is referred to as the light-dependent reactions, and the other is the light-independent reactions. Which of the following events occurs during the light-independent reactions?

- A) The production of oxygen
- B) The splitting of a molecule of water
- C) The production of ATP
- D) The production of G3P
- E) The formation of NADPH

Choice (D) is the correct answer. The production of G3P occurs in the stroma of the chloroplast, using products of the light reactions (ATP and NADPH) to fix carbon in either light or dark conditions. Choices (A), (B), (C) and (E) all occur during the light-dependent reactions and are necessary for the capture and conversion of energy. Only choice (D), the production of G3P, is an event that does not directly require light.

22

Changes in temperature and pH often have great effects on the efficiency of enzymes because

- A) the energy of activation will be raised or lowered.
- B) the three-dimensional protein structure of enzymes is altered.
- C) changes affect substrate surfaces and make them unrecognizable.
- D) all enzymes work best at normal body temperature and a neutral pH.
- E) cofactors are not available under abnormal conditions.

Choice (B) is the correct answer. Both temperature and pH can alter tertiary protein structure, changing the active site where enzymatic activity occurs. There is a certain optimal temperature at which an enzyme's catalytic activity is greatest. Above this temperature, the enzyme structure denatures because intra- and intermolecular bonds are broken. Each enzyme also works within a specific pH range. Changes in pH can make and break intra- and intermolecular bonds. Choice (A) is incorrect because the energy of activation does not change. Choice (C) is incorrect because it does not address the effect on the enzyme. Choice (D) is incorrect because enzymes have different optimal conditions depending on their location in the body and function. Choice (E) is incorrect because cofactor availability would not normally be affected by physical conditions.