

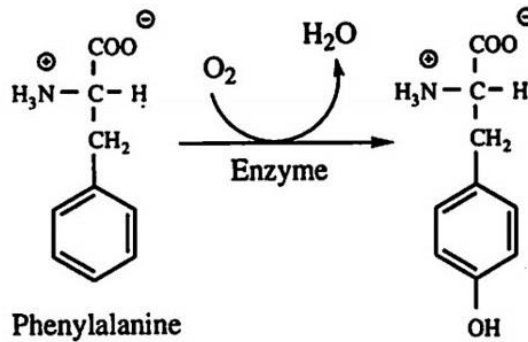
Bio League  
Competition  
2022 Phase  
Two

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# Biochemistry & Cell Biology:

- 1- Phenylalanine, an essential amino acid, is converted to tyrosine in the following reaction:  
This reaction can be described as a \_\_\_\_\_.



- a) carboxylation
- b) hydrolysis
- c) hydroxylation
- d) hydration

- 2- Which of the following is a "reduction" reaction?

- a)  $\text{Na} + \text{H}_2\text{O} \rightarrow \text{Na} + \text{HO} + 2\text{H}_2$
- b)  $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$
- c)  $\text{CH}_4 + \text{O}_2 \rightarrow \text{CH}_2\text{O} + \text{H}_2\text{O}$
- d)  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
- e)  $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$

- 3- At puberty, an adolescent female body changes in both structure and function of several organ systems, primarily under the influence of changing concentrations of estrogen and other steroid hormones. How can one hormone, such as estrogen, mediate so many effects?

- a) Estrogen is produced in very large concentrations by nearly every tissue of the body.
- b) Each cell responds in the same way when steroids bind to the cell surface.
- c) Estrogen is kept away from the surface of any cells, not able to bind it at the surface.
- d) Estrogen binds to specific receptors inside many kinds of cells, each with different responses.

- 4- An animal cell in a hypertonic solution would \_\_\_\_\_.

- a) swell
- b) swell and exhibit turgor
- c) exhibit plasmolysis
- d) shrink and then swell
- e) not be affected; only a plant cell would be affected

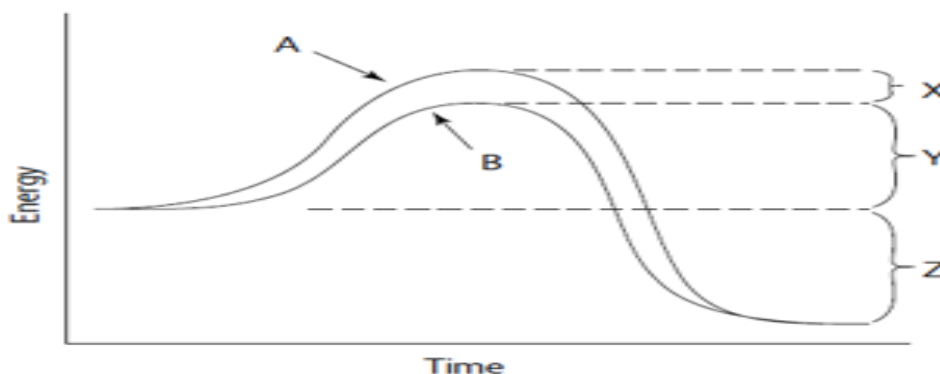
- 5- During cell respiration, most ATP is formed as a direct result of the net movement of\_\_\_\_\_.
- a) sodium ions diffusing across a membrane
  - b) electrons flowing against a gradient
  - c) electrons flowing through a channel
  - d) protons flowing through a channel
  - e) protons flowing against a gradient
- 6- From where are the flagella and cilia originated?
- a) centriole
  - b) mitochondria
  - c) basal body
  - d) Golgi body
- 7- A person with a bacterial infection usually develops a fever. This fever helps protect the person by inhibiting the growth of bacteria because\_\_\_\_\_.
- a) bacteria reproduce more rapidly at higher body temperatures.
  - b) fever blocks the synthesis of proteins in bacteria.
  - c) the higher temperature increases the metabolic rate of bacteria.
  - d) sweating removes cofactors required by bacteria from the blood.
  - e) enzymes do not function as well at temperatures other than that which is optimal.
- 8- Can a protein be used for energy storage?
- a. Yes, but only in the liver.
  - b. Yes; proteins store about 4 kcal per gram.
  - c. No; energy storage is reserved for carbohydrates.
  - d. No; energy storage is reserved for lipids.
  - e. Yes, but only in thermophilic bacteria.
- 9- Gamma-aminobutyric acid is\_\_\_\_\_.
- a) a regulator of HGH production.
  - b) an enzyme inhibitor associated with HCl production in the stomach.
  - c) a neurotransmitter with a role in pain perception.
  - d) an animal hormone that has great structural similarities to plant hormones.
  - e) a substance that stimulates the production of calcitonin.

10- Thalidomide and L-dopa (see figure) are examples of pharmaceutical drugs that occur as enantiomers, or molecules that \_\_\_\_\_.



- a) have identical three-dimensional shapes
- b) are mirror images of one another
- c) are mirror images of one another and have the same biological activity
- d) are cis-trans isomers

11- For the graph given below, the two curves describe the potential energy of substances during the progress of a chemical reaction. All of the following items could apply to this graph EXCEPT:



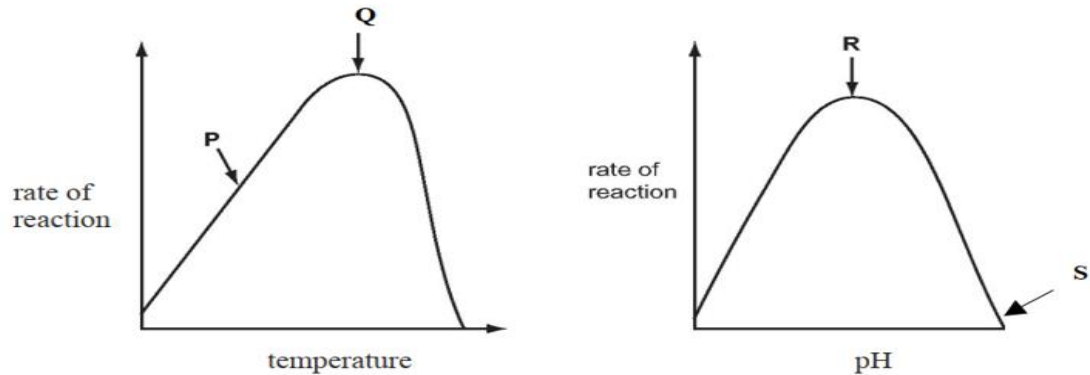
- a) Curve B could be showing the influence of an enzyme.
- b) The sum of energy in the products of the reaction is less than the sum of energy in the reactants.
- c) The activation energy of this reaction could be given by X+Y+Z.
- d) This reaction graph could describe the reaction  $\text{ATP} \rightarrow \text{ADP} + \text{P}$
- e) This is an exergonic reaction.

12- The inability of an integral protein to diffuse transversely in a membrane is MOST likely due to \_\_\_\_\_.

- a) strong hydrophilic forces between the membrane and the protein.
- b) the protein's asymmetric distribution.
- c) the protein's numerous hydrophobic amino acid residues in the membrane's nonpolar interior.

d) strong hydrogen-bonding forces between the protein and the membrane.

13- Which statement explains the enzyme activity at the point shown?



- a) At P, hydrogen bonds are formed between enzyme and substrate.
- b) At Q, the kinetic energy of enzyme and substrate is highest.
- c) At R, peptide bonds in the enzyme begin to break.
- d) At S, the substrate is completely denatured.

14- In an experiment of mitotically dividing animal cells, nuclei of cells in G1 and G2 phases were removed.

In the subsequent step, the G2 phase nuclei were introduced in enucleated cells of the G1 phase. If these cells are cultured, what will be the consequence?

- a) Cells will abort the cell cycle and enter the G<sub>0</sub> phase.
- b) Cells will shift directly from G1 to the G2 phase.
- c) Cells will continue to stay in the G1 phase.
- d) Cells will proceed from G1 to the S phase.

15- Which is an example of a feedback mechanism?

- a) Phosphofructokinase, an allosteric enzyme that catalyzes step 3 of glycolysis, is inhibited by ATP.
- b) NAD carries hydrogen to the ETC.
- c) ATP is produced in mitochondria as protons flow through the ATP- synthase channel.
- d) Energy is released from glucose as it decomposes into CO<sub>2</sub> and H<sub>2</sub>O.
- e) Lactic acid gets converted back to pyruvic acid in the human liver.

16- Which one is NOT correct about where the Calvin cycle occurs?

- a) in the spongy mesophyll in C-3 plants
- b) in the mesophyll in C-4 plants
- c) in the palisade layer in C-3 plants
- d) in the bundle sheath in C-4 plants

17- Which of the following interactions is most responsible for the structural stability of soluble globular proteins?

- a) Dipole-dipole interactions.
- b) Electrostatic interactions.
- c) Hydrogen bonds.
- d) The Hydrophobic Effect.
- e) Van der Waal forces.

18- Which Cell-Cell adhesion molecule is dependent on  $\text{Ca}^{+2}$ ?

- a) Their activity can be modulated by effector molecules.
- b) They demonstrate cooperativity.
- c) Their activity can be modulated by substrate concentration.
- d) They follow Michaelis-Menten kinetics.
- e) Plots of their rate of product formation versus substrate concentration are sigmoidal in shape.

19- Maltose is a disaccharide that can easily be digested into glucose molecules. The glycosidic linkage between glucose molecules in maltose is \_\_\_\_\_.

- a)  $\beta$  1-4
- b)  $\alpha$  1-2
- c)  $\alpha$  1-4
- d)  $\beta$  1-2

20- Endorphin is a natural analgesic secreted by the pituitary gland. Upon binding to its receptor in brain cells, endorphin can relieve pain and create a sense of euphoria. Morphine can achieve similar pain relief effects by binding to the endorphin receptor. Why do both endorphin and morphine bind to the endorphin receptors in brain cells?

- a) Sizes of both molecules are similar
- b) Molecular weights of both molecules are similar.
- c) Both are isomers.
- d) Shapes of both molecules are similar.
- e) Net charges of both molecules are identical.

21- Which structural or physiological feature of bacteria can be used as a target for developing drugs to kill bacteria effectively but with no harm to human cells?

- a) Glycolysis
- b) Components of plasma membrane
- c) Components of ribosome
- d) Components of the electron transport chain in aerobic respiration
- e) Requirement of oxygen

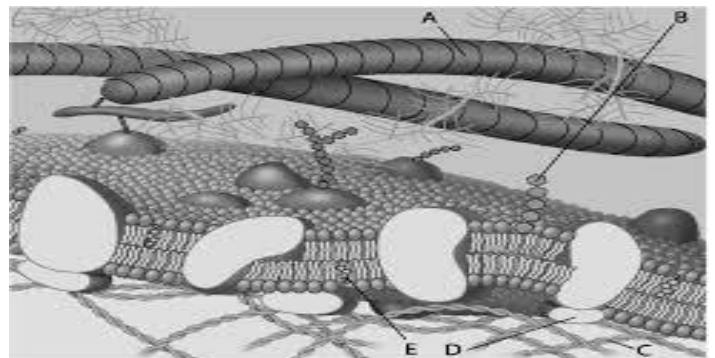
22- People need to inhale oxygen, O<sub>2</sub>, because\_\_\_\_\_.

- a) Oxygen helps dissolve glucose
- b) Oxygen combines with carbon dioxide to form glucose
- c) Oxygen is the final electron acceptor in respiration
- d) Oxygen transports electrons to the Krebs cycle
- e) We take electrons from oxygen during glycolysis

23- A glycosidic linkage is analogous to which of the following in proteins?

- a) an amino group
- b) a peptide bond
- c) a disulfide bond
- d) a  $\beta$  pleated sheet

24- Which component in the accompanying figure is a microfilament (actin filament) of the cytoskeleton?



- a) B
- b) D
- c) A
- d) E
- e) C

25- A research team is working on the design of a new drug for the treatment of lung cancer. To be most effective, this drug must specifically enter the cytoplasm of lung cells while not entering the cells of other tissues. Which of the following characteristics would likely enhance the specificity of this drug?

- a) the relative hydrophobicity of the drug molecule
- b) phospholipid composition of lung cell plasma membranes
- c) specificity of the drug molecule for binding to the extracellular matrix of lung cells
- d) similarity of the drug molecule to other molecules normally transported lung cells

26- Signal transduction is the process by which cells convert chemical signals delivered extracellularly into altered gene expression within the cell. In some pathways, signal transduction is accomplished by covalently linking serine and threonine residues in signaling proteins to phosphate. What is the name of the enzyme that carries out this process, and what is one reactant required for the reaction?

- a) Hydrolases, ATP
- b) Kinases, ATP
- c) Lyases, ATP
- d) Mutases, ATP
- e) Phosphatases, NADH

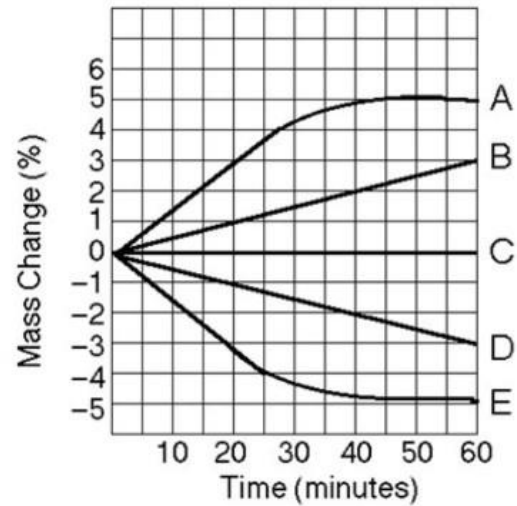


- 27- Insulin is an important protein hormone in the regulation of blood glucose levels. Insulin-dependent diabetics are unable to synthesize their own insulin and must rely on the biotechnology industry to produce the insulin they cannot. Mature insulin consists of 2 polypeptide chains are linked by several disulfide bonds. To synthesize correctly assembled insulin, the two amino acid chains are generated in separate strains of *E. coli* and purified. The purified chains are then combined under conditions favoring disulfide formation. Which of the following aspects of insulin structure remain unchanged throughout this process?
- Primary structure.
  - Tertiary structure.
  - Quaternary structure.
  - All aspects of structure are altered during this process.
  - All aspects of the structure remain unchanged during this process but differ from the structure of insulin produced in a healthy individual
- 28- Comparing the effect of an inhibitor with an uncoupler of oxidative phosphorylation, the\_\_\_\_\_.
- inhibitor would allow electrons to pass through the electron transport chain
  - inhibitor would increase the pumping of protons by the electron transport chain
  - uncoupler would increase heat production by the mitochondria
  - uncoupler would inhibit the reduction of oxygen by the electron transport chain
  - uncoupler would stop the oxidation of NADH by the electron transport chain
- 29- In classical Michaelis-Menten enzyme kinetics, the two constants  $V_{max}$  and  $K_m$  determine the activity of an enzyme that acts on one substrate. You are studying the effects of various chemicals on these constants for your favorite enzyme, and find one molecule that increases its  $K_m$  but leaves  $V_{max}$  constant. Your molecule is most likely to be \_\_\_\_\_.
- a substrate analog
  - the enzyme's substrate
  - a coenzyme that increases catalytic efficiency
  - an allosteric inhibitor that decreases the enzyme's affinity for the substrate
  - an allosteric enhancer that increases the enzyme's affinity for the substrate
- 30- A baby is born with congenital lactic acidosis because she has a defective electron transport protein. This causes a decrease in the rate at which NADH and FADH can be oxidized to produce ATP using oxidative phosphorylation. You would expect all of the following EXCEPT:
- the concentration of ADP in the cell would increase and activate glycolysis.
  - increased glycolysis would produce increased NADH and pyruvate.
  - the inhibition of the electron transport chain would increase the concentration of NADH.
  - increased concentration of NADH would increase the conversion of pyruvate to acetyl CoA
  - extra NADH and pyruvate would be converted to lactate-by-lactate dehydrogenase.
- 31- Which treatment is most effective in breaking as many hydrogen bonds as possible in an aqueous solution (pH 7.0) of 1 mg/mL DNA and 10 mg/mL protein?
- Addition of hydrochloric acid to make the pH 1.0.

- b) Addition of sodium hydroxide solution to make the pH 13.0.
  - c) Addition of urea to a concentration of 6 mol/L.
  - d) Addition of sodium dodecyl sulfate (a detergent) to a concentration of 10 mg/mL
  - e) Heating the solution to 121°C.
  - f) Freezing the solution to -80°C.
- 32-** The movement of a ciliated protozoan is controlled by a protein called RacerX. When this protein binds to another protein, Speed, found at the base of the cilia, it stimulates the cilia to beat faster and the protozoan to swim faster. Speed can only bind to RacerX after phosphorylation of a specific threonine residue. How would you expect the mutant protozoan to behave if this threonine residue in Speed is replaced by an alanine residue?
- a) Swims fast occasionally.
  - b) Always swims fast.
  - c) Never swims fast.
  - d) Switches rapidly back and forth between fast and slow swimming.
  - e) Cannot move at all.
- 33-** A scientist, studying the process of photosynthesis, illuminates a culture of unicellular green algae for a certain period of time. Then she turns off the light and adds radioactive CO<sub>2</sub> by bubbling it in the culture for 30 minutes. Immediately she measures radioactivity in the cells. What is she likely to observe?
- a) No radioactivity in the cells, because light is necessary to produce sugars starting from CO<sub>2</sub> and water.
  - b) No radioactivity in the cells, because CO<sub>2</sub> is used to produce O<sub>2</sub> during the light-dependent reactions.
  - c) No radioactivity in the cells, because CO<sub>2</sub> is taken by the plant cells only during illumination.
  - d) Radioactivity in the cells, because CO<sub>2</sub> is used to produce sugars even in the dark.
  - e) Radioactivity in the cells, because CO<sub>2</sub> is incorporated into NADPH in the dark.
- 34-** In eukaryotic cells, the oxidative phosphorylation reactions are catalyzed by various enzymes. Which of the following is correct?
- a) All of these enzymes are coded in nuclear DNA, synthesized in ribosomes and imported into mitochondria.
  - b) Some of these enzymes are coded in mitochondrial DNA. Their messenger RNA is exported outside mitochondria and the enzymes are synthesized in ribosomes. The enzymes are then imported back into mitochondria.
  - c) Some of them are coded in mitochondrial DNA and synthesized in mitochondrial ribosomes.
  - d) All of them are coded in mitochondrial DNA and synthesized in mitochondrial ribosomes.
  - e) A copy of mitochondrial DNA is exported outside mitochondria. The synthesized enzymes are imported into mitochondria.
- 35-** Five dialysis bags, constructed of a type of membrane that is permeable to water and impermeable to sucrose, were filled with various concentrations of sucrose and then placed in separate beakers containing an initial concentration of 0.6 M sucrose solution. At 10-minute intervals, the bags were massed (weighed), and the percent change in mass of each bag was graphed.

Which line or lines in the graph represent(s) bags that contain a solution that is hypertonic at 50 minutes?

- a) D
- b) A and B
- c) D and E
- d) B



## Genetics & Evolution:

- 1- The SRY gene is best described as \_\_\_\_\_.
  - a) a gene present on the X chromosome that triggers female development
  - b) an autosomal gene that is required for the expression of genes on the Y chromosome
  - c) a gene present on the Y chromosome that triggers male development
  - d) an autosomal gene that is required for the expression of genes on the X chromosome
  
- 2- Why are males more often affected by sex-linked traits than females?
  - a) Male hormones such as testosterone often alter the effects of mutations on the X chromosome.
  - b) Female hormones such as estrogen often compensate for the effects of mutations on the X chromosome.
  - c) X chromosomes in males generally have more mutations than X chromosomes in females.
  - d) Males are hemizygous for the X chromosome.
  
- 3- The cow *Bos primigenius* (which is bred for meat and milk) has a smaller brain and larger eyes than closely related wild species of ungulates. These traits most likely arose by \_\_\_\_\_.
  - a) natural selection, because these traits evolved in the population over time
  - b) natural selection, because these traits were not consciously selected by humans
  - c) artificial selection, because changes in these traits co-occurred with human selection for high milk output and high muscle content
  - d) artificial selection, because these animals differ from their close relatives and common

- 4- Which of the following statements is incorrect?
- a) Messenger RNA must be processed before it can leave the nucleus of a eukaryotic cell.
  - b) A virus in the lysogenic cycle does not kill its host cell, whereas a virus in the lytic cycle destroys its host cell.
  - c) DNA polymerase is restricted in that it can add nucleotides only in a 5'-to-3' direction.
  - d) During translation, the A site holds the tRNA carrying the growing protein, while the P site holds the tRNA carrying the next amino acid.
- 5- All the following are players involved in the control of gene expression except\_\_\_\_\_.
- a) Episomes.
  - b) repressors.
  - c) operons.
  - d) methylation.
- 6- Anna has a genetic condition caused by a single variant on the copy of chromosome 17 that she inherited from her mother. This condition would be characterized as \_\_\_\_\_.
- a) Sex-linked recessive
  - b) Sex-linked dominant
  - c) Autosomal dominant
  - d) Autosomal recessive
- 7- The first step in ecosystem restoration is to \_\_\_\_\_.
- a) restore the physical structure
  - b) restore native species that have been extirpated due to disturbance
  - c) remove competitive invasive species
  - d) remove toxic pollutants
- 8- Which of the following would be considered an example of bioremediation?
- a) adding nitrogen-fixing microorganisms to a degraded ecosystem to increase nitrogen availability
  - b) using a bulldozer to regrade a strip mine
  - c) dredging a river bottom to remove contaminated sediments
  - d) adding fertilizer to soil poor in nutrients to increase plant growth
- 9- Imagine that a phylogeny was developed for a group of mammals based on bone structure. Which of the following statements would be a reasonable prediction about a phylogeny for the same group of species based on similarities and differences in the structure of a particular enzyme?
- a) The same phylogeny would be unlikely.
  - b) The same phylogeny would be predicted.
  - c) No prediction could be made.
  - d) The amino acid sequence would be identical in all species.

10- An X-linked allele determines the coat color of cats with orange being dominant and black being recessive. Which of the following statements regarding the inheritance pattern of orange/black mosaic cats is correct?

- a) Half of all male cats are mosaic.
- b) The mosaic phenotype is a consequence of gene interaction.
- c) The mosaic phenotype is correlated with genomic imprinting.
- d) The mosaic phenotype results from random X-chromosomal inactivation.
- e) The offspring from matings of orange males and black females are mosaic.

11- Which of the following can children only inherit from their mother?

A mutation:

- a) on the X chromosome.
- b) on the Y chromosome.
- c) in the mitochondrial genome.
- d) in a maternally imprinted gene.
- e) in the hypervariable region of an antibody gene.

12- Male to male transmission is a key feature of which pattern of inheritance?

- a) Autosomal dominant
- b) Autosomal recessive
- c) X-linked dominant
- d) X-linked recessive

13- A small amount of lethal mutation is always present in the population due to \_\_\_\_\_.

- a) Positive selection
- b) Negative selection
- c) Frequency-dependent selection
- d) Mutation-selection balance

14- A patient suffers from an infection. A doctor cultures a blood sample from the patient to determine the nature of the infection. From the blood sample, the doctor is able to identify that a single species is responsible for causing the infection and is able to develop an experimental treatment. The doctor administers the experimental treatment to the patient, and successfully controls the infection. Then, the doctor takes a second blood sample from the patient. Analysis of the second blood sample reveals large numbers of dead bacteria as well as large numbers of virus particles. The doctor smiles and nods her head knowingly. What was the most likely active component of the treatment?

- a) Small-molecule antibiotic
- b) Small-molecule antiviral
- c) Protein-based antibiotic
- d) Protein-based antiviral
- e) Phage

15- ATP, the common energy-carrying molecule, most resembles the \_\_\_\_\_.

- a) adenine RNA nucleotide
- b) adenine DNA nucleotide
- c) adenine DNA nucleotide with two extra phosphates
- d) adenine RNA nucleotide with two extra phosphates
- e) adenine nitrogen base

16- There is a degenerative disease which develops in people between 35 and 45 years old. It is caused by a dominant allele. A couple has two children, who are both younger than 20 years old. One parent has the disease (heterozygote), but the other parent, who is 50 years old, does not. What is the probability that the both children will develop this disease when they become older?

- a) 1/16
- b) 3/16
- c) 1/4
- d) 9/16
- e) 3/4

17- Which of the following statements is a correct representation of gene density?

- a) Humans have 1,000 Mb per genome.
- b) *C. elegans* has ~20,000 genes.
- c) Humans have ~20,000 protein-encoding genes in a 3,000 Mb.
- d) *Saccharomyces* has a genome 40 times the size of a human genome.

**Karyotypes represent a display of the chromosomes present in eukaryotic cells. The following diagram shows a normal human male karyotype. (Q18-Q20)**

18- Karyotyping is routinely performed on cells that are undergoing which process?

- a) Prophase in meiosis
- b) Anaphase in mitosis
- c) Metaphase in mitosis
- d) Telophase in mitosis
- e) Interphase

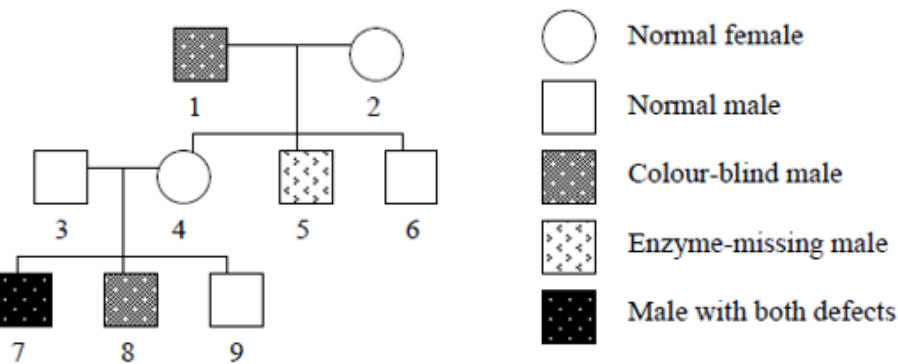
19- What are the structures circled at position 6 in the diagram called?

- a) two sister chromatids
- b) a homologous pair of chromosomes
- c) a chromosome
- d) interphase chromosomes
- e) RNA

20- The technology that produced the karyotype shown in the diagram has been largely superseded and replaced by which of the following?

- a) light microscopy together with color photography
- b) fluorescent in situ hybridizing (FISH) DNA probes called chromosome paints
- c) electron microscopy and color lithograph techniques
- d) the polymerase chain reaction
- e) RNA silencing using short interfering RNAs (siRNA)

21- A 49. Two X-linked genetic defects have been studied by genealogical method (family history): color blindness and deficiency of certain enzyme in red blood cells. The pedigree shows the results:



Which individual (-s) show (-s) that crossing over has occurred?

- a) 8 and 9
- b) 1
- c) 7 and 8
- d) 7 and 9
- e) 5

22- Starting from the wild mustard *Brassica oleracea*, breeders have created the strains known as Brussels sprouts, broccoli, kale, and cabbage. Therefore, which of the following statements is correct?

- a) In this wild mustard, there is enough heritable variation to permit these different varieties.
- b) Heritable variation is low in wild mustard-otherwise this wild strain would have different characteristics.
- c) Natural selection is rare in wild populations of wild mustard.
- d) In wild mustard, most of the variation is due to differences in soil or other aspects of the environment.

23- Which statements are correct?

1. Some autotrophic bacteria obtain energy oxidizing  $\text{NH}_4^+$  to  $\text{NO}_2^-$  or  $\text{NO}_2^-$  to  $\text{NO}_3^-$
2. Some autotrophic bacteria obtain energy reducing  $\text{NO}_2$  or  $\text{NO}_3$
3. Nitrogen-fixing cyanobacteria can utilize atmospheric nitrogen ( $\text{N}_2$ )
4. The ocean serves as a buffer, stabilizing the atmospheric  $\text{CO}_2$  concentration
5. Coral reefs are very productive ecosystems, but they contain a minor portion of the global amount of assimilated C

- a) 3, 4 and 5
- b) 2, 3, 4 and 5
- c) 1, 4 and 5
- d) 1, 3, 4 and 5
- e) Only 4 and 5

24- Many strains of *Mycobacterium tuberculosis*, the bacterium that causes tuberculosis, are resistant to standard drug therapy. This is the result of:

- a) Bottleneck
- b) Adaptive radiation
- c) Directional selection
- d) Sexual reproduction
- e) Sympatric speciation.

25- All of the following are kingdoms EXCEPT:

- a) Chordata
- b) Monera
- c) Plantae
- d) Fungi
- e) Protista

26- A man is brought to court in a paternity case. His blood type is B, Rh positive. The mother blood type is B, Rh negative. The child's blood type is A, Rh negative. What can be said about the man's chances of being the father?

- a) he is not the father.
- b) he might be the father.
- c) he is the father.
- d) he might not be the father
- e) More information is required to determine.

27- Multigene families are groups of two or more identical or very similar genes. Which of the following statements about multigene families is correct?

- a) Globin gene families do not have pseudogenes, because globins are essential for oxygen transport.
- b) Ribosomal RNA gene families in multicellular eukaryotes have many identical genes, because many ribosomes are required for active protein synthesis.

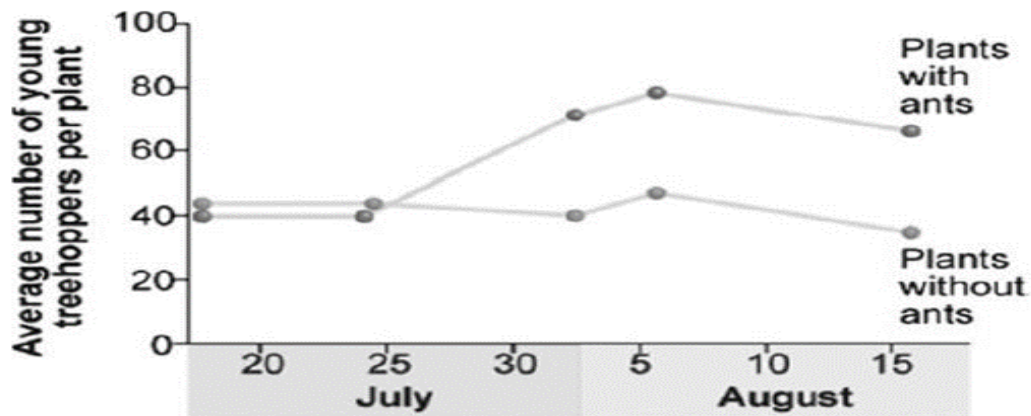


- c) Compared with multicellular eukaryotes, prokaryotes have many multigene families, because prokaryotes have to reproduce very quickly.
- d) The number of genes in a multigene family always increases by unequal crossing over.
- 28-** There is a degenerative disease which develops in people between 35 and 45 years old. It is caused by a dominant allele. A couple has two children, who are both younger than 20 years old. One parent has the disease (heterozygote), but the other parent, who is 50 years old, does not. What is the probability that the both children will develop this disease when they become older?
- a) 1/16
- b) 3/16
- c) 1/4
- d) 9/16
- e) 3/4
- 29-** Suppose that at a neutrally evolving genomic region of a species the mutation rate from the base pair GC to AT is three-times the mutation rate from AT to GC. What is the expected GC content at equilibrium?
- a) 1/2
- b) 1/3
- c) 1/4
- d) 1/5
- e) 1/6
- 30-** How does the occurrence of self-fertilization relative to cross-fertilization affect the fixation of an advantageous and recessive allele that newly appeared in a population by mutation?
- a) The allele will be fixed most quickly when the relative occurrence of self-fertilization is highest.
- b) The allele will be fixed most quickly when the relative occurrence of self-fertilization is lowest.
- c) The allele will be fixed most quickly when the relative occurrence of self-fertilization is moderate.
- d) The relative occurrence of self-fertilization does not affect the fixation of the allele.
- e) The relative occurrence of self-fertilization affects the fixation of the allele only when the population is very small.
- 31-** *Claytonia virginica* is a woodland spring herb with flowers that vary from white, to pale pink, to bright pink. Slugs prefer to eat pink-flowering over white-flowering plants (due to chemical differences between the two), and plants experiencing severe herbivory are more likely to die. The bees that pollinate this plant also prefer pink to white flowers, so that *Claytonia* with pink flowers have greater relative fruit set than *Claytonia* with white flowers. A researcher observes that the percentage of different flower colors remains stable in the study population from year to year. Given no other information, if the researcher removes all slugs from the study population, what do you expect to happen to the distribution of flower colors in the population over time?
- a) The percentage of pink flowers should increase over time.
- b) The percentage of white flowers should increase over time.
- c) The distribution of flower colors should not change.
- d) The distribution of flower colors should randomly fluctuate over time.

32- Which of the following is an example of a commensalism?

- a) fungi residing in plant roots, such as endomycorrhiza
- b) bacteria fixing nitrogen on the roots of some plants
- c) rancher ants that protect aphids in exchange for sugar-rich honeydew
- d) cattle egrets eating insects stirred up by grazing bison

33- Treehoppers (a type of insect) produce honeydew, which ants use for food. Treehoppers have a major predator, the jumping spider. Researchers hypothesized that the ants would protect the treehoppers from the spiders. In an experiment, researchers followed study plots with ants removed from the system and compared them to a control plot. From the figure, what can you conclude?



- a) Ants do somehow protect the treehoppers from spiders.
- b) Ants eat the honeydew produced by treehoppers.
- c) Ants reduce the numbers of treehoppers.
- d) No specific conclusions can be drawn from this figure.

34- In recent times, it has been shown that adult cells can be induced to become pluripotent stem cells (iPS). To make this conversion, what has been done to the adult cells?

- a) A retrovirus is used to introduce four specific master regulatory genes.
- b) The adult stem cells must be fused with embryonic cells.
- c) Cytoplasm from embryonic cells is injected into the adult cells.
- d) The nucleus of an embryonic cell is used to replace the nucleus of an adult cell.

35- Organisms share many conserved core processes and features, including transcription and translation, using a uniform genetic code. Scientists have used these shared processes and features in biotechnology. For example, for the process of some transformations, a plasmid is constructed when a eukaryotic gene of interest is added with an antibiotic resistant gene such as beta-lactamase, which is used for ampicillin resistance. This plasmid is then inserted into a prokaryotic bacterial cell, such as E. coli, through a transformation process that leads to the production of the product protein from the eukaryotic organism. To culture the bacteria and obtain the protein product, the bacteria must grow.

**-Select the appropriate condition to determine if the plasmid has entered the E. coli bacterial cell.**

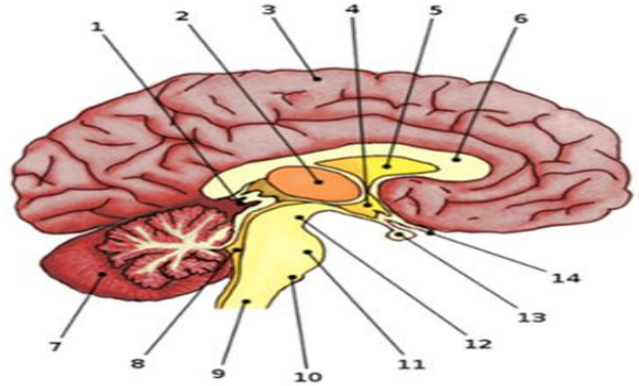
- a) nutrient broth to which no antibiotic has been added
- b) water to which ampicillin has been added
- c) nutrient broth to which ampicillin has been added
- d) nutrient broth to which other resistant bacteria have been added

## Anatomy & Physiology:

- 1- Which of the following types of plants is not able to self-pollinate?
  - a) dioecious
  - b) monoecious
  - c) complete
  - d) wind-pollinated
  
- 2- In certain large animals, this type of neuron can extend beyond one meter in length:
  - a) glial cell in the brain.
  - b) a sensory neuron.
  - c) a neuron that controls eye movements.
  - d) a glial cell at a ganglion.
  
- 3- All of the following are plant adaptations to life on land except \_\_\_\_\_.
  - a) tracheid and vessels
  - b) root hairs.
  - c) cuticle.
  - d) the Calvin cycle of photosynthesis.
  
- 4- What regulates the opening of the esophagus into the stomach?
  - a) A membranous valve
  - b) A muscular sphincter
  - c) A mesodermal septum
  - d) A cartilaginous flap
  
- 5- Pores on the leaf surface that function in gas exchange are called \_\_\_\_\_.
  - a) sclereids.
  - b) xylem cells.
  - c) phloem cells.
  - d) stomata.

6- What is the part that consists of the three parts indicated by the numbers 12,11, and 10?

- a) Midbrain
- b) pons
- c) brain stem
- d) Medulla oblongata



7- Men with long-term erectile dysfunction, the disorder is due to failure in the vasodilation action of a local regulator. That regulator was supposed to relax the muscles in the blood vessels enhancing the blood flow in the erectile tissues. What is this local regulator to be treated?

- a) Prostaglandin
- b) Testosterone
- c) Nitric oxide
- d) Oxytocin

8- Which cells and which signaling molecules are responsible for initiating an inflammatory response?

- a) phagocytes: lysozymes
- b) phagocytes: chemokines
- c) dendritic cells: interferons
- d) mast cells: histamines
- e) lymphocytes: interferons

9- The trachea is lined with\_\_\_\_\_.

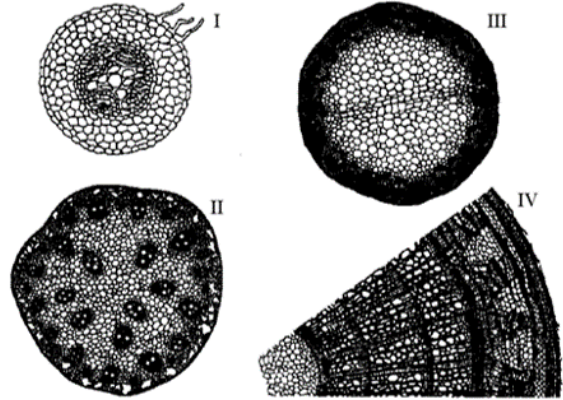
- a) ciliated simple squamous epithelium
- b) stratified squamous epithelium
- c) pseudostratified ciliated columnar epithelium
- d) pseudostratified squamous epithelium

10- In the communication link between a motor neuron and a skeletal muscle, \_\_\_\_\_

- a) the motor neuron is considered the presynaptic cell and the skeletal muscle is the postsynaptic cell.
- b) the motor neuron is considered the postsynaptic cell and the skeletal muscle is the presynaptic cell.
- c) the motor neuron fires action potentials but the skeletal muscle is not electrochemically excitable.
- d) action potentials are possible on the skeletal muscle but not the motor neuron.

11- A plant that is at least 3 years old is represented by \_\_\_\_.

- a) I only.
- b) III only
- c) both I and III.
- d) IV only.



12- If you were able to walk into an opening cut into the center of a large redwood tree, when you exit from the middle of the trunk (stem) outward, you would cross, in order,

- a) the annual rings, phloem, and bark.
- b) the newest xylem, oldest phloem, and periderm.
- c) the vascular cambium, oldest xylem, and newest xylem.
- d) the secondary xylem, secondary phloem, and vascular cambium.

13- An example of stretch reflex triggered by passive muscle movement is the \_\_\_\_.

- a) tendon reflex
- b) ipsilateral reflex
- c) flexor reflex
- d) patellar reflex

14- An element plays important function in nitrogen fixation, \_\_\_\_.

- a) zinc.
- b) manganese.
- c) molybdenum.
- d) copper.

15- A human develops a condition in which their output of T3 and T4 (thyroxin) from the thyroid gland dropped dramatically. The metabolic output of cells in their body would \_\_\_\_ and the levels of circulating thyroid-stimulating (TSH) and thyrotropin-releasing hormone (TRH) in the body would \_\_\_\_.

- a) increase; increase
- b) increase; decrease
- c) be unchanged; increase
- d) decrease; decrease
- e) decrease; increase

16- A sustained muscle contraction due to a lack of relaxation between successive stimuli is called:

- a) tonus
- b) tetanus
- c) an all-or-none response.
- d) fatigue.

17- You are studying a plant from the arid southwestern United States. Which of the following adaptations is least likely to have evolved in response to water shortages?

- a) closing the stomata during the hottest time of the day
- b) development of large leaf surfaces to absorb water
- c) formation of a fibrous root system spread over a large area
- d) a thick waxy cuticle on the epidermis

18- The primary difference between estrous and menstrual cycles is that\_\_\_\_\_.

- a) the endometrium shed by the uterus during the estrous cycle is reabsorbed but the shed endometrium is excreted from the body during the menstrual cycle.
- b) behavioral changes during estrous cycles are much less apparent than those of menstrual cycles.
- c) season and climate have less pronounced effects on estrous cycle than they do on menstrual cycles.
- d) copulation normally occurs across the estrous cycle, whereas in menstrual cycles copulation only occurs during the period surrounding ovulation.

19- While exercising, your muscles have an increased demand for oxygen and a requirement to get rid of excess carbon dioxide. Which of the following consequences of exercising results in a lower affinity for oxygen on hemoglobin and increased oxygen delivery to muscles?

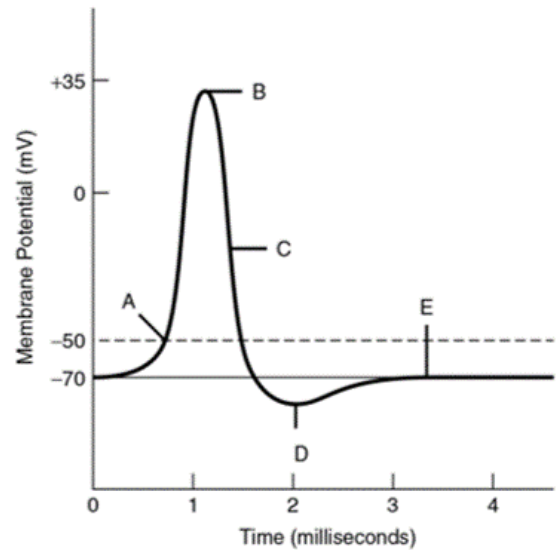
- a) Heat produced by muscles.
- b) Acidity produced by local concentrations of CO<sub>2</sub>.
- c) Increased CO<sub>2</sub> locally will increase CO<sub>2</sub> binding, which lowers affinity of hemoglobin for O<sub>2</sub>.
- d) Both a and b
- e) All of a, b and c

20- Which of the following could be associated with peristalsis helping its locomotion?

- a) hydrostatic skeletons and smooth muscle
- b) hydrostatic skeletons and movement in earthworms
- c) smooth muscle and contractions along the human digestive tract causing movement of the contents within
- d) A, B, and C

21- For the following question, relate the statement below to the graph of an action potential in a neuron. After receiving an external stimulus, repolarization of the cell is in progress, as the sodium ion ( $\text{Na}^+$ ) channels are closing or closed, and many potassium ion ( $\text{K}^+$ ) channels have opened, at label:

- a) D only
- b) C only
- c) B only
- d) A, C



22- The human body responds quickly to a decrease in the partial pressure of oxygen ( $\text{PO}_2$ ) in the blood or an increase in the partial pressure of carbon dioxide ( $\text{PCO}_2$ ) in the blood. Which statement about how homeostasis regulates levels of  $\text{O}_2$  and  $\text{CO}_2$  in the blood is **CORRECT**?

- a) A low  $\text{PO}_2$  is detected by the pituitary gland which then releases hormones that stimulate an increase in breathing rate to restore blood  $\text{O}_2$  to normal levels.
- b) A low  $\text{PO}_2$  is detected by nerves within alveoli that stimulate increased diffusion of oxygen from the lungs into the blood.
- c) A high  $\text{PCO}_2$  causes blood pH to drop; specialized nerves detect the pH change and stimulate an increase in breathing rate to increase  $\text{CO}_2$  removal from the blood.
- d) A low  $\text{PO}_2$  triggers a release of cortisol from the adrenal gland, which stimulates the diaphragm to contract more frequently, ultimately increasing oxygenation of the blood.
- e) A high  $\text{PCO}_2$  triggers more hemoglobin to be produced which increases the oxygen-carrying capacity of the blood.

23- During human heterosexual (mutual) excitement, Vaso congestion:

- a) occurs only in the penis.
- b) occurs only in the testes.
- c) occurs only in the clitoris.
- d) occurs in the clitoris, vagina, and penis.

24- As a youngster, you drive a nail in the trunk of a young tree that is 3 meters tall. The nail is about 1.5 meters from the ground. Fifteen years later, you return and discover the tree has grown to a height of 30 meters. The nail is now \_\_\_\_\_ meters above the ground.

- a) 15.0
- b) 1.5
- c) 3.0
- d) 28.5

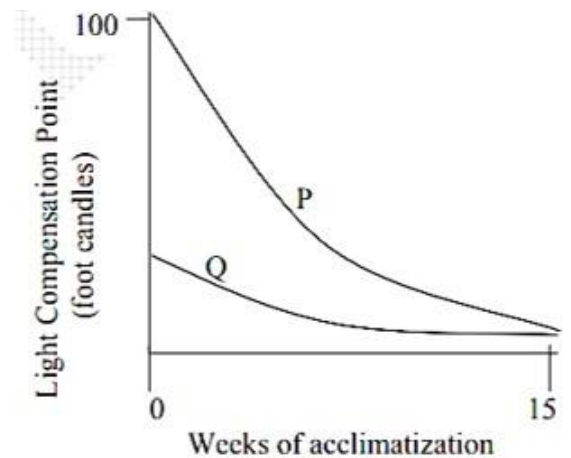
25- In humans, the hormone insulin is secreted by the increase in response to increased blood glucose levels. Insulin helps cells take up glucose from the bloodstream. Type II diabetes is a condition where body cells lose their sensitivity to insulin.

How will a person with type II diabetes respond to a rise in blood glucose?

- a) Blood insulin levels will increase
- b) Blood insulin levels will decrease
- c) Blood insulin levels will not change
- d) Glucose levels will decrease slowly

26- When two plants P and Q were grown in a heavily shaded greenhouse, they showed the following changes in light compensation points.

- a) The graph P indicates acclimatization of sun plants to low light intensities.
- b) The graph Q indicates that the plant is a shade plant and cannot function at light intensities below a critical level.
- c) The graph indicates that the plant P is a shade plant and acclimatizes much faster to low light conditions as compared to Q.
- d) The graph indicates that plant Q is a sun plant and cannot acclimatize to low light intensities.

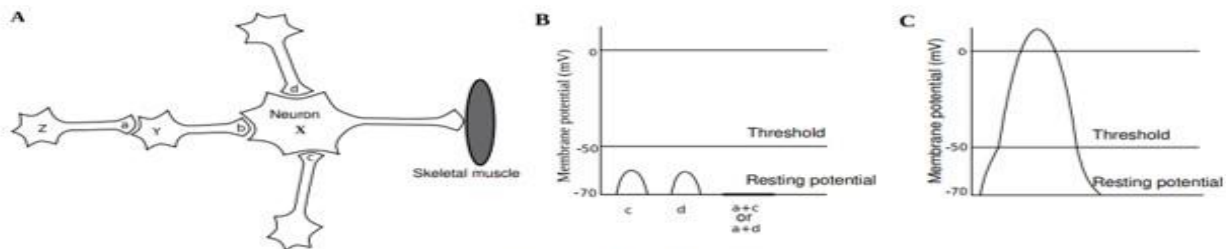


27- Observe these graphs then choose the correct statement regarding these data.

**Figure Q.76A** shows neuron X receives signals directly from three separate nerve terminals *b*, *c* and *d*. Neuron Y receives signals from nerve terminal *a*.

**Figure Q.76B** shows the various postsynaptic potentials recorded in neuron X after receiving input signals directly from terminals *b*, *c*, and *d* and indirectly from terminal *a*.

**Figure Q.76C** shows the action potential recorded in neuron Y after receiving input signals from the presynaptic terminal *a*.



Figures Q.76A, B, and C

- a) Synapses *a*, *d*, and *c* can all stimulate the neuron X
- b) When three nerve terminals *a*, *c* and *d* are stimulated simultaneously, the postsynaptic potentials recorded in neuron X are smaller than those when the nerve terminals *c* and *d* are stimulated simultaneously.



- c) Nerve terminal a releases inhibitory neurotransmitter and nerve terminal b releases excitatory neurotransmitter.
- d) A and C are correct

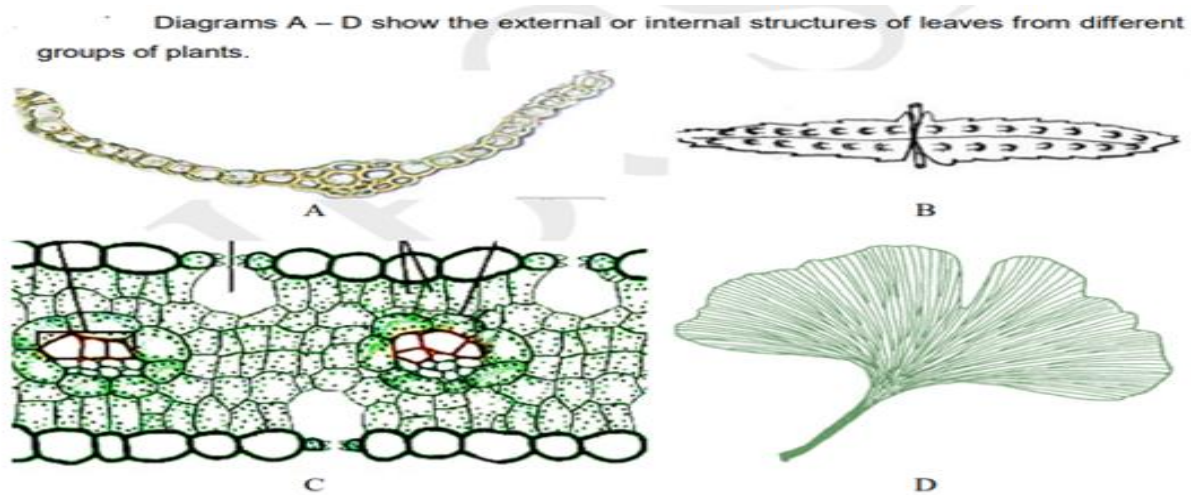
**28-** Match these diagrams with the plants described by statements I - IV.

I. The sexual reproductive structures are formed on an independent non-dominant plant body.

II. Plants in this group have leaves with a haploid number of chromosomes.

III. Plants in this group are seed-bearing and amongst the earliest evolved extant trees.

IV. The mega gametophytes develop within enclosed ovules.



- a) I-B, II-A, III-D, IV-C
- b) I-B, II-D, III- C, IV-A
- c) I-C, II-A, III-B, IV-D
- d) I-D, II-B, III-A, IV-C

**29-** After observing the following data, four conclusions can be estimated:

I- Cardiac output increased by two-fold during exercise.

II- Stroke volume during exercise was higher than that before exercise.

III- Physical exercise caused a reduction in hemoglobin's binding for oxygen in tissues, resulting in a three-fold increase in the amount of oxygen released to tissues.

IV- The number of heart beats required to supply a tissue with 3000 mL of oxygen during exercise is 240.

Cardiac output (CO) is the volume of blood pumped by the heart in one minute. Cardiac output is affected by the stroke volume (SV) and the heart rate (HR). Cardiac output can be measured indirectly using the Fick's equation:  $CO = Q/(A-V)$ , where Q is the rate of oxygen consumption (mL/min), A-V is the difference between oxygen concentration in the oxygenated blood (A) and in the deoxygenated blood (V). The data below were measured from a healthy person before and during physical exercise.

Parameters	Before Exercise	During Exercise
Rate of oxygen consumption (Q)	250 mL/min	1500 mL/min
Oxygen difference (A-V)	50 mL/L blood	150 mL/L blood
Heart rate (HR)	60 beats/min	120 beats/min

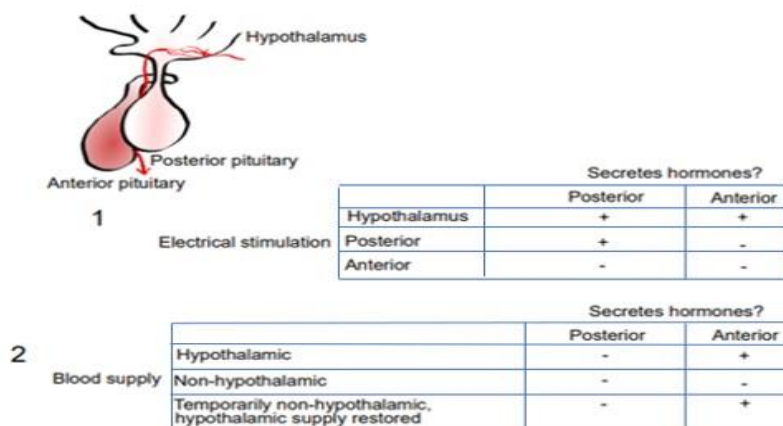
According to the given data, which of the following is correct?

- a) I
- b) II
- c) III
- d) IV

30- After observing the following tables, four conclusions can be estimated:

- I- The hypothalamus controls secretion of hormones from both pituitary glands.
- II- Hypothalamic blood specifically has factors necessary for the survival of the anterior pituitary.
- III- Hypothalamic neurons innervate the posterior pituitary.
- IV- Hypothalamic hormones cause the posterior pituitary to secrete hormones.

The hypothalamus is the central regulator of homeostasis, whilst diverse hormones from the posterior and anterior pituitary glands orchestrate most bodily functions. To investigate how these three structures coordinate their actions in rats (*Rattus norvegicus*), each was electrically stimulated, and the effect on hormone secretion from both pituitary glands was observed (1). Secondly, whole rat pituitary glands were transplanted to locations with different blood supplies, to reveal why they usually receive blood from hypothalamic veins (2).



- According to the given data, which of the following is correct?

- a) II and IV
- b) I, III, and IV
- c) I and III
- d) I, II, III, and IV