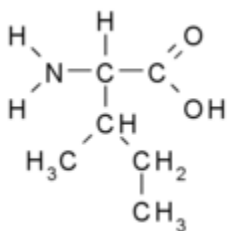
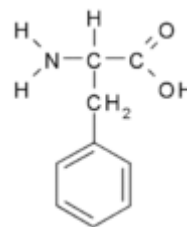


1. Rank the following biological molecules in order of how readily they diffuse across the plasma membrane from the most diffusible to the least diffusible.
 - I. CO_2
 - II. Cl^-
 - III. Sucrose
 - IV. Glycerol
 - A. I, III, IV, II
 - B. II, IV, III, I
 - C. III, II, IV, I
 - D. I, IV, III, II
 - E. II, I, III, IV
2. You perform a Western blot on two proteins of similar molecular weights (~50kDa) and find only one band developed on your SDS-PAGE gel. How would you modify your assay to distinguish the two proteins?
 - A. Use a lower concentration of acrylamide to raise the resolution of your gel
 - B. Use a non-ionic detergent to denature your protein
 - C. Focus your sample isoelectrically on a pH gradient
 - D. Remove reducing agents like mercaptoethanol or dithiothreitol
 - E. Switch the anode and cathode on your gel
 - F.
3. The tiny hairs on a gecko's toes enable it to climb walls. The hairs are made of hydrophobic keratin and adhere to surfaces via van der Waals interaction. At the tiny interface where the gecko's toe hairs touch the surface it climbs, which amino acid are you LEAST likely to find?

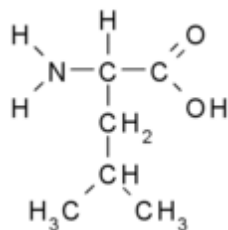
A. Isoleucine



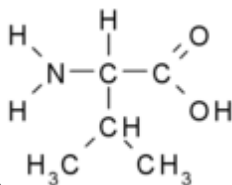
D. Phenylalanine



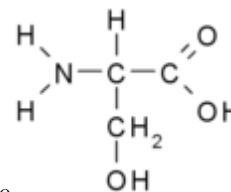
B. Leucine



C. Valine



E. Serine



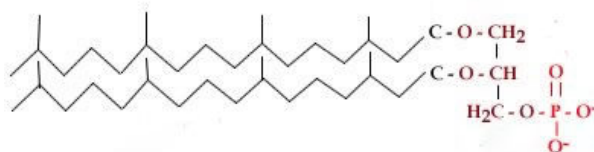
4. When found on the extracellular side of the cell, which of the following classes of membrane molecules is a marker for the phagocytosis of apoptotic cells?
- A. Glycolipid
 - B. Sphingomyelin
 - C. Phosphatidylethanolamine
 - D. Phosphatidylserine
 - E. Phosphatidylcholine
5. The presence of which of the following amino acids in the channel region of aquaporins contributes to the electrostatic selectivity to allow water, but not other molecules, to pass through?
- A. Valine
 - B. Tryptophan
 - C. Asparagine
 - D. Methionine
 - E. Leucine
6. While preparing to teach an organic chemistry class, Professor Dach has managed to mix up several beakers. He has taken samples from each beaker and enlisted your help in identifying them. Below are the results of a series of reagent tests.

Beaker	Biuret	Benedict's	Ninhydrin	Iodine	Sudan
1	Blue	Blue	Blue	Orange	Rather pale
2	Blue	Blue	Pale yellow	Red-orange	Red-orange
3	Purple	Blue	Pale yellow	Orange	Rather pale
4	Blue	Red precipitate	Pale yellow	Orange-yellow	Rather pale
5	Blue	Blue	Pale yellow	Orange	Rather pale

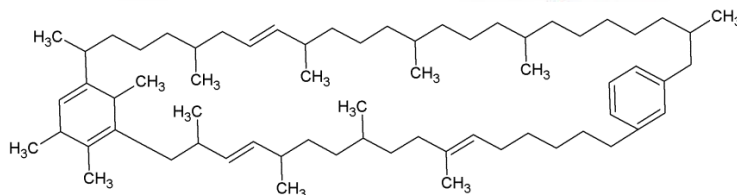
Which of the following correctly matches each beaker to its possible contents?

- A. 1: Gelatin, 2: Corn oil, 3: A solution of asparagine, 4: A solution of glucose, 5: A solution of sucrose
- B. 1: Gelatin, 2: Triglycerides, 3: A solution of asparagine, 4: A solution of sucrose, 5: A solution of glucose
- C. 1: A solution of asparagine, 2: Triglycerides, 3: Gelatin, 4: A solution of glucose, 5: A solution of sucrose
- D. 1: A solution of sucrose, 2: Corn oil, 3: A solution of glucose, 4: A solution of asparagine, 5: Gelatin
- E. 1: A solution of glucose, 2: Triglycerides, 3: A solution of sucrose, 4: A solution of asparagine, 5: Gelatin

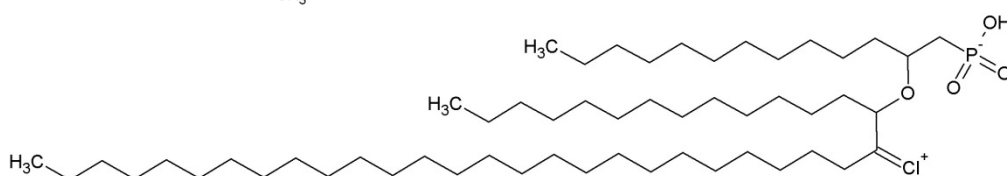
7. There are some rare organisms that do not have lipid bilayers, but instead have lipid monolayers. Which of these is a plausible structure for the lipids they use to make up their lipid monolayers?



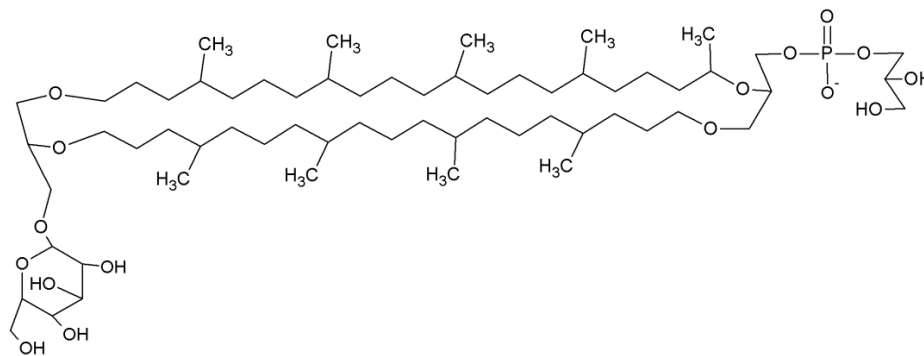
A.



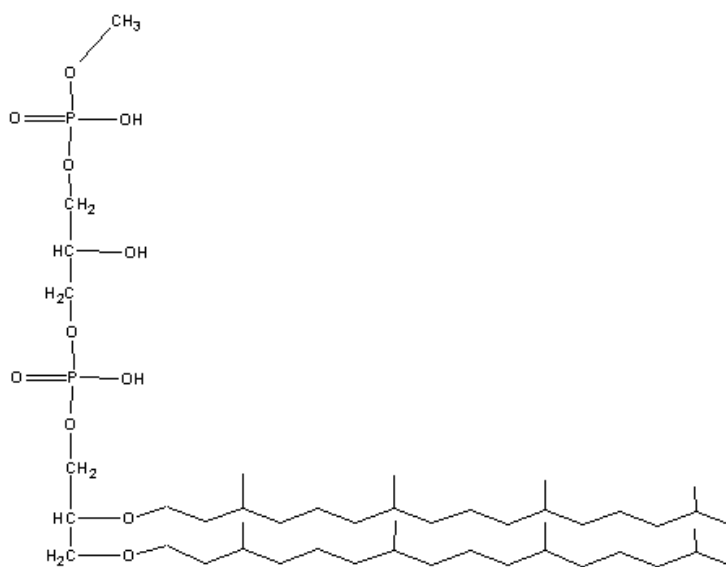
B.



C.



D.



E.

8. One of your classmates has symptoms of protein deficiency. You suspect that she might have a mineral deficiency due to her diet of nothing but canned spaghetti. Which of the following minerals should you test for first?
- A. Iron
 - B. Copper
 - C. Manganese
 - D. Molybdenum
 - E. Sulfur
9. A new therapeutic drug can treat the symptoms of the demyelinating disease multiple sclerosis (MS) by blockage of voltage-gated potassium channels. Neuron action potential conduction improves because:
- A. More potassium is allowed to enter the axon which increases the amplitude of the action potential
 - B. The high resting leak of potassium out of the axon is minimized
 - C. Less potassium is allowed to leave the axon which increases the size and duration of the action potential
 - D. Less potassium is allowed to leave the axon which prevents the inactivation of voltage-gated sodium channels increasing the amplitude of the action potential
 - E. The resistance of the plasma membrane decreases which increases the amplitude of the action potential
10. Which component of Fick's Law of Diffusion is MOST optimized in the ventilation of fish gills compared to mammalian lungs?
- A. Diffusion coefficient
 - B. Gradient for diffusion
 - C. Surface area
 - D. Path length
 - E. Temperature
11. Pollen grains were treated with colchicine in culture. The resulting plants were
- A. No more than large calluses
 - B. Dihaploid and fertile
 - C. Dihaploid and sterile
 - D. Haploid and sterile
 - E. Haploid and fertile
12. Which of the following statements about seeds is FALSE?
- A. Coleorhizae are found in monocotyledonous seeds
 - B. Both monocotyledonous and dicotyledonous seeds have radicles
 - C. Both monocotyledonous and dicotyledonous seeds have a pericarp
 - D. The coleoptile is found only in monocotyledonous seeds
 - E. The aleurone layer is found only in dicotyledonous seeds
13. Which of the following terms describes the closing of leaves or flowers at night?
- A. Epinasty
 - B. Nyctinasty
 - C. Seismonasty
 - D. Thermonasty
 - E. Thigmonasty

14. Which of the following statements about carnivorous plants is FALSE?

- A. All carnivorous plants are angiosperms.
- B. All carnivorous plants are evolved for nutrient-poor environments.
- C. All carnivorous plants are limited to small arthropods or, in the case of bladderwort, zooplankton as prey.
- D. All carnivorous plants have mechanisms to attract and capture prey.
- E. All carnivorous plants derive energy from trapping and consuming arthropods and/or zooplankton

15. Roots absorb cations from the soil by a process called:

- A. Cation absorption
- B. Cation exchange
- C. Cation transfer
- D. Cation cotransport
- E. Cation reduction

16. Which of the following statements about plant stomata is TRUE?

- A. When the guard cells are filled with water and turgid, the stoma is closed.
- B. Cellulose microfibrils are oriented along the longer axis of guard cells.
- C. After a certain point, stomata closure is irreversible.
- D. Stomata open with the active uptake of K^+ ions by the guard cells.
- E. Only CO_2 depletion contributes to stomatal opening.

17. Which of the following features of flowers is NOT meant to facilitate its pollination by animals?

- A. The production of nectar at the base of the flower.
- B. The presence of leaf-like sepals.
- C. Brightly-colored and conspicuous petals.
- D. A strong odor of rotting meat.
- E. Patterns only visible under ultraviolet light.

18. The food source of *Rhizopus stolonifer* (black bread mold, a zygomycete) has been depleted. Which of these is most likely to happen?

- A. Zygosporangia form.
- B. Mycelia increase the rate of asexual reproduction.
- C. Mycelia produce conidia (pigmented haploid spores).
- D. The *Rhizopus* forms mycorrhizal interactions with root plants.
- E. The *Rhizopus* forms flagellated zoospores to spread via aquatic transportation.

19. Stressful stimuli cause a number of physiological reactions. Which of the following is NOT a correctly matched statement about stress-related hormones?

- A. Epinephrine - Stimulate glucose production from glycogen
- B. Mineralocorticoids - Increase blood pressure and volume
- C. Glucocorticoids - Reduce immune system activity
- D. Norepinephrine - Increase breathing rate
- E. ACTH - Stimulate adrenal medulla to secrete hormones

20. Which one of these hormones is NOT secreted by the anterior pituitary gland?

- A. Growth hormone
- B. Prolactin
- C. Antidiuretic hormone
- D. Luteinizing hormone
- E. Adrenocorticotrophic hormone

21. A patient presents the following symptoms: diarrhea, dermatitis, and dementia, as well as “necklace” lesions on the lower neck, hyperpigmentation, thickening of the skin, inflammation of the mouth and tongue, digestive disturbances, amnesia, and delirium. Which of the following is deficient in this person’s system?
- A. Vitamin D3 (cholecalciferol)
 - B. Vitamin B3 (niacin)
 - C. Vitamin C (ascorbic acid)
 - D. Vitamin B1 (thiamine)
 - E. Vitamin E (tocopherol)
22. Which of the following membranes is/are responsible for respiration in developing birds and reptiles?
- A. Amnion
 - B. Allantois
 - C. Chorion
 - D. A and C
 - E. B and C
23. What is the primary source of food for developing zebrafish larvae up to 5 days post fertilization (dpf)?
- A. Yolk Sac
 - B. Larval fish food flakes
 - C. No food required
 - D. Paramecium
24. The virus *Ijustmadethisup* causes the following symptoms: overly fragile bones, fatigue, bone pain, an abnormal EKG with a short QT interval and a long T wave, kidney stones, constipation, and vomiting. You theorize that the virus is infecting endocrine cells and causing the overproduction of a certain hormone. Which hormone should you test for first?
- A. Prolactin
 - B. Parathyroid hormone (PTH)
 - C. Triiodothyronine
 - D. Melatonin
 - E. Oxytocin
25. The flippers of dolphins are exposed to cold water away from the main mass of the body and employ countercurrent heat exchange. Which of the following statements is FALSE?
- A. Each artery in the flipper is surrounded by several veins, allowing efficient heat exchange.
 - B. As long as there is a difference in temperatures, heat transfer occurs from the warmer vessel to the cooler one.
 - C. The coolest blood is found at the tip of the dolphin flipper.
 - D. Dolphins are the only mammals known to employ countercurrent heat exchange.
 - E. Once the arterial blood has been cooled past a certain point, it will no longer transfer heat to the veins.



The diagram above depicts:

- A. Developing human sperm cells
 - B. Human blood smear
 - C. Human lung section
 - D. Frog eggs
 - E. Frog blood smear
27. Which statement best explains why the ascending limb of the loop of Henle is thicker than the descending limb?
- A. Many cells with aquaporin are present in the ascending limb
 - B. The ascending limb receives a better blood supply
 - C. The triple-pumps ($\text{Na}^+/\text{K}^+/\text{Cl}^-$) of the ascending limb consume a lot of ATP and need many mitochondria.
 - D. Unexplained proliferation of cells around the ascending limb
 - E. Descending limb has evolved completely while the thickness of the ascending limb is a vestigial feature.
28. A child has overdosed on acetaminophen, causing acute liver failure. He displays symptoms of severe jaundice and swelling of the abdomen. Which of the following processes is not directly impacted?
- A. Bile synthesis
 - B. Bilirubin glucuronidation
 - C. Production of serum albumin
 - D. Erythropoietin synthesis
 - E. Glycogenesis
29. Fixation is a lab procedure used to prevent biological tissues from decay. In instances where perfect morphology of the whole animal is desired, cardiac fixation is the preferred method. Where should the researcher inject the fixative to ensure the best results?
- A. Right atrium
 - B. Abdominal cavity
 - C. Right ventricle
 - D. Left atrium

E. Left ventricle

30. What is the primary mechanism by which ADH exerts its effects on the kidney?

- A. glomeruli Formation of water-impermeable junctions by the podocytes of nephron
- B. Decreasing circulatory flux through renal afferent arterioles
- C. Raising the osmolarity of nephron medullae to ~ 1500 mosm/L
- D. Increasing expression of aquaporins in the distal convoluted tubule
- E. Synthesis of additional cation pumps in the ascending Loop of Henle

31. In the picture below – taken from the work of N. Tinbergen – a cardinal feeds minnows, which rose to the surface looking for food. The bird fed the fish for several weeks, probably because its nest had been destroyed.



The cardinal's behavior is best understood as:

- A. Habituation
- B. Imprinting
- C. Fixed action pattern
- D. Associative learning
- E. Operant conditioning

32. Which of the following is an example of habituation?

- A. Chickadees learning new songs when they shift from living in small groups to living in large winter flocks.
- B. Lion cubs stalking and attacking litter mates
- C. Hydra initially contracting when gently touched, and then soon stopping to respond
- D. Golden plovers migrating yearly from Arctic breeding grounds to southeastern South America
- E. A mother eagle flying beneath her young to prevent them from falling

33. By convincing soldiers that they are part of a "brotherhood," and thus increasing the likelihood that they will protect, and even die for each other, the military is—consciously or unconsciously—tapping into genes that were adaptive in our ancestors due to

- A. Individual selection
- B. Kin selection
- C. Neoteny
- D. Inclusive selection
- E. Heterochrony

34. A certain plant you are studying has alleles **R** and **r** for pointed and round leaves, and alleles **B** and **b** for blue and white petals. You perform a cross between homozygous dominant (**RRBB**) and homozygous recessive (**rrbb**) plants. The offspring are then crossed with a homozygous recessive (**rrbb**) plant. You observe the results. 1600 offspring are produced. Which of the following data is **CLOSEST** to what you would expect given a recombination frequency of 25%?
- A. 100 **rrbb**, 300 **rrBb**, 300 **Rrbb**, 900 **RrBb**
 - B. 600 **rrbb**, 600 **rrBb**, 200 **Rrbb**, 200 **RrBb**
 - C. 200 **rrbb**, 200 **rrBb**, 600 **Rrbb**, 600 **RrBb**
 - D. 900 **rrbb**, 300 **rrBb**, 300 **Rrbb**, 100 **RrBb**
 - E. 600 **rrbb**, 200 **rrBb**, 200 **Rrbb**, 600 **RrBb**
35. In birds, the keel is an extension of the sternum where the powerful pectoral flight muscles attach. Which of the following orders of birds is most likely to have a reduced keel?
- A. Piciformes
 - B. Anseriformes
 - C. Sphenisciformes
 - D. Struthioniformes
 - E. Galliformes
36. What provides the best evidence for the independent origin of microphylls and megaphylls?
- A. Microphylls have a single unbranched vein, while megaphylls have a branching vascular system
 - B. Microphylls have a branching vascular system, while megaphylls have a single unbranched vein
 - C. Microphylls are small, while megaphylls are larger
 - D. Both are vascularized
 - E. Both appear as lateral appendages
37. A male child with Klinefelter's syndrome is found to be color-blind (a recessive X-linked trait). Both the mother and father have normal vision. How can this be explained?
- A. Nondisjunction during the mother's meiosis I
 - B. Nondisjunction during the mother's meiosis II
 - C. Nondisjunction during the father's meiosis I
 - D. Nondisjunction during the father's meiosis II
 - E. Failure of X inactivation in the child
38. Birds and mammals share all the following characteristics **EXCEPT**:
- A. Amniotic eggs
 - B. A notochord
 - C. Bi-directional breathing
 - D. Endothermy
 - E. A four-chambered heart
39. Which of these is **NOT** true about allopatric speciation?
- A. It describes formation of a new species due to geographic isolation
 - B. It is more rare than sympatric speciation
 - C. It can be caused by sexual selection
 - D. It can be caused by natural selection under different environmental conditions
 - E. It can prevent interbreeding with the parent population
40. Which of the following is **NOT** true about genetic drift?
- A. Can cause harmful alleles to become fixed
 - B. Can cause allele frequencies to change at random
 - C. Significant in small populations
 - D. Can lead to a loss of genetic variation within populations
 - E. Prevents allele frequencies from fluctuating over time

41. An individual with Turner Syndrome would have which of the following sex chromosomes arrangements?
- A. XO
 - B. XXYY
 - C. XXXXY
 - D. YO
 - E. XXX
42. When the base composition of DNA from bacterium *Fusobacterium novum* was determined, 32% of the bases were found to be guanine. What is the pyrimidine content?
- A. 18%
 - B. 32%
 - C. 50%
 - D. 64%
 - E. 72%
43. From which geological period over 500 million years ago did fossils first show all of the major body plans we see today?
- A. Burgess period
 - B. Cambrian period
 - C. Carboniferous period
 - D. Cretaceous period
 - E. Ediacaran period
44. Robert MacArthur and E. O. Wilson studied island biogeography and developed the island equilibrium model. Which of the following scenarios will DEFINITELY result in an island X having a greater equilibrium number of species than island Y?
- A. Island X is bigger than Island Y. The two islands are the same distance from the mainland.
 - B. Island X is farther from the mainland than Island Y. The two islands are the same size.
 - C. Island X is bigger than Island Y and farther from the mainland.
 - D. Island X is smaller than Island Y and closer to the mainland.
 - E. Island X and Y have the same rate of immigration and extinction.
45. Which of the following is NOT an adaptation to survival in a grassland biome?
- A. Grasses have basal meristems that allow them to grow from the base of the plant instead of the tip.
 - B. Trees retain their moisture below the ground and have bark that lacks resin or cork.
 - C. Grasses have deep roots to anchor them and provide starch reserves.
 - D. Grasses have bulliform cells that can change in turgor pressure allowing the plant to furl its blade and shelter its stomata.
 - E. Grazing animals have long distance vision with eyes placed well above their snouts.
46. In many bird and mammal species, more often males have secondary sexual characters like the antlers of the deer or colored plumage in birds and/or perform elaborate courtship displays in order to attract females for copulations. Why do you think females are often said to be the 'choosy' sex?
- A. Sperm production by the male is more expensive than egg production by the females, so they can invest more time in mate choice.
 - B. The embryo usually develops inside females until birth or egg laying. This involves a great amount of energy and causes females to be choosy.
 - C. Males produce much more sperm than females produce eggs. The limited gamete production by females makes them more choosy than males.
 - D. A, B and C

- E. B and C
47. **Males of a small tropical bird species spend 6 months of the year jumping around in a small area on the forest floor exposing their bright yellow beard during landing. Males don't contribute anything other than sperm to the production of their offspring. Which of the following statements best explains why males display themselves in such an obvious manner that also would make them an easy prey?**
- A. Males that display more frequently and move faster obtain more matings, as females use displaying capabilities as indicators of male quality on which they base their mate choice.
 - B. Males that display more frequently and faster obtain less matings, as females prefer males that perform such displays as little and slow as possible so they don't get eaten by predators.
 - C. Males that perform the courtship behavior more frequently and faster obtain more matings as this is direct evidence of good male genetic quality important for healthy offspring.
 - D. Males perform such noisy and startling behaviors as there are very few predators in the tropics.
 - E. Males that display more frequently and move faster are selected for because displays improve their chance of survival.
48. **Sexual selection is a case of natural selection that describes evolution due not to variable survival rates due to fitness, but rather due to variable reproductive rates stemming from characteristics that allow an individual to successfully attract a mate. These traits are called secondary sexual characters. Which answer is NOT a correct statement about secondary sexual characteristics?**
- A. The peacock's tail is a secondary sexual character.
 - B. Reproductive organs are secondary sexual characters.
 - C. Bird song can be used for mate attraction.
 - D. The roaring of deer can be used for mate attraction.
 - E. Sexual selection can select for traits that decrease individuals' likelihood of survival.
49. **You observe an animal in the early stages of development. The zygote divides radially into eight cells. If you separate these early cells, each one can successfully develop into an animal on its own and the coelom forms from an infolding pocket of the archenteron. Which of the following is a valid candidate for the animal you are observing?**
- A. Horseshoe crab (Chelicerata)
 - B. Fruit fly (Insecta)
 - C. Sea urchin (Echinoidea)
 - D. Land snail (Gastropoda)
 - E. Earthworm (Oligochaeta)
50. **Which of the following classes contains organisms lacking a closed circulatory system?**
- A. Polychaetes
 - B. Cephalopoda
 - C. Insecta
 - D. Reptilia
 - E. Eutheria