

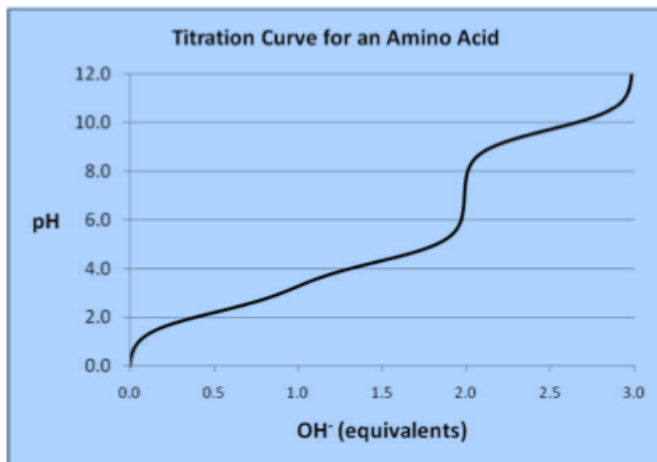
## Cell and Molecular Biology

1. Which of the following processes occur in the cytosol? Select all that apply.
  - A. RNA splicing
  - B. RNA degradation
  - C. Glycolysis
  - D. Modification of proteins for export
  - E. Pentose phosphate pathway (specifically in animals)
2. Which of the following is NOT involved with regulating gene expression?
  - A. snRNA
  - B. Histone acetylation
  - C. Formation of heterochromatin
  - D. Ubiquinone
  - E. Ubiquitin
3. Which of the following macromolecules would most likely be used in a plant seed for energy storage?
  - A. Carbohydrate with alpha linkages
  - B. Carbohydrate with beta linkages
  - C. Triglycerides with saturated fatty acid tails
  - D. Triglycerides with unsaturated fatty acid tails
  - E. Dideoxy nucleic acids
4. Which of the following biotechnology procedures would be most useful in identifying the varying transcription levels of a select gene over the course of an organism's lifetime?
  - A. Southern Blotting
  - B. Northern Blotting
  - C. Western Blotting
  - D. PCR
  - E. Sanger Sequencing
5. When conducting a Western Blotting experiment, your results indicate fluorescence across nearly the entire nitrocellulose membrane. Which of the following mistakes in your procedure could lead to this result?
  - A. Not adding beta mercaptoethanol
  - B. Not adding SDS
  - C. Not blocking the membrane with a milk protein mix

These problems were created by Yilun Du, Varun Mangalick, and Abhijit Mudigonda and are the intellectual property of them and their biology tutoring business, Study of Life. If you have any questions, email us at [studyoflife.info@gmail.com](mailto:studyoflife.info@gmail.com)

- D. Not adding a primary antibody
- E. Not adding a secondary antibody

6. Abhijit forgot to label his amino acid solutions in the lab! Luckily, using his chemistry skills, he quickly conducts a titration of one of the amino acids and obtains the following plot.



Which of the following amino acids is the solution composed of?

- A. Aspartic Acid
- B. Lysine
- C. Glycine
- D. Asparagine
- E. Histidine

7. Which of the following cytoskeletal functions or structures is incorrectly matched with the type of cytoskeletal element that performs or forms it?

- A. Cytoplasmic streaming - microfilaments
- B. Spindle tubules - microtubules
- C. Eukaryotic Flagella - microtubules
- D. Nuclear lamina - intermediate filaments
- E. Transferring vesicles to cell plate - microfilaments

8. Inside a cell, we have molecule A and molecule B. The cell produces molecule A at 5 units per second and the molecule has a half life of 20 seconds. Molecule B is produced at 10 molecules per second and has a half life of 15 seconds. Which of the following statements regarding molecule A and molecule B are true? Select all that apply.

- A. At equilibrium there are 300 units of Molecule B inside the cell

These problems were created by Yilun Du, Varun Mangalick, and Abhijit Mudigonda and are the intellectual property of them and their biology tutoring business, Study of Life. If you have any questions, email us at [studyoflife.info@gmail.com](mailto:studyoflife.info@gmail.com)

- B. At equilibrium there are 250 units of Molecule A inside the cell
- C. If a hormonal signal C caused both the production of A and B to double, the concentration of B will reach equilibrium first.
- D. Suppose a hormonal signal D decreases both the production rate of A and B by  $\frac{1}{2}$ . The concentration of A will reach equilibrium first.
- E. Suppose the half life of both molecule A and B were reduced by half by a chemical messenger. Molecule A will reach equilibrium first.

9. The interconversion of molecules is very important in cells of all types. Which of the following interconversions can occur in animal cells? Select all that apply.

- A. Sugar to Amino Acid
- B. Sugars to Fats
- C. Nucleotides to Sugars
- D. Amino Acids to Sugars
- E. Fats to Sugars

10. Which of the following is the most important mechanism in preventing cells from becoming cancerous?

- A. G1 Checkpoint
- B. S Checkpoint
- C. G2 Checkpoint
- D. M Checkpoint
- E. Telomerase

## Genetics and Evolution

You travel to an unknown island and find a population of strangely colored slugs! Upon close investigation, you notice that 16% of the slugs have a shriveled tails, a most terrible condition you decide to name *Yilunemia*. This condition makes the affected slugs have a 50% chance of surviving to reproduce. This is a autonomic recessive condition caused by a single gene, and heterozygotes are not affected.

11. What percent of the slugs are heterozygous for the *Yilunemia* allele?

- A. 90%
- B. 72%
- C. 48%
- D. 24%
- E. 12%

12. Assuming *Yilunemia* confers no discernible evolutionary advantage, how many generations should it take for the proportion of slugs with the *Yilunemia* disease to fall below 5%?

- A. 5
- B. 6
- C. 7
- D. 8
- E. 9

13. Intrigued about why *Yilunemia* still affects these slugs, you conduct more studies and discover *Yilunemia* confers resistance to some rare, but dangerous diseases. Slugs that are homozygous dominant at the *Yilunemia* locus (meaning they don't have *Yilunemia*) have only a  $(100-P)\%$  chance of surviving to reproduce, while slugs that are heterozygous at that locus have a  $(100-P/2)\%$  chance of surviving to reproduce. For what value of P would the current frequency of the *Yilunemia* allele remain stable?

- A. 30
- B. 50
- C. 20
- D. 60
- E. 40

14. Wanting to rid the slugs of the annoyance of *Yilunemia*, you use gene therapy to give all the slugs the resistance advantage that *Yilunemia* confers, whether or not they have the *Yilunemia* allele. Over time, you predict, the *Yilunemia* allele will fade out of the population by selection. Which of the following statements are true? Select all that apply.

- A. *Yilunemia* would leave the population more quickly if it was a dominant allele
- B. *Yilunemia* would leave the population less quickly if it was a dominant allele
- C. *Yilunemia* would still fade out of the population even if only germ cells were mutated
- D. *Yilunemia* would still fade out of the population even if only somatic cells were mutated
- E. Retaining the *Yilunemia* allele confers no significant advantage

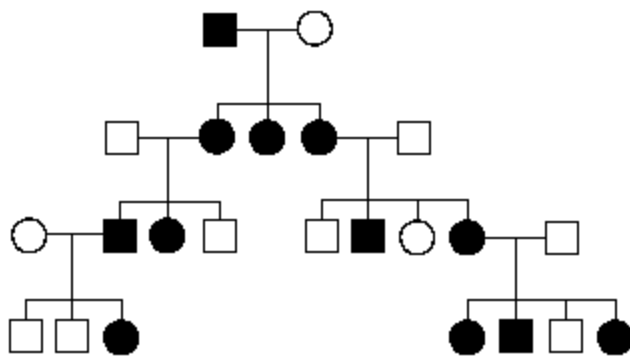
15. A certain species has somatic cells with ploidy  $3n$  (the organism inherits three sets of homologous chromosomes from each of three parents - don't ask). At a certain locus, there are three possible alleles  $A_1$ ,  $A_2$ ,  $A_3$ , which are completely dominant in the order  $A_1 > A_2 > A_3$ . The proportion of organisms exhibiting traits  $A_1$ ,  $A_2$ , and  $A_3$  are respectively 0.614, 0.306, and 0.08. In addition, the proportion of organisms that are completely heterozygous (genotype  $A_1A_2A_3$ ) is 0.18. Which of the following are allele frequencies of  $A_1$ ,  $A_2$ , and  $A_3$ , respectively?

- A.  $f(A_1) = 0.5$ ,  $f(A_2) = 0.3$ ,  $f(A_3) = 0.2$
- B.  $f(A_1) = 0.3$ ,  $f(A_2) = 0.5$ ,  $f(A_3) = 0.2$
- C.  $f(A_1) = 0.3$ ,  $f(A_2) = 0.4$ ,  $f(A_3) = 0.3$
- D.  $f(A_1) = 0.6$ ,  $f(A_2) = 0.2$ ,  $f(A_3) = 0.2$
- E.  $f(A_1) = 0.7$ ,  $f(A_2) = 0.2$ ,  $f(A_3) = 0.1$

16. During which of the following geological time period did most animal phyla emerge?

- A. Ediacaran
- B. Cambrian
- C. Triassic
- D. Cenozoic
- E. Devonian

17. Consider the pedigree below:



What is the most likely mode of inheritance?

- A. X-linked dominant
- B. X-linked recessive

- C. Autosomal dominant
- D. Autosomal recessive
- E. Mitochondrial Inheritance

18. The following table displays approximate recombination frequencies (in percentage units) between the genes A, B, C, D, and E. Which of the following answer choices represents a possible relative order of the genes along a chromosome?

A and B	7
C and D	20
B and D	6
C and E	11

- A. CEDBA
- B. DBCAE
- C. CEABD
- D. DBCAE
- E. EDBAC

19. In the species *X. abhijiticus*, allele B and b encode for brown and blond hair respectively and allele R and r encode for red and green skin. You cross purebred brown haired red skinned animals with blond hair green skinned animals. You then cross the F1 generation with blond hair green skinned animals. Given that the recombination rate between R and B is 12%, how many offspring of each genotype do you expect given that you produce 1000 F2 offspring?

- A. 380 RrBb, 120 Rrbb, 120 rrBb, 380 rrbb
- B. 380 RrBb, 380 Rrbb, 120 rrBb, 120 rrbb
- C. 250 RrBb, 250 Rrbb, 250 rrBb, 250 rrbb
- D. 440 RrBb, 60 Rrbb, 60 rrBb, 440 rrbb
- E. 440 RrBb, 440 Rrbb, 60 rrBb, 60 rrbb

20. Which of the following would promote allopatric specification?

- A. An earthquake causes the collapse of a land bridge
- B. A failure in pollen cell division leads to a polyploid plant
- C. One migrant group of animals loses contact with others
- D. Both A and C
- E. All of the above would cause allopatric specification

## Biodiversity and Systematics

21. Which of the following groups are monophyletic? Select all that apply.

- A. Protista
- B. Reptilia
- C. Aves
- D. Mammalia
- E. Amniota



22. Ghouls are a species endemic to Tokyo that possess up to four muscular appendages but are otherwise *outwardly* indistinguishable from humans. They extraordinary regenerative capabilities and their appendages can adhere to solid surfaces by using hydraulic pressure to create suction. The blastopore of a ghoul

gastrula develops into the anus. What phylum would ghouls *best* be categorized under?

- A. Chordata
- B. Cnidaria
- C. Arthropoda
- D. Cephalopoda
- E. Echinodermata

## Plant Anatomy and Physiology

23. Which of the following represents the order of layers in a woody plant stem moving from the outermost layer to the innermost?

- I. Vascular Cambium
- II. Cork cambium
- III. Primary Xylem
- IV. Periderm
- V. Primary Phloem
- VI. Cortex
- VII. Pith
- VIII. Secondary Phloem
- IX. Secondary Xylem

These problems were created by Yilun Du, Varun Mangalick, and Abhijit Mudigonda and are the intellectual property of them and their biology tutoring business, Study of Life. If you have any questions, email us at [studyoflife.info@gmail.com](mailto:studyoflife.info@gmail.com)

- A. IV, II, VI, VIII, V, I, III, IX, VII
- B. IV, II, VI, V, VIII, I, IX, III, VII
- C. IV, I, VI, V, VIII, II, III, IX, VII
- D. IV, I, VII, VIII, V, II, IX, III, VI
- E. IV, I, VII, V, VIII, II, III, IX, VI

24. Which of the following is NOT true of auxins?

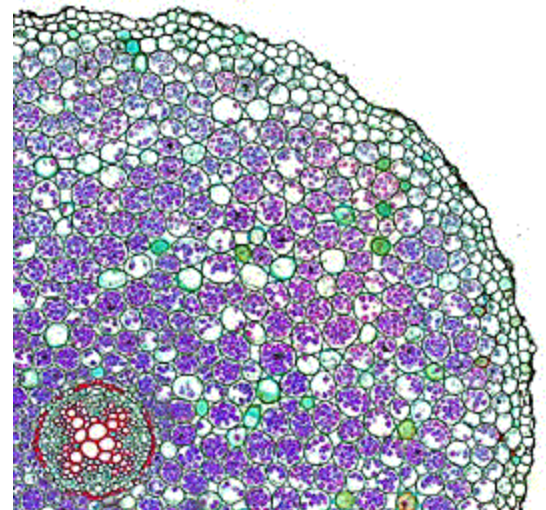
- A. The most well-known auxin is Indole-3-acetic acid
- B. Auxin-based pesticides are widely sprayed on crops to kill monocot weeds
- C. Auxins promote growth in phototropism and inhibit growth in gravitropism
- D. Auxins released by the apical meristem promotes apical dominance
- E. A callus treated with auxins and cytokinins in a 3:1 ratio will develop roots

25. Which of the following groups of compounds would you most likely find accumulated in greatest relative concentration at areas of plant injury and infection?

- A. Flavonoids
- B. Cardiac glycosides
- C. Phytoalexins
- D. Strigolactones
- E. Cytokinins

26. Which of the following is true of the image?

- A. The xylem development in this plant was endarch
- B. The most medial cells are sieve tube elements
- C. The image depicts a monocot root
- D. The image depicts a eudicot stem
- E. The blueish-purple colored cells contain starch



27. Which of the following statements are TRUE regarding synergids? Select all that apply.

- A. Eudicot seeds possess two synergids



- B. Synergids release compounds that help guide the pollen tube towards the micropyle
- C. Synergids are located near the opening in the integuments
- D. Synergids are part of the female angiosperm gametophyte, and are thus haploid
- E. Synergids partially surround the angiosperm egg, and are thus part of the angiosperm archegonium

28. Maple syrup is extracted in the winter from maple and birch trees. Large trees often store sugar in the ray parenchyma surrounding their xylem, and maple syrup, perhaps unexpectedly, is thus harvested from the xylem sap rather than the phloem sap. Below are five claims and corresponding justifications. Which of the five is MOST valid?

- A. **Claim:** Spigots are drilled into the centermost heartwood of the tree. **Justification:** The xylem in eudicot stems can be found in a star-like pattern at the center of the stem/trunk, and xylem sap can thus be most effectively harvested here.
- B. **Claim:** The xylem sap rises upwards in the winter due to negative pressure from leaf transpiration. **Justification:** Evaporation of water from stomata increases surface area and creates negative pressure, thus pulling water up the trunk
- C. **Claim:** The xylem sap rises upwards in the winter due to positive pressure from the roots. **Justification:** Because of the high concentration of solutes in the soil, the solute potential of water is lower in the roots, and there is thus a water potential gradient forcing water from the roots to the trunk
- D. **Claim:** Phloem sap would be an ineffective source of maple syrup. **Justification:** Phloem sap flow is limited during the winter in deciduous plants because plants store sugar for growth in the springtime.
- E. **Claim:** Phloem sap would be difficult to collect. **Justification:** The phloem layer is in incredibly thin layer (less than the thickness of bark) and would be difficult to use a spigot to extract sap.

29. Which of the following features are present in monocots? Select all that apply.

- A. Tap root
- B. Coleoptile/Coleorhiza at seed stage
- C. Petal counts in multiples of 3

- D. Pollen grain with two openings
- E. Parallel venation

30. In the ABC model of flower development, if a mutation leads to the destruction of function of the B gene, which whorls of the flower will be affected? Select all that apply.

- A. Calyx
- B. Corolla
- C. Androecium
- D. Gynoecium

### **Animal Anatomy and Physiology**

31. Which of the following cells of the retina are responsible for increasing contrast in vision? Select all that apply.

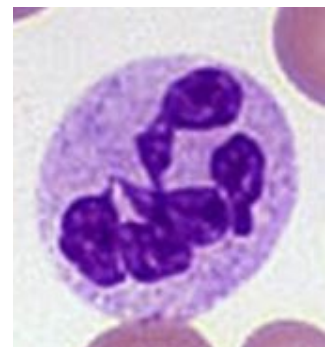
- A. Rods/Cones
- B. Horizontal cells
- C. Bipolar cells
- D. Amacrine cells
- E. Ganglion cells

32. Which of the following hormones is incorrectly matched with its primary or a secondary function?

- A. Glucocorticoids - raise blood glucose level
- B. Parathyroid hormone - raises blood calcium levels
- C. Antidiuretic hormone - raises blood solute levels
- D. Glucagon - raises blood glucose level
- E. Epinephrine - raises blood glucose level

33. What type of blood cell is pictured to the right?

- A. Eosinophil
- B. Neutrophil
- C. Lymphocyte
- D. Macrophage
- E. Basophil



34. Recently, Varun keeps hearing echoes in addition to a main sound. Which of the following parts of his ear is most likely damaged?

- A. Cochlea
- B. Round Window
- C. Oval Window
- D. Stirrup
- E. Tympanic Canal

35. From which embryonic layer is the lens of eye derived from?

- A. Endoderm
- B. Mesoderm
- C. Ectoderm

36. You are left-handed, and are sitting at a desk. At the left side of your visual field is a blue sphere, and at the right side of your visual field is a red sphere. Which of the following is true?

- A. You see the blue sphere exclusively through your right eye
- B. You see the red sphere exclusively through your right eye
- C. You see the red sphere exclusively through the left halves of both eyes
- D. You see the blue sphere exclusively through the left halves of both eyes
- E. You see the blue sphere exclusively through your left eye

37. Which of the following statements regarding hearing in humans is true?

- A. The auditory canal lies in the middle ear
- B. Pitch is measured by sound vibrating different parts of the basilar membrane through different resonant frequencies
- C. Pitch is measured by sound directly making different hairs vibrate due to their different resonant frequencies
- D. Sound information is processed in the occipital lobe of the brain
- E. High frequency sounds vibrate the inner loops of the cochlea.

38. Which of the following organs are separated from the blood by an immunological and/or physical barrier? Select all that apply.

- A. Testes
- B. Brain
- C. Liver
- D. Eyes
- E. Thymus

39. Which of the following statements regarding kidney function in humans is true? Select all that apply.

- A. Kidney function is regulated by two strictly opposing hormones: ADH and RAAS
- B. The kidney uses a countercurrent exchange system to produce hyperosmotic urine
- C. The kidney is composed primarily of juxtamedullary nephrons
- D. The inner cortex of the kidney has high levels of urea.
- E. The ascending limb of the Loop of Henle actively transports sodium chloride across the membrane.

40. Which of the following is NOT true of neurotransmitters?

- A. Carbon monoxide is produced by heme oxygenase
- B. Acetylcholine has an excitatory effect on heart muscle
- C. Selective serotonin reuptake inhibitors like Prozac are used to treat clinical depression
- D. The active agent in marijuana is chemically similar to brain endocannabinoids
- E. Dopamine is produced in the substantia nigra from tyrosine

41. Abhijit goes to the Minnesota State Fair (while visiting his best friend Varun) and eats a deep-fried stick of butter. What he does not know is that Yilun has replaced the oxygen atoms of the triglycerides with the radioactive isotope O-18. In what order would the O-18 FIRST pass through Abhijit's following vessels and compartments?

- I. Hepatic Vein
- II. Hepatic Artery
- III Left Atrium
- IV. Pulmonary Artery
- V. Pulmonary Vein
- VI. Vena Cavae
- VII. Lacteal

- A. VII, I, VI, III, V, IV, II
- B. I, VI, III, IV, VII, V, II
- C. VII, II, VI, IV, V, III, I
- D. VII, VI, IV, I, II, V, III
- E. VII, VI, IV, V, III, II, I

These problems were created by Yilun Du, Varun Mangalick, and Abhijit Mudigonda and are the intellectual property of them and their biology tutoring business, Study of Life. If you have any questions, email us at [studyoflife.info@gmail.com](mailto:studyoflife.info@gmail.com)

42. Abhijit is hiking in the mountains surrounding Yellowstone. However, he is unused to the high elevation of the mountains. Which of the following physiological traits will Abhijit not experience?

- A. Increased production of alkaline urine
- B. Drowsiness
- C. Fatigue
- D. Fast heart beat
- E. Higher than normal binding affinity of hemoglobin to oxygen

### **Ethology**

43. A perfectly logical member of the species *P. logicus* (let's call him A) notices another member of the species (let's call him B) is drowning in quicksand. With his perfect logic skills, A deduces he would have an 80% chance of saving B (who would otherwise die), but in doing so, would have a 12% chance of dying himself, so A decides not to risk it. However, after seeing a vine he could hold on to that would lower his chance of death to 8%, A does decide to save B (though the vine breaks and they both drown anyways). How closely related were A and B?

- A. Identical twins
- B. Siblings
- C. Parent-offspring
- D. First cousins
- E. Second cousins

44. Which of the following would be an example of an ethological study?

- A. The response of pandas to zoo enclosure
- B. The effects of snow on piranhas
- C. The behavior of domesticated cows in the wild
- D. Insect growth in an abandoned barn
- E. Siberian tigers hunting in the wild

45. Which of the following are traits that would be more prevalent in polyandrous species? Select all that apply.

- A. Highly ornamented males
- B. Highly ornamented females

- C. More prominent male genitalia
- D. Long-term sperm storage in females
- E. Female parental care

## Ecology

46. While wandering a most dangerous jungle, you stumble upon a wasp with a black and yellow striped coat. You back away cautiously, only to see another wasp, this one of a physically smaller species, that has the same coloration. As you continue to venture forward and away from the wasps, you keep noticing more members of various bee and wasp species, all with similar coloration. Which of the following terms does this situation BEST illustrate?

- A. Cryptic coloration
- B. Aposematic coloration
- C. Batesian mimicry
- D. Mullerian mimicry
- E. Amensalism

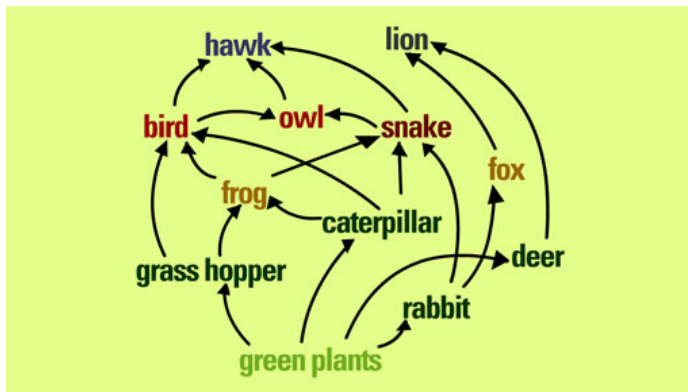
47. You are in an area where it's pretty rainy and cold (10-12° C) in the winter, though summer temperatures can reach 40° C. The landscape is dominated with shrubs and small trees with the occasional deer or goat. In which biome are you?

- A. Savanna
- B. Chaparral
- C. Temperate grassland
- D. Northern coniferous forest
- E. Tundra

48. You want to study the population of river trout in a local pond. You capture 20 fish from the local pond and tag them. Two weeks later, you then randomly capture 30 fish and find that 5 of them are tagged. Approximately how many fish are in the pond?

- A. 120
- B. 150
- C. 200
- D. 250
- E. 300

49. Consider the food web given below:



The population of frogs in the environment has become dangerously low. Using the top-down method of control, you should increase the levels of what species?

- A. Owl
- B. Hawk
- C. Lion
- D. Grasshopper
- E. Green plants

50. Which of the following characteristics is not an adaptation of the temperate forest biome?

- A. Broad thin leaves in the summer.
- B. Migration of birds during the winter.
- C. Thick bark on trees
- D. Wildflower growth in early spring
- E. Bulliform cells on grass leaves