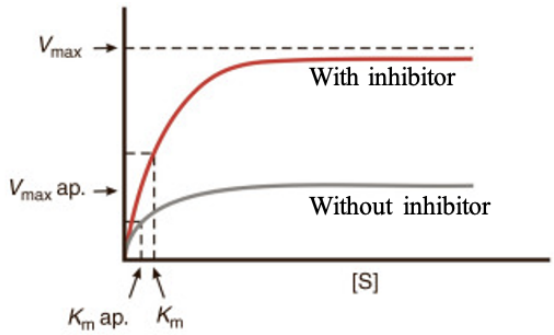
Harvard Undergraduate Science Olympiad India
2024 Open Round
Biology (9th-10th Grade) Exam
ANSWER KEY

Biochemistry

1. Which of the following amino acid sequences is the most hydrophobic?
   A. FFKDHRSR
   B. LQAGYMP
   C. MKRNAYE
   D. KQIHLSRQ
   E. LRSTPISHY

2. You are studying the effect of a mystery inhibitor on an enzyme and decide to measure the Vmax of an enzyme under various substrate concentrations for a solution with and without the inhibitor. Your results are shown to the right. Based on your results, what type of inhibitor are you studying?
   A. Competitive inhibitor
   B. Mixed inhibitor
   C. Noncompetitive inhibitor
   D. Uncompetitive inhibitor



3. Which of the following reactions and enzyme pairs does NOT occur in gluconeogenesis?
   A. pyruvate oxaloacetate, pyruvate carboxylase
   B. fructose 1,6-bisphosphate fructose 6-phosphate, phosphofructokinase
   C. 3-phosphoglycerate 1,3 bisphosphoglycerate, phosphoglycerate kinase
   D. glucose 6-phosphate glucose, glucose 6-phosphatase

Cell Biology

4. Which of the following is the most accurate equation representing cellular respiration?
   A. $CO2 + H2O \rightarrow Sugar + O2$
   B. $Sugar + CO2 \rightarrow O2 + H2O$
   C. $Sugar + O2 \rightarrow CO2 + H2O$
   D. $Sugar + O2 + H2O \rightarrow CO2$

5. Which of the following choices denotes the movement of water across a selectively permeable membrane to balance solute concentration?
   A. diffusion
   B. osmosis
   C. facilitated transport
   D. endocytosis

6. Which of the following choices correctly describes the products of the light-dependent reactions?
    A. NADPH, ATP, and O2
    B. NADPH, ATP, and glucose
    C. NADP+, ADP, and O2
    D. NADP+, ATP, and glucose

Plant Anatomy & Physiology

7. Which of the following nutrients is NOT a plant macronutrient?
    A. Phosphorus
    B. Potassium
    C. Chloride
    D. Nitrogen

8. Which of the following is NOT associated with axesual reproduction in plants?
    A. Budding
    B. Fragmentation
    C. Pollination
    D. Vegetative propagation
    E. None of the above

9. Some plants, such as potatoes, use horizontal stems that run across the ground to produce new plants asexually. What are these structures called, commonly called runners?
    A. Rhizoid
    B. Tuber
    C. Rhizome
    D. Stolon

10. Below is a chart demonstrating the ABC hypothesis of flower development. In this hypothesis, the expression pattern of genes A, B, and C determine the spatial development of different flower structures. A mutation in the C gene that completely knocks out its expression would result in the presence of what floral organs?

Pattern of gene expression	Floral structure
A	Sepal
A + B	Petal
C + B	Stamen
C	Carpel

A. Sepals only
B. Sepals and petals only
C. Stamens and carpels only
D. Sepals, petals, stamens, and carpels
E. Impossible to determine with the given information

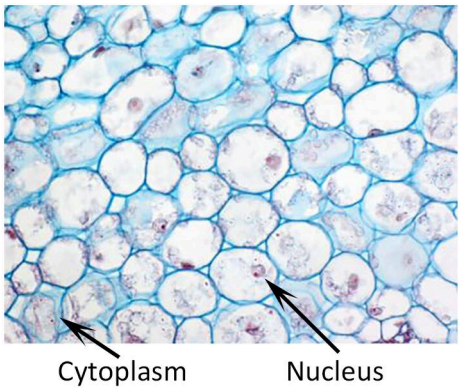
11. In a plant undergoing secondary growth, order the following stem tissues from innermost and outermost:

I. Cork cambium
II. Primary xylem
III. Secondary xylem
IV. Vascular cambium

A. I, II, III, IV
B. I, III, II, IV
C. II, III, IV, I
D. III, II, IV, I
E. IV, I, II, III

12. Which of the following plant tissues has the lowest rate of O2 consumption?
A. Collenchyma
B. Parenchyma
C. Phloem
D. Sclerenchyma
E. Xylem

13. Based on the structure of the plant tissue shown in the image below, what is the most likely function of this tissue?

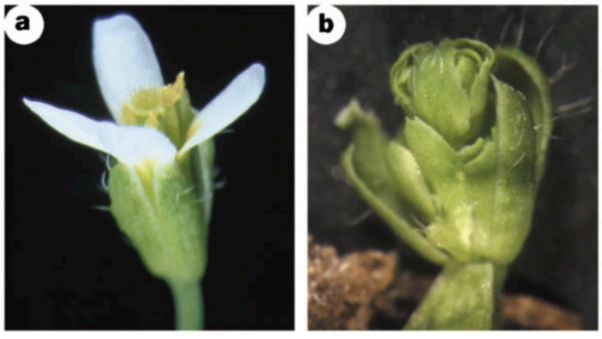


Credit: University of Florida

A. Photosynthesis and metabolism
B. Flexible support during plant growth
C. Rigid support in mature plant tissues
D. Transport of sugars and other nutrients
E. Transport of water and minerals

14. Which of the following processes will increase the transpiration rate of plants?
A. Increase in humidity
B. Increase in temperature
C. More wind
D. Closure of stomata
E. None of the above

15. In the figure below, (a) shows a wild-type flower while (b) shows a mutant flower. What floral organ is overexpressed in (b)?



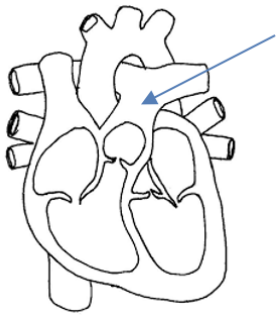
Credit: Pelaz et al., 2000

A. Carpals
B. Petals
C. Sepals
D. Stamens

Animal Anatomy & Physiology

16. Also called folate, this vitamin can be used to treat anemia and are given to pregnant women. It helps promote brain and nerve function and is found in leafy green such as spinach or broccoli. What is this vitamin?
    A. K
    B. B3
    C. B9
    D. B12

17. A human heart is shown in the figure at right. Which blood vessel is indicated by the arrow?
    A. Aorta
    B. Pulmonary artery
    C. Pulmonary vein
    D. Superior vena cava
    E. Inferior vena cava



18. The material that passes into the small intestine from the stomach is known as chyme, containing hydrochloric acid and partly digested food. After entering the small intestine, chyme mixes with pancreatic juice to further digest food. Which of the following is NOT found in pancreatic juice?
    A. carboxypeptidase
    B. trypsinogen
    C. pepsinogen
    D. phospholipase

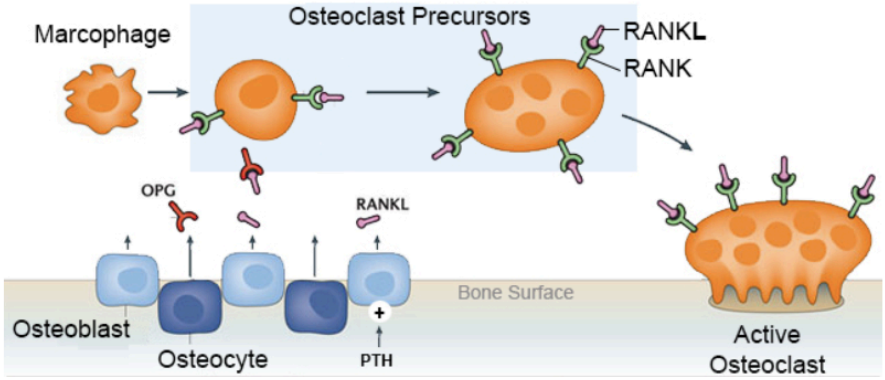
19. Which of the following glands is matched incorrectly to a hormone it produces?
    A. Anterior pituitary- antidiuretic hormone
    B. Ovaries- estrogen
    C. Posterior pituitary- oxytocin
    D. Thyroid- calcitonin

20. What brain region is responsible for controlling vital rhythms such as breathing and heart rate?
    A. Cerebellum
    B. Midbrain
    C. Medulla
    D. Pons

21. In a series of experiments in 1923, Roger Hubbard and Samuel Munford found that urine pH increased in those who had eaten a standard meal. In patients who could not secrete stomach acid, no increase in pH occurred. Based on these findings, which of the following is a reasonable conclusion?
    A. Secretion of acid by the stomach causes bicarbonate levels to decrease in the blood, leading to an increase in blood pH.
    B. Secretion of acid by the stomach causes bicarbonate levels to increase in the blood, leading to an increase in blood pH.
    C. Secretion of acid by the stomach causes bicarbonate levels to decrease in the blood, leading to an decrease in blood pH.
    D. Secretion of acid by the stomach causes bicarbonate levels to increase in the blood, leading to an decrease in blood pH.
    E. None of the above

22. Grey and white matter compose the brain and spinal cord. Grey matter consists primarily of neuron cell bodies while white matter consists primarily of neuron axons. Which of the following is TRUE regarding the organization of grey and white matter in the spinal cord and brain?
    A. Grey matter is surrounded by white matter in the spinal cord and brain
    B. White matter is surrounded by grey matter in the spinal cord and brain
    C. Grey matter is surrounded by white matter in the spinal cord and white matter is surrounded by grey matter in the brain
    D. White matter is surrounded by grey matter in the spinal cord and grey matter is surrounded by white matter in the brain
    E. None of the above

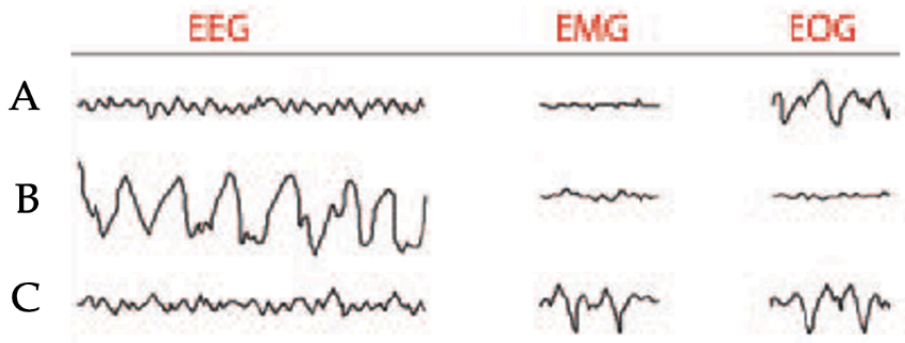
23. Bone growth is determined by a balance between the action of osteoclasts and osteoblasts in the bone, which perform bone deposition and resorption respectively. The action of these cells is determined by the RANKL system, shown in the diagram below.



Which of the following statements is TRUE?

A. An estrogen-secreting tumor would result in osteoblast overexpression.
B. The use of an antibody that irreversibly binds RANKL is an effective treatment for osteoporosis.
C. Osteoclasts secrete phosphoric acid, causing demineralization of bone.
D. Osteoprotegerin is upregulated in patients with osteoporosis.

24. The diagram below shows an electroencephalogram (EEG), electromyogram (EMG), and electrooculogram (EOG) during 2 stages of sleep and wake in no particular order (Stages A-C).



Which of the following statements is TRUE?

A. You are likely dreaming in Stage A.
B. You are likely most awake in Stage A.
C. You are likely most awake in Stage B.
D. You have likely entered REM sleep in Stage B.
E. You have likely entered REM sleep in Stage C.

The next 3 questions are based on the hemodynamic data of a car-accident patient below:

Oxygen Contents	
Superior vena cava	10.2 cc/100 cc blood
RA	10.5
RV	12.8
Pulmonary artery	12.0
Brachial artery	13.6

Oxygen consumption: 251 cc/min

25. Calculate the systemic blood flow.
    A. 0-5 L/min
    B. 5-10 L/min
    C. 10-15 L/min
    D. 15-20 L/min
    E. Greater than 20 L/min

26. Calculate the pulmonary blood flow.
    A. 0-5 L/min
    B. 5-10 L/min
    C. 10-15 L/min
    D. 15-20 L/min
    E. Greater than 20 L/min

27. Which of the following findings is most consistent with the data?
    A. Right ventricular failure
    B. Ventricular septum rupture
    C. Ventricular fibrillation
    D. Open ductus arteriosus
    E. Pericardial effusion

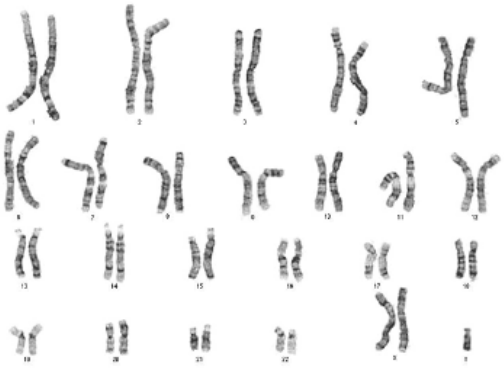
Genetics and Evolution

28. A mother has an A blood type, while the father has an AB blood type. The percent probability that the child offspring will have an B blood type like the father is 50%. What is the genotype of the mother?
    A. AO
    B. AA
    C. AB
    D. OO

29. What enzyme is responsible for completing the sugar phosphate backbone after Okazaki fragments are replaced by DNA nucleotides?
    A. DNA polymerase
    B. DNA ligase
    C. Helicase
    D. Topoisomerase

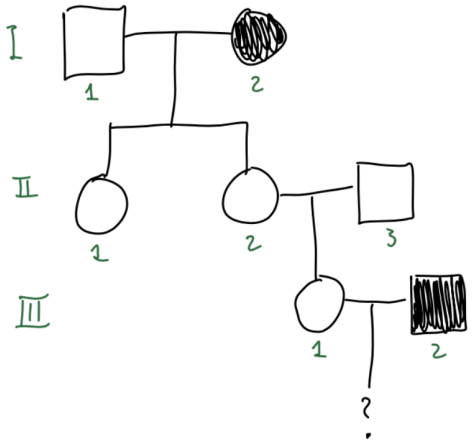
30. Examples of these structures include muscles or a heart. What are these structures, found in many species of organisms which can be used to demonstrate evolution from a common ancestor?
    A. interspecies structures
    B. homologous structures
    C. analogous structures
    D. vestigial structures

31. Examine the karyotype to the right. What genetic disorder does this karyotype display, if any?
    A. Turner syndrome
    B. Klinefelter's syndrome
    C. Down syndrome
    D. Cri du Chat
    E. None of the above



32. If the nucleotide thymine in a single-stranded DNA genome is 34% of all nucleotides, what is the percentage of cytosine in this genome?
    A. 16%
    B. 32%
    C. 34%
    D. 68%
    E. Cannot be determined

33. Examine the pedigree below showing the inheritance of a fully-penetrant disease through 3 generations. Individual I-1 is homozygous dominant and Individual II-3 is heterozygous. What is the probability that the offspring of Individuals III-1 and III-2 will be affected by the disease?



A. Between 0.7 and 1.0.
B. Between 0.5 and 0.7.
C. Between 0.3 and 0.5.
D. Between 0.2 and 0.3.
E. Between 0 and 0.2.

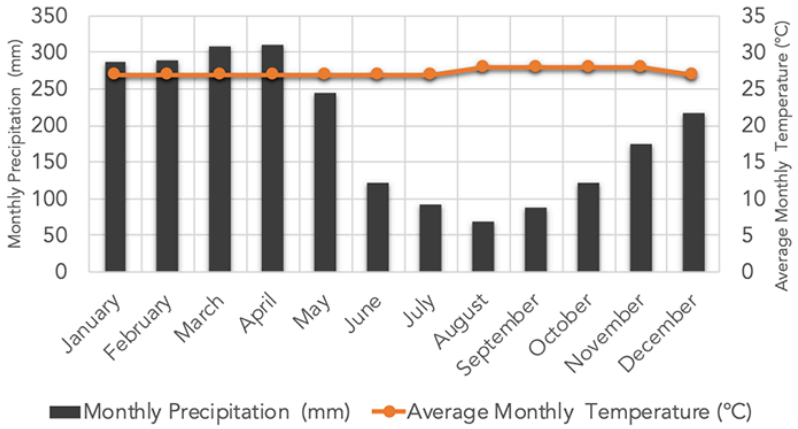
Ecology

34. Which of the following is NOT considered an abiotic factor in an ecosystem?
    A. Decomposers
    B. Humidity
    C. Soil
    D. Temperature

35. Interspecific interactions are interactions among different species. These interactions can be represented by a "/" notation. For example, a predator-prey interaction can be represented by a +/- notation. Which of the following correctly matches the interspecific interaction with its "/" notation?
    I. Commensalism (+/+)
    II. Mutualism (+/0)
    III. Parasitism (+/-)

    A. II only
    B. III only
    C. I and III only
    D. I and II only
    E. I, II, and III

36. Climographs measure average rainfall and temperature in a location over the year. The climograph below most likely represents which biome?

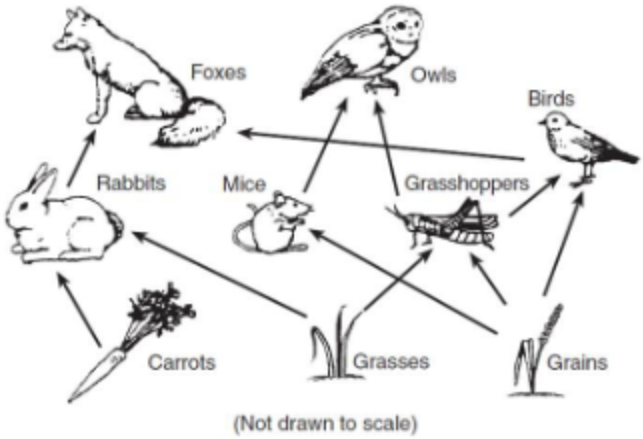


Credit: NASA

    A. Desert
    B. Savannah
    C. Temperate forest
    D. Tropical rainforest
    E. Tundra

37. Examine the food web at right. What would most likely occur if the local bird population went extinct?

A. the population of owls would decrease
B. the population of grasses would decrease
C. the population of foxes would increase
D. the population of carrots would increase
E. None of the above



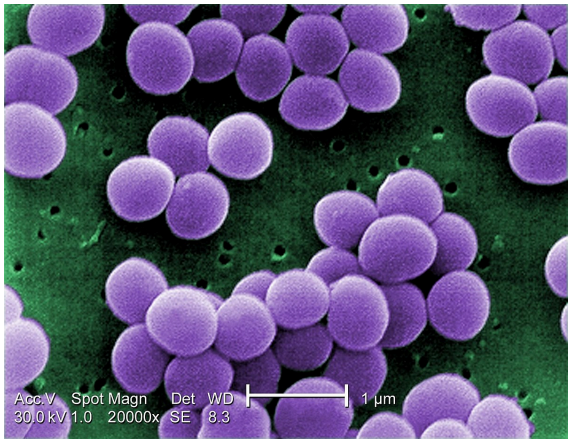
Biosystematics

38. Which of the following are vertebrate classes?

I. Arthropoda
II. Aves
III. Chondrichthyes
IV. Nematoda

A. I only
B. II and III only
C. I and IV only
D. II, III, and IV only
E. I, II, III, and IV

39. Which of the following best describes the shape of the bacteria shown below?



Credit: Wikipedia

A. Diplococcus
B. Streptobacillus
C. Streptococcus
D. Staphylococcus

40. Taxonomy makes it easy to identify and communicate what species a scientist is referring to. In what order are kangaroos and wombats in?
    A. Eulipotyphla
    B. Diprotodontia
    C. Chiroptera
    D. Afrosoricida