

## USA Biology Olympiad 2005 Open Exam

Congratulations! You are about to take the USABO Open Exam, the first exam in a series of competitions to qualify you for the USA Biology Olympiad and the International Biology Olympiad. ***Please try to complete as much of this multiple-choice exam as you can.*** The exam measures aptitude and assists in identifying candidates for selection to the Semifinals through comparison of the results from the applicant pool.

The fact that you have been nominated for this exam marks you as an outstanding biology student. By taking this exam, you may qualify to be one of the top 10% who will be invited to take the USABO Semifinal Exam in March 2005. The top 20 students from the Semifinal Exam will be selected to go on to attend the all-expenses-paid USABO National Finals at George Mason University. From the National Finals, four students will represent the United States at the International Biology Olympiad in Beijing, China July 10-20, 2005.

Please put away your books and other materials. Clear your desk of all but the following items:

- USA Biology Olympiad Open Exam
- Number 2 pencils and erasers
- Scrap paper
- Non-programmable calculator (*optional*)

You have 45 minutes to take this exam. Please wait until your teacher tells you before beginning the exam. Indicate your answer by filling in the correct box on your Scantron sheet, choice A, B, C, D or E.

Please sign and date this exam, certifying your identity, acknowledging your participation in the 2005 USA Biology Olympiad and pledging that you have followed the rules governing this competition.

### Please Print Carefully

Full Name: \_\_\_\_\_

Teacher Name: \_\_\_\_\_

School Name: \_\_\_\_\_

Student I.D. Number: \_\_\_\_\_

Date: \_\_\_\_\_

Signature: \_\_\_\_\_

*Instructions:* Please mark the correct answer (A, B, C, D or E) by filling in the designated box on your Scantron sheet.

*Sample Question:*

0. What insect transmits dog heartworm?
- [a] Dung beetles
  - [b] Flies
  - [c] Fleas
  - [d] Mosquitoes
  - [e] Dragonflies

1. The production of the genetically engineered “golden rice” could be important to the people of developing nations, especially in South-East Asia, because:

- A. people are more likely to consume yellow grains than white
- B. golden rice is less expensive to grow and harvest than white rice
- C. golden rice is resistant to most commercially available herbicides
- D. golden rice contains higher concentrations of  $\beta$ -carotene than white rice
- E. golden rice has been engineered to produce biodegradable plastics

2. A large population of laboratory rats was allowed to breed randomly for a number of generations. In this population, a dominant allele at the A locus codes for agouti fur (A), and a recessive allele codes for black fur (a). At the beginning of the breeding cycles, 49% of the rats had black fur. At the end of the breeding cycles, this percentage was the same. The rest of the animals had agouti fur with heterozygotes indistinguishable from homozygous dominants.

What percentage of this population is probably heterozygous for the fur color trait assuming the rats are following Hardy-Weinberg population genetics?

- A. 7%
- B. 30%
- C. 42%
- D. 49%
- E. 70%

3. In Pompe’s disease, the liver is damaged due to the accumulation of glycogen. What organelle is most likely malfunctioning?

- A. endoplasmic reticulum
- B. golgi apparatus
- C. lysosome
- D. nucleus
- E. vacuole

4. Transport of which nutrient across the intestinal epithelium is by passive diffusion?

- A. alanine
- B. fructose
- C. glucose
- D. glutamine
- E. all of the above

5. Which two brain centers control mammalian respiration?

- A. medulla oblongata and substantia nigra
- B. medulla oblongata and pons
- C. medulla oblongata and red nucleus
- D. substantia nigra and red nucleus
- E. red nucleus and pons

6. The presence of a vertebral column is with respect to all vertebrates [first term], but is with respect to all chordates [second term].

- A. analogous; homologous
- B. analogous; derived
- C. derived; primitive
- D. homologous; analogous
- E. primitive; derived

7. The *main* explanation for the lack of a continuing abiotic origin of life on Earth today is that:

- A. there are no molten surfaces on which weak solutions of organic molecules could polymerize
- B. all habitable places on earth are already filled to capacity
- C. there is much less visible light reaching Earth now than when life first originated
- D. there is not enough lightening to provide an energy source
- E. our oxidizing atmosphere is not conducive to spontaneous formation of complex molecules

8. Scientists have determined that three classes of genes (named A, B, and C) control development of the four flower parts: Sepals, Petals, Stamen, and Carpels. Genes A and C mutually repress each other. Gene B is not regulated by either Genes A or C. The expression pattern of these genes in wild-type flowers is shown below, where +++ indicates gene activity.

Flower Formation				
	Sepals	Petals	Stamen	Carpels
Gene A	+++	+++		
Gene B		+++	+++	
Gene C			+++	+++

A mutation in Gene C, which prevents its expression, will result in which of the following floral patterns?

- A. Sepals-Petals-Stamen-Carpels
- B. Sepals-Petals-Petals
- C. Sepals-Petals-Petals-Sepals
- D. Sepals-Petals-Petals-Carpels
- E. Sepals-Petals-Stamen

9. An inbred strain of plants has a mean height of 24 cm. A second strain of the same species also has a mean height of 24 cm. When these plants are crossed, the  $F_1$  are also 24 cm. However, when the  $F_1$  plants are crossed, the  $F_2$  plants show a wide range of heights; the majority of  $F_2$  are like  $P_1$  and  $F_1$ , but approximately 4 of 1000 are only 12 cm tall and 4 of 1000 are 36 cm tall. What fraction of the  $F_2$  plants will be 27 cm in height? [Assume that for the genes involved in determining plant height, each allele contributes the same amount.]

- A. 3/4
- B. 9/16
- C. 56/256
- D. none
- E. cannot be determined from the information given

10. To be functional, a linear chromosome most often contains at least:

- A. two telomeres, one centromere, and a large number of origins of replication
- B. one telomere, two centromeres, and a large number of origins of replication
- C. two centromeres and an origin of replication
- D. one centromere and an origin of replication
- E. two telomeres and an origin of replication

11. Which of the following subdivisions of the autonomic nervous system would be most important to a zebra fleeing from a lion?

- A. the sympathetic nervous system
- B. the enteric nervous system
- C. the parasympathetic nervous system
- D. the somatic nervous system
- E. both the parasympathetic and enteric nervous systems

12. To keep their dog breeds "pure," breeders will keep dogs of different breeds in physically separate areas when the female is in heat. This aspect of artificial selection is most closely analogous to which of the following reproductive isolating mechanisms?

- A. mechanical isolation
- B. gametic isolation
- C. cooperative breeding
- D. ecological isolation
- E. hybrid breakdown

13. A man and a woman get married and soon learn that they both have a rare, genetically inherited recessive disease that makes them prone to migraine headaches. Worried about the fate of their children, they seek the advice of a genetic counselor. He sequences their genomes and assures them that none of their children will have the disease. What information did he have to obtain from the sequencing procedure to make this claim?

- A. The man and the woman have mutations in different genes that result in the same migraine headache phenotype.
- B. The migraine headache disease is an autosomal recessive trait.
- C. The man and the woman are related genetically causing the same migraine headache phenotype.
- D. The migraine headache disease is linked to the sex chromosomes.
- E. It is impossible for the man and the woman to have unaffected children - the genetic counselor is wrong.

14. You are trying to isolate glyoxysomes and peroxisomes from a mixture of cellular organelles using differential centrifugation. After a few centrifugation steps, you think you may have a relatively pure suspension. How might you determine that your suspension does indeed include these organelles?

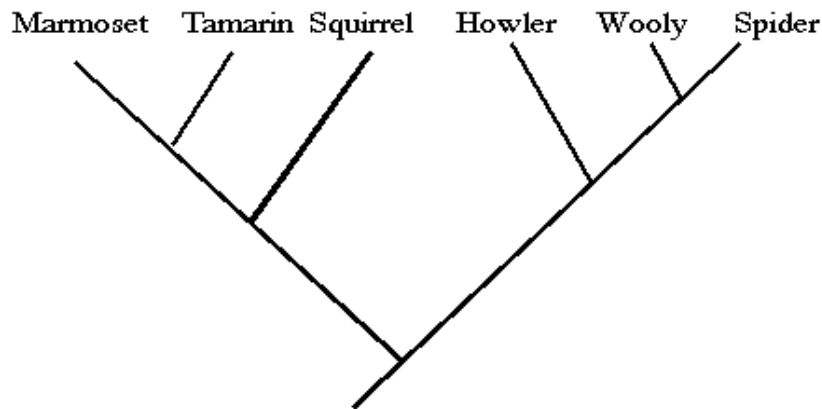
- A. do an assay for the enzyme catalase
- B. do an assay for the enzyme succinate dehydrogenase
- C. do an assay for the presence of nucleic acids
- D. examine microscopically for a double membrane bound organelle
- E. cannot be determined experimentally

15. An animal experiences an acid-base imbalance in the arterial blood that results in acidosis. To increase pH toward normal, which direction would the ventilation rate be changed and what would be the corresponding change in arterial  $P_{CO_2}$ ?

- A. ventilation rate increases, arterial  $P_{CO_2}$  increases
- B. ventilation rate increases, arterial  $P_{CO_2}$  decreases
- C. ventilation rate decreases, arterial  $P_{CO_2}$  increases
- D. ventilation rate decreases, arterial  $P_{CO_2}$  decreases
- E. none of the above

16. Plants, animals and a quantity of air were sealed into a large glass bottle, which is contained in a balanced aquarium. After three months, the plants and animals in the aquarium appear to be alive and healthy. Which of the following statements is invalid?

- A. no energy has entered the bottle from the outside
- B. potential energy in one organism has entered another organism
- C. some atoms from water molecules have become part of organic compounds
- D. the air above the water contains  $CO_2$
- E. during the three months, the average biomass of plant matter was greater than the average biomass of animal matter



17. A valid taxonomic group for this cladogram [above] would include:

- A. Tamarin + Squirrel
- B. Tamarin + Squirrel + Howler
- C. Squirrel + Howler + Woolly
- D. Woolly + Spider
- E. all are valid groups

18. In plant cells grown in the presence of a metabolic poison that specifically inhibits mitochondrial  $F_1ATP$  synthase, one would expect:

- A. the overall pH difference across the cristae to be altered
- B. the electron transport chain to become inoperative
- C. photosynthesis efficiency to be improved
- D. oxygen consumption to cease
- E. water to move out of the mitochondria by osmosis

19. Convergent evolution produces \_\_\_\_\_.

- A. analogous structures
- B. homologous structures
- C. divergent structures
- D. both A and C
- E. both B and C

20. The fluidity of a lipid bilayer is enhanced with:

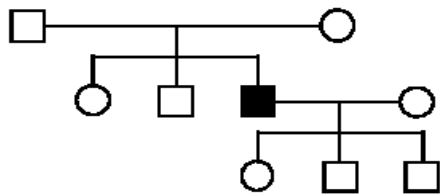
- A. decreased temperature
- B. increased unsaturation in fatty acid tails
- C. increased unsaturation in polar head groups
- D. increased saturation in fatty acid tails
- E. increased fatty acid chain length

21. Elevation of the patient's eosinophil count may reflect infection by which of the following organisms?

- A. HIV
- B. *Salmonella*
- C. *Schistoma*
- D. *Staphylococcus*
- E. *Vibro cholerae*

22. The strongest evidence for the endosymbiotic origin of eukaryotic organelles is the similarity between:
- eukaryotic and prokaryotic ribosomes
  - prokaryotic and eukaryotic flagella
  - prokaryotic and eukaryotic cell walls
  - some prokaryotes and mitochondria
  - some prokaryotes and ribosomes
23. By convincing soldiers that they are part of a "brotherhood," which increases the likelihood that they will protect and die for each other, the military is—consciously or unconsciously—tapping into genes that were adaptive in our ancestors because of:
- individual selection
  - kin selection
  - neoteny
  - inclusive selection
  - heterochrony
24. A red pigment is extracted from a marine alga. Which best supports the hypothesis that the pigment is involved in photosynthesis? The red pigment:
- has an absorption spectrum similar to that of chlorophyll
  - is also found in land plants
  - has a molecular structure similar to that of chlorophyll
  - contains iron which is a transition element similar to magnesium
  - has an absorption spectrum similar to the photosynthetic action spectrum for that same marine alga

25. Given the following pedigree:



What is (are) the possible mode(s) of inheritance?

- Autosomal dominant
- Autosomal recessive
- X-linked dominant
- X-linked recessive

- II only
- I or III only
- II or IV only
- all four modes of inheritance (I, II, III and IV)
- none of the above

26. Color-blindness is a recessive, X-linked trait. A couple, who are both blood type A and who both have normal vision, have a son who is blood type O and colorblind. What is the probability that their next child will be a daughter who is blood type O and has normal vision?
- 1/2
  - 1/4
  - 1/8
  - 1/16
  - zero - not possible

27. A strain of bacteria living in a hospital is found to have a plasmid containing two genes: one for sex pilus construction, and one for tetracycline resistance. If these bacteria were to undergo conjugation with bacteria lacking this plasmid, and thus transferred the plasmid to the other bacteria, the most likely result would be:
- A. a genetically identical clone of bacteria containing the same plasmid
  - B. rapid spread of tetracycline resistance to other bacteria in the hospital
  - C. the subsequent loss of tetracycline resistance in the initially resistant strain
  - D. production of endospores in the bacterial progeny
  - E. temporary diploidy of the conjugating bacteria
28. How do Aspirin and Ibuprofen produce anti-inflammatory effects?
- A. by blocking receptors for histamine
  - B. by binding to and exciting white blood cells
  - C. by inhibiting prostaglandin synthesis
  - D. by triggering granulation
  - E. by triggering chemokine synthesis
29. Group hunting can favorably influence the ability to obtain different food resources and the efficiency of a capture as a result of:
- A. decreased chance of catching prey
  - B. decreased success when competing with other species
  - C. increased chance of capturing larger prey
  - D. increased chance of active defense by prey
  - E. all of the above
30. A fruit with an endocarp composed of sclerenchyma cells, but fleshy mesocarp and exocarp, is called a:
- A. pome
  - B. pepo
  - C. hesperidium
  - D. drupe
  - E. berry
31. Most of today's biological diversity has arisen via:
- A. anagenesis
  - B. hybridization
  - C. cladogenesis
  - D. phyletic evolution
  - E. sympatric speciation
32. Which of the following would act as an "uncoupler" of electron transport and ATP synthesis in the mitochondrion?
- A. dinitrophenol
  - B. urea
  - C. the  $F_0$  base piece of the ATP synthase (without the  $F_1$  subunit)
  - D. all of the above
  - E. A and C only
33. Concentration of urine is essential to the survival of many vertebrates. Which class of vertebrates would you expect does not use this mechanism for homeostasis?
- A. Aves
  - B. Lepidosauria
  - C. Mammalia
  - D. Osteichthyes
  - E. Testudines

- 34. A comparison of the energy expenditures (kcal/kg/day) for a penguin and for a python (assuming they are of equal size) would show that:**
- A. the energy expenditure of the penguin is greater than that for the python
  - B. the energy expenditure of the penguin is less than that for the python
  - C. the energy expenditure of the penguin is equal to that for the python
  - D. the comparison is meaningless because they are not the same type of animal
  - E. the comparison is meaningless because the energy expenditure cannot be calculated
- 35. Which of the following is the least dependable method for determining the adaxial surface of a leaf?**
- A. the relative location of xylem and phloem
  - B. the distribution of stomata
  - C. the relative location of spongy and palisade mesophylls
  - D. the presence of a hypodermis
  - E. the absence of chloroplasts
- 36. What is the probability of obtaining the given genotype in the offspring, AAbbCCdd, from the parents AaBbCcDd x AABbCcDd (assume independent assortment of all gene pairs)?**
- A. 1/64
  - B. 1/128
  - C. 3/128
  - D. 9/256
  - E. none of the above
- 37. Which of the following statements is NOT characteristic of polygyny?**
- A. Females compete for 'status' in communal displays (leks) and males choose among females.
  - B. Polygyny should be more common in patchy environments where there is more variation in territory quality.
  - C. Polygyny can be found in environments with superabundant resources where males are not territorial.
  - D. By mating with a dominant male, females may obtain for their offspring the genes responsible for a male's superior traits.
  - E. None of the above.
- 38. The inner surface of the urethra, the tube through which urine exits the body, is lined with which type of epithelial cells?**
- A. cuboidal cells
  - B. simple squamous epithelia
  - C. simple columnar epithelia
  - D. stratified columnar epithelia
  - E. stratified squamous epithelia
- 39. Which of the following are characteristics of both bacteria and fungi?**
- A. cell wall, unicellularity, and mitochondria
  - B. cell wall, DNA, and plasma membrane
  - C. nucleus, organelles, and unicellularity
  - D. plasma membrane, multicellularity, and Golgi apparatus
  - E. nucleus, RNA, and cell wall
- 40. Net primary productivity, in most ecosystems, is important because it represents the:**
- A. storage of chemical energy that would be available to heterotrophs
  - B. total solar energy converted to chemical energy by producers
  - C. energy used in respiration by heterotrophs
  - D. energy available to producers
  - E. biomass of all producers



41. In general, where are the vessels found in "ring porous wood?"
- A. next to vascular cambium
  - B. in the summer wood
  - C. in the spring wood
  - D. in the periderm
  - E. scattered throughout the growth ring
42. Terminally differentiated cells are most often found in which phase of the cell cycle?
- A. G<sub>0</sub>
  - B. G<sub>1</sub>
  - C. G<sub>2</sub>
  - D. M
  - E. S
43. During the first 6 to 8 weeks of gestation, the principal source of estrogen and progesterone is:
- A. ovarian follicle
  - B. corpus luteum
  - C. placenta
  - D. anterior pituitary
  - E. posterior pituitary
44. There is evidence that anadromous migration – from ocean to headwaters of rivers - by fish such as *Salmo salmon*:
- A. is predominantly based on kinesis
  - B. is predominately based on magnetic fields
  - C. may be based on electroreception in *Anguilla* eels
  - D. probably derives from a trophic adaptation in freshwater fishes
  - E. collates with up-river benthic environments
45. Insulin release results in all of the following physiological effects EXCEPT:
- A. decreased glycogen stores in liver cells
  - B. up-regulation of glucose transporters in liver cells
  - C. increased fat production from glycerol and fatty acids in adipose tissue
  - D. inhibition of glycogen phosphorylase
  - E. activation of glycogen synthase
46. The endosperm of a plant with "monosporic" development has 72 chromosomes. How many chromosomes does the egg cell have?
- A. 24
  - B. 28
  - C. 72
  - D. 98
  - E. 120
47. An allergic reaction is caused by an antigen with this class of immunoglobulin:
- A. IgA
  - B. IgD
  - C. IgE
  - D. IgG
  - E. IgM

- 48. What effect do sexual processes (meiosis and fertilization) have on allele frequencies in a population?**
- A. They reduce the frequency of deleterious alleles.
  - B. They increase the frequency of advantageous alleles.
  - C. They tend to selectively combine favorable alleles into the same zygote without changing overall allele frequencies.
  - D. They tend to increase the frequency of new alleles and decrease the frequency of old ones.
  - E. **They have no direct effect on allele frequencies.**
- 49. A mutation in the gene encoding cyclin D:**
- A. may cause the production of a mutated protein
  - B. may cause the production of a non-mutated protein
  - C. may prevent transcription of the cyclin D gene
  - D. A and B only
  - E. **A, B or C**
- 50. The velocity of carrier-mediated diffusion across cellular membranes:**
- A. **can increase up to a maximum value**
  - B. is always proportional to substrate concentration
  - C. is greater in uniporters than symporters
  - D. does not depend on saturation of the carrier
  - E. varies with substrate concentration in the same way as that observed for simple diffusion