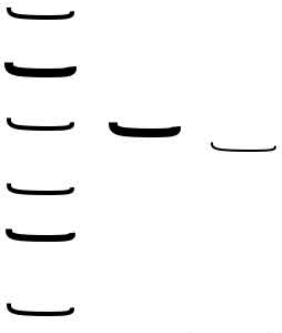
# USABO Open Exam 2021

**1.** A sequencing method to characterize eukaryotic genes of interest in which a hyperactive mutant transposon is added to the cell culture. The transposon cleaves genomic DNA and tags it with sequencing adaptors that allow these fragments to be purified, amplified, and read. Which of the following would be sequenced LEAST effectively with this method?

A. DNA region located near many acetylated histones.
B. DNA region located near many deacetylated histones.
C. Noncoding region of a gene whose transcriptional activity is high.
D. Protein-coding region of a gene whose transcriptional activity is high.
E. Region that experiences a high rate of spontaneous mutation.

**2.** The year is 2381. The Borg Invasion has begun and has recently been shown to be caused by infection of somatic cells causing them to secrete the protein Borgin, which eventually makes its way to the central nervous system. You are interested in the effects of a new drug called Resistance in not Futile (RNF) which has been shown to reduce the production of Borgin. You treat C2C12 (mouse myoblast) Borgin-producing cells with RNF, and perform a Western blot with an anti-Borgin antibody on cellular extracts:




Assuming RNF has a single mechanism of action, which of the following could represent the activity of RNF?

A. RNF binds to Borgin and causes it to be targeted to the proteasome.
B. RNF is a transcriptional inhibitor of the borgin gene.
C. RNF spans the vesicular membrane and targets vesicles to the lysosome if bound to Borgin.
D. RNF binds Borgin in the ER lumen, preventing it from being secreted.
E. RNF forms a complex with Borgin that can embed into the mitochondrial membrane, killing any cells producing Borgin

**3.** You are a scientist from the Centers for Disease Control (CDC). You are testing animals around the site of a recent outbreak of H7N9 avian flu to determine if local animals serve as reservoirs for the pathogen that is causing the epidemic. You run a seroprevalence test using ELISA and a PCR test of tissues collected from the animals. How do the tests differ in the information that they provide

you?

A. The ELISA determines which animal is infected now, but the PCR test determines which animal was infected in the past.
B. The PCR test determines which animal is infected now, but the ELISA determines which animal was infected in the past.
C. The ELISA determines which animals can spread the disease, but the PCR test only determines which animals are infected.
D. The PCR test determines if the animal will die from the disease, but the ELISA test only determines if the animal is infected.
E. Both tests provide the same information.

**4.** You observe no fluorescence on your nitrocellulose membrane completing a Western blot. Which of the following are possible errors that could have produced this result?

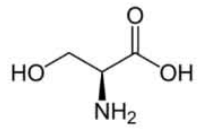
I. Acrylamide concentration of the gel is too high.
II. Failure to add primary antibody.
III. Failure to coat the membrane with nonspecific protein.
IV. Insufficient transfer time between gel and nitrocellulose membrane.

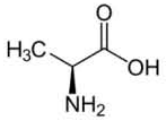
A. I and II.
B. I and III.
C. II and III.
D. II and IV.
E. III and IV.

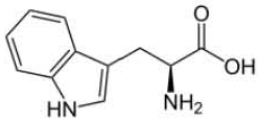
**5.** A microorganism is needed to detect toxins affecting humans. You design a genetic circuit in **E. coli** that dynamically regulates the expression of a reporter protein, green fluorescent protein (GFP), in response to metabolic toxins. You wish for GFP expression to be high in the presence of metabolic toxins and low in the absence of toxins. GFP fluorescent levels are easily visualized in fluorescence microscopy. Which of the following is a valid design consideration for your hypothetical genetic circuit?

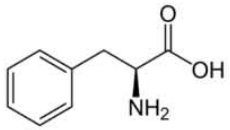
A. An introduced genetic circuit could place the GFP gene under the control of a repressible promoter using co-repressors that bind to metabolic toxins.
B. An introduced genetic circuit should have a constitutive (always active) promoter paired to GFP, which would result in easy visualization due to high GFP expression.
C. Eukaryotic proteins like GFP (which was isolated from a jellyfish) cannot be expressed in prokaryotic cells because they lack a rough ER.
D. GFP expression is dependent on cellular energy state, so a metabolic toxin could have a false-negative result with your engineered organism.
E. Since E. coli is a Gram-negative bacterium, it will not efficiently take up foreign genetic material from the environment, so the genetic circuit will not be integrated and GFP will not be expressed in appreciable amounts

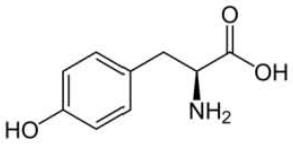
**6.** Which of the following amino acids is most likely to be found within, NOT on the surface of, a soluble protein?

A. 


B. 


C. 


D. 


E. 


**7.** A DNA segment is treated with restriction enzymes, pipetted into a well of polyacrylamide gel, and subjected to an electric field. Next, the gel is stained with ethidium bromide and visualized under ultraviolet light. What laboratory technique does this describe?

A. Enzyme-linked immunosorbent assay.
B. Gel electrophoresis..
C. Northern blot.
D. Polymerase chain reaction.
E. Southern blot.

**8.** Propose an explanation for the cause of hyperchromicity, a phenomenon where denatured DNA tends to absorb 30-40% more 260 nm UV radiation than double-stranded DNA.

A. The 3′ and 5′ -OH groups force nucleotides into a new conformation with increased conjugation, increasing absorption of 260 nm UV light.
B. Denatured DNA only exists in the laboratory setting, where there is increased UV light for C. absorption.
C. Decreased base-stacking interactions increase the average conjugation for each nucleotide, leading to more UV light absorption.
D. Association of double-stranded nuclear DNA with proteins and extrachromosomal material reduces 260 nm UV light absorption.
E. Denatured DNA binds to RNA, which absorbs UV light exceptionally well at 260 nm.

**9.** In the electron transport chain, the degree of reduction of each carrier is determined by internal mitochondrial conditions. The cultured cells are subjected to various conditions and predicts the state of oxidation of cytochrome **c** compared to the normal resting state. Cytochrome **c** transfers electrons from Complex III to Complex IV in the electron transport chain. Which of the following predictions are consistent with the structure of the electron transport chain?

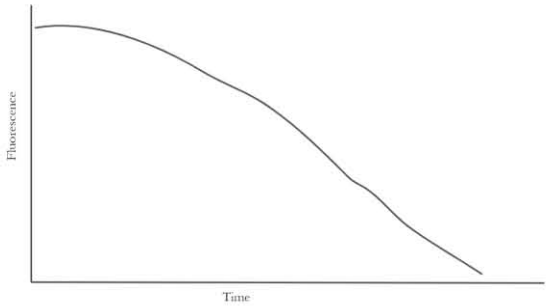
I. When the cells are subjected to the addition of potassium cyanide (a Complex IV inhibitor), cytochrome **c** will become more oxidized.
II. When the cells are subjected to increased $O_2$ levels and decreased NADH levels, cytochrome **c** will become more oxidized.

III. When the cells are subjected to the addition of oligomycin (an ATP synthase inhibitor), cytochrome **c** will become more oxidized.

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

**10.** Mouse white blood cells were allowed to equilibrate to an extracellular solution with an osmolarity of 300 mOsm/L. The cells are then moved to an extracellular solution with osmolarity 600 mOsm/L and allowed to equilibrate to the new environment. What is closest to the ratio of the final cell volume to the original cell volume? Assume that the membrane is impermeable to solutes.
A. 4. B. 2. C. 1. D. 0.5. E. 0.25.

**11.** An experiment is devised to treat a plant undergoing active secondary growth with a fluorescent tag. The fluorescent tag is incorporated into all the newly produced cells. The plant is treated with the fluorescent tag for a week and the treatment is stopped (no more fluorescence is incorporated after this point). Over the next month, the fluorescence is measured in one specific layer of the plant. The graph of the observed fluorescence is shown below. Which of the following layers were most likely monitored for fluorescence?




A. Pith.
B. Primary xylem.
C. Secondary xylem.
D. Primary phloem.
E. Secondary Phloem

**12.** Phenylurea is an herbicide used on corn fields to injure and kill dicot weeds after the seeds germinate. This herbicide functions by irreversibly binding to the D1 quinone-binding protein of photosystem II (PSII) and inhibiting the movement of electrons to plastoquinone, thereby shutting off the linear photosynthesis pathway. How will the pH of the stroma and the thylakoid space change immediately after a leaf cell takes up phenylurea?

A. The stromal pH and the pH of the thylakoid space will both increase.
B. The stromal pH and the pH of the thylakoid space will both decrease.

C. The stromal pH will increase, and the pH of the thylakoid space will decrease.
D. The stromal pH will decrease, and the pH of the thylakoid space will increase.
E. The stromal pH will remain unchanged, and the pH of the thylakoid space will decrease.

**13.** You are experimenting with a type of **Fabaceae**, which normally have complete flowers. You wish to create a strain of "super-breeder" flowers that only express a combination of stamens and carpels across all whorls, with no petals or sepals. Based on your knowledge of the ABC hypothesis, which of the following changes would produce a "super-breeder"?

I. Deletion of gene A in parts of the flower that normally express gene B.
II. Overexpression of A gene throughout the entire flower.
III. In a mutant flower with the phenotype "sepal, petal, petal, sepal" (outer whorl to inner whorl), replacement of all gene A expression with gene C expression.

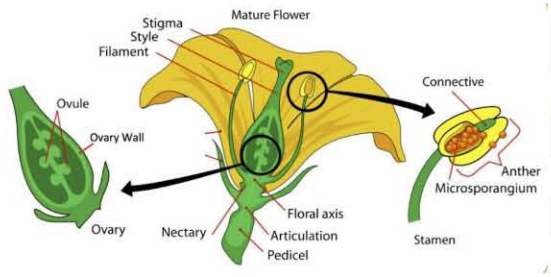
A. I only.
B. III only.
C. I and III.
D. II and III.
E. None of these

**14.** Which of the following plants are most likely to flower?

I. A short-day plant that receives a 660-nm light flash in the middle of its dark period.
II. A short-day plant that receives a 750-nm light flash in the middle of its dark period.
III. A long-day plant that receives a 660-nm light flash in the middle of its dark period.
IV. A long-day plant that receives a 750-nm light flash in the middle of its dark period.

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

**15.** Your favorite fruit are bell peppers (yes - bell peppers are fruits), and you are interested in learning more about them. You obtain the diagrams of the bell pepper flower and fruit shown below. Which of the following best describes the bell pepper flower?






A. Epigynous with free-central placentation.
B. Hypogynous with axile placentation.

C. Perigynous with parietal placentation.
D. Hypogynous with parietal placentation.
E. Epigynous with axile placentation.

**16.** Your good friend Dr. Zhang needs your help in identifying the characteristics of a particular plant and provides you with the following images, both from the same specimen:

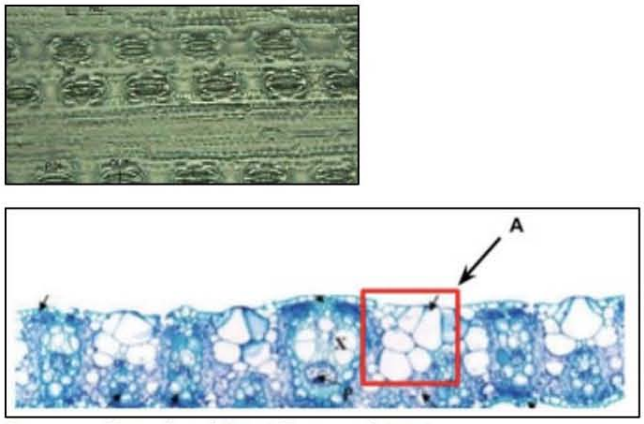



*Image sources: Figueiredo et al. (2015), Ferreira et al. (2007)*

Using the images above, identify which of the following statements are TRUE.

I. The plant is a $C_4$ plant.
II. The plant is a monocot.
III. The structures labeled A are thin-walled parenchyma cells and will lose turgidity in response to decreased water potential outside the cell.
IV. This plant has a thick cuticle and is well adapted for arid climates.

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

**17.** Which of the following intracellular changes in stomatal guard cells is NOT expected following production of abscisic acid in the roots?

A. Increase in cytosolic $Ca^{2+}$ concentrations.
B. Increase in cell water potential.
C. Loss of turgidity and subsequent plasmolysis.
D. Uptake of $K^+$ ions.
E. Raise in cellular pH.

**18.** Equal amounts of xylem, phloem, parenchyma, sclerenchyma, and collenchyma from a plant in your house. You forget to label your samples and want to confirm which tissue is which. You evaluate different relative characteristics of the tissues and obtain the results below. What is the identity of tissue III?

| Tissue | Pressure | Water Potential | Monosaccharides/ Disaccharides | Starch Content | $O_2$ Production |
|---|---|---|---|---|---|
| I | Positive | Negative | Moderate | High | High |
| II | Positive | Negative | High | Low | Minimal |
| III | Positive | Negative | Moderate | Low | Moderate |
| III | Negative | Negative | Low | Low | None |
| V | Zero | Zero | None | Low | None |

A. Collenchyma.
B. Parenchyma.
C. Phloem.
D. Sclerenchyma.
E. Xylem.

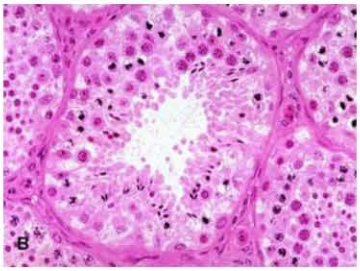
**19.** You are a clinician whose patient has two copies of the Glu to Val mutation responsible for sickle cell disease. However, your patient also has a deletion in a regulatory region which causes fetal hemoglobin expression to persist into adulthood. When examining the patient's oxygen-hemoglobin dissociation curve and clinical symptoms, which of the following is TRUE?

A. Left-shifted curve, reduced symptoms.
B. Left-shifted curve, increased symptoms.
C. Right-shifted curve; reduced symptoms.
D. Right-shifted curve; increased symptoms.
E. Right-shifted curve; typical symptoms.

**20.** With Dr. Bailey on leave, an intern oversees managing the ER at Seattle Grace Hospital. One night, a motor vehicle collision patient comes in. The patient has massive hemorrhaging. Which of the following changes in physiological parameters would you NOT expect to see?

A. Increased heart rate.
B. Increase in systemic arteriolar vasoconstriction.
C. Decreased renin secretion.
D. Decreased gut motility.
E. Decreased glomerular filtration rate.

**21.** As you are cleaning up the pathology lab, you discover an unlabeled human tissue specimen. To satisfy your curiosity, you stain it, and obtain the image shown below:



Which of the following is the most likely function of the tissue sample you obtained?

A. Maintaining the capillary oncotic pressure.
B. Production of haploid cells.
C. Excretion of nitrogenous wastes.
D. Storage of emergency blood reserves.
E. Maintaining blood oxygenation.

**22.** The transport maximum for glucose in the kidneys is 375 mg/min. If the plasma concentration of glucose is 300 mg/100 mL, the glomerular filtration rate is 140 mL/min, and the urine output is 1.8 L per day, what is the concentration of glucose in the urine?

A. 0 mg/mL.
B. Between 0 mg/mL and 15 mg/mL.
C. Between 15 mg/mL and 30 mg/mL.
D. Between 30 mg/mL and 45 mg/mL.
E. Greater than 45 mg/mL.

**23.** A patient suffers from primary adrenal insufficiency. In this condition, the adrenal gland fails to produce adequate amounts of cortisol. Tests were to be run but were forgotten. With 10 minutes left for rounds, her hormone levels, and her ability to respond to stress are noted. Which of the following statements is TRUE?

A. Elevated ACTH, Reduced CRH, can tolerate lower amounts of stress than normal.
B. Elevated ACTH, Elevated CRH, can tolerate higher amounts of stress than normal.
C. Elevated ACTH, Elevated CRH, can tolerate lower amounts of stress than normal.
D. Reduced ACTH, Elevated CRH, can tolerate lower amounts of stress than normal.
E. Reduced ACTH, Elevated CRH, can tolerate higher amounts of stress than normal.

**24.** Counterpart cells are mature B lymphocytes that have already undergone immunoglobulin gene rearrangement. Diagnosis of Chronic Lymphocytic Leukemia (CLL) relies on using fluorescently conjugated antibodies to measure expression of surface proteins, which include the following:

- -Normal B-cell surface antigens such as CD19, CD20, CD22.
- -An antigen normally expressed on T lymphocytes (CD5).
- -Immunoglobulin light chain (kappa or lambda).

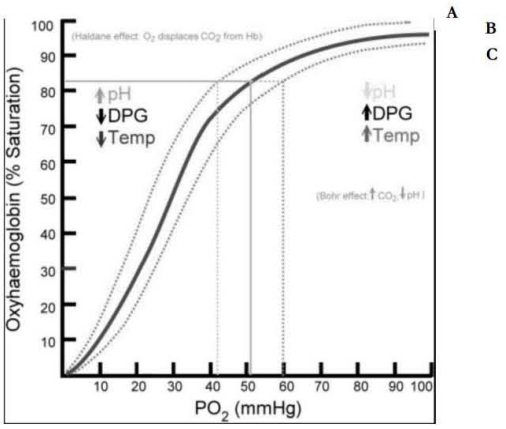
Which of the following is MOST TRUE based on general immunologic and neoplastic principles?

A. Since CLL is a clonal malignancy, it will lack all normal lymphocyte antigens (B cell or T cell), and express neither kappa nor lambda light chains on its membranes.
B. Since CLL derives from B-cells, the CLL population will exhibit a mixture of kappa light chain and lambda light chain specificities and cannot express the T-cell marker CD5.
C. Since CLL is a clonal malignancy derived from the B lymphocytes of a patient's immune system, it produces immunoglobulins of its own and cannot be assessed with an assay that utilizes artificial antibodies (false positive artifact).
D. Since CLL is a clonal malignancy, it may co-express B-cell antigens (CD19, CD20, CD22)

along with proteins not normally expressed in B-cells (CD5) and will be limited to either kappa or lambda light chain expression.

E. Since CLL is a clonal malignancy, observation of surface proteins is not a sufficient tool for diagnosis without correlation with DNA sequencing of genes involved in normal B-cell function

**25.** The following curve represents the affinity of human hemoglobin for oxygen. Refer to the curve as needed when answering the following four questions about a hospitalized patient in septic shock. The monitor shows the following vitals: heart rate 112, oxygen saturation 82%, blood pressure 88/54 mmHg, temperature 38.6 degrees Celsius (101.5 °F).




The patient's organs are not receiving adequate oxygen to perform aerobic cellular respiration, and lactate production rises. What cellular process is resulting in lactate production?

A. Glycolysis.
B. Oxidative phosphorylation.
C. Krebs cycle.
D. Lipolysis.
E. Pentose Phosphate Pathway.

**26.** The patient has a pulse oximeter (measures oxygen saturation level) on, and the monitor shows an oxygen saturation of 82%. You ask the nurse to draw an arterial blood gas sample. What would the approximate partial pressure of oxygen be?

A. 90mmHg.
B. 80mmHg.
C. 70mmHg.
D. 60mmHg.
E. 50mmHg.

**27.** Which of the following statements are TRUE regarding the process of meiosis?

I. Segregation of unlinked alleles occurs during meiosis.
II. Kinetochores are responsible for aligning chromatids during meiosis I.

III. At the end of meiosis, the amount of chromosome in each daughter cell is half of the parental cell.

IV. At the end of meiosis, the amount of DNA in each daughter cell is half of the parental cell

A. I, III

B. II, III.

C. I, II, III.

D. II, III, IV.

E. I, II, III, IV.

**28.** Which of the following is NOT an example of an interaction that happens in the immune response to a virus?

A. Dendritic cells congregate at lymph nodes and present viral antigens to lymphocytes, triggering the adaptive immune response.

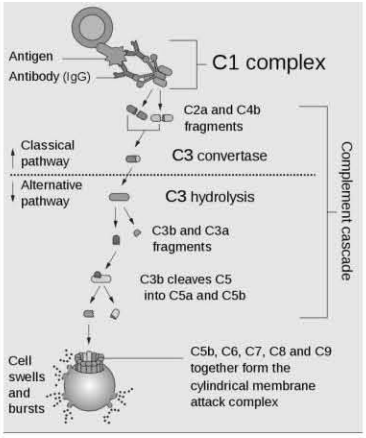
B. Natural killer cells trigger apoptosis in infected cells as part of the rapidly acting innate immune response.

C. B lymphocytes proliferate and secrete IgM and IgG antibodies that target viral particles.

D. T lymphocytes identify cells with abnormal antigens displayed in their MHC II surface proteins and trigger lysis in these cells.

E. Infected cells secrete signaling molecules that cause nearby cells to increase their defenses against viral infection.

**29.** The complement system provides innate immunity through serum proteins binding to and lysing pathogens by the pathway shown below. To improve efficiency and reduce hypersensitivity, the complement system has evolved multiple safeguards. Which of the following is not an adaptation of the complement system?



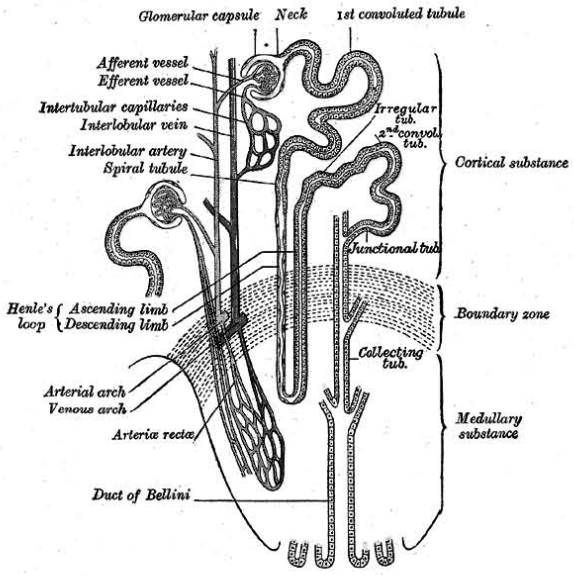

A. Having multiple parts in the membrane attack complex to lyse the cell increases enzyme stability, increasing its activity and effectiveness.

B. Unbound complement proteins are bound to other regulatory proteins to prevent premature activation.

C. Glycolipid-associated enzymes on the membrane of the host cell decays parts of the complement system for self/non-self-discrimination.

D. Multiple functions of the C3 and C4 proteins conserve resources and improve the efficiency of the complement system.
E. C1q of the C1qrs complex remains bound to the immune complex to lower reaction time for phagocytosis.

**30.** A thin 25-year-old woman presents to her primary care physician stating that her blood pressure was high at 178/114 mmHg when she measured it on a machine at her pharmacy. She is also found to have decreased potassium levels, sodium and water retention, increased aldosterone levels, and decreased plasma renin levels. The diagram below shows the renal nephron.




Which of the following is the most likely diagnosis?
A. Ingestion of loop diuretics, which inhibit sodium reabsorption in the loop of Henle.
B. Ingestion of thiazide diuretics, which inhibit sodium reabsorption in the distal tubule.
C. Defective transport of sodium chloride in the loop of Henle (Bartter syndrome).
D. Defective transport of sodium chloride in the distal tubule (Gitelman syndrome).
E. Primary hyperaldosteronism, which increases active transport of sodium in the distal tubule.

**31.** In a particular bird species, all individuals attempt to breed independently at the beginning of each breeding season. However, some individuals fail to breed and end up becoming "helpers" for other breeders by helping them raise their offspring. You hypothesize that this "helper" behavior evolved due to kin selection. All the following observations would support your hypothesis EXCEPT:
A. This bird species exhibits a monogamous system of mating.
B. Offspring survival rate for a given nest increases as the number of helpers raising the chicks in that nest increases.
C. Birds can distinguish between the calls of its relatives and those of other individuals.
D. Female birds who become helpers gain the ability to lay some of their own eggs in the nest at which they are helping.

E. Birds who fail to breed and become helpers in their first breeding season are likely to remain as helpers for the rest of their lifespan without ever successfully breeding

**32.** A marine biologist conducted a series of time-lapsed photographs that recorded the schooling behavior of the fish **Pagrus major**. Food was added to water at two different locations via a time released mechanism. The data is shown graphically below.

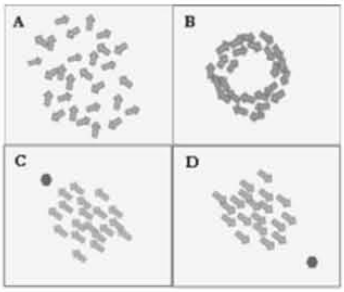



*Image source: Cousin et al.*

**Graphs A and B**: Fish behavior before the stimuli was added. **Graphs C and D**: After the food was added at two different locations (shown in dark grey hexagons) of the test area.

Which of the following behaviors is demonstrated here?

A. Short-term habituation.
B. Collective cognition.
C. Operant conditioning.
D. Phenotypic plasticity.
E. Redirected behavior.

**33.** Lakshay is observing his herd of **A. alces** and notes that they appear optimal in their foraging. To test this, he creates a habitat with two foods of different distributions. FOOD1 is abundant, but only nets an individual 100 calories and takes 30 minutes to eat (during which the organism cannot move). FOOD2 is far less abundant, but nets 1,000 calories and takes 180 minutes to eat. The search time for FOOD2 is 80 minutes 80% of the time, and 150 minutes the other 20% of the time. An **A. alces** individual encounters FOOD1. To maximize its overall rate of energy gain, should it eat FOOD1 or leave to search for FOOD2, and why?

A. Leave. The profitability of FOOD2 is greater than FOOD1 even in the worst-case search time.
B. Leave. The profitability of FOOD2 at the expected search time is greater than FOOD1, even though the profitability of FOOD2 in the worst-case search time is less.
C. Eat FOOD1. The profitability of FOOD2 in the worst-case search time is less than the profitability of FOOD1.
D. Eat FOOD1. The profitability of FOOD2 at the expected search time is less than FOOD1, even though the profitability of FOOD2 in the best-case search time is greater.
E. Eat FOOD1. The profitability of FOOD2 is less than FOOD1 even in the best-case search time.

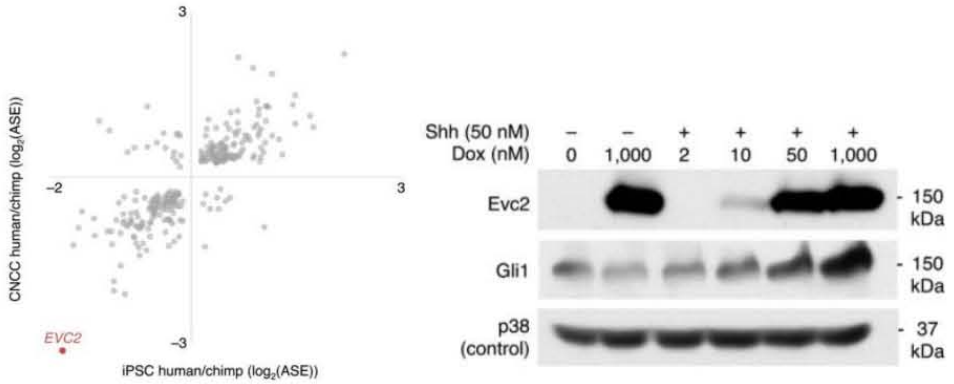
**34.** Professor Bonzu studies sky bison, which are very attentive to the high-pitched sound of a bison

whistle. Seeking to better understand the inheritance of the whistle-attentive gene, denoted by "**W/w**", he crosses a true-breeding whistle-attentive male with a true-breeding non-whistle-attentive female. All offspring of this cross are whistle attentive. Then, Professor Bonzu crosses two $F_1$ bison to produce 1600 $F_2$ offspring. In this $F_2$ generation, there are 1300 whistle-attentive bison and 300 non-whistle-attentive bison. Which of the following mechanisms reasonably explains Professor Bonzu's results?

A. There is a dominant activator gene (A/a) in addition to the W gene that can reverse the recessive phenotype at W. The parental generation male shows the genotype AA, while the parental generation female shows the genotype aa.
B. There is a recessive suppressor gene (S/s) in addition to the W gene that can reverse the recessive phenotype at W. The parental generation male shows the genotype ss, while the parental generation female shows the genotype SS.
C. The parental generation male shows a normal upstream enhancer sequence for the whistle response gene, but the parental generation female has a loss-of-function mutation in the enhancer sequence. Assume that the enhancer sequence is passed down in a simple Mendelianlike manner in this case.
D. The W locus is affected by another gene product (D/d) that acts as a dominant negative mutation. The parental generation male shows the genotype dd, while the parental generation female shows the genotype DD.
E. The w allele is approximately 15% penetrant into the whistle response phenotype.

**35.** You are studying the morphological differences between humans and chimpanzees and attempting to understand the genetic basis of these differences. Most notably, you believe that several anatomical differences between the two species can be explained by divergent gene regulation in developmental pathways. To test your hypothesis, you decide to create human–chimpanzee tetraploid hybrid induced pluripotent stem cells (iPSC) and cranial neural crest cells (CNCCs) from the NIH/3T3 cell line. Note that exposing NIH/3T3 cells to doxycycline (Dox) induces the expression of Evc2. Upon verifying that the tetraploid cells express a full set of human and chimpanzee chromosomes, you plot the chimpanzee-to-human allele specific expression (ASE) ratio in hybrid iPSCs and CNCCs for all skeleton-related genes that are differentially expressed in both cell types (Figure 1). Additionally, you measure Gli1, a product of a signaling pathway involved in differentiation of embryonic cells induced by Shh, across different levels of Shh and Dox (Figure 2).

I. In hybrid cells, alleles from different species may be subject to differential environmental pressures.
II. Any allele-specific expression is due to **trans**-regulatory or epigenetic differences between species in hybrid cells.
III. **EVC2** is the most down-regulated skeleton-related gene in humans compared with chimpanzees.
IV. Evc2 expression promotes the induction of Gli1 expression by Shh.
V. Gli1 exerts feedback inhibition on Evc2 expression at low levels of Dox.




Choose ALL the above statements that are TRUE.

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

**36.** Two haploid yeast cells are us. One can grow on a medium without leucine and is resistant to amphotericin. The other cell needs leucine supplemented medium for growth and is sensitive to amphotericin. These two yeast cells are mated to produce diploids, which then sporulate to form a tetrad. Four types of tetrads (all the cells of the tetrads have the same phenotype) are seen:

| Need Leucine to grow? | Amphotericin resistant? | Number of tetrads |
|---|---|---|
| Yes | Yes | 25 |
| Yes | No | 27 |
| No | Yes | 26 |
| No | No | 28 |

What can be concluded about the genes coding for leucine synthesis and amphotericin sensitivity in yeast (assume amphotericin resistance is encoded by the chromosomal DNA, not the plasmid DNA)?

A. The genes have a distance 25cM between them and are on the same chromosome.
B. The genes have a distance 12.5 cM between them and are on the same chromosome.
C. The genes are unlinked from their centromeres and are on separate chromosomes.
D. The gene for leucine synthesis is tightly linked to the centromere and is on a different chromosome than the gene for amphotericin resistance.
E. The genes are tightly linked to their centromeres and are on separate chromosomes.

**37.** A plasmid carries genes for streptomycin (StrR), ampicillin resistance (AmpR), and erythromycin resistance (EryR). The AmpR gene is cut with restriction enzymes, and donor DNA treated with the same enzymes is added. Which genotype needs to be selected to show evidence of transformation? (R = resistant, S = susceptible)

A. StrR AmpR EryR.
B. StrR AmpR EryS.
C. StrR AmpS EryR.

D. StrS AmpS EryS.
E. StrS AmpR EryS.

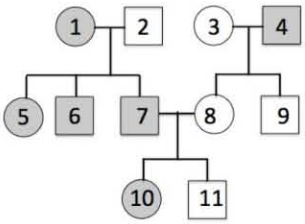
**38.** Which of the following examples is paired INCORRECTLY with its type of selection?
A. Directional selection: The tusk length of elephants in response to poaching.
B. Stabilizing selection: The clutch size of birds.
C. Disruptive selection: The fur color of mice in response to a volcanic eruption that wipes out most of the population.
D. Frequency-dependent selection: The aposematic coloring of poison dart frogs.
E. Heterozygote advantage: One copy of the cystic fibrosis allele decreases susceptibility to tuberculosis infection.

**39.** Genes A, B, C, and D are linked on the same chromosome. Genes A and B have a recombination frequency of 5%, genes A and D have a recombination frequency of 11%, genes B and C have a recombination frequency of 17%, and genes C and D have a recombination frequency of 23%. Which of the following is the most likely order of these genes on the chromosome?
A. ABCD.
B. ACBD.
C. BCAD.
D. CABD.
E. CBAD.

**40.** Which of the following mechanisms leads to gene duplication and gene evolution over time in diploid organisms such as humans?
A. Epigenetic chromosomal changes in germline cells.
B. Epigenetic chromosomal changes in somatic cells.
C. Telomere shortening of chromosomes in somatic cells.
D. Translocation between nonhomologous chromosomes in somatic cells.
E. Unequal crossing over of misaligned chromosomes in germline cells.

**41.** Lesch-Nyhan syndrome is a recessive X-linked disorder. People with Lesch-Nyhan syndrome exhibit high uric acid levels and neurological symptoms like chewing their fingers and lips. A woman whose parents are healthy and whose brother has Lesch-Nyhan syndrome marries a normal man. What is the probability that her first child will have Lesch-Nyhan syndrome?
A. 0% B. 6.25% C. 12.5% D. 25% E. 50%

**42.** Your Biology teacher gives you the following pedigree. She asks you to make one change to the pedigree so that it shows the mitochondrial mode of inheritance. Which individual would you change?




A. Make Individual 3 affected.
B. Make Individual 7 unaffected.
C. Make Individual 8 affected.
D. Make Individual 10 unaffected.
E. Make Individual 11 affected.

**43.** A wild population of mice exhibits three coat colors: black, gray, and brown. Coat color is controlled by a single locus, where the black allele is dominant to the gray allele and the gray allele is dominant to the brown allele. The population of mice is in Hardy-Weinberg equilibrium for coat color and contains 510 black mice, 240 gray mice, and 250 brown mice. Which of the following lists the three alleles in increasing order of frequency?

A. Black < gray < brown.
B. Black < brown < gray.
C. Gray < black < brown.
D. Gray < brown < black.
E. Brown < gray < black.

**44.** You obtain a water sample from Yellowstone's Grand Prismatic Spring, streak a portion of the sample onto nutrient agar, and incubate the dish at 55°C for 36 hours with a standard atmospheric composition of gases. Green and gray colonies appear on the agar at the end of the incubation period. Which of the following descriptions is MOST accurate for these colonies?

A. Thermophilic and aerobic.
B. Mesophilic and aerobic.
C. Cryophilic and aerobic.
D. Thermophilic and anaerobic.
E. Mesophilic and anaerobic.

**45.** Farmer John has been using inorganic fertilizer containing nitrogen and phosphorus to grow his crops. Recently, a massive rainstorm caused large amounts of fertilizer from his farm to enter a local freshwater ecosystem via runoff. One month later, which of the following values would you expect to have increased in the freshwater ecosystem?

I. The dissolved oxygen levels of the freshwater ecosystem.
II. The turbidity of the freshwater ecosystem.
III. The biodiversity of the freshwater ecosystem.
IV. The net primary productivity of the freshwater ecosystem.

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

**46.** Crop damage caused by ants in Hungary has been recorded since the 19th century. As a researcher, you collect 100 ants from a nest near a maize crop, mark them, and release them. Your assumptions are none die, none are born, and they mix randomly in the nest. The next day you observe the first 500 that emerge from the nest. Only 8 are marked. You estimate the size of the ant colony but suspect the markers you used may have killed the ants. Which of the following is your BEST estimate of the population?

A. 512.5 ants but realize it is an underestimate (there are more).
B. 608 ants but realize that it is an underestimate (there are more).
C. 608 ants and that is the best estimate possible.
D. 6250 ants but realize it is an overestimate (there are fewer).
E. 6250 ants but realize that it is an underestimate (there are more).

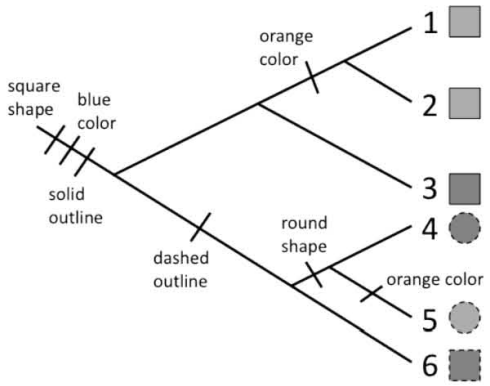
**47.** Which of the following is LEAST likely to be true of a pioneer species in an area devastated by a volcanic eruption?

A. Semelparous.
B. r-selected.
C. Type I survivorship curve.
D. Low soil nutrient requirements.
E. Population is controlled primarily by density-independent factors.

**48.** With respect to ecological succession, which statement below is LEAST likely valid?

A. During succession, the species community composition changes continuously.
B. The total number of species increases initially and then stabilizes.
C. After the initial stages, the total ecosystem biomass decreases.
D. Total amount of nonliving matter increases in the ecosystem.
E. The amount of new organic matter synthesized remains about the same initially, while the percentage used by the various trophic levels rises

Questions49 and 50: Use the following figure.



**49.** Based on the species and phylogeny shown, which of the following species has a complete set of ancestral character states for shape, color, and outline?

A. Species 1 and 2.
B. Species 3.
C. Species 4.
D. Species 5.
E. Species 6.

**50.** Based on the species and phylogeny shown, which of the following character states shows a pattern of convergent evolution?

A. Blue color.
B. Dashed outline.
C. Orange color.
D. Solid outline.
E. Round shape.