

Human Biology and Scientific Method Sample Questions

1. A scientist is evaluating a proposal for raising large numbers of fish in oceans pens for human consumption. As part of the evaluation, the scientist is designing a plan for investigating how the fish in the ocean pens might affect nearby ecosystems. Which of the following is the most appropriate factor to use as the dependent variable in the experimental investigation?

- The amount of metabolic waste in the water where the fish are being raised.
- The water temperature in the natural habitat of the fish being studied.
- The types of fish that are preferentially consumed by humans.
- The amount of time it takes for fish to digest a meal.

2. Epinephrine is a protein hormone found in many animals. Epinephrine stimulates a signaling pathway that results in the breakdown of glycogen to glucose in the liver cells. Which of the following describes the initial steps in the process whereby epinephrine stimulates glycogen breakdown.

- Epinephrine binds to a cell-surface receptor; the activated receptor stimulates production of a second messenger, cAMP.
- Epinephrine binds to a cell-surface receptor; the activates receptor catalyzes the conversion of glycogen to glucose.
- Epinephrine diffuses through the plasma membrane; the hormone dimerizes in the cytosol.
- Epinephrine is taken into the cell by endocytosis; glycogen is converted to glucose in the endocytotic vesicle.

3. A group of students designed an experiment to determine the effect of compost on the germination and growth of plants. The students set up experimental plots by mixing different ratios of soil and compost. They planted 20 pea and 20 melon seeds in each plot and watered each plot regularly. The students recorded the number of seeds that germinated, and as the plants grew they recorded the plant length, number and size of leaves, and general health observations.

The following observations were recorded.

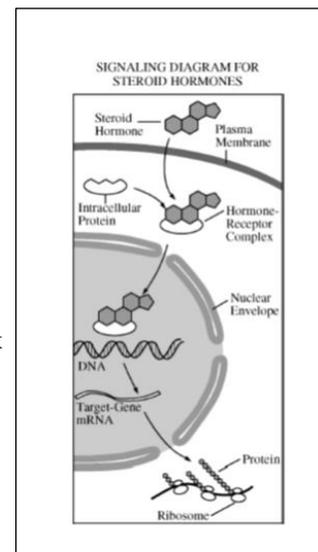
- In all treatments, more pea seeds germinated than melon seeds
- There was a week of rainy weather at 3 weeks
- Melon plants developed a fungal growth at four weeks
- Melon plants grew longer than pea plants, but many melon leaves showed signs of yellowing as the weeks passed

The students concluded that pea plants grew better in compost than did melon plants. Which of the following best addresses the validity of the conclusion made by the students?

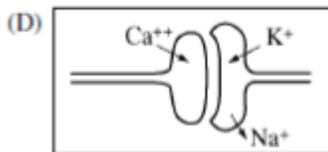
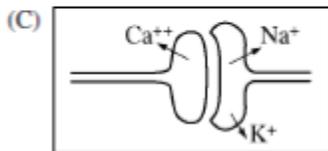
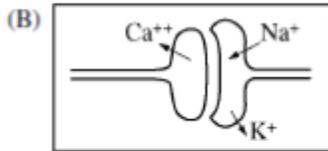
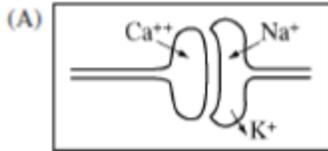
- The conclusion is valid because the independent and dependent variables in the experiment were controlled.
- The conclusion is valid because the experimental design included a large sample size.
- The conclusion is invalid because other variables in the experiment affected the results.
- The conclusion is invalid because the units of measurement were not given in the experimental design.

4. Steroid hormones, such as testosterone, pass through the plasma membrane and bind to an intracellular protein, as shown in the diagram. The hormone receptor complex then enters the nucleus, where it interacts with DNA to promote transcription of a specific gene. Based on the information presented, which of the following will also occur in response to steroid signaling?

- Histone protein synthesis will increase because histones maintain the DNA in optimal conformation for chromosome assembly.
- Ribosome production will increase because ribosomes are specific to mRNA with which they bind during translation.
- DNA replication will increase as a result of the binding of the hormone-receptor complex of the DNA.
- Production of a specific mRNA will increase as a result of the binding of the hormone-receptor complex to the DNA.



5. Transmission of an action potential across a synapse involves the release of neurotransmitters by the presynaptic neuron. The arrival of the action potential triggers a rise in the calcium concentration in the synaptic terminal, and the change in concentration triggers a release of neurotransmitters into the synaptic cleft. Which of the following representations of the movement of calcium, sodium and potassium ions best shows how an action potential is transmitted to the postsynaptic neuron?



Section II: 8 questions (90 minutes)

Questions 1 and 2 are long free response questions that require about 22 minutes each to answer and are worth 10 points each. Questions 3 – 8 are short free response questions that require about 6 minutes each to answer. Questions 3 – 5 are worth 4 points and questions 6-8 are worth 3 points each.

1. In an investigation of the effect of a particular insecticide on plant growth and development, researchers established 20 test plots containing mature *Haplopappus squarrosus* shrubs. *H. squarrosus* is pollinated by certain species of insects and is eaten by other species of insects. Ten test plots were sprayed with the water-soluble insecticide, and ten test plots were sprayed with water only. The researchers recorded the numbers of plants or plant parts at different life stages in each test plot. The results of the investigation are shown in the table.

EFFECT OF INSECTICIDE TREATMENT ON PLANT GROWTH AND DEVELOPMENT

Plant Life Stage	Plant or Plant Part	Treatment		P-values*
		Water Spray	Insecticide Spray	
		Mean Density $\pm 2SE_T$ (numbers/m ²)		
Flowering	Flowers	8,220 \pm 360	9,490 \pm 1900	≥ 0.05
Seed formation	Immature seeds	2,440 \pm 78	3,100 \pm 480	≥ 0.05
Seed maturation	Mature seeds	60 \pm 44	1,200 \pm 1020	≤ 0.001
Seedling development	Seedlings	1.4 \pm 0.4	33.1 \pm 15	≤ 0.01

*based on an analysis of variance (ANOVA) test

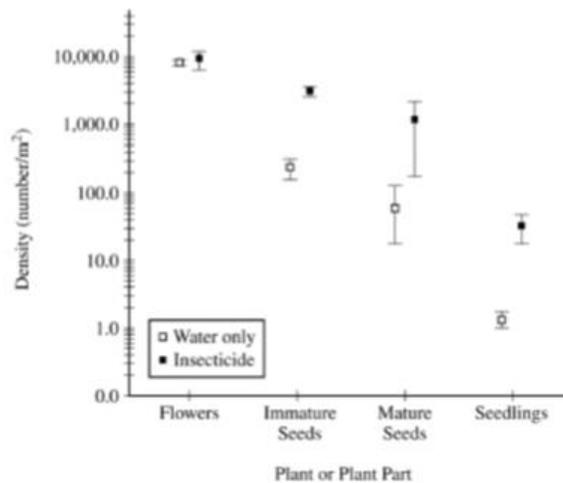


Figure 1. Student-constructed graph of data with a plotting error

- Identify the control treatment in the original experiment. Provide reasoning to support the researcher's decision to not use a set of unsprayed plants as a control.
- A student incorrectly plotted one value from the table on a graph (Figure 1). Identify the error in the student-constructed graph. Provide reasoning to support the student's choice of a logarithmic scale on the Y axis.
- Using the template provided, calculate the percent of plants or plant parts remaining from one life stage to the next life stage. Round your answer to one decimal place. Based on your calculations, identify the plant stage of life at which insects have the greatest impact on the life cycle of the plant. Justify your answer. Describe the most likely interaction between the insects and the plants.
- in a second experiment, researchers used a different insecticide that affects a different group of insects. In this treatment, the number of seeds formed was greatly reduced compared to the control. Based on this observation, describe the most likely interaction between the affected insects and the plants in this experiment. Justify your response.

Plant Life Stage	Water Spray	Percent Remaining	Insecticide Spray	Percent Remaining
Flowering	8820		9490	
Seed Formation	2440		3100	
Seed maturation	60		1200	
Seedling Development	1.4		33.1	

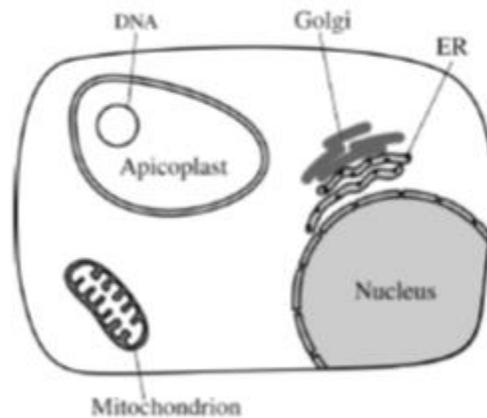


Figure 1. Simplified diagram of the cellular structures of *Plasmodium falciparum*

4. The eukaryotic protozoan parasite *P. falciparum* is the causative agent of malaria. *P. falciparum* cells contain an organelle called apicoplast (see Figure 1). Apicoplasts synthesize precursors of biomolecules that are required for growth and reproduction of the parasite.

- Based on Figure 1, describe TWO pieces of evidence a researcher could use to support the claim that apicoplasts evolved from free-living, prokaryotic organisms.
- Doxycycline is a drug used to treat malaria and some bacterial infections. Doxycycline binds to the prokaryotic 30S ribosomal subunit and inhibits its function. Explain how doxycycline can be an effective treatment for a *P. falciparum* infection in humans.

NUMBER OF DIFFERENCES IN THE FIRST 60 AMINO ACIDS OF THE NEUROMODULIN PROTEIN ISOLATED FROM FIVE SPECIES

	Finch	Gecko	Turtle	Frog	Zebra fish
Finch	0	2	2	6	10
Gecko		0	1	7	11
Turtle			0	7	11
Frog				0	13
Zebra fish					0

6. Neuromodulin is an essential protein that is highly conserved among vertebrates. Researchers compared the first 60 amino acids of the neuromodulin protein from each of five different species. The results are shown in the table above.

Based on the data in the table, construct a cladogram on the template provided to represent the evolutionary relatedness of the five species. Using the data justify the placement of the zebra fish on the cladogram. On the cladogram, circle the position of the most recent common ancestor of the two most closely related species.

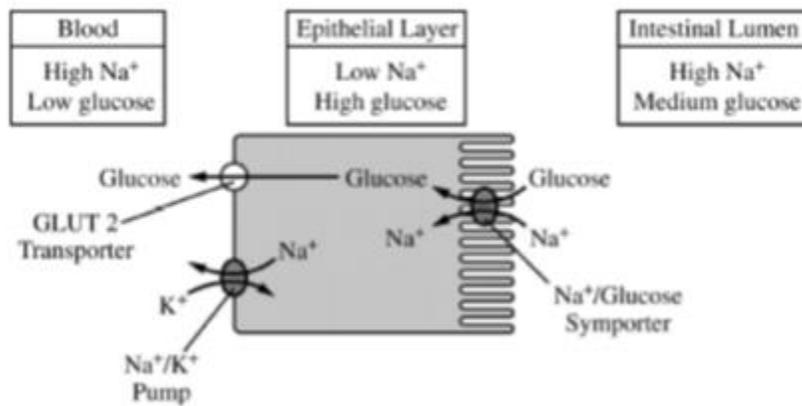
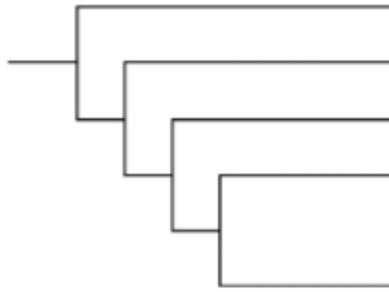


Figure 1. A single cell from the epithelial layer lining the intestine, illustrating movement of glucose and Na^+ from the intestinal lumen to the blood

8. Glucose and sodium move from the lumen of the small intestine into the blood via transport proteins in the epithelial cells lining the small intestine (Figure 1). Based on Figure 1, describe the direct source of energy used to move glucose into the epithelial cells from the intestinal lumen. Explain how this system maximizes glucose absorption from the intestinal lumen into the epithelial cells and from the epithelial cells into the blood.