IJSO Theory Solutions

Biology Mock Test no. 1

Problem 1 – Adaptations in Organisms Living in Freezing Conditions (10 points)

Part A. The Molecular Biological Adaptations to the Cold

A.1. Many psychrophilic bacteria possess enzymes that maintain catalytic efficiency at low temperatures. A common molecular strategy to achieve this involves a higher proportion of:

(1.00 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

A.2. Fill in the blanks:

(0.50 points)

To prevent the formation of lethal ice crystals inside their cells, some freeze-avoiding organisms synthesize and accumulate osmolytes such as glycerol or glucose. These compounds act as _____ (electrolytes/ anti freeze/, cryo protectant) by lowering the intracellular freezing point and protecting cellular structures from dehydration. The cell membranes of organisms adapted to cold temperatures typically exhibit an increased proportion of _____ (saturated, unsaturated, trans) fatty acids. This structural modification is crucial for maintaining membrane _____ (permeability, fluidity, stability)at low temperatures, preventing it from becoming rigid and dysfunctional.

A.3. Beyond simple freezing point depression, specialized antifreeze proteins (AFPs) in polar fish primarily function by:

(1.00 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

Part B. Physiological Architectures for Enduring Cold

B.1. Endothermic polar animals like arctic foxes and penguins utilize a countercurrent heat exchange system in their extremities (e.g., paws, flippers). This mechanism functions by:

(0.25 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

B.2. Non-shivering thermogenesis (NST) in mammals, particularly relevant in cold adaptation, involves which of the following processes in brown adipose tissue (BAT)?

(1.25 points)

Check ALL correct answers:

▢ A.

▢ B.

▢ C.

▢ D.

▢ E.

B.3. Some freeze-tolerant organisms, such as the wood frog (Rana sylvatica), can survive having up to 65% of their total body water frozen. This is largely achieved by:

(0.25 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

B.4. The exceptionally low heart rate and metabolic rate observed in some diving marine mammals (e.g., seals, whales) when under ice is an example of:

(0.25 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

Part C. Ecological Dynamics of Polar Life

C1. The formation of sea ice is crucial for the early spring bloom of ice algae (sympagic algae). These algae form the base of the "cryopelagic" food web. Check all that apply regarding the ecological advantages of growing within or on the underside of sea ice for these primary producers:

(0.75 points)

Check ALL correct answers:

▢ A.

▢ B.

▢ C.

▢ D.

▢ E.

C2. The biomagnification of persistent organic pollutants (POPs) is a significant concern in polar food webs. Which of the following statements best explains why apex predators like polar bears accumulate very high concentrations of these toxins?

(1.25 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

C3. During the polar winter, many marine birds and mammals migrate away from the extreme cold. However, species like Emperor Penguins endure the Antarctic winter. Their survival in breeding colonies during winter relies heavily on:

(0.50 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

Part D: Global Change and the Cryosphere

D1. **Fill in the blanks:**

(0.50 points)

The thawing of vast permafrost regions in the Arctic is a significant concern for the global carbon cycle. As permafrost thaws, the immediate biological process that contributes to the release of greenhouse gases (CO_2 and CH_4) is the _____ (accumulation/ decomposition/ photosynthesis)of long-frozen organic matter by _____ (abiotic/ microbial/ geological) activity.

D2. Check all that apply: The accelerated melting of Arctic sea ice has several direct and indirect ecological consequences. Which of the following are likely to occur?

(0.75 points)

Check ALL correct answers:

▢ A.

▢ B.

▢ C.

▢ D.

▢ E.

D3. Ocean acidification, driven by increased atmospheric CO_2 absorption, poses a particular threat to calcifying organisms in cold polar waters. This is because (fill in the blanks):

(1.25 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

D4. **Fill in the blank:**

(0.50 points)

The concept of "Arctic amplification" refers to the phenomenon where the Arctic warms faster than the rest of the planet. A key biological feedback mechanism contributing to this is the _____ effect, where the loss of highly reflective ice and snow cover leads to increased absorption of solar radiation by darker ocean and land surfaces.

Problem 2 – Homeostasis (15.00 points)

Part A. Glucose Homeostasis – Fundamental Mechanisms

A1. After a carbohydrate-rich meal, blood glucose levels rise. Which of the following accurately describes the immediate physiological response orchestrated by the pancreas to restore glucose homeostasis?

(0.75 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

A2. **Fill in the blanks:**

(1.00 points)

When insulin binds to its receptors on target cells (e.g., muscle and adipose tissue), it triggers the translocation of _____ (SGLT1 / GLUT4 / Na+/K+ pump) transporters to the cell membrane, thereby increasing cellular uptake of glucose from the bloodstream. Simultaneously, in the liver, insulin promotes the conversion of excess glucose into _____ (fatty acids / amino acids / glycogen) for storage.

A3.

Check ALL correct answers:

(0.75 points)

▢ A.

▢ B.

▢ C.

▢ D.

▢ E.

Part B: Glucose Homeostasis - Clinical Insights

B1. A patient undergoes an Oral Glucose Tolerance Test (OGTT). After consuming a glucose solution, their blood glucose levels are monitored over several hours. In a healthy individual, which of the following glucose level patterns would be observed?

(1.00 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

B2. Check all that apply: Prolonged and uncontrolled hyperglycemia (high blood glucose) in diabetes can lead to severe long-term complications affecting various organ systems. Which of the following are recognized consequences of chronic hyperglycemia?

(1.00 points)

Check ALL correct answers:

▢ A.

▢ B.

▢ C.

▢ D.

▢ E.

B3. Fill in the blanks:

(0.50 points)

Type 1 diabetes mellitus is an autoimmune condition characterized by the destruction of pancreatic _____ (alpha / beta) cells, leading to an absolute deficiency of insulin production. In contrast, Type 2 diabetes mellitus is primarily characterized by insulin _____ (resistance / sensitivity), where target cells do not respond effectively to insulin, often compounded by a relative deficiency in insulin secretion over time.

Part C: Thermoregulation- Maintaining Core Body Temperature

C1. When an individual is exposed to a cold environment, the body initiates several responses to conserve heat. Which of the following accurately describes a primary physiological response mediated by the hypothalamus to prevent excessive heat loss?

(1.00 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

C2. Check all that apply: Beyond involuntary physiological responses, humans and many other endotherms employ conscious behavioral adaptations to regulate their body temperature. Which of the following are examples of such behavioral thermoregulation?

(0.50 points)

Check ALL correct answers:

▢ A.

▢ B.

▢ C.

▢ D.

▢ E.

C3. **Fill in the blanks:**

(0.25 points)

Heat is primarily transferred from the body to the environment through four main physical mechanisms: (conduction / convection / radiation). Heat transfer through direct contact is called _____ (conduction / convection / evaporation). Heat transfer by the movement of fluid (air or water) is called _____.

C4. Approximately how much energy (in kJ) does the body use solely to convert 1 liter of cold water (5°C) to body temperature (37°C), without taking into account other metabolic processes? (Specific heat capacity of water = 4.18 J/g°C)

(1.50 points)

Calculation:

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

Part D: Interplay of Homeostatic systems

D1. During prolonged strenuous exercise, both glucose homeostasis and thermoregulation are significantly challenged. Which of the following best describes a key physiological adjustment that allows the body to meet the increased energy demand and manage heat production simultaneously?

(1.00 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

D2. Check all that apply: Homeostatic control systems typically operate via negative feedback loops to maintain stability. Which of the following are essential components of a generic negative feedback loop?

(0.75 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

D3. Fill in the blanks:

(0.25 points)

Water plays a critical role in thermoregulation due to its high _____ (specific heat capacity / latent heat of vaporization / density), allowing the body to absorb and release significant amounts of heat with minimal temperature change. This property is particularly evident in the process of sweating, where the _____ (specific heat capacity / latent heat of vaporization / density) of water facilitates efficient cooling as sweat evaporates from the skin.

D4. During intense physical activity in hot conditions, the body can lose up to 2–3 liters of sweat per hour. If an athlete drinks water without replacing electrolytes, what is the most likely physiological outcome?

(1.00 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

D5. Which mechanism precisely describes why the body inhibits the secretion of the hormone vasopressin (ADH) in a state of hyperhydration?

(1.00 points)

Select the correct answer:

▢ A.

▢ B.

▢ C.

▢ D.

Part E: Effects of Physiological Modulators (2.75 points) - 0.4 PER correct sub-answer.

For each physiological process listed below, indicate whether the modulating factor described would typically have an Increasing (I), Decreasing (D), or Unrelated (U) effect on the rate or magnitude of the process.

Biological Process	Modulating Factor	Effect (I/D/U)
E1. Rate of nerve impulse conduction	Severe demyelination of the axon	
E2. Oxygen unloading from hemoglobin at peripheral tissues	Increased tissue CO_2 concentration (e.g., during exercise)	
E3. Glomerular Filtration Rate (GFR)	Severe constriction of the afferent arteriole	
E4. Net fluid movement out of capillaries at the arterial end	Significant increase in plasma protein concentration	
E5. Activity of the Na+/K+ pump	Absence of ATP	
E6. Secretion of Antidiuretic Hormone (ADH)	Significant decrease in blood osmolarity	
E7. Calcium reabsorption in the renal tubules	Increased parathyroid hormone (PTH) levels	

Problem 3 – Global Warming and Biodiversity in the Arctic

Part A. Glucose Homeostasis – Fundamental Mechanisms

A1. **Select the correct answer:**

(1.00 points)

▢ A.

▢ B.

▢ C.

▢ D.

A2. Determine if the statements are true or false (4.00 points) – 0.80 points PER correct answer

Statement:	True/false (mark T for true and F for false)
1. If organism A has a narrower ecological valence for a given factor than organism B, organism B is less likely to survive in an environment with a different intensity of the given factor.	
2. The ecological valence of an organism is more likely to change if there have been mixings between the gene pools of populations occupying different ecosystems and ecological niches.	
3. An isolated population is more likely to migrate when the abiotic factors are changing than a population with high gene flow.	
4. Climate change and global warming aren't one of the main reasons for species extinction.	
5. In the pelagic arctic biome there is bottom-up control because of the large populations of phytoplankton and algae.	