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10 Marks Questions – 300-400 words Each

Q. - (a) Explain how the respiratory system maintains the acid-base balance in mammals.

ANS.- The respiratory system plays a central role in maintaining acid-base balance by regulating the concentration of carbon dioxide (CO_2) in the blood. CO_2 acts as a major component of the bicarbonate buffer system, the primary physiological buffer in mammals. When CO_2 dissolves in blood, it forms carbonic acid (H_2CO_3), which dissociates into hydrogen ions (H^+) and bicarbonate ions (HCO_3^-). Any change in the rate of breathing therefore directly influences blood pH.

During increased production of CO_2, such as in strenuous activity, the blood becomes more acidic due to elevated H^+ concentration. The respiratory centre in the medulla oblongata detects this change and stimulates faster and deeper breathing. This enhanced ventilation eliminates excess CO_2 through the lungs, shifting the bicarbonate buffer equilibrium and reducing the level of H^+, thereby raising the blood pH back toward normal.

Conversely, when CO_2 levels fall, as in slow or shallow breathing, fewer H^+ ions are produced, making the blood more alkaline. To correct this, the respiratory centre reduces the respiratory rate, allowing CO_2 to accumulate and restore balance. Thus, through constant monitoring of CO_2 and pH, the respiratory system provides rapid and efficient regulation of acid-base homeostasis.

(b) What are the chromophores ? Discuss their practical applications.

ANS.- Chromophores are molecular groups or atoms responsible for the colour of a compound. They possess conjugated double-bond systems that absorb light at specific wavelengths, causing electrons to shift to higher energy levels. The absorbed wavelength corresponds to the visible colour perceived. Common chromophores include nitro groups, azo groups, carbonyls, and aromatic rings.

Chromophores have wide practical applications in biology, chemistry, and industry. In biochemistry, they are crucial components of pigments such as hemoglobin, chlorophyll, and visual pigments, enabling essential processes like

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oxygen transport, photosynthesis, and vision. They are used extensively in spectrophotometry, where absorption patterns help in identifying biomolecules, measuring enzyme activity, and analysing metabolic pathways.
In medicine, chromophore-based dyes help in diagnostic staining techniques, highlighting tissues and cells for microscopic study. They are also vital in laser therapies, where specific chromophores absorb particular wavelengths to target tissues without damaging surrounding areas. Industrially, chromophores form the basis of dyes, inks, food colouring agents, and textile pigments. Their ability to absorb light also makes them important in solar cells and optical sensors. Chromophores thus remain key functional units in diverse scientific and technological applications.

Q. - (a) Explain gastrointestinal hormones in mammals.

ANS.- Introduction

Gastrointestinal (GI) hormones are chemical messengers secreted by specialized endocrine cells present in the stomach, intestine, and pancreas. These hormones coordinate digestive processes, regulate enzyme secretion, control motility, and maintain overall digestive homeostasis.

Major Gastrointestinal Hormones

One of the major GI hormones is **gastrin**, produced by G-cells of the stomach. Gastrin stimulates the secretion of hydrochloric acid (HCl) from parietal cells and promotes gastric motility. **Secretin**, released from the duodenum, plays a vital role in neutralizing acidic chyme entering the intestine by stimulating bicarbonate secretion from the pancreas. **Cholecystokinin (CCK)** is secreted by intestinal mucosa and stimulates the release of pancreatic digestive enzymes and bile from the gallbladder, aiding in the digestion of fats and proteins.

Regulatory Functions

Another important hormone is **Gastric Inhibitory Peptide (GIP)**, which slows gastric motility and promotes insulin release. **Motilin** regulates gastrointestinal motility during fasting and initiates the migrating motor complex. Together, these hormones ensure coordinated digestion, nutrient absorption, and efficient flow of food along the GI tract.

(b) Describe temperature regulation in homeotherms.

ANS.- Introduction

Homeotherms are organisms capable of maintaining a constant internal body temperature regardless of external environmental fluctuations. Mammals and birds are the best examples of homeotherms. Their thermoregulatory mechanisms ensure optimal functioning of metabolic processes.

Heat Production Mechanisms

Temperature regulation is controlled by the hypothalamus, which acts as the body's thermostat. Heat is produced mainly through metabolic activities, muscular contractions, and shivering thermogenesis. In some mammals, **non-shivering thermogenesis** occurs in brown adipose tissue, where thermogenin helps generate heat without muscle activity.

Heat Loss Mechanisms

When the body overheats, heat is lost through vasodilation, sweating, and increased respiratory rate. Vasodilation increases blood flow to the skin, enhancing heat loss through radiation and convection. Sweating allows cooling through evaporation.

Cold and Heat Adaptations

In cold conditions, vasoconstriction minimizes heat loss, and piloerection traps insulating air close to the skin. Behavioral responses like seeking shelter or huddling also assist in maintaining temperature. In hot conditions, animals reduce activity, seek shade, and increase water intake.

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Conclusion

Thus, temperature regulation in homeotherms involves a combination of physiological and behavioral strategies controlled by the central nervous system to maintain thermal balance and ensure survival.

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Q. - (a) Explain how are enzyme inhibitors used as therapeutic drugs.

ANS.- Enzyme inhibitors play a crucial role in modern medicine because many diseases arise from abnormal or excessive activity of specific enzymes. By blocking or reducing the activity of these enzymes, enzyme inhibitors help restore normal physiological balance. Therapeutic enzyme inhibitors are designed to bind either to the active site or to an allosteric site of the target enzyme, thereby preventing the substrate from forming the product.

Types and Applications:

Competitive inhibitors are widely used, such as *methotrexate*, which inhibits dihydrofolate reductase to block DNA synthesis in cancer therapy. Non-competitive and irreversible inhibitors are also valuable in treatment strategies. For example, *aspirin* irreversibly inhibits cyclooxygenase (COX) enzymes, reducing prostaglandin production and providing anti-inflammatory, analgesic, and antipyretic effects.

Role in Disease Management:

Enzyme inhibitors are essential in controlling chronic diseases. ACE inhibitors like *captopril* and *enalapril* block angiotensin-converting enzyme to reduce blood pressure and prevent heart failure. *Statins* inhibit HMG-CoA reductase to lower cholesterol levels and prevent cardiovascular disorders. Antiviral drugs such as *HIV protease inhibitors* block viral enzyme activity, thereby inhibiting viral replication. Thus, enzyme inhibitors provide targeted and effective treatment options with high therapeutic value.

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(b) Discuss the evolution of electrosensory system and electric organs.

ANS.- The evolution of the electrosensory system is an important adaptation seen mainly in aquatic animals, particularly fishes. This system allows organisms to detect electric fields generated by surrounding objects or other animals, giving them advantages in navigation, prey detection, and communication. Early electrosensory abilities likely evolved from mechanoreceptors present in ancestral fishes, gradually modifying into electroreceptors capable of detecting weak electric signals.

Development in Different Groups:

In bony fishes like catfish and gymnotiforms, electroreception evolved independently, showing convergent evolution. These species developed specialized electroreceptors such as *ampullary organs* and *tuberous receptors* adapted for passive and active electroreception. Passive electroreception helps detect external electric fields, while active electroreception is used when the animal generates its own electric signals.

Evolution of Electric Organs:

Electric organs evolved from modified muscle cells called *electrocytes*. Over time, these cells lost their ability to contract and became specialized for generating electric discharges. In species like electric catfish, electric rays, and

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electric eels, these organs developed independently, highlighting multiple evolutionary origins. Electric organs serve various functions including prey stunning, self-defense, communication, and electrolocation.
Overall, the evolution of electrosensory systems and electric organs demonstrates remarkable adaptations that improved survival in diverse aquatic environments.

Q. - Differentiate between the following pairs of terms :

(a) Hypoxia and Hypercapnia

ANS.- Meaning:

Hypoxia refers to a condition where the tissues receive insufficient oxygen, even though blood flow may be normal. It commonly arises at high altitudes, due to respiratory disorders, or reduced hemoglobin levels.
Hypercapnia, on the other hand, denotes an abnormal increase in carbon dioxide (CO_2) concentration in the blood, usually caused by inadequate ventilation.

Physiological Effects:

In hypoxia, cells shift towards anaerobic metabolism leading to fatigue, confusion and lactic acid buildup.
In hypercapnia, CO_2 retention triggers respiratory acidosis, increased heart rate, headaches and in severe cases, unconsciousness.

Compensatory Responses:

Hypoxia stimulates increased breathing rate and erythropoietin production.
Hypercapnia activates chemoreceptors that enhance ventilation to remove excess CO_2.

(b) Acclimatization and Acclimation

ANS.- Nature of Process:

Acclimatization is a gradual physiological adjustment of an organism to natural environmental changes such as seasonal temperature variation or high-altitude exposure.
Acclimation involves similar adjustments but occurs under controlled laboratory or experimental conditions.

Duration:

Acclimatization happens over days to months depending on environmental stress.
Acclimation is faster and occurs under specific experimental protocols.

Scope:

Acclimatization is holistic, influencing multiple systems like respiration, circulation, and metabolism.
Acclimation generally targets specific variables such as temperature or salinity.

(c) Concerted (MWC) model and Sequential (KNF) model of Allosteric enzyme

ANS.- Basic Concept:

The **Concerted or MWC Model** proposes that all subunits of an allosteric enzyme exist in either a low-affinity (T) state or high-affinity (R) state together, shifting simultaneously.
The **Sequential or KNF Model** suggests that substrate binding induces stepwise conformational changes in individual subunits.

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