

# Chapter 15

## HOMEOSTASIS

**Definition:**

Protection of internal environment from the harms of fluctuation in external environment.

**Importance:**

- (i) Homeostasis is the central requirement in the maintenance of suitable environment for an organism.
- (ii) It brings the adaptations in organism due to constant changing environmental conditions and contributes in the evolutionary process.
- (iii) Homeostasis keeps the internal fluctuation in a narrow range with various control systems (sweating/shivering etc.) as compared to wider external changes.

**Components of Cell and Effect of External Change:**

Water solutes and temperature are the components of cell which are affected by changes in external environment of an organism. These are controlled by following methods:

1. **Osmoregulation:** The mechanism of regulation of solutes and gain or loss of water is called osmoregulation.
2. **Excretion:** The mechanism which removes nitrogenous wastes from the body is called excretion.
3. **Thermoregulation:** The maintenance of internal body temperature within a tolerable range is called thermoregulation.

**Homeostasis: (At Cellular Level)**

Homeostasis does not mean to keep a fixed interval environment at cellular level, as changes within a specific range are necessary for normal body functions. For example water availability may vary tremendously for the organism in the external environment from abundant supply to almost dry conditions. However, the central system of homeostasis process would not let the body flooded with water in abundant supply and also not to dehydrate in dry conditions.

**Working of Living Control System:**

1. **Definition:**

The control system in an individual performs variety of homeostatic functions. These living control system work exactly on the mechanism of physical control system.

## 2. Component of Control System:

Each control system has three components:

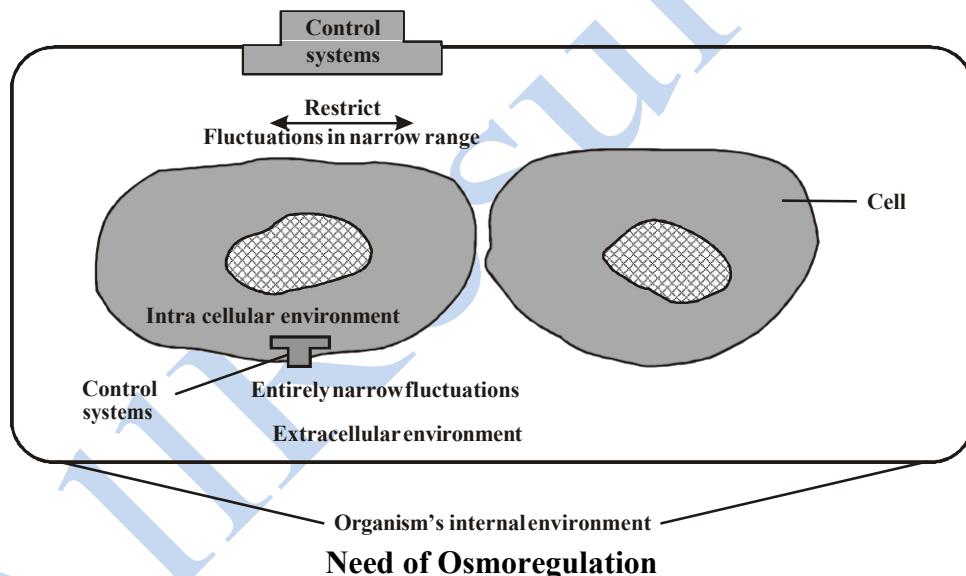
(i) Receptor      (ii) Control center      (iii) Effector

In living system there is set point in temperature regulated (endothermic) animals. The receptors detect temperature change e.g., of increase / decrease, and signal to control center for action of cooling / warmth system.

**3. Feedback Mechanism:** Detection of change and conveying it to control center for effector's response is called feedback mechanism.

## 4. Negative Feedback mechanism:

In these processes there is an inverse effector's response due to the change in external environment and there is generally cooling effector's response to warmth sensing in external environment thus are called negative feedback mechanisms.



### (i) Water relation of cell

Water is the solvent for many solutes in the cell. Each cell has been adapted to particular quantity of water in relation to perform its functions. Homeostasis mechanism generally maintain this balance in salt and water.

#### 1. Balance of water and solutes in the body.

##### (i) Hypotonic Environment

If the environment of the cell are more diluted than cell salt concentration, such environment are called hypotonic environment. Hypotonic environment osmotically

causes entry of water into the cell due to which cell solution becomes more diluted. The cell also becomes turgid harming cells proper function.

### (ii) Hypertonic Environment

More concentrated external environment than internal environment is called hypertonic environment.

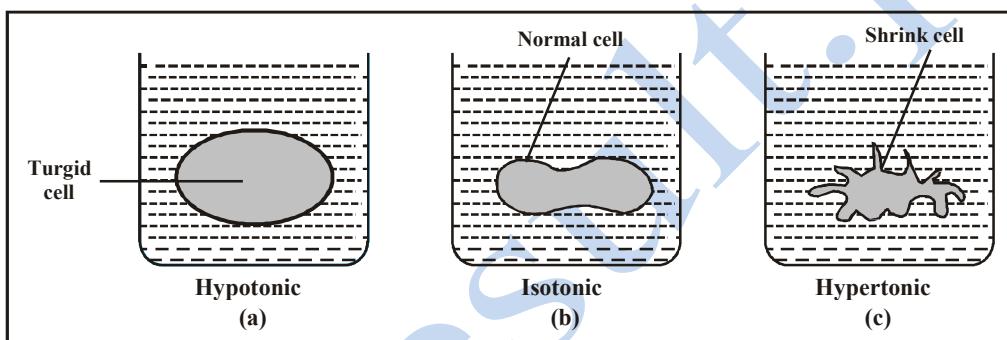
### Effect to Cell

Due to hypertonic environment water moves from inside of cell to outside causing the cell to shrink.

### (iii) Isotonic Environment

External environment that resembles to internal solution is termed as isotonic environment.

**Effect to Cell:** No effect to cell.



Response of the cell to various external environments i.e. different concentrations of solution without any regulation with control system at cell membrane, cell remain in normal state despite differences in its internal to external environments.

## OSMOREGULATION IN PLANTS

Plants are classified differently according to their habitats.

### 1. Hydrophytes:

**(i) Definition:** These are aquatic plants and have the adaptations to remove the excess water.

### **(ii) Adaptations:**

**(a)** In this type of plants the surface area of leaves is very large to transpire water excessively.

**(b)** Extensive stomata are present on the upper surface promoting loss of water.

**Examples:** Lilly, Trapa.

### 2. Mesophytes:

**(i) Definition:** Plants growing in moderate supply of water are called mesophytes.

### **(ii) Adaptations:**

**(a)** In sufficient supply of water stomata are open to promote loss of excess water.

(b) In restricted supply stomata are closed to prevent evaporation

**Example:** Brassica, rose, mango etc.

### 3. Xerophytes:

(i) **Definition:** these plants grow in extremely shortage of water and developed following adaptations to prevent water loss.

#### (ii) **Adaptations:**

(a) Many xerophytes possess small, thick leaves to prevent water loss by reducing surface area proportional to volume.

(b) Their cuticle is thick, waxy and leathery.

(c) Stomata are on the lower surface of leaves and located in depression.

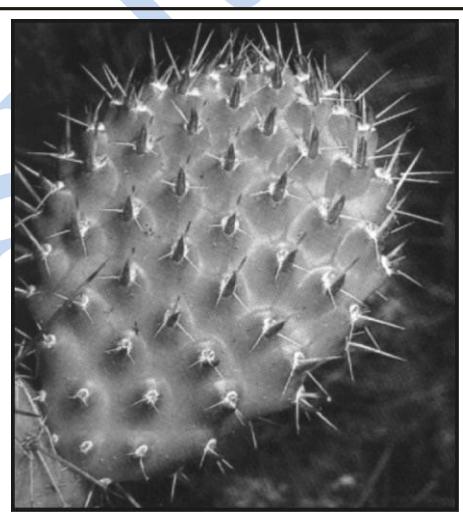
(d) Some xerophytes as cacti, during the driest season, shed their leaves to restrict transpiration completely, thus stems are the photosynthetic organs.

(e) In rainy seasons stem stores water for use in dry conditions.

**Examples:** Cacti, Euphorbia.



A hydrophytic plant



A xerophytic plant

## OSMOREGULATION IN ANIMALS

The animal cells require more critical balance of water and solutes in the body. They cannot survive without water gain or loss. Water continuously enter or leave the cells. However, the quantity of water and the solute is kept in balance.

### 1. Osmoconformers:

#### **Definition:**

The animals which do not require to actively adjust in their internal osmotic state are called osmoconformers.

**Adaptations:**

These animals keep their body fluid isotonic (same) to the external environment. They even keep their body fluid isotonic to marine and salt water environment.

**2. Osmoregulators:****Definition:**

The animals which actively adjust their internal osmotic state according to external environment are called osmoregulator.

**Adaptations:**

Their body fluid concentration differs greatly with outside environment. They release excess water in hypotonic environment (dilute outside) and excrete salt in hypertonic environment (concentrated outside). The animals living in different environment have distinct adaptations to regulate osmotic balance. These environments may be marine, freshwater and terrestrial environment.

## **OSMOREGULATION IN ANIMALS IN DIFFERENT ENVIRONMENT**

**1. Marine Environment:**

- (i) **Marine Invertebrates:** Most marine invertebrates are osmoconformers.
- (ii) **Hag Fishes:** The hag fishes keep their environment isotonic to surrounding sea water.
- (iii) **Cartilaginous Fishes:**

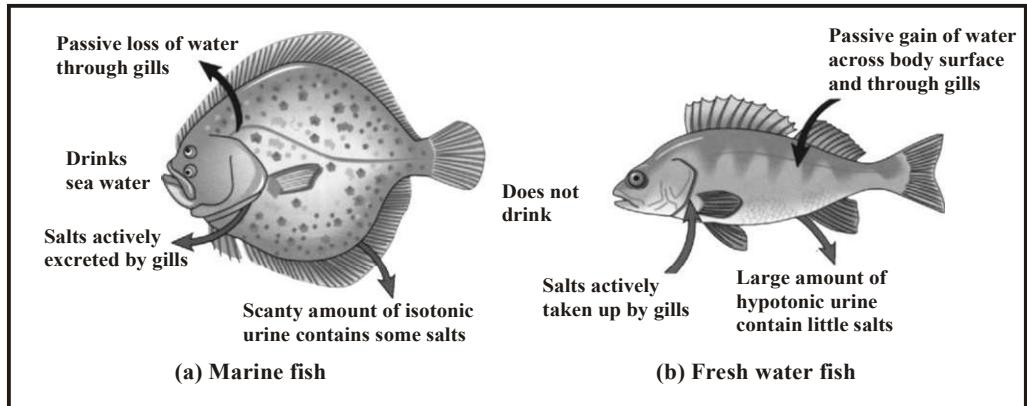
Most of the cartilaginous fishes maintain lower internal salt concentration than seawater. Their kidney and gills excrete salts for osmoregulation. Moreover, they also have salt secreting organs like rectal glands. These fishes use active transport mechanism to remove salt against the concentration gradient.

- (iv) **Urea Retaining marine Fishes:**

Some fishes have relatively low salts in the body fluid. But they retain urea in adequate concentration for making this fluid to isotonic as compared to sea. Urea is harmful in high concentration. So these fishes retain another chemical called **trimethylamine oxide**. This chemical protects the fishes against the harms of urea.

- (v) **Bony Fishes:**

Bony marine fishes which are considered as descendants of freshwater ancestors, constantly lose water from their hypotonic body fluids to hypertonic environment. These fishes have adopted to drink large amount of sea's water and excrete concentrated urine resulting in maximum salt excretion and minimum water loss.



Osmoregulation in: (a) Marine fish (b) Fresh water fish

## 2. Fresh Water Environment:

Fresh water animals constantly face the problem of flooding of body fluid. So they lose salts. Freshwater protozoa like amoeba and paramecium pump out excess water by **contractile vacuole**. Many freshwater fishes remove excess water by excreting large volume of very dilute urine. These animals compensate this loss of salt by eating salt containing foods and by active uptake of salts by gills and skin.

## 3. Terrestrial Environment:

Terrestrial animals lose water by evaporation which leads to dehydration. This water loss is a major problem for terrestrial animals. The Arthropods and other vertebrates by taking following adaptations solve the problem of dehydration.

- (i) The body surface of these animals is covered with structure which reduce the loss of water. These are:
  - (a) Waxy exoskeleton of insects.
  - (b) Terrestrial vertebrates have dead multilayered skin. These layers are composed of **keratinized** skin cells.
- (ii) They drink and eat moist food to compensate the loss of water.
- (iii) These animals also show metabolic and behavioral adaptations. Some desert mammals like **kangaroo rat** survive without drinking water. It feeds on seeds of desert plants. These seeds contain more carbohydrate which produce enough water during metabolism.

- (iv) Terrestrial animals have kidney. Kidney absorbs most of the filtered water in the process of excretion thus producing concentrated urine.
- (v) Terrestrial animals have developed different methods to tolerate dehydration. The toleration of dehydration is called **anhydrosis**.

## EXCRETION

### Definition:

The removal of wasteful metabolites, especially the nitrogenous wastes from the body is called excretion. The breakdown of carbohydrates and lipids produce  $\text{CO}_2$  and  $\text{H}_2\text{O}$  while the metabolism of proteins produces nitrogenous wastes in different forms in different animals. These nitrogenous wastes are toxic for cells so it must be removed from cell by excretion.

## EXCRETION IN PLANTS

### 1. Excretory products;

- (a) **Oxygen and  $\text{CO}_2$  Gases:** Oxygen is produced in photosynthesis, excess oxygen is released through stomata. In the same way  $\text{CO}_2$  produced in respiration, if not used in photosynthesis is released into air through stomata.
- (b) **Water:** Water is a waste product in both respiration and photosynthesis. It is lost through transpiration or just used for maintaining the turgor in the cell.
- (c) **Organic and Inorganic Compounds:** Plants also produce several organic and inorganic compounds. These compounds are stored in different organs and removed when necessary.

### 2. Methods of Excretion:

#### (a) Vacuoles:

Plant cells have large vacuoles, these can be used for either storage of useful compounds, or the storage of waste products. These waste products are then transformed into crystals in vacuoles.

#### (b) Leaves:

Certain inorganic and organic wastes are stored in leaves. When leaves fall off during autumn. These leaves are good manure and gardeners use it to increase soil fertility. In some cases, leaves die off and leave stalk or certain bulb underground. The bulb grows next year. The falling of yellow leaves in autumn is the seasonal time for plants to get rid of the accumulated wastes. Due to this behaviour leaves are called **excretophore**. Yellow colour of leaves is not due to loss of chlorophyll, microscopic examination reveals that some pigmented compounds and many toxic materials like heavy metals impart yellowness.

### 3. Stems:

Some trees deposits strange chemicals in the xylem of trunk. These xylem are no longer in use. This takes place in **ebony**. It produces very black wood in the center. These are considered as wastes by plant physiologists.

#### **4. Roots:**

Some plants actively secrete waste compounds into the soil, occasionally using these chemicals as weapons against other competing plants e.g., conifers.

## **EXCRETION IN ANIMALS**

The animals have following excretory products which are:

## 1. Water:

Water is released from the body in hypotonic environment. So it is waste product in these conditions.

## 2. Salts:

Salts are removed from the body in hypertonic environment. So salts are the excretory products for these animals.

### **3. Nitrogenous Wastes:**

The nitrogenous waste are the chief excretory products. The catabolism of amino acid releases amino group (-NH<sub>2</sub>) during **deamination**. This amino group is not reused for the recycling of amino acids, and are removed from the body after dissolving in water so to avoid toxicity in blood plasma. The rise of level of these compounds in the blood can cause convulsions, coma or death. Mostly excess nitrogen are excreted in three forms:

- (i) Ammonia      (ii) Urea      (iii) Uric acid

Lower quantity of nitrogen is excreted in the form of other compounds like:

- (i) Creatinine
  - (ii) Creatine
  - (iii) Trimethylamine oxide
  - (iv) Amino acids (very small quantity)
  - (v) Purine and pyrimidine (very small quantity)
  - (vi) Metabolism of purine and pyrimidine produces hypoxanthine, xanthine, uric acid, allantoin, urea and ammonia.

## **NATURE OF EXCRETORY PRODUCTS TO HABITATS:**

There are following relationship of excretory products with the nature of habitat.

## 1. Ammonia:

Ammonia is kept as excretory product in those animals which live in hypotonic environment like fresh water. Ammonia is very toxic substance. It dissolves quickly in the body fluid. Thus it must be kept in low concentration in the body. A large amount of water is required to eliminate ammonia in the form of urine. This is possible only in

hypotonic environment. About 500 ml water is needed to excrete 1 gm of ammonia nitrogen. The animal secreting ammonia as excretory products are called **ammonotelic**.

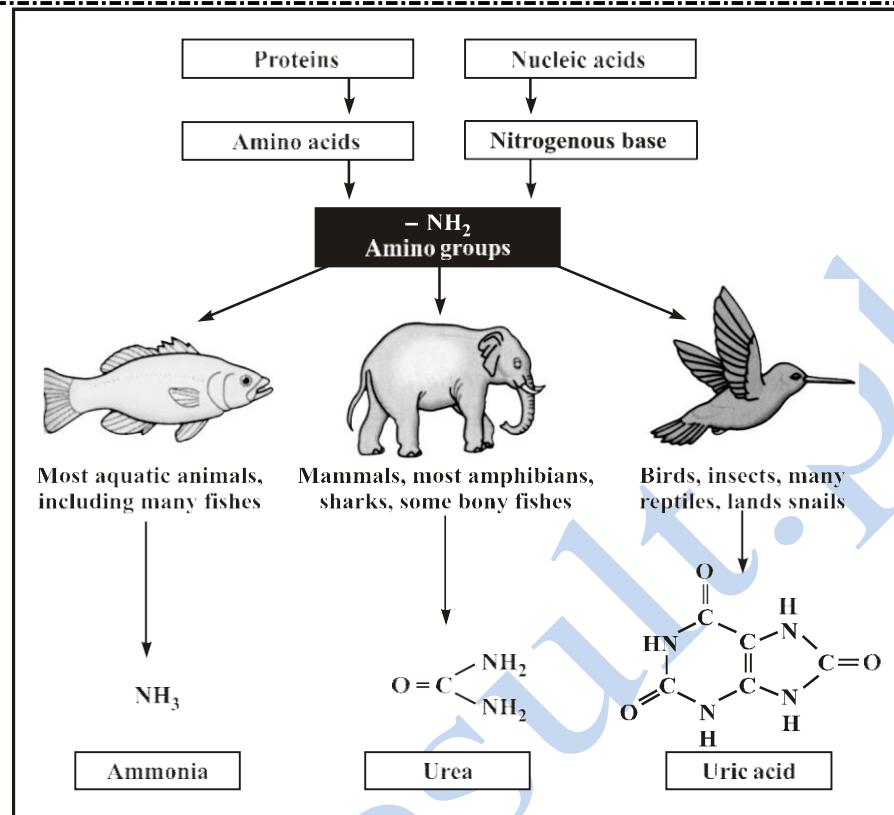
### 2. Urea:

The animal living in low supply of water secrete urea. Ammonia cannot be kept as excretory product in low supply of water. So it is changed into less toxic substance like urea. Urea requires only 50 ml of water for 1 gm of nitrogen removal. Thus the excretory nitrogen is metabolically converted into urea by urea cycle in the animals live in low supply of water e.g., terrestrial animals. The animals secreting urea as their excretory products are called **ureotelic**.

### 3. Uric Acid:

The animals living in acute shortage of water produce uric acid. Uric acid is excreted with minimum amount of water. Only 1 ml of water is required to eliminate 1 gm of nitrogen in the form of uric acid. The reptiles and birds live in arid conditions. So they excrete uric acids as excretory product. The animals secreting uric acid as their waste product are called **uricotelic**.

Ureotely and uricotely are evolutionary adaptations for nitrogenous wastes in their habitat. The animals have adapted themselves chemically to these habitats. They also show various adaptations and produce diversity in excretory structures.



### Excretion in Hydra:

Hydra does not have a specialized excretory structure. Its waste products are simple diffused into the outer iso-osmotic surroundings.

### Excretion in Planaria

#### (i) Excretory System:

Planaria (flatworms) has simple tubular excretory system called **protonephridium**. A protonephridium is a network of closed tubules without internal openings.

#### (ii) Excretory Organ:

Tubular system is spread through out the body. End branches are capped by a cellular setup termed as **flame cell**.

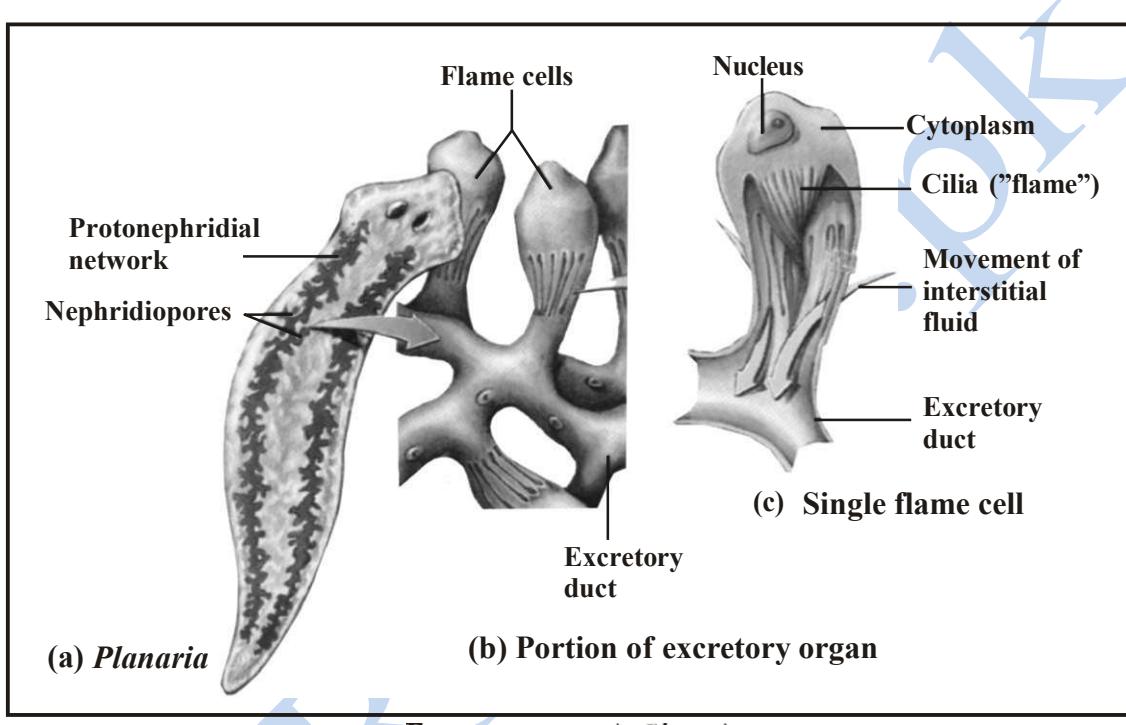
#### (iii) Working of Flame Cell:

Each flame cell has tuft of cilia, whose beating propel interstitial fluid into the tubular system (The beating of cilia looks like a flickering flame, therefore these cells are

termed as flame cells). The tubular system is drained into excretory ducts, which open to the exterior through several nephridiopores.

**(iv) Nature of Excretory Material:**

Fresh water flatworms excrete very dilute urine. The parasitic flatworms, which are isotonic to the host environment mainly function in disposing nitrogenous wastes.



Excretory system in *Planaria*

## EXCRETION IN EARTHWORM

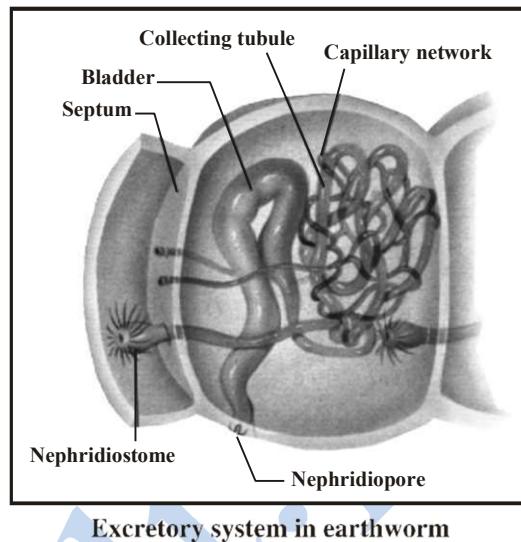
**(i) Excretory System:**

**Metanephridium:** Earthworm has tubular excretory system called as **metanephridium**. Each segment of earthworm has a pair of metanephridia.

**(ii) Function of Nephridium:**

This system has an internal ciliated opening **nephrostome** immersed in coelomic fluid and enveloped by a network of capillaries. Nephrostome collects coelomic fluid. As fluid moves along the tubule, epithelium reabsorbs the salt from lumen and

send to blood vessels surrounding the nephridium. The left over appears as urine containing nitrogenous waste.



## EXCRETION IN COCKROACH

**(i) Excretory Structure:**

In the insects, excretory products are collected from hemolymph in sinuses through suspended tubular structures called **malpighian tubules**. These malpighian tubules remove nitrogenous waste from the hemolymph. These are the only excretory structures in animal kingdom that are associated with digestive tract.

**(ii) Function of malpighian tubules:**

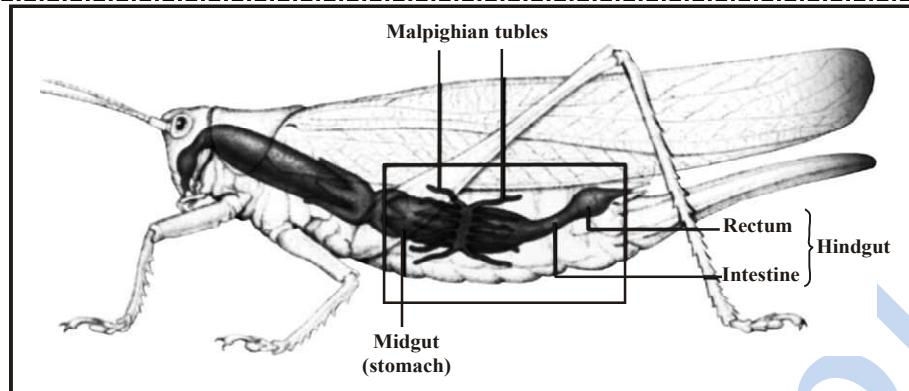
The epithelium lining of the tubules transports solutes including salts a nitrogenous waste from haemolymph into tubes lumen. Fluid then passes to hind gut into the rectum. Rectum reabsorbs most of the salt and water, thus nitrogenous wastes are excreted as solid excreta, in the form of uric acid crystals along the feces.

**(iii) Distinguishing feature of insects excretory system**

Insects are the only group of the animals, who eliminate excretory waste with feces, otherwise in all others there is not structural and functional relationship between nutritive and excretory systems.

**(iv) Importance:**

This important kind of adaptation in excretion is the success of these animals on land with the shortage of water.



Excretory system in insect

## EXCRETION IN VERTEBRATES

### **Evolution of Kidney:**

#### **(i) Metanephridium in Earthworm:**

The ancestors of vertebrates, the invertebrates have segmentally arranged excretory structures throughout the body like the metanephridia in earthworm.

#### **(ii) Hagfishes:**

This character is well represented in the primitive vertebrates hagfishes which have kidneys with segmentally arranged tubules.

#### **(iii) Appearance of Kidney:**

Evolution proceeded in other vertebrates with the appearance of kidneys. Kidneys contain numerous tubules, not arranged segmentally, and closely associated with a dense network of capillaries. The basic functional structure in the kidneys is **nephron**.

## EXCRETION IN HUMAN

### **Normal Mechanisms:**

#### **(i) Metabolic Waster:**

Various chemical reactions occurring in the body all the time, their waste products are called metabolic wastes.

#### **(ii) Types:**

These include urea, produced from the metabolism of amino acids; creatinine, produced from muscle creatine; uric acid, from nucleic acids; bilirubin, end products of haemoglobin breakdown and metabolites of various hormones. Metabolic wastes also include the toxins produced within the body and ingested into the body such as pesticides, drugs and food additives.

#### **(iii) Importance:**

The presence of the wastes in body causes serious hazards and thus are required to be eliminated by excretory system.

## EXCRETORY ORGANS

Liver and kidneys are the primary structures for eliminating waste products.

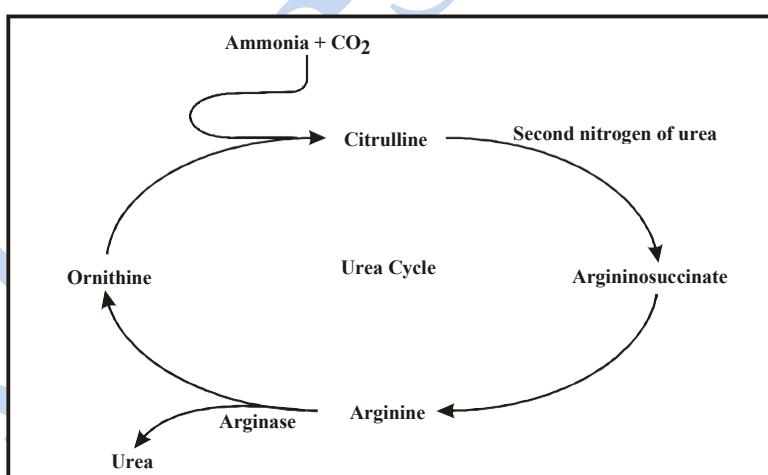
### Liver:

#### 1. EXCRETORY ROLE:

- (i) It is the central station of metabolism and serves as body's central metabolic clearing house.
- (ii) Due to this characteristic liver functions are pivotal role to homeostasis with most of body's organs system.
- (iii) Liver supports the excretory role of the kidney by detoxifying many chemical poisons and produce ammonia, urea and uric acids from the nitrogen of amino acids.

#### (iv) Urea Cycle:

Among the various nitrogenous wastes, urea is the principal excretory product and liver forms it from the waste nitrogen. The metabolic pathways involved in the production of urea are termed as **urea cycle**. Two ammonia and one carbon dioxide molecule are shunted into the cycle to generate one molecule of urea. One ammonia molecule combines with carbon dioxide and already available precursor from previous cycle, **ornithine** to form **citrulline**. Afterward another ammonia combines to form **arginine**. The arginine is split by **arginase** to form urea and the precursor ornithine for next cycle.



#### 1. Major Homeostatic Functions of the Liver:

Liver is not only involved in the synthesis of nitrogenous wastes to assist kidney in their disposal, but also have numerous crucial functions of homeostasis importance. These functions belong to synthesis, storage, conversion, recycling and detoxification categories.

Functions	Major effects on homeostasis
<b>Synthesis:</b> Nitrogenous wastes: NH <sub>3</sub> , urea, uric acid	Support kidney in waste disposal.
Plasma proteins: like (a) prothrombin, fibrinogen (b) albumin etc.	(a) Blood clotting (b) maintain osmotic balance of blood
Bile	Emulsifies fats in small intestine
Lipids, cholesterol, lipoproteins	Regulate blood chemistry, store energy and help to maintain cell membranes
<b>Storage:</b> Iron	oxygenation of tissues as constituent of hemoglobin.
Glycogen	Energy reserves
<b>Conversion:</b> Excess glucose in blood to glycogen, lactic acid to glycogen and stored glycogen to glucose.	Energy storage and use
<b>Recycling:</b> Contents of old red blood cells (e.g., iron and other constituents of haemoglobin)	Oxygenation of tissue
<b>Detoxification:</b> Many harmful chemicals (e.g., food additives, pesticides, drugs etc.)	Assist kidney in toxin disposal

Why removal of salts from skin is not considered of excretion.

Removal of salts with water by the sweat glands and of sebum by sebaceous glands seems to be excretory in nature. The removal of water and salts from sweat glands is for the purpose of thermoregulation and of definition of excretion, skin may not be considered as an excretory organ.

## URINARY SYSTEM

Urinary Bladder, Ureter, Kidney, Urethra, Urethral Orifice

**(i) Structure:**

A pair of kidney, consists of millions of functional units, **nephrons**. The nephrons have extensive blood supply via the renal arteries, which leaves each kidney via the renal vein.

**(a) Importance of Kidney:**

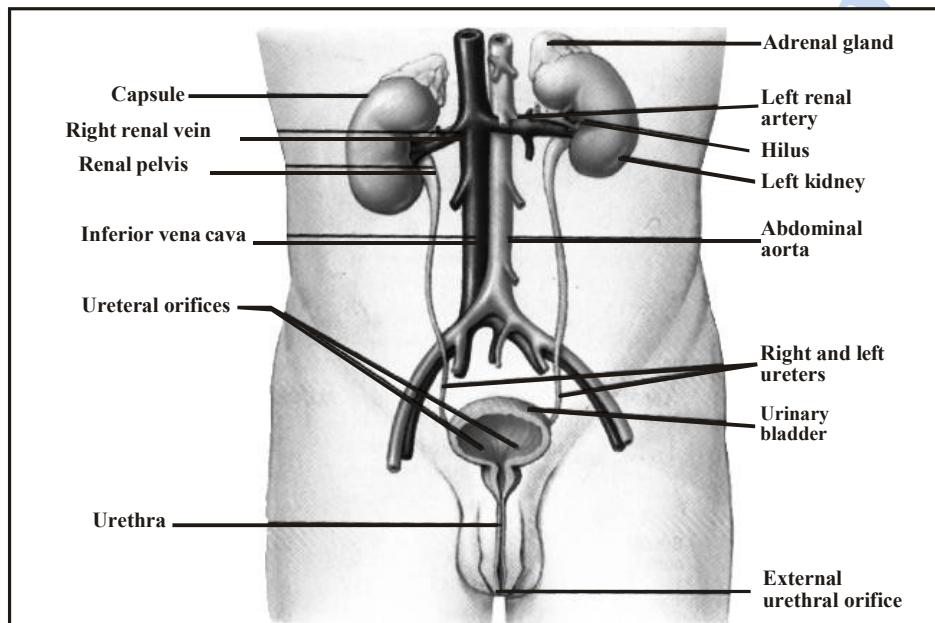
The function of kidney and blood in clearing wastes from body is very evident from the fact that weights of kidneys account for less than 1% of the total body weight

while it receive 20% of blood supplied with each cardiac beat.

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**(ii) Passage of Urine from Pelvis to Outside the Body:**

Following filtration of blood and further processing through tubular system urine is collected in a central cavity of the kidney, **pelvis**. Urine leaves the kidney through a duct **ureter**. The ureters of both the kidneys drain into **urinary bladder** through ureteral orifice. Urine leaves the body, during urination, from the bladder through a tube called the **urethra**, which empties near the vagina in females or through the penis in males. Sphincter muscles near the junction of the urethra and the bladder control the urine in bladder.



**Human urinary system**

## NEPHRON

The functional units, nephrons, in human kidneys are arranged along two distinct regions, an outer **cortex** and an inner **medulla**.

**(i) Type of nephron:**

**(a) Cortical Nephron:**

The nephrons arranged along the cortex are called as **cortical** nephron.

**(b) Juxtamedullary Nephron:**

Those arranged along the border of cortex and medulla with their tubular system looping deep in inner medulla are **juxtamedullary nephron**.

**Function:**

These juxtamedullary nephrons are specifically instrumental in the production of concentrated urine.

### (ii) Structure of nephron:

In each nephron inner end forms a cup-shaped swelling, called **Bowman's capsule** and it is around a ball of capillaries called **glomerulus**. Glomerulus circulates blood through capsule as it arrives through **afferent arteriole** and leaves the capsule by **efferent arterioles**. The blood vessel subdivides again into another network of capillaries, the **peritubular capillaries**. Bowman's capsule forms extensively convoluted **proximal tubule**, **loop of Henle** and the **distal tubule**, which empties into **collecting tubules**. The collecting tubules open into pelvis.

### (iii) Function (Urine formation)

The filtrate from glomerulus passes through these structures and is processed ultimately for urine formation. The peritubular capillaries intermingle with proximal and distal tubules of the nephron. In juxamedullary nephrons additional capillaries extend down to form a loop of vessels called **vasa recta**.

#### (a) Filtration:

Blood passing through glomerulus is filtered into Bowman's capsule. It is specifically filtered here, because glomerulus walls are porous, and the fraction of the blood pressure reaching here provides the **filtration pressure**. The filtrate appearing in glomerulus is called as **glomerular filtrate**, which contains numerous useful substances such as glucose, amino acids, salts etc., in aqueous solution.

#### (b) Reabsorption:

All the useful constituents of the glomerular filtrate are reabsorbed in proximal tubules and when filtrate leaves proximal tubules, it mostly contains nitrogenous wastes.

#### (c) Secretion:

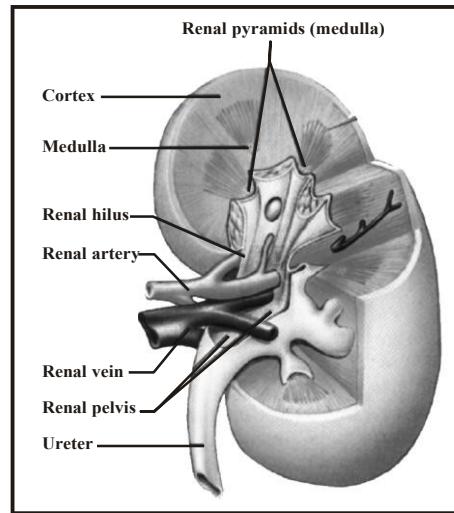
The tubular epithelium also secrete substances into the lumen, this secretion is very selective and is mainly of hydrogen ions to balance pH value of the filtrate passing through the tubule.

## CONCENTRATION OF EXCRETORY PRODUCTS

Mammalian kidney including human is adapted to conserve water by over 99.5% reabsorption of glomerular filtrate.

#### (i) Situation in Excess Water Supply:

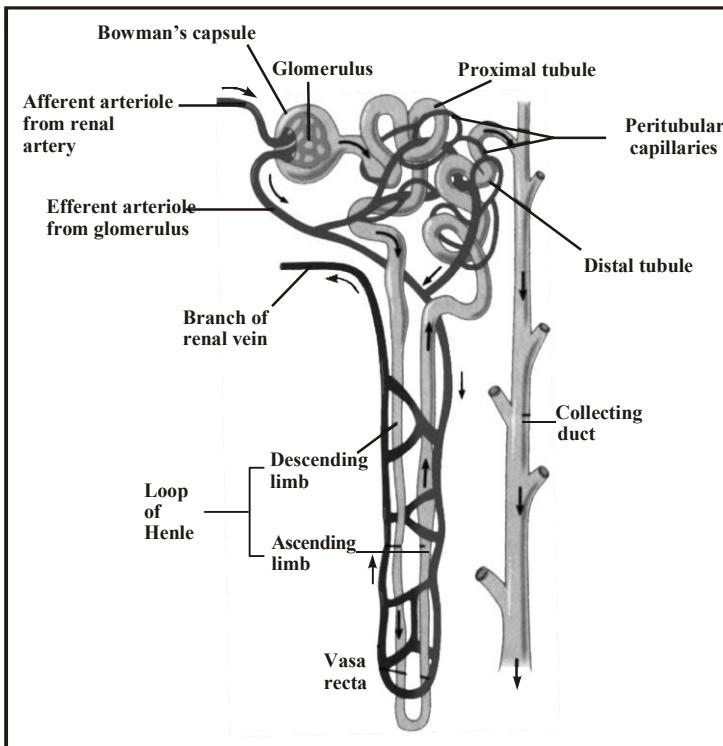
In the sufficient or excess supply of water, reabsorption of water from the filtrate is reduced, specifically due to inhibition of release of antidiuretic hormone in the presence of hyposmotic body fluids. The reduction in reabsorption causes large volumes of diluted urine.



The structure of a kidney

## (ii) Situation in Restricted Water Supply

In restricted supply of water, the conservation of water is the principal function of the body. This is done by concentration of the filtrate by counter current and hormonal mechanism.



### (a) Counter Current Multiplier:

The interstitial fluid of the kidney is gradually concentrated from cortical to medullary part, thus inner medulla is highly concentrated with the presence of urea and through a mechanism of **counter-current multiplier**. This mechanism caused gradual osmotic outflow of water from the filtrate back to kidney as it passes downward in the descending loop of Henle. Furthermore, ascending loop of Henle does not allow outflow of water from its filtrate, instead actively transports Na ions into kidney interstitium to sustain its high concentration. Gradually increasing osmotic concentration from cortex to inner medulla is a main factor for the production of hypertonic (concentrated) urine in mammals including human.

### (b) Hormones:

The active uptake of sodium in the ascending limb or thick loop of Henle is promoted by the action of **aldosterone**, the hormone secreted from **adrenal cortex**. The other site in the nephron, where reabsorption of water takes place is collecting tubules. **ADH** released from **posterior pituitary lobe** acts to actively transports water from filtrate in collecting tubules back to kidney.

### Kidney as Osmoregulatory Organ:

The production of varied concentrations of urine depending on the availability of water exhibits clearly that kidney functions as an osmoregulatory organ along its excretory role of nitrogenous wastes.

## KIDNEY PROBLEMS AND CURES

Unusual situations may arise in the function of kidney by factors originating within kidney or outside. These cause serious kidney diseases.

### 1. Kidney Stones:

#### (i) Definition:

Stony materials are found in the kidney and these cause urinary obstruction and are generally complicated by infections. These stones have specified chemical nature. These are formed in

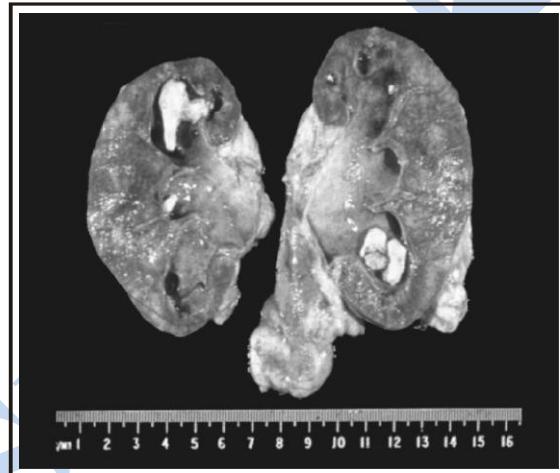
#### (iii) Sources:

metabolic disease.

#### (ii) Types of Kidney Stone:

(a) **Hypercalcemia** i.e., high level of circulating calcium in blood because of other diseases.

(b) **Hyperoxaluria** i.e., higher blood level of oxalates is other contributing factor in the formation



The kidney stones: Stone of phosphates are formed and trapped in the pelvis area.

Oxalates are present in green vegetables and tomatoes therefore may be the source of hyperoxaluria.

#### (iv) Incidence:

The incidence of calcium oxalate types stones are 70% of all the kidney stones. The incidence of other types of stones of calcium phosphate and of uric acid is 15% and 10% respectively.

#### (v) Formation:

These salts are precipitated out during urine formation and accumulate later to form stone.

### Treatment of Kidney Stone

#### Lithotripsy:

##### (i) Definition:

The kidney stones have been removed by kidney surgery. Presently **lithotripsy** is used for non-surgical removal of kidney stone. It is the technique used to break up stones that form in the kidney ureter or gall bladder.

**(ii) Method:**

The most common method is extracorporeal shock wave lithotripsy. High concentrations of X-ray or ultrasound are directed from a machine outside the body to the stone inside. The shock waves break the stone in tiny pieces or into sand, which are passed out of the body in urine.

**Renal Failure:****(i) Causes:**

Various pathological and chemical factors may destroy nephron, particularly glomerular part

**(ii) Effects:**

This results in increase of the plasma level of urea and other nitrogenous wastes causing complication of increase in rise of blood pressure and anemia

**DIALYSIS****(i) Introduction:**

In chronic renal failure, the function of the kidney is lost completely and now it can never remove nitrogenous waste. To remove nitrogenous wastes particularly the urea, the blood of the patient is treated through dialysis.

**(ii) Method:**

It cleans the blood either by passing it through an artificial kidney or by filtering it within abdomen. The wastes and excess water are removed during the treatment as being done by the healthy kidneys.

**(iii) Types:**

There are two types of dialysis: **hemodialysis** and **peritoneal dialysis**.

**(a) Hemodialysis** means ‘cleaning the blood’. In this procedure blood is circulated through machine which contains a **dialyzer** also called an aritcial kidney. Dialyzer has two spaces separated by thin mambrane. Blood passes from the blood through the membrane and dialysis fluid on the other. The wastes and excess water pass form the blood through the membrane into the dialysis fluid.

**(b) Peritoneal dialysis:**

Abdomen has a **peritoneal cavity**, lined by a thin epithelium called **peritoneum**. Peritoneal cavity is filled with dialysis fluid that enters the body through a catheter. Excess water and wastes pass through the peritoneum into the dialysis fluid. This process is repeated several times in a day.

**Kidney Transplant:**

In high degree of renal failure also called as **uremia** or **end-stage renal disease**, the dialysis has become difficult, thus the surgical transplantation of a matching donor kidney is the only option left as the permanent treatment.

## THERMOREGULATION

Control systems operate in organisms to cope with environment stresses including temperature extremes.

### THERMOGULATION IN PLANTS

Adaptations in Plants to Low and High Temperature.

#### HIGH TEMPERATURE

##### (i) Effects of High Temperature:

High temperature denature the enzymes and damages the metabolism therefore harms or kills the plants.

##### (ii) Adaptations Made by Plants:

(a) **Evaporation:** Plants use evaporative cooling to manage with high temperature.

##### (b) **Heat shock protein and its role:**

Hot and dry weather, however, causes water deficiency resulting in closing of stomata, thus plants suffer in such conditions. Most plants have adapted to survive in heat stress as the plants of temperate regions face the stress of 40°C and above temperature. The cells of these plants synthesize large quantities of special proteins called **heat-shock proteins**. These proteins cover enzymes and other proteins thus help in preventing denaturation.

#### LOW TEMPERATURE

(1) **Change in membrane fluidity:** In low temperature the fluidity of the cell membrane is altered, because lipids of the membrane become locked into crystalline structures, which affects the transport of the solutes. The structure of the membrane proteins is also affected.

##### (i) Adaptations:

(a) **Unsaturated fatty acid deposition in membrane:** Plants respond to cold stress by increasing proportion of unsaturated fatty acids, which help membrane to maintain structure at low temperature by preventing crystal formation. This adaptation requires time because of this reason rapid chilling to plants is more stressful than gradual drop in air temperature.

##### 2. **Ice Crystal Formation within Protoplasm:**

##### (i) **Effects:**

Freezing temperature causes ice crystal formation. The presence of ice formation around cell wall does not affect as badly and plants survive, however, formation of ice crystals within protoplasm perforates membranes and organelle hence killing the cells.

##### (ii) **Adaptation**

##### (a) **Change in cytoplasm to supercool:**

The plants native to cold region such as oaks, maples, roses and other plants have adapted to bring changes in solutes composition of the cells, which cause cytosol to super cool without ice formation, although ice crystals may form in the cell walls.

## THERMOREGULATION IN ANIMALS

### **Body Heat, heat Gain and Loss.**

#### **(i) Body heat:**

Temperature of an animal depends upon rate of change of body heat which in turn depends upon, a) the rate of heat production through metabolic process, b) the rate of external heat gain and rate of heat loss.

#### **(ii) Method of Heat Gain and Loss:**

##### **(a) Heat Gain:**

Principally, infrared thermal radiation and direct and reflected sunlight transfer heat into the animal.

##### **(b) Heat Loss:**

Whereas radiation and evaporation transfer heat out to the environment.

### **Temperature Classification of Animals:**

#### **1. Poikilothermic and Homeothermic Classification:**

##### **(i) Poikilothermic:**

These are animals in which body temperature tends to fluctuate more or less with surrounding temperature where air or water temperatures are changed. These are called **poikilotherms** and all **invertebrates, amphibians** and **reptiles** are considered in this category.

##### **(ii) Homeothermic:**

The animals which when exposed to changing air or water temperature maintain their body temperature are called the **homeotherms** and include **birds** and **mammals**.

##### **(iii) Objections on this Classification:**

**(a)** It is observed that deep sea fishes maintain their body temperature due to the constant natural surroundings.

**(b)** Lizards regulate their body temperature.

**(c)** Numerous birds and mammals vary their body temperature.

#### **2. Classification Based on Source of Heat Production:**

A more widely applicable temperature classification scheme is based on the source of heat production.

**(i)** **Endotherm:** According to this animals that generate their own body heat through heat production as by-product during metabolism are **endotherms** include **birds, mammal some fishes and flying insects**.

**(ii)** **Ectotherm** animals, which produce metabolic heat at low level and that is also exchanged quickly with the environment, however, absorb heat from their surroundings are called ectotherm. Most **invertebrates, most of fish, amphibians** and **reptile** are in this category.

**(iii)** **Heterotherms:** Those animals who are capable of varying degrees of endothermic heat production but generally do not regulate their body temperature within a narrow range e.g., **humming bird** etc.

## REGULATION OF HEAT EXCHANGE BETWEEN ANIMALS AND ENVIRONMENT

Animals use different mechanism for such regulation and these are of structural, physiological and behavioral nature.

(i) **Structural Adaptations:**

(a) **Pelage deposition:**

These may be long term changes in sub dermal fatty layer insulation and **pelage**.

(b) **Sweating and panting:**

The presence of **sweat glands** and lungs modified for **panting**.

(ii) **Physiological Adaptations:**

(a) **Increase and restricted supply of blood to skin:**

These regulate blood flow to the skin specifically greater blood flow in warmth to dissipate heat and lower in colds to economize heat loss.

(b) **Plumage Fluffing:**

Activation of certain muscles cause plumage fluffing. Similarly activation of sweat glands is done for evaporative cooling.

(iii) **Behavioral Adaptations:**

(a) **Minimizing heat exchange:**

These include moving of the animal to an environment where heat exchange between these is minimal e.g., ground squirrels move to burrow in midday heat and lizards bask in sun to gain heat in winter.

(b) **Controlling heat exchange by change in body posture:**

Animals also control the amount of surface area available for heat exchange by adjusting their postures.

## THERMOREGULATION IN MAMMALS (HUMAN)

### Regulatory Strategies:

(i) **Mammals and Advantages of Endothermy:**

Mammals including human maintain their high body temperature within a narrow range of about 36-38°C because of their endothermic characteristics. Due to this, a) they keep on high metabolic rate and availability of energy round the clock, b) it is helpful in better adaptations and distribution in different regions of the earth.

(ii) **Regulatory Mechanism:**

(a) **Shivering thermogenesis:**

The rate of heat production is increased by increased muscle contraction by movements or shivering, it is called as **shivering thermogenesis**.

(b) **Non-shivering thermogenesis:**

When hormones trigger the heat production (as do **thyroid** hormones) it is termed as **non-shivering thermogenesis**.

**(c) Depositon of brown fat:**

Some mammals possess brown fat, which is specialized for rapid heat production.

**(d) Skin an organ of thermoregulation:**

In mammals, skin has been adapted as the organ of thermoregulation.

**In Cold Temperature:**

Mammals have various mechanisms that regulate heat exchange with their environment.

**(i) Vasodilation and Vasoconstriction:**

These effect heat exchange and also cause temperature differences with in an animal. On a cool day a human's temperature may be several degrees lower in the arms and leg than in the trunk, where the most vital glands are situated.

**(ii) Fur Development:**

Most land mammals responds to cold by raising their furs thereby trapping the thicker layer of still air and it acts as good insulator between animal skin and the surroundings.

**(iii) Fat Below Skin:**

Human mostly rely on a layer of fat just beneath the skin as insulating material against heat loss.

**(iv) Blubber in Marine Mammals:**

Marine mammals such as whales and seals which inhabit much colder water than their body temperature, have a very thick layer of insulting fat called as blubber just under the skin.

**In Warm Temperature:**

**(i) Role of Skin in Marine Mammals:** Marine mammals dispose off their excess heat into warm seas by large number of blood vessels in the outer layer of the skin. This dissipates the heat form the skin surface.

**(ii) Terrestrial Animals and Evaporating Mechanism:** In terrestrial mammals, sweat gland activity and the evaporative cooling is the one of the major temperature reducing strategy.

**(iii) Role of Panting:** Panting, the evaporative cooling in the respiratory tract, is the other mechanism as represented in the dogs.

**(iv) Use of saliva and urine producing cooling.** Bats etc. use saliva and urine for evaporative cooling.

**THERMOSTAT FUNCTION AND FEEDBACK CONTROLS IN HUMAN****(i) Role of Hypothalamus:**

The body temperature regulation is based on complex homeostatic systems along with by feedback mechanisms. The homeostatic thermostat is present in the hypothalamus, a brain part. It responds to the changes in the temperature above and below a set point which is 37°C.

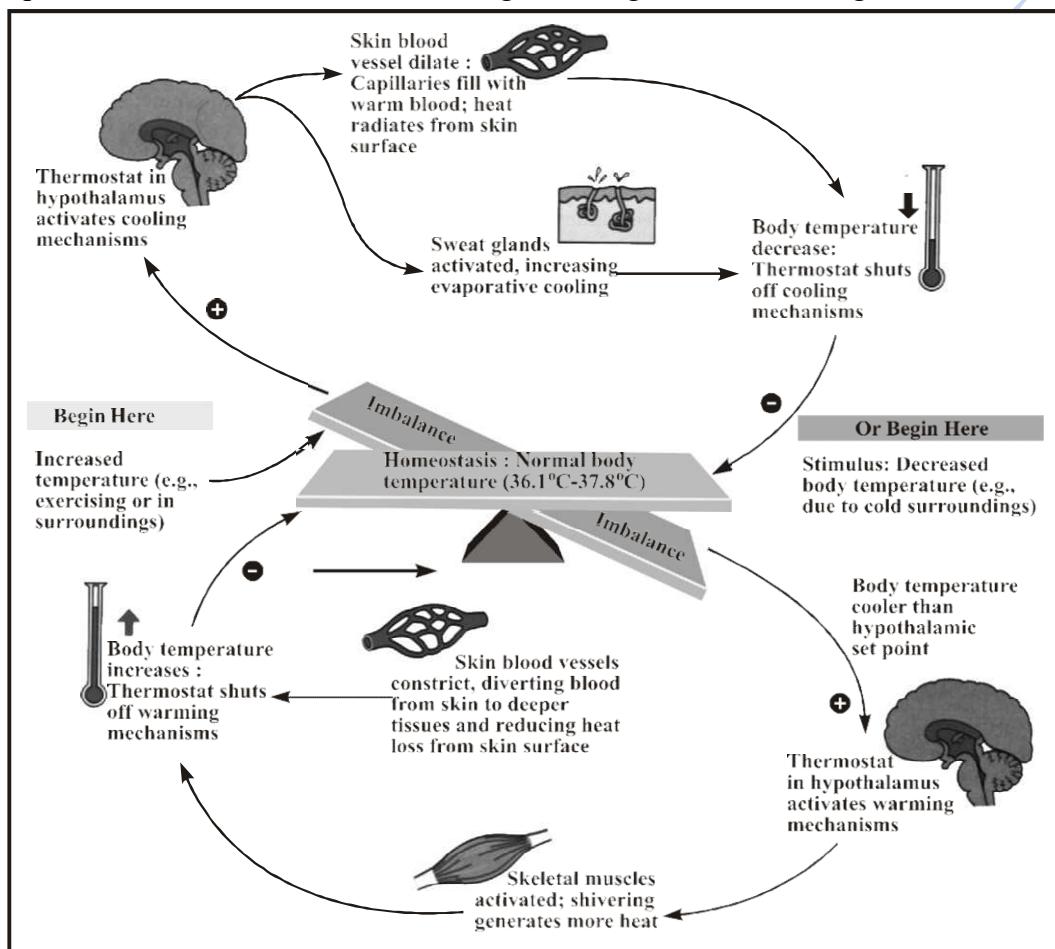
**(ii) In High Temperature:**

In case of increase in temperature above the set point, certain warm temperature sensitive thermo receptors in skin, hypothalamus and other parts of nervous systems send

the signals to the system that increase the blood flow to the skin and also cause sweat gland activation.

### (iii) In Cold Temperature:

In cold temperature, the cold receptors send the impulses to hypothalamus to inhibit heat loss mechanisms and activate the heat conservation mechanisms. This includes constriction of superficial blood vessels and stimulating shivering and non-shivering mechanism.



The thermostat function of the hypothalamus and feed back control mechanisms in human thermoregulation.

### Temperature in Fever (Pyrexin)

#### Pyrogens and its Role:

In bacterial and viral infections mainly, leukocytes increase in number. These pathogen; and the blood cells produce chemicals called as **pyrogens**. Pyrogens displace the set point of hypothalamus above the normal point of 37°C. Fever or high temperature helps in stimulating the protective mechanisms against the pathogens.

**Q.1 Fill in the blanks:**

- (i) \_\_\_\_\_ is the ability of an organism to regulate its fluid contents.
- (ii) The detoxification of ammonia excretion to \_\_\_\_\_ requires the precursor of ornithine.
- (iii) In kidney nephron is closely associated with network of \_\_\_\_\_.
- (iv) In insects salt and water reabsorption takes places in the organ \_\_\_\_\_.
- (v) The antidiuretic hormone act on \_\_\_\_\_ to promote.
- (vi) The nephrons arranged along the border of cortex and medulla with tubular system looping deep in the inner medulla, are called \_\_\_\_\_ nephrons.
- (vii) The non-surgical procedure of removing kidney stone is termed as \_\_\_\_\_.
- (viii) \_\_\_\_\_ is the homeostatic thermostat in human.

**ANSWERS**

(i) Osmoregulation	(ii) Urea
(iii) Blood capillaries	(iv) Rectum
(v) Collecting tubules	(vi) Juxtamedullary
(vii) Lithotripsy	(viii) Hypothalamus

**Q.2 Encircle the correct answer from the multiple choices:**

- (i) The protection of an internal environment from the harms of fluctuations is the definition of which of following:
  - (a) Osmoregulation
  - (b) Excretion
  - (c) Thermoregulation
  - (d) Homeostasis
- (ii) The category of the plants that has adaptations of small and thick leaves to limit water loss are called:
  - (a) Hydrophytes
  - (b) Xerophytes
  - (c) Mesophytes
  - (d) Hygrophytes
- (iii) The environment where the animals produce large volumes of diluted urine:
  - (a) Hypotonic aquatic
  - (b) Isotonic aquatic
  - (c) Hypertonic aquatic
  - (d) Terrestrial

ANSWERS

- |      |     |      |     |       |     |        |     |
|------|-----|------|-----|-------|-----|--------|-----|
| (i)  | (d) | (ii) | (b) | (iii) | (a) | (iv)   | (c) |
| (v)  | (b) | (vi) | (d) | (vii) | (c) | (viii) | (d) |
| (ix) | (b) | (x)  | (c) |       |     |        |     |

### ***Q.3 Short Questions:***

- (i) Differentiate between osmoconformers and osmoregulators.

**Ans: Osmoconformers:**

Animal body fluids are kept isotonic to the external environment even for marine saltwater environment. These animals thus do not require actively to adjust their internal osmotic state, so are known as **osmoconforms**.

### Examples:

- (1) Hag Fish (2) Most Marine Invertebrates

**Osmoregulators:**

In the animals whose body fluid concentrations differ noticeably with outside environment actively regulate to discharge excess water and excrete salts in hypotonic and hypertonic conditions respectively, therefore are called as **osmoregulators**.

**Example:**

Cartilaginous Fish.

- (ii) Define anhydrobiosis with an example.

**Ans. Anhydrobiosis:**

Terrestrial animals can tolerate dehydration and it differs in various animals. This characteristic is known as **anhydrobiosis**. Cammel can tolerate 25% dehydration.

- (iii) Why does filtration takes place only at glomeruli part of nephron and nowhere else?

**Ans:** Blood passing through glomerulus is filtered into Bowman's capsule. It is specifically filtered here, unlike at the other parts of the vessels, because glomerulus walls are porous, and the fraction of the blood pressure reaching here provides the **filtration pressure**.

- (iv) Mention two metabolic altered states that generally (70%) cause kidney stone formation.

**Ans:** 1. **Hypercalcemia** i.e., high level of circulating calcium in blood due to other diseases.

2. **Hyperoxaluria** i.e., higher blood level of oxalates is other contributing factor in the formation of calcium oxalate stones.

- (v) What is a renal failure?

**Ans:** The renal failure is the condition when kidney fails to remove nitrogenous wastes, it is also called end stage renal disease.

- (vi) Account one each main adaptation in plants to high and low temperatures.

**Ans:** Plants use **evaporative cooling** to manage with high temperature. Plants respond to cold stress by **increasing proportion of unsaturated fatty acids**.

**Q.4 Extensive Questions:**

- (i) Discuss nature of excretory products in animal to various habitats, specifically in association of water availability.

**Ans:** See text.

- (ii) Account the excretory system in earthworm.

**Ans:** See text.

- (iii) **Highlight the role of liver as an excretory organ.**  
Ans: See text.
- (iv) **Draw a labelled diagram of a vertebrate nephron with all blood supply. State the function of each part.**  
Ans: See text.
- (v) **Describe thermoregulatory strategies in mammals including human in cold temperature.**  
Ans: See text.
- (vi) **Discuss excretion in plants.**  
Ans: See text.
- (vii) **Discuss some kidney problems.**  
Ans: See text.