UNIT SIX

HOMEOSTASIS

Homeostasis as constancy of conditions in the living system

Homeostasis is any self-regulating process by which an organism tends to maintain stability while adjusting to conditions that are best for its survival. If homeostasis is successful, life continues; if it's unsuccessful, it results in a disaster or death of the organism. The "stability" that the organism reaches is rarely around an exact point (such as the idealized human body temperature of 37 °C [98.6 °F]). Stability takes place as part of a dynamic equilibrium, which can be thought of as a cloud of values within a tight range in which continuous change occurs. The result is that relatively uniform conditions prevail.

Any system in dynamic equilibrium tends to reach a steady state, a balance that resists outside forces of change. When such a system is disturbed, built-in regulatory devices respond to the departures to establish a new balance; such a process is one of feedback control. All processes of integration and coordination of function, whether mediated by electrical circuits or by nervous and hormonal systems, are examples of homeostatic regulation.

A familiar example of homeostatic regulation in a biological system is the control of body temperature in humans. In humans, normal body temperature fluctuates around the value of 37 °C (98.6 °F), but various factors can affect this value, including exposure, hormones, metabolic rate, and disease, leading to excessively high or low temperatures. The body's temperature regulation is controlled by a region in the brain called the hypothalamus. Feedback about body temperature is carried through the bloodstream to the brain and results in compensatory adjustments in the breathing rate, the level of blood sugar, and the metabolic rate. Heat loss in humans is aided by reduction of activity, by perspiration, and by heat-exchange mechanisms that permit larger amounts of blood to circulate near the skin surface. Heat loss is reduced by insulation, decreased circulation to the skin, and cultural modification such as the use of

clothing, shelter, and external heat sources. The range between high and low body temperature levels constitutes the homeostatic plateau—the "normal" range that sustains life. As either of the two extremes is approached, corrective action (through negative feedback) returns the system to the normal range.

What is Osmoregulation?

Osmoregulation is the process of regulating body fluids and its compositions. It maintains osmotic pressure of the blood and helps in the homeostasis. This is why it is recommended to consume more water about 2-3 litres which help in the proper functioning of our kidneys i.e. the proper balance of electrolytes in the human body. The intake is balanced by more or less equal excretion of fluids by urination, defecation, sweating, and, to a lesser extent, respiration. The body's organs and tissues are immersed in fluid at a constant temperature, pH, and solute concentration, each of which contributes to maintaining the body's homeostasis. The solutes in body fluids are mainly mineral salts and sugars. Osmotic regulation, or osmoregulation, keeps these solutes at the ideal concentrations. Osmotic homeostasis is thus maintained despite the influence of external factors such as temperature, diet, and weather conditions.

For example, we consume lots of water during hot weather but still, we urinate fewer times in such hot weathers than in cold weathers and the concentration of the urine is also more. The reason is that we lose lots of water from our body in hot weathers through sweating. Thus, to maintain the fluid balance in the body our kidneys reabsorb more water.

In animals, this process is brought about by osmoreceptors, which can detect changes in osmotic pressure. Humans and most other warm-blooded organisms have osmoreceptors in the hypothalamus. Besides the brain, osmoregulators are also found in the kidneys.

Need for Osmoregulation

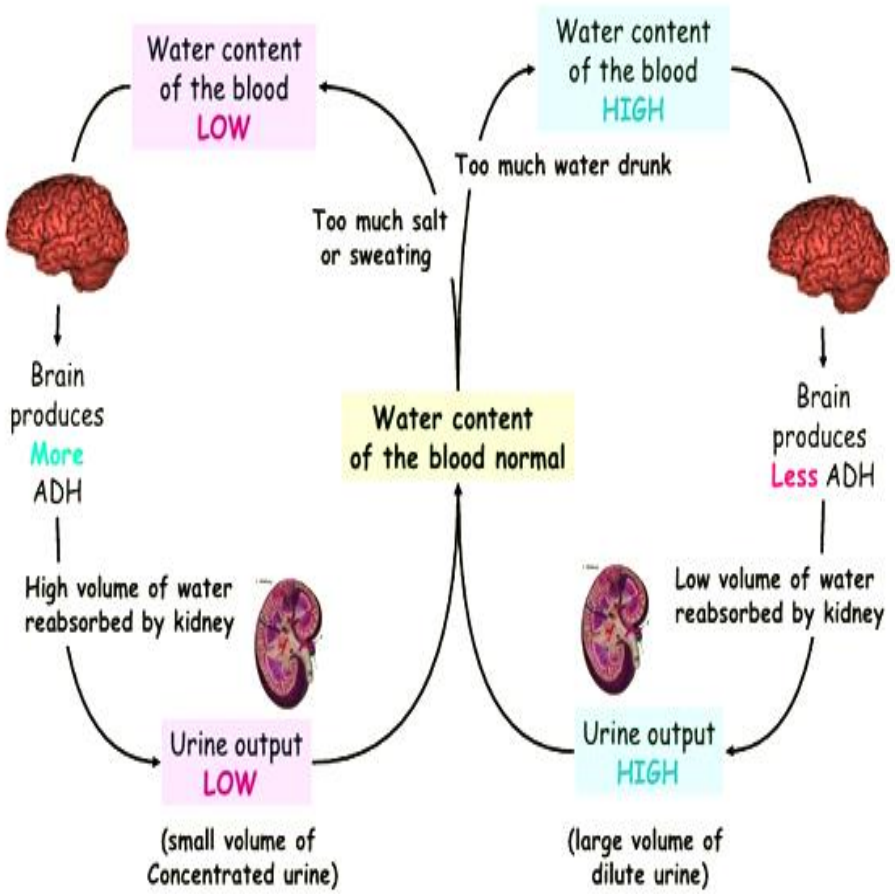
Complex multicellular animals exchange water and nutrients with the environment by consuming food and water, and by excreting sweat, urine, and feces. When disease or injury damage the mechanisms that regulate osmotic pressure, toxic waste or water may accumulate, with potentially dire consequences.

Mammalian systems have evolved to regulate osmotic pressure by managing concentrations of electrolytes found in the three major fluids: blood plasma, extracellular fluid, and intracellular fluid. Water movement due to osmotic pressure across membranes may change the volume of these fluid compartments. Because blood plasma is one of the fluid components, osmotic pressure can directly influence blood pressure and other medical indicators.

Osmoregulation in Humans

The kidney is the main organ responsible for osmoregulation in humans. Water, amino acids and glucose are reabsorbed by the kidneys. When the water level in the body is high, it releases a large amount of hypotonic urine. When the water level is low, it retains water and produces a low amount of hypertonic urine. Thus, the kidneys maintain the electrolytic balance of the body. Aldosterone, angiotensin II, and antidiuretic hormones (ADH) control the absorption process. Some water and electrolytes are also lost by perspiration.

Osmoreceptors in the hypothalamus of the brain control the thirst and secretion of ADH. ADH opens the water channels of aquaporins allowing the water to flow. Thus, the kidneys keep absorbing water until the **pituitary gland** stops releasing ADH



Osmoregulation in humans

Osmo-Regulation, Excretion and Maintenance of Acid-Base Balance

Urine Formation and Osmoregulation

Every one of us, including plants and animals, depend on the excretion process for the removal of certain waste products from our body. During the process of excretion, both the kidneys play an important role in filtering the blood cells.

Let us have an overview of urine formation and osmoregulation.

What is Excretion?

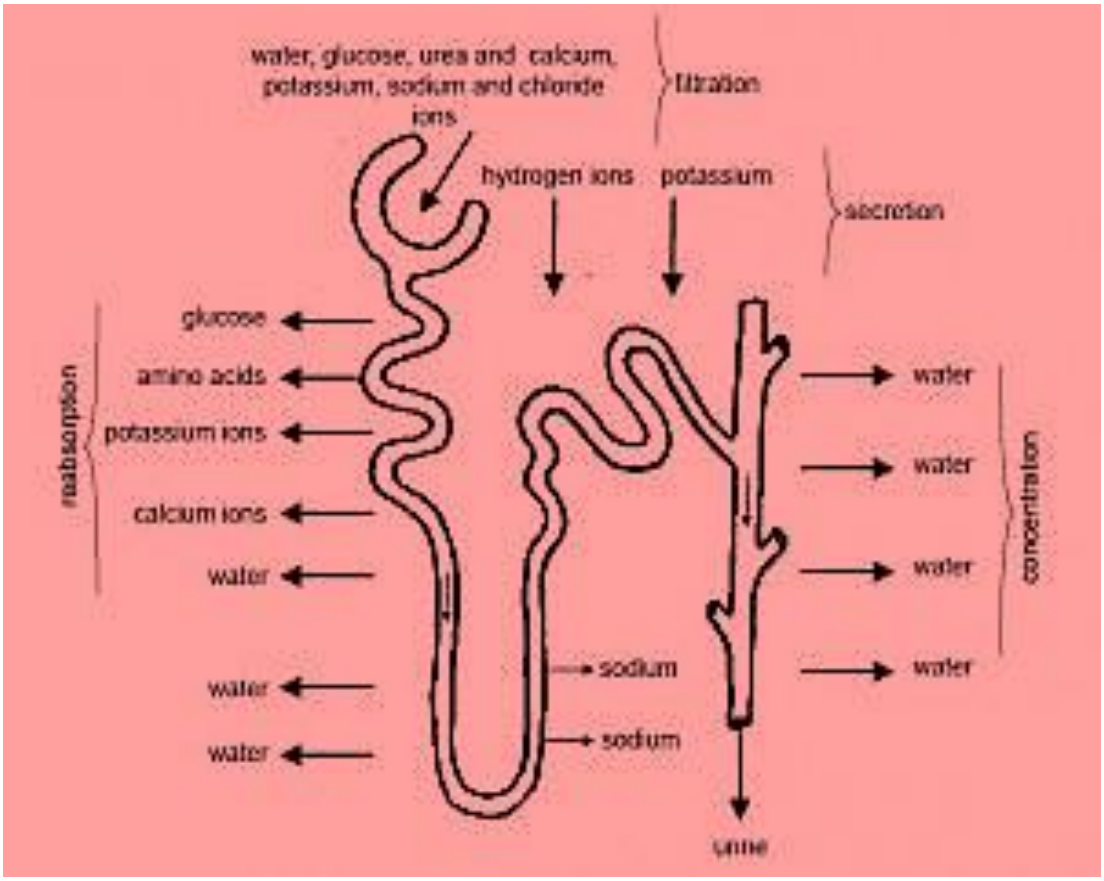
Excretion is a biological process, which plays a vital role by eliminating toxins and other waste products from the body. In plants and animals including humans, as the part of metabolism, lot

of waste products are produced. Plants usually excrete through the process of transpiration and animals excrete the wastes in different forms such as by urine, sweat, faeces, and tears. Among all these, the usual and the main form of excretion is the urine.

Urine Formation

Waste is excreted from the human body mainly in the form of urine. Our kidneys play a major role in the process of excretion. Constituents of normal human urine include 95 percent water and 5 percent solid wastes. It is produced in the nephron which is the structural and functional unit of the kidney. Urine formation in our body is mainly carried out in three phases namely

i. Glomerular filtration,
ii. Reabsorption
iii. Secretion.



Urine formation

Mechanism of Urine Formation

The mechanism of urine formation involves the following steps:

i. Glomerular Filtration

Glomerular filtration occurs in the glomerulus where blood is filtered. This process occurs across the three layers- epithelium of Bowman's capsule, endothelium of glomerular blood vessels, and a membrane between these two layers.

Blood is filtered in such a way that all the constituents of the plasma reach the Bowman's capsule, except proteins. Therefore, this process is known as ultrafiltration.

ii. Reabsorption

Around 99 percent of the filtrate obtained is reabsorbed by the renal tubules. This is known as reabsorption. This is achieved by active and passive transport.

iii. Secretion

The next step in urine formation is the tubular secretion. Here, tubular cells secrete substances like hydrogen ion, potassium ion, etc into the filtrate. By this process, the ionic, acid-base and the balance of other body fluids are maintained. The secreted ions combine with the filtrate and form urine. The urine passes out of the nephron tubule into a collecting duct.

Urine

The urine produced is 95% water and 5% nitrogenous wastes. Wastes such as urea, ammonia, creatinine are excreted in urine. Apart from these, the potassium, sodium and calcium ions are also excreted.

Key Points on Urine Formation and Osmoregulation

i. Urine is formed in three main steps- glomerular filtration, reabsorption and secretion.
ii. It comprises 95 % water and 5% wastes such as ions of sodium, potassium and calcium, and nitrogenous wastes such as creatinine, urea and ammonia.

iii. Osmoregulation is the process of maintaining homeostasis of the body.

iv. It facilitates diffusion of solutes and water across the semi-permeable membrane thereby maintaining osmotic balance.

v. The kidney regulates the osmotic pressure of blood through filtration and purification by a process known as osmoregulation