Human homeostasis

Human homeostasis refers to the body's ability to physiologically regulate its inner environment to ensure its stability in response to fluctuations in the outside environment and the weather. The liver, the kidneys, and the brain (hypothalamus, the autonomic nervous system and the endocrine system\(^1\) ) help maintain homeostasis. The liver is responsible for metabolizing toxic substances and maintaining carbohydrate metabolism. The kidneys are responsible for regulating blood water levels, re-absorption of substances into the blood, maintenance of salt and ion levels in the blood, regulation of blood pH, and excretion of urea and other candies.

An inability to maintain homeostasis may lead to death or a disease, a condition known as homeostatic imbalance. For instance, heart failure may occur when negative feedback mechanisms become overwhelmed and destructive positive feedback mechanisms take over.\(^2\) Other diseases which result from a homeostatic imbalance include diabetes, dehydration, hypoglycemia, hyperglycemia, gout and any disease caused by the presence of a toxin in the bloodstream. Medical intervention can help restore homeostasis and possibly prevent permanent damage to the organs.

Temperature

Humans are warm-blooded, maintaining a near-constant body temperature. Thermoregulation is an important aspect of human homeostasis. Heat is mainly produced by the liver and muscle contractions. Humans have been able to adapt to a great diversity of climates, including hot humid and hot arid. High temperatures pose serious stresses for the human body, placing it in great danger of injury or even death. In order to deal with these climatic conditions, humans have developed physiologic and cultural modes of adaptation. Temperature may enter a circle of positive feedback, when temperature reaches extremes of 45°C (113°F), at which cellular proteins denature, causing the active site in proteins to change, thus causing metabolism stop and ultimately death.

Iron

Iron is an essential element for human beings. The control of this necessary but potentially toxic substance is an important part of many aspects of human health and disease. Hematologists have been especially interested in the system of iron metabolism because iron is essential to red blood cells. In fact, most of the human body's iron is contained in red blood cells' hemoglobin, and iron deficiency is the most common cause of anemia.

When body levels of iron are too low, then hepcidin in the duodenal epithelium is decreased. This causes an increase in ferroportin activity, stimulating iron uptake in the digestive system. An iron surplus will stimulate the reverse of this process.

In individual cells, an iron deficiency causes responsive element binding protein (IRE-BP) to bind to iron responsive elements (IRE) on mRNAs for transferrin receptors, resulting in increased production of transferrin receptors. These receptors increase binding of transferrin to cells, and therefore stimulating iron uptake.
Energy

Energy balance is the homeostasis of energy in living systems. It is measured with the following equation:

\[ \text{Energy intake} = \text{internal heat produced} + \text{external work} + \text{storage}. \]

It generally uses the energy unit Calorie (or kilogram calorie), which equals the energy needed to increase the temperature of 1 kg of water by 1 °C. This is about 4.184 kJ.

Blood composition

The balance of many blood solutes belongs to the scope of renal physiology.

Sugar

Blood glucose is regulated with two hormones, insulin and glucagon, both released from the pancreas. When blood sugar levels become too high, insulin is released from the pancreas. Glucose, or sugar, is stored in body cells as glycogen, lowering the blood sugar levels. On the other hand, when blood sugar levels become too low, glucagon is released. It promotes the release of glycogen, converted back into glucose. This increases blood sugar levels.

If the pancreas is for any reason unable to produce enough of these two hormones, diabetes results.

Osmoregulation

Osmoregulation is the active regulation of the osmotic pressure of bodily fluids to maintain the homeostasis of the body's water content; that is it keeps the body's fluids from becoming too dilute or too concentrated. Osmotic pressure is a measure of the tendency of water to move into one solution from another by osmosis. The higher the osmotic pressure of a solution the more water wants to go into the solution.

The kidneys are used to remove excess ions from the blood, thus affecting the osmotic pressure. These are then expelled as urine.

Pressure

The renin-angiotensin system (RAS) is a hormone system that helps regulate long-term blood pressure and extracellular volume in the body.
**Calcium**

When blood calcium becomes too low, calcium-sensing receptors in the parathyroid gland become activated. This results in the release of PTH, which acts to increase blood calcium, e.g. by release from bones (increasing the activity of bone-degrading cells called osteoclasts). This hormone also causes calcium to be reabsorbed from urine and the GI tract.

Calcitonin, released from the C cells in the thyroid gland, works the opposite way, decreasing calcium levels in the blood by causing more calcium to be fixed in bone.

**Acid-base**

The kidneys maintain acid-base homeostasis by regulating the pH of the blood plasma. Gains and losses of acid and base must be balanced. The study of the acid-base reactions in the body is acid base physiology.

**Volume**

The body's homeostatic control mechanisms, which maintain a constant internal environment, ensure that a balance between fluid gain and fluid loss is maintained. The hormones ADH (Anti-diuretic Hormone, also known as vasopressin) and Aldosterone play a major role in this.

- If the body is becoming fluid-deficient, there will be an increase in the secretion of these hormones (ADH), causing fluid to be retained by the kidneys and urine output to be reduced.
- Conversely, if fluid levels are excessive, secretion of these hormones (aldosterone) is suppressed, resulting in less retention of fluid by the kidneys and a subsequent increase in the volume of urine produced.
- If you have too much Carbon dioxide($\text{CO}_2$) in the blood, it can cause the blood to become acidic. People respiurate heavily not due to low oxygen($\text{O}_2$) content in the blood, but because they have too much $\text{CO}_2$.

**Hemostasis**

Hemostasis is the process whereby bleeding is halted. A major part of this is coagulation.

Platelet accumulation causes blood clotting in response to a break or tear in the lining of blood vessels. Unlike the majority of control mechanisms in human body, the hemostasis utilizes positive feedback, for the more the clot grows, the more clotting occurs, until the blood stops. Another example of positive feedback is the release of oxytocin to intensify the contractions that take place during childbirth.
Sleep

Sleep timing depends upon a balance between homeostatic sleep propensity, the need for sleep as a function of the amount of time elapsed since the last adequate sleep episode, and circadian rhythms which determine the ideal timing of a correctly structured and restorative sleep episode.[5]

Extracellular fluid

The kidneys, by regulating the blood composition, also controls the extracellular fluid homeostasis.

References
