Switching thirst off

A study by a group of scientists has revealed a hierarchy in the structure of the brain, which regulates water ingestion by the body

S ANANTHANARAYANAN

There are chemical sensors and messengers that detect when the body needs water and get the body to do something about it by creating the feeling of thirst. The body dutifully seeks water and drinks. But it takes time for water to reach the bloodstream and then to the body cells that are starved of water. So what is it that tells the body to stop drinking when it has drunk enough?

Vineet Augustine, Sertan Kutal Gokce, Sangjun Lee, Bo Wang, Thomas J Davidson, Frank Reimann, Fiona Gribble, Karl Deisseroth, Carlos Lois and Yuki Oka from the California Institute of Technology, the University of California, Stanford University and the University of Cambridge, in the journal, *Nature*, describe their study of the mechanism. They find that while the thirst signal has a chemical origin and the surfeit signal has a mechanical origin, there is an arrangement by which the second kind of signal suppresses the response to the first.

It is needless to state that the complexity of the processes going on in the body would dwarf that of other systems — manmade chemical factories, computers and machinery or the interplay of market forces. Most of the processes in the body are chemical and there is need to maintain the necessary conditions of temperature, saltiness, acidity and the concentration of components, including the available water content. This balance of parameters is called homeostasis.

The human body has a huge number of conditions that have to stay within narrow limits all the time. And there is a complex system of sensors, control centres and effectors that regulate the levels, which is necessary for the body to function without disease and often to function at all. The regulation is done through organs that act as the sensor of what needs control, the control centre and then the organ that brings about the control.

An example of the trio is the mechanism to control the sugar level in the bloodstream. The liver has the marked ability and the function of extracting glucose from the bloodstream or of pouring glucose back into the bloodstream. The liver is thus the effecter.

The liver needs a signal from the control centre to get into action. The signal is the level of insulin in the bloodstream. When there is insulin, the liver absorbs sugar and when the insulin level drops, it puts sugar back into the bloodstream. The control centre, which secretes the insulin, is the pancreas and it acts through cells that sense the level of sugar in the bloodstream.

When the sugar content is at its normal level, there is no secretion of insulin and other cells, liver cells particularly, do not absorb glucose from the bloodstream. And then, when the glucose level drops below normal, the pancreas produces glucagon, which prompts the liver to act in reverse, by using its store of energy to created glucose units and glucose alternatives for different cells to use.

While the control of sugar is an example of maintaining homeostasis, there are a great many other substances whose levels and concentration need to be controlled. And the mother substance for most cell processes is water. When the amount of water in the bloodstream falls, the water content of cells diffuses through the cell walls and the water contents of cells gets depleted. This can disable all kinds of body processes and needs to be reversed as soon as possible.

While the brain does not have blood flow in the normal sense, there are clusters of cells that are attached to the brain and do have normal blood supply. When the glucose levels drop, these cells detect the change and communicate the condition to the brain. The brain then sends "thirst" signals to different parts of the body, and the person or animal responds by drinking water.

The paper in *Nature* explains that the role of the cells in the brain that receive the signals of the levels of the body water content has been verified by artificial stimulation of these cells, leading to drinking water. This balance of parameters is called homeostasis.

The question that now arises is, how do the cells attached to the brain, and hence the brain, know that the person or animal has drunk enough water and the sensation of thirst can be turned off? It would take some time, typically a few minutes, for the water that has entered the body to be absorbed and to enter the bloodstream and then the cells. If the sensation of thirst persists, the person would drink too much water, leading to dilution of the bloodstream and the swelling of cells, like prunes soaked in clear water. The cell processes would also be affected by dilution of the cell contents.

The authors of the paper in *Nature* then studied the factors that inhibit the desire to drink, or the suppression of thirst. Using methods of blanking different brain components and imaging the activity of others, they identified a glucagon-like main factor that inhibited the action of cells that were first activated when the water content dropped. They found that this factor was acutely activated when the animal started the physical action of drinking — even of lightly salted water or a liquid that was not water.

As a control test, it was found that this factor responded when a food-deprived mouse licked a source of sucrose solution, but not when it was given solid peanut butter, which was equally nutritious. It was clear that the factor was activated by the physical action of ingesting a fluid and this did not depend on the nature of the fluid. The factor was not activated even if the animal gently sipped real water, the gulping action was necessary. "These neurons act like fluid flow-metres that tell the brain when the body has had enough to drink. This circuit may be the reason why the brain knows how to stop drinking well before the stomach has fully absorbed all the water an animal has drunk," says Vineet Augustine, one of the authors of the paper.

The value of the study is that it has revealed a hierarchy in the structure of the brain, which regulates water ingestion by the body. This is important as the regulation of the body's water content is the issue in a number of diseases, like diabetes, control of blood pressure, and even schizophrenia.

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Performing critical functions

Here's a look at the endocrine and paracrine hormone systems

TAPAN KUMAR MAITRA

To regulate the function of various cells and tissues, both plants and animals use chemical signals called hormones. Hormones are chemical messengers secreted by one tissue that regulate the function of other cells or tissues in the same organism. In contrast to growth factors, hormones often act over large distances. In plants and animals, hormones are often transported via the vasculature. Hundreds of different hormones regulate a wide variety of functions, many critical for maintaining the physiological steady state of an organism.

Though it can consider them as a group based on their regulatory functions, hormones differ in many ways. Some hormones are steroids or other hypdrophobic molecules that are targeted to intracellular receptors. Others, such as adrenergic hormones, are targeted to a wide variety of different G protein-linked receptors.

Both plants and animals produce a wide array of hormones. For example, plants produce steroid hormones called brassinosteroids that regulate leaf growth. Similarly, the organic molecule ethylene regulates ripening of fruit, and abscicic acid causes the closing of stomata during drought conditions.

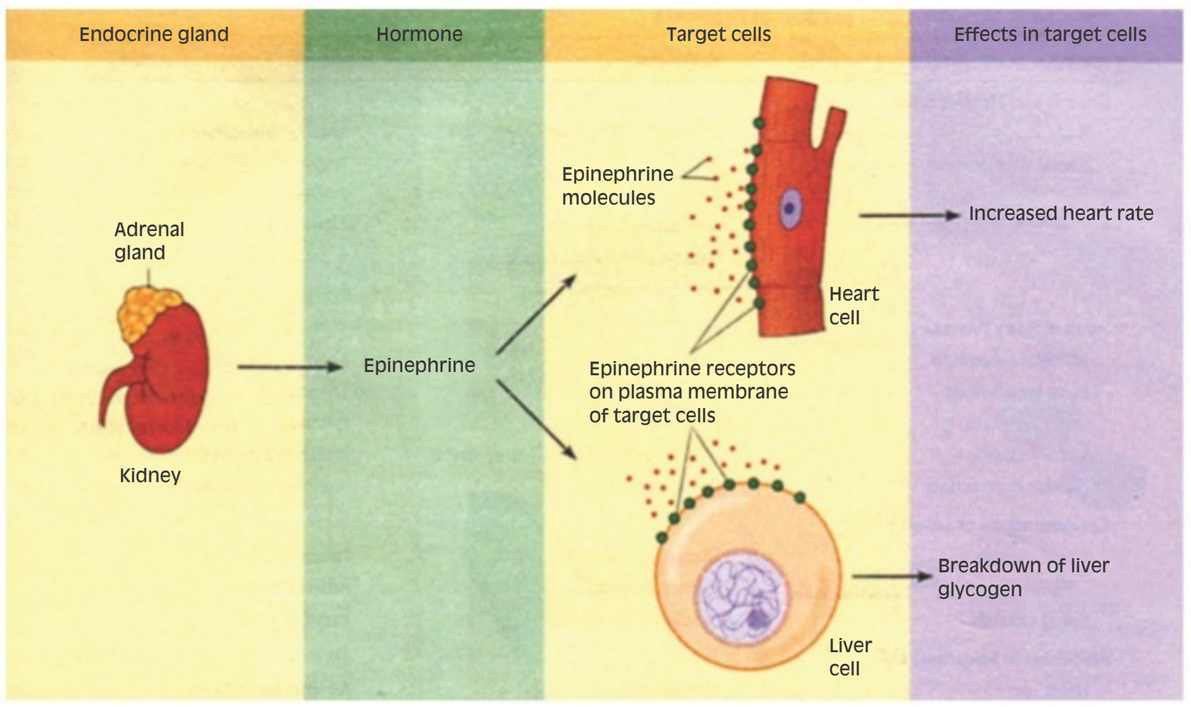
Hormonal signals can be classified by the distance they travel to their target cells. Even animal hormones can be placed in one of two categories depending on the distance over which it operates.

An endocrine hormone travels by means of the circulatory system from the cells where it is released to other cells, where it regulates one or more specific functions. A paracrine hormone is a more local signal that is taken up, destroyed, or immobilised so rapidly that it can act only on cells in the immediate environment.

Endocrine hormones are synthesised by the endocrine tissues of the body and are secreted directly into the bloodstream. Once secreted into the circulatory system, endocrine hormones have a limited life span, ranging from a few seconds for epinephrine (a product of the adrenal gland) to many hours for insulin.

As they circulate in the bloodstream, hormone molecules come into contact with receptors in tissues throughout the body. A tissue that is specifically affected by a particular hormone is called a target tissue for that hormone. For example, the heart and the liver are target tissues for epinephrine, whereas the liver and skeletal muscles are targets for insulin.

Hormones regulate a wide range of physiological functions, including growth and development, rates of body processes, concentrations of substances, and responses to stress and injury. For example in humans, somatotropin is involved in the regulation of overall growth of the body, whereas androgens and estrogens, the sex hormones, control the differentiation of tissues and the consequent attainment of secondary sex characteristics. Thyroxine regulates the rate at which the body makes energy available and is therefore an example of a rate-controlling hormone.



Cells in a target tissue have hormone-specific receptors embedded in their plasma membranes (or, in the case of the steroid hormones, present in the nucleus or cytosol). Heart and liver cells can respond to epinephrine synthesised by the adrenal glands because these cells have epinephrine-specific receptors on their outer surfaces. A specific hormone may elicit different responses in different target cells. Epinephrine causes an increase in heart rate but stimulates glycogen breakdown in the liver.

Hormones that control the concentrations of substances include insulin (control of blood glucose level), aldosterone (control of blood sodium and potassium levels), and parathyroid hormone (control of blood calcium level). The body's response to stress is regulated by epinephrine, norepinephrine, and cortisol, and its response to local injury is regulated by the release of histamine and the production of prostaglandins.

Hormones can be classified not only according to function and the distances over which they act, but also according to their chemical properties. Chemically, the endocrine hormones fall into four categories — amino acid derivatives, peptides, proteins, and lipid-like hormones such as steroids. An example of an amino acid derivative is epinephrine, derived from tyrosine. Antidiuretic hormone (also called vasopressin) is an example of a peptide hormone, whereas insulin is a protein. Testosterone is an example of a steroid hormone. The steroid hormones are derivatives of cholesterol that are synthesised either in the gonads (the sex hormones) or in the adrenal cortex (the corticosteroids).

Examples of paracrine hormones are histamine and the prostaglandins. Histamine is produced by decarboxylation of the amino acid histidine and is responsible for local inflammatory responses. The prostaglandins, so named because they were first identified in human semen as a secretion of the prostate gland, are derived from arachidonic acid and are important in smooth muscle function.

Paracrine hormones are substances secreted by cells that affect other cells a short distance away. In this case, the messenger clearly has a limited range of action. One example of a messenger commonly classified as a paracrine hormone is prostaglandin. Typically, the prosta-glandins act on G protein-linked receptors to stimulate either the cAMP or the inositol-trisphosphate-calcium second messenger pathway. Prostaglandins have a variety of effects, many of which involve smooth muscle.

For example, prostaglandins contained in semen stimulate uterine smooth muscle contraction, which helps transport sperm to the egg. Prostaglandins also help to initiate smooth muscle contraction during labour and can be used to induce labour clinically.

Some prostaglandins cause smooth muscle relaxation and can, for example, cause bronchiole dilation or lowering of blood pressure. Prostaglandins are also important in the activation of blood platelets, essential components of the blood-clotting mechanism that plug sites where blood vessels are ruptured.

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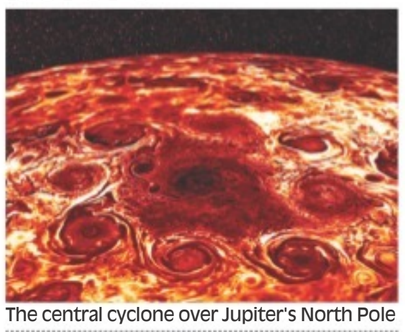

The central cyclone over Jupiter's North Pole

Jupiter is covered in intense, massive storms far more complex than anyone had expected, Nasa has revealed.

The geometric clusters of cyclones that cover the planet's poles are just one of the various discoveries reported by scientists studying data sent back from Nasa's Juno spacecraft, which is circling the planet.

The team has seen the cyclones churning in Jupiter's deep atmosphere in far greater detail than ever before. One group uncovered a constellation of nine cyclones over Jupiter's North Pole and six over the South Pole. The wind speeds exceed Category 5 hurricane strength in places, reaching 220 mph (350 kph). The massive storms haven't changed position much — or merged — since observations began.

Team leader Alberto Adriani of Italy's National Institute for Astrophysics in Rome was surprised to find such complex structures. Scientists thought they'd find something similar to the six-sided cloud system spinning over Saturn's North Pole. "We were wrong about it," he said via email.

Instead, they found an octagon-shaped grouping over the North Pole, with eight cyclones surrounding one in the middle, and a pentagon-shaped batch over the South Pole. Each cyclone measures several thousand kilometers across.

The fifth planet from our sun, gas giant Jupiter is by far the largest planet in our solar system. Launched in 2011, Juno has been orbiting Jupiter since 2016 and peering beneath the thick ammonia clouds. It's only the second spacecraft to circle the planet after Galileo did it from 1995 to 2003.

The Independent

Beware of 'Disease X'

The World Health Organisation has added a mysterious "Disease X" to a list of viruses it fears could cause a global pandemic in the future. The organisation released a list of diseases it considers pose a high risk to the public due to their potential to spark an epidemic and the limited treatment available to combat them.

Virus such as Ebola, Zika, Lassa fever and severe acute respiratory syndrome (Sars), which have all seen outbreaks in recent years, are included as serious threats.

However, the WHO has included the ominous-sounding Disease X to its priority list for the first time this year after a review by health experts in February. Disease X is in fact not a newly-discovered threat in itself, but a hypothetical virus, which could emerge in the future and cause widespread infection across the globe.

"Disease X represents the knowledge that a serious international epidemic could be caused by a pathogen currently unknown to cause human disease", the WHO said in a statement.

It added healthcare officials were planning for a currently unidentified threat now to ensure, "research and development preparedness that is relevant for an unknown Disease X as far as possible."

"History tells us that it is likely the next big outbreak will be something we have not seen before", John-Arne Rottingen, chief executive of the Research Council of Norway and a scientific adviser to the WHO committee told The Telegraph.

Rottingen said Disease X could come from a variety of sources, although it was most likely developed through zoonotic transmission, where an infectious disease which usually afflicts animals jumps to humans.

The WHO said several other groups of diseases, such as haemorrhagic fevers and emergent non-polio enteroviruses, were omitted from its priority list. It did however say these pathogens did post a serious risk to public health and need to be "watched carefully" and potentially considered for inclusion next year.

The Independent