THE ENDOCRINE SYSTEM

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The Endocrine system consists of ductless glands which secrete chemical messengers – hormones- directly into the blood stream. The hormones have highly specialized effects on various organs and systems of the body.
The endocrine system is controlled mainly by the hypothalamus, a prune-sized organ, pink and grey in colour, located just below the brain in the middle of the head.

I. The hypothalamus receives a richer supply of blood than any other part of the body and its cells are extremely sensitive to the presence and concentration of hormones in the blood, as well as to blood temperature, the concentration of minerals and water, of glucose, and to any change brought about by stress. A. The hypothalamus itself secretes two hormones which pass through the stalk by which the pituitary gland is attached to it down into the posterior lobe of the pituitary gland. When the cells of the hypothalamus perceive the need for these hormones in the body, they send releasing factors (RF) through the stalk to the pituitary gland with a signal to excrete the appropriate hormones.

1. One of these hormones is vasopressin. This is anti-diuretic. It keeps the kidneys from removing too much water from the blood. A shortage of vasopressin allows the passage of large amounts of pale dilute urine. If the loss of water is excessive thirst is felt. If morbid, it is called diabetes insipidus.
2. The other hormone is oxytocin. In women this causes contraction of the womb during orgasm and in childbirth. It also releases milk in the breasts in response to suckling, thus controlling its excretion. In men, the role of oxytocin is uncertain, but it may also be linked with orgasm.

B. The hypothalamus also secretes six releasing factors to the anterior lobe of the pituitary gland. These control the excretion of six corresponding hormones by the pituitary gland according to the need for them as perceived by the hypothalamus.
In these ways, the hypothalamus acts as the feed-back system which enables the body to maintain or restore a state of balance (homeostasis) as far as possible no matter what demands are made of it. The general term for such demands is stress. The hypothalamus also has extensive connections, direct and indirect, with the nervous system.

II. The Pituitary gland is located just below the hypothalamus and is attached to it by a short stalk through which it receives its messengers or messages. The pituitary gland is ovid in shape, has two lobes, and weighs about 0.6 gr. (1/50th oz). It secretes less than a millionth of a gram of hormones per day. They are at least 8, probably 10 in number. Six produced by the anterior lobe are as follows:

1. The growth hormone: it raises and conserves the concentration of glucose in the blood by making cells other than brain and liver cells impervious to glucose and thus keeping them from using glucose for fuel. At the same time, it stimulates the breakdown of fat into fatty acids so it can be used as fuel in place of glucose. Growth factor counterbalances the effect of insulin which stores excessive glucose away in the liver and muscles as glycogen and fat. Growth factor also stimulates the synthesis of protein from amino acids for many purposes.
2. Prolactin: this hormone prepares a pregnant woman's breasts for milk production and causes milk to be secreted by the milk glands.
3. Thyroid stimulating hormone (TSH). It stimulates the thyroid gland to secrete thyroxine and calcitonin.
4. Adrenocorticotropic hormone (ACTH): It stimulates the adrenal/cortex (outer layer) to secrete the cortisol group of hormones.
5. Follicle stimulating hormone (FSH): It stimulates the hundreds of thousands (or millions) of primitive follicles in the ovaries of a girl at birth to produce oestrogen. This controls the development of the reproductive organs to maturity and then determines the sexual cycle and fertility. Oestrogen is responsible for the woman's secondary sexual characteristics such as enlargement of the breasts, growth of pubic and axillary hair, a general rounding and softening of the figure, and a typical feminine outlook on life.

6. Luteinizing hormone (LH): it helps the cells at the surface of the ovarian follicle after ovulation to form the corpus luteum which in turn secretes progesterone.

lll. **The Thyroid gland**: it is located in the lower throat, just below and to both sides of the larynx (Adam's Apple). It weighs about two thirds of an ounce (20 grams) and produces less than a hundred thousandths of an ounce of thyroxine a day, all under the control of TSH from the pituitary.

A. Thyroxine

1. Thyroxine determines the rate at which the body burns up energy. This is called the metabolic rate. Thyroxine is essential in plentiful but not too abundant amounts for normal development of body and mind. It works together with the growth hormone and with insulin in accomplishing this purpose. At the same time it requires much iodine for its own construction. Both thyroxine and calcitonin (the second thyroid hormone) contain about two –thirds iodine.
2. Thyroxine enables adrenaline and the sympathetic nervous system to work effectively. The heartbeat rate increases and decreases as more or less thyroxine is produced.
3. Thyroxine affects the level of cholesterol in the blood by lowering it.
4. Thyroxine helps convert carotene into vitamin A. A yellow tinge in the skin may denote a deficiency of thyroxine.
5. A shortage of thyroxine causes the hair to go thin, the skin to become course and dry. Other effects of a shortage are lethargy, slowness of movement, thought and speech, intolerance of cold, constipation, a tendency to put on weight, hoarseness of throat. It may also cause myxoedema which is characterized by the accumulation of jelly-like substance in the sub-cutaneous tissues of the face and lower legs. All these symptoms and changes are reversible – though hair regeneration may prove problematic.
6. Excessive thyroxine production causes hyperactivity, the inability to be still, nervousness, loss of weight, looseness of bowels, intolerance of heat and undue sweating. These need not be concurrent!

B. Calcitonin is produced by small clumps of cells lying between larger vesicles formed by thyroxine secreting cells and containing the thyroxine. Calcitonin balances the effects of the parathyroid hormone, parathormone. It keeps it from raising the calcium level of the blood too high and draining too much calcium from the bones.

IV. **The Parathyroid Glands**, four in number lie embedded in the back of the lower and mid sections of the thyroid gland, two on each side of the windpipe. They are like small beans in appearance and produce parathormone as stimulated by the concentration of calcium in the blood. Its task is to raise the level when needed by increasing the solubility of calcium in the bones so that it can be withdrawn into the blood until the concentration is just right. At the same time, it reduces excretion of calcium by the kidneys and stimulates excretion of phosphates by the kidneys. Excessive phosphates in the blood tend to combine with calcium, forming insoluble deposits which may damage tissue, whether muscle or bone.

A shortage of parathormone can cause tetany or muscular twitching because calcium is necessary for the conduction of an impulse along a nerve fibre and for the contraction of muscle tissue. Calcium gives tone to the muscles.

Excessive parathormone may lead to excessive calcium precipitating out of the blood and forming kidney and/or salivary gravel or stones. Calcium may also be deposited on arterial walls, with consequent hardening of the arteries. If too much calcium is withdrawn from the bones, the skeleton is left weak and cystic in appearance. This disease is called osteitis fibrosa cystica.

V. **The Islets of Langerhans**: scattered throughout the bulk of the pancreas the six-inch-long digestive gland directly behind the stomach, are numerous small clusters of cells, like islets which have an endocrine function. The cells are of two types: Alpha and Beta; they number about one million.

A. The Beta Cells produce insulin which has the following tasks:

1. It promotes the use of glucose as fuel by the cells of the body. This is of special importance for the brain and liver because glucose is the only fuel they can utilize. Insulin is a light-weight protein with 51 amino acids in each molecule and as such it facilitates the passage of glucose through the outer membranes of

cells into their interiors where it can be stored or oxidized as fuel.
2. It stores up glucose in the liver and in muscle tissue for future use as fuel by converting it into glycogen, an insoluble starchy substance. It converts excess glucose into fat in the liver and in adipose tissue.
3. It stimulates the synthesis of amino acids into protein for numerous purposes.

B. The Alpha Cells produce glucagon, a hormone which compliments and balances the functions of insulin in the chemical control of glucose in the body.
1. It changes insoluble glycogen into soluble glucose so that it can be absorbed by the blood, thus raising the glucose level in the blood.
2. It facilitates the breakdown of protein into glucose (with urea as the chief by-product) when the body is desperately short of glucose, as in starvation.

N.B. Besides insulin and glucagon, several other hormones are involved in the chemical control of glucose in the body, namely:
1. Growth hormone from the pituitary gland (Cf. above) which stops cells other than brain and liver cells using glucose for fuel by rendering them impermeable to glucose; and which breaks down fat into fatty acids so that they can be used as fuel instead of glucose.
2. Cortisol from the adrenal glands (Cf. below) which breaks down protein into glucose (with urea as the chief by-product) especially in conditions of stress. It can also form glucose from fat.
3. Adrenaline from the adrenal glands (Cf. below) which mobilizes glucose in the blood during emergencies, to ensure sufficient fuel for the brain.

Through this complicated interplay of hormones under the control of the autonomic nervous system, partially through the hypothalamus, the glucose concentration in the blood is normally kept between 80 and 120 milligrams of glucose per 100 millilitres of blood. Usually there is about a sixth of an ounce of glucose circulating in the blood, i.e., 5gr. or a level teaspoonful.
If the Islets of Langerhans fail to produce sufficient insulin to reduce excess glucose in the blood, hyperglycaemia (Diabetes Mellitus) results. The excess must then be excreted by the kidneys. If these cannot cope coma, follows.
If the other hormones cannot maintain the normal level of glucose, hypoglycaemia results. This is characterized by a wide variety of symptoms, such as: weakness, uneasiness, anxiety, sweating, cold hands and feet, inner trembling, fast heartbeat, palpitation, over sensitivity to pain, noise and light, various allergies, itching and crawling sensations, dry or burning mouth. Hypoglycaemia can cause fainting and can lead to many other complications. It seems to be far more widespread than expected and may be caused by over production of insulin due to over stimulation of the Islets of Langerhans by excessive use of sugar, especially refined sugar. It can also result from a shortage of cortisol due to adrenal gland exhaustion (Cf. below)

VI. **The Adrenal Glands** Perched atop the kidneys, they consist of two parts: the medulla or main body of the gland, and the cortex or shell.

A. The medulla produces two hormones in response to stimulation by the sympathetic nervous system and these hormones in turn act as part of it. The sympathetic system originates from nerve cells in the spinal cord along its entire length. These form a chain of ganglia (relay stations) on either side of the backbone from which branches of nerves spread out throughout the body mainly along the arteries.
The sympathetic nerves themselves act by releasing adrenaline and noradrenaline (= USA epinephrine & norepinephrine) – except for the nerves of the sweat glands which release acetyl choline; but the medullas of the adrenal glands are major producers of adrenaline and noradrenaline.
These hormones increase body temperature by stimulating the use of oxygen by the tissues. They raise blood sugar (glucose) by breaking down glycogen in the liver and they break down adipose tissue to provide free fatty acids for fuel. However, each of these hormones has its own characteristics.

1. Adrenaline stimulates the heart, raises blood pressure, increases the circulation of blood in the muscles (including the muscle of the heart), stimulates deeper breathing and dilates the air passages, especially the bronchi. It also produces a sense of excitement. But at the same time, it damps down digestion and excretion, it reduces blood flow to other parts of the body except the heart muscle and other muscles. It literally prepares the body for action – for fight or for flight. This is the classic response of the body to stress of any kind: mental, emotional, or physical. Adrenaline is produced in large amounts by the medulla to cope with emergencies.

2. Noradrenaline has more of a routine role to play. It maintains an even blood pressure by adjusting the resistance of the small arteries to the flow of blood. It varies their contraction.
It also acts as the chemical transmitter of nervous energy along the sympathetic nerve fibres from the ganglia to the organs or muscles. Like adrenaline, noradrenaline is also active in the brain. It has a role in determining mood and emotion. Noradrenaline boosts the spirits and destroys depression. Ten minutes of vigorous exercise can double the amount of noradrenaline in the blood and give one a general feeling of well-being and alertness for hours afterwards.

B. The cortex secretes 3 groups of hormones whose functions somewhat overlap. (they are all corticosteroid hormones).

1. The glucocorticoids, now generally named after the main hormone of the group; cortisol or hydrocortisone. Cortisol production is controlled by the releasing factor ACTH (adrenocorticotrophic hormone) from the pituitary gland, and this in turn by the feed-back system of the hypothalamus. Cortisol has the following functions:

a) It makes extra fuel available to the body by converting protein and fat into glucose (gluconeogenesis). A shortage may cause hypoglycaemia.

b) It plays a part in maintaining water balance in the body. In its absence water is only slowly excreted.

c) It has an important role in blood pressure regulation.

d) It influences the production of red blood cells.

e) It acts against inflammation and allergies when produced in larger amounts than usual.

N.B. In times of stress cortisol production can be increased five-fold. Excess cortisol has the following effects:

a) It interferes with collagen (a protein in fibrous connective tissue) and muscles, making them weak.

b) It causes loss of calcium and phosphate via the kidneys. The calcium must be replaced and may be withdrawn from the bones, making them weak.

c) It raises blood sugar excessively and this must be disposed of by insulin. Much of it is often deposited as fat around the shoulders and abdomen. At the same time the legs may become spindly through loss of protein for fuel and the inability of the body to replace it (Cf. a).

2) The Mineralocorticoids: Aldosterone. The main member of the group

a) increases potassium excretion by the kidneys.

b) decreases sodium and chloride excretion.

N.B. Aldosterone production is controlled not by ACTH from the pituitary but by the enzyme renin which is secreted by the medulla of the kidney, in response to low sodium and low blood pressure (which are often associated). Renin not only stimulates the production of aldosterone by the adrenals but also reacts with angiotensin, a simple protein floating in the blood, to make a substance which raises the blood pressure to ensure proper circulation of blood in the kidneys, but thereby raising blood pressure throughout the circulatory system. Angiotensin with renin causes the arterioles to contract and this puts more pressure both on the arteries and on the capillaries - first of all in the kidneys to ensure local circulation, but eventually throughout the body. Thus, high blood pressure is a common complication of kidney diseases.

3) The Androgen: Sex hormones, both male and female - but predominantly male - are produced by the adrenal cortex as an intermediate stage in the synthesis of cortisol. Hence, they are under the control of ACTH from the pituitary. When, through faulty cortisol synthesis or through cortisone therapy an excess of androgens is built, male characteristics, such as hirsutism, tend to develop in females and overdevelop in males.

N.B. A natural therapy based on the meridian energy system used in acupuncture can be quite simply and safely employed to stimulate cortisol production by the adrenals. This may serve as a substitute (and a very welcome one) for artificial cortisone therapy. One great advantage is that it increases cortisol, but not androgen, secretion. Thus the undesirable side effects of cortisone therapy, particularly hirsutism and moon-shaping of the face are avoided. The natural therapy consists in applying moxibustion on the pair of Bladder acupuncture points (B23) located just below the transverse process of lumbar vertebra No. 3 on each side of the spine. This can be done by holding the glowing end of a moxa roll (a 'cigar') made from the herb artemisia vulgaris) near the points until the skin around them becomes reddened with heat and infra-red rays emitted by the moxa roll. The production of cortisol is also dependent upon the presence of ACTH, vitamin C, vitamin B2 and B5 (pantothenic acid) in adequate proportions, and it is wise to take generous vitamin supplements to ensure against a shortage.
The circulation of blood in the areas of the adrenals and pituitary glands can be enhances by (a relaxing and then stimulating) massage of their respective reflex zones. (Cf. Better Health with Foot Reflexology by Byers) The result is that these glands can then fulfil their function better.

VII. The Gonads: the sex glands.

A. The testes (singular = testis, i.e., witness) produce the male sex hormone testosterone, which initiates and maintains the secondary male sex characteristics: growth of the beard, hair in the axillary and pubic regions, deepening of the voice, and the mental outlook and emotional response more characteristic of men than of women. Testosterone also promotes synthesis of protein and the growth of muscle and bone. Men tend to be more muscular and taller than women because the production of testosterone is limited to the adrenal cortex in women whereas in men it is produced by the testes as well. After puberty, the increase of androgens causes the ends of the bones to harden gradually, thus ending growth.
B. The ovaries produce the female hormones of which there are two groups: the oestrogens (mainly oestradiol) and the progestogens (mainly progesterone).
   1} The oestrogens do not alter the basic body form as much as the androgens do, but they mature the woman, body, mind and emotions, and give her feminine characteristics. They cause the reproduction organs to grow to normal size by puberty and the initiate ovulation and the menstrual cycle.
   2) Progesterone is secreted by the corpus luteum which forms in the scar left in the ovary after the release of an ovum. It causes thickening of the wall of the womb and the laying down of glands and glycogen in the endometrium to provide a "nest" for the fertilized ovum in case of conception.

N.B. As menopause approaches and oestrogen secretion by the ovaries is reduced, the adrenal cortex should normally make up the difference, if for some reason it does not, menopausal problems occur such as hot flushes (disturbed blood vessel reflexes), palpitations, some emotional instability which may partially be the cause of depression. Rather than trying to control these symptoms by prosthesis (the taking of small doses of oestrogens) which long term may also have undesirable side effects, e.g., the danger of cancer, the adrenal glands should be helped to supply the needed hormone by massage of their reflex zones and through lymph drainage.