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The thyroid gland

Where is the thyroid gland?

Normally the thyroid gland lies in the front of the neck just below the Adam's apple (Fig. 1.1). The gland is shaped like a bow tie or a butterfly and consists of two lobes joined together in the middle. The left and right lobes, each about the size and shape of half a plum cut vertically or about the size of the top segment of a person's thumb, lie on either side of the windpipe (trachea) and are connected by a bridge of thyroid tissue, known as the isthmus, which runs across the front of the windpipe.

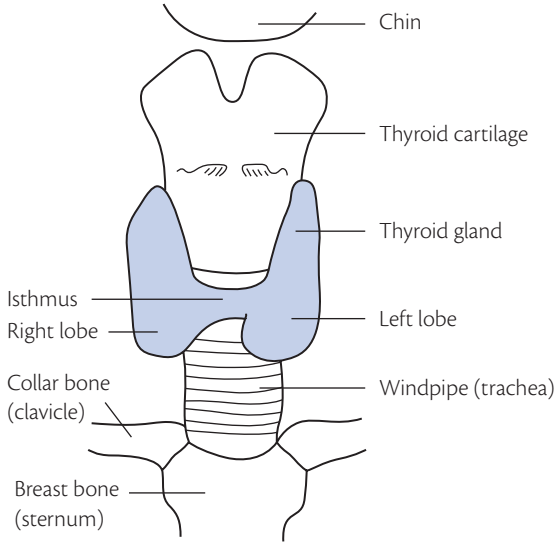

Figure 1.1 The anatomy of the thyroid gland

In men a normal thyroid gland is seldom sufficiently large to be visible, but in a young woman with a thin neck it may be just discernible, particularly when the chin is lifted up. If visible, the gland will be seen to move up and down when swallowing. A healthy gland is smooth and is not tender. It is not lumpy or hard. In some normal people the gland may extend downwards to lie wholly or partially behind the upper part of the breastbone or sternum (a retrosternal thyroid).

Where does the thyroid come from?

In the baby developing in the womb (the fetus), the thyroid gland has its origins at the root of the tongue. As the fetus grows, the thyroid moves down the neck and long before the baby is born it occupies the usual adult position. The path of this descent is marked by a narrow cord, the thyroglossal duct, running from the tongue (the glossus) to the neck. The bottom few centimetres of this duct may contain thyroid tissue and it is then called the pyramidal lobe. This extra lobe of the thyroid extends upwards from the isthmus and may lie in the mid-line or on one side of the larynx.

What happens if the thyroid does not descend properly?

In very rare circumstances in babies the thyroid gland does not descend properly and remains in its original position near the root of the tongue. A misplaced thyroid gland like this seldom functions properly, and it is an important cause of an underactive thyroid in a newborn baby (see Chapter 14).

What does the thyroid do?

The thyroid manufactures chemical substances (hormones) that are passed into the bloodstream and act on cells and tissues elsewhere in the body. Other hormone-producing glands (known as endocrine glands) include the pituitary, ovaries, testes, pancreas, and the adrenal glands.

The thyroid makes two hormones. One is thyroxine which, because it contains four atoms of iodine, is also called T_4. The other is triiodothyronine which contains three iodine atoms and is called T_3. Both these hormones are secreted into the bloodstream and carried round the body. In distant tissues the thyroxine is converted to triiodothyronine, and it is the triiodothyronine which actually influences the distant cells and is the so-called active hormone.

What do the thyroid hormones do?

The thyroid hormones control the metabolism of cells, which is their speed of activity. If there is too little hormone, the body cells work too slowly; too much

results in them working too fast. Thyroid hormones regulate the rate of oxygen consumption. This metabolic action influences the utilization of the main components of food: sugars, protein, and fat. Although thyroid hormones have a similar effect and influence the proper working of all body cells, their action is particularly evident in certain tissues and for certain functions. For example, the physical and brain development of a baby growing in the womb depends on the presence of the correct amount of thyroid hormones in the mother until the twelfth week of the pregnancy when the baby's own thyroid gland begins to function. In a child, too little hormone will slow up growth, whereas too much may make the child grow faster than normal. Thyroid hormones also have very noticeable effects on bone, fat, the heart, and muscle amongst other organs.

The manufacture of thyroid hormones

Thyroxine and triiodothyronine are formed in the cells of the thyroid gland. Both hormones contain iodine, which is essential for their manufacture or synthesis. This essential element is extracted from the bloodstream by the specialized thyroid cells. Inside the cells of the thyroid gland, the iodine is amalgamated with other substances in a number of chemical steps to form T_4 and T_3. Once formed, the two hormones are stored in 'parking areas' within the gland. The 'parked' hormones are released from storage into the bloodstream as and when the body cells need them.

Where does iodine come from?

Normally iodine is provided in food, particularly fish. Iodine is found in the soil from which crops grow and on which cows graze to produce milk, all of which contain iodine in minute quantities. The iodine is derived from the rain that falls on the soil, and this in turn comes from the water vaporized from the sea to form rain. In parts of the world far removed from the sea the soil is likely to be deficient in iodine. This happens in Central Africa, the Andes in South America, the Himalayas in the Indian subcontinent, Switzerland in Central Europe, around the Great Lakes in the USA, and in certain other landmasses such as Spain and Iran. Insufficient iodine in the diet in these areas may cause difficulty in making thyroid hormones and public health measures have to be taken to supplement the dietary intake of iodine (e.g. provision of iodized salt).

How is the secretion of thyroid hormones controlled?

Secretion of thyroid hormones is controlled by the pituitary gland. The pituitary is an endocrine gland the size of a grape which lies at the base of the brain.

It secretes many different hormones, but thyroid-stimulating hormone, also known as TSH or thyrotrophin, is the hormone that controls thyroid function. Other pituitary hormones control the testes, ovaries, and adrenal glands, as well as regulating growth and enabling women to produce breast milk.

Thyroid hormone secretion works like the control of the central heating in a home. Certain cells within the pituitary act like the thermostat sensing the temperature. If the temperature falls below a certain preset level, the thermostat activates the boiler to produce more heat, and when it rises, the thermostat turns the boiler off or reduces its heat production. Similarly, if thyroid hormone levels fall, the pituitary senses this by monitoring the levels in the blood and producing TSH, which stimulates the thyroid to increase production of thyroid hormone. If thyroid hormone levels rise, the pituitary reduces or switches off TSH production to reduce production of thyroid hormone. This is called a negative feedback mechanism (Fig. 1.2).

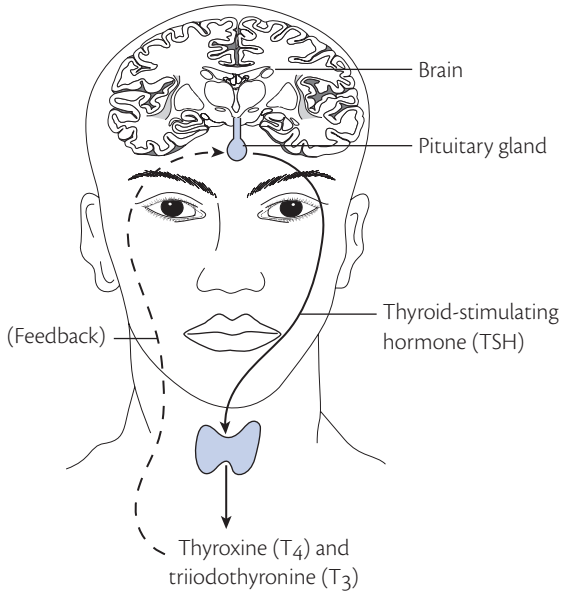

Figure 1.2 Mechanism controlling the secretion by the thyroid gland of thyroxine (T_4) and triiodothyronine (T_3). As the levels of T_4 and T_3 rise in the bloodstream, the secretion of thyroid-stimulating hormone (TSH) from the pituitary gland is reduced or switched off (feedback control mechanism). As the levels of T_4 and T_3 fall, the pituitary gland secretes more TSH so that activity of the thyroid gland is increased.

The pituitary gland is very sensitive to changes in thyroid hormone levels in the blood, which means that very subtle changes in TSH production are the earliest evidence that the thyroid is producing more or less hormone than previously. The pituitary also responds to hormones released from the higher centres in the brain, particularly from another small endocrine gland called the hypothalamus. This gland is important in functions such as the control of appetite and body temperature.

How do the thyroid hormones move around in the bloodstream?

Nearly all of both thyroid hormones T_4 and T_3 are loosely attached to certain proteins in the blood and therefore are biologically inactive. Only when the hormone is released does it become biologically active. A small fraction of the thyroid hormones (less than 0.1 per cent) are free in the circulation and are biologically active. The active thyroid hormone that can be used immediately is T_3 which influences nearly all the major body systems by entering into cells and controlling genes and enzymes. Approximately 20 per cent of the total amount of T_3 is produced and released directly by the thyroid gland, while the remaining 80 per cent is converted to T_3 from inactive circulating T_4 in tissues such as the liver, kidney, and brain by enzymes called deiodinases, which remove one iodine atom.

Questions and answers

Q.1 What is the thyroid gland?

A. It is a small gland that controls the activities of the cells of the body.

Q.2 Where is the thyroid gland?

A. It lies in the front of the neck below the Adam's apple in the position where a man knots his tie.

Q.3 What does the thyroid do?

A. It produces the thyroid hormones, which are chemical messengers that circulate in the blood to the rest of the body.

Q.4 What controls the output of thyroid hormones?

A. The levels of thyroid hormones circulating in the blood are regulated by the thyroid-stimulating hormone (TSH) produced by the pituitary gland at the base of the brain. If the levels of thyroid hormones fall, TSH stimulates the thyroid to make more hormones. If the levels of thyroid hormones rise above normal, TSH is suppressed.