Thyroid

Largest endocrine gland. H-shaped or butterfly-shaped gland, having 2 pyramidal lobes connecting by an isthmus.
→ Highly vascularized - (mainly because it is close to the major blood vessels that arise from the arch of the aorta)
→ Thyroid gland is located anterior to the trachea at the level of the 5th to 7th cervical vertebrae
→ The biggest laryngeal cartilage (not a complete structure, open from the posterior)
→ It is the first gland to start the embryogenesis (around day 22 of gestation) and is fully functional by the 12th week

Surrounding the anterior surface of the trachea just below the larynx → C5-T1 vertebrae

Thyroid gland has 2 capsules
→ True capsule is composed of connective tissue
→ Outer (false) capsule is derived from the **pre-tracheal layer of cervical fascia** and is The gland moves up and down with deglutition as it is enclosed in the pre-tracheal fascia to be partially attached to larynx and trachea
↳ The capillary plexus lying beneath the true capsule of the gland
↳ Upper Limitation of thyroid gland is Pretracheal fascia

Each lobe is pear-shaped, has apex, base, 2 borders (anterior and posterior), and 3 surfaces (medial, lateral, and posterolateral).

Apex	Reaches the oblique line of thyroid cartilage (directed upwards).
Base	Reaches the 4th or 5th tracheal ring (directed downwards).

Consists of right & left lobes, connected by a narrow isthmus.

Anatomy

The isthmus extends across the midline in front of the 2nd -4th tracheal rings

A third tiny pyramidal lobe (40%) <> It is an excess connective tissue of the thyroid due to embryological disturbance (not pathological), and it projects upward from the isthmus (band connects it to the Hyoid bone <> levator glandulae thyroideae

Berry ligament, a suspensory (fibrous) ligament of the thyroid that passes from the thyroid gland to the trachea, playing a key role in voice modulation

Relations of lobes

RELATIONS OF LOBES

- Medial
  - Laryne, pharynx, trachea, esophagus
  - 2 muscles (Cricothyroid and sternothyroid)
  - Each nerve (External laryngeal nerve with one of the blood vessels that supply the thyroid)
- Anterolateral
  - External laryngeal nerve with Superior thyroid artery
  - Recurrent laryngeal nerve with Inferior thyroid artery
- Posterolateral
  - Carotid sheath containing common carotid artery, internal jugular vein, and Vagus nerve
- Posterior
  - Superior and inferior parathyroid glands + Anastomosis between the superior and inferior thyroid arteries.

Isthmus Relations

- Superior
  - Terminal branches of superior thyroid arteries (+anastomosis)
- Inferior
  - Related to inferior thyroid veins
- Anterior
  - Related to:
    - Skin and pretracheal fascia
    - 2 muscles (sternohyoid and sternothyroid)
    - Anterior jugular vein
- Posterior
  - 2-4 tracheal rings

Arterial supply

- Superior thyroid artery (originates from ECA (external carotid artery))
  - Divides into ant., post., and lateral branches. Accompanied by the external laryngeal nerve
- Inferior thyroid artery (from thyrocervical trunk TCT, which is a branch from subclavian a.)
  - Divides into sup. and int branches. Accompanied by recurrent laryngeal nerve
- The thyroidea ima, from Brachiocephalic artery
- Arch of aorta
- (8) common carotid
  - Presents in (10%), It ascends in front of the trachea to the isthmus.
  - Single artery not a pair

Anastomosis

- Anastomosis is between Superior thyroid arteries (left and right.)
- There's extensive anastomosis between thyroid arteries:
  - Superior's terminal branches anastomose together
  - Superior anastomoses with contralateral inferior
  - Superior and the inferior anastomose together.

Venous supply

- Superior and middle thyroid
- Drain into IJV (internal jugular vein).
- Inferior thyroid
  - The vn' thyroid v. originates from the pretracheal plexus either as:
    - 2 veins that anastomose together and drain into the (1) Brachiocephalic & Rt- Vn Rt Atrium or Superior Vena Caval.
    - Or originate as 3 trunk that drains in (1) BRC v. RIBC v. or SVC.
      - Usually both inferior thyroid veins unite to form single vein

Lymph drainage

- Lymph (of drains into) ⟶ Prelaryngeal, pretracheal, paratracheal ⟶ Then deeper into ⟶
  - Sup. Deep cervical nodes
  - Inf. deep cervical nodes
- Drains mainly into the deep cervical lymph nodes
  - A few lymph vessels to the paratracheal nodes (prelaryngeal, pretracheal)

These lymph nodes are important in GI cancer, as cancer cells escaped the primary tumor into the lymph drainage and metastasized there Or breast cancers, where most of the times the tumor goes unrecognized as it is deep in the breast, and it first metastasizes to enlarged lymph nodes filed w cancer cells.

During surgical removal of the tumor, if the lymph nodes are suspected to have metastasis ⟶ Freeze section is sent to a pathologist

Nerve supply

- Autonomic innervation
  - From the 3 cervical sympathetic ganglia: (Superior, middle, and inferior cervical sympathetic ganglia)
  - The autonomic nervous system consists of two neurons circuits (the first preganglionic neuron in the T1-L2 segments of the spinal cord and the nucleus in the brain), the axons synapse at the ganglia
  - 2 post-ganglionic neurons
- The Vagus nerve provides the main parasympathetic fibers

Applied anatomy

- Goiter ⟶ is the disease of diffuse enlarged thyroid gland.
- Hypothyroidism
- Hyperthyroidism

Enlarged thyroid gland can compress the different related structures causing symptoms according to the compressed structure

- Trachea: dyspnea (difficult breathing).
- Esophagus: dysphagia (difficult swallowing).
- Recurrent laryngeal nerve: hoarseness of voice.
- Sympathetic chain: Horner's syndrome.

During thyroidectomy (surgical removal of thyroid gland)

Superior thyroid artery is ligated near the gland (to avoid injury of external laryngeal nerve)

Inferior thyroid artery is ligated away from the gland (to avoid injury of recurrent laryngeal nerve)

Hoarseness in the pt's voice after surgery

Embryology

Development begins as:

- (1) Median endodermal thickening ⟶
  - Originates from **endoderm** between the **1st/2nd pharyngeal pouches** near the base of the tongue.
  - Develop from the ultimobranchial body (from 5th pharyngeal pouch), which invades the gland
- Follicular cells ⟶ "Thyrocytes"
- Parafollicular cells ⟶

A diverticular outgrowth from the primitive pharynx, the diverticulum then descends inferiorly to reach its final destination in the neck.

(2) During its descent, the thyroid connects to the tongue by the **thyroglossal duct** (contributing to the gland so its final destination without descending further beyond) then disappears

- (3) Thyroid gland

Remnants:

- Thyroglossal duct
- Foramen cecum
- Pyramidal lobe of thyroid

Embryology

Tissue remnants of **thyroglossal duct** in childbirth:

- A foramen cecum in tongue
- Pyramidal lobe of thyroid

Cysts:

- Around day 24, endodermal cells of the primitive pharynx proliferate → Thyroid diverticulum
- By the 5th week, the diverticulum migrates (usually tracked, attached to the tongue by thyroglossal duct)
- In early descent, the thyroid is hollow but then solidifies during migration (follicular elements of the thyroid)
- Division of the thyroid into right and left lobes.
- Ultimobranchial bodies arise from the 4th/5th pharyngeal pouches give rise to parafollicular c cells.

Anomalies of the thyroid gland

- By the 7th week, TG reach its final destination (in front of the trachea)
- By the 10th week TSD degenerates, incomplete obliteration of the duct can lead to abnormalities
- Thyroid gland is fully developed by 20 weeks
- By the 12th week Functionally mature (fully functional and secreting hormones)

Thyroid agenesis	Congenital absence of thyroid gland, causing congenital cretinism
Incomplete Degeneration Of Thyroglossal Duct	Halfway through the duct the cells proliferate and start to produce mucus forming a cyst Found early in children mostly Midline neck mass , painless, move up on swallowing or tongue protrusion
incomplete descent of thyroid	Thyroid tissue along the course of the thyroglossal duct (lingual, supra-hyoid, retrohyoid, or infra-hyoid thyroid) The gland doesn't fully descend from foramen cecum and stays at the base of the tongue Blocking food and air passageway Detected early after birth

- LINGUAL THYROID

Histology

Each follicle is surrounded by **cuboidal epithelial cells differentiated to become glandular**

Parenchyma: Rounded epithelial thyroid follicles with variable diameter, each **central lumen densely** filled with gelatinous acidophilic colloid (protein and gelatinous material that is rich in thyroglobulin, it is the precursor of thyroid hormone).

- Thyrocytes range in shape from squamous to low columnar
- Have a receptor for TSH
- TSH receptors are located on the surface of thyrocytes inside the anterior pituitary gland

The follicular cells (thyrocytes)

- The cells exhibit organelles indicating active **protein synthesis**
- They have a good amount of **rERs** to make thyroglobulin
- The nucleus is generally round and central
- Basally positioned. (rER, golgi apparatus, basally), granules containing hormones, and other organelles, like the lysosomes (more apicity)

Is covered by a fibrous capsule sends out septa

Stroma is very well vascularized with fenestrated capillaries (sinusoids)

Only endocrine gland in which a **large quantity** of secretory product is **stored**

- Storage is outside the cells (extracellular), in the colloid of the follicle lumen
- There is sufficient hormone in follicles to supply the body for up to **3 months**
- In case of iodine deficiency, the person is covered in that initial period with no symptoms, but after 3 months, restoring iodine levels is necessary for hormone production.

- Thyroid colloid contains large glycoprotein thyroglobulin (The precursor for the active thyroid hormones)

Synthesis Process

The process begins with the uptake of iodine by the thyroid gland, followed by its oxidation and incorporation into the amino acid **tyrosine**, which is part of the protein thyroglobulin. This leads to the formation of T4 and T3.

The parafollicular cells function in **regulating Ca2+ homeostasis** according to Ca2+ in the blood.

- Found inside the basal lamina of the follicular cells
- attaining the same basal lamina or as isolated clusters between follicles.
- Derived from the neural crest or endoderm between the 4th and 5th pouches

Smaller amount of 0.1%, large C/sp complexes, **numerous small granules containing calcitonin.**

Secretion of calcitonin is triggered by T Ca blood, it inhibits osteoclast activity, reducing the resorption of bone matrix.

- How do C differentiate between them and follicular cells? → They are larger than **follicular cells**, Stain less **intense** and have **larger** cells
- Follicular cells **also have more** eosinophilic cytoplasm and closer to the **colloid/lumen of the follicle.**

- Cells look flattened due to inactivity, they appear as squamous epithelial cells (Squamoid).
- Less active
- More flattened
- Less cytoplasm
- <> Hyperthyroidism

- The active cells appear **rounded colloidal cells**
- More active
- Taller cells
- <> Hyperthyroidism

- The amount of cytoplasm is somehow an indication of the activity of the cells.

Thin capsule (CT, septa (T)

The lumen (L), present are large pale-staining parafollicular (C), Rounded (colloidal) cells + active cells

Thyrocytes (T): From parafollicular C cells (C) by their smaller size and darker staining

- Thyrocytes have acidophilic cytoplasm.
- Parafollicular C are bigger and lightly stained. They appear as empty cells.

Follicles are very packed and contain colloids within it.

- The Thyroid gland has a true capsule which sends in septa to compose the tissue into small compartments (unlike the pituitary gland)
- Around the follicles we have some reticular fibers to support the follicles, if we had a high amount of it, it would intervene with the transport of the hormone. Other than that, we will only see some connective tissue in the form of septa

Low magnification

High magnification

All these are septa (pinkish nodules) which are part of the stroma

Two important terms to differentiate between:

- Septa: Connective tissue for support, for the gland.
- Parenchyma: the functional cells.

- Black arrows: Colloids
- Yellow arrow: Parafollicular cells
- Yellow arrow: Sinusoid
- Yellow circles: Active follicles
- Blue arrows: septa
- Green arrow: Small blood vessel you can notice the endothelium
- Red arrow: Follicular cell cluster

If capillary gets its thickness mainly from the endothelium and has some reticular fibers around it only, in addition to pericytes.

Pics "THYROID ACTIVE OR INACTIVE"

How to differentiate between them? We look at the lumen, sinusoids have relatively larger lumens, while this BV here has a very narrow lumen.

The black arrow here represents parafollicular cells

Blood vessel

These follicles: Inactive (flattened cells)

- Blue arrow: Blood vessel, notice the endothelium & flattened nuclei
- Brown arrows: Portions of the capsule

- Blue arrows: Follicles
- Green arrows: Follicular cells
- Red arrow: Parafollicular cell clustered between follicles

Follicles which are active because cells have cuboidal nuclei, not flat.

Blue arrow represents a parafollicular cell.