



University of Jordan - Faculty of Medicine
(2013-19)



Endocrine System

Anatomy/Embryology/Histology

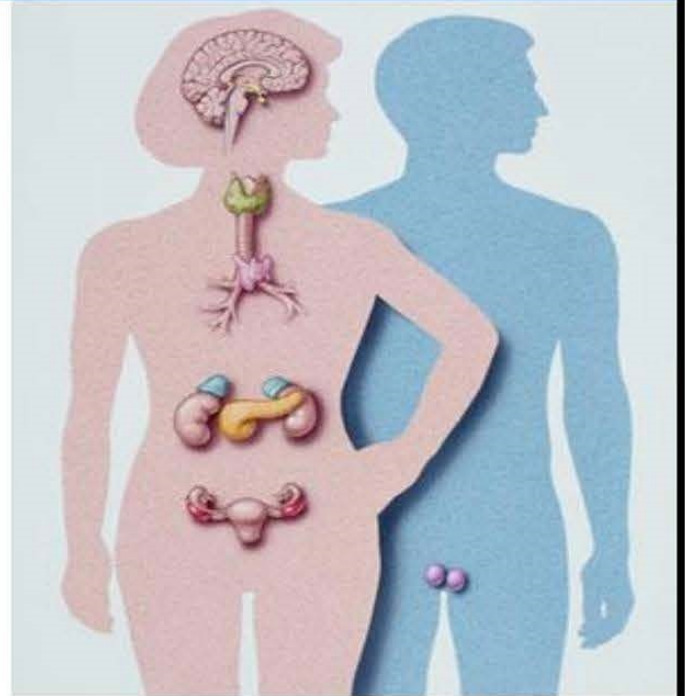
Biochemistry

Physiology

Pharmacology

Pathology

PBL



Slide

Sheet

Handout

Other

Lecture #: **2**

Date: **24-6-2015**

Dr's Name: **Darwesh Badran**

Price:

Written by: **Ali Khresat**

Designed by: Zakaria W. Shkoukani

THE THYROID GLAND

Note : this sheet will talk about the thyroid gland embryology , anatomy , histology and the clinical applications in order , don't forget to check the past paper questions at the end of this sheet (thanks to Rashid dahabreh for collecting them)

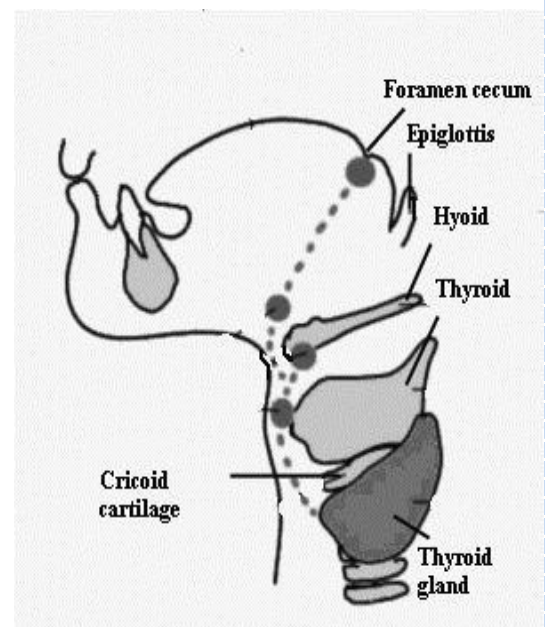
Embryology

The first gland to start functioning in the body is the thyroid gland; it starts working after the development of the cardiovascular system which develops at day number 21 of gestation.

Now, the thyroid gland starts to develop from the floor of the primitive pharynx , recall that the posterior 1/3 of the tongue also develops from the floor of the primitive pharynx so the primordium of the thyroid gland will be connected to the tongue so they called it the thyroglossal primordium (thyro : thyroid , glossal : tongue)

Then the tongue starts to develop upwards and forwards while the thyroid gland descends downwards, the site of fusion between the anterior 2/3 and the posterior 1/3 of the tongue marks an important v-shaped line called : the **sulcus terminalis** and at the tip of this v-shaped line there is a depression called : **the foramen cecum** which marks the embryological thyroglossal swelling where the gland started to develop and descend downwards .

After that the thyroid gland starts to descend anterior to the structures which were developing at the same time in the neck , in particular the *hyoid bone* , *cricoid cartilage* and *the cartilage of the trachea* and it reaches its destination on the trachea at the **7th week of development** .Consequently the infrahyoid muscles of the neck that will develop later on and must attach to the hyoid bone will find the thyroid gland in their way so they will become **anterior** to it. Always keep in mind that any structure that goes from one place to the other in embryology will have abnormalities in their movement so you might find the thyroid gland high up or down to its designated position as we'll see later in the thyroid gland abnormalities.

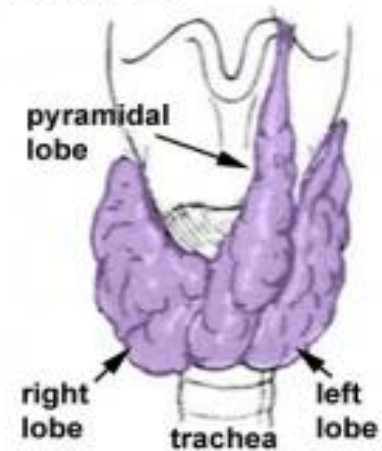


While the thyroid gland is descending it remains connected to its origin in the floor of the primitive pharynx by the **thyroglossal duct** which begins to obliterate later on after the gland reaches its location at the 7th week of development .

After the thyroglossal duct obliterates, its terminal part sometimes deviates to the left and remains connected to the hyoid bone forming the pyramidal lobe of the gland.

Sometimes this connection causes the formation of smooth muscle called **levator glandulae thyroideae**, it is called levator because if it contracts it will pull the gland upwards but this muscle is always not functioning.

Thyroid Pyramidal Lobe
(neck ventral view)



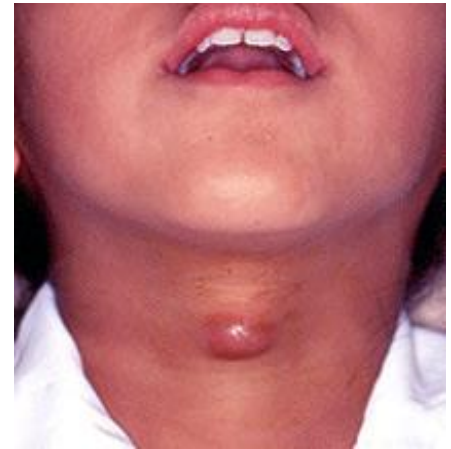
Initially the thyroid gland was hollow and then the thyroid cells began to proliferate which made the gland lobulated, later on the gland was invaded by blood vessels making the thyroid cells arranged in such a way that their secretions will reach the blood vessels and eventually to the circulation, so they will form rounded structures called **Follicles** which are defined as a group of cells resting on the same basal lamina and facing the same lumen .

Once the gland begin its secretion of thyroxin it attaches it to a colloid material called **thyroglobulin** in order to store them in the lumen , and when it wants to secrete thyroxin to the blood it absorbs some of the secretions inside by phagocytosis and liberates the thyroxin from the thyroglobulin and release it to the blood! so it is important to know that the thyroid gland is the only gland in the body that stores its secretions outside the cell .(i.e in order to secrete thyroxin : 1- **thyroxin** is bound to **thyroglobulin** and sent *outside* the cell 2- its phagocytosed *back to the cell* and set free 3- secreted *outside* to the blood ..)

As we said yesterday that all endocrine glands have 2 embryonic origins and we already said that the thyroid gland arise from the endoderm of the primitive pharynx ,at a later stage of thyroid gland growth it receives cells called C-cells or parafollicular cells which originates from the **Ultimobranchial body** that comes from the 5th pharyngeal pouch .

Thyroglossal duct cyst (clinical application)

it is a medical condition characterized by persistent thyroglossal duct that was supposed to be obliterated at the 7th week of development, now in the case when it fails to obliterate leading to an open communication between the posterior one third of the tongue at the foramen cecum level and the thyroid gland which will cause accumulation of fluid in the thyroid gland leading to a swelling called : *thyroglossal duct cyst*.



This condition usually appears in children at the age of 4-5 years, usually the major complication that arise from it is *thyroglossal fistula* it happens with persistent scratching of the swelling in the neck leading to 1- cracks in the skin 2- infection and abscess formation and 3- eventually rupture of the cyst causing an opening (communication) with the skin (a fistula)

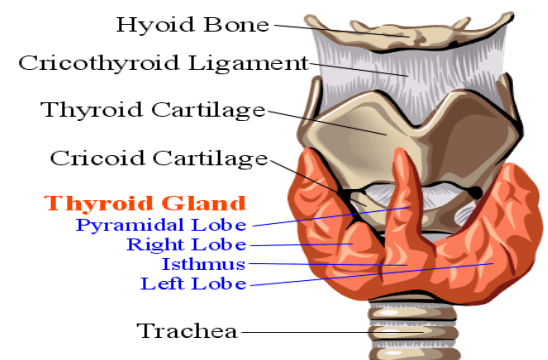
Diagnosis : since a lot of masses and swellings can happen in the neck like branchial cleft cysts or lymph nodes swelling we need to be able to differentiate between these cases and the best way to do that is to *ask the patient to swallow and if the swelling moved upwards then it is a thyroglossal duct cyst*.

Anatomy

The most important purpose of studying the anatomy of the thyroid gland is to know the structure, relations, the layers covering it and the blood supply.

The structure of the thyroid gland :-

The thyroid gland is typically made of right and left lobes separated by an isthmus, pyramidal lobe (if present) which is the remnant of thyroglossal duct.

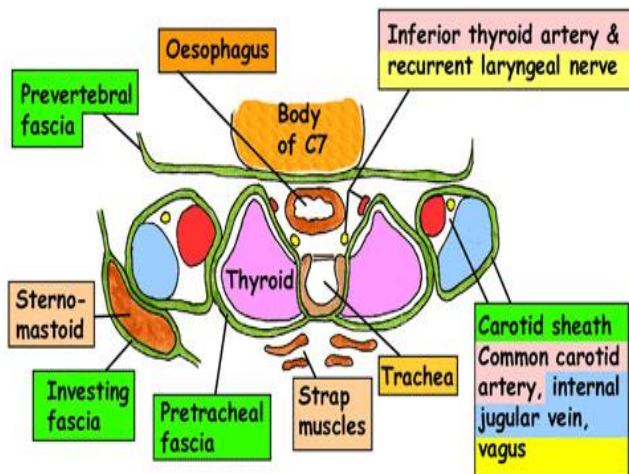


Adapted from Corel Draw 9

family
practice
notebook.com
a Resource for Physicians

Relations of the thyroid gland

Anterior relations : Imagine you're a surgeon ! and you're about to perform a surgery on the thyroid gland . First the patient must be in supine position with his neck hyper extended (*by applying sand bags behind the patient's shoulder*) to increase the field that you will work on ,then you bring a strong nylon fibers (zy 5ee6 el msb7a) and push it down on the patient's neck making a tunnel (*more like lining your incision pathway on the patients neck*) that you can move the scalpel in .



Then you're trying to reach the thyroid gland, you cut through the layers (**skin** ,superficial fascia and the **platysma muscle** inside the superficial fascia) ,then you cut through the **pre-tracheal fascia**, after that you will see the **infra-hyoid muscles** (sternohyoid , sternothyroid ,omohyoid , thyrohyoid) you have to cut them out **except the thyrohyoid muscle! Why? Because this muscle is not anterior to the thyroid it is above its level**

What about The sternocleidomastoid muscle? it lies lateral to the thyroid gland with its **anterior border laying anterior to the gland** , most of the times you don't have to cut this muscle you only retract its anterior border , *but in cases of thyroid cancer you have to cut it* . Congratulations you've finally reached and have a visual on the thyroid gland.

So we have concluded the anterior relations of the thyroid gland: 1- skin 2-superficial fascia 3-platysma muscle 4- pre-tracheal fascia 5-infra-hyoid muscles ***except the thyrohyoid*** 6-the anterior border of sternocleidomastoid .

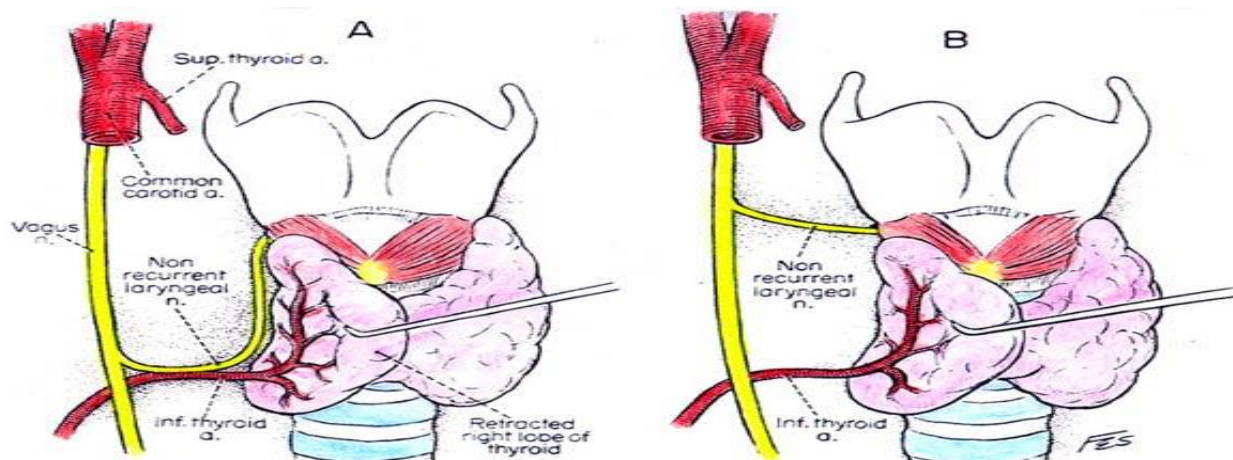
Medial relations :after you see the thyroid gland you will start to mobilize it ,since the thyroid gland lies on the **thyroid ,cricoid cartilage and the upper 2-3 tracheal rings** so they will be medially related to thyroid gland , the medial surface of the thyroid gland is described to be concaved because the thyroid and cricoid cartilage are convexed consequently in order for the medial surface of the thyroid gland to fit it needs to be **concaved** ,Because the thyroid gland lies on the thyroid and cricoids cartilage ,any structure that is attached to these cartilages are medially related to the thyroid gland and those structures include **the inferior constrictor muscle of the pharynx with its 2 parts : thyropharyngeus (attached to thyroid cartilage) and cricopharyngeus (att to cricoid cartilage) muscles** .

Moreover, there is an important nerve that is found in the groove between the trachea and the esophagus called the **recurrent laryngeal nerve** and its medially related to the thyroid gland. This nerve is 1- a branch from the vagus nerve 2- supplies the intrinsic muscles of the larynx 3- it arises in the neck at the right side and in the thorax at the left side, in the left side it loops around the ductus arteriosus posterior to the aorta and ascend to the larynx. They have the same relation in the neck but there is **NO** right recurrent laryngeal nerve in the thorax.

Surgical mistakes that could happen in thyroid surgery

- 1- If you accidentally cut through the cricopharyngeus muscle this will disturb the normal sphincteric action of the esophagus because the cricopharyngeus muscle is the only muscle in the body that contracts when it is not working! in order to prevent the entry of air to the esophagus and it relaxes once the bolus of food reach it in the laryngopharynx and once the bolus enter to the esophagus it will contract again to push it downward so any injury to this muscle is catastrophic.
- 2- If you accidentally cut the recurrent laryngeal nerve two events can happen : A) if you cut the nerve from both sides the patient is lucky but B) if you cut it partially on one side this will be catastrophic why ?

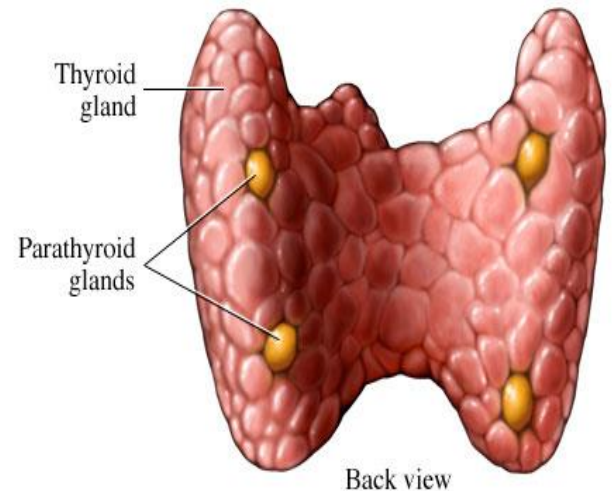
Because this nerve supplies the intrinsic muscles of the larynx that operates on the vocal cords and all these muscles are adductors but only one muscle is an abductor called **posterior cricoarytenoid muscle**, if the nerve was partially cut the first muscle to be lost is the posterior cricoarytenoid muscle so there will loss of abduction and the vocal cords will be adducted blocking the patient's airway, if it was cut from both sides the vocal cords will go into cadaveric (relaxed) position with no risk on the patients airway but his language will not be clear anymore meaning he will suffer from speaking impairments.



Posterior relations of the thyroid gland

The largest posterior structure to the thyroid is the **common carotid artery** and posterior to that artery there is a muscle called **longus coli muscle**, if you cut through the common carotid artery then the blood will be all over your face and the operating room ceiling as if the patient is bleeding from his heart.

There are 4 **parathyroid glands** on the posterior aspect of the thyroid gland 2 on right and 2 on left, this gland secretes parathormone (*parathyroid hormone*) which is critical for the absorption of Ca^{++} from the renal tubules and the intestines, if you remove the parathyroid glands by mistake the body Ca^{++} store will be enough for 24 hours then the patient will go into tetanus state and the first group of muscles to become tetanized are the muscles of the vocal cords closing the patient's airway that's why after thyroidectomy surgery they bring a tracheostomy kit and the patient must be monitored for 24 hours just in case if tetanus happens they use the tracheostomy kit as fast as possible and intubate the patient to maintain his airway.

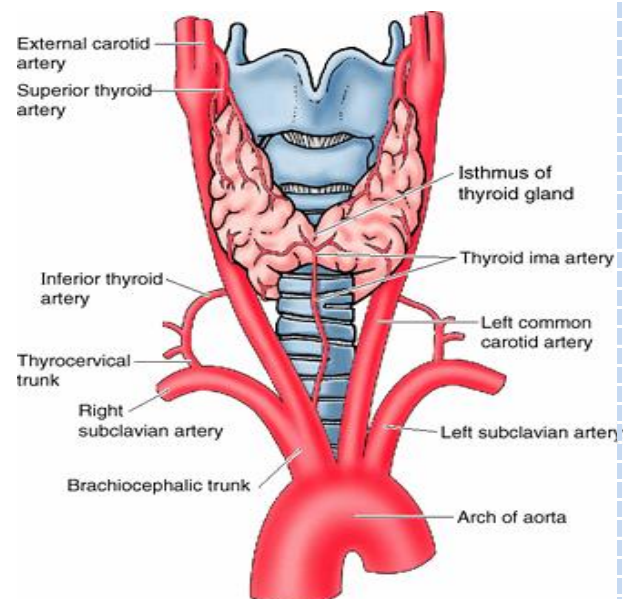


The blood supply of the thyroid gland

Before you remove the thyroid gland you have to ligate its blood supply. As we mentioned yesterday that endocrine gland (*and most of the glands*) have enormous blood supply because their function requires that.

The blood supply of the thyroid gland comes from 2 sources:

- 1- **Superior thyroid artery:** it is the first branch from the anterior aspect of the external carotid artery, it supplies the upper 1/3 of thyroid lobe and upper 1/2 of thyroid isthmus, this artery pass through the capsule of the gland and enters the thyroid gland then it branch inside the material of the gland. this artery runs with a nerve called **superior laryngeal nerve** and as



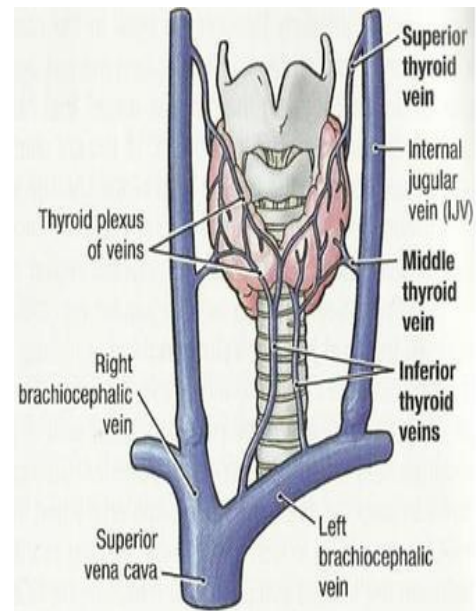
the artery become closer to the gland it diverge from the superior laryngeal nerve and becomes easier to ligate away from its **branching site inside the gland** .

- 2- **Inferior thyroid artery**: it is a branch from the thyrocervical trunk that arise from the 1st part of the subclavian artery ,in order for this artery to reach the thyroid gland it needs to turn (notice the figure) and while it is turning it immediately divides into 4-5 branches and these branches are closely related to the **recurrent laryngeal nerve** (anterior ,posterior or in between) so it's easier to ligate this artery away from the thyroid gland to avoid the branching and to avoid the recurrent laryngeal nerve .

Important note : there is a rare artery that supply the thyroid gland called the thyroid ima artery , it arises from the arch of the aorta and supplies the isthmus of the gland , if it was there and I accidently cut this artery it will retract and fall in the thorax without being noticed so the patient will have an internal bleeding in his thorax and because this bleeding is direct from the arch of the aorta it is a disaster ,so we need to dissect the region of the isthmus carefully to avoid the thyroid ima artery if it was there

Venous drainage of the thyroid gland

- 1- Superior thyroid vein : the only constant vein in its presence and termination , it drain the **apex** of each lobe and terminates in the internal jugular vein
- 2- Middle thyroid vein : not always present , it drains the **lateral** aspect of each lobe and terminates in the internal jugular vein
- 3- Inferior thyroid vein: drains the **basal** part of the gland, sometimes it terminates in the brachiocephalic vein or sometimes in the internal jugular vein.

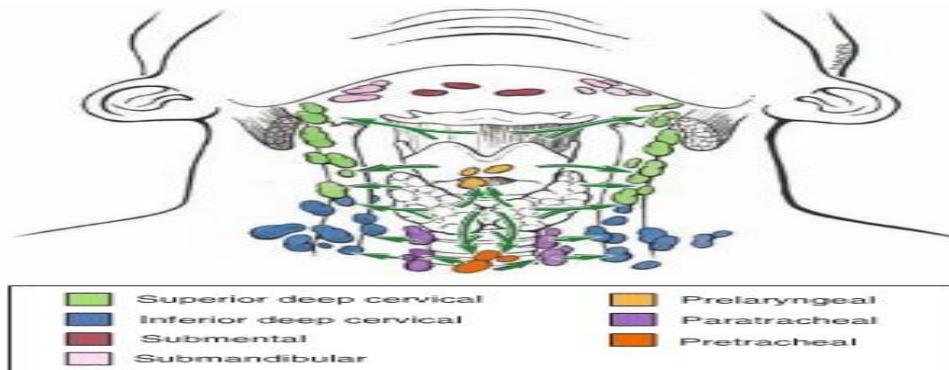


Lymphatic drainage of the thyroid gland(from slides)

- 1- Prelaryngeal lymph nodes : in front of the cricothyroid muscle
- 2- Pretracheal lymph nodes : in front of the trachea
- 3- Paratracheal lymph nodes : along the sides of the trachea
- 4- Upper and lower deep cervical lymph nodes : along the sides of the internal jugular vein

5- Brachiocephalic lymph nodes : in the superior mediastinum

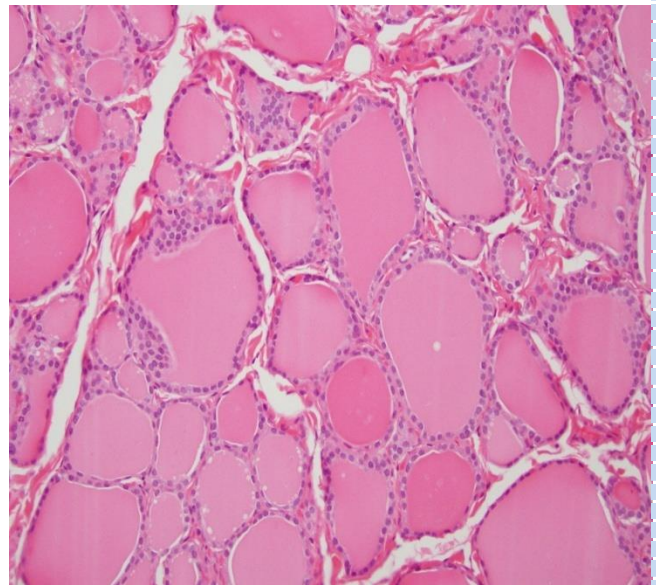
All the lymph from the thyroid gland eventually drains in the **deep cervical lymph nodes**.



Histology

Under the microscope the thyroid gland appears as clusters of cells forming follicles with variable sizes and shapes, the cells lining the follicle are called **follicular cells** and they are typical protein synthesizing cells, so they have abundant rough endoplasmic reticulum so their cytoplasm appears basophilic with H&E stain.

In addition to the rER the follicular cells contain a high amount of **lysosomes** because these cells require hydrolytic reactions in high amounts to liberate the thyroxin from the thyroglobulin that's attached to it and most of the time those lysosomes are found in the **apical** portion of the cell.

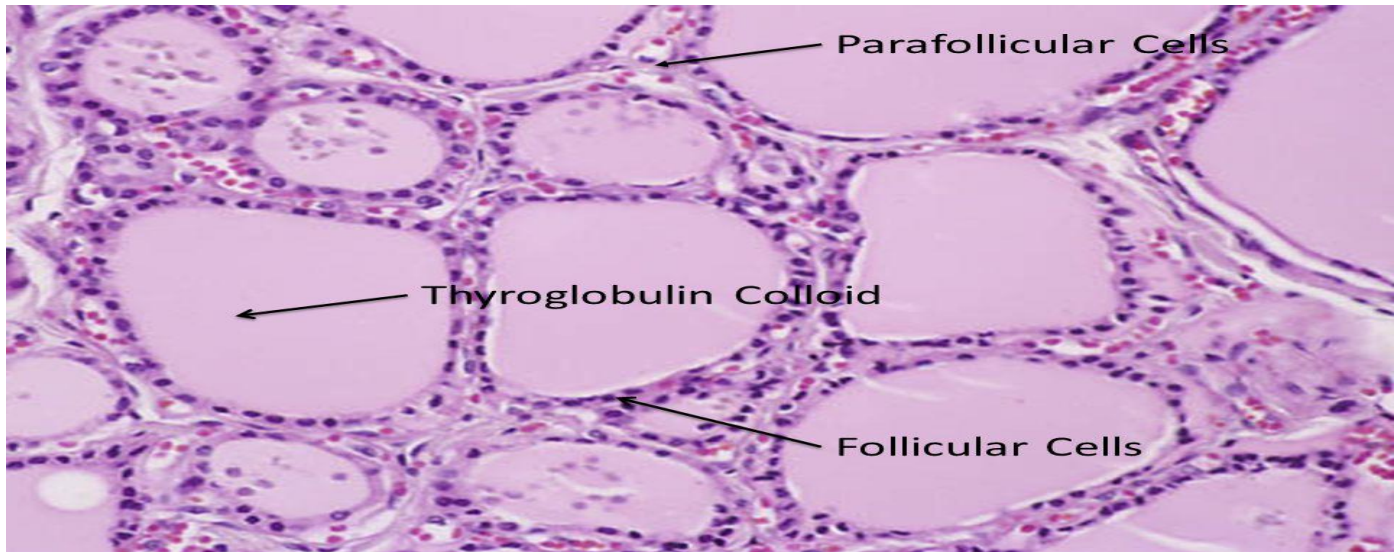


The follicular cells lining the follicle are **cuboidal** in shape under normal conditions (*euthyroid status*) but if there is **hyperactivity** in the thyroid gland they tend to be **columnar**, and if there is **hypoactivity** in the thyroid gland they tend to be **squamous** in shape.

There are some cells in the thyroid gland that don't stain with H&E and they were initially named as **clear cells** but then they named it **C-cells** or **para-follicular cells** (the doctor thinks that the nomenclature of these cells as para-follicular is not accurate because these C-cells are not always between follicles they can be inside the follicle), also they secrete **calcitonin**

hormone and as we mentioned they're difficult to be stained by H&E in addition to that they are larger than follicular cells.

When you take pathology in the next few weeks there is a nasty form of cancer called medullary carcinoma of the thyroid gland which originates from these C-cells.



Extra notes from slides: - follicular cells have: round ovoid nucleus with 2 nucleoli, supra nuclear Golgi complex, apical microvilli and numerous vesicles in their cytoplasm

-Parafollicular cells occur singly or as clusters and regarding follicular cells, they have moderate rER, well developed Golgi complex, small dense and basal secretory granules

-Calcitonin is stimulated for secretion when Ca^{++} levels are high and it inhibits bone resorption by osteoclasts .

Note: slide 20-24 are not required because we will take them in physiology .

Clinical applications

- 1- Thyroid gland swelling: examined by lateral view of the patient's neck to notice the bulging.



- 2- This man has hypothyroidism, if you describe him you will notice that he has puffiness around the eyes , his breasts and abdomen are apparently enlarged and this presentation is called **Myxedema** .Hypothyroidism in females causes disturbances in menstrual cycle called hypomenorrhea in which she will have her menstrual cycle once every 35-40 days which is different from the normal once menstrual cycle every 28 day



- 3- This patient has hyperthyroidism if we describe how she looks we will find that she is apparently emaciated (very thin) because people with hyperthyroidism have hyper metabolic state , her eyes are bulging (**exophthalmos**) which will make the eyelids unable to cover the entire eye so the cornea will be exposed to air for a long time and might require cornea transplant eventually .



At the end the doctor talked about the history of thyroid gland and ابو القاسم الزهراوي if you are interested to know about him check section 2 recording from 39:30 till 44:43.

Past papers and USMLE questions

1- About thyroid relations which of the following is incorrect :

- A- In thyroid surgery you have to cut the platysma muscle in the superficial fascia
- B- Cricopharyngeus muscle is medially related to the thyroid gland
- C- Thyrohyoid muscle is medially related to the thyroid gland
- D- Inferior thyroid artery must be ligated distal to the thyroid gland
- E- Right and left Recurrent laryngeal nerve are found in neck and they are medial to the thyroid gland

Answer: C

2- Which is not correct about the thyroid gland :

- A- The only gland that stores its secretions outside the cells
- B- Hyperactive follicular cells are columnar epithelium
- C- In case of hypothyroidism the follicular cells tend to be cuboidal
- D- Injury to the parathyroid glands in thyroid surgery will cause immediate tetanus in the muscles of the patient
- E- C+D

Answer : E

3- Which of the following muscles doesn't have to be removed in thyroid surgery :

- A- Sternothyroid
- B- Sternohyoid
- C- Thyrohyoid
- D- Omohyoid
- E- Platysma

Answer : C

4- Which of the following is wrong about the thyroid gland :

- A- Parafollicular cells show intense basophilic
- B- Follicular cells have numerous apical lysosomes and mitochondria
- C- Middle thyroid vein if presented will drain in the internal jugular vein
- D- Both superior and inferior thyroid arteries are related to nerves
- E- Pyramidal lobe of the thyroid is always presented and connected to the hyoid bone

Answer : A because parafollicular cells don't stain by H&E

USMLE questions

1- A 6-year-old boy is brought to the office for evaluation of a neck mass. His mother reported that he first developed the mass 3 days ago, and it has not resolved. Further questioning reveals that he has recently recovered from a viral upper respiratory tract infection. He is otherwise healthy and is up to date on all recommended vaccinations. Physical examination shows 2-cm neck mass in the midline immediately below the thyroid cartilage notch. The mass elevates when he sticks his tongue out of his mouth. Which of the following is most likely the diagnosis?

- A- Reactive lymph node
- B- Branchial cleft cyst
- C- Thyroglossal duct cyst
- D- Head and neck neoplasm
- E- Thyroid nodule

Answer : C

2- 42 year old man under surgery for medullary carcinoma of the thyroid. After his surgery, he complained about a "noisy quality" to his voice. This condition was most likely due to damage of:

- A- Internal laryngeal nerve
- B- Recurrent laryngeal nerve
- C- Thyroarytenoid muscle
- D- Vestibular folds
- E- Vocal folds

Answer : B

3- Which endocrine gland was developed from endoderm?

- A- adrenal cortex
- B- interstitial cells of the testis
- C- adrenal medulla
- D- thyroid *

The end