LECTURE OUTLINE: ENDOCRINE SYSTEM:
THYROID & PARATHYROID GLANDS

THYROID GLAND
Location: Lower larynx, upper trachea
Gross Anatomy:
Lobes: right and left
Isthmus: band connecting lobes across midline.
Pyramidal process: present in about 33% of individuals

Blood supply:
Superior thyroid a. from external carotid
Inferior thyroid a. from thyrocervical trunk of subclavian a.

Microscopic Anatomy:
Connective tissue capsule
Follicles (roughly spherical structures of varying sizes)
Around 20-30 million
0.2 – 0.9 mm in diameter
Contain colloid (stored hormone)
Simple cuboidal epithelium + basal lamina
Principal or follicular cells = 99.9% of cells
Parafollicular cells = 0.1% of cells
Located outside principal cells, but inside basal lamina.
Connective tissue with fenestrated capillaries

Functions:
Thyroid Hormone: T3 (triiodothyronine) + T4 (thyroxin, tetraiodothyronine)

Synthesis & Storage: Principal cells
GER + Golgi → thyroglobulin (a glycoprotein containing tyrosine) → exocytosis → interior of follicle

GER + Golgi → peroxidase: iodide → iodine → iodine links to tyrosines in thyroglobulin → MIT, DIT, T3, T4

Around 3–4 months supply stored in thyroid
Follicle size depends upon amount stored

T3 / T4 Release: Principal cells
Thyroglobulin uptake (pseudopods, pinocytosis) →
lysosomes release T3 + T4 → exocytosis → tissue fluids →
thyroid capillaries (most binds with albumin or TH1 binding globulin) → bloodstream → released into tissue fluids as T3 or T4 → target cells (most body cells).

Actions
Increases metabolic rate.

T3/T4 → cell → nuclear receptors → gene transcription →
mRNA → ribosomes → enzyme synthesis → metabolic rate (protein, carbohydrate, lipid metabolism)

T4 secretion ~ 10x that of T3, but T3 ~ 4x more potent.
Large amounts of T4 converted to T3 in liver & kidneys

Control: Negative Feedback Loop
Hypothalamic neurons → TRF (Thyroid releasing hormone) → anterior pituitary thyrotrophs → TSH (thyroid stimulating hormone) → thyroid principal cells → synthesis and release of T3 / T4 → hypothalamic neurons and pituitary thyrotrophs

Pathologies:
Hypothyroidism: TH deficiency → decreased metabolic rate.

Infancy onset: Cretinism.
Stunted growth, retarded mental development
Adult onset: Myxedema.
Sallow, puffy face; dry sparse hair; lethargy; slow cerebration
Hyperthyroidism (Grave’s disease, exophthalmic goiter)
TH secretion 5-10x normal → increased metabolic rate
Wt loss, nervousness, fatigue, rapid heart rate, thyroid gland swelling (goiter), eyes bulge due to swelling of orbital tissues.

Etiology: IgG → TSH receptors → prolonged stimulation of principal cells.

Calcitonin
Parafollicular cells.

Calcium (Ca++): critical for many cell functions.
Equilibrium: Cells ↔ Blood ↔ Bone (calcium phosphate)
Osteoblasts incorporate calcium into bone matrix.
Osteoclasts release Ca from bone matrix.
Secrete acids & hydrolases that break matrix down.

Parafollicular cells sensitive to blood Ca++ levels.
If levels increase above normal, release calcitonin → bloodstream:
(1) osteoclast activities suppressed → decreased bone resorption → decreased Ca++ release → blood Ca++ levels decreased
(2) kidney tubules: increased excretion of Ca++ in urine.

**PARATHYROID GLANDS**

**Location & Gross Anatomy:**
Usually 4 (two right, two left), but may be more.
Located on back of thyroid gland, inside its capsule.
Size: 5mm x 4mm x 2mm. Wt. ~25-50mg.
Ectopic: 5-10% people.

**Microscopic Anatomy:**
Chief (principal) cells. Most numerous.
Oxyphils: Less numerous.

**Functions:**
Parathyroid hormone (parathormone, PTH)

Synthesis: Chief cells:
GER ribosomes → preproparathyroid hormone (115 amino acids)
GER cisternae → proparathyroid hormone (90 amino acids)
Golgi → parathyroid hormone (84 amino acids)

Actions: Affects calcium levels
Normal plasma Ca++: 8.5–10.5mg/100 ml blood
If Ca++ level drops or phosphate (PO4) increases:
Chief cells → PTH → bloodstream:
Bone:
Rapid response:
Osteoblasts: (osteocytic osteolysis) bone matrix breakdown (osteocytic osteolysis) → Ca++ released → bloodstream: Ca++ levels increase
Slow response:
Osteoclasts: bone matrix breakdown (osteoclastic bone resorption) → Ca++ released → bloodstream: Ca++ levels increase
Kidneys
Increased distal tubular resorption of Ca++ + increased PO4 excretion in urine
Increased vitamin D3 formation → intestinal cells → increased uptake of dietary calcium
Vitamin D: UV radiation → stratum granulosum cells: pro-vitamin D to cholecalciferol → liver cells: cholecalciferol to 25-(OH) D3 → kidneys: 25-(OH) D3 to 1,25-(OH)2 D3
Pathologies
Hyperparathyroidism: Increased Ca\(^{2+}\) & decreased PO\(^{4-}\)
Pathological deposition of calcium in kidneys, arteries, other soft organs
Bone decalcification; bone cysts (osteitis fibrosa cystitidis); increased fractures

Hypoparathyroidism: Decreased Ca\(^{2+}\) & increased PO\(^{4-}\)
Increased bone density; increased neuron excitability, tetany (spastic muscular contractions), convulsions.

REVIEW QUESTIONS
1. The target cells for TSH are _____. (a) in the ovaries and testes (b) in the adrenal cortex (c) in the thyroid gland (d) in the mammary gland (e) most body cells
2. As the levels of T3 and T4 in the blood increase, the secretion of TRH by hypothalamic neurons _____. (a) increases (b) decreases.
3. The thyroid gland _____. (a) usually consists of two lobes and a connecting isthmus. (b) is located around the lower larynx and upper trachea (c) is supplied by branches of the superior and inferior thyroid arteries (d) is the only endocrine gland that stores its hormones extracellularly before releasing them (e) all of these
4. _____. cells are responsible for the synthesis, storage, and release of thyroid hormone. (a) parafollicular (b) chromaffin (c) thyrotrrophic (d) principal (e) none of these
5. Principal cells _____. (a) make up around 99% of all thyroid cells (b) form the walls of thyroid follicles (c) are regulated by the glycoprotein TSH (d) have the characteristics of protein secreting cells (e) all of these
6. Thyroid parafollicular cells _____. (a) are located between the principal cells and the basal lamina surrounding a follicle (b) are larger than principal cells (c) account for only about 0.1% of all thyroid cells (d) produce the hormone calcitonin (e) all of these
7. When blood levels of Ca++ _____. thyroid parafollicular cells _____. their synthesis and secretion of calcitonin. (a) increase, decrease (b) decrease, increase (c) increase, increase (d) decrease, decrease (e) c and d
8. Calcitonin ____. (a) suppresses osteoclast activity (b) increases tubular secretion of calcium in the kidney (c) increases tubular reabsorption of calcium in the kidney (d) a and b (e) a and c
9. There are normally _____. parathyroid glands embedded in the back of the lobes of the ____. (a) 2, thyroid (b) 4, adrenal glands (c) 2, brain (d) 4, thyroid gland (e) 2, thymus.
10. Parathyroid chief cells secrete PTH in response to a(n) _____. in the calcium ion or a(n) _____. of the phosphate concentrations in the blood. (a) decrease, decrease (b) decrease, increase (c) increase, increase (d) increase, decrease.
11. PTH ___. (a) increases the release of calcium from bone matrix by osteoclasts (b) increases the tubular reabsorption of calcium ions in the kidneys (c) has opposite effects than calcitonin on calcium concentrations in the blood and in the urine (d) all of these (e) none of these