Figure 12-02. **Pituitary gland and brain stem, normal dog.** Longitudinal section of the pituitary region illustrating the close relationship to the optic chiasm (O), hypothalamus (H), and overlying brain. The pars distalis (D) forms a major part of the adenohypophysis and completely surrounds the pars nervosa (N). The residual lumen of Rathke’s pouch (arrow) separates the pars distalis and pars nervosa and is lined by the pars intermedia.

**Pituitary Gland**

Adenohypophysis or anterior pituitary

Pars distalis

Largest

Secretes pituitary trophic hormones

Acidophils

Somatotrophs

GH

LActotrophs

Prolactin

Corticotrophs
ACTH
Basophils
Gonadotrophs
LH, FSH
Thyrotrophs
TSH
CHromophobes
Lack secretory granules
ACTH and MSH secreting cells
Non-secretory follicular cells
De-granulated acidophils or basophils
Undifferentiated stem cells

Pars intermedia
Located between pars distalis and pars nervosa
Lines the residual lumen of Rathke’s pouch
Dogs- B cells secrete ACTH

Pars tuberalis
Extension of adenohypophysis
Scaffold for capillaries of the hypophyseal portal system from the median eminance to the pars distalis

Posterior pituitary (Neurohypophysis)
Pars nervosa
Secretions are synthesized in the hypothalamus
Secretes ADH (vasopressin)
Oxytocin
Infundibular stalk
Joins pars nervosa to the hypothalamus
Capillaries
Supported by modified glial cells
Figure 12-03. Pituitary gland, pars distalis, normal dog. Follicular cells (NF) in the pars distalis form a framework and extend cytoplasmic processes (arrows) around extracellular accumulations of colloid (C). Adjacent follicular cells are joined by prominent terminal bars (T). Acidophils in the storage phase of the secretory cycle contain numerous large, uniformly electron-dense secretory granules (S), scattered lipofuscin (L) bodies, a small amount of endoplasmic reticulum (ER), and a small Golgi apparatus. Hypertrophied acidophils (NA) have few mature secretory granules but many distended profiles of endoplasmic reticulum and large Golgi apparatuses (GA) associated with prosecretory granules in the process of formation. TEM. Uranyl acetate and lead citrate stain.
Figure 12-07. **Thyroid follicular cells, thyroid gland, normal dog.** Thyroid follicular cells with long microvilli (V) that extend into the colloid (C) within the follicular lumen. Numerous lysosomes (L) and colloid droplets (CD) are present in the apical portion of the follicular cells. An interfollicular capillary (arrow) is present at the base of the follicle. TEM. Uranyl acetate and lead citrate stain.
Figure 12-09. **Hyperplasia, thyroid gland, sheep.** Follicular epithelial cells under prolonged thyroid-stimulating hormone stimulation are columnar, and many follicles are nearly depleted of colloid and are partially collapsed (arrow). Periodic acid–Schiff reaction.
Figure 12-10. Atrophy, thyroid gland, dog. Thyroid follicular epithelial cells (arrow) after long-term administration of exogenous thyroxine are cuboidal. Thyroid follicles are distended with dense colloid. Periodic acid–Schiff reaction.

Thyroid gland

**Thyroid hormone**

Final assembly takes place extracellularly in the lumen of the follicle

Follicular cells trap raw materials

Iodine- sodium iodide symporter in the basolateral membrane

In the lumen iodide is oxidized by thyroperoxidase (in the microvilli) to iodine (I2)

**Thyroglobulin**

Synthesized in follicular cells

Packaged into vesicles and extruded into the follicular lumen

Tyrosine is essential component

Iodine is bound to tyrosyl residues in thyroglobulin at the apical surfaces of cells to form Monoiodotyrosine (MIT), and Diiodotyrosine (DIT) which combine to form T3 and T4

Secretion of thyroid hormone
Elongation of microvilli
TSH → pseudopodia extend into lumen and phagocytose colloid
Colloid within follicular cells fuse with lysosomes → T3 and T4 are released from thyroglobulin
T3 and T4 diffuse across the follicular cell BM and enter adjacent capillaries
TSH binds to basally located receptors → adenylate cyclase activation
Sustained TSH → follicular cells become more columnar and take up more colloid
PAS positive droplets in the hypertrophic follicular cells

**T3 and T4**
T4 → T3 to become active → binds to nuclear receptors
T4 → reverse T3 → inactive (during protein starvation, hepatic or renal disease)
T4 and T3 bind to cytosol receptors which activate transcription factors or T4 and T3 bind to the inner mitochondrial membrane and increase oxidative phosphorylation

**Thyroid C (parafollicular) cells**
Situated with the BM in the follicular wall
Or in small groups adjacent to interfollicular capillaries
Secretory pole is oriented toward the interfollicular capillaries
Within cells are numerous small, membrane-limited secretory granules in cytoplasm

**Calcitonin**
Polypeptide hormone
Increased blood calcium → increased calcitonin secretion
Rapid release of preformed granules
Target cells in bone and kidneys
Decreases osteoclastic activity (antagonistic to PTH)
Decreased renal tubular resorption of phosphorus (synergistic to PTH)

**Parathyroid glands**
2 pairs of glands- dog and cat have internal and external
Pig and lab rats have single pair cranial to the thyroid embedded in the thymus or fat
Chief cells predominate
Vary in secretory activity and transition to oxyphilic cells

**PTH** secreted by chief cells
Straight-chained polypeptide consisting of 84 AA
Small amounts of preformed hormone but can rapidly secrete the hormone
Feedback is by calcium and magnesium concentration
Calcium
Controls biosynthesis and secretion of PTH
Increased calcium inhibits uptake of AA by chief cells (inhibits proPTH synthesis, its conversion to PTH and secretion of stored PTH)

**PTH function**
- Direct action → kidneys and bone
- Indirect action → intestine

**Oxyphilic** cells increase with age
Larger than chief cells and abundant cytoplasm is filled with numerous large often bizarre-shaped mitochondria

**PTH physiology**
Kidney
Proximal tubule
Block tubular reabsorption of phosphorus
Distal convoluted tubule
Enhance tubular reabsorption of calcium

**Ensures proper ratio of P to Ca**

**Vitamin D**
Increases calcium and phosphorus absorption from intestine
Both of these **ensures there are enough raw materials** for mineralization of bone
**Pancreatic Islets**
Endocrine

**Islets of Langerhans**
Surrounded by acinar exocrine cells

**Beta cells**
Most common
Synthesize Insulin\* secretion requires adequate calcium in ECM and Glucose
Co-secrete Islet amyloid protein

**Alpha cells**
Glucagon

**Delta**
Secrete somatostatin

**F or PP cells**
Secrete pancreatic polypeptide
Exocrine cells
Have a common etiology with endocrine cells

Insulin
Tissues
Skeletal muscle
Cardiac muscle
Adipose tissue
Fibroblasts
Hepatocytes
Leukocytes
Mammary glands
Cartilage
Bone
Skin
Aorta
Pituitary gland
Peripheral nerves
Function
Stimulate anabolic reactions
Cell structure proteins
Energy storing
Transfer of glucose into cells
Enhances glucose oxidation and glycogenesis
Stimulates lipogenesis
Forms ATP
DNA, RNA formation
Decreases catabolic pathways
Lipolysis
Proteolysis
Ketogenesis
Gluconeogenesis
Figure 12-11. **Thyroid C cell, thyroid gland, normal dog.** Thyroid C (parafollicular) cell with numerous secretory granules (S) and moderate development of Golgi apparatus and rough endoplasmic reticulum. Microvilli from follicular cells *(arrow)* extend into the colloid of the follicular lumen *(C)*. The secretory polarity of the C cell is directed toward an interfollicular capillary *(arrowhead)* with fenestrae. TEM. Uranyl acetate and lead citrate stain.
Figure 12-15. Pancreatic islet, normal dog. Gomori’s aldehyde fuchsin stains the centrally located β cells (B) surrounded by a thin rim of poorly staining α cells and δ cells (arrow) at the periphery. The islets are surrounded by the exocrine pancreas. Gomori’s aldehyde fuchsin.
**Figure 12-16. Pancreatic islet, normal dog.** Differences in secretion granules between β cells (*B*) and α cells (*A*); the internal cores of secretion granules in β cells (*arrowheads*) are bar- or Y-shaped, with a prominent space between the limiting membrane and internal core. Secretion granules of the glucagon-secreting α cells have an electron-dense, circular, internal core with a narrow submembranous space (*arrow*). TEM. Uranyl acetate and lead citrate stain.
Figure 12-17. Secondary hypofunction of an endocrine gland, brain, pituitary gland and adrenal glands, dog. A large nonfunctional chromophobe adenoma (A) has invaded and completely destroyed the adenohypophysis and hypothalamus, and infiltrated into the thalamus. Destruction of the adenohypophysis has resulted in a lack of secretion of thyrotropin, adrenocorticotropin, and other pituitary trophic hormones. This resulted in severe trophic atrophy of the adrenal cortex (arrowheads), especially the adrenocorticotropic hormone–dependent zona fasciculata and zona reticularis, and consequently, in a relatively more prominent medulla (M).

Adrenal Gland
Cortex
Mesodermal origin
From the coelomic epithelium
3 layers
Zona Glomerulosa (15% cortical volume)
Outer zone also called Multiformis
Sigmoid or arch like columns of cells
Secretes Mineralocorticoids
Zona Fasciculata (middle zone)
Long anastomosing cords separated by small capillaries
80% of the cortical volume
Cells contain abundant lipid
Secretes glucocorticoid hormones
Zona Reticularis (5% of cortical volume)
Cells arranged in small groups surrounded by capillaries
Secrets Sex steroid hormones
Chromaffin tissue and sympathetic ganglion
From neuroectoderm of the neural crest
Dogs
Adrenal cortex is firm and yellow and surrounds the medulla
C:M ration is normally 2:1

Cortical Hormones
Mineralocorticoids
Affect ion transport by epithelial cells
Cause excretion of potassium
Conservation of sodium
Aldosterone
Acts on distal tubules of nephrons
Increases Na/Cl co transporter to reabsorb NaCl
Potassium and H+ are excreted by ion balancing diffusion
Addisons disease can result in lethal retention of potassium and low sodium levels
Glucocorticoids
Cortisol
Tend toward hyperglycemia
Spare glucose
Breakdown protein
Increased glucose production
Increase lipolysis → release glycerol and FFA
Suppress inflammatory and immunologic processes
Inhibition of fibroblast proliferation and collagen synthesis
Sex Steroids
Progesterone
Androgens
Estrogens
Corticotropic Chromophobe adenoma
A= adenoma- leads to bilateral enlargement of adrenal glands (pituitary dependent hyperadrenocorticism)
Zona glomerulosa is not affected

Figure 12-18. **Secondary hyperfunction of an endocrine organ, brain, pituitary gland and adrenal glands, dog.** Corticotroph (adrenocorticotropic hormone [ACTH]-secreting) chromophobe adenoma (A) in the pituitary gland and bilateral enlargement of the adrenal glands. The chronic secretion of ACTH has resulted in hypertrophy and hyperplasia of secretory cells of the zona fasciculata and zona reticularis in the adrenal cortex (arrows) and excessive secretion of cortisol.

Secondary Hyperfunction of an endocrine gland
Pituitary corticotroph adenoma
Bilateral adrenal cortical hyperplasia
Fasiculata
Reticularis
Sometimes pituitary is normal sized
Age related increase in monoamine oxidase in the hypothalamus and increased metabolism of dopamine
Results in reduced inhibition of ACTH production by the pars intermedia
Adrenal Medulla
Produces catecholamine hormones
Tyrosine $\rightarrow$ 1-dihydroxyphenylalanine (dopa) $\rightarrow$ 3,4 dihydroxyphenylethylamine (dopamine) $\rightarrow$ Norepinephrine
Norepinephrine $\rightarrow$ epinephrine; is corticosteroid hormone dependent
Adrenal Cortical atrophy due to exogenous administration of glucocorticoids → decreased ACTH release → atrophy of zona fasciculata and reticularis

**Figure 12-19. Iatrogenic syndrome of hormone excess, adrenal glands, dog.** Hyperadrenocorticism, caused by long-term administration of exogenous corticosteroids, has resulted in notable trophic atrophy of the adrenocorticotropic hormone–dependent zona fasciculata and zona reticularis of the adrenal cortex (C). The adrenal medulla (M) occupies a relatively greater percentage of the atrophic adrenal gland than of a normal adrenal gland.
Iatrogenic acromegaly (akros= extremities)
Exogenous administration of Medroxy-progesterone acetate
Causes excess somatotropin production from hyperplastic ductular epithelial cells

Figure 12-20. Iatrogenic acromegaly, beagle, center (compared with unaffected littermates, left and right). Note the coarseness of the facial features and the marked thickening and folding of the skin of the face. These characteristic changes are the result of the protein anabolic effects of somatotropin (produced by hyperplastic ductular epithelial cells), which has been stimulated by the exogenous administration of medroxyprogesterone acetate
Figure 12-21. Cystic Rathke’s pouch, brain, sagittal section, dog. A large, multiloculated cyst (C) is noted on the ventral aspect of this brain where the adenohypophysis would normally be located.
Figure 12-22. **Panhypopituitarism (“pituitary dwarfism”), 5-month-old German shepherd and littermate.** The unaffected littermate weighed 27.3 kg, whereas the dwarf puppy weighed only 4 kg. The pituitary dwarf has retained its puppy hair coat.

**Hypopituitarism**

Aplasia and prolonged gestation

Ewes

Veratrum californicum

12-14 d gestation

Alkaloids inhibit neural tube development resulting in cyclopia

Arrhinencephaly and lack of nasal bones, proboscis

Unable to secrete normal ACTH due to lack of hypothalamic control

Inadequate secretion of cortisol

Failure to induce 17alpha-hydroxylase in the placenta

Converts progesterone to estrogen
Leads to failure of PGF2 synthesis in the uterus and lack of smooth muscle contraction
Pregnancy is maintained until C section
Adrenal cortex does not develop
Sub-normal SHH expression
Ewes and calves
Increased SHH expression
Diprosopus- two faced

Normal Gestation and parturition
Fetal hormones are necessary for final growth and development of the fetus in certain animals
Normal parturition requires an intact hypothalamic-pituitary-adrenocortical axis

Pituitary Cysts and Panhypopituitarism and pituitary dwarfism
Rathkes pouch
Oropharyngeal ectoderm
Failure to differentiate into pars distalis
Progressively large multiloculated cyst
Abscense of the adenohypophysis
German Shepherd
Normal from birth up to 2 months
Slower growth
Retention of puppy haircoat, lack of primary guard hairs
Simple autosomal recessive
Somatomedin (ILGF) is low
**Figure 12-23. Hirsutism, skin, horse.** The hirsutism is the result of a failure to shed of hair due to an adenoma of the pars intermedia.

Pars Intermedia Adenomas
- Horse > dogs >>>>>>other spp
- Functionally inactive
- Hypopituitarism and diabetes insipidus
- Functionally Active
- Excess ACTH
- PD Hyperadrenocorticism
  - Corticotrophs have abundant eosinophilic cytoplasm and widely scattered follicles
  - Derived from ACTH (B cell) not MSH (A cell)
- Clinical syndromes in horses
  - PU/PD
  - Muscle weakness
  - Somnolence
  - Hyperhidrosis
Hirsutism because of failure to shed hairs
Insulin resistant hyperglycemia
Compression of the hypothalamus leading to increased appetite, deranged carbohydrate metabolism, and hypertrichosis and hyperhidrosis

Corticotroph adenomas
Dogs- pars distalis
Horses- pars intermedia

Inactive chromophobe adenomas
Dogs, cats, lab rodents, parakeets
Causes compressive lesions of adjacent tissues
Decreased spontaneous activity
Incoordination
Disturbances of balance
Weakness and collapse
Blindness and dilated pupils

Pituitary gland carcinomas
Usually endocrinologically inactive
Destroy pars distalis and neurohypophyseal system
Lead to panhypopituitarism and diabetes insipidus
Large and invade extensively
Brain
Basisphenoid bone
Cause osteolysis
Highly cellular and have areas of necrosis and hemorrhage
Giant cells nuclear pleomorphism and mitotic figures

Craniopharyngiomas
Benign
Derived from epithelial remnants of oropharyngeal ectoderm of Rathkes pouch
Suprasellar or infrasellar locations
Causes panhypopituitarism and dwarfism in young dogs
Causes abnormal secretion of somatotrophin
Alternating solid and cystic areas
Figure 12-24. Adenoma, brain, pituitary gland, horse. The pituitary gland is notably enlarged because of an adenoma (A) of the pars intermedia.
Figure 12-25. Adenoma, pituitary gland, pars intermedia, horse. Adenoma composed of cords and ribbons of well-differentiated, tall cuboidal to columnar cells with ample amounts of granular basophilic cytoplasm. H&E stain.
Figure 12-26. **Adenoma, pituitary gland, dog.** A large pituitary adenoma (A) has extended dorsally and compresses the overlying brain. The optic chiasm (arrow) is also severely compressed. The adenohypophysis, neurohypophysis, and hypothalamus have been destroyed by the neoplasm.
Figure 12-27. **Craniopharyngioma (C), pituitary area, adrenal glands, thyroid glands, dog.** The neoplasm has extended dorsally through the hypothalamus and compressed the thalamus (*black arrows*). The neoplasm has also destroyed the adenohypophysis and neurohypophysis, resulting in severe trophic atrophy of the adrenal cortex (*white arrow*). The adrenal glands consist predominantly of medulla (*M*) surrounded by a thin rim of cortex (capsule plus zona glomerulosa). Although the thyroid follicular cells are atrophic, the overall gland (*T*) size is within normal limits because of colloid involution of the follicles.

**Diabetes Insipidus**

**Central**

Lack of ADH produced

Compression or destruction of the pars nervosa, infundibular stalk, or supraoptic nucleus

**Nephrogenic**

ADH targets don’t respond
Figure 12-28A.  Adrenocortical hemorrhage (Waterhouse-Friderichsen syndrome), adrenal gland, horse.  A, Diffuse hemorrhage (arrow) affecting the adrenal cortex is frequently seen in endotoxic shock.
Figure 12-28B. Adrenocortical hemorrhage (Waterhouse-Friderichsen syndrome), adrenal gland, horse.

B. Subgross of diffuse hemorrhage (arrow) affecting the adrenal cortex. H&E stain.

Adrenocortical Hemorrhage (Waterhouse-Friderichsen Syndrome)
Massive diffuse bilateral adrenocortical hemorrhage
From sepsis- gram positive or gram negative shock

Idiopathic Adrenocortical atrophy
Bilateral
Young adult dogs
Causes Addisons
Foci of lymphocytes and plasma cells
**Figure 12-29. Adrenal cortical atrophy, brain stem and pituitary gland, adrenal glands, dog.** Bilateral atrophy of all three cortical layers (*arrows*) is characteristic of hypoadrenocorticism. The pituitary gland (*arrowhead*) was grossly normal with microscopic evidence of corticotroph hyperplasia.

**Disorders of the adrenal cortex**

- Hypoadrenocorticism
- Hyperkalemia
- Hyponatremia
- Increased insulin sensitivity
- Hypoglycemia
- Increased MSH secretion
- Atrophy of adrenal cortex

- Adrenalitis
Bacteria
Parasitic
Toxoplasmosis
Histiocytic and necrosis
Fungus
Granulomatous inflammation with central necrosis
Blasto, histo, cryptococcus
Figure 12-30. Cushing’s-like disease, hypercortisolism, dog, poodle.

Hypercortisolism followed exogenous corticosteroid administration for the treatment of idiopathic adrenal cortical hyperplasia. Muscle asthenia is the cause of the pendulous abdomen. Note the alopecia of the skin of the abdomen, ventral cervical region, and tail.

Cushings
Functional Pituitary Corticotroph tumor
Bilateral cortical hypertrophy

Congenital Adrenal Hyperplasia (adrenogenital Syndrome)
Hypo and Hyperadrenocorticism
Deficiency in 21-Hydroxylase
Mineralocorticoid and glucocorticoid synthesis
Low cortisol □ increased ACTH □ adrenocortical hyperplasia □ increased androgens (not need 21 hydroxylase)
Leads to sexual ambiguity in newborns and premature closure of physis
Figure 12-31. **Nodular adrenal cortical hyperplasia, adrenal gland, dog.**
Multiple discrete nodules (arrows) of cortical hyperplasia extend into the medulla.

Adrenal Hyperplasia
Nodular hyperplasia
Figure 12-32. Adrenocortical adenoma, adrenal gland, horse. Note the well-demarcated, large, yellowish-tan, adrenocortical adenoma (A) compressing the adjacent unaffected medulla (M). C, Adrenal cortex.
Figure 12-33. Adrenocortical carcinoma and contralateral cortical atrophy, adrenal glands, dog. The adrenal gland (right) has a large adrenocortical carcinoma that is almost half the size of an adult kidney (left). Multifocal to coalescing areas of hemorrhage and necrosis are apparent (arrowheads) in this tumor. The cortex of the contralateral adrenal gland (lower) is notably thinned (arrow) because of severe trophic atrophy of the zona fasciculata and zona reticularis.
Figure 12-34. Adrenocortical carcinoma with myxoid differentiation, adrenal gland, ferret. Note that the cystic spaces lined by neoplastic cells contain abundant mucinous material. Alcian blue stain.
Figure 12-35. **Hyperplasia, adrenal medulla, bull.** Bilateral diffuse hyperplasia of adrenal medulla in a bull with a concomitant C-cell carcinoma of the thyroid gland. The expanded adrenal medulla (*bottom*) has compressed the surrounding adrenal cortex (*arrows*). H&E stain
Pheochromocytoma, adrenal gland, horse
Compresses adjacent unaffected adrenal cortex
Often associated with C-cell neoplasia in bulls and humans

Figure 12-36. Pheochromocytoma, adrenal gland, horse. A pheochromocytoma compressing the adjacent unaffected adrenal cortex.
Figure 12-37. Pheochromocytoma, kidney, adrenal gland, caudal vena cava, dog. A large pheochromocytoma \((P)\) has obliterated the adrenal gland medial to the kidney \((K)\) and has extensively invaded into the lumen of the caudal vena cava \((arrow)\).
Figure 12-38. **Hypothyroidism, skin, dog.** Hyperkeratosis (arrows) has resulted in thickening of the epidermis of the skin. H&E stain.
Figure 12-39. Atherosclerosis, hypothyroidism with marked hyperlipidemia, heart, coronary arteries, dog. Note the atherosclerosis (arrows) of the coronary arteries which are thickened, firm, yellow-white, and often beaded.
Figure 12-40. **Lymphocytic thyroiditis in a dog with severe hypothyroidism.** A lymphocyte (L) and macrophage (M) are present in the colloid (C) of a thyroid follicle. A plasma cell (P) within the follicular basement membrane (B) is infiltrating between thyroid follicular cells. TEM. Uranyl acetate and lead citrate stain.
Figure 12-41. Hyperplasia, hyperthyroidism, thyroid glands, cat.
Multinodular follicular cell hyperplasia (arrowheads) involves both thyroid lobes.
Figure 12-42. **Hyperplastic goiter, thyroid gland, dog.** Papillary projection (arrow) extends into the follicular lumen. Note the partial collapse of the majority of the follicles. Periodic acid–Schiff reaction
Figure 12-43. Congenital dyshormonogenetic goiter, thyroid gland, lamb.
The symmetrically enlarged thyroid (T) lobes are fused at the midline ventral to the larynx (L) and trachea
Figure 12-44. Thyroid carcinoma, thyroid gland, dog. The poorly circumscribed and well-vascularized thyroid carcinoma (CA) is locally invasive and has extended into the wall of the esophagus. E, Esophageal mucosa
Figure 12-45. **C-cell adenoma, thyroid gland, horse.** The adenoma (A) is confined by the thyroid capsule and a rim of compressed thyroid gland (*arrow*) at the periphery of the mass.
Figure 12-46. C-cell carcinoma and metastases, thyroid and cervical lymph nodes, Holstein bull. Note the swellings in the neck (arrows) as a result of lymphadenopathy of the cranial cervical lymph nodes from metastases.
Figure 12-47. Parathyroid cyst (left), parathyroid gland, dog. The parathyroid cyst (arrow) was formed from the persistent and distended embryonic duct that connects parathyroid-thymic primordia in the III and IV pharyngeal pouches (Kürsteiner’s cyst). Besides the parathyroid cyst, both parathyroid glands (P) are hyperplastic because of chronic renal failure.
Figure 12-49. **Diffuse lymphocytic parathyroiditis, parathyroid gland, dog.**

The external parathyroid gland (P) has been completely replaced by lymphocytes, plasma cells, fibroblasts, and neocapillaries. T, Thyroid gland. H&E stain
Figure 12-50. **Adenoma, parathyroid gland, dog.** The adenoma consists of closely packed chief cells arranged in small groups separated by fine fibrous septa containing capillaries (*arrowheads*). It is partially encapsulated and has compressed the adjacent, nonneoplastic parathyroid tissue (*arrows*), which has undergone trophic atrophy. H&E stain
Figure 12-51. Adenoma, parathyroid gland, dog. Active chief cells have large lamellar arrays of rough endoplasmic reticulum (E), prominent Golgi apparatus (G), and large mitochondria (M) but few secretory granules (S). N, Nucleus of chief cell. TEM. Uranyl acetate and lead citrate stain.
Figure 12-52. Primary hyperparathyroidism, humerus, dog. Severe thinning of cortical bone and large resorptive cavities (arrow) have resulted from localized resorption of bone by osteoclasts.
Figure 12-53. Adenocarcinoma, apocrine glands of right anal sac, anus, dog. The right perianal region is distended by a small adenocarcinoma (arrow), which has compressed the right side of the anus. It also projects, as two nodules, on the dorsolateral margin of the anus. T, Tail
Figure 12-54. Adenocarcinoma, apocrine glands, anal sac, dorsal plane, formalin fixed specimen, dog. A 1-cm-diameter nodule (arrows) derived from apocrine glands of the wall of the right anal sac (glands of the perianal sinus) protrudes into the lumen of the right anal sac. Anal sacs (A) are present on both sides of the rectum (R).
Figure 12-55. Adenocarcinoma, anal sac, dog. Projections (P) of apical cytoplasm extend into the acinar lumen (L). Small membrane-limited secretory granules (arrowheads) are present in the cytoplasm. TEM. Uranyl acetate and lead citrate stain.
Figure 12-56. Schematic diagram of calcium homeostasis in cows fed a high-calcium prepartal diet. In this case, calcium homeostasis is primarily dependent on intestinal calcium absorption. The rate of bone resorption is low, and parathyroid glands are inactive. Anorexia and gastrointestinal stasis that often occur near parturition interrupt the major inflow of calcium into the extracellular fluid calcium pool. Outflow of calcium with the onset of lactation exceeds the rate of inflow into the calcium pool, and cows develop a progressive hypocalcemia and paresis. CT, Calcitonin; PTH, parathyroid hormone
Figure 12-57. Chronic relapsing pancreatitis, pancreas and duodenum, cross section, dog. The pancreas is multinodular and firm with areas of hemorrhage (arrow), fibrosis, and necrosis. D, Duodenum.

Pancreatic Islets
Endocrine
Islets of Langerhans
Surrounded by acinar exocrine cells
Beta cells
Most common
Synthesize Insulin secretion requires adequate calcium in ECM and Glucose
Co-secrete Islet amyloid protein
Alpha cells
Glucagon
Delta
Secrete somatostatin
F or PP cells
Secrete pancreatic polypeptide
Exocrine cells
Have a common etiology with endocrine cells

**Insulin**

Tissues
Skeletal muscle
Cardiac muscle
Adipose tissue
Fibroblasts
Hepatocytes
Leukocytes
Mammary glands
Cartilage
Bone
Skin
Aorta
Pituitary gland
Peripheral nerves

Function
Stimulate anabolic reactions
Cell structure proteins
Energy storing
Transfer of glucose into cells
Enhances glucose oxidation and glycogenesis
Stimulates lipogenesis
Forms ATP
DNA, RNA formation
Decreases catabolic pathways
Lipolysis
Proteolysis
Ketogenesis
Gluconeogenesis

**Glucagon**
Stimulates energy release from target cells
Secreted in response to reduction in blood glucose

Pineal gland
N euroendocrine organ
Influences circadian rhythm
Loose neuroglial stroma
Nests of pinealocytes
Scattered calcified bodies
Brain sand
Corpora arenacea
Secrete melatonin during dark periods
Influences circadian rhythm
Reproductive activity in mammals
Inhibition of GnRH

Chemoreceptor organs
Carotid body
Aortic body
Parasympathetic
Increase depth, rate and minute volume of respiration
Sympathetic
Increase heart rate
Elevate arterial BP
Nodose ganglion of vagus nerve
Ciliary ganglion in the orbit
Pancreas
Internal jugular bodies below the middle ear
Glomus jugular along recurrent branch of the glossopharyngeal nerve
Figure 12-58. Chronic pancreatitis, pancreas, dog. vv The pancreas (P) is markedly atrophied and its parenchyma almost completely replaced by fibrous connective tissue in “end-stage” pancreatitis. D, Duodenum.
Figure 12-59. Hydropic (“vacuolar”) degeneration, pancreatic islet, cat. Discrete vacuoles (arrowheads) are present in the cytoplasm of β cells. E, Exocrine pancreas. H&E stain.
Figure 12-61. **Amyloidosis, pancreatic islets, cat.** Note the deposits of amyloid (A) and degeneration and loss of islet cells. H&E stain.
Figure 12-63. **Cirrhosis, liver, diaphragmatic surface, dog.** All lobes of the liver are considerably firm and have a coarsely nodular surface. The nodules (arrows) represent areas of regenerative hyperplasia of hepatocytes.
Figure 12-64. Diabetes mellitus, eyeball, lens, dog. Early stellate lesion (arrowheads) along the sutures of the lens. In dogs (not in cats), cataracts (stellate lesions) can occur in poorly regulated diabetes mellitus, because glucose is metabolized in the lens by a sorbitol pathway, which leads to edema of the lens.
Figure 12-65. Glycogen “nephrosis,” diabetes mellitus, kidney, dog. The radially arranged light areas in the inner cortex of the kidney (arrow) represent tubules with abnormal accumulations of glycogen.
Figure 12-66.  β-Cell adenoma, pancreatic islet, dog. A solid islet adenoma, surrounded by a fibrous capsule of variable thickness has compressed the adjacent exocrine pancreas (arrow). H&E stain.
Figure 12-67.  β-Cell carcinoma, pancreatic islet, dog. The whitish-red carcinoma (CA) is well demarcated from the lobular exocrine pancreas (P). (
Figure 12-68. **Carcinoma, aortic body, dog.** Note the large mass (C) at the base of the heart (H). Contiguous portions of the right-middle and diaphragmatic lung lobes are atelectatic. L, Lungs
Figure 12-69. Carcinoma, ectopic thyroid tissue, cranial mediastinum, Cross Section, dog. Neoplastic tissue \( (T) \) surrounds the trachea \( (arrow) \) and other structures in the cranial mediastinum.