Oxytocin

- Oxytocin is a strong stimulant of uterine contraction
- Regulated by a positive feedback mechanism to oxytocin in the blood
- This leads to increased intensity of uterine contractions, ending in birth
- Oxytocin triggers milk ejection (“letdown” reflex) in women producing milk
- Synthetic and natural oxytocic drugs are used to induce or hasten labor
- Plays a role in sexual arousal and satisfaction in males and nonlactating females

Antidiuretic Hormone (ADH)

- ADH helps to avoid dehydration or water overload
- Prevents urine formation
- Osmoreceptors monitor the solute concentration of the blood
- With high solutes, ADH is synthesized and released, thus preserving water
- With low solutes, ADH is not released, thus causing water loss from the body
- Alcohol inhibits ADH release and causes copious urine output

Thyroid Gland

- The largest endocrine gland, located in the anterior neck, consists of two lateral lobes connected by a median tissue mass called the *isthmus*
- Composed of follicles that produce the glycoprotein *thyroglobulin*

Thyroid Gland

- Colloid (thyroglobulin + iodine) fills the lumen of the follicles and is the precursor of thyroid hormone
- Other endocrine cells, the parafollicular cells, produce the hormone *calcitonin*

Thyroid Hormone (TH)

- Thyroid hormone – the body's major metabolic hormone
- Consists of two closely-related iodine-containing compounds
- T_4 – thyroxine; has two tyrosine molecules plus four bound iodine atoms
- T_3 – triiodothyronine; has two tyrosines with three bound iodine atoms

Effects of Thyroid Hormone

- TH is concerned with:
- Glucose oxidation
- Increasing metabolic rate
- Heat production
- TH plays a role in:
- Maintaining blood pressure
- Regulating tissue growth
- Developing skeletal and nervous systems
- Maturation and reproductive capabilities

Transport and Regulation of TH

- T_4 and T_3 bind to thyroxine-binding globulins (TBGs) produced by the liver
- Both bind to target receptors, but T_3 is ten times more active than T_4
- Peripheral tissues convert T_4 to T_3
- Mechanisms of activity are similar to steroids
- Regulation is by negative feedback
- Hypothalamic thyrotropin-releasing hormone (TRH) can overcome the negative feedback

Synthesis of Thyroid Hormone

- Thyroglobulin is synthesized and discharged into the lumen
- Iodides (I^-) are actively taken into the cell, oxidized to iodine (I_2), and released into the lumen
- Iodine attaches to tyrosine, mediated by peroxidase enzymes, forming T_1 (monoiodotyrosine, or MIT), and T_2 (diiodotyrosine, or DIT)
- Iodinated tyrosines link together to form T_3 and T_4
- Colloid is then endocytosed and combined with a lysosome, where T_3 and T_4 are cleaved and diffuse into the bloodstream

Calcitonin

- A peptide hormone produced by the parafollicular, or C, cells
- Lowers blood calcium levels in children
- Antagonist to parathyroid hormone (PTH)
- Calcitonin targets the skeleton, where it:
- Inhibits osteoclast activity and thus bone resorption and release of calcium from the bone matrix
- Stimulates calcium uptake and incorporation into the bone matrix
- Regulated by a humoral (calcium ion concentration in the blood) negative feedback mechanism

Parathyroid Glands

- Tiny glands embedded in the posterior aspect of the thyroid

- Cells are arranged in cords containing oxyphil and chief cells
- Chief (principal) cells secrete PTH
- PTH (parathormone) regulates calcium balance in the blood

Effects of Parathyroid Hormone

- PTH release increases Ca^{2+} in the blood as it:
- Stimulates osteoclasts to digest bone matrix
- Enhances the reabsorption of Ca^{2+} and the secretion of phosphate by the kidneys
- Increases absorption of Ca^{2+} by intestinal mucosal cells
- Rising Ca^{2+} in the blood inhibits PTH release

Adrenal (Suprarenal) Glands

- Adrenal glands – paired, pyramid-shaped organs atop the kidneys
- Structurally and functionally, they are two glands in one
- Adrenal medulla – nervous tissue that acts as part of the SNS
- Adrenal cortex – glandular tissue derived from embryonic mesoderm

Adrenal Cortex

- Synthesizes and releases steroid hormones called *corticosteroids*
- Different corticosteriods are produced in each of the three layers
- Zona glomerulosa – mineralocorticoids (chiefly aldosterone)
- Zona fasciculata – glucocorticoids (chiefly cortisol)

  Zona reticularis – gonadocorticoids (chiefly androgens)

Mineralocorticoids

- Regulate the electrolyte concentrations of extracellular fluids

- Aldosterone – most important mineralocorticoid
- Maintains Na^+ balance by reducing excretion of sodium from the body
- Stimulates reabsorption of Na^+ by the kidneys
- Aldosterone secretion is stimulated by:
- Rising blood levels of K^+
- Low blood Na^+
- Decreasing blood volume or pressure

The Four Mechanisms of Aldosterone Secretion

- Renin-angiotensin mechanism – kidneys release renin, which is converted into angiotensin II

  that in turn stimulates aldosterone release

- Plasma concentration of sodium and potassium – directly influences the zona glomerulosa

  cells

- ACTH – causes small increases of aldosterone during stress
- Atrial natriuretic peptide (ANP) – inhibits activity of the zona glomerulosa

Glucocorticoids (Cortisol)

- Help the body resist stress by:
- Keeping blood sugar levels relatively constant
- Maintaining blood volume and preventing water shift into tissue
- Cortisol provokes:
- Gluconeogenesis (formation of glucose from noncarbohydrates)
- Rises in blood glucose, fatty acids, and amino acids

Excessive Levels of Glucocorticoids

- Excessive levels of glucocorticoids:
- Depress cartilage and bone formation
- Inhibit inflammation
- Depress the immune system
- Promote changes in cardiovascular, neural, and gastrointestinal function

Gonadocorticoids (Sex Hormones)

- Most gonadocorticoids secreted are androgens (male sex hormones), and the most important

  one is testosterone
- Androgens contribute to:
- The onset of puberty
- The appearance of secondary sex characteristics
- Sex drive in females
- Androgens can be converted into estrogens after menopause

Adrenal Medulla

- Made up of chromaffin cells that secrete epinephrine and norepinephrine
- Secretion of these hormones causes:
- Blood glucose levels to rise
- Blood vessels to constrict
- The heart to beat faster
- Blood to be diverted to the brain, heart, and skeletal muscle
- Epinephrine is the more potent stimulator of the heart and metabolic activities
- Norepinephrine is more influential on peripheral vasoconstriction and blood pressure

Pancreas

- A triangular gland, which has both exocrine and endocrine cells, located behind the stomach
- Acinar cells produce an enzyme-rich juice used for digestion (exocrine product)
- Pancreatic islets (islets of Langerhans) produce hormones (endocrine products)
- The islets contain two major cell types:
- Alpha (α) cells that produce glucagon
- Beta (β) cells that produce insulin

Glucagon

- A 29-amino-acid polypeptide hormone that is a potent hyperglycemic agent
- Its major target is the liver, where it promotes:
- Glycogenolysis – the breakdown of glycogen to glucose
- Gluconeogenesis – synthesis of glucose from lactic acid and noncarbohydrates
- Releases glucose to the blood from liver cells

Insulin

- A 51-amino-acid protein consisting of two amino acid chains linked by disulfide bonds
- Synthesized as part of proinsulin and then excised by enzymes, releasing functional insulin
- Insulin:
- Lowers blood glucose levels
- Enhances transport of glucose into body cells
- Counters metabolic activity that would enhance blood glucose levels

Effects of Insulin Binding

- The insulin receptor is a tyrosine kinase enzyme
- After glucose enters a cell, insulin binding triggers enzymatic activity that:
- Catalyzes the oxidation of glucose for ATP production
- Polymerizes glucose to form glycogen
- Converts glucose to fat (particularly in adipose tissue)

Regulation of Blood Glucose Levels

- The hyperglycemic effects of glucagon and the hypoglycemic effects of insulin

Diabetes Mellitus (DM)

- Results from hyposecretion or hypoactivity of insulin
- The three cardinal signs of DM are:
- Polyuria – huge urine output
- Polydipsia – excessive thirst
- Polyphagia – excessive hunger and food consumption
- Hyperinsulinism – excessive insulin secretion, resulting in hypoglycemia

Gonads: Female

- Paired ovaries in the abdominopelvic cavity produce estrogens and progesterone
- They are responsible for:
- Maturation of the reproductive organs
- Appearance of secondary sexual characteristics
- Breast development and cyclic changes in the uterine mucosa

Gonads: Male

- Located in an extra-abdominal sac (scrotum), they produce testosterone

- Testosterone :
- Initiates maturation of male reproductive organs
- Causes appearance of secondary sexual characteristics and sex drive
- Is necessary for sperm production
- Maintains sex organs in their functional state

Pineal Gland

- Small gland hanging from the roof of the third ventricle of the brain
- Secretory product is melatonin
- Melatonin is involved with:
- Day/night cycles
- Physiological processes that show rhythmic variations

Thymus

- Lobulated gland located deep to the sternum in the thorax
- Major hormonal products are thymopoietins and thymosins
- These hormones are essential for the development of the T lymphocytes (T cells) of the

  immune system

Other Hormone-Producing Structures

- Heart – produces atrial natriuretic peptide (ANP), which reduces blood pressure, blood

  volume, and blood sodium concentration
- Gastrointestinal tract – enteroendocrine cells release local-acting digestive hormones
- Placenta – releases hormones that influence the course of pregnancy

- Kidney – secrete erythropoietin, which signals the production of red blood cells
- Skin – produces cholecalciferol, the precursor of vitamin D
- Adipose tissue – releases leptin, which is involved in the sensation of satiety

Developmental Aspects

- Hormone-producing glands arise from all three germ layers
- Endocrine glands derived from mesoderm produce steroid hormones
- Endocrine organs operate smoothly throughout life
- Most endocrine glands show structural changes with age, but hormone production may or

  may not be effected
- GH levels decline with age and this accounts for muscle atrophy with age
- Supplemental GH may spur muscle growth, reduce body fat, and help physique
- TH declines with age, causing lower basal metabolic rates
- PTH levels remain fairly constant with age, and lack of estrogen in women make them more

  vulnerable to bone-demineralizing effects of PTH

Developmental Aspects: Gonads

- Ovaries undergo significant changes with age and become unresponsive to gonadotropins
- Female hormone production declines, the ability to bear children ends, and problems

  associated with estrogen deficiency (e.g., osteoporosis) begin to occur
- Testosterone also diminishes with age, but effect is not usually seen until very old age