Endocrine System
Pancreas

- Endocrine pancreas - Islets of Langerhans
  - A or alpha cells $\Rightarrow$ glucagon
  - B or beta cells $\Rightarrow$ insulin
  - Delta cells $\Rightarrow$ somatostatin
<table>
<thead>
<tr>
<th>GLAND</th>
<th>HORMONE</th>
<th>TARGET</th>
<th>ACTION</th>
</tr>
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<tbody>
<tr>
<td>Pancreas</td>
<td>Absorptive phase hormone: storage of foodstuffs</td>
<td>Muscle, fat, liver, et al.</td>
<td>↓ plasma glucose etc.</td>
</tr>
<tr>
<td></td>
<td>β cells</td>
<td>Insulin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>α cells</td>
<td>Glucagon</td>
<td>Liver, fat cells</td>
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</table>
Glucagon & Metabolism

– Produced by beta cells of Islets
– Primary sugar hormone in birds
– Catabolic hormone – breaks down material to get sugar
– Its release results in:
  • Circulating glucose ↑
  • Liver Glycogen ↓
  • Adipose Triglyceride ↓
  • Gluconeogenesis ↑
Insulin & Metabolism

- Produced by beta cells of Islets of Langerhan in the Pancreas

- Primary sugar hormone in mammals but not birds

- Insulin secretion is only modestly increased by blood glucose levels in birds.

- Injection of insulin can kill:
  - 5 IU/Kg of Body weight kills rabbit
  - 5000 IU/Kg of body weight kills chicken
Insulin & Metabolism

- Anabolic hormone – builds up sugar storage
- It promotes uptake of glucose and amino acids by cells

- Its release results in:
  - Circulating glucose ↓
  - Glycogen ↑
  - Triglyceride ↑
  - Gluconeogenesis ↓
Gut hormones

Gastrin
• Stimulates release of gastric acid
• Presence of injesta - gastrin release
• Produced by specific cells in proventriculus
Gut hormones

Ghrelin

• Increases appetite (acting in hypothalamus/brain)
• Produced by specific cells in proventriculus

Other hormones in small intestine - CCK, VIP, motilin
Adipose tissue

- Leptin
- Acts on satiety center in the hypothalamus to decrease food consumption
Anatomy

Thymus

Thyroids

Parathyroid

Parathyroids
Thyroids

- Only endocrine glands that store secretory particles in an extracellular site for release at a later time. Other glands just release hormones from the cell into the blood.

- The extracellular sites of storage are called follicles and they are filled with thyroxine (T4) bound to thyroglobulin.
Thyronine = dimer of two tyrosine molecules

Thyroxine $T_4 = $ tetraiodothyronine – four iodine atoms,
inactive form, 95% of hormone produced
Monodeiodinase enzyme removes one iodine.
Growth Hormone increases the level of this enzyme.
Activated in target cells

$T_3 = $ triiodothyronine – active form which acts on genes to increase BMR

95% of the hormone produced by the thyroid follicles is the inactive $T_4$. But $T_4$ is converted to the active $T_3$ by the target cells. $T_3$ enters the nucleus to activate genes which increase the basal metabolic rate (BMR).
Thyroid Hormones

Monoiodotyrosine

Diiodotyrosine

Triiodothyronine

Thyroxine
Thyroxin (T4)

• Converted to active hormone - triiodothyronine (T3) in the liver

• Release stimulated by thyroid stimulating hormone (TSH) (aka thyrotropin)

• T3 is often bound to protein in blood
T3 actions

- Melanin deposition in feathers
- Molting of feathers
- Increase speed of nerve transmission
- Increases $O_2$ utilization
- Increases metabolic rate
- Increases body temperature
- Increases heat production
The stimulus for increased T4 and T3 production is an increase in energy demanding activities. This is mediated through the hypothalamus which sends out more TRH. TRH then increases the TSH produced by the adenohypophysis, which in turn increases the production of hormones by the thyroid. By activating genes which produce enzymes important in cell metabolism they facilitate the demand for energy by the cells and also raise the BMR slightly. The increase in thyroid hormones T4 and T3 feeds back to the hypothalamus to control the process.
Hypothyroidism

• Results in:
  – Less T4 and T3 produced
  – Goiter - Increased thyroid gland size (300-500x)
  – Fatigue
  – Weight gain
  – Mentally slow
Hypothyroidism

• Caused by:
  – Thyroidectomy
  – Goitrogen
  • $^{131}\text{I}$ kills thyroid used to treat hyperthyroidism
Goitrogen

• Cause Goiters – very swollen neck due to over production of thyroglobulin

• They block synthesis of T4 and T3 so no negative feedback and thyroid size increases.

• This is why our salt contains iodine.
Hyperthyroidism

- Excess T4 and T3 produced
- Results in:
  - Weight loss
  - Insomnia
  - Large eyes
  - Nervousness
Parathyroid Glands

• 4 in a chicken

• A pair of glands located slightly caudal to thyroids on each side of midline.

• Composed of *chief cells*
  – Synthesize, package, and secrete *parathyroid hormone*
    • Increases blood calcium levels

• Putting birds on low Ca diet will increase the size of these glands.
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<tr>
<td>Parathyroid glands</td>
<td>Parathormone</td>
<td>GI, kidneys, skeleton</td>
<td>↑ blood calcium</td>
</tr>
</tbody>
</table>

The most important hormone for Ca^{+2} homeostasis.

1) Increases absorption of Ca^{+2} by activating more Vit D_3
2) Increases reabsorption of Ca^{+2} in the kidneys.
3) Increases osteoclastic activity in bones
Mechanism of PTH Action

1) Increases absorption of $\text{Ca}^{+2}$ by activating more Vit $\text{D}_3$

2) Increases reabsorption of $\text{Ca}^{+2}$ in the kidneys.

3) Increases osteoclastic activity in bones

Figure 17.11
Ultimobranchial Glands

- Located posterior to the parathyroids on each side

- Secrete *calcitonin (CT)*
  - Very high levels in birds
  - Possibly regulates calcium concentration in birds??????
  - But injection of CT has no effect on plasma Ca.
  - And removal of ultimobranchial gland does not affect Ca levels
Adrenal Gland
Figure 22-2. Microanatomy of the avian adrenal. (A) Distribution of chromaffin (C) and adrenal cortical (A). (B) Structure of the loops of adrenal cortical cells with the adrenal capsule also indicated (OCC). (Taken from Chester-Jones and Phillips, 1985.)
Adrenalectomy Causes:

- Hypoglycemia = low blood glucose
- Less liver glycogen
- More Na lost in urine
- Less plasma Na
- More plasma K
- Lower blood pressure and renal failure
- More infections
- Unable to survive environmental stressors
Adrenal Chromaffin cells

• In medulla in mammalian adrenal, in clumps in avian adrenal
• Epinephrine and norepinephrine released due to nerve input and not ACTH
  – Cause ACTH release = Fight or flight
  – Plasma glucose up, fatty acids in plasma up
  – Heart rate up
  – Blood pressure up due to vasoconstriction
Adrenal cortical cells

• In mammal these are in cortex of adrenal but in birds, in clumps
• At least two cell types
  • One produces Aldosterone
  • One produces Corticosterone
• Both of these are steroids
Fig. 1.—Probable pathways of steroidogenesis by the adrenal glands of embryonic and young chickens: based on Nakamura et al. (1978).
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<td>Adrenal cortex</td>
<td>Corticosteroids:</td>
<td>kidneys</td>
<td>Electrolyte balance, ↑ Na⁺ reabsorption</td>
</tr>
<tr>
<td></td>
<td>Mineralcorticoids e.g. aldosterone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Glucocorticoids e.g. cortisol</td>
<td>Liver, muscle, connective, connective,</td>
<td>Gluco-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>neogenesis</td>
</tr>
<tr>
<td></td>
<td>Gonadocorticoids e.g. sex hormones, testosterone, estrogen</td>
<td>Gonads and other tissues</td>
<td>Complement gonadal secretion</td>
</tr>
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Controlled by ACTH
Corticosterone

- Production stimulated by pituitary hormone Adrenocorticotropic hormone (ACTH)
- The “stress” hormone
Corticosterone

• Like cortisol in mammals
• A glucocorticoid =
  – Increases plasma glucose levels and liver glycogen
  – Blocks actions of Insulin
  – Causes breakdown of proteins (muscle) to release amino acids for gluconeogenesis (making glucose)
  – Increases fat breakdown and free fatty acids in plasma
  – Decreases lymphocytes
Corticosterone

• Circulates in blood bound to a carrier protein
  – Hormone reservoir
  – Increases time hormone is in blood and not filtered by kidneys

• Continuous exposure to stress results in less corticosterone = exhaustion phase
Corticosterone
What causes it to increase in blood?

• STRESS!!!!!!!!!!
  – Starvation, dehydration, hypo and hyperthermia, pollution, anesthesia, electrocution, restraint, infection, exertion
Aldosterone

• A mineralocorticoid
• Production stimulated by angiotensin
• Action- sodium retension