Hormones that influence blood glucose level, and a short list of important terms:

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Tissue of Origin</th>
<th>Metabolic Effect</th>
<th>Effect on Blood Glucose</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin</td>
<td>Pancreatic β Cells</td>
<td>1) Enhances entry of glucose into cells. 2) Enhances storage of glucose as glycogen, or conversion to fatty acids (Glycogenesis). 3) Enhances synthesis of fatty acids and proteins. 4) Suppresses breakdown of proteins into amino acids, of adipose tissue into free fatty acids.</td>
<td>↓</td>
<td>Hypo -D MI &amp; DMII</td>
</tr>
<tr>
<td>Glucagon</td>
<td>Pancreatic α Cells</td>
<td>Among other things: Enhances release of glucose from glycogen (Glycogenolysis)</td>
<td>↑</td>
<td>Problem with diabetes MI</td>
</tr>
<tr>
<td>Cortisol</td>
<td>Adrenal cortex</td>
<td>Among other things: Enhances glucose.</td>
<td>↑</td>
<td>Cushing’s Addison’s</td>
</tr>
<tr>
<td>ACTH</td>
<td>Anterior pituitary</td>
<td>Among other things: Enhances release of cortisol.</td>
<td>↑</td>
<td>Cushing’s Addison’s</td>
</tr>
<tr>
<td>Growth Hormone</td>
<td>Anterior pituitary</td>
<td>Gluconeogenesis.</td>
<td>↑</td>
<td>Hyper, early - GIGANTISM Hyper, adult - ACROMEGALY Hypo, early - DWARFISM Hypo, adult - SIMMONDS’ DISEASE</td>
</tr>
<tr>
<td>Thyroxine</td>
<td>Thyroid</td>
<td>1) Glycogenolysis 2) Enhances absorption of sugars from intestine</td>
<td>↑</td>
<td>Hypo, adult-Myedema Hyper, adult -Grave’s Hypo, early -Cretinism</td>
</tr>
</tbody>
</table>

Gluconeogenesis = also increases fat metabolism

Hyperglycemia = ↑
### Summary Table, Pituitary Hormones:

<table>
<thead>
<tr>
<th>Releasing hormone (hypothalamus)</th>
<th>Pituitary hormone</th>
<th>Target</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADH</td>
<td>ADH</td>
<td>Kidneys, sweat glands, circulatory system</td>
<td>Water balance</td>
</tr>
<tr>
<td></td>
<td>OT</td>
<td>Female reproductive system</td>
<td>Triggers uterine contractions during childbirth</td>
</tr>
</tbody>
</table>

#### Posterior Pituitary Hormones

<table>
<thead>
<tr>
<th>Releasing hormone (hypothalamus)</th>
<th>Pituitary hormone</th>
<th>Target</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>GnrRH (inhibited by Phit)</td>
<td>LH</td>
<td>Reproductive system</td>
<td>Stimulates production of sex hormones by gonads</td>
</tr>
<tr>
<td>GnrRH (inhibited by Phit)</td>
<td>FSH</td>
<td>Reproductive system</td>
<td>Stimulates production of sperm and eggs</td>
</tr>
<tr>
<td>TRH</td>
<td>TSH</td>
<td>Thyroid gland</td>
<td>Stimulates the release of thyroid hormone (TH), TH regulates metabolism</td>
</tr>
<tr>
<td>PRH (inhibited by Phit)</td>
<td>PRL</td>
<td>Mammary glands</td>
<td>Promotes milk production</td>
</tr>
<tr>
<td>GnrRH (inhibited by Grin)</td>
<td>GH</td>
<td>Liver, bone, muscles</td>
<td>Induces targets to produce insulin-like growth factors (IGF), IGF promotes body growth and a higher metabolic rate</td>
</tr>
<tr>
<td>CRH</td>
<td>ACTH</td>
<td>Adrenal glands</td>
<td>Induces targets to produce glucocorticoids, which regulate metabolism and the stress response</td>
</tr>
</tbody>
</table>
Quick Reference Notes: everything you need to know in one place!

Summary of important terms/concepts for each hormone covered:

A) HYPOTHALAMUS
- Stimulates the pituitary to secrete its hormones.
- TROPIC hormones.

B) PITUITARY GLAND or HYPOPHYSIS: Actually 2 glands!
- Sometimes called the "master gland", because it controls the output of so many other glands and tissues.

**Pituitary, Part I. ADENOHYPOPHYSIS** (anterior lobe of pituitary gland)

The NON-TROPIC HORMONES

1. **HUMAN GROWTH HORMONE** (hGH)
   - **Target**: Skeleton and skeletal muscles.
   - **Main Variable(s)**: Growth, Blood Glucose.
   - **Effects**: Causes body cells to grow and to maintain their size, Hyperglycemia.
   - **Pathologies**: Hypersecretion, early years - GIGANTISM
     Hypersecretion, adult - ACROMEGALY
     Hyposecretion, early years – one type of DWARFISM

2. **PROLACTIN or Lactogenic Hormone**
   - **Target**: In females - the mammary glands
   - **Main Variable(s)**: Lactation/milk production.
   - **Effects**: Milk production by the mammary glands.

The TROPIC HORMONES

3. **THYROID STIMULATING HORMONE** (TSH) or Thyrotropic
   - **Target**: Thyroid gland
   - **Main Variable(s)**: see thyroid hormones.
   - **Effects**: It stimulates the synthesis and secretion of hormones produced by the thyroid gland.
   - **Pathologies**: See thyroid hormone.

4. **ADRENOCORTICOTROPIC HORMONE** (ACTH)
   - **Target**: Adrenal gland, specifically the adrenal cortex.
   - **Effects**: Stimulates the secretion of glucocorticoids.
   - **Main Variable(s)**: see adrenal hormones, especially the glucocorticoids.
   - **Pathologies**: Related to hypersecretion of glucocorticoids.
5. FOLLICLE STIMULATING HORMONE (FSH)

**Target** - In females - the primary follicles of the ovary

**Main Variable(s)** – Female reproductive cycle.

**Effects** - Development of a primary follicle into a Graafian follicle (mature follicle) each month.

6. LUTEINIZING HORMONE (LH)

**Target** - The Graafian follicle of the ovary.

**Main Variable(s)** – Female reproductive cycle.

**Effects** - Ovulation

- Luteinizing hormone also stimulates the formation of the corpus luteum in the ovary.

7. INTERSTITIAL CELL STIMULATING HORMONE (ICSH) – Actually, LH in men!

**Target** - The interstitial cells of the testes.

**Effects** - It stimulates the interstitial cells to develop and secrete testosterone.

8. MELANOCYTE STIMULATING HORMONE (MSH)

**Target** - The skin.

**Main Variable(s)** – Melanin production.

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**Pituitary, Part II. NEUROHYPOPHYSIS** (posterior lobe of the pituitary gland) - Not actually a gland. Releases 2 hormones produced by the hypothalamus:

1. ANTIDIURETIC HORMONE (ADH) [VASOPRESSIN]

   **Target** - The kidneys.

   **Main Variable(s)** – water conservation at the kidney (increases blood pressure).

   **Pathologies:**

   - Hyposecretion - DIABETES INSIPIDUS - results in an increased urine output.

2. OXYTOCIN (OT) [Pitocin]

   **Target** - Pregnant uterus; mammary glands.

   **Main Variable(s)** – Labor during birth.
C) OVARIES (and other female reproductive organs)

1. ESTROGENS Produced primarily by the theca cells and granulosa cells of developing follicles.
   
   **Target** - Uterus, vagina, external genitalia, pelvis, breasts
   
   **Effects** –
   
   1. Promote development and maintenance of female reproductive structures. Including the secondary sex characteristics.
   
   They stimulate mammary tissue development.
   
   We remove ovaries if there is cancerous growth of some tissues, especially breast.
   
   2. Regulate ovarian and uterine cycle (female reproductive cycles).
   
   3. They help control fluid and electrolyte balance. Role in calcium homeostasis: Stimulating the osteoblasts to form new bone.
   
   **Pathologies:**
   
   Hypo – Adult: Osteoporosis.

2. PROGESTERONE (PROG) - Produced primarily by the corpus luteum proper.

   **Target** – Many. More detail in Reproduction & Development chapter.

   **Main Variable(s)** – Many. Especially female reproductive cycle.

3. RELAXIN (RLX)

   **Target** - Pubic area

   **Main Variable(s)** – Pregnancy.

   **Effects** - It relaxes the symphysis pubis and helps dilate the uterine cervix toward the end of pregnancy.

4. INHIBIN (in women)

   **Target** - Pituitary gland

   **Main Variable(s)** – Pregnancy.

   **Effects** - It inhibits the secretion of Follicle Stimulating Hormone towards the end of the menstrual cycle.

D) TESTES

1. ANDROGENS - Produced by the interstitial cells of the testes. Testosterone is the primary androgen [male sex hormones].

   **Target** - Bone, skeletal muscle, external genitalia

   **Main Variable(s)** – Many. Especially male sexual characteristics, sperm production and protein anabolism.

   **Effects** - It controls the development, growth, and maintenance of the male sex organs.

   - Including the secondary sex characteristics.

   - It stimulates the descent of the testes before birth.
E) THYROID GLAND

1. “THYROID HORMONE” - triiodothyronine (T3) and thyroxine (T4)
   
   **Target** - Body cells

   **Main Variable(s)** – Growth, glucose metabolism, and development of the nervous system.

   **Notes:**

   - Production of the hormone detail:
     1. **Occurs in the colloid and in the follicular cells**
     2. Iodide ion (I-) is necessary
     3. The precursor molecule is brought back into the follicular cells. **Here, they are modified into the active T3 & T4 molecules**, and released into the bloodstream.
     4. **Both T3 & T4 are active hormones.** T3 is stronger acting.

   **Effects** –

   1. The **body’s regulation of metabolism and energy balance** (increase carbohydrate & lipid metabolism)
      - Increases blood sugar (breakdown of glycogen)
      - HYPERGLYCEMIA
   2. Help GH in regulation of growth and development
      - Involved in brain development
   3. Regulation of the activity of the nervous system.
   4. Increased **ATP and heat production (temperature)** by tissues in general.

   **Pathologies:**

   - ENDEMIC GOITER - low iodine in diet.
   - Hypersecretion, adult - **One type** is GRAVES’ DISEASE [autoimmune disorder].
     - GOITER
     - EXOPHTHALMOS
   - Hypossecretion, prepuberty [fetal life or infancy] - Congenital hypothyroidism (“CRETINISM”).
     - Severe mental retardation. Jaundice. If diagnosed early, cretinism can be prevented by giving oral thyroid hormone.
   - Hypossecretion, adult – MYXEDEMA (severe). BMR below normal, weight gain, decreased metabolism, edema, & sterility.

2. CALCITONIN (CT)
   
   **Target** - Blood calcium

   **Main Variable(s)** – Seral calcium.

   **Effects** – It lowers blood calcium.

   **Pathologies:**

   - hypo: Bad case: leaching of bones.
   - hyper: TETANY.
   - Sign: Carpal spasms.
F) PARATHYROID GLANDS

1. PARATHYROID HORMONE (PTH).
   
   **Target**: Blood Calcium

   **Main Variable(s)** – Seral calcium.

   **Effects**: Increases blood calcium.

   **Pathologies**:
   
   Hyposcretion - TETANY.

G) ADRENAL GLANDS

Adrenal, Part I.  ADRENAL CORTEX

1. **zF: GLUCOCORTICOIDS - CORTISOL [HYDROCORTISONE]**
   
   **Target**: Body cells

   **Main Variable(s)** – Metabolism, blood glucose, and lowered immune response (in several ways).

   **Effects** - The Glucocorticoids regulate metabolism and resistance to stress.

   - Promote metabolism.
   - Gluconeogenesis.
   - Glucocorticoids provide resistance to stress.  Lower inflammation.  Slow connective tissue repair.

   **Pathologies**:
   
   Hypersecretion of glucocorticoids - CUSHING’S SYNDROME.  They have a rounded "moon face," and spindly arms and legs.  Hyperglycemia.

   Hyposcretion - ADDISON’S DISEASE.  Symptoms include:  mental lethargy, hypoglycemia.

2. **zG: ALDOSTERONE** (one of the mineralocorticoids).  Also, see the Mineralocorticoids in your book

   **Target**: The kidneys

   **Main Variable(s)** – Seral sodium and BP.

   **Effects** - Aldosterone increases the reabsorption (conservation) of sodium, which increases blood pressure by drawing in water (water follows sodium).

3. **zR**: Gonadocorticoids are mostly weak androgens, which are converted to testosterone and estrogens in the tissue cells.

Adrenal, Part II.  ADRENAL MEDULLA

1. The Catecholamines (cat - a - col - amines) - EPINEPHRINE [ADRENALINE] (80%) and NOREPINEPHRINE [noradrenaline]

   **Target**: Body cells

   **Main Variable(s)** – many, including blood glucose.

   **Effects** - These two hormones mimic the effects brought about by the Sympathetic Division of the ANS.  They are responsible for the flight-or-flight response.
H) PANCREAS - Islets of Langerhans

1. GLUCAGON - produced by the alpha cells of the islets
   - **Target**: Blood glucose.
   - **Main Variable(s)**: Blood glucose.
   - **Effects**: To increase the blood glucose levels.
     Glycogenolysis, gluconeogenesis.

2. INSULIN - produced by the beta cells of the islets
   - **Target**: Blood glucose
   - **Main Variable(s)**: many, including blood glucose.
   - **Effects**: Effects - To lower the blood glucose levels. It accelerates the transport of glucose from the blood into cells, especially skeletal muscle. Glycogenesis.
   - **Pathologies**: Hypersecretion - results in a decrease of blood glucose - HYPOGLYCEMIA.
   - Hyposecretion - results in an increase of blood glucose - DIABETES MELLITUS.

**NOTE**: insulin & Glucagon are ANTAGONISTS

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**Diabetes Mellitus (DM) Overview**

Diabetes refers to “excessive discharge of urine”. **HYPERGLYCEMIA**.

**Type 1** is characterized by an **absolute deficiency of insulin secretion**. “Insulin Dependent” diabetes.

Type 1 is an autoimmune disorder, with the islets being destroyed by immune cells.

If not controlled, **nitrogen buildup in the bloodstream**.
Ketoacidosis. **Ketosis** is the presence of ketones in their urine.

Dehydration is characteristic of DM1.

**Type 2** is characterized by a **lack of insulin receptor activity** (which varies in severity). “Adult Onset” diabetes. More common than DM1.

*This is exacerbated by poor diet and exercise. However, usually the insulin concentrations in DM2 are high enough to prevent proteolysis, so tissue catabolism and tissue wasting doesn’t occur as with DM1.

Gestational diabetes and “alcoholic” diabetes are other forms. Also, several illnesses can lead to this (Cushing’s, acromegaly) as well as any disease of the pancreas (cystic fibrosis, pancreatitis).
Endocrine Summary

I) THYMUS GLAND
- The thymus gland is relatively large at birth, growing only slowly until puberty. After puberty, it begins to decrease in size.
  1. Thymosin
     - **Target**: T cell Lymphocytes
     - **Main Variable(s)**: Immune system response. Maturation of T cell Lymphocytes.

J) PINEAL GLAND
  1. MELATONIN - Produced during darkness
     - **Target**: Pituitary gland
     - **Main Variable(s)**: Many. Timing of reproduction.
     - **Effects**: In many mammals including humans, it seems to play a role in prohibiting females from reaching sexual maturity before their bodies can handle it.
     - **Pathologies**: Deficiency in melatonin responsible for some types of insomnia.

K) PLACENTA
  1. HUMAN CHORIONIC GONADOTROPIN (hCG)
     - **Target**: Ovary, specifically the corpus luteum
     - **Main Variable(s)**: Female reproductive cycle.
     - **Effects**: It stimulates the ovary to produce progesterone and estrogen, turning off both ovulation and the menstrual cycle during pregnancy.
     - **Pathologies**: Failure to produce hCG may result in a spontaneous abortion.

L) HEART - cardiac muscle fibers of the atria
  1. ATRIAL NATRIURETIC FACTOR (ANF)
     - **Target**: Blood vessels, kidneys, among others
     - **Main Variable(s)**: blood pressure.
     - **Effects**: Decreases blood pressure.

M) PROSTAGLANDINS
   - **Target**: Prostaglandins are a family of compounds: "local hormones." COX-1 and COX-2.
   - **Main Variable(s)**: Especially immune response (inflammation and blood clotting) and increase pain.
   - **Effects**: Many. Inflammation. Pain sensation. Also, upkeep of stomach lining.
   - **Notes**: Prostaglandin are involved in fear, nerve impulse, and other reactions.
   - **NSAIDs**: (Non-steroidal antiinflammatory agents) & Tylenol (acetaminophen) inhibit prostaglandins.
N) The skin produces cholecalciferol, an inactive form of vitamin D3 or Calcitriol. It is activated by UV radiation.

**Target** – Blood calcium levels

**Main Variable(s)** – Seral calcium. In general, it increases blood levels.

**Effects** – Its role is on maintaining seral levels necessary for healthy bones. Complicated role, not easily described.

**Pathologies:**

Osteomalacia (or rickets when it occurs in children) became a problem as smog worsened in cities during the Industrial Revolution, and exposure to sunlight was lessened.