ENDOCRINOLOGY
Endocrine Glands

• Endocrine glands
  • Produce substances called hormones.
  • Ductless glands, i.e., they release hormones directly into the bloodstream
  • Hormones only act at their target tissue where there are receptors for the hormone
  • By definition, the target tissue is far from the gland that produces the hormone.
  • Contrast with exocrine (ducted) glands and paracrines (local-acting substances)
Estrogens - Estradiol

- **Target tissue**: every cell of the body.
- Reproductive system effects include:
  - **Proliferation of endometrial cells** during the follicular phase of the monthly cycle.
  - **Build up of mammary tissue** in the breast during the luteal phase and during pregnancy.
  - **Proliferation of muscle cells in the uterus** during pregnancy.
Estrogens - Estradiol

• Non-reproductive system actions:
  • Control fat storage
    • Puberty: directs fat to female appropriate sites
    • Adult: decreases the rate of storage of calories as fat
  • Increases general activity level
  • Suppresses food intake and appetite
  • Softens skin, maintains skin thickness and resilience
Estrogens - Estradiol

• Non-reproductive system actions:
  • Affects bone development
    • Puberty: initiates and, later, stops the adolescent bone growth spurt
    • Adulthood: helps retain calcium in bones
  • Blood pressure – natural estrogens prevent marked increases and marked decreases of blood pressure (synthetic estrogens raise blood pressure)
Progesterone

- **Target Tissue** – all cells of the body.
- Some effects similar to estrogen; some effects are the exact opposite of estrogen.
Progesterone – Reproductive System Effects

• Stimulate the secretion of fats and glycogen into the endometrial cells in the luteal phase.
• Stimulate mammary gland development during the luteal phase and during pregnancy.
• Prevents coordinated contractions of the uterus during pregnancy.
Progesterone – Non-Reproductive Actions

• **Controls fat storage**: Reverses the effect of estrogen and increases the rate of storage of excess calories as fat.

• **Stimulates food intake and appetite.**

• **Prevents coordinated contractions of smooth muscle** throughout the body (basis of diarrhea or constipation during the luteal phase and during pregnancy)
Progesterone – Non-Reproductive Actions (con’t)

• **Blood pressure effects**: Like estrogen, prevents marked increases or decreases of blood pressure.

• **Central nervous system depressant** – causes somnolence.
Hypothalamus-Pituitary System

Hypothalamus

Pituitary (Hypophysis)
Hypothalamic-Pituitary Connection

Hypothalamus

Anterior Pituitary

Infindibulum

Posterior Pituitary
Hypothalamus-Posterior Pituitary Connection

- Hypothalamus
- Anterior Pituitary
- Posterior Pituitary (Neurohypophysis)
Neuron

- Dendrites (Input)
- Cell Body (soma)
- Axon (Output)
- Axon Terminals
The posterior pituitary DOES NOT PRODUCE any hormones!

The posterior pituitary contains terminals of axons from hormone-producing neurons in the paraventricular and supraoptic hypothalamus.
Hypothalamus-Posterior Pituitary Connection

Produces mostly **oxytocin**

Paraventricular Nucleus of the Hypothalamus
Oxytocin

• Stimulates milk let-down during breast feeding.
  • Primary stimulus for oxytocin release is suckling at the breast.
  • Oxytocin production and release can be conditioned to occur to stimuli related to suckling such as a crying baby.
Oxytocin

• Stimulates contractions of the uterus.
  • Levels are high during labor.
  • Administration of synthetic oxytocin (Pitocin) can stimulate labor. Used with prostaglandin to induce labor.

• Tend and Befriend; emotional attachment to others (mother:child; pair bonding)
Hypothalamus-Posterior Pituitary Connection

Supraoptic Nucleus of the Hypothalamus

Produces mostly Antidiuretic Hormone (ADH) - also called Vasopressin (AVP)
Antidiuretic Hormone (ADH) (arginine) Vasopressin (AVP)

- Promotes retention of water by blocking water loss in urine.
- Increases blood pressure.
- Attachment/bonding in males???
HYPOTHALAMUS - ANTERIOR PITUITARY CONNECTION
Hypothalamus-Anterior Pituitary Connection

Produces hormones called **Releasing Hormones** in a variety of nuclei and transports them to the **median eminence**.
Hypothalamus-Anterior Pituitary Connection

Nucleus at the base of the hypothalamus where Releasing Hormones enter the hypothalamo-hypophysial portal system
Hypothalamus-Anterior Pituitary Connection

Specialized blood vessel system which transports Releasing Hormones through the infundibulum from the Median Eminence to the Anterior Pituitary
Hypothalamus-Anterior Pituitary Connection

Anterior Pituitary (Adenohypophysis)

Produces and releases Tropic Hormones in response to Releasing Hormones
Tropic Hormones

1. Adrenocorticotropic Hormone (ACTH)
   • ACTH stimulates the production and release of hormones by the adrenal cortex.

2. Thyroid-Stimulating Hormone (TSH)
   • TSH stimulates the production and release of hormones by the thyroid gland.

3. Growth Hormone (aka Somatotropin)
   • GH acts stimulates growth of muscle (directly) and bones (through its action on the liver).
4. Melanocyte-Stimulating Hormone (MSH)
   - MSH acts at skin to increase pigmentation. Involved in increased pigmentation of skin during pregnancy.

5. Beta-Lipotropic Hormone (BLPH)
   - Precursor of endorphins

6-8. The 3 gonadotropic hormones
   (All gonadotropic hormones are also tropic hormones.)
Tropic Hormones

Gonadotropin Hormones
6. **Follicle-Stimulating Hormone (FSH)**
   1. Works with LH to stimulate ovulation.
   2. Stimulates growth of the ovarian follicle(s).
Gonadotropic Hormones

7. **Luteinizing Hormone (LH)**
   1. Stimulates estrogen production by the ovarian follicle.
   2. Works with FSH to stimulate ovulation.
   3. Stimulates the formation of the corpus luteum.
   4. Stimulates estrogen production by the corpus luteum.
8. **Prolactin (PRL)**
   1. Stimulates progesterone production.
   2. Stimulates milk production by mammary glands.
HYPOTHALAMUS - ANTERIOR PITUITARY CONNECTION

Releasing Hormones
Hypothalamus-Anterior Pituitary Connection

Produces hormones called **Releasing Hormones** that control the production and release of the tropic hormones by the anterior pituitary
Releasing Hormones

1. Corticotrophic Releasing Hormone (CRH)
   CRH → ACTH (→ = stimulates)

2. Thyrotrophic Hormone Releasing Hormone (TRH)
   TRH → TSH

3. Somatostatin
   Somatostatin→growth hormone(somatotropin)
   (→ = inhibits)

4. Growth Hormone Releasing Hormone (GHRH)
   GHRH → growth hormone
5. Gonadotropin Hormone Releasing Hormone (GnRH)

\[ \text{GnRH} \rightarrow \text{LH} \]
\[ \text{GnRH} \rightarrow \text{FSH} \]

Problem: Pattern of LH and FSH release is not identical. How can they be different?

\[ \text{Inhibin} \not\rightarrow \text{FSH} \]
6. Dopamine
   Dopamine $\leftrightarrow$ prolactin
7. Prolactin Stimulating Hormone (PSH)
   PSH $\rightarrow$ prolactin
Negative Feedback

- Hormone A $\rightarrow$ Hormone B
Negative Feedback

- GnRH → LH

- GnRH → LH → Estrogen (moderate)
LH, FSH and GnRH

- GnRH → LH
- GnRH → FSH
- inhibin → FSH
- LH → GnRH
- FSH → GnRH
Estrogen/GnRH

- Very low estrogen → GnRH
- Moderate estrogen → GnRH
- Very high estrogen → GnRH
Positive Feedback

- Hormone A → Hormone B

- GnRH → LH → very high estrogen
<table>
<thead>
<tr>
<th>LH</th>
<th>FSH</th>
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<tbody>
<tr>
<td>E</td>
<td>Prog</td>
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**Ovarian Cycle**

<table>
<thead>
<tr>
<th>Follicular</th>
<th>Luteal</th>
</tr>
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<tbody>
<tr>
<td>Mns.</td>
<td>Prolif.</td>
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**Uterine Cycle**
Estrogen (Estradiol) Levels across the Monthly Cycle

1. Levels start to increase on Day 1 and gradually increase throughout the preovulatory phase.
2. Surge (sharp increase) 24 hours prior to ovulation.
3. Levels decrease after surge (through ovulation).
Estrogen (Estradiol) Levels across the Monthly Cycle

4. Levels rise during the postovulatory phase as the corpus luteum develops.

5. Drop off just before menses when the corpus luteum dies – but not too dramatically because follicles start growing at the same time the corpus luteum is dying.
Progesterone Levels across the Monthly Cycle

1. Levels low on Day 1.
2. Stay very low throughout the preovulatory phase.
3. Increase during the postovulatory phase with the development of the corpus luteum.
4. Drop off just before menses with the death of the corpus luteum.
Estrogen

Progesterone

Day 1

Ovulation

Day 1
FSH Levels across the Monthly Cycle

1. Begin to rise at the end of the postovulatory phase.
2. Decrease in late preovulatory phase.
3. Surge at the time of ovulation.
4. Decrease after ovulation and stays low throughout most of the postovulatory phase.
LH Levels across the Monthly Cycle

1. Begin to increase on Day 1.
2. Rise to moderate level and stay relatively steady for the rest of the preovulatory phase.
3. Surge on the day of ovulation.
4. Declines right after ovulation.
5. Increases toward the end of the luteal phase and then declines again.
The graph illustrates the levels of FSH (follicle-stimulating hormone) and LH (luteinizing hormone) during the ovulation cycle. The peak of LH is associated with ovulation, occurring between Day 1 and the peak of LH. Prior to this, FSH levels increase to prepare the ovaries for ovulation.