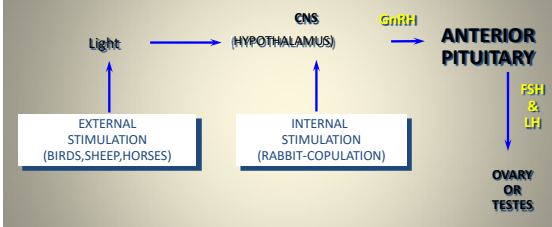
# Endocrine System

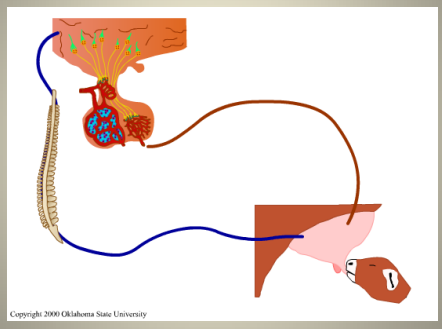
## Functions of the Endocrine System - Integration of Body Functions

- nervous and endocrine system are similar
- nervous system
  - integration over seconds
- endocrine system
  - integration over minutes and hours

## Neuro-humoral-interaction




## Neuro-endocrine Response




## Endocrine Gland

- A ductless gland
- Secretes substances into blood or lymph that affect cells elsewhere in the body
- The secretion does not involve loss of tissue

## Exocrine Gland

- A gland with ducts that are used for secretion

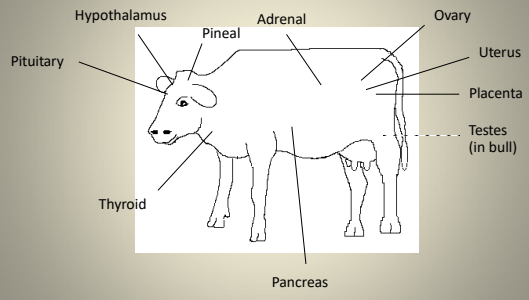
## Hormone

- Substance produced by endocrine gland
- Acts on cells, tissues or organs at a place other than where produced
- Acts as a catalyst in that it is effective at small amounts and is not used up.

## Endocrinology

- Study of how hormones and their receptors regulate body functions.

## Endocrine Glands




## Classification and Properties of Hormone

A. Site of Production

B. Type of action

1. Primary hormone of reproduction
2. Metabolic hormone

C. Chemical Structure

1. General structure
   - *Proteins and polypeptides*
   - *Steroids*
   - *Fatty acids*
   - *Modified amino acid*
2. Size

## Classification and Properties of Hormone

C. Chemical Structure
   1. Proteins and polypeptides (hypothalamic and pituitary hormones)
   2. Steroids (gonadal and adrenal)
   3. Fatty acids (prostaglandins)
   4. Modified amino acid (melatonin)

## Chemical Structure of Hormones

| polypeptide | modified amino acid | protein | sex steroid | fatty acid |
|---|---|---|---|---|
| GnRh | melatonin | LH | Estradiol | $PGF_{2\alpha}$ |
| TRH | | FSH | Progesterone | |
| CRH | | Prolactin | Testosterone | |
| GHRH | | ACTH | | |
| Somatistatin | | TSH | | |
| Oxytocin | | GH or STH | | |
| | | Relaxin | | |
| | | Inhibin | | |

## Chemical Structure of Hormones

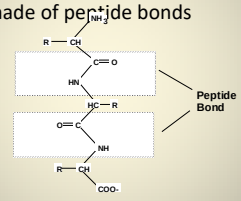
Molecular size of hormones that regulate reproduction

| Hormone | Molecular Weight |
|---|---|
| FSH | 30,000 to 37,000 |
| LH | 26,000 to 32,000 |
| Prolactin | 23,000 to 25,000 |
| HCG | 37,700 |
| eCG | 28,000 |
| Relaxin | 6,500 |
| ACTH | 4,500 |
| Inhibin | >10,000 |
| Oxytocin | 1,007 |
| GnRH | 1,200 |
| Estradiol | 300 |
| Testosterone | 300 |
| Progesterone | 300 |
| $PGF_{2\alpha}$ | 300 |

## Chemical Structure of Hormones Cont.

Polypeptide and protein hormones

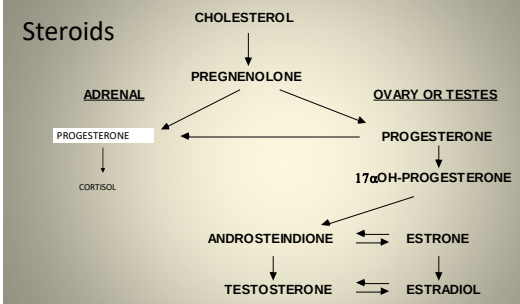
are made of peptide bonds




**These hormones can not be given orally!**

## Chemical Structure of Hormones Cont.

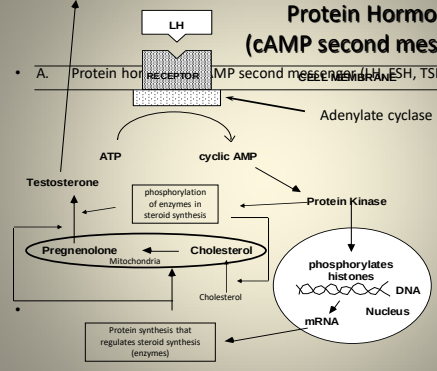
Steroids




**These hormones can be given orally!**

## Mechanism of Hormone Action

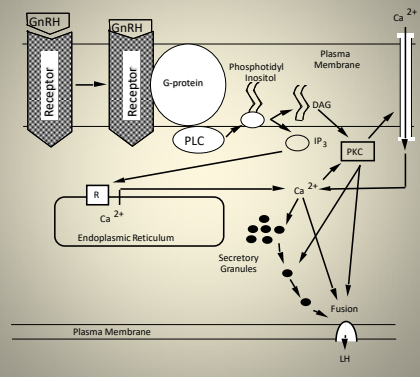
**Protein Hormones (cAMP second messenger)**




## cAMP Second Messenger Hormones

- Anterior Pituitary Hormones
  - LH, FSH, Prolactin
  - STH, ACTH, TSH
- Placental Hormones
  - HCG, eCG

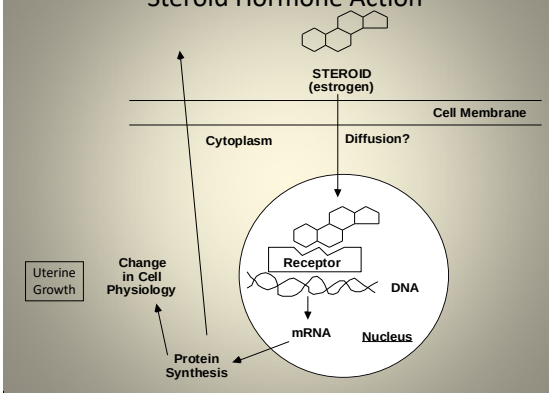
## Protein Hormones ($Ca^{2+}$ Second Messenger)



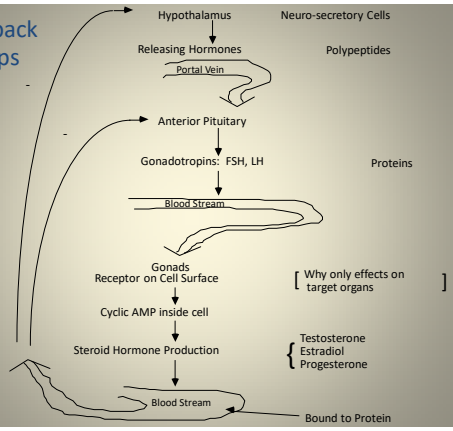
## Calcium Second Messenger Hormones

- GnRH
  - – triggers release of LH in anterior pituitary
- Oxytocin
  - – triggers contractions of smooth muscle
- $PGF_{2\alpha}$
  - – triggers apoptosis of cell
  - – inhibition of progesterone synthesis

## Steroid Hormone Action




## Feedback Loops




## Releasing Hormones of the Hypothalamus

A. Structure

- short chain polypeptides (3 - 44 amino acids)

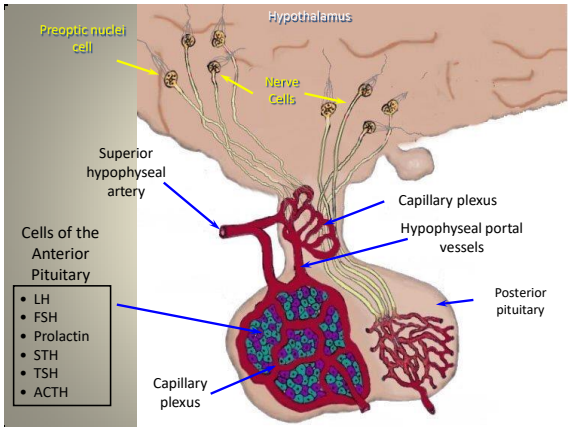
B. General Function

- to cause the release of trophic hormones from the anterior pituitary gland

## Releasing Hormones of the Hypothalamus

C. Hormones

- Gonadotropin releasing hormone (GnRH)
  - »LH, FSH release
- Thyrotrophin releasing hormone (TRH)
  - »TSH and prolactin release
- Corticotrophin releasing hormone (CRH)
  - »ACTH release
- Growth hormone releasing hormone (GH-RH)
- Somatostatin (growth hormone inhibiting hormone)



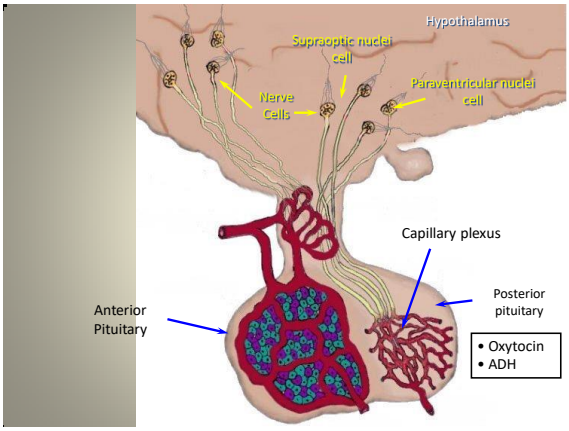
## Anterior Pituitary Hormones

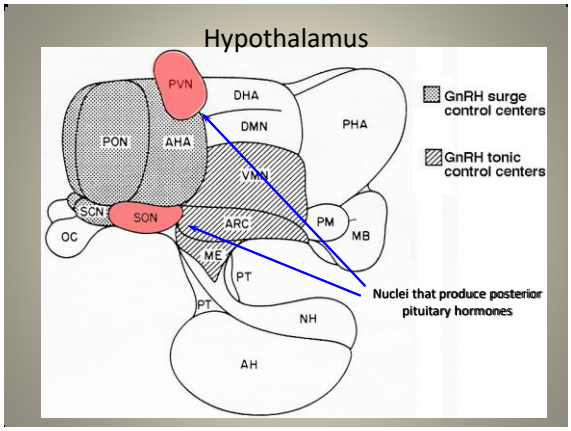
A. Structure
   1. glycoproteins or proteins

B. Hormones
   1. gonadotropins
      – Follicle stimulating hormone (FSH)
      – Luteinizing hormone (LH)
      – Prolactin (PRL)

## Anterior Pituitary Hormones

2. Other trophic hormones
   - Adrenal Corticotropic Hormone (ACTH)
   - thyroid stimulating hormone (TSH)
   - growth hormone or somatotropin (GH or STH)




## Posterior Pituitary Hormones

A. Structure
   - polypeptides (9 amino acids)

B. Hormone
   - Oxytocin - causes contraction of smooth muscle such as in mammary gland, uterus, oviduct

C. Other facts of importance
   - produced in the hypothalamus but released in posterior pituitary
   - also produced in the corpus luteum of some species

## Placental Hormones

A. Pregnant mare serum gonadotropin (PMSG) or equine chorionic gonadotropin (eCG)
   1. Contains mainly FSH-like activity but also some LH-like activity.
   2. Has a longer half-life than FSH.
   3. Found in the blood and not the urine.
   4. Function
      - stimulates follicular development during pregnancy in the mare
      - the LH-like activity stimulates some developing follicles to ovulate and form accessory CLs

## Placental Hormones (cont.)

5. Other commercial hormones from the equine placenta
   - Estrogens (several)
     - ➢ Found in mare urine
     - ➢ Premarin is commercial name
     - ➢ Treatment of postmenopausal women
       - ✓ Estrogen replacement therapy
       - ✓ Prevents osteoporosis
       - ✓ Reduces heart disease

## Placental Hormones (cont.)

B. Human Chorionic Gonadotropin (hCG)
   1. Has LH-like activity.
   2. Found in blood and urine.
   3. Function
      - prevents CL regression

C. Placental Lactogen (PL)
   1. Has both GH- and prolactin-like activity. The primary effect is to prepare the mother's mammary gland for lactation.

## Gonadal Polypeptide Hormones

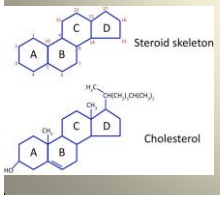
A. Relaxin
   1. Made of 2 polypeptides that are connected with disulfide bonds. It is similar in size and structure to insulin.
   2. Secreted by CL during pregnancy.
   3. In some species it may be secreted by the uterus and/or placenta.
   4. Generally requires tissue first be exposed to estrogens for its effects.
   5. Functions
      - cervical dilation
      - inhibits uterine contractions

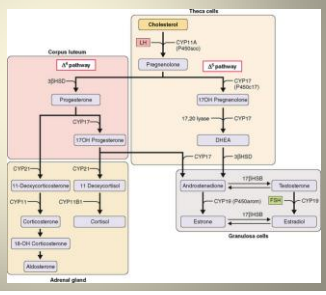
## Gonadal Polypeptide Hormones

B. Inhibin
   1. Secreted by sertoli cells in the male and granulosa cells in the female.
   2. Function
      - inhibits FSH secretion without altering LH secretion

## Gonadal Steroids

A. General
   1. Origin - ovary, testis, adrenal
   2. Basic structure

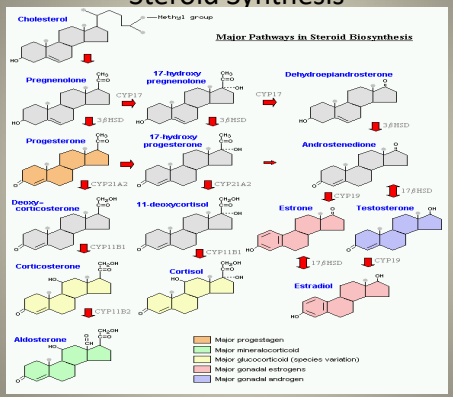



## Gonadal Steroids

3. Type of activity can be predicted by structure
   - cholesterol - 27 carbons
   - progestin - 21 carbons
   - androgen - 19 carbons
   - estrogen - 18 carbons

## Steroid Synthesis




## Gonadal Steroids Cont.

B. Androgens

1. An example is testosterone.
2. Produced by Leydig cells in the testis, theca interna in the follicle and by the adrenal gland.
3. Transported in the blood by binding to the protein, steroid binding globulin.
4. Active form is often dihydrotestosterone.

## Gonadal Steroids cont.

5. Function in the male
   - stimulates spermatogenesis
   - maintain the function of the epididymis
   - promotes the growth, development, and activity of accessory sex glands and secondary sex organs
   - development of male secondary sex characteristics
   - anabolic activity
   - inhibits GnRH and LH release

## Gonadal Steroids Cont.

C. Estrogens

1. An example is estradiol.
2. Produced by granulosa cells of the follicle, sertoli cells in the testis, the placenta, and the adrenal gland.
3. Transported in blood by steroid binding globulin

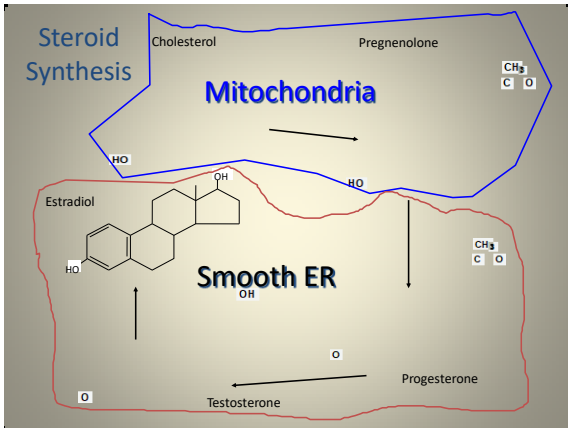
## Gonadal Steroids Cont.

4. Functions
   - effects on the CNS
   - increases the mass of the uterus
   - increases the contractility of the uterus
   - development of female secondary sex characteristics
   - growth of the mammary gland ducts
   - stimulates or inhibits GnRH and LH release
   - nonreproductive
     a. calcium uptake and bone ossification
     b. anabolic and growth effects

## Gonadal Steroids Cont.

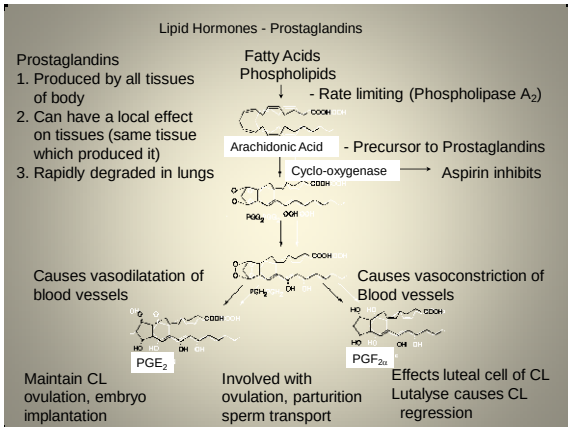
D. Progestins

1. An example is progesterone
2. Produced in the CL, the placenta and the adrenal gland.
3. Transported in the blood bound to steroid binding globulin.
4. Functions
   - prepares the uterus for implantation and pregnancy
   - acts with estrogen to induce the behavior patterns of estrus
   - develops alveoli of mammary gland
   - inhibits the rise of LH that causes ovulation by inhibiting GnRH and LH release




## Other Hormones

A. Prostaglandins
   1. An example is $PGF_{2\alpha}$




## Other Hormones

B. Melatonin
   1. Secreted from the pineal gland.
   2. Is a modified amino acid
   3. Functions to integrate effects of light on reproductive processes.

## Other Hormones

C. Human Menopausal Gonadotropin (hMG)
   1. Secreted from the anterior pituitary gland during and after menopause.
   2. Has FSH-like activity and is actually a modified FSH molecule with a longer half-life. Results from lack of estradiol feedback.
   3. Can be collected in the urine and sold to stimulate follicular development in women.

## Function of Hypothalamus

- appetite
- thirst
- body temperature
- vasomotor activity
- emotion
- use of body nutrient reserves
- activity of intestine
- sleep
- sexual behavior
- release of trophic hormones