Hormones
and
Feedback Mechanisms

03.01.05

How the endocrine system controls everything

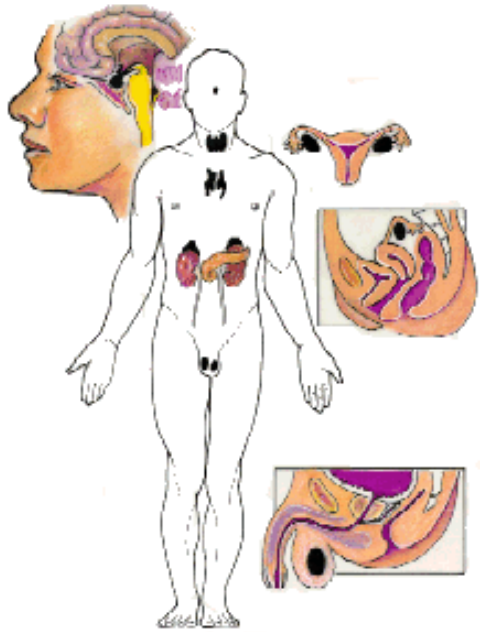
The Endocrine System

I. General Overview

II. Basic Anatomy

III. Control of the endocrine system

IV. Specific endocrine events

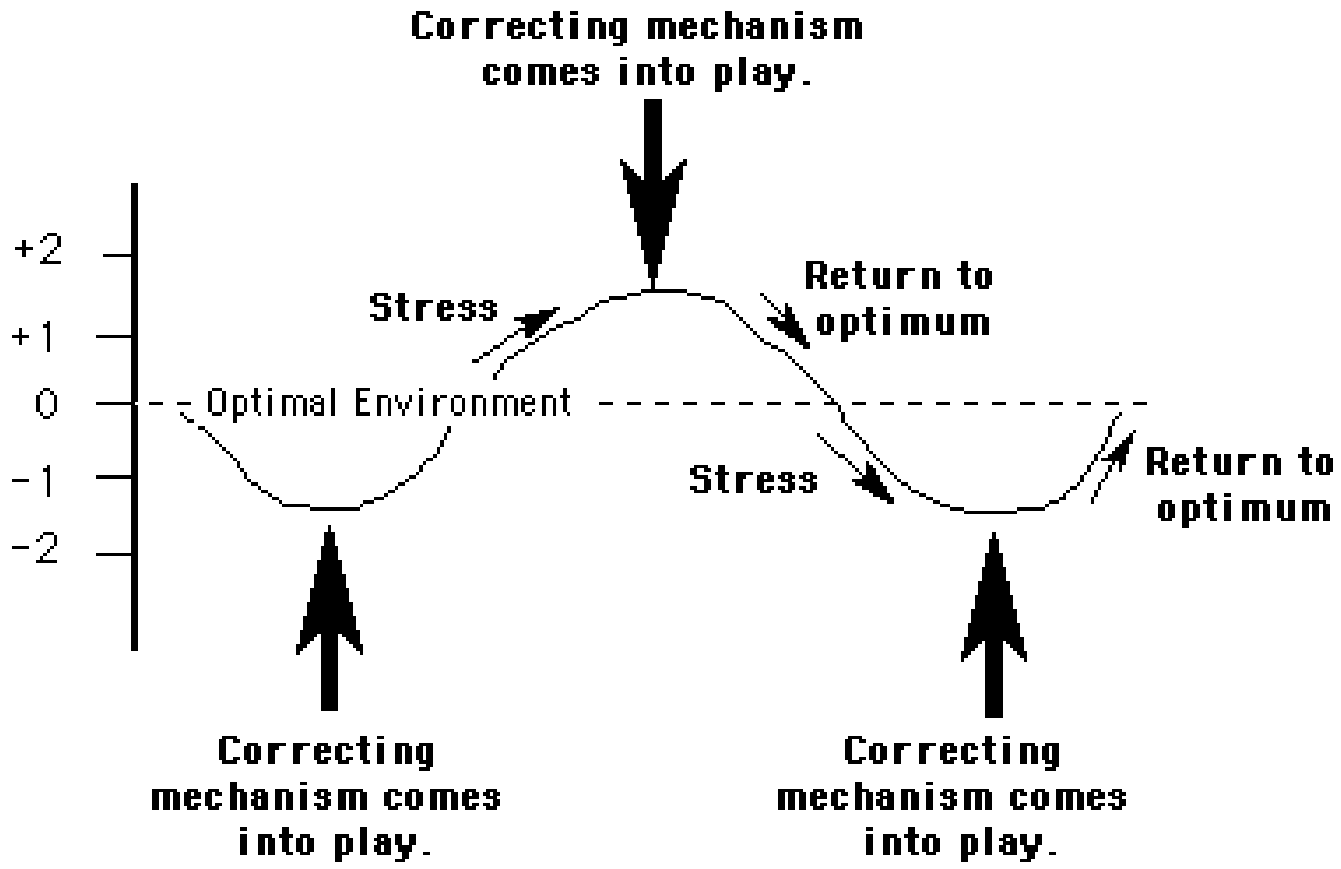


I. A General Overview

- ES (endocrine system) and homeostasis
- Anatomy
  - Endocrine glands, cells, neurosecretory cells
  - Hormones
  - Target cells
- ES as a Control System
  - Hormone + target = change in cell function (return to homeostasis)

ES and Homeostasis

- Homeostasis

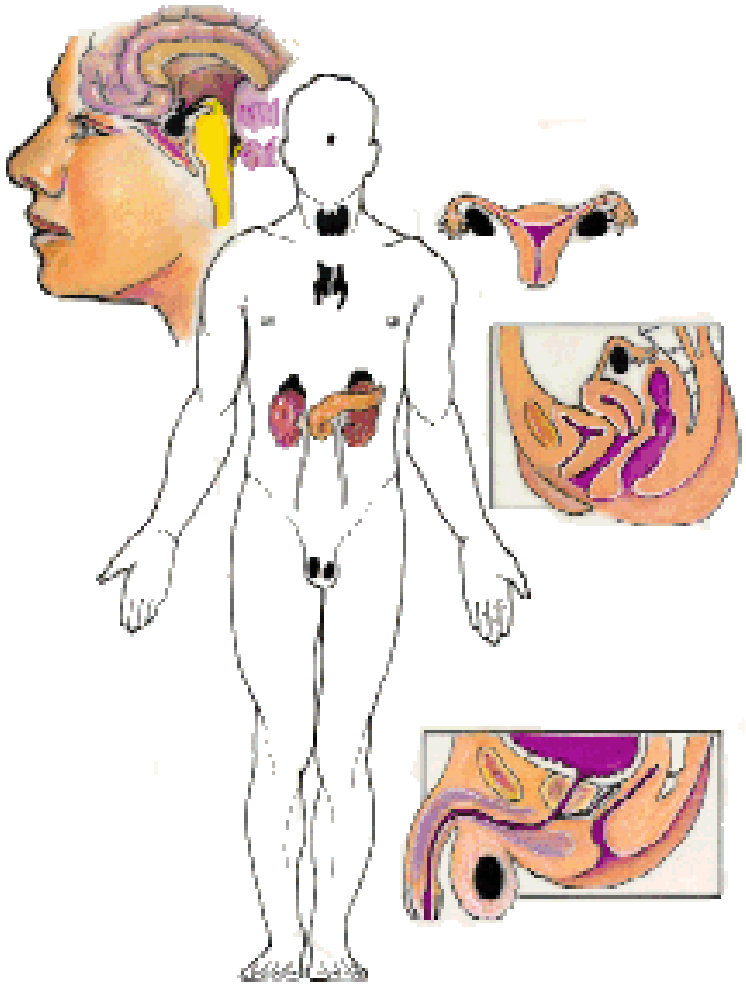


Feedback Mechanisms

- Stimulus
  - change in homeostatic environment
  - signal sent to CNS
- Response
  - signal sent from CNS
  - produce effect
  - body returns to homeostasis

Basic ES cont.

- ES and NS = 2 main control systems of body
- Endocrine organs located throughout body
- Actions mediate all tissues
- Control of ES through feedback mechanisms



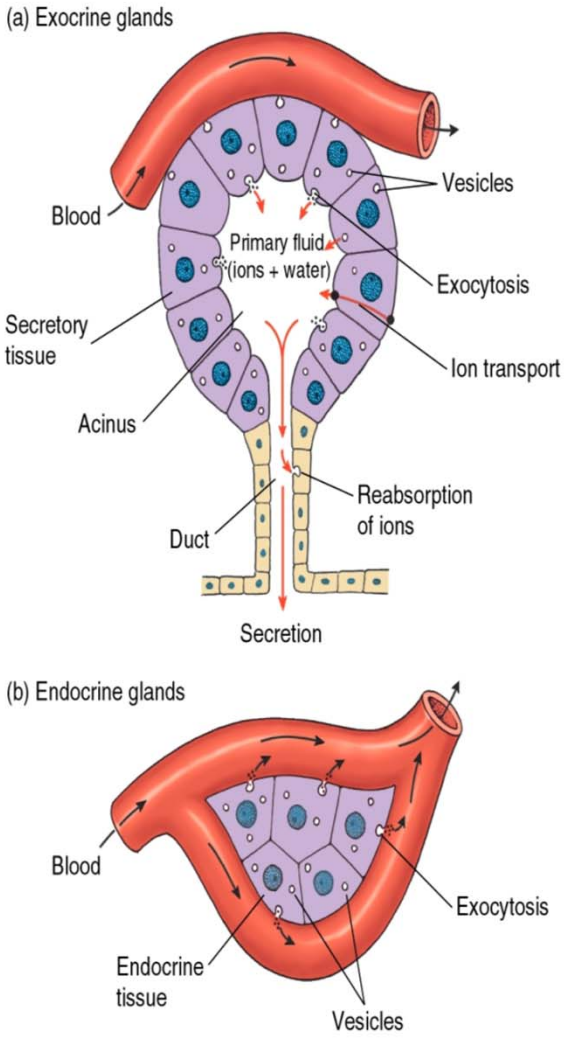
II. ES anatomy basics

A. Exocrine gland

- Ducts
- Lumen and surfaces

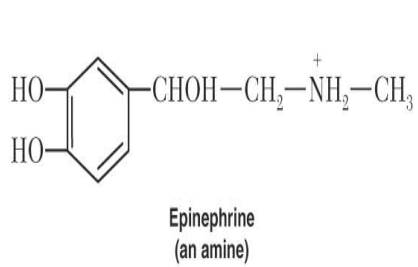
B. Endocrine gland

- Chemical messengers
- Blood stream

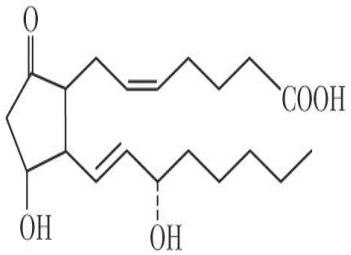


C. Hormones

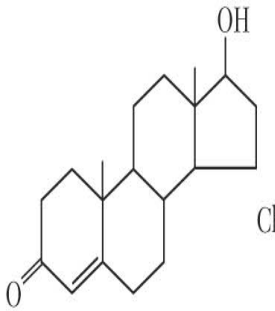
- Chemical messenger
  - Secreted by endocrine gland
  - Specific to target
  - Activate cellular change
  - Of 4 different chemical types



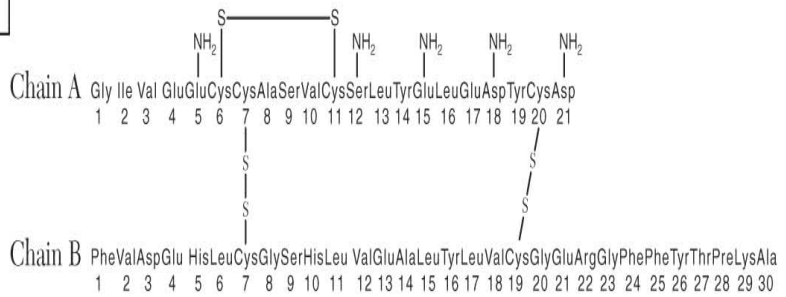
Epinephrine
(an amine)



Prostaglandin PGE_2
(an eicosanoid)



Testosterone
(a steroid)

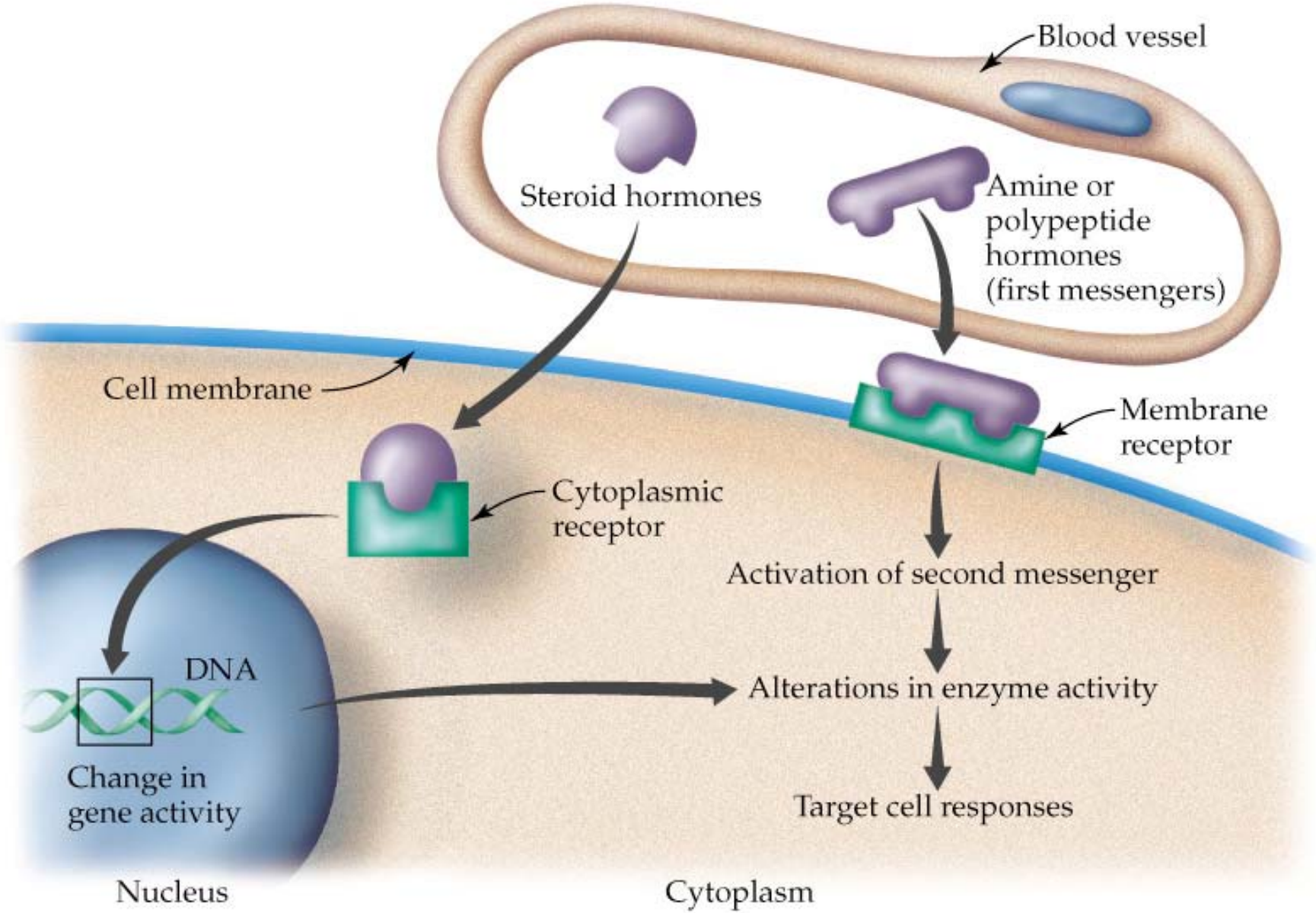


Insulin (bovine)
(a peptide)

C. 4 Classes of Hormones

1. Peptide/ Protein
2. Steroid
3. Amine
4. Eicosanoid

Hormone + Receptor



Protein/Peptide Hormones

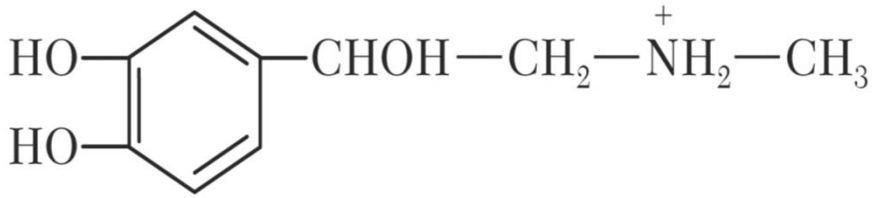
- Hydrophilic
- Large
- Can't fit through membrane
- Second messenger mechanism of action
- Most hormones
- Example: Insulin

Steroid Hormones

- Small
- Hydrophobic/Lipophilic
- Travel in blood w/carrier
- Cytoplasmic or nuclear receptors
- change protein synthesis
- Example: estradiol

Amine

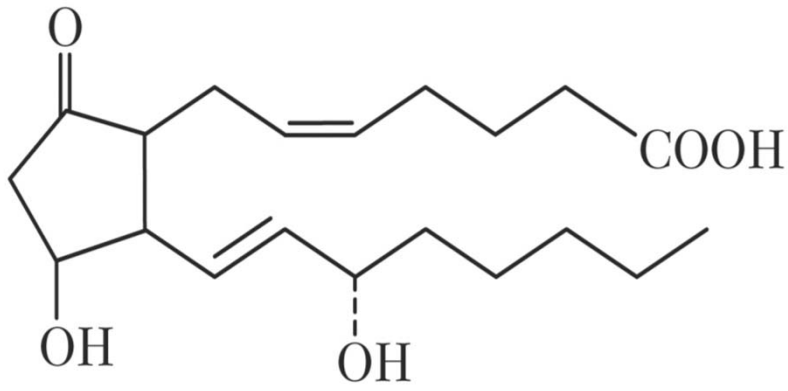
- Synthesized from a single amino acid
- Melatonin from tryptophan
- Thyroid hormone from tyrosine
- Catecholamines (EPI, DA) from tyrosine



Epinephrine
(an amine)

Eicosanoid

- Produced from 20-carbon fatty acid, arachadonic acid
- Produced in all cells except RBCs
- 2nd messenger
- Prostaglandins and leukotrienes
- inflammation



Prostaglandin PGE_2
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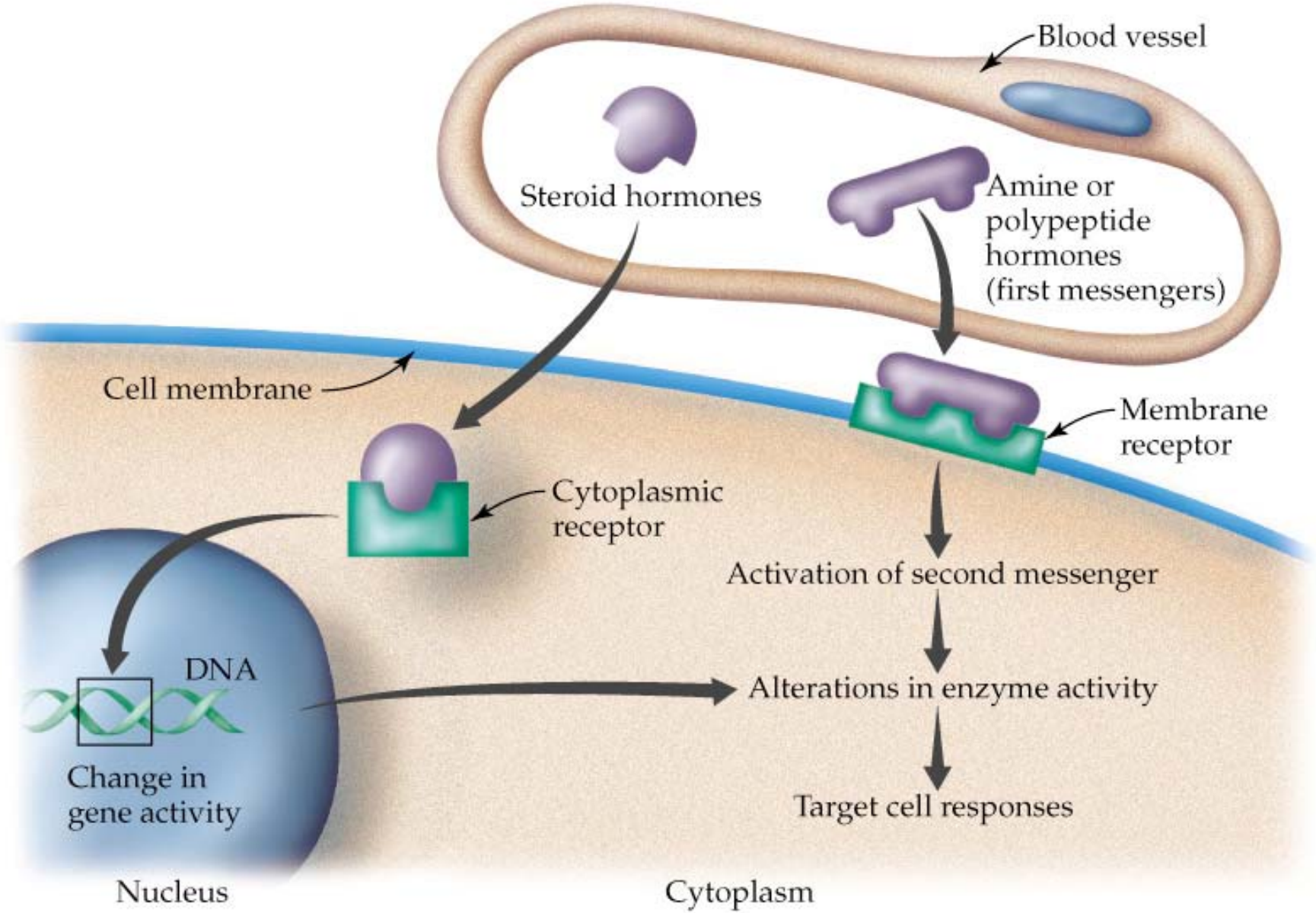
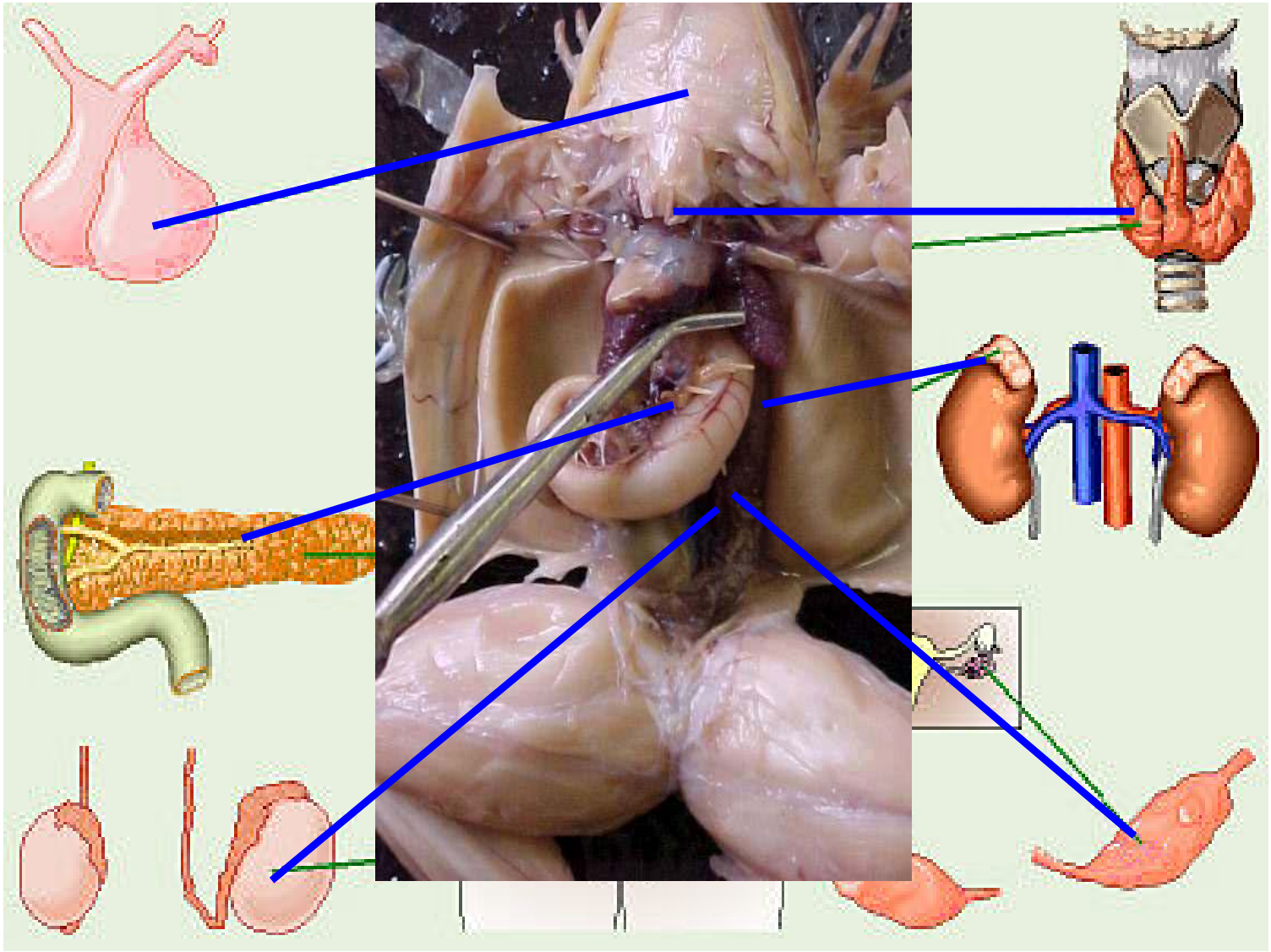
Hormone + Receptor

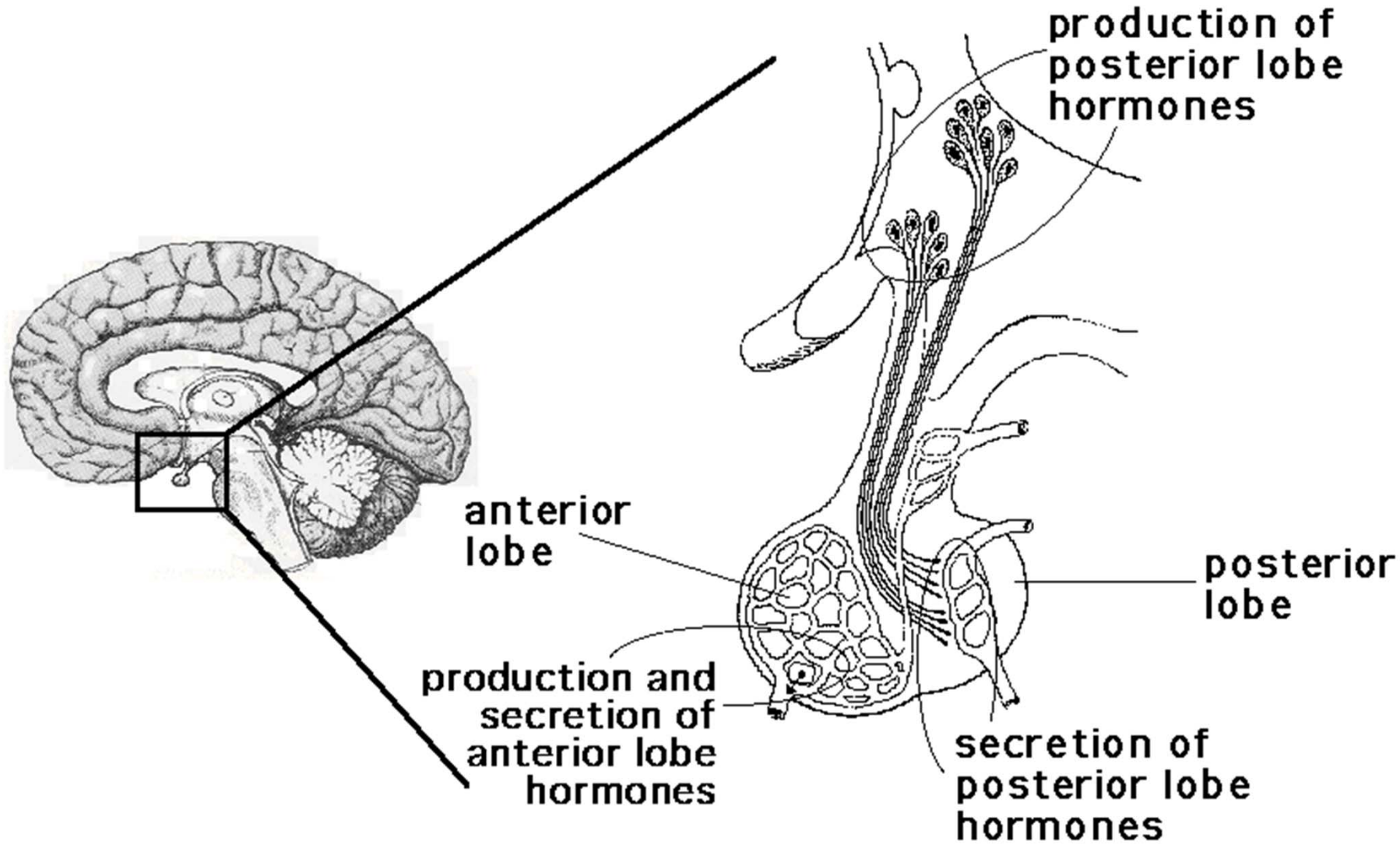


Where are Hormones Made ?



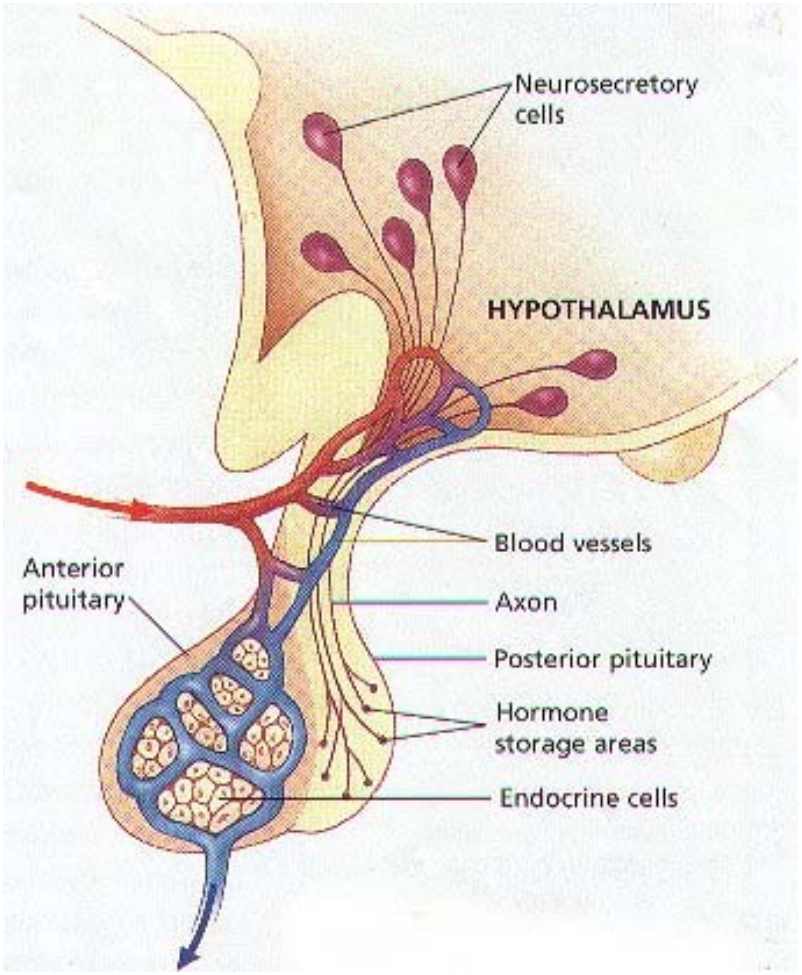
The H-P-A Hypothalamic-Pituitary Axis

- Most feedback loops run through this axis
- HPA mediates growth, metabolism, stress response, reproduction.
- is secondarily in charge of almost everything else.



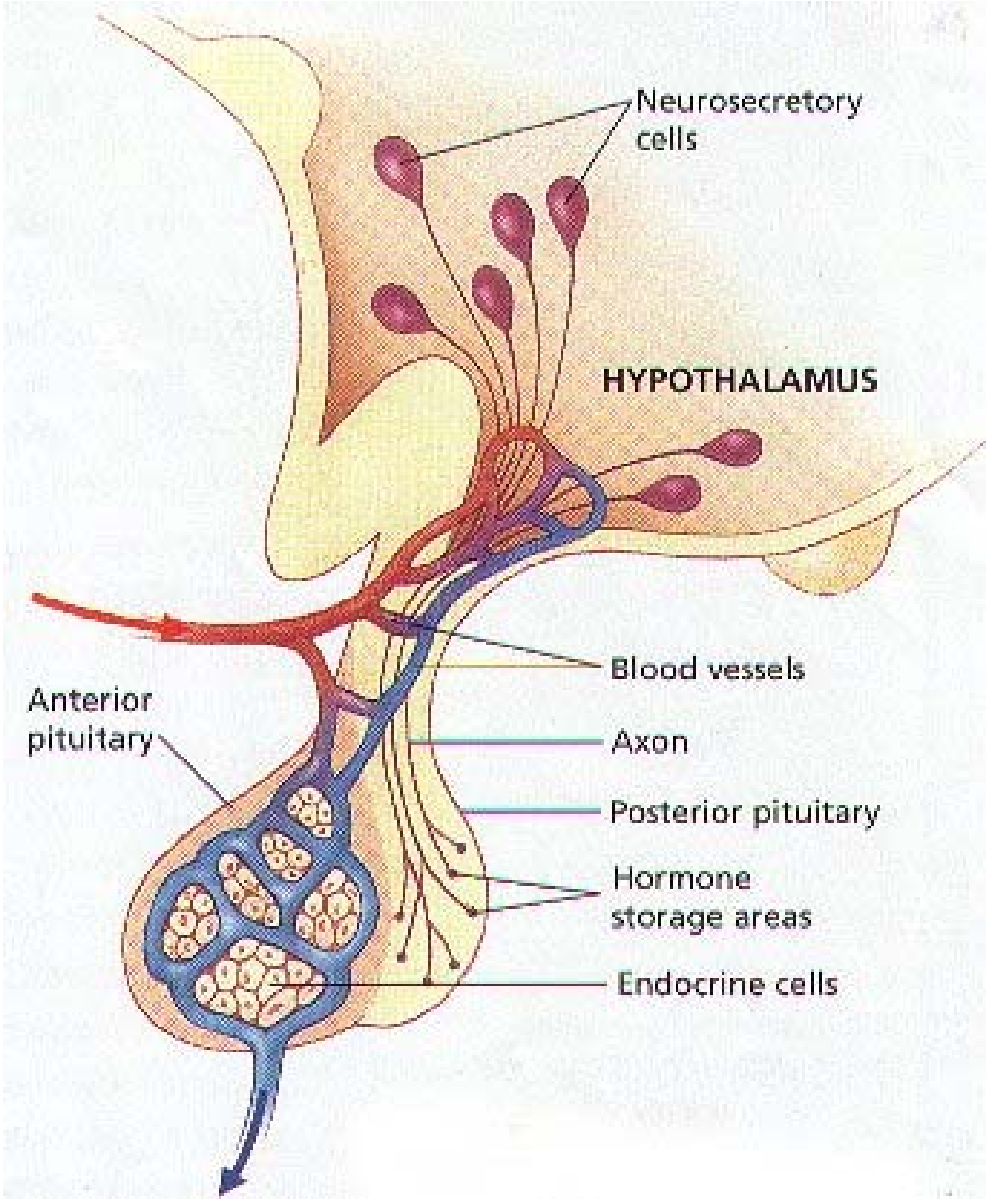
D. Neurosecretory Cells

1. Specialized neurons
   - Synthesize and secrete hormones
2. Extend from HYPOTHALAMUS to POSTERIOR PITUITARY



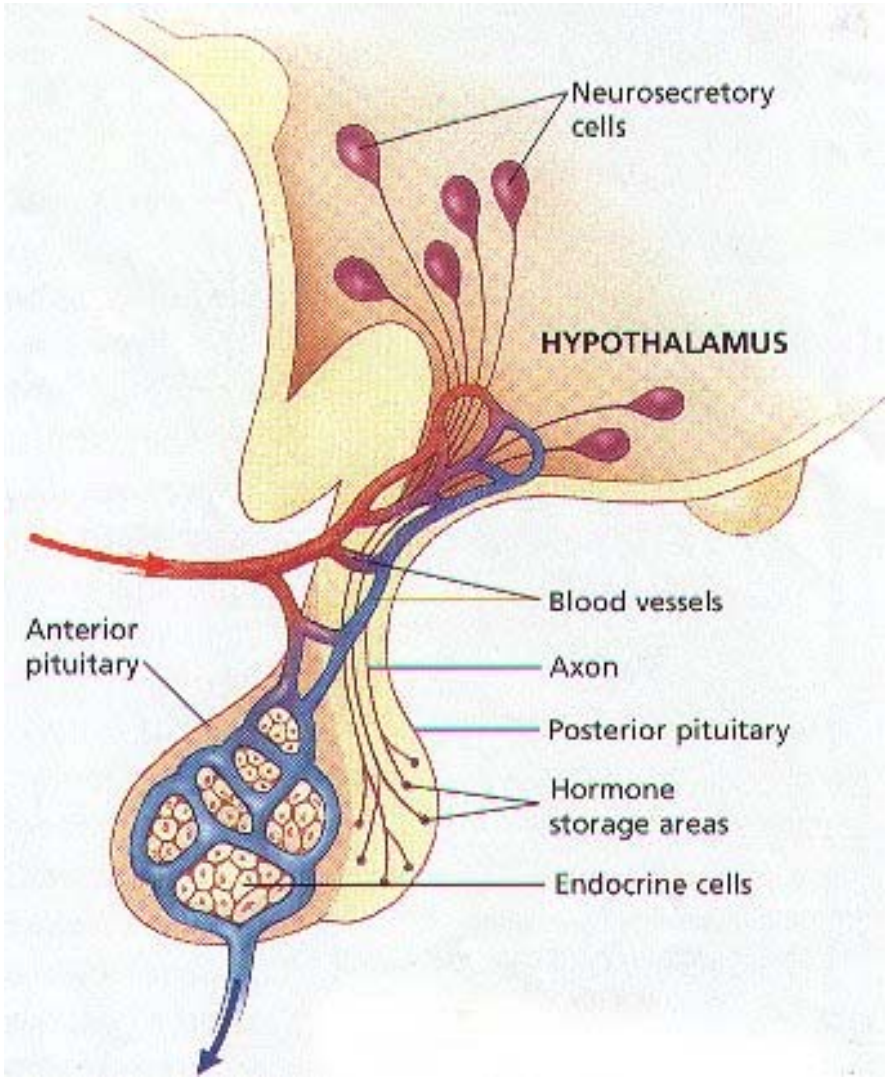
2. Neurosecretory cells in Hypothalamus

- Nuclei synthesize and secrete hormones
- Neuronal connection to POSTERIOR pituitary
- Antidiuretic Hormone (ADH), Oxytocin



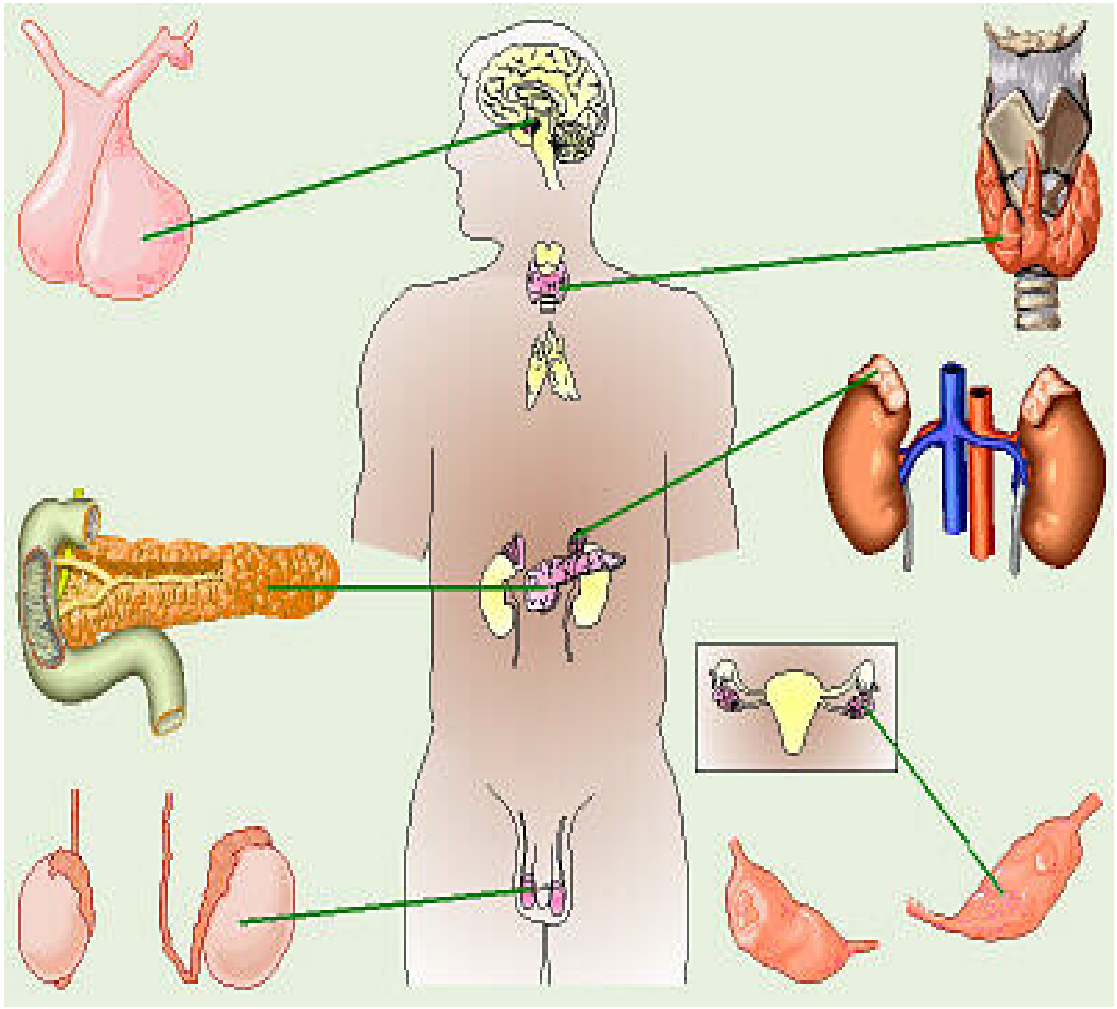
E. Hypothalamus (general)

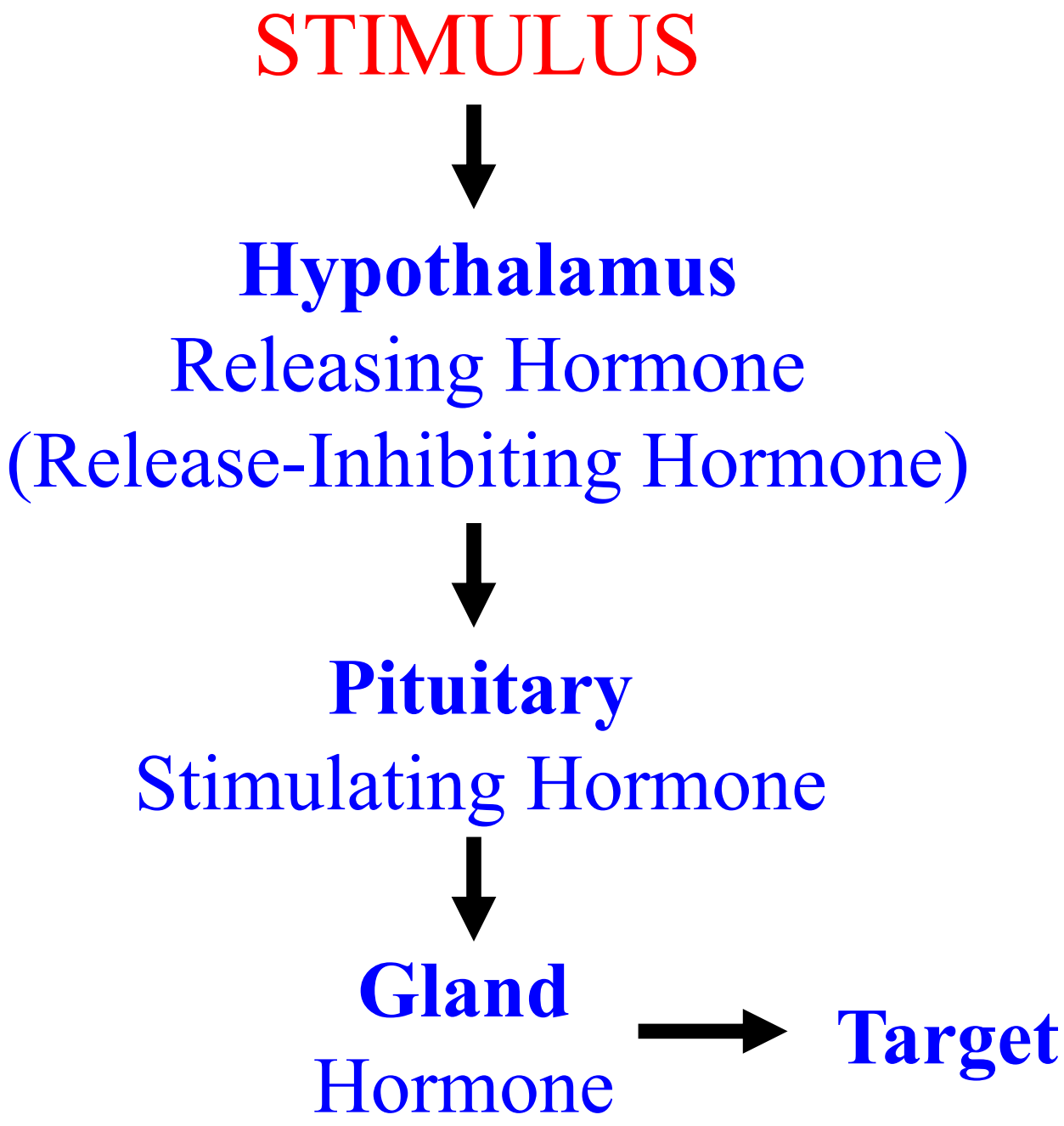
- Connection to pituitary
  - Neuronal to POSTERIOR PITUITARY
  - Endocrine to ANTERIOR PITUITARY
    - RH = Pituitary releasing hormones
    - RIH = Pituitary release inhibiting hormones



Why is the Hypothalamus so Important?

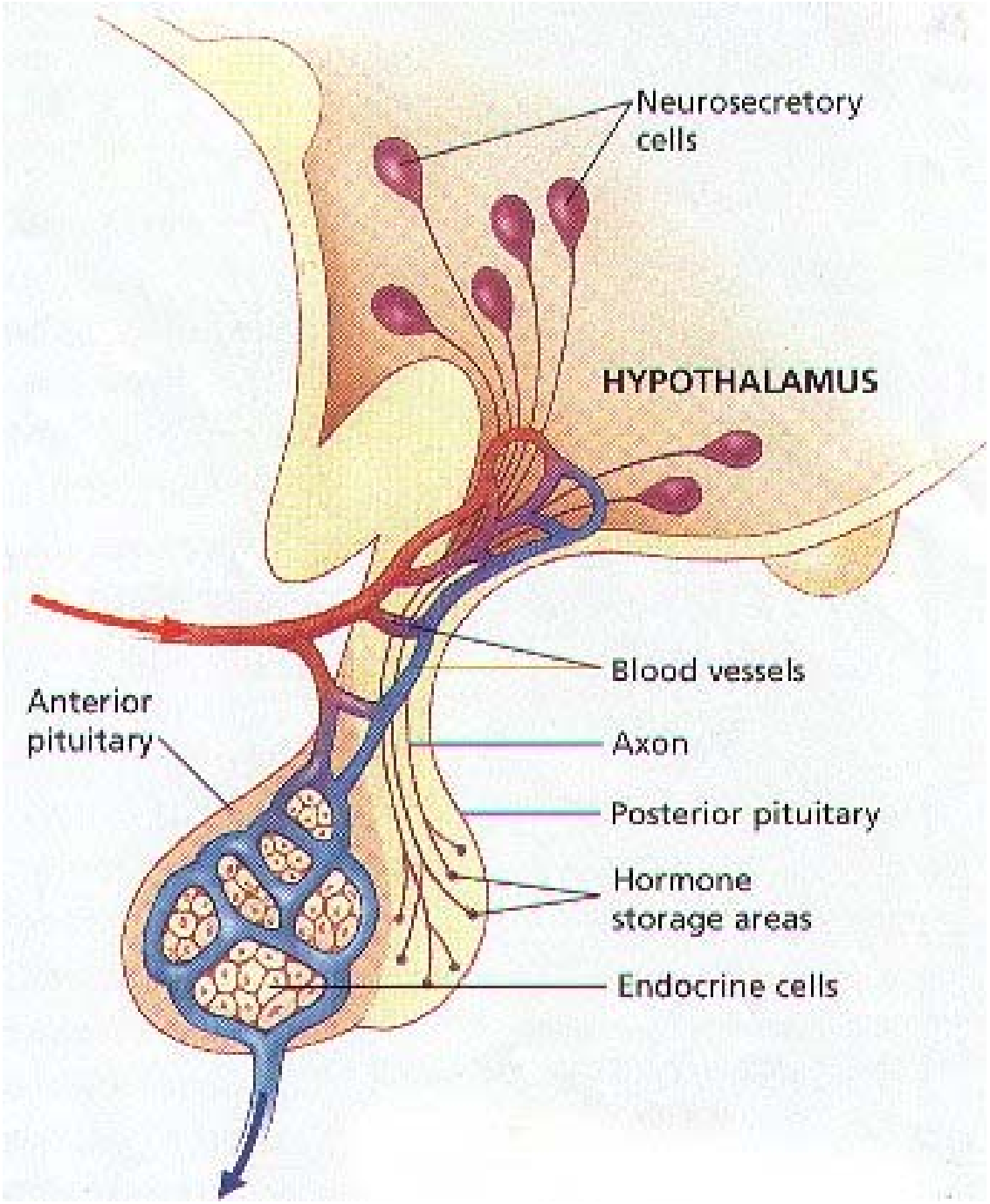
- Secretes regulatory homones
  - RH
  - RIH
- "Directs" pituitary





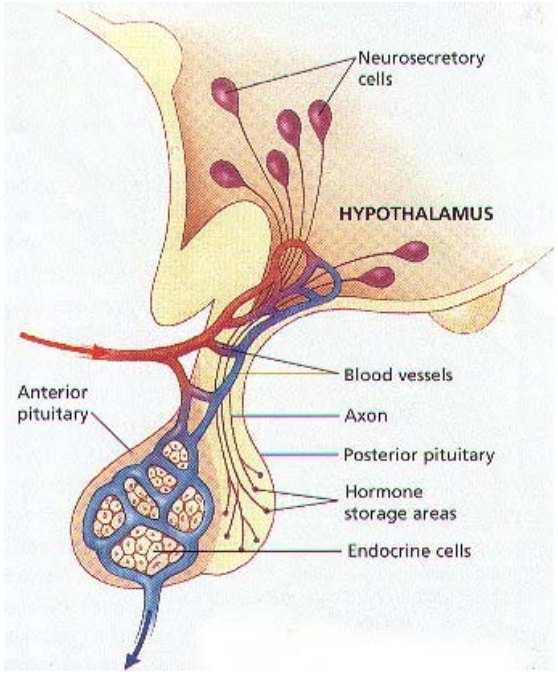
Hypothalamic Hormomes

- Release Inhibiting Hormones
  - Somatostatin
  - Prolactin release inhibiting hormone-PIH
- Releasing Hormones
  - Thyrotropin releasing hormone-TRH
  - Growth hormone releasing hormone-GHRH



1. Posterior Pituitary Hormones

- Manufactured in Hypothalamus, released from Post. Pit.
- Oxytocin
  - Target = smooth ms. Uterus and Breast (&brain)
  - Function = labor and delivery, milk ejection,(pair bonding)
- ADH (Vasopressin AVP)
  - Target = kidneys
  - Function = water reabsorption



How about in frogs ?

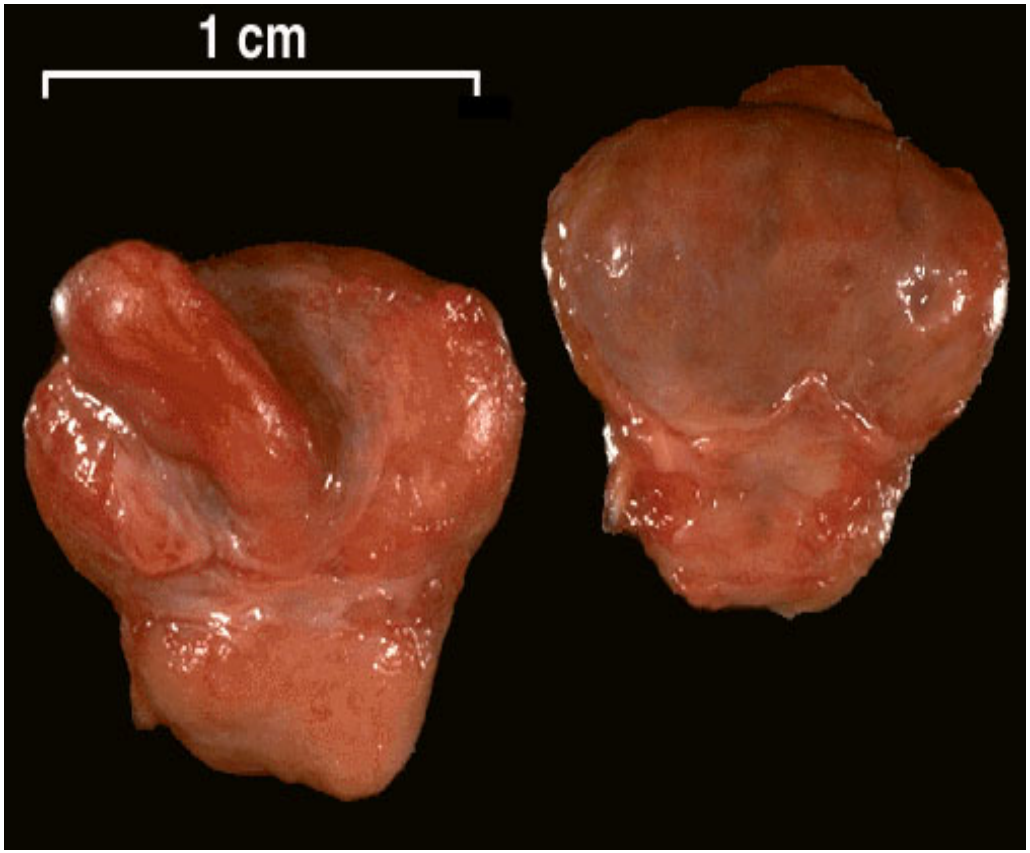
- Hormone structure/function tightly conserved
- Mesotocin
  - yolking of eggs
  - egg-laying
- Vasotocin (AVT)
  - water balance
  - REPRODUCTIVE BEHAVIORS

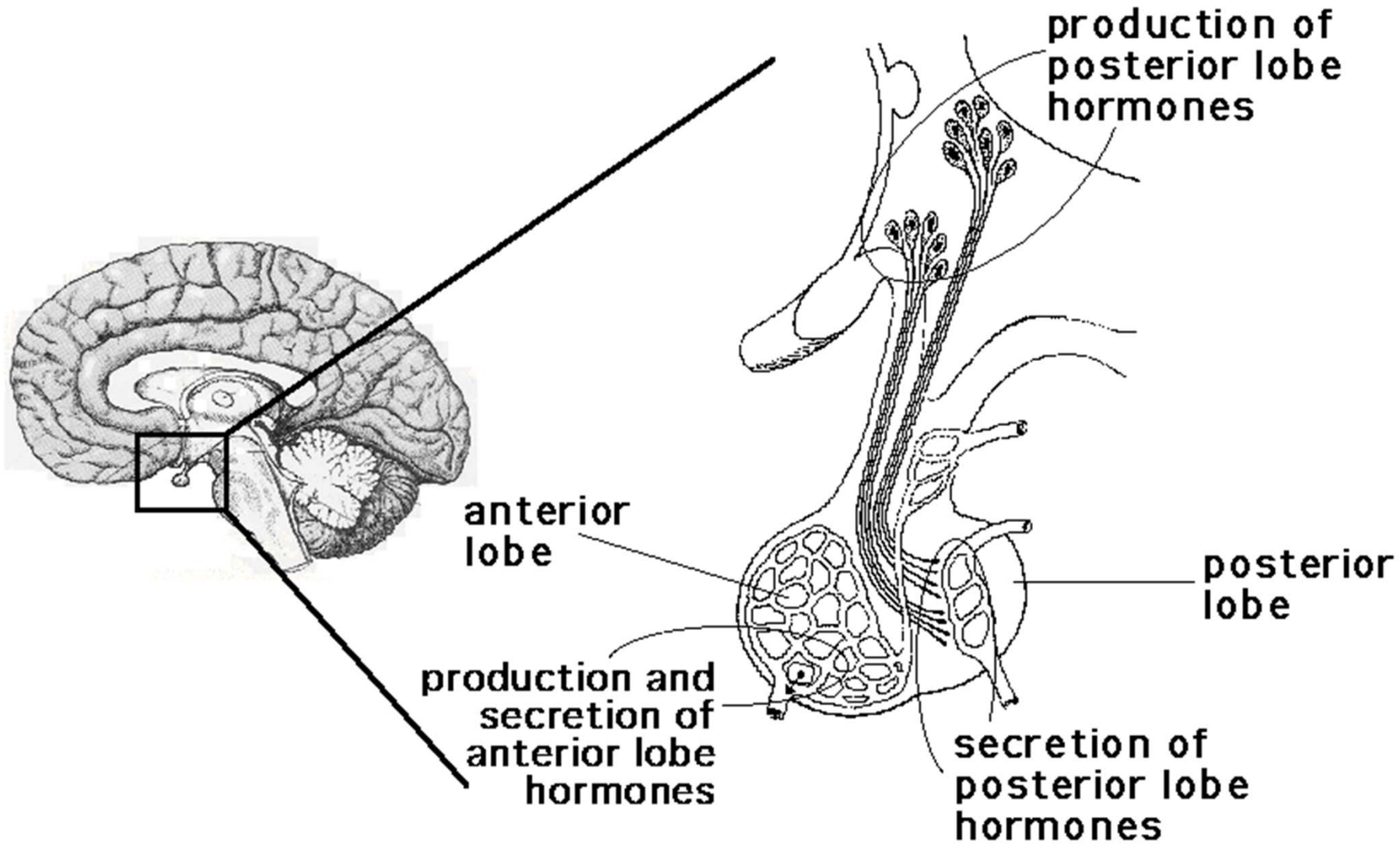
E. Pituitary gland

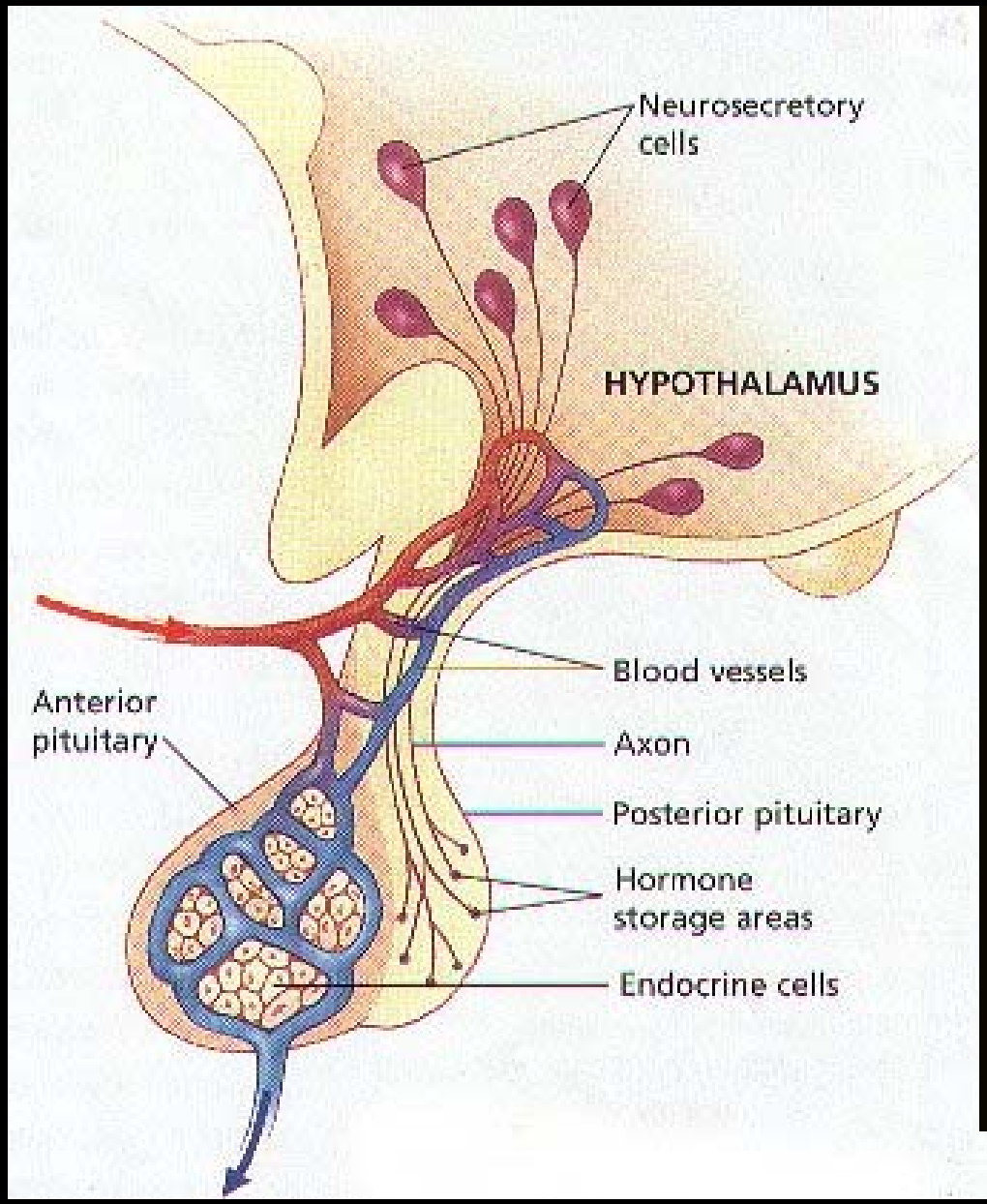
MASTER GLAND

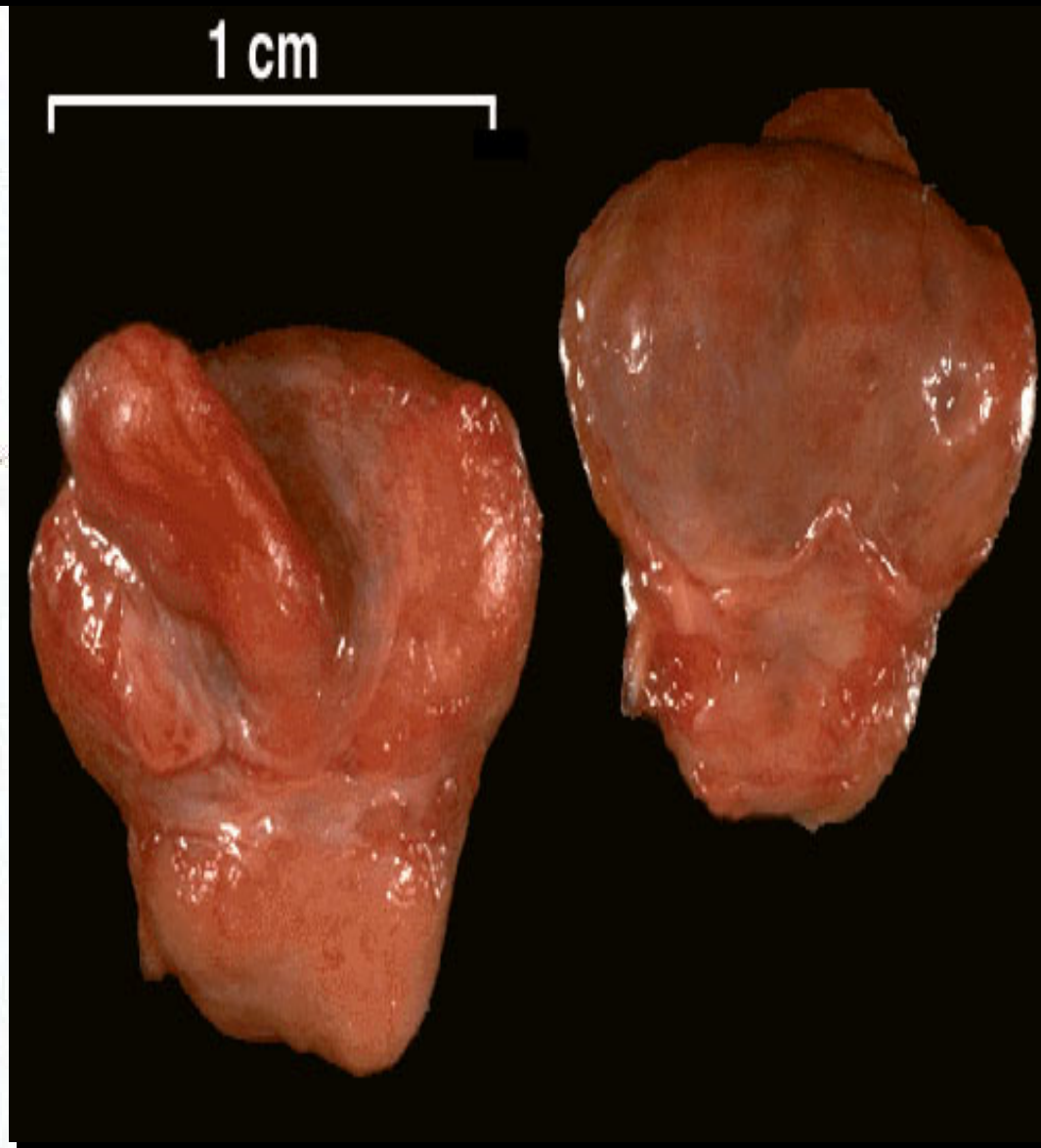
- Anterior and posterior portions

1. Posterior connected to hypothalamus by infundibulum
2. Anterior connected via blood stream









2. Anterior Pituitary Hormones

HORMONE	TARGET	FUNCTION
Thyroid (TSH) Stimulating	Thyroid gland	TH synthesis & release
Growth (GH)	Many tissues	growth
Adrenocortico-Tropin (ACTH)	Adrenal cortex	Cortisol release (androgens)
Prolactin (Prl)	Breast	Milk production
Follicle (FSH)	Gonads	Egg/sperm prod.
Luteinizing (LH)	Gonads	Sex hormones

Hormones To Study

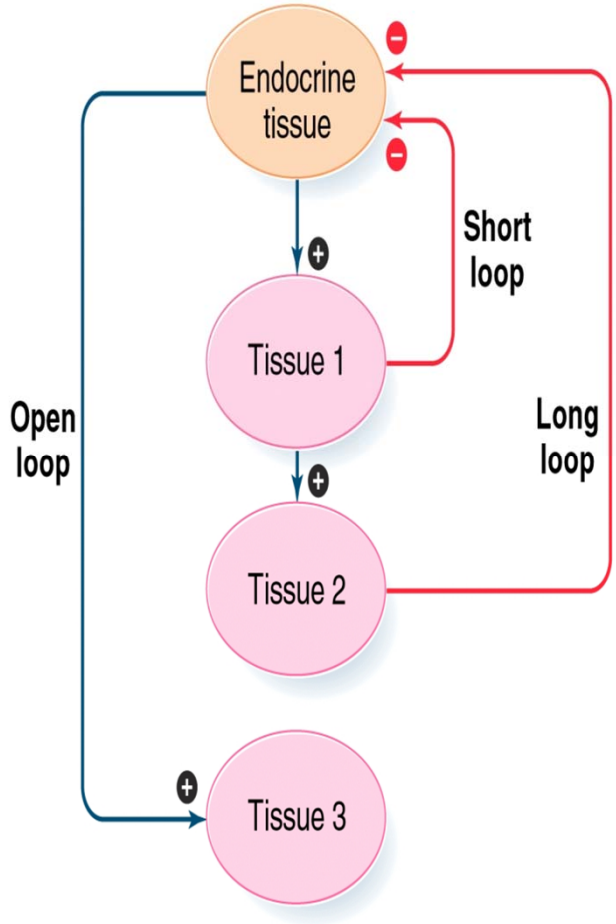
- Hypothalamic Hormones
- Posterior Pituitary (Neurohypophysis)
- Anterior Pituitary (Adenohypophysis)
  - Thyroid
  - Growth
  - Sex Steroid

III.Control of Endocrine Function

A. Positive

B. or Negative Feedback mechanisms

- Self-regulating system



STIMULUS

↓

Hypothalamus

Releasing Hormone

(Release-Inhibiting

Hormone)

↓

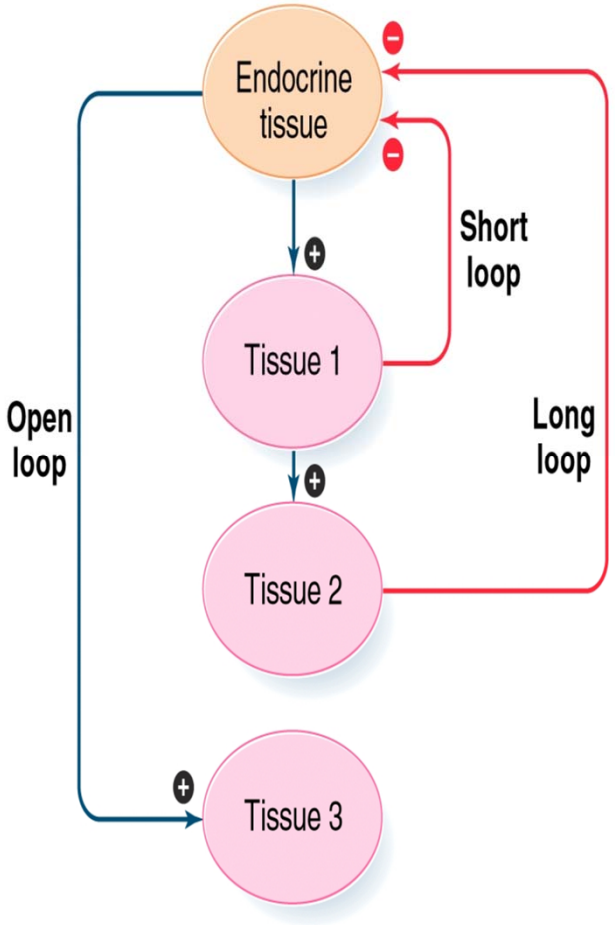
Pituitary

Stimulating Hormone

↓

Gland → **Target**

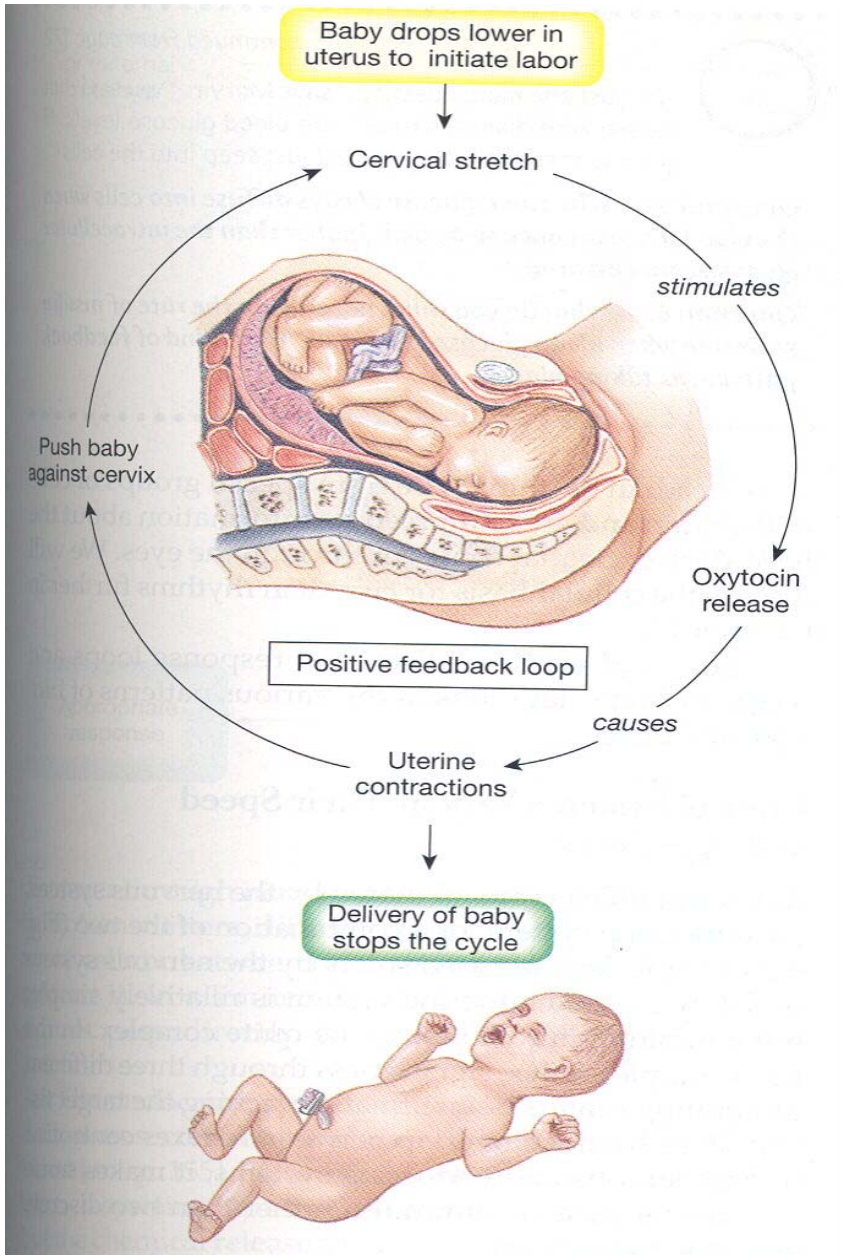
Hormone



A. Positive Feedback

- Not common
- Classic example:

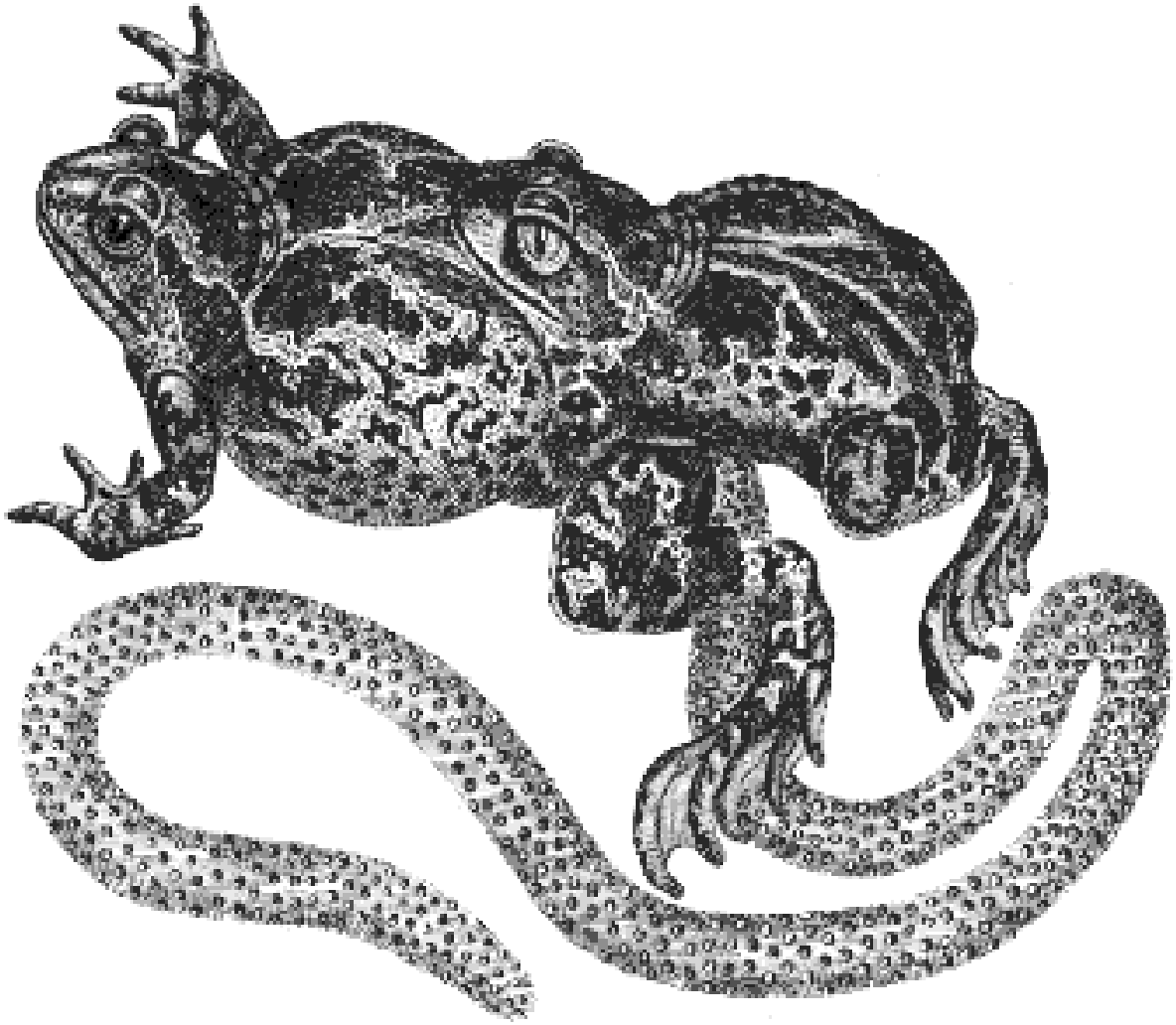
  Action of OXYTOCIN on uterine muscle during birth.



Positive Feedback

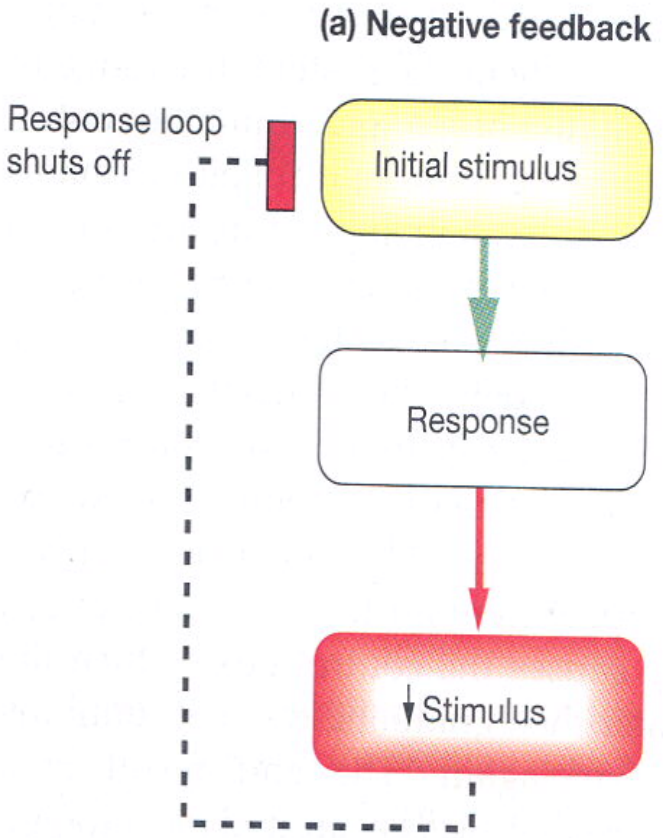
- Baby pushes on cervix
- Nervous signal to Hypothalamus
- Hypothal. manufactures OXY
- OXY transported to POSTERIOR PITUITARY & released
- OXY stimulates uterine contraction
- Loop stops when baby leaves birth canal

Same with frogs?

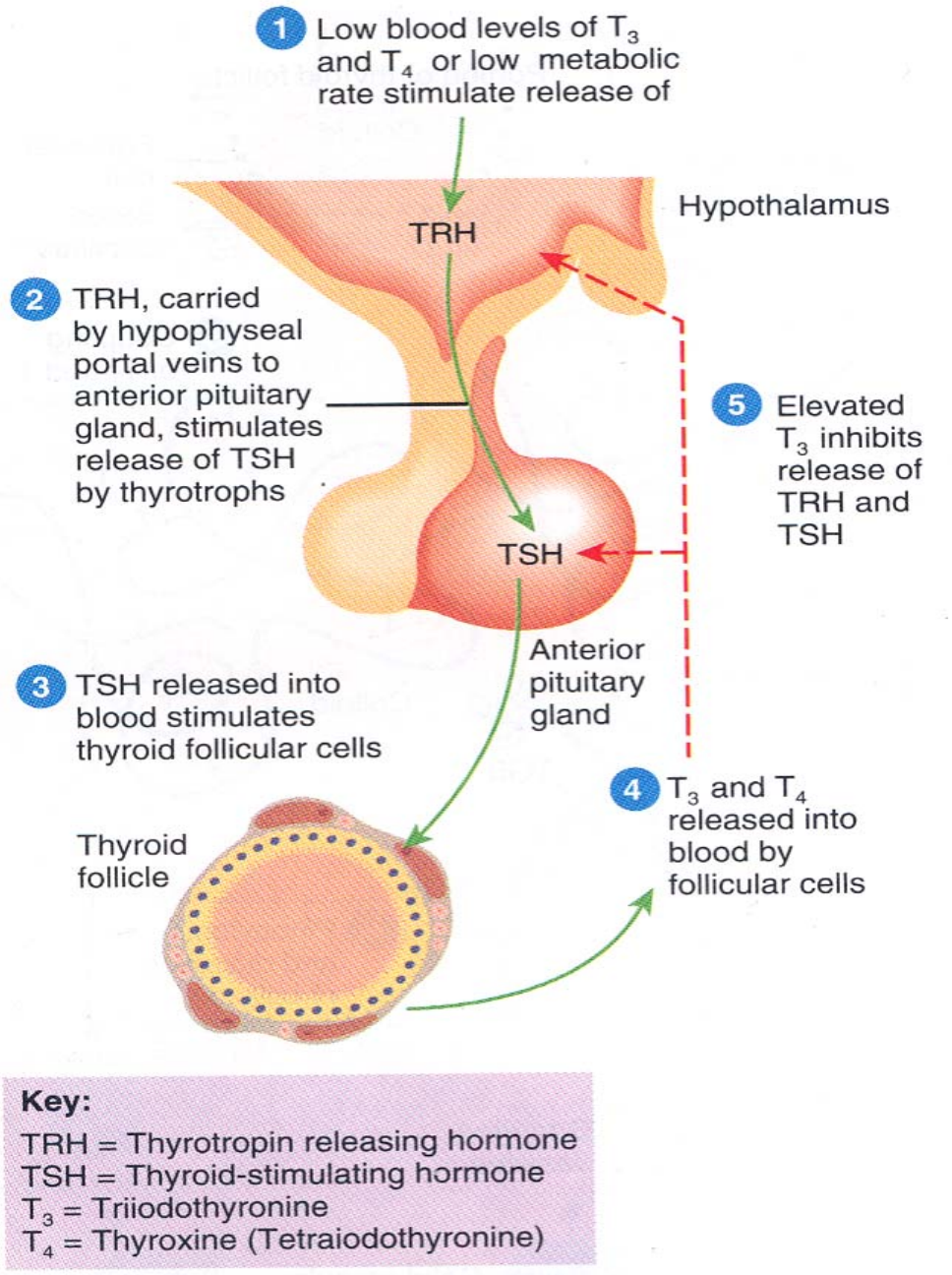


B. Negative Feedback

- Most common control mechanism
- Level of hormone in blood or body's return to homeostasis shuts off loop at hypothalamus and pituitary



Negative Feedback: Thyroid



Basic Structure of Feedback Loop

- Environmental Stimulus
- Stimulates Control Center (Brain-hypothal.)
- Hypothalamic hormones stim. Pituitary
- Pituitary hormone stim. Target area
- Target area produces change
- Change acts negatively or positively on the cycle.

IV. Specific Endocrine Events

A. Thyroid Hormone

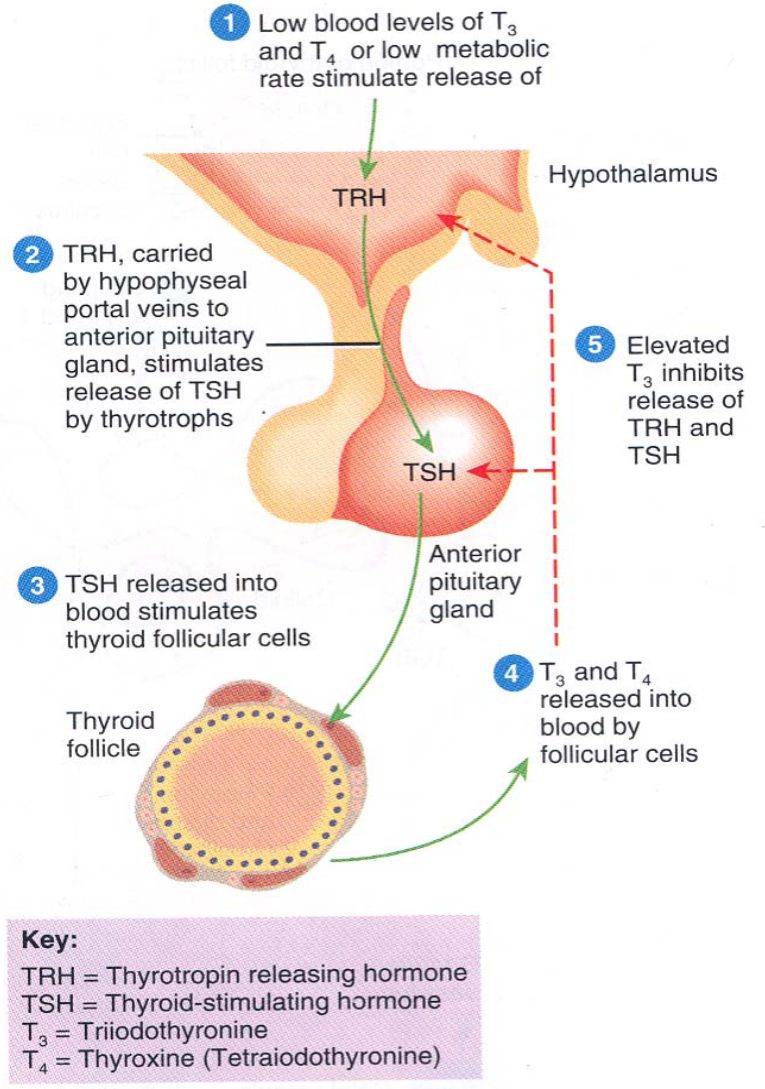
B. Growth Hormone

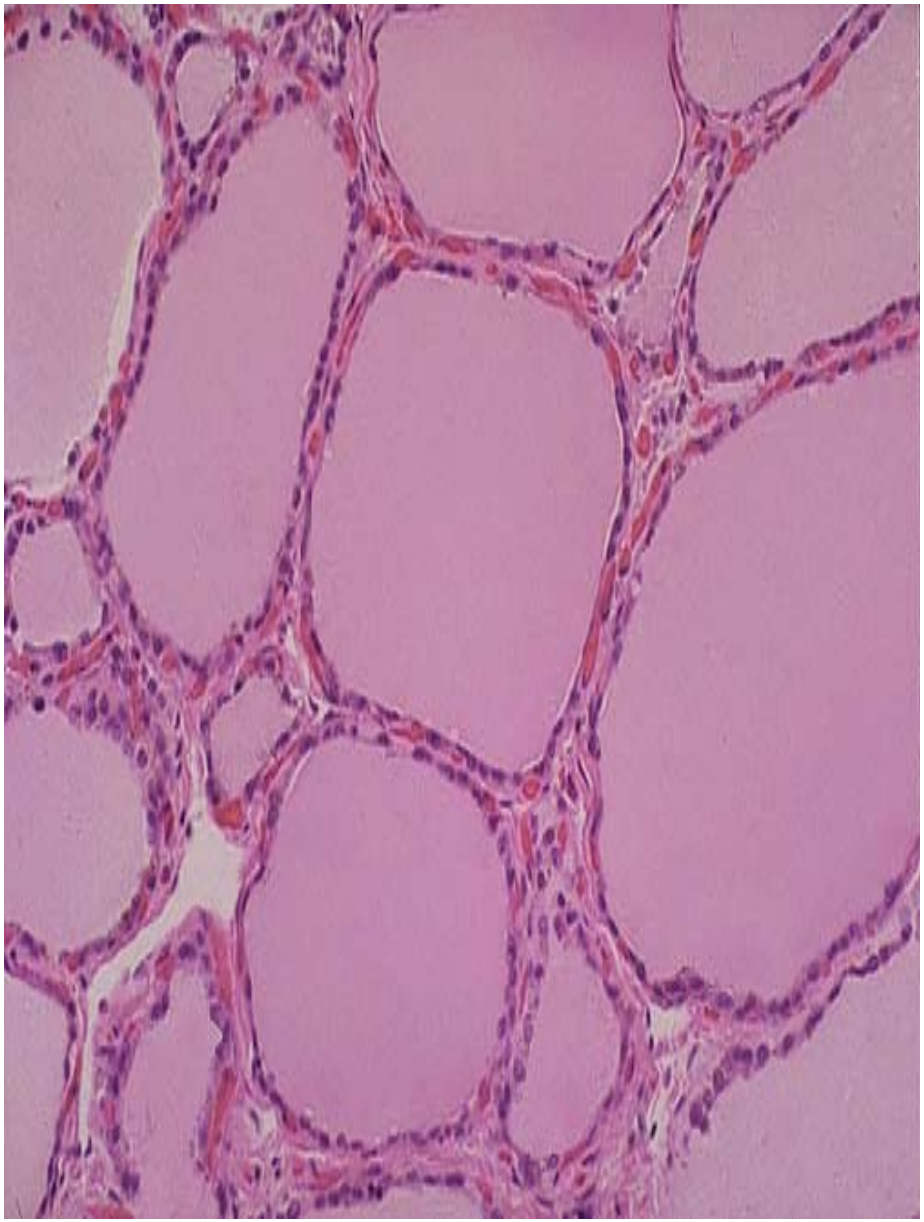
C. Adrenal Cortex Hormones

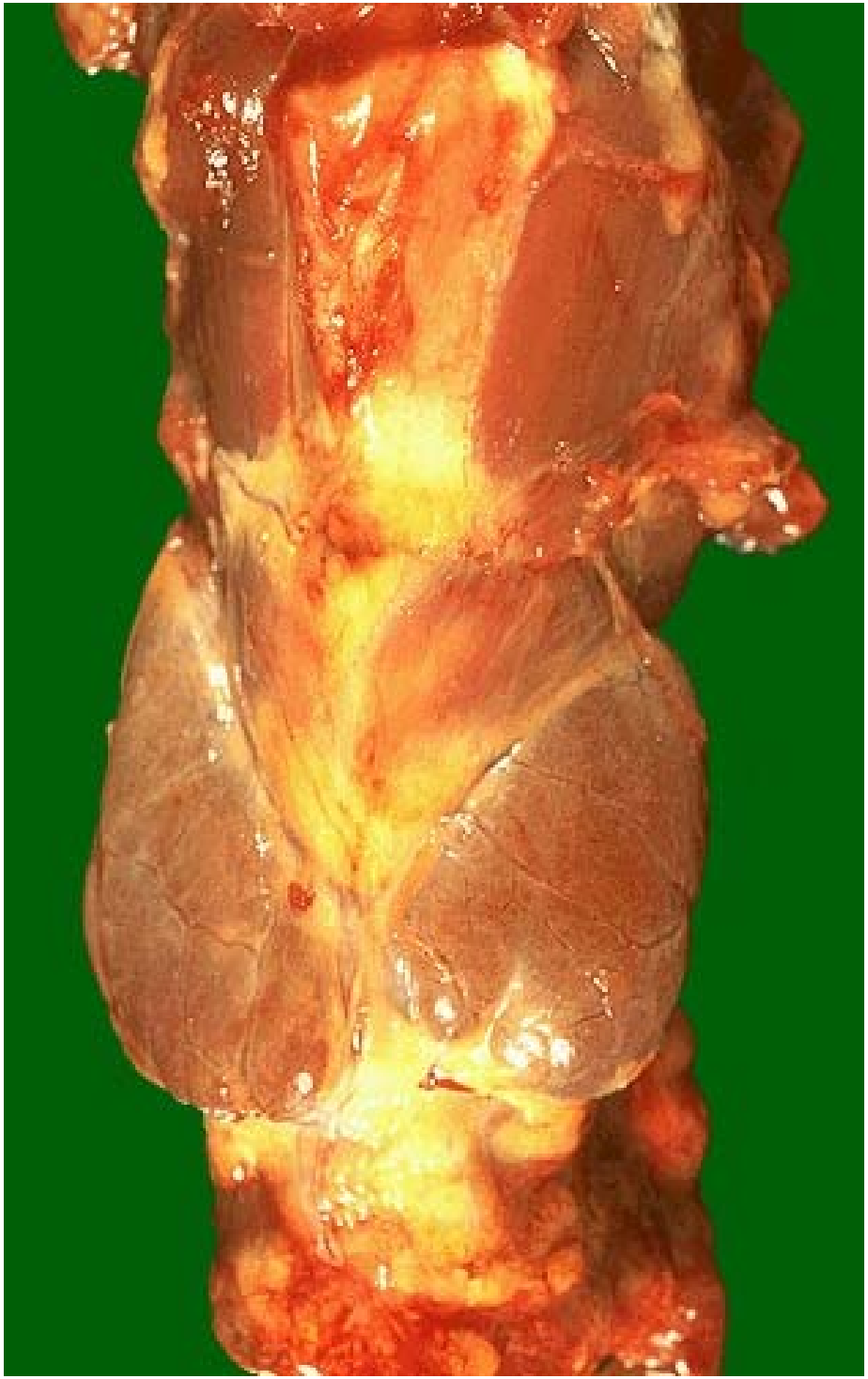
D. Sex Steroids

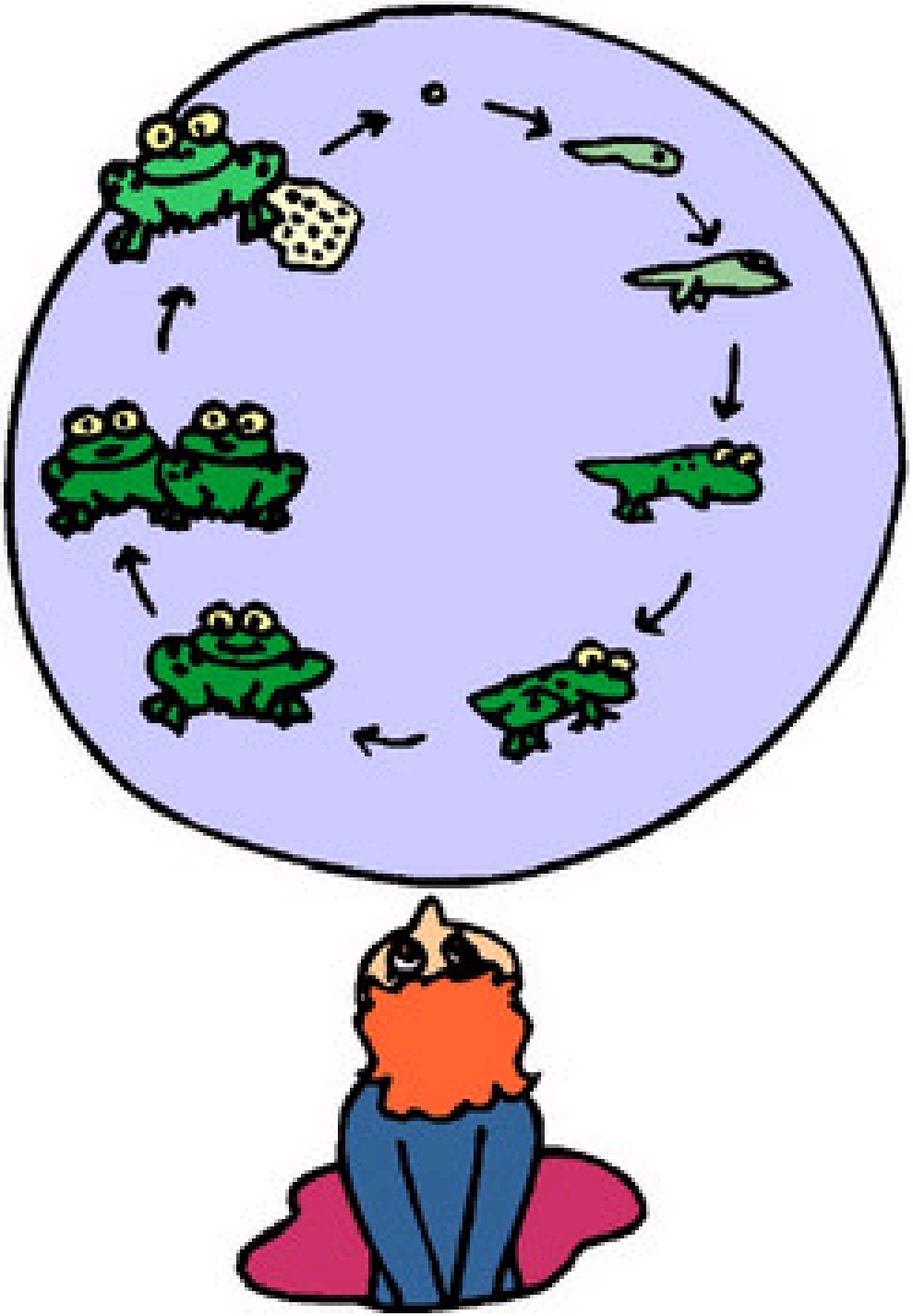
A. Thyroid Hormone

- ↓ T3 & T4 stim. Or environmental stim. Hypothalamus
- TRH stim. Anterior Pituitary
- TSH stim. Thyroid
- ↑ T3 & T4 shuts off TRH and TSH production







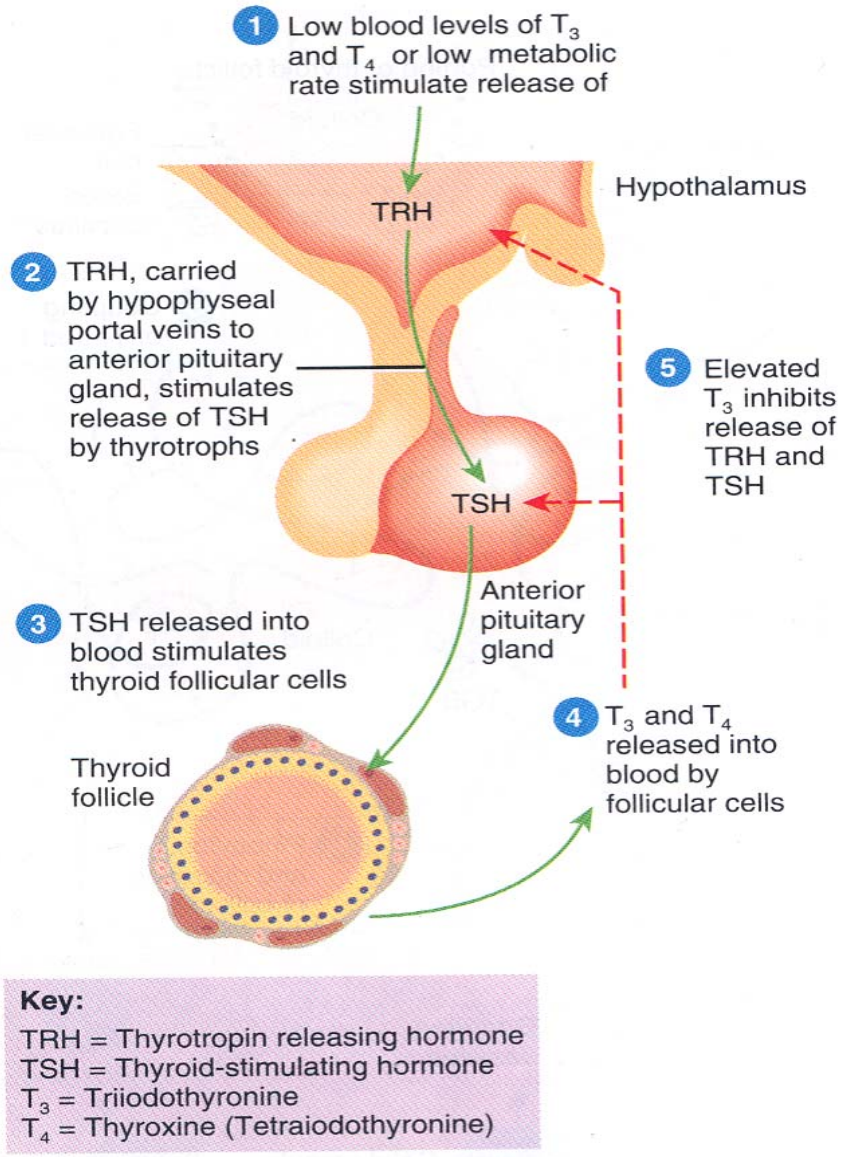


Growth

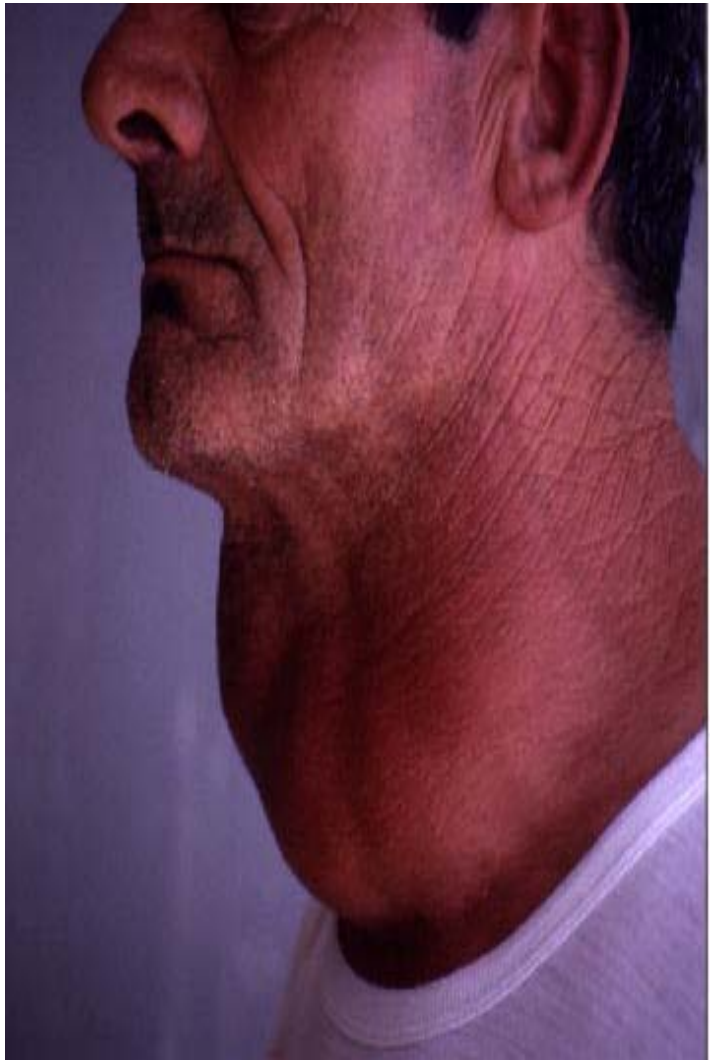
metabolism and growth

Thyroid Problems

- What would happen if the thyroid could no longer produce T3 and T4?
- No negative feedback to hypothalamus and anterior pituitary

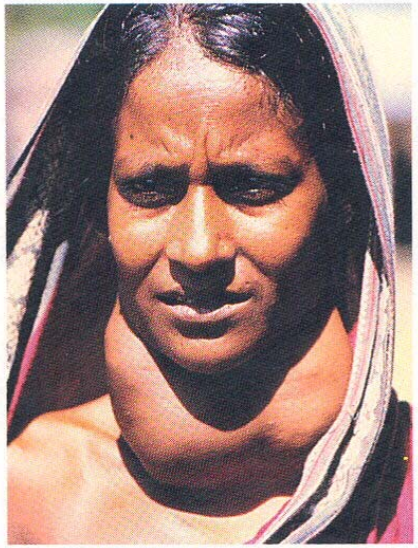


Goiter



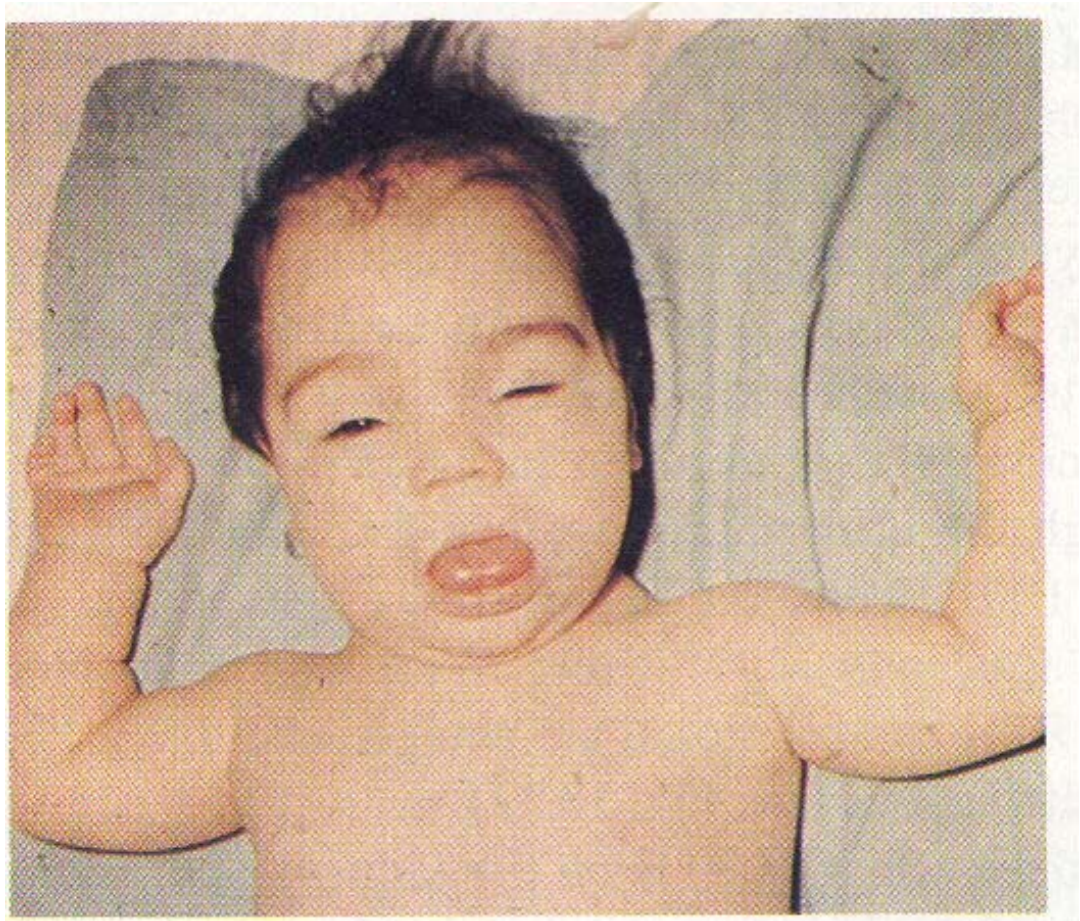
Hypersecretion of TSH or TH

(b) Exophthalmos



(c) Goiter

Hyposecretion of TH

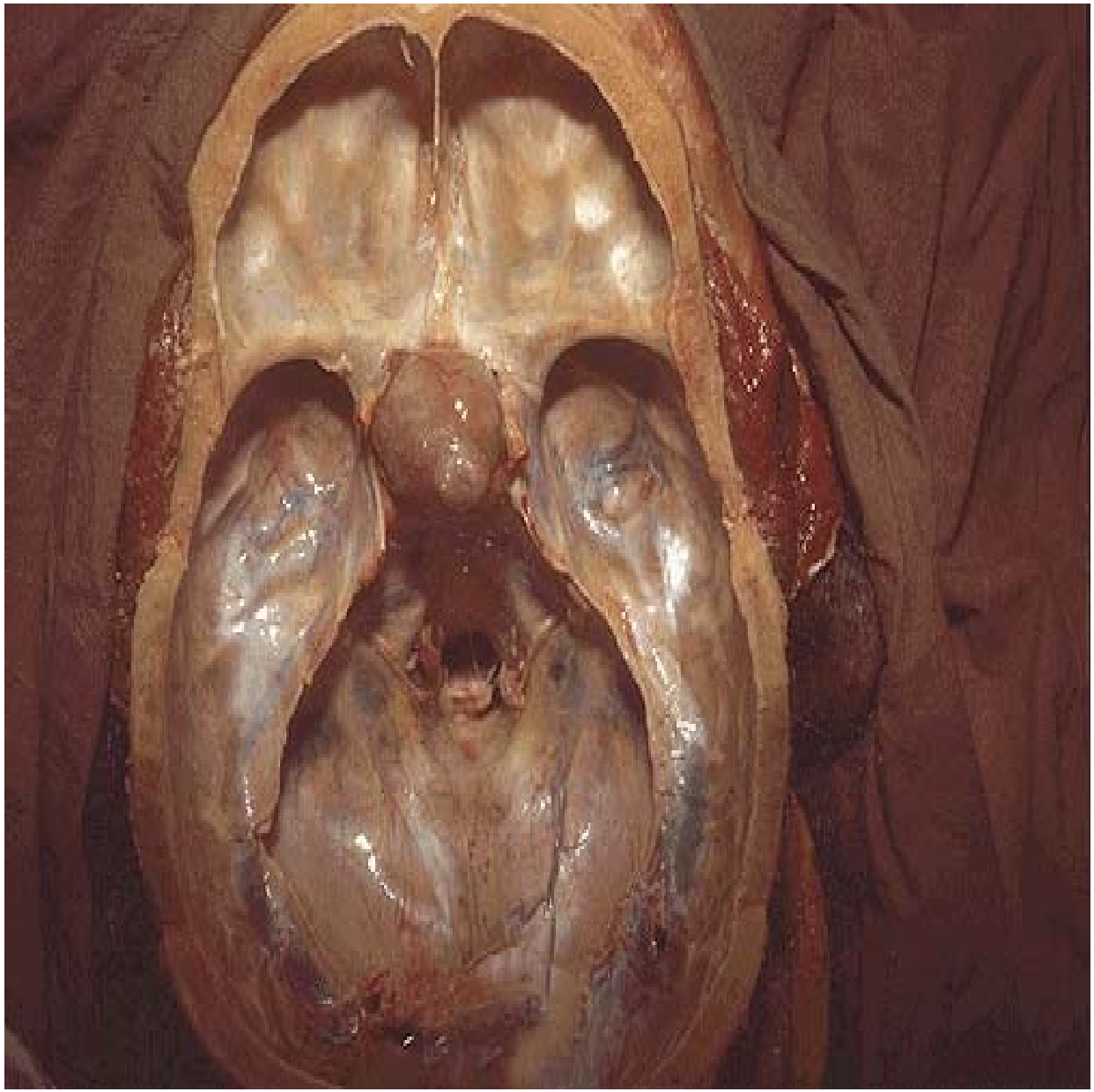


(a) Cretinism

B. Growth Hormone

- Stimulus = Tissue growth/ repair
- Hypothalamus releases GHRH
- Anterior Pituitary releases GH
- ↑ Protein synthesis, growth, etc.
- ↑GH and release of somatostatin shuts off GHRH and GH release

What happens with excess GH?



↑GH as Juvenile

↑GH as an Adult

How Does Hypersecretion of GH Happen?

↓GH = pituitary dwarfism

Adrenal Gland

- Adrenal gland located atop kidney
- Outer part = cortex
  - Secretes Cortisol (stress), Androgens, Aldosterone (electrolytes)
- Inner part = medulla
  - SNS control
  - Secretes EPI & NEPI (fight or flight)

Adrenal Insufficiency

- Addison's disease--hyposecretion of cortisol
- JFK
- Darkened skin (ACTH mimics MSH)
- Weight loss, hypoglycemia
- Find the anomaly in the feedback loop.
- Inability to handle stress

4. Sex Steroids

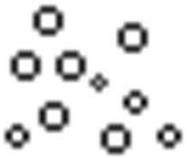
- Stimulus = low circulating T or E
- Hypothalamus = GnRH
- Anterior Pituitary = FSH & LH
- Gonads produce T and E
- High T and E shut off GnRH and FSH/LH

Importance

- Reproduction/Mating Behavior (duh)
- Formation of reproductive organs
  - gonads
  - brain

Gym Steroids

Widely used. Safety profile is "so-so".



mood swings

hair loss

acne

accelerated atherosclerosis

Are you breaking the law?

ruptured tendon

xanthomas

gynecomastia

prostatitis

altered libido

testicular atrophy (sweet peas)

short stature for life (younger athletes)

jaundice

cholestasis

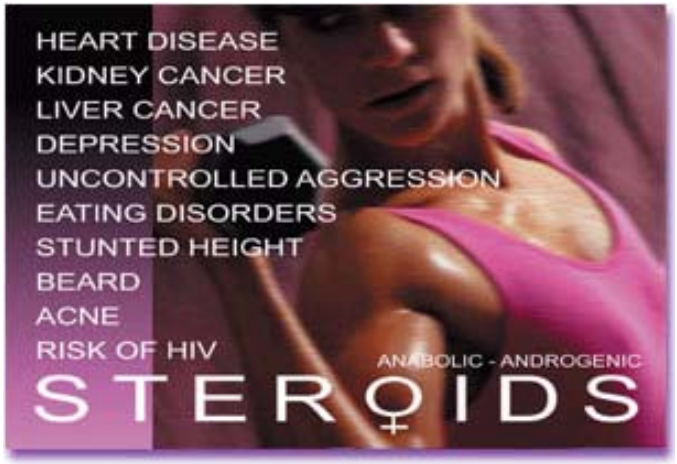
peliosis

hepatocellular carcinoma

personality changes

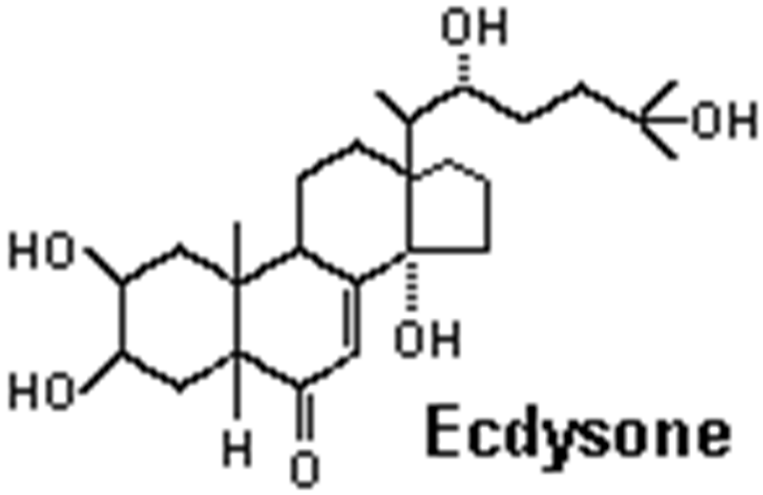
They DO enhance muscle growth for strength sports. It is your decision.

Too many steroids



Invertebrates

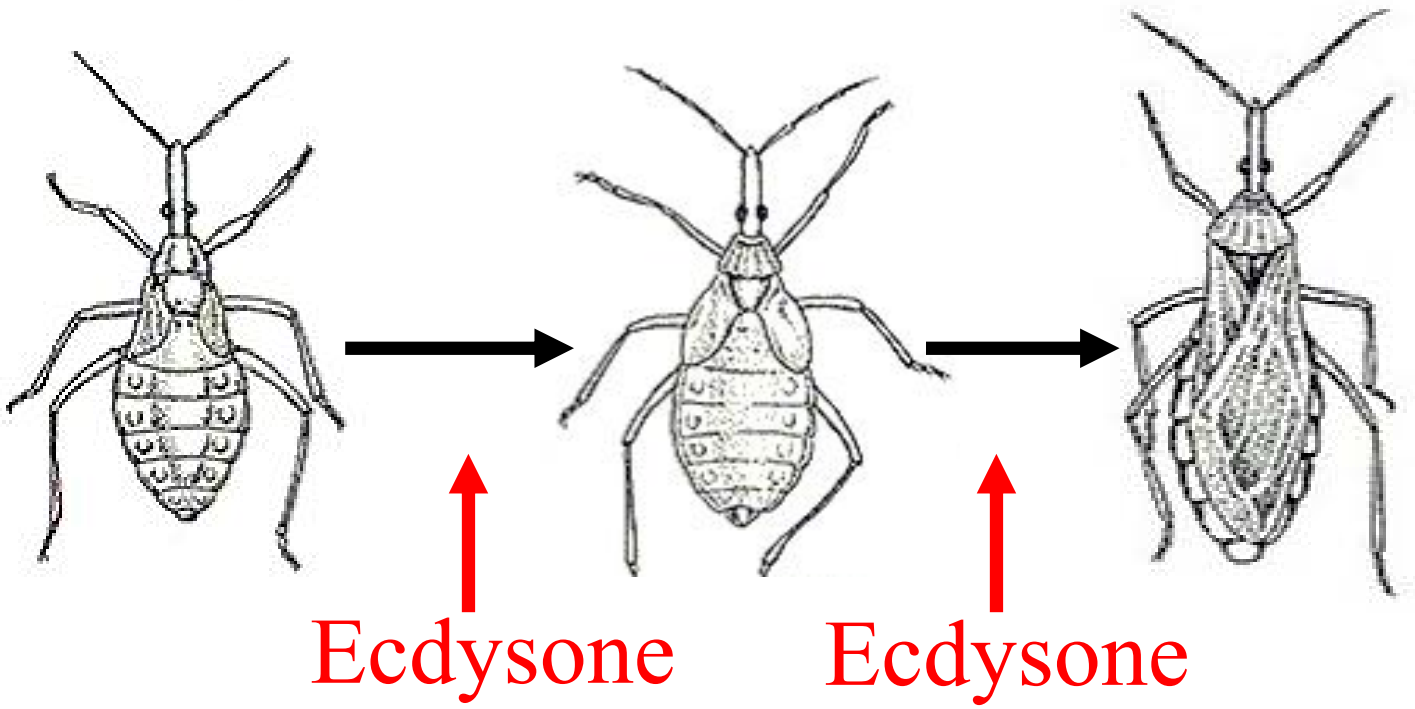
- Hormones involved in:
  - Molting
  - Pupation
  - Metamorphosis



Ecdysone

Insect Hormones

- **Juvenile Hormone**
  - maintains juvenile cuticle for pre-adulthood molts
  - secreted by corpus allatum near brain
- **Ecdysone**
  - Molting Hormone
  - Prothoracic Glands (in thorax of insect)
  - PTTH = Brain hormone that stimulates Prothoracic Glands

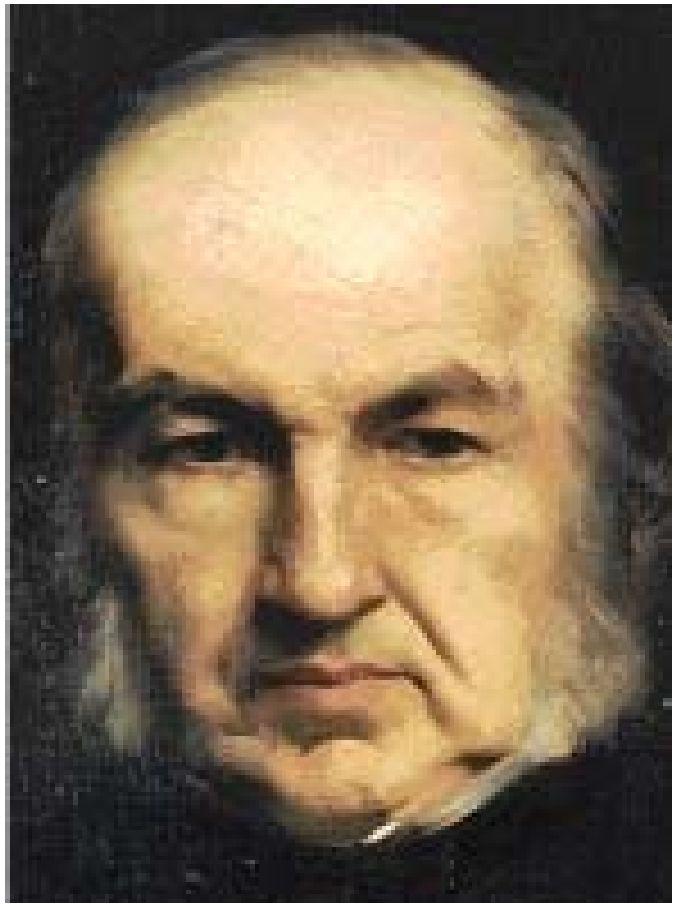


Juvenile Hormone

Points

- History
- Anatomy
- Terms
- Hormones
- Feedback control
- Specific Points discussed

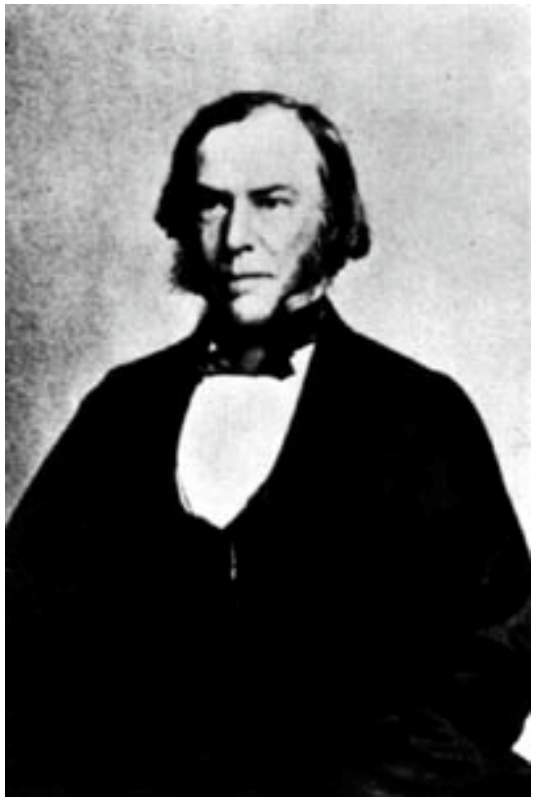
I. Endocrine History



- Claude Bernard (mid 1800s)
  - pancreas, liver
  - brain, smooth ms.
  - internal environ.
- A.A. Berthold (1849)
  - repro hormones and behavior

Endocrine History

- Charles Brown-Sequard (1889)
  - Harvard 1864-1868
  - M.D. in NY 1873-1878
  - bull testis extracts



Important Physiologists

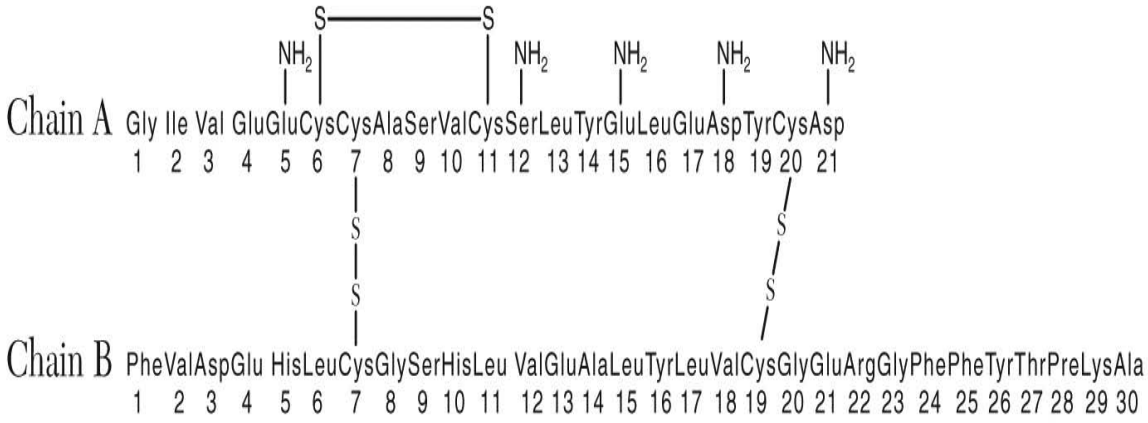
- Walter Cannon
  - homeostasis
  - sympathetic nervous system
    - Bodily Changes in Hunger, Fear, and Rage

1. Peptide/Protein Hormones

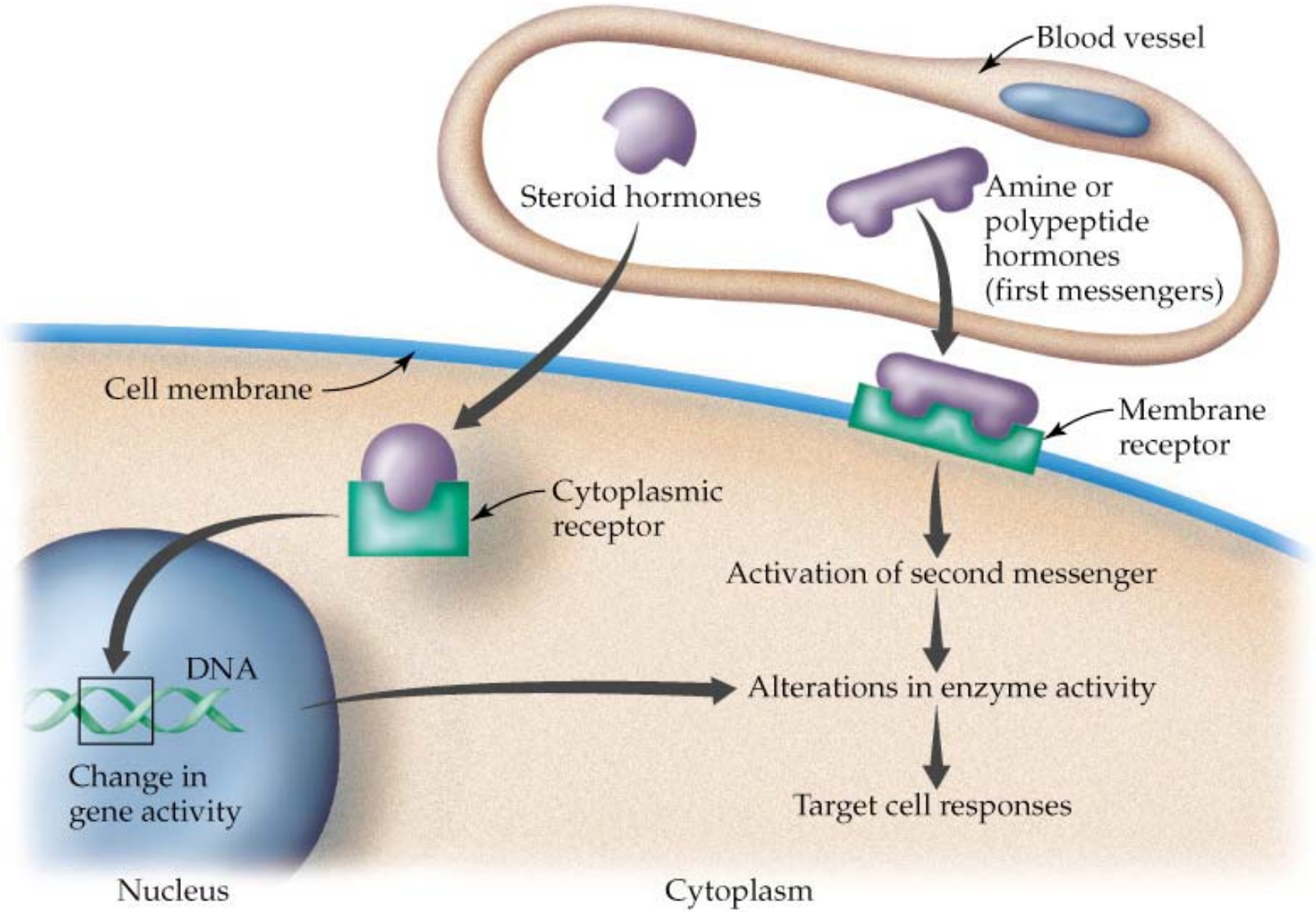
- Most common hormone
- translated, packaged, & sent
- Hydrophilic/Lipophobic
- **Bind surface receptors at target**
- **Binding mediates signal transduction/2nd messenger system**

Peptide Hormones cont.

- Short 1/2-life
- Pancreas
  - Insulin/glucagon
- **Hypothalamus**
  - RH (releasing hormones)
  - RIH (release inhibiting hormones)



Insulin (bovine)
(a peptide)

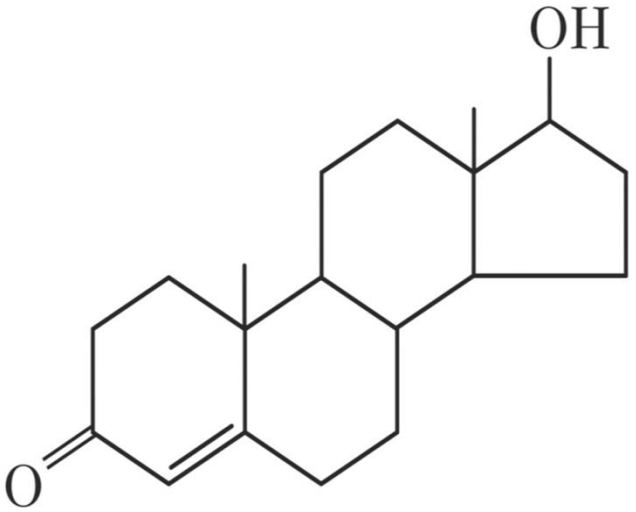


2. Steroid Hormones

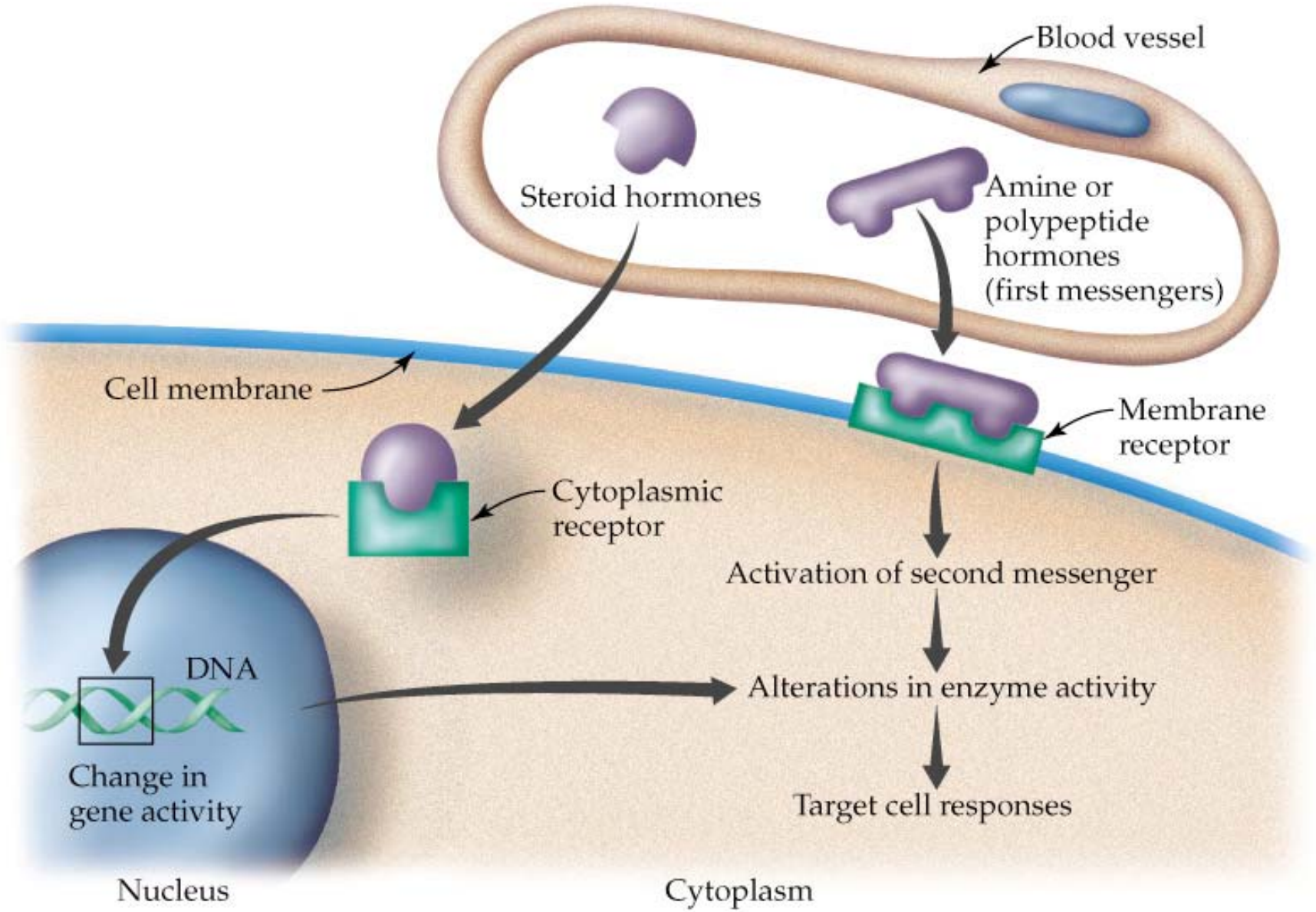
- Derived from cholesterol
- Hydrophobic/Lipophilic
- Travel with a protein carrier
- Long 1/2-life
- **Binds to cytoplasmic or nuclear receptor**
  - 1st Messenger

Steroid hormones cont.

- Genomic effect
  - Activates genes
  - Directs synthesis of new proteins
- Lag time between hormone binding and effect = long time.
- Gonads & placenta
- Adrenal cortex

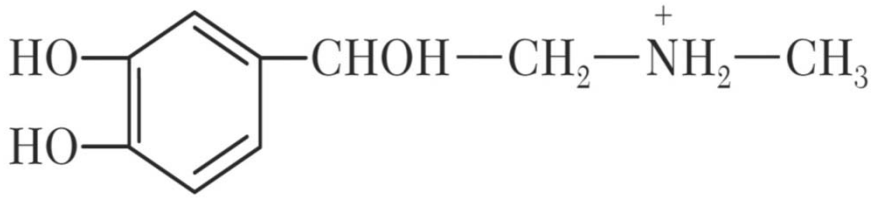


Testosterone
(a steroid)



3. Amine Hormones

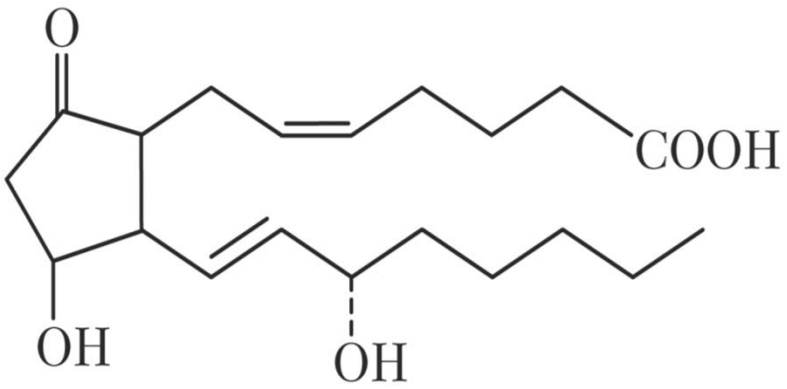
- Synthesized from a single amino acid
- Melatonin from tryptophan
- Thyroid hormone from tyrosine
- Catecholamines (EPI, DA) from tyrosine



Epinephrine
(an amine)

4. Eicosanoid hormones

- Produced from 20-carbon fatty acid, arachadonic acid
- Produced in all cells except RBCs
- 2nd messenger
- Prostaglandins and leukotrienes
- inflammation



Prostaglandin PGE_2
(an eicosanoid)

4 Classes of Hormones

A. Peptide/ Protein 2M
B. Steroid
C. Amine
D. Eicosanoid

4 Classes of Hormones

A. Peptide/ Protein 2M

B. Steroid 1M

C. Amine

D. Eicosanoid

4 Classes of Hormones

A. Peptide/ Protein 2M

B. Steroid 1M

C. Amine 2M

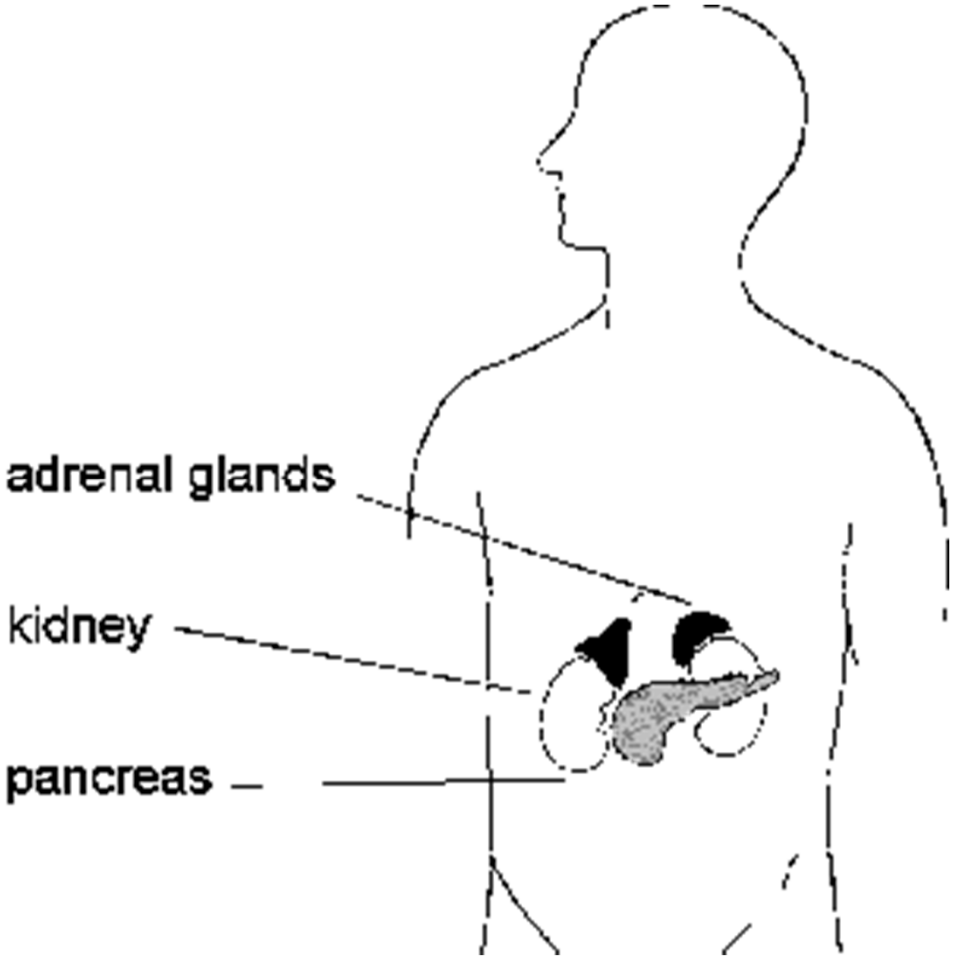
D. Eicosanoid

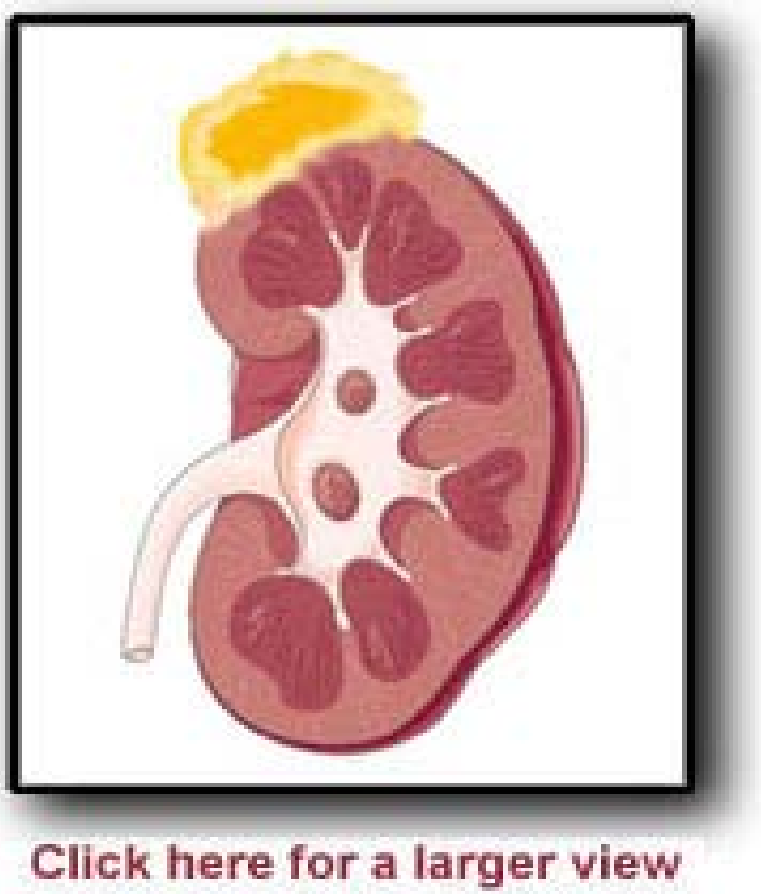
4 Classes of Hormones

A.	Peptide/ Protein	2M
B.	Steroid	1M
C.	Amine	2M
D.	Eicosanoid	2M

Negative Feedback

- Low levels of T3 or T4 in blood or low BMR = stimulus
- Hypothalamus releases TRH
- TRH stimulates the ANTERIOR PITUITARY to release TSH
- TSH stim. Thyroid to release T3 & T4
- Levels of T3 & T4 shut off Hypothal. & Anterior Pituitary

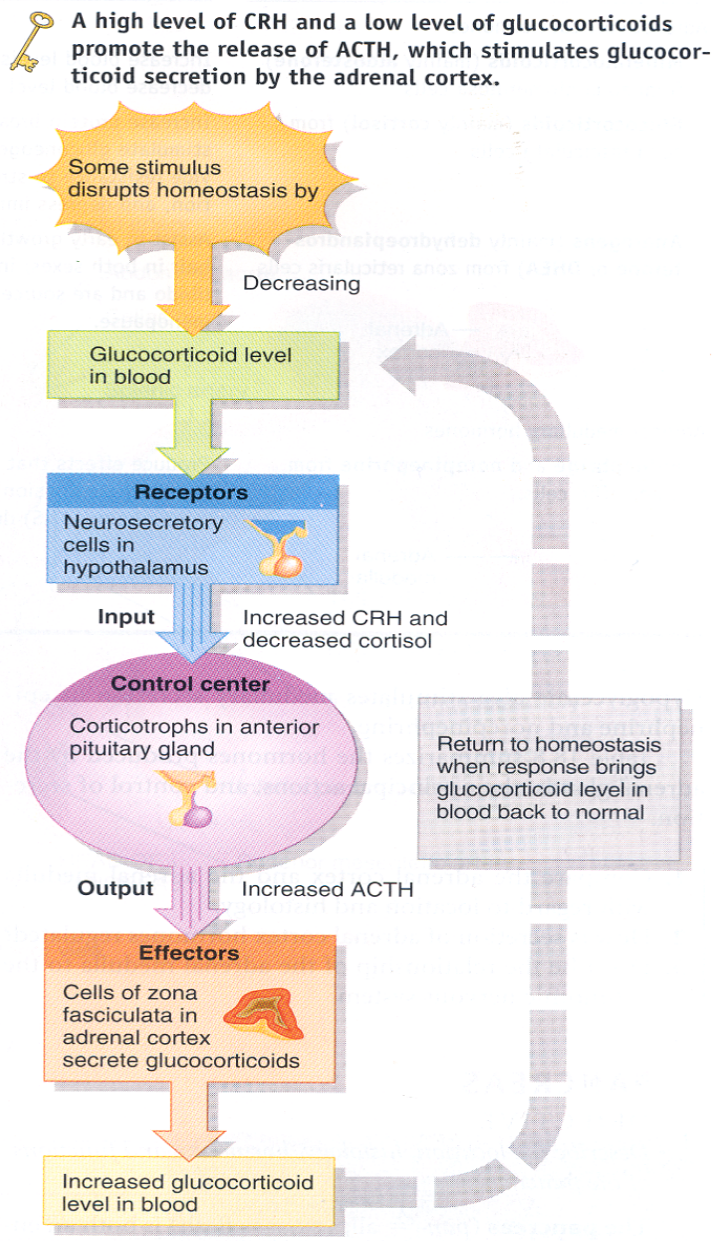




Click here for a larger view

Adrenal cortex feedback

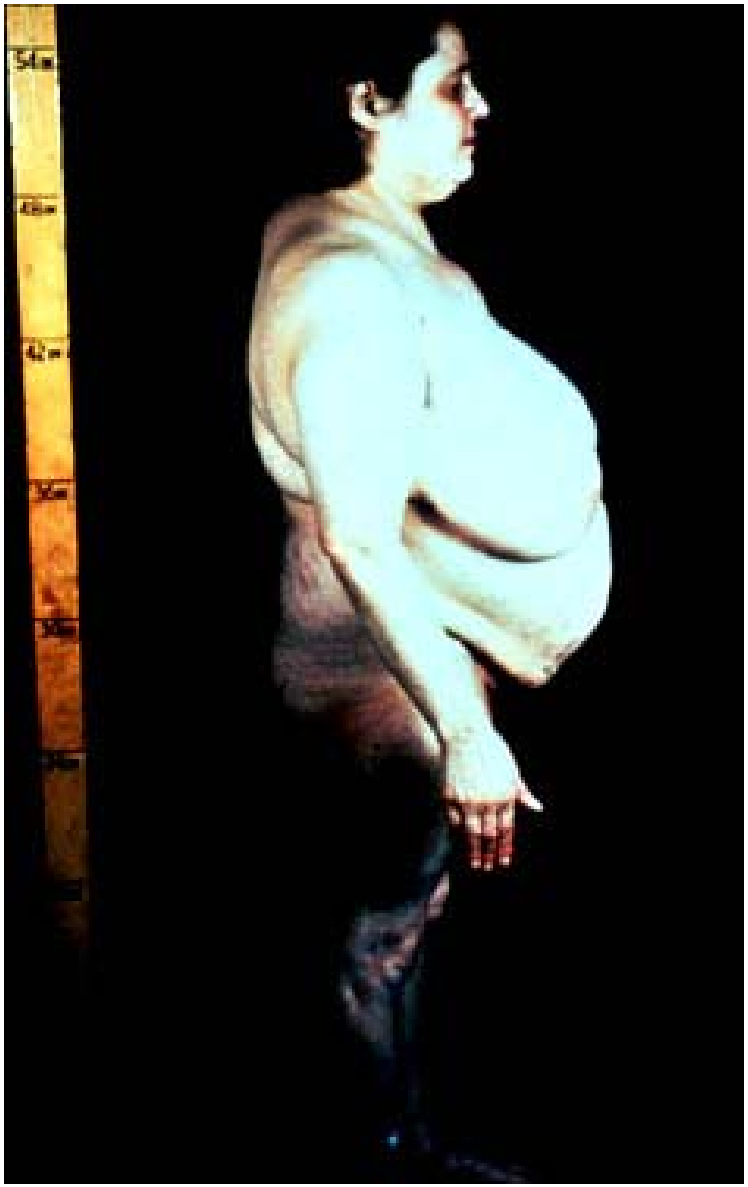
- Low glucocorticoid (cortisol) levels or low blood sugar
- Stim. Hypothal. = CRH
- CRH stim. Anterior Pit. = ACTH
- ACTH stim. Adrenal Cortex.
- Increase glucocort. Level then blood sugar level



Adrenal gland

Adrenal Problems

Hypersecretion of Adrenal Cortex



What Would the Feedback Loop Look Like for Cushing's Syndrome?

(a) Facial features

(b) Pendulous abdomen with striae