



SECOND FACULTY OF MEDICINE  
CHARLES UNIVERSITY

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# **The Adrenal Gland, Corticoids Including Clinical Use**

**Lecture from the Medical Physiology**

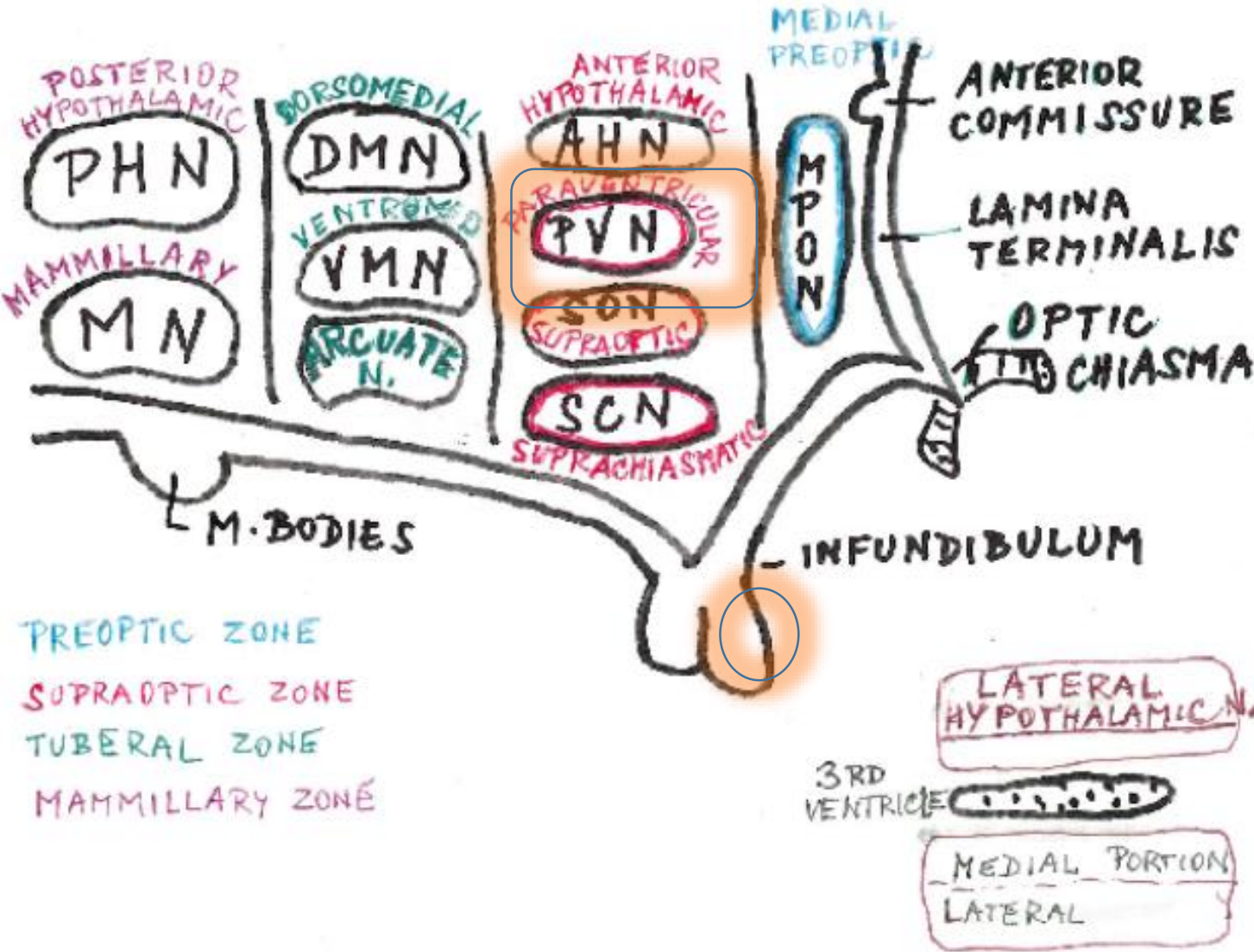
**Olga Vajnerová**

Department of Physiology, Second Faculty of Medicine, Charles University

2024

# MOODLE

# Hypothalamus - Adrenal Gland

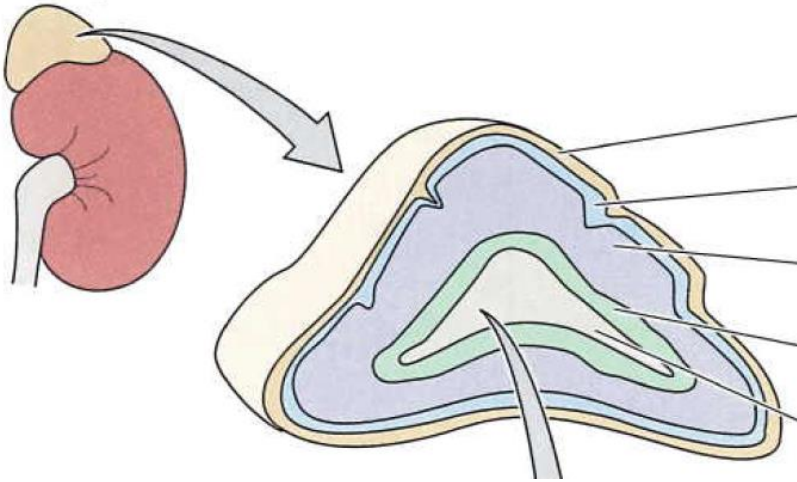


- PREOPTIC ZONE
- SUPRAOPTIC ZONE
- TUBERAL ZONE
- MAMMILLARY ZONE

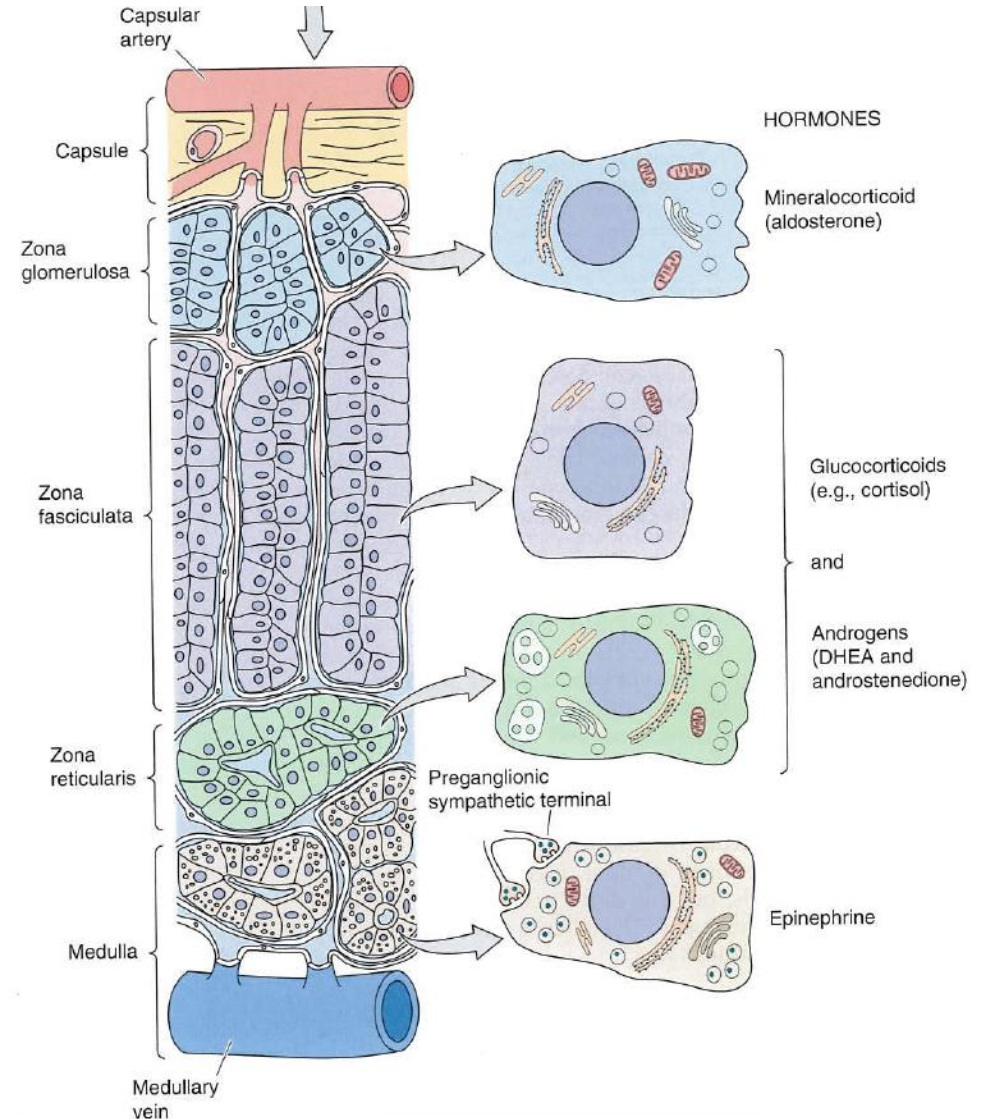
CRH

corticotrophs  
ACTH

# Adrenal gland



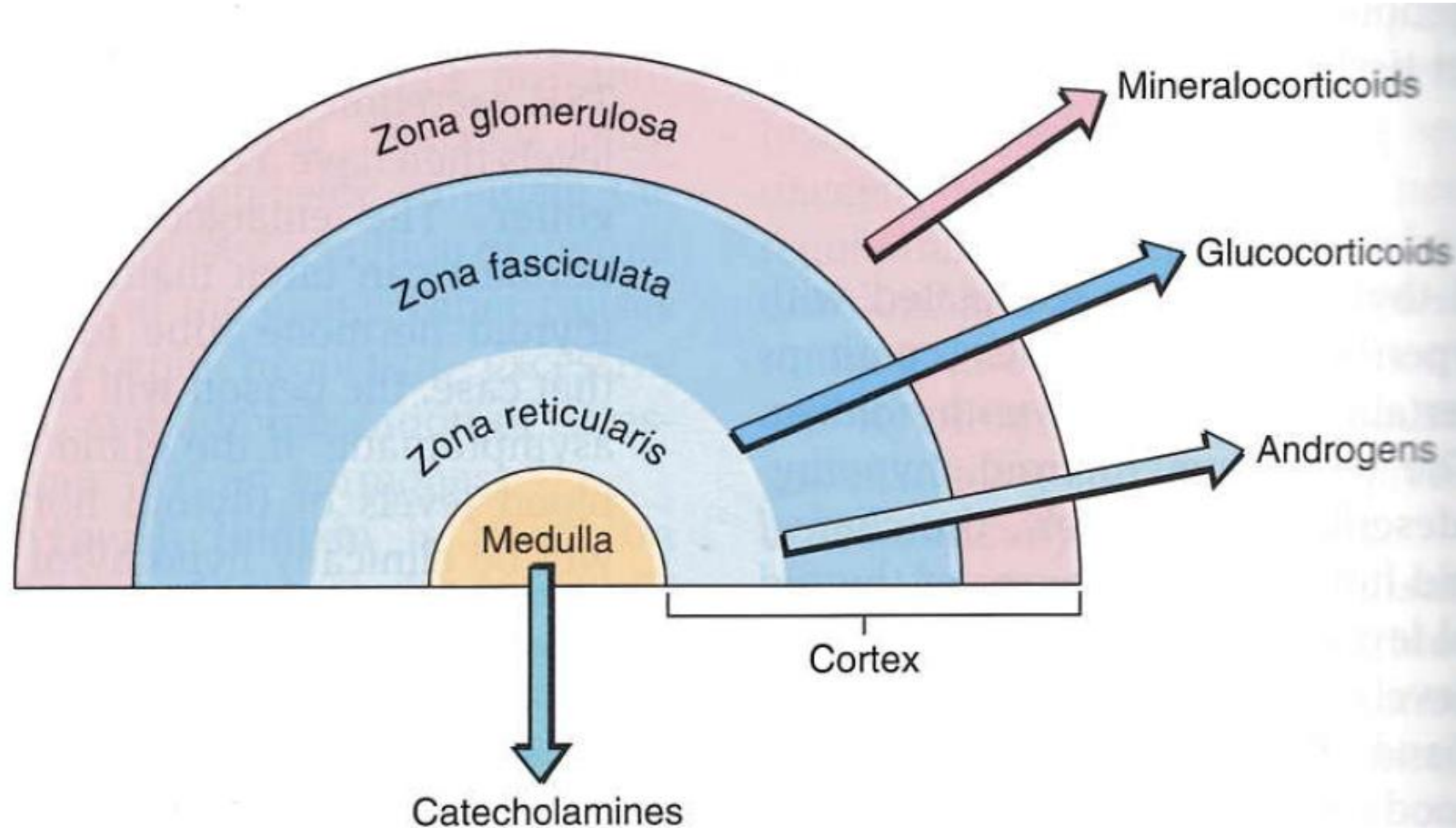
Anatomy of the adrenal gland



Boron, Boulpaep: Medical Physiology, 2003

# Adrenal gland

Secretions of the adrenal medulla and adrenal cortex



# Aldosterone - Secretion

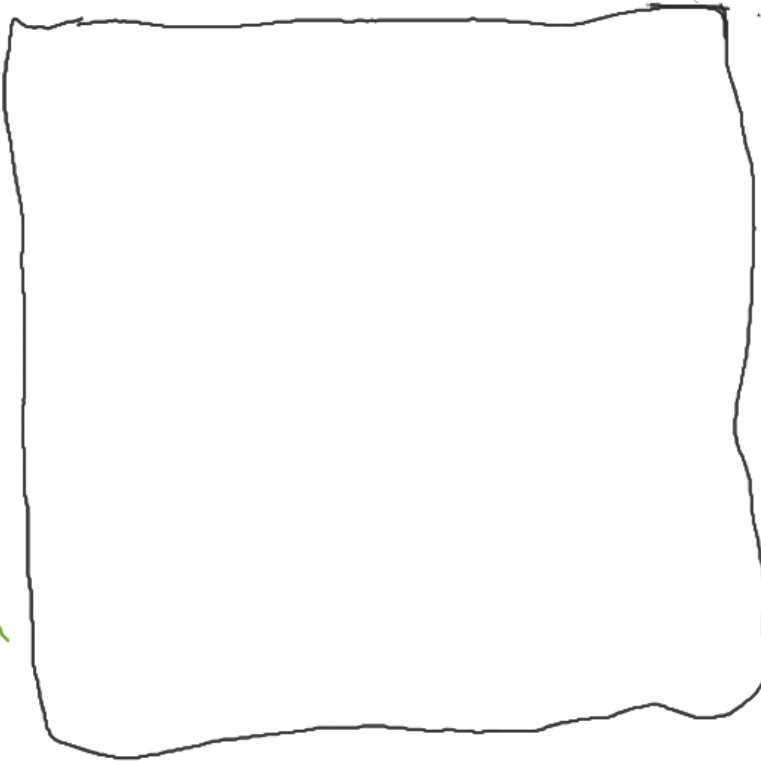
## Mineralocorticoids

Blood pressure



Plasma ion composition

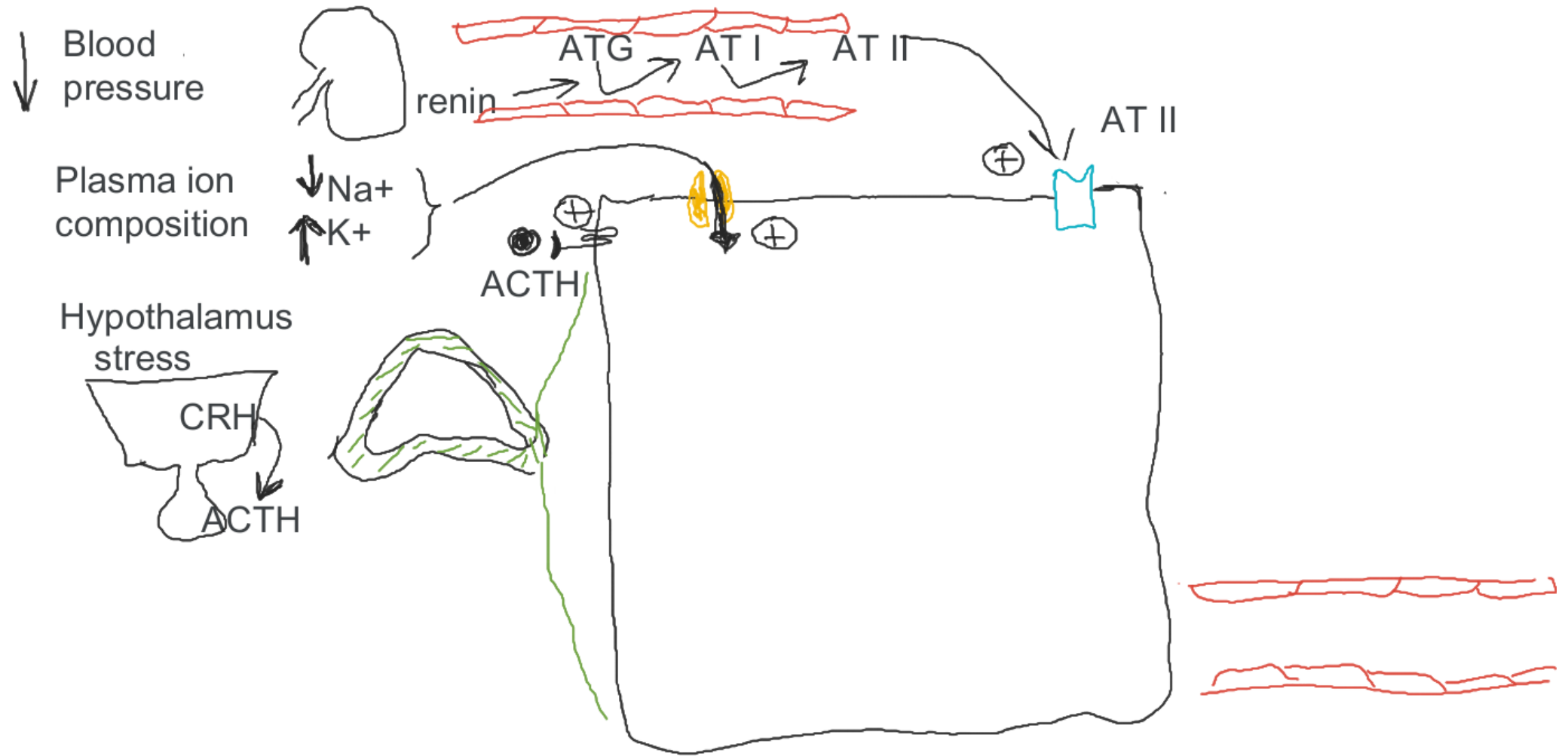
Hypothalamus



# Aldosterone - Secretion

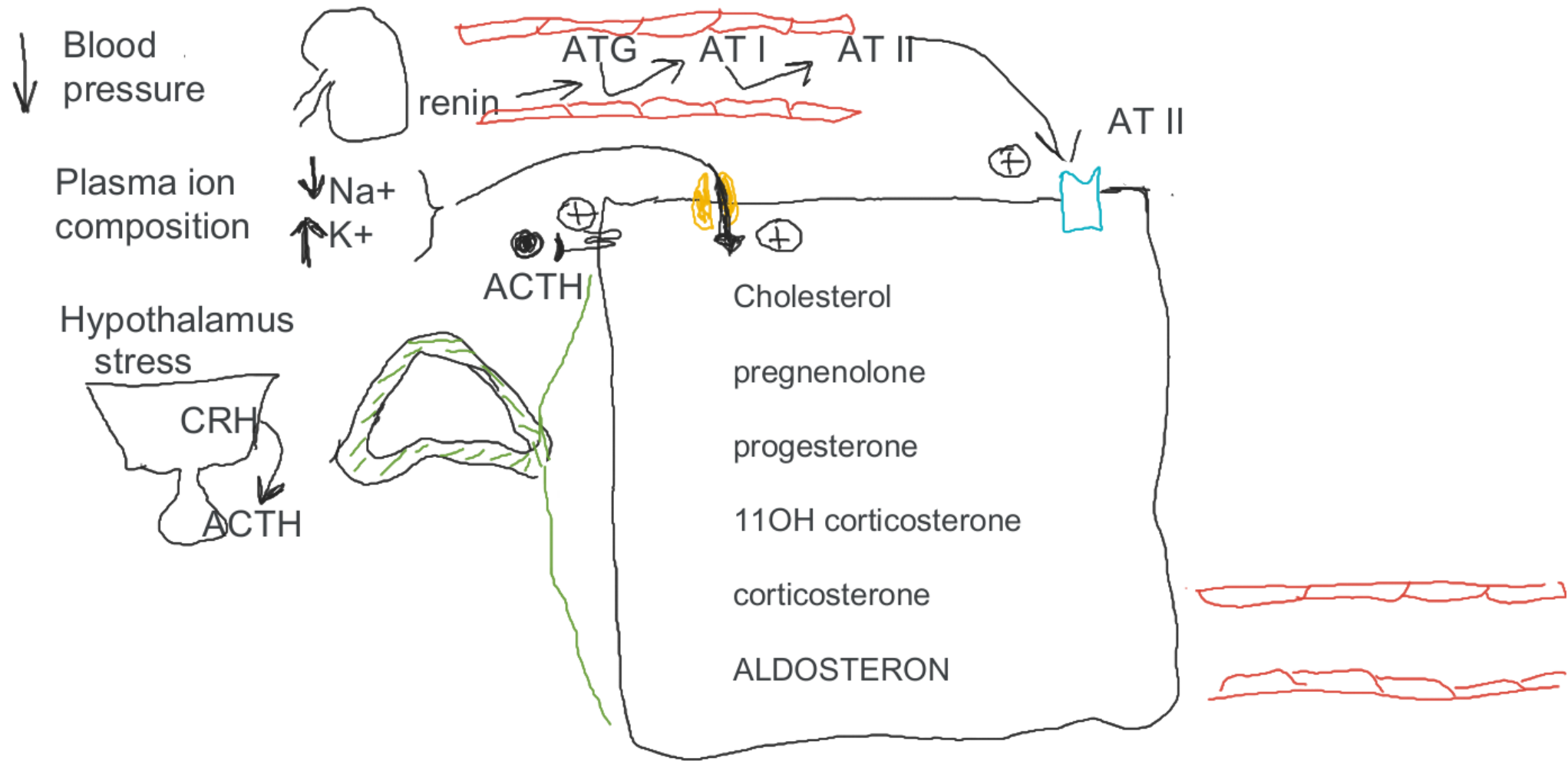


# Aldosterone - Secretion

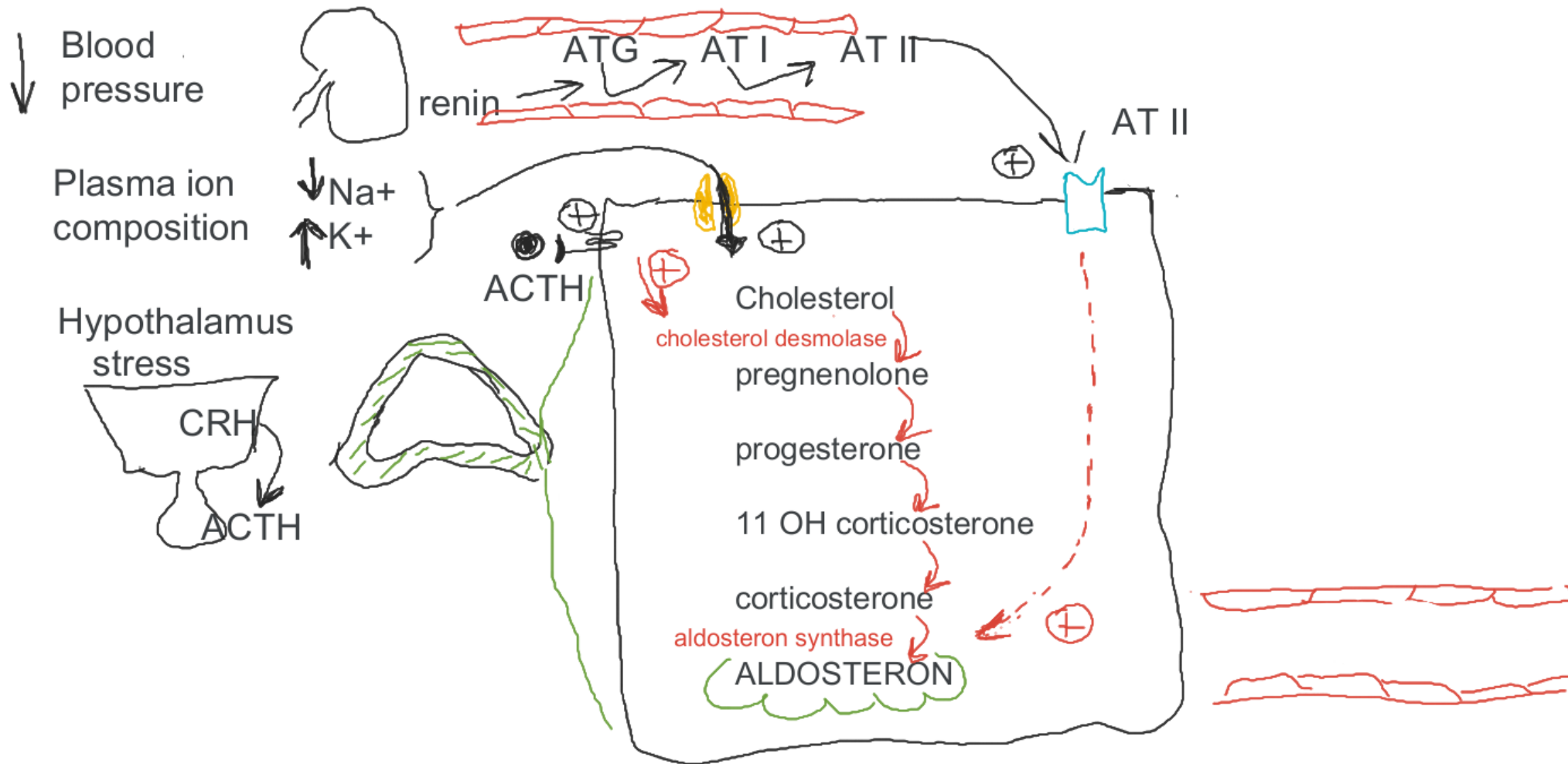




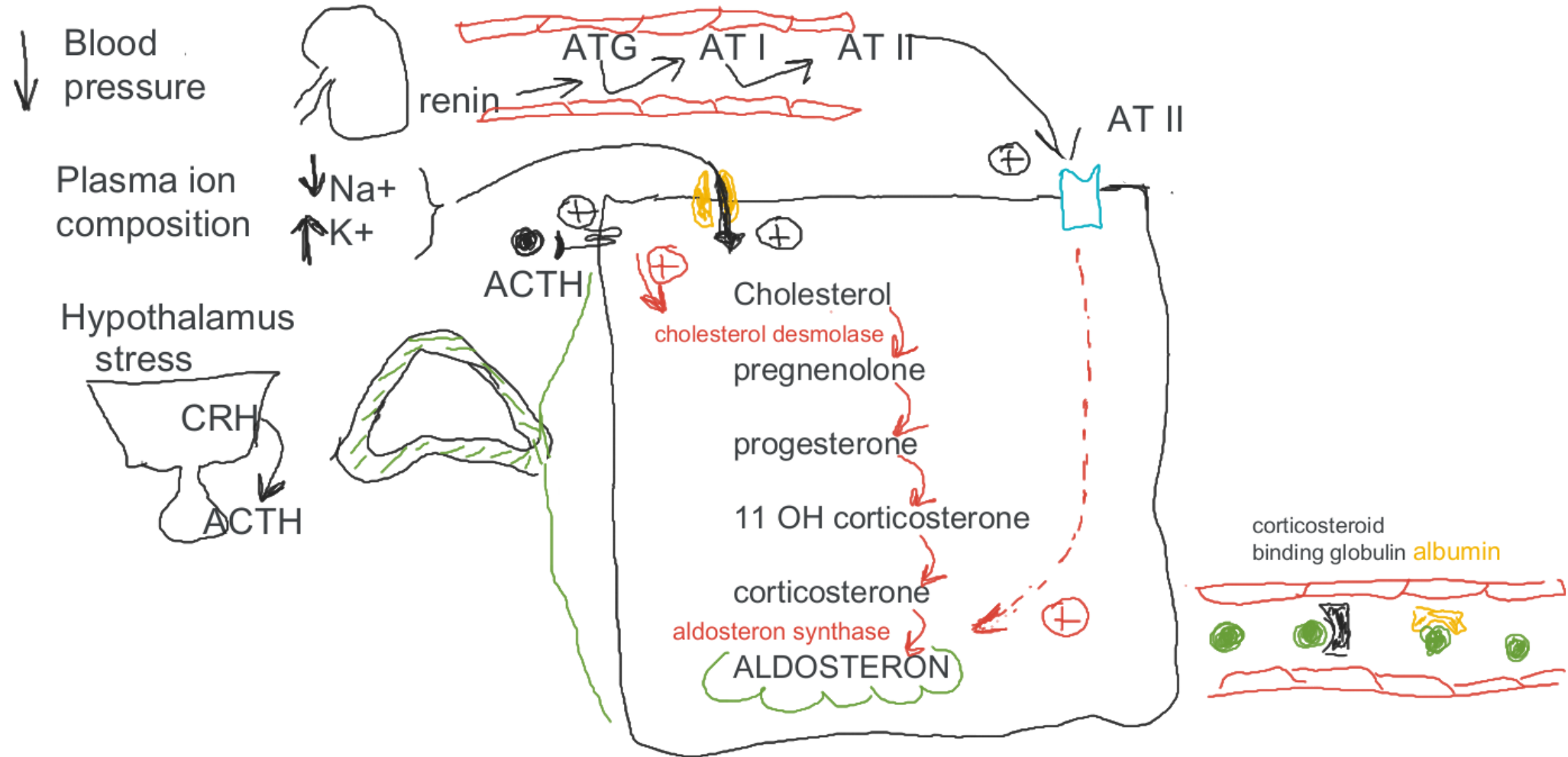
# Aldosteron - Secretion



# Aldosterone - Secretion



# Aldosterone - Secretion



# Aldosterone - Actions

EFFECT OF ALDOSTERON



# Aldosterone - Actions

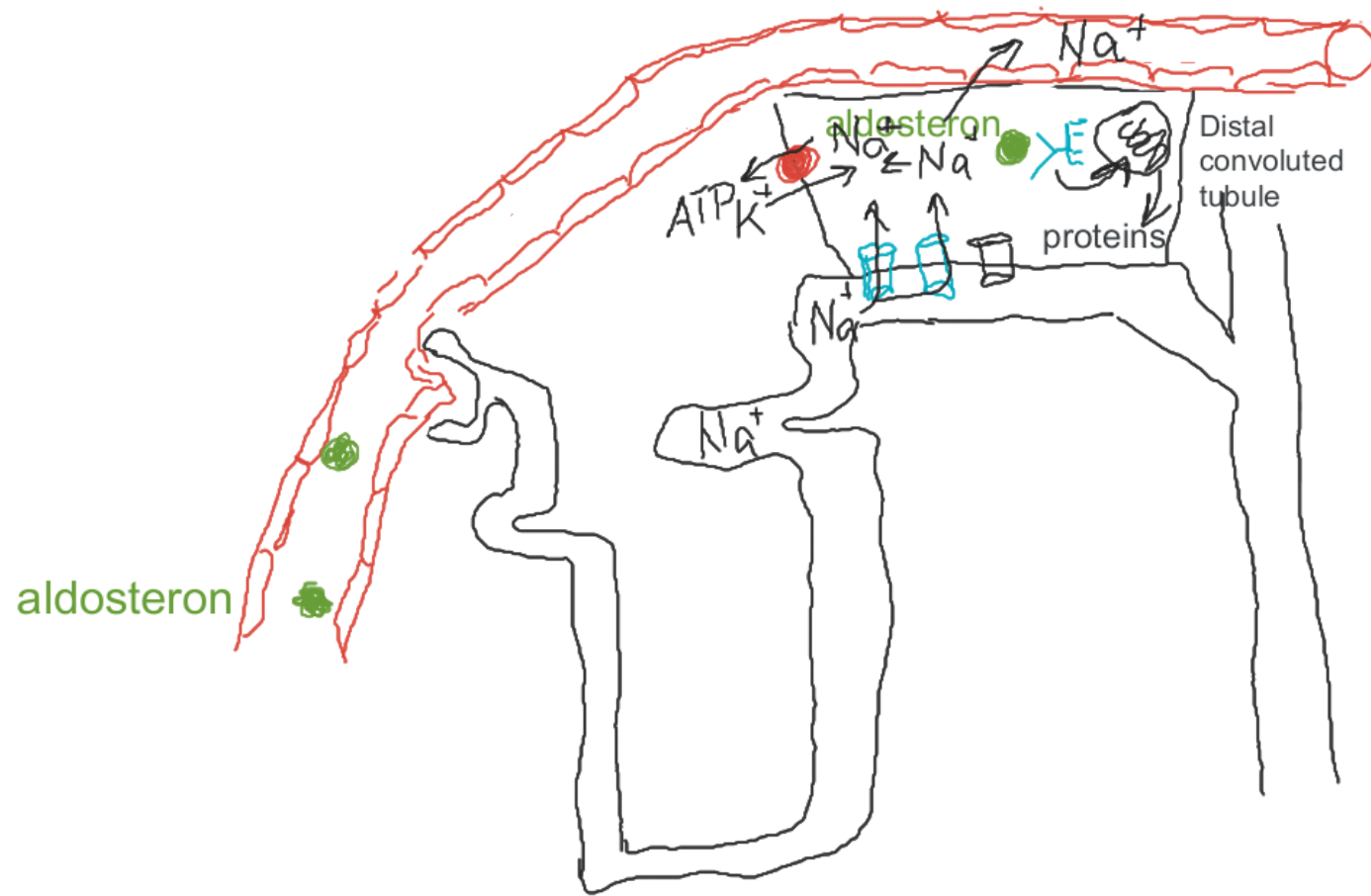


Principal cells of late distal tubule and collecting duct

# Aldosterone - Actions



# Aldosteron - Actions

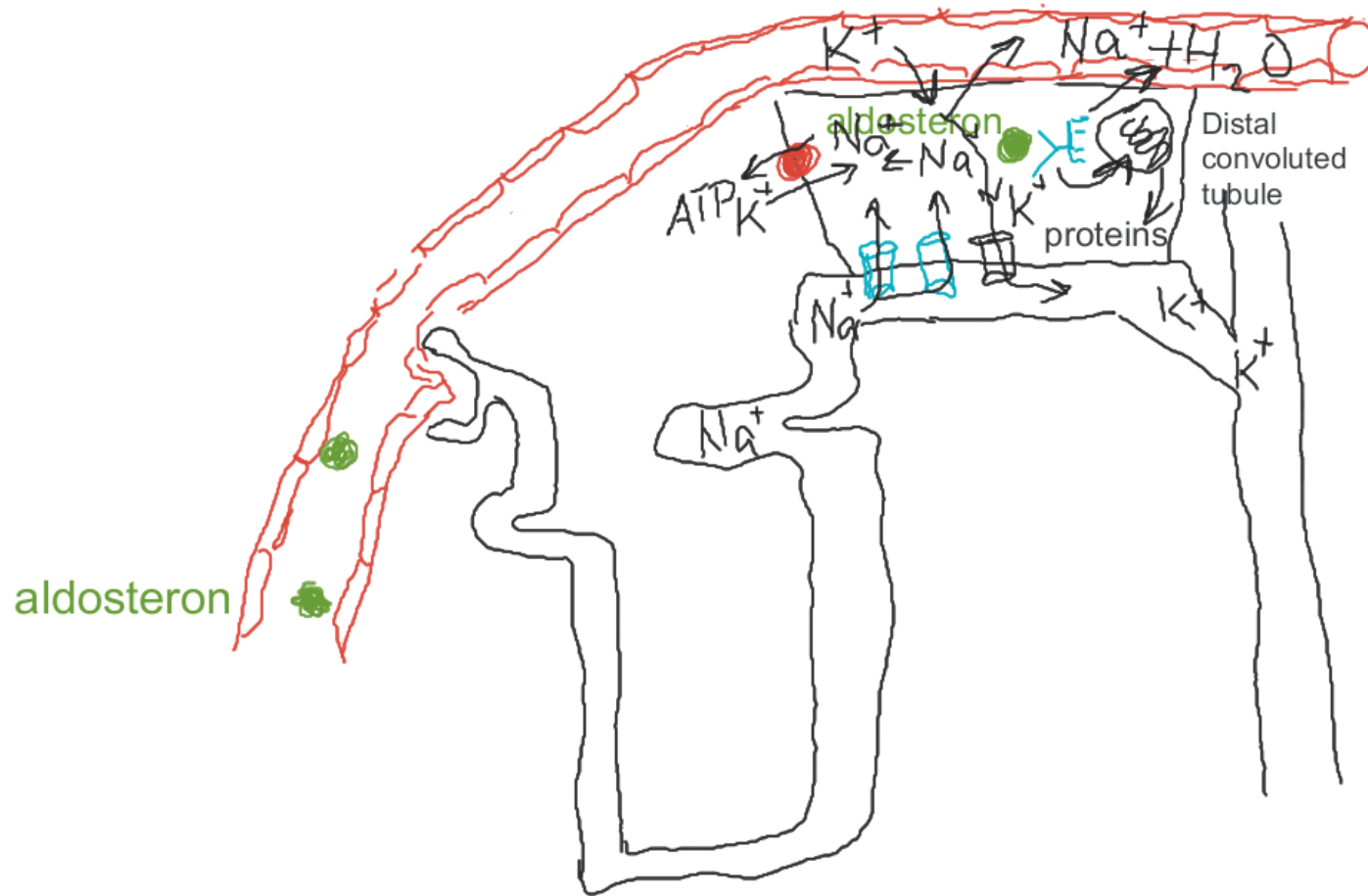


# Aldosteron - Actions



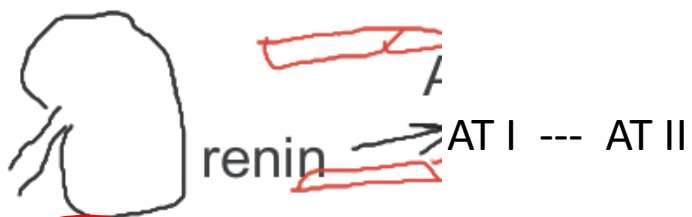


# Aldosteron - Actions



Na<sup>+</sup> reabsorption  
water reabsorption  
higher blood volume  
higher blood pressure  
K<sup>+</sup> excretion

↓ Blood pressure

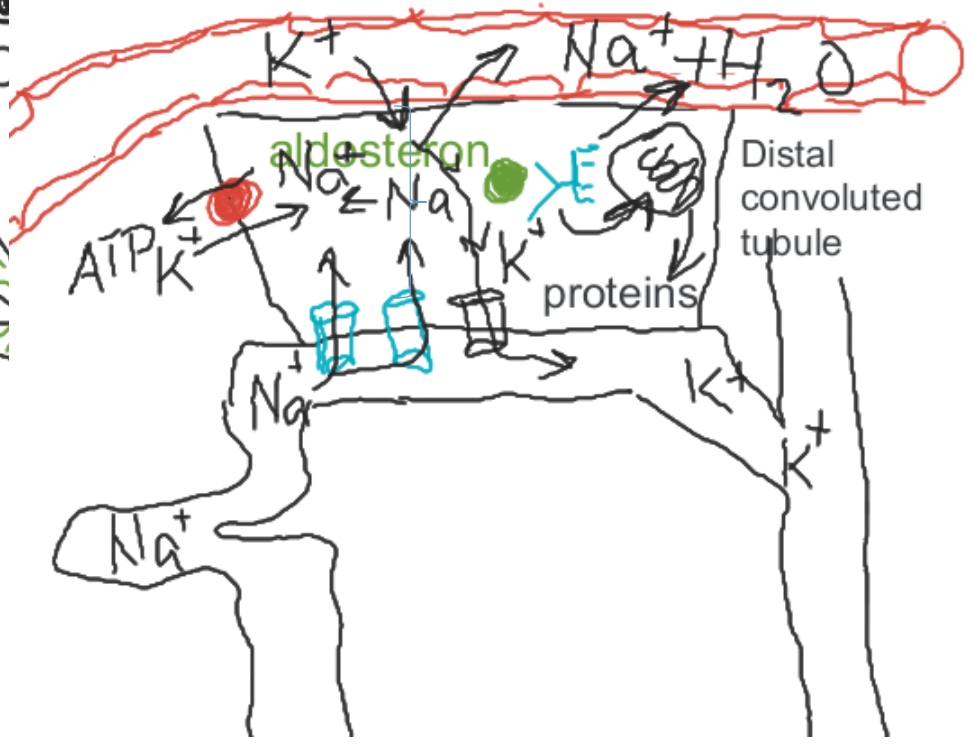
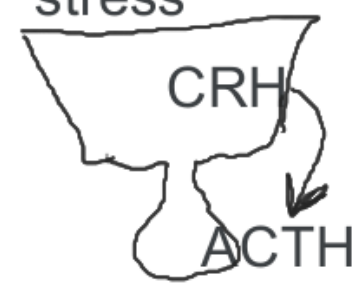


Plasma ion composition

↓ Na+  
↑ K+

aldosterone

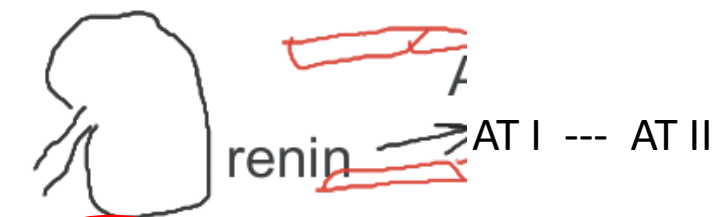
Hypothalamus stress



Na+ reabsorption  
water reabsorption  
higher blood volume  
higher blood pressure  
K+ excretion

↓  
Blood pressure  
Plasma Na+  
Plasma K+

↓ Blood pressure

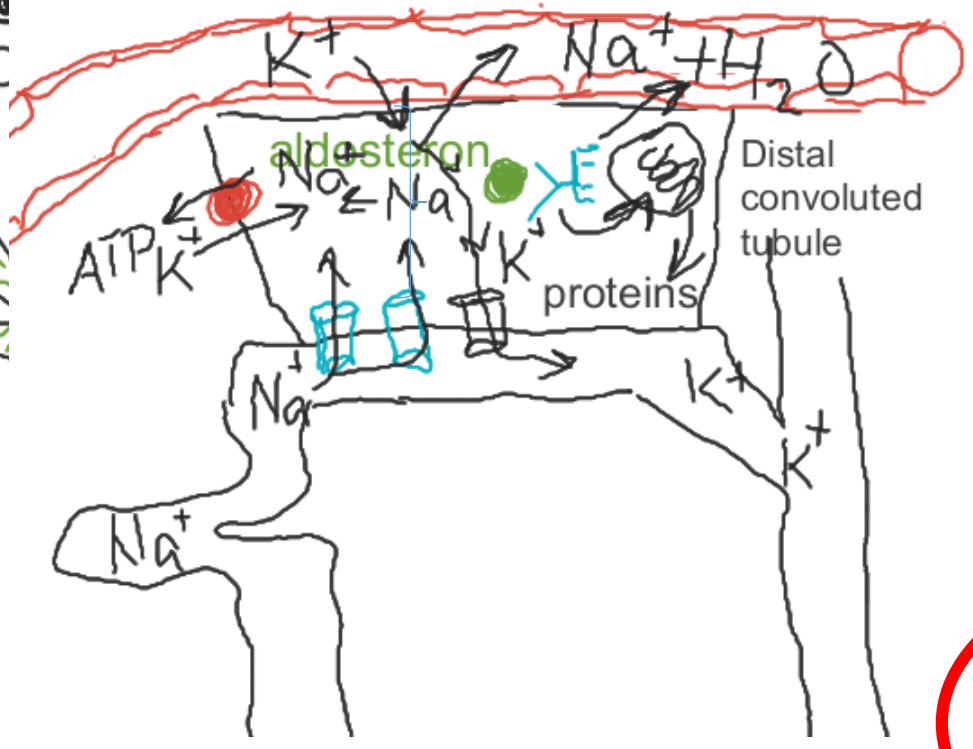
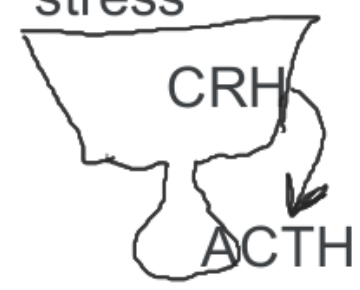


Plasma ion composition

↓ Na+  
↑ K+

aldosterone

Hypothalamus stress



Na+ reabsorption  
water reabsorption  
higher blood volume  
higher blood pressure  
K+ excretion

↓  
Blood pressure  
Plasma Na+  
Plasma K+

# Aldosterone – AB Balance

EFFECT OF ALDOSTERON

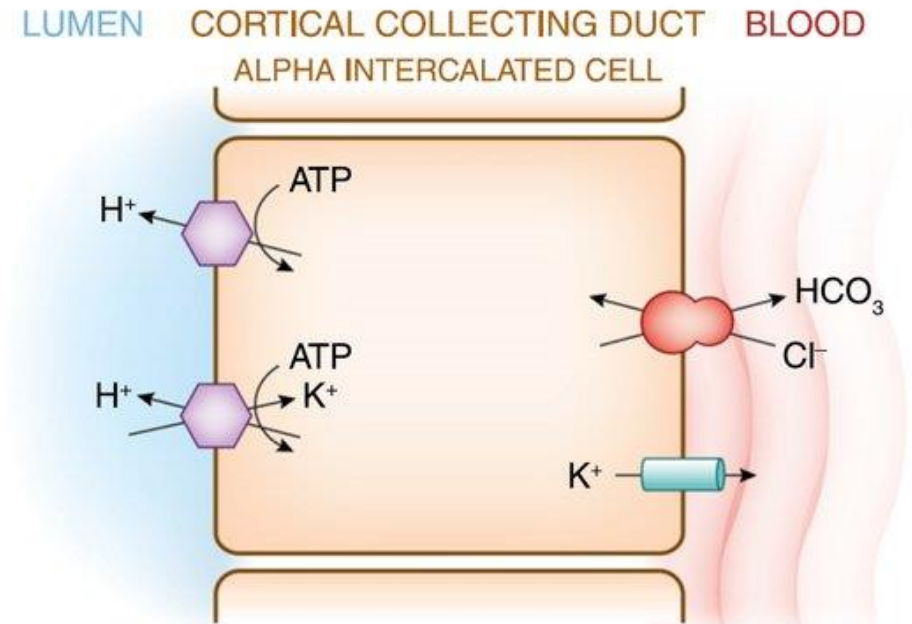


# Aldosterone – AB Balance

## EFFECT OF ALDOSTERON



Aldosterone stimulates secretion of  $H^+$  via the  $H^+/ATPase$  in the intercalated cells of the cortical collecting tubules.

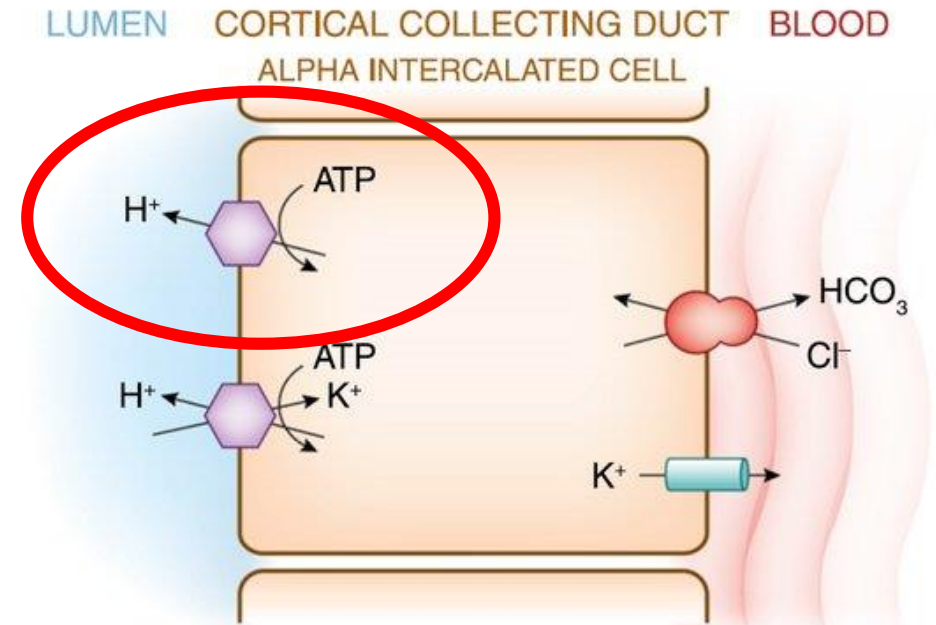


# Aldosterone – AB Balance

## EFFECT OF ALDOSTERON



Aldosterone stimulates secretion of  $H^+$  via the  $H^+/ATPase$  in the intercalated cells of the cortical collecting tubules.



# Aldosteron - Actions

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Essencial for life

## Actions of Mineralocorticoids

Increase  $\text{Na}^+$  reabsorption

Increase  $\text{K}^+$  secretion

Increase  $\text{H}^+$  secretion

# Aldosteron – AB Balance

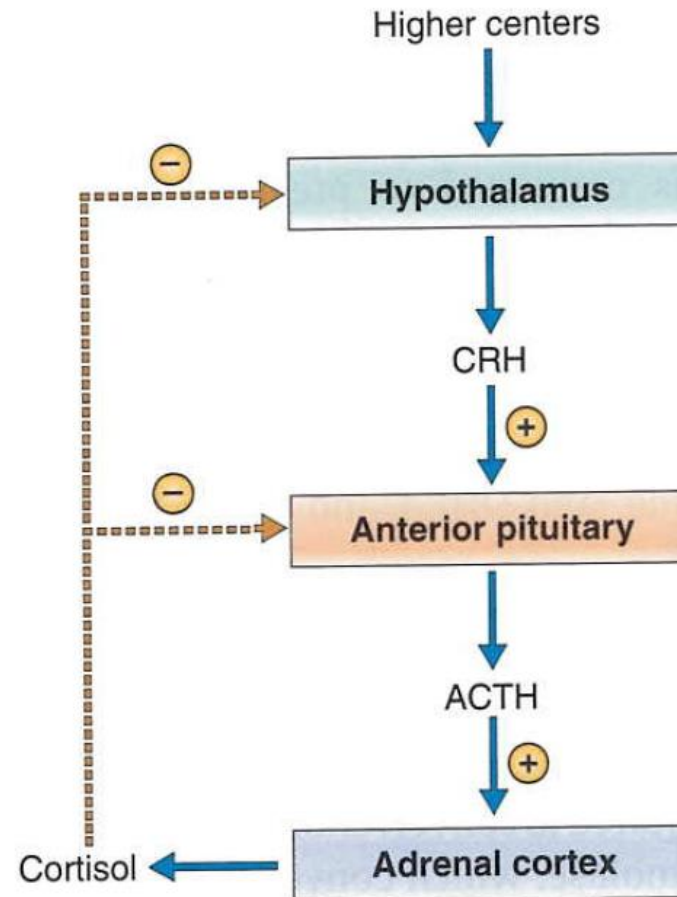
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# Glucocorticoids - Regulation

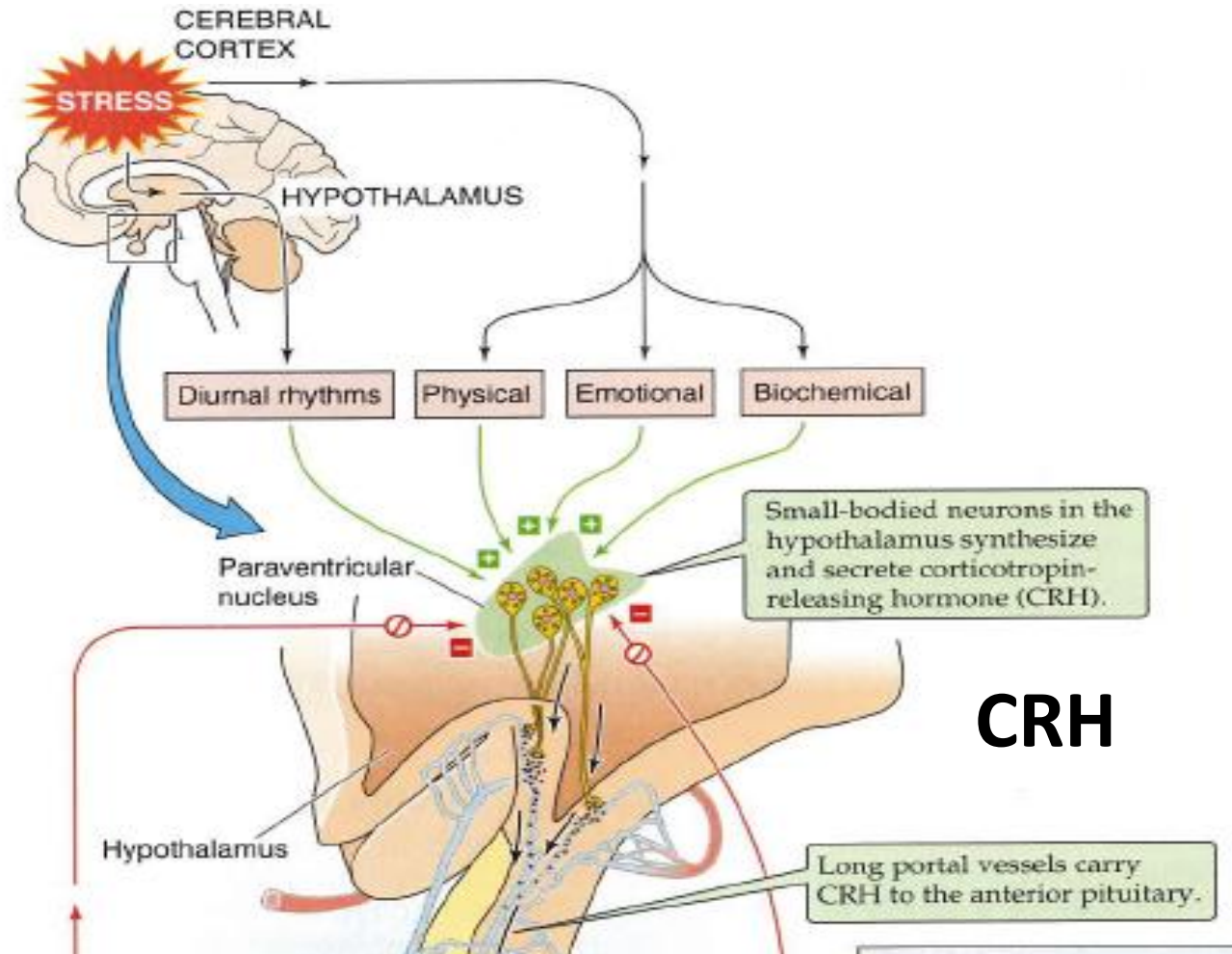
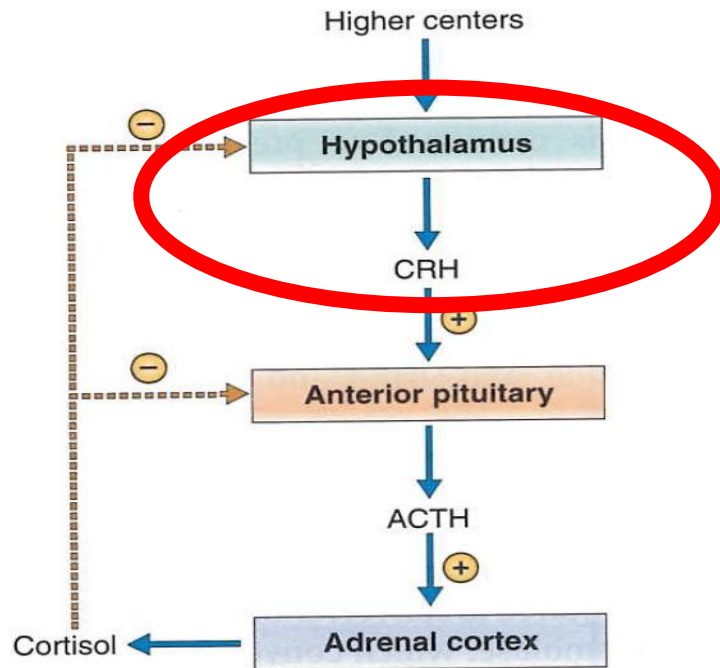
Glucocorticoids – regulation

The hypothalamic-pituitary-adrenocortical axis



# Glucocorticoids - Regulation

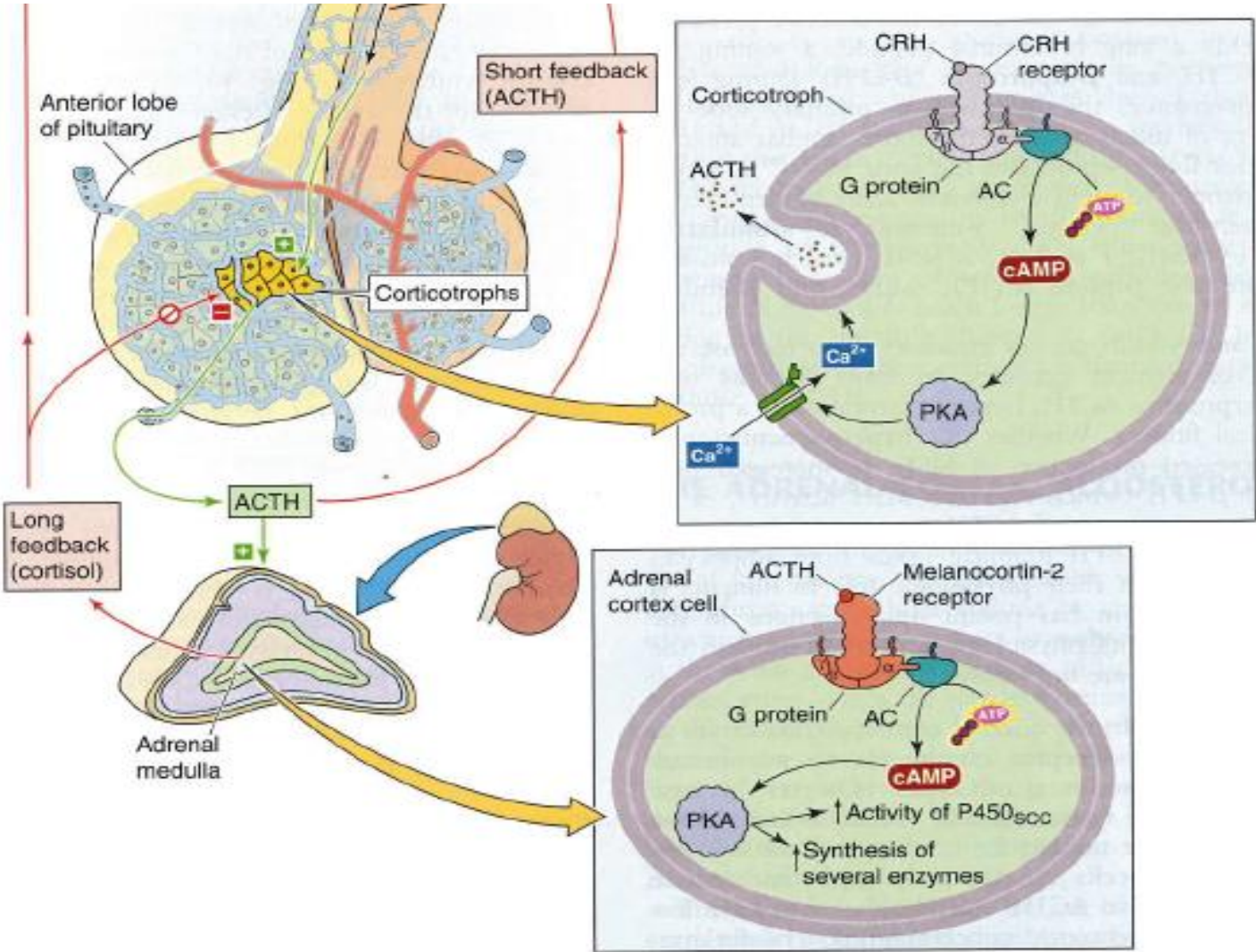
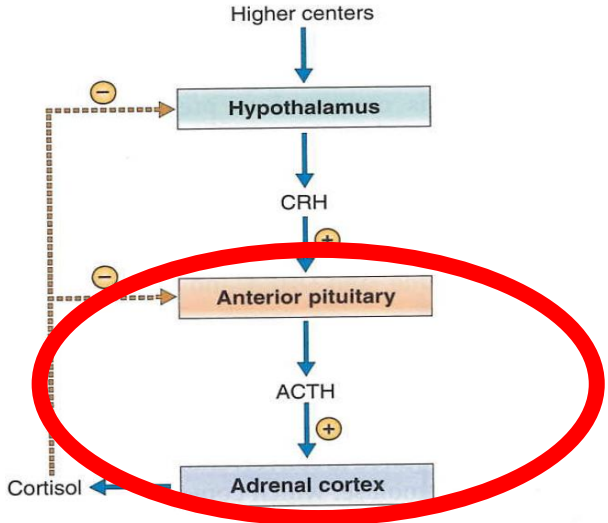
The hypothalamic-pituitary-adrenocortical axis



Boron, Boulpaep: Medical Physiology, 2003

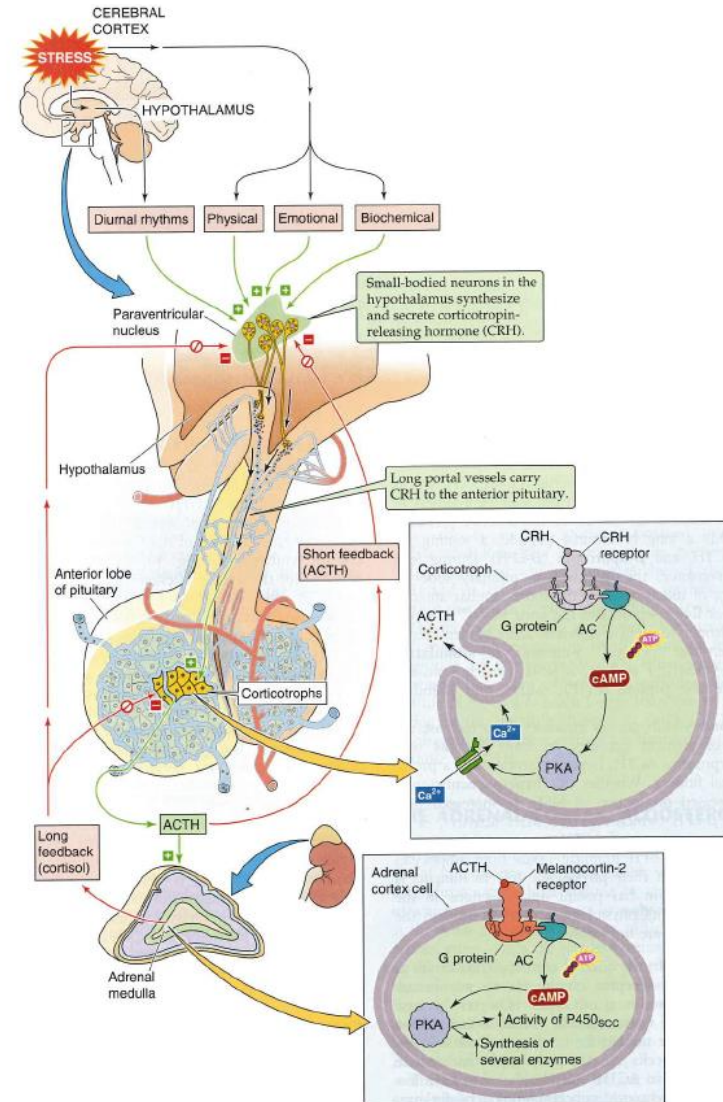
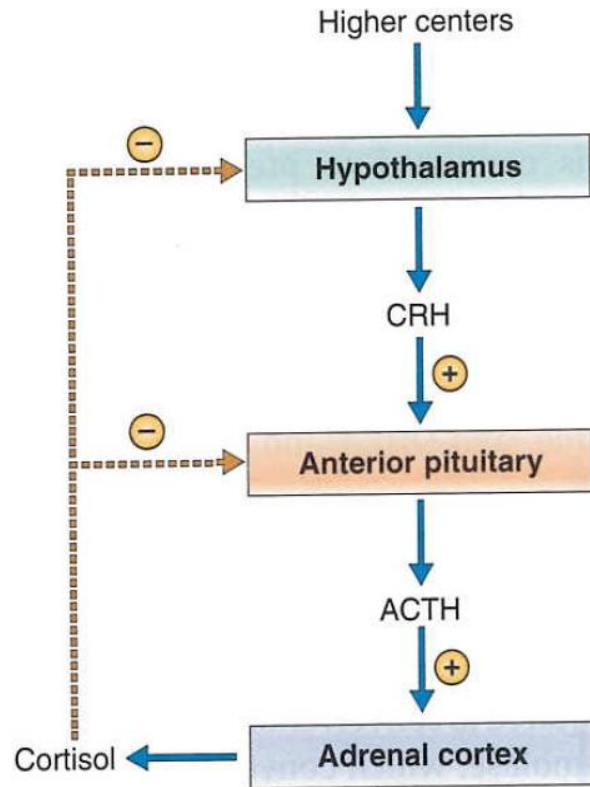
# Glucocorticoids - Regulation

The hypothalamic-pituitary-adrenocortical axis

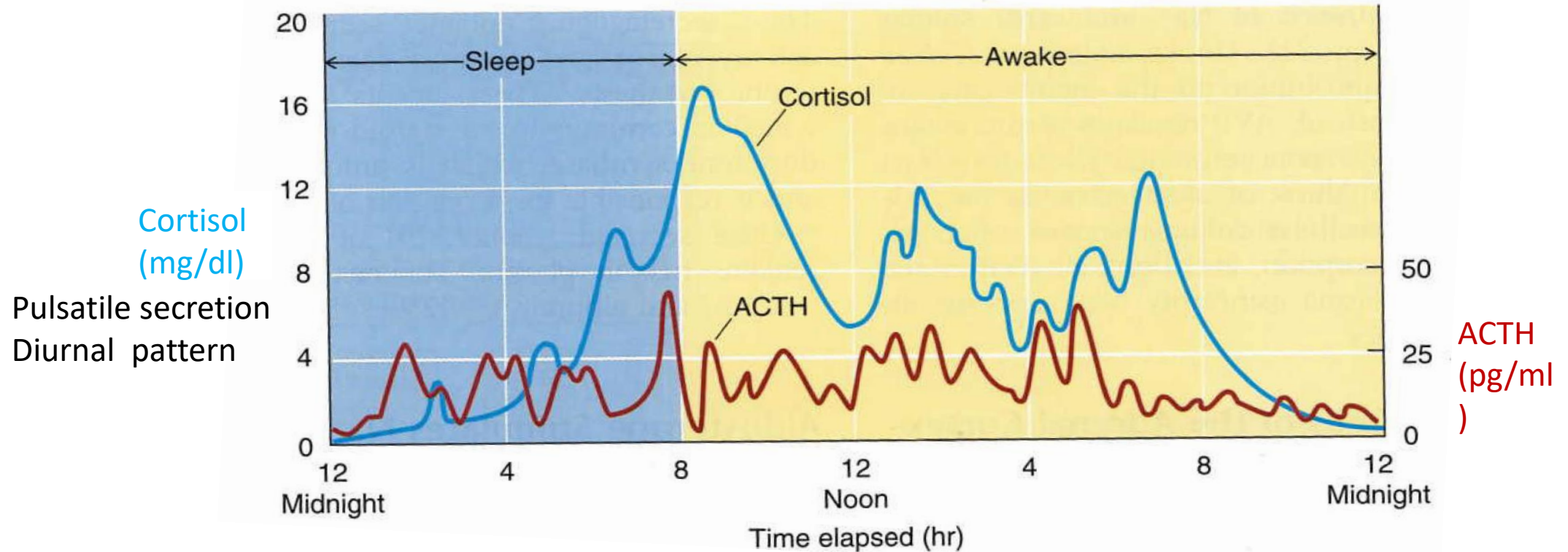


# Glucocorticoids - Regulation

Negative feedback of cortisol  
on hypothalamic-pituitary (CRH-ACTH) axis



# Glucocorticoids – Diurnal Secretion

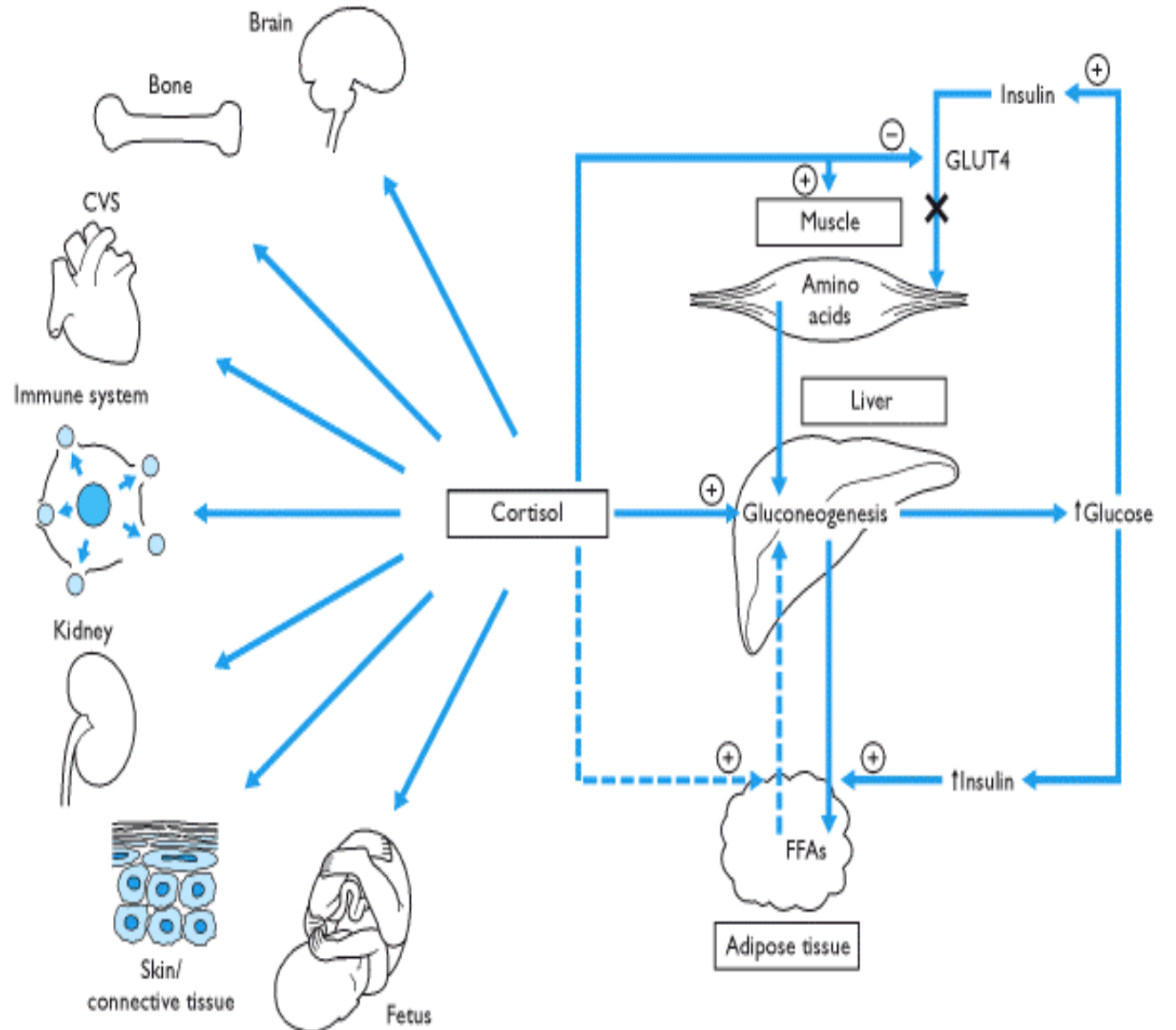


# Glucocorticoids – Actions

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# Glucocorticoids – Actions

Many Effects of Glucocorticoids



# Glucocorticoids – Actions

## Increase Blood Glucose Concentrations

Muscle – proteocatabolism - AA

Adipose tissue – lipolysis – glycerol (FFA)

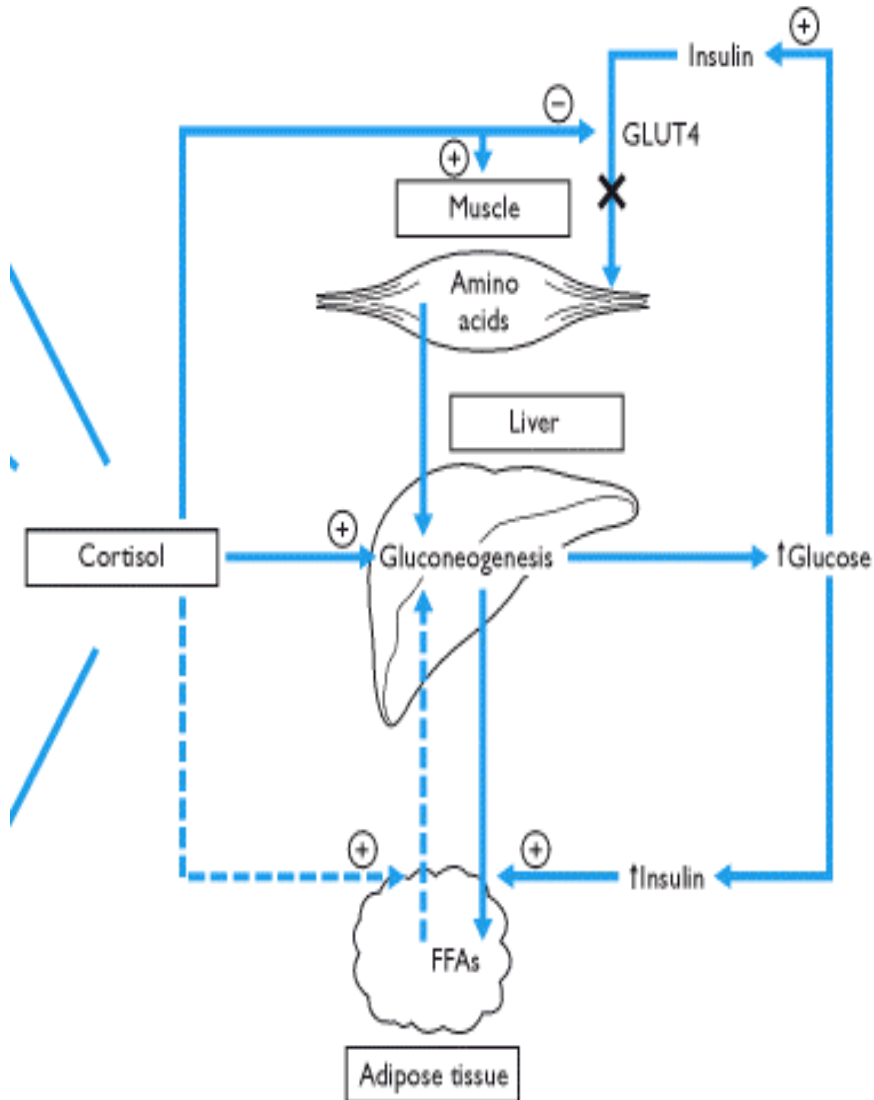
Liver – gluconeogenesis

Cortisol - Decreases insulin sensitivity

**SURVIVAL DURING FASTING**

**HYPOCORTISOLISM (Addison disease)**

**HYPER (Cushing syndrome) -**





# Glucocorticoids – Actions

## Increase Blood Glucose Concentrations

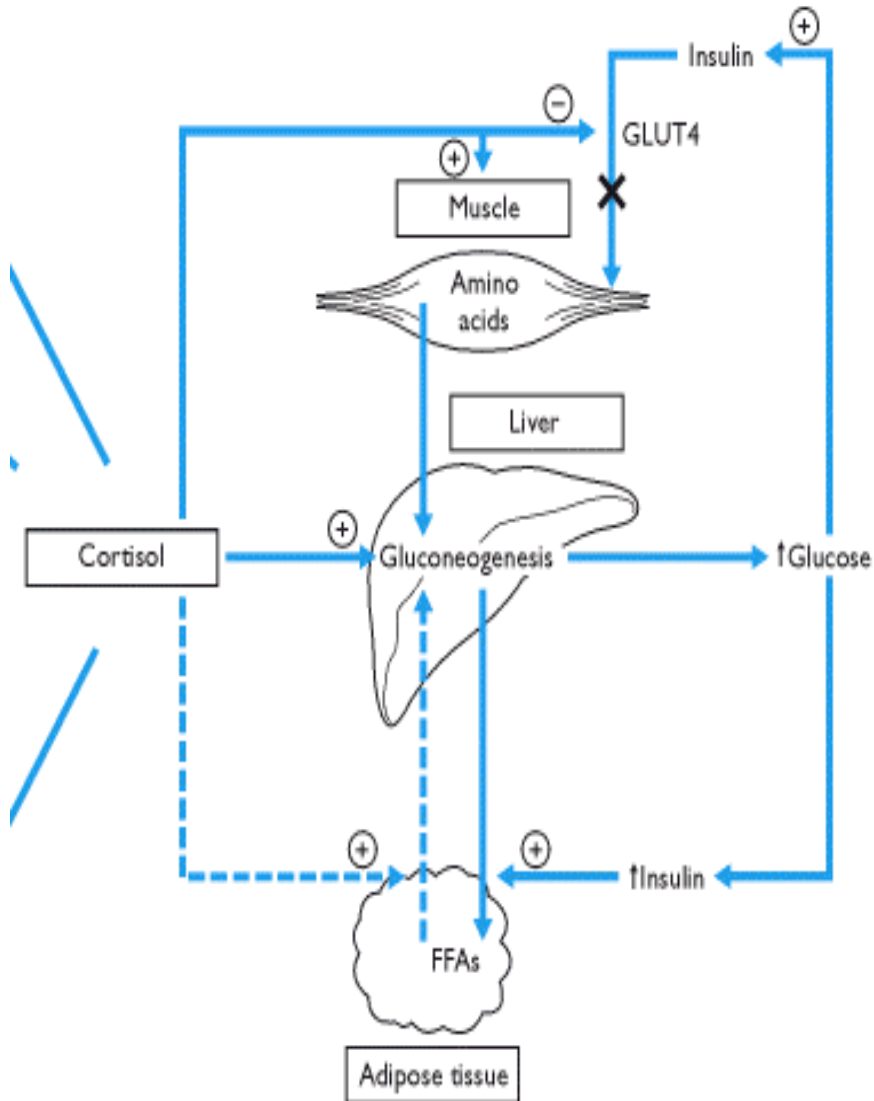
Muscle – proteocatabolism - AA  
Adipose tissue – lipolysis – glycerol (FFA)  
Liver – gluconeogenesis

Cortisol - Decreases insulin sensitivity

SURVIVAL DURING FASTING

HYPOCORTISOLISM (Addison disease) – Glycemia???

HYPER (Cushing syndrome) -



# Glucocorticoids – Actions

## Increase Blood Glucose Concentrations

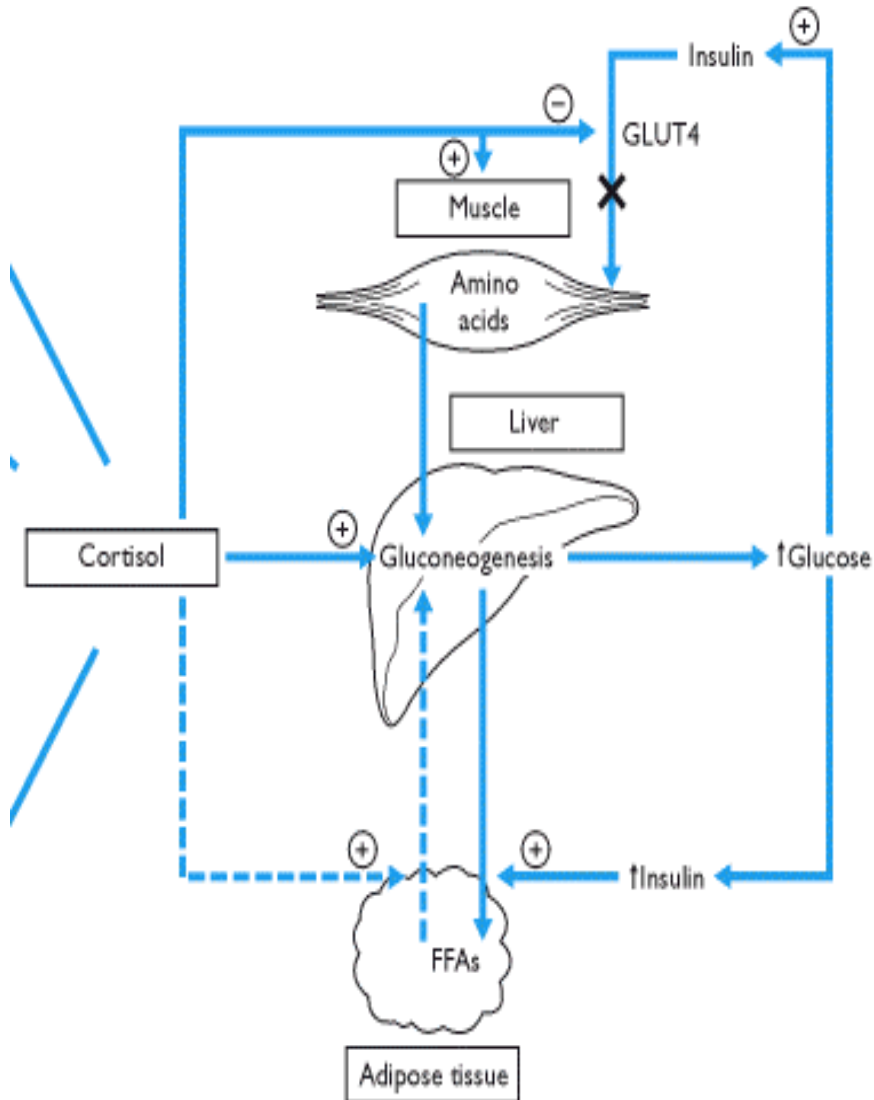
Muscle – proteocatabolism - AA  
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Cortisol - Decreases insulin sensitivity

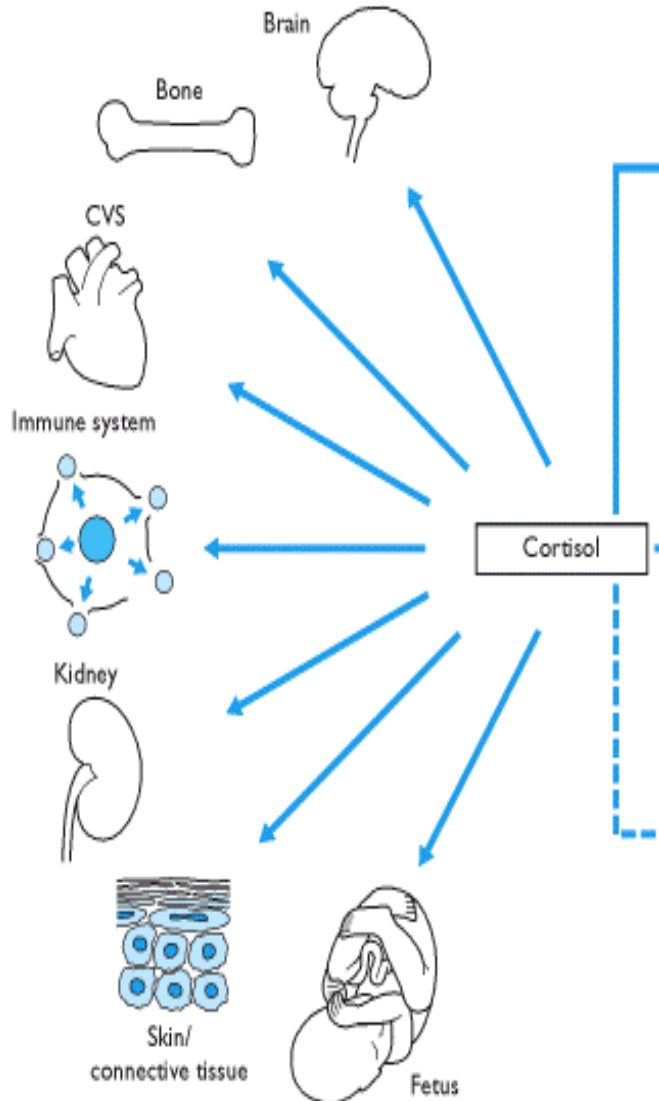
SURVIVAL DURING FASTING

HYPOCORTISOLISM (Addison disease) – HYPOGLYCEMIA

HYPER (Cushing syndrome) - HYPERGLYCEMIA



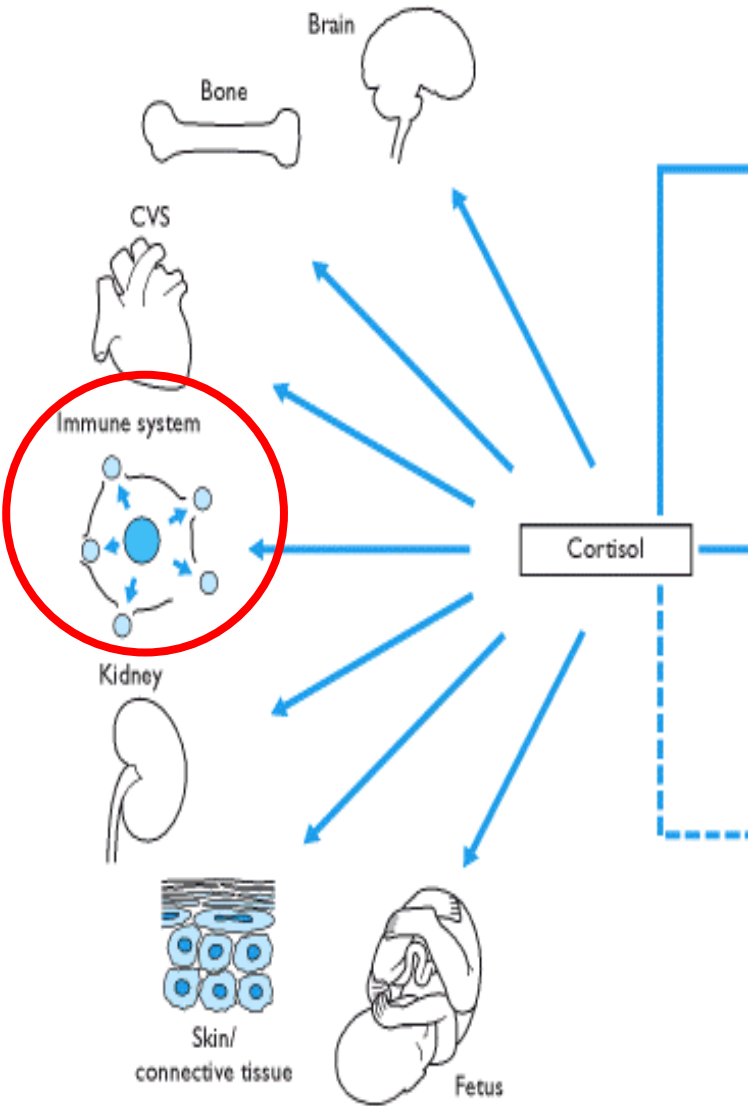
# Glucocorticoids – Actions



- **Anti-inflammatory effects**

- 1. Cortisol induces the synthesis of LIPOCORTIN – inhibit synthesis of prostaglandins and leukotriens
- 2. Cortisol inhibits the production of IL-2.
- 3. Cortisol inhibits the release of histamin and serotonin from mast cells and platelets

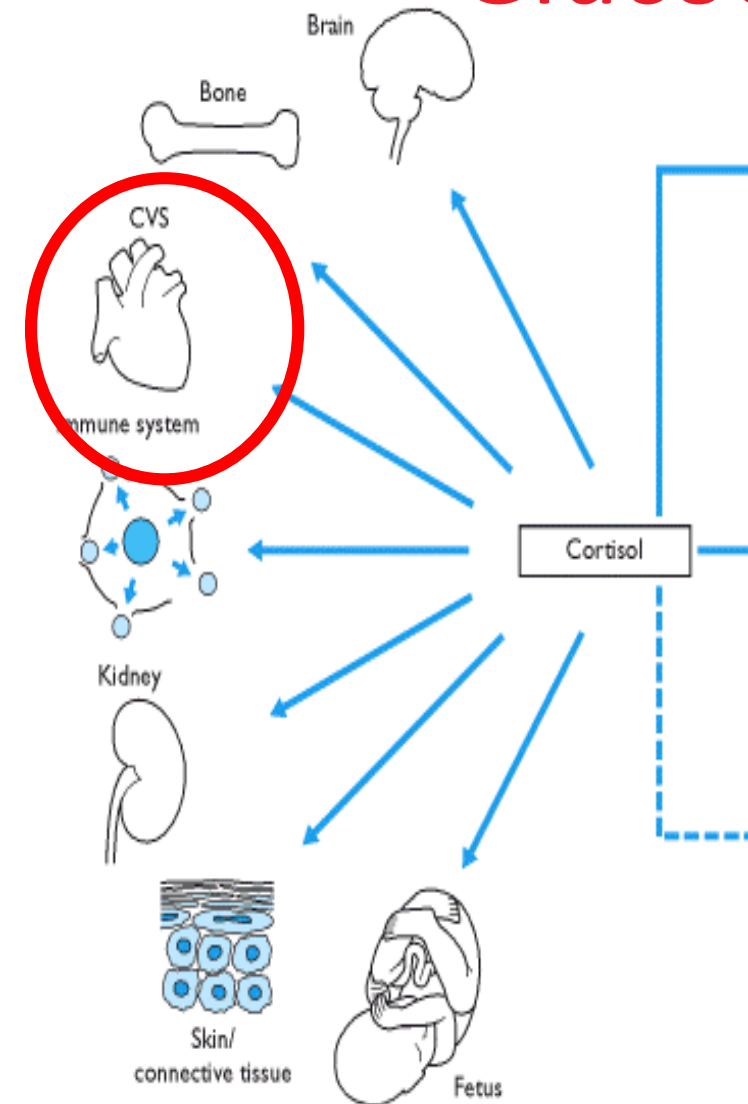
# Glucocorticoids – Actions



- **Supression of immune response**

- glucorticocoids reduce the number of circulating thymus derived lymphocytes (T- cells) and as a result the recruitment of B lymphocytes.
- They also affect the numbers and functions of circulating neutrophils, eosinophils and fibroblasts
- The net result is to reduce both cellular and humoral immunity.

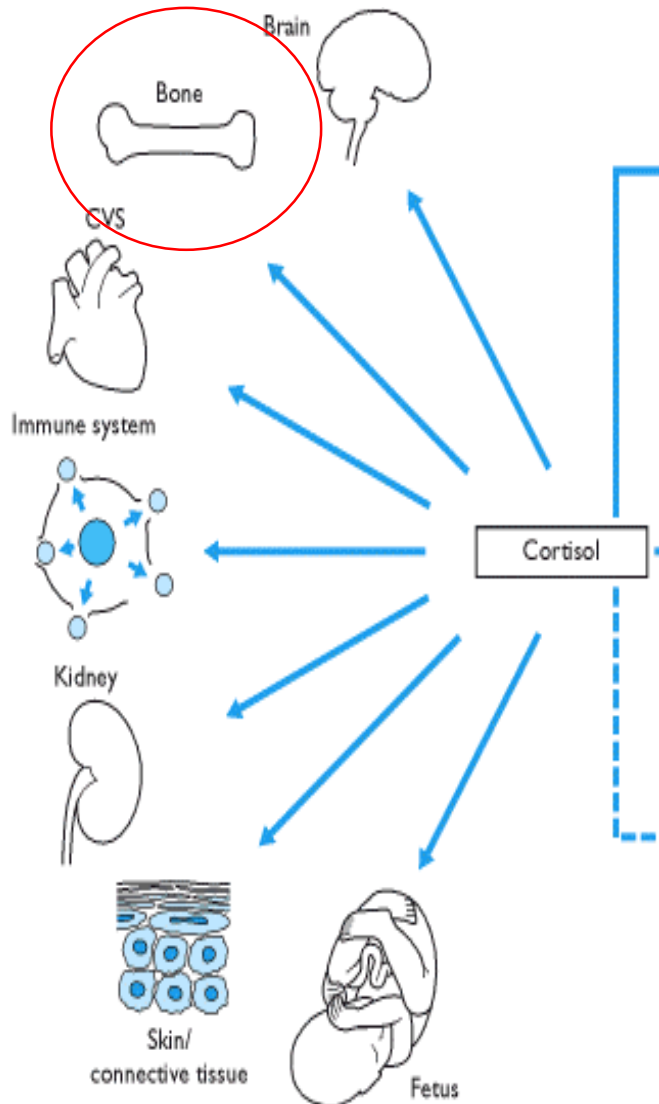
# Glucocorticoids – Actions



## Maintenance of vascular responsiveness to catecholamines

- **In the cardiovascular system**, it is required for sustaining normal blood pressure by maintaining normal myocardial function and the **responsiveness of arterioles to catecholamines** and angiotensin II.

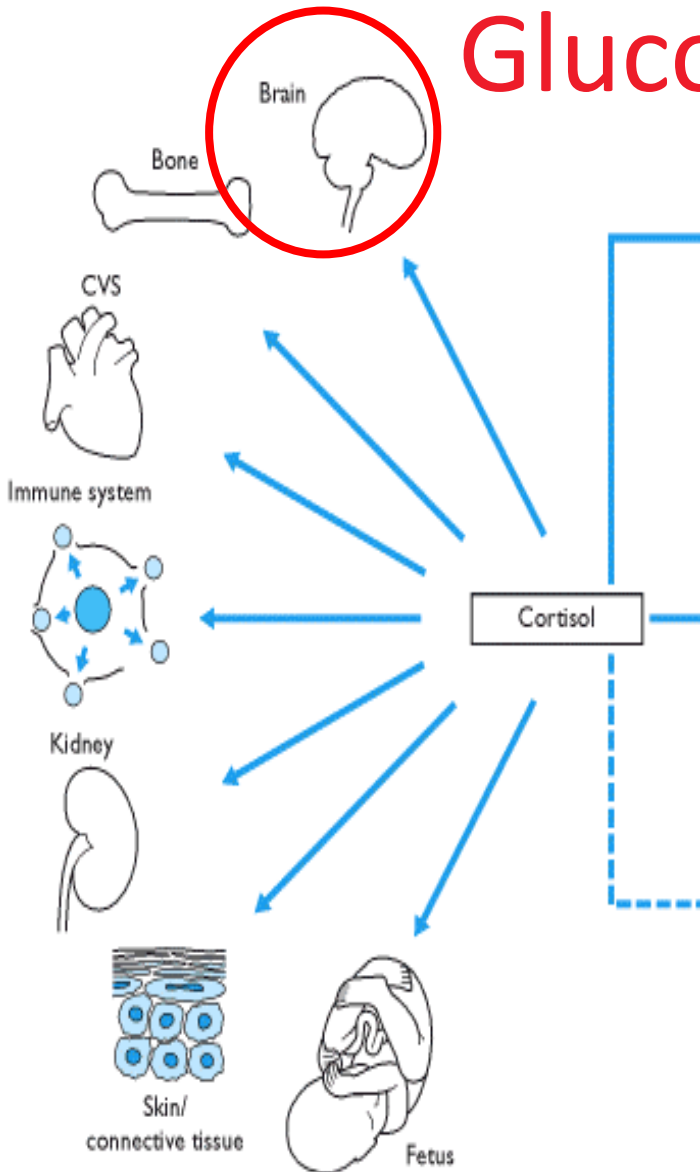
# Glucocorticoids – Actions



- **Inhibition of bone formation**

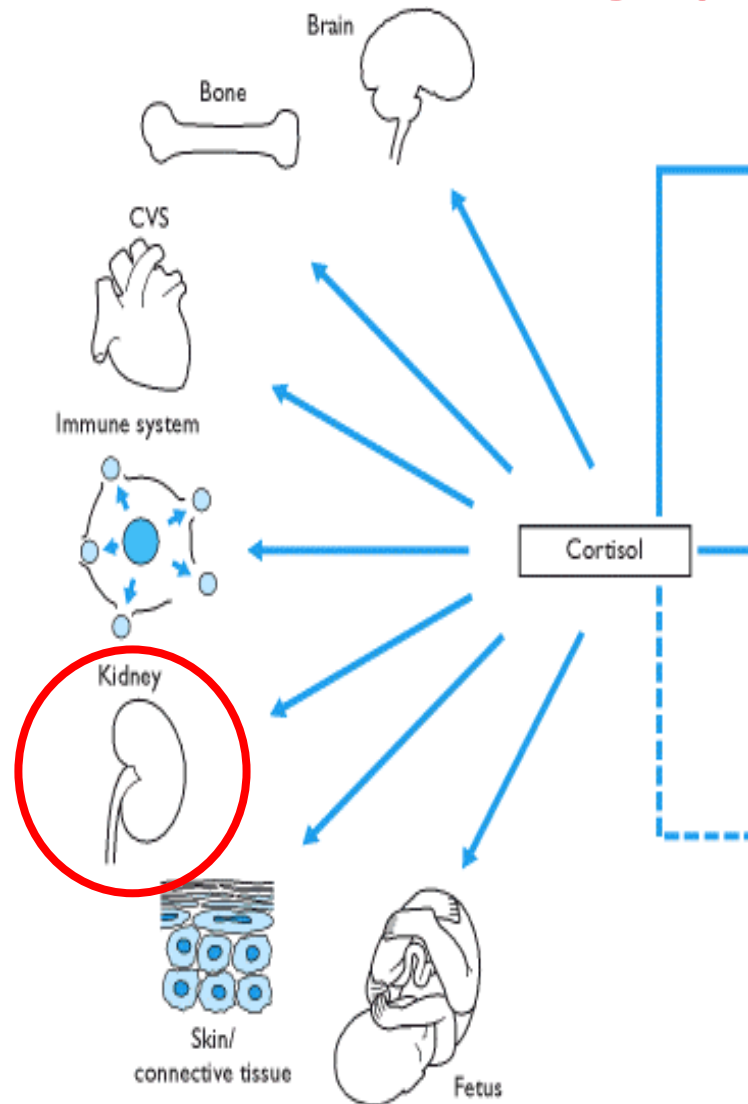
- Cortisol decreases osteoblast function and decreases new bone formation; decrease synthesis of type I collagen.
- Furthermore, glucocorticoids decrease gut calcium absorption thus adversely affecting calcium balance.

# Glucocorticoids – Actions



- In the **CNS**, cortisol can alter the excitability of neurons, induce neuronal death (particularly in the hippocampus) and **can affect the mood and behavior** of individuals.
- **Depression** may be a feature of glucocorticoid therapy.

# Glucocorticoids – Actions

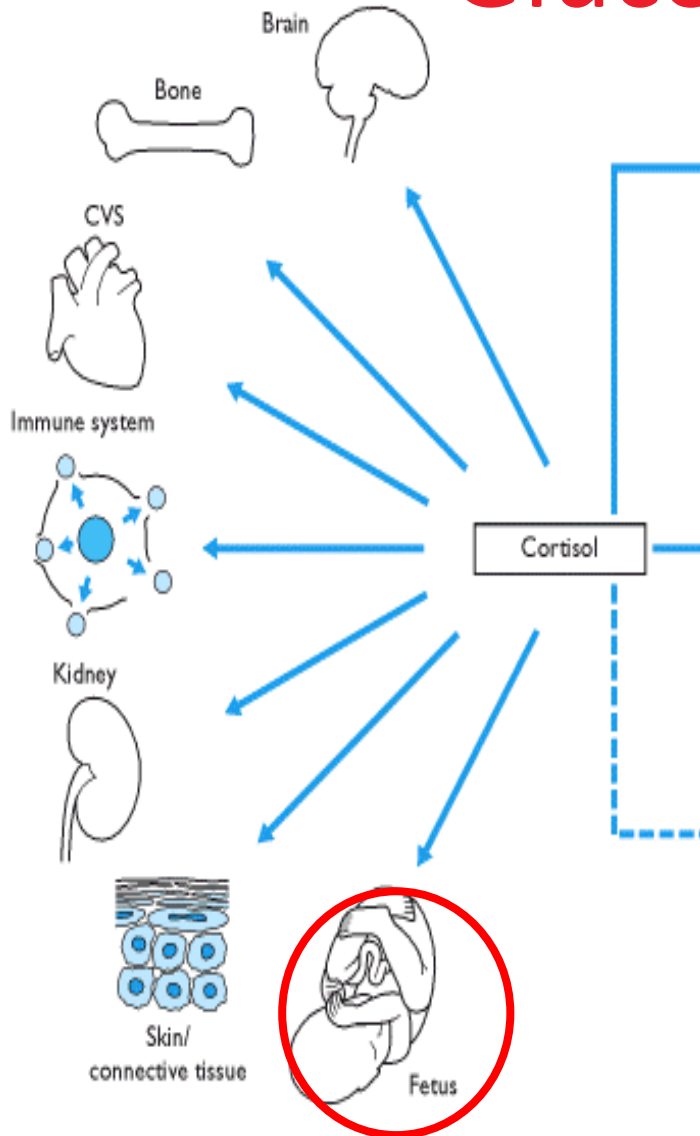


## Increases in glomerular filtration rate

- **In the kidney, cortisol increases glomerular filtration rate** by increasing glomerular blood flow and increases phosphate excretion by decreasing its reabsorption in the proximal tubules.
- **In excess, cortisol has aldosterone-like effects in the kidney causing salt and water retention.**



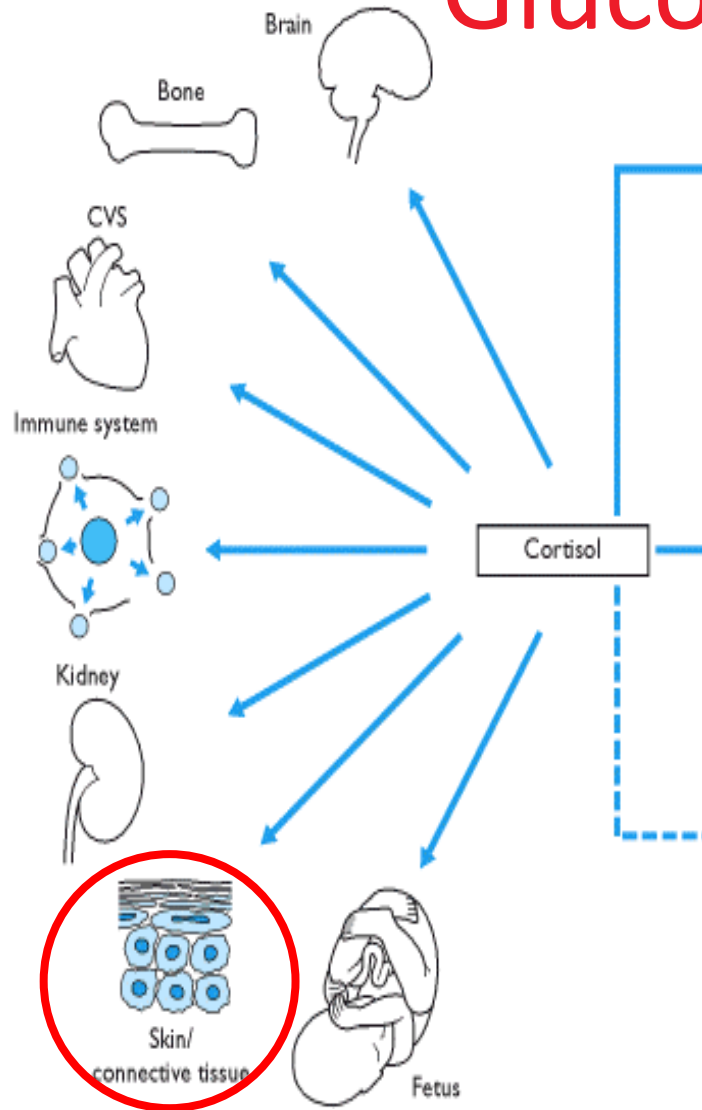
# Glucocorticoids – Actions



## Fetal maturation

- Cortisol also facilitates **fetal maturation** of the central nervous system, retina, skin, gastrointestinal tract and lungs.
- It is particularly important in the **synthesis of alveolar surfactant** which occurs during the last weeks of gestation.

# Glucocorticoids – Actions



- Skin and connective tissue - proteolysis

total oral or intravenous administration

## Glucocorticoids in therapy

When prescribed in certain doses, corticosteroids help **reduce inflammation**. This can ease symptoms of inflammatory conditions, such as arthritis, asthma and skin rashes. rheumatoid arthritis, inflammatory bowel disease (IBD), allergies and many other conditions.

Corticosteroids also **suppress the immune system**. This can help control conditions in which the immune system mistakenly attacks its own tissues. They also are used to prevent organ rejection in transplant recipients.



# Glucocorticoids in Therapy

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Endocrinology - replacement therapy

Respiratory system – asthma – inhalation



Cancer therapy – immunosuppression – lympholytic effect, inhibition of proliferation

Musculoskeletal therapy – rheumatology

Ophthalmology - eye drops

ORL - nasal drops - allergic rhinitis

Dermatology - topical corticosteroids

Immune system



# CUSHING Syndrome

## Side Effects of Corticosteroid Therapy

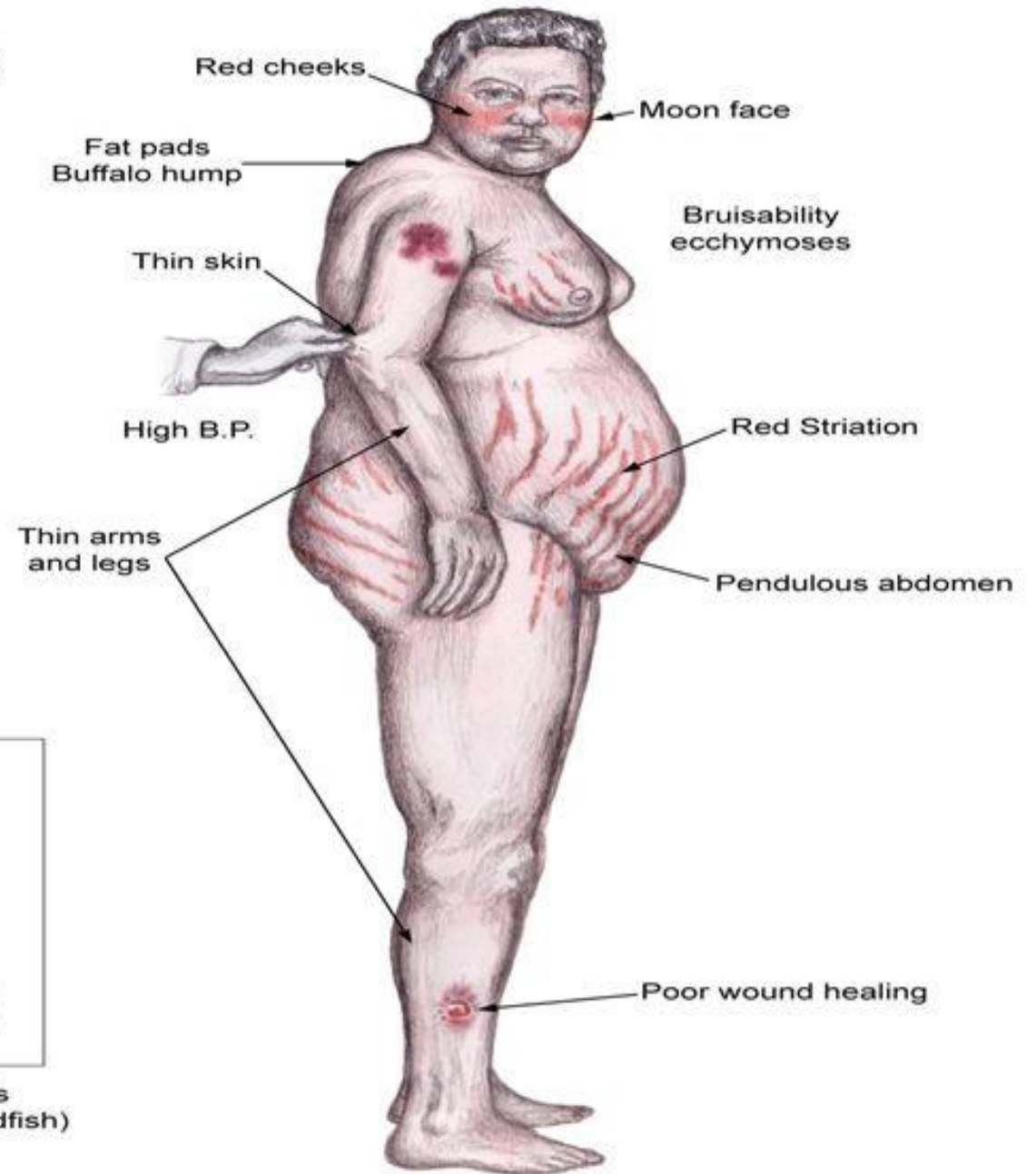


### Background

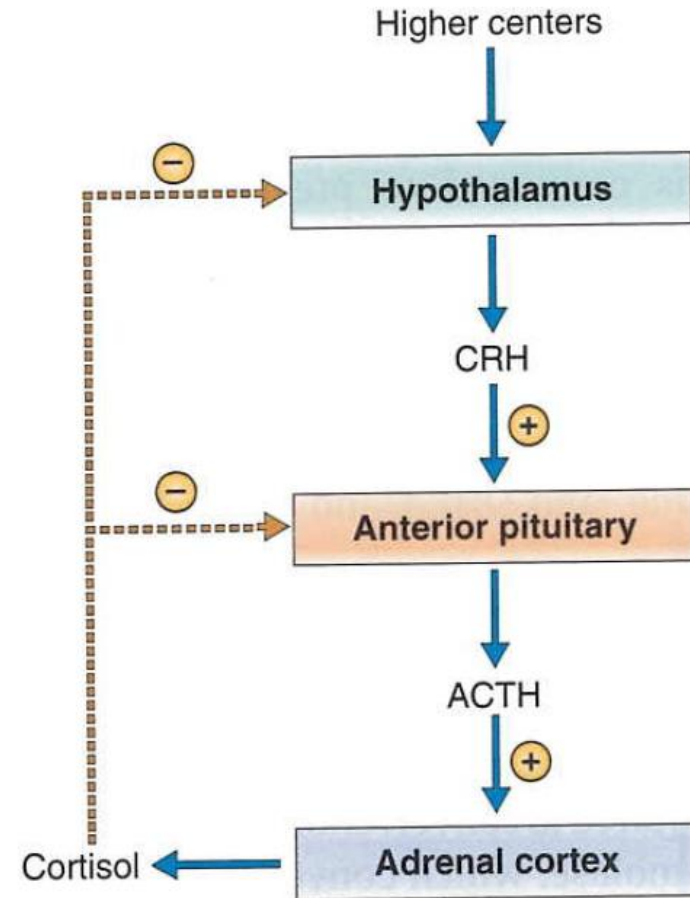
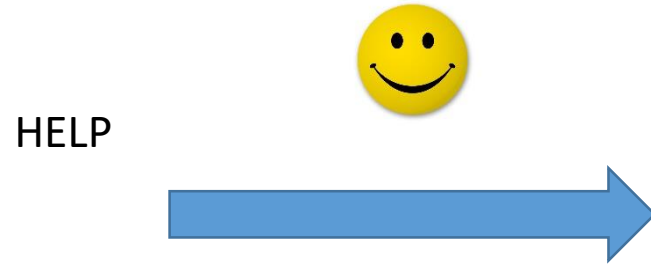
Cushing syndrome is caused by prolonged exposure to elevated levels of either endogenous glucocorticoids or exogenous glucocorticoids



Osteoporosis compressed (codfish) vertebrae



Why the glucocorticoid therapy must not be suddenly interrupted?

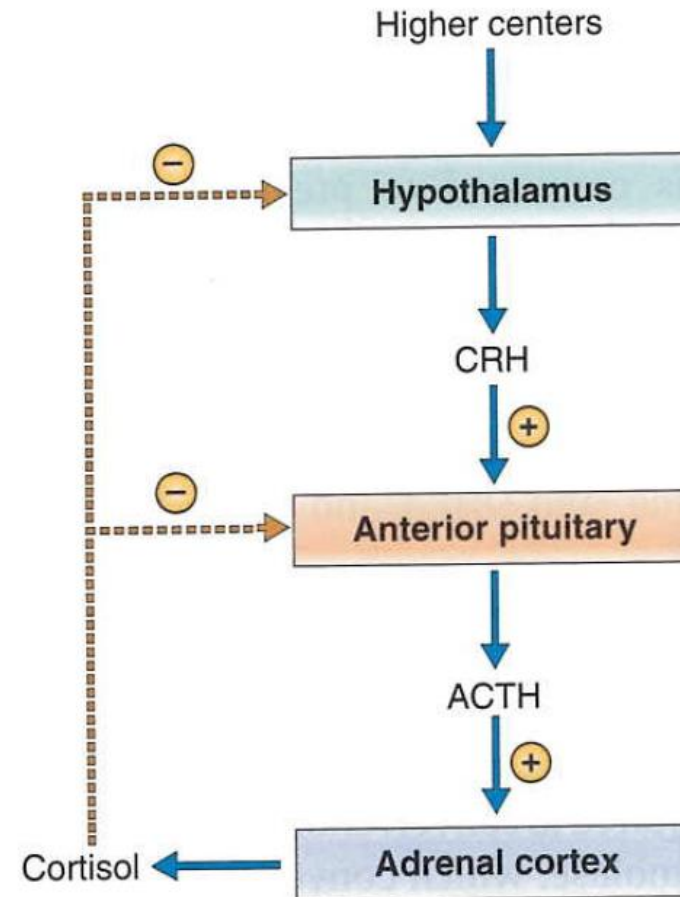


Why the glucocorticoid therapy must not be suddenly interrupted?

### Negative feedback

Glucocorticoid drugs (similarly as cortisol itself) inhibit hypothalamic CRH and pituitary ACTH. Tapering must be done carefully to avoid **possible cortisol deficiency** resulting from hypothalamic-pituitary-adrenal axis (HPA) suppression during the period of steroid therapy.

sudden withdrawal - **possible cortisol deficiency**



## Function of the Adrenal Medullae

Stimulation of the sympathetic nerves to adrenal medullae – epinephrine and norepinephrine released into circulating blood  
epinephrine 80% and norepinephrine 20%

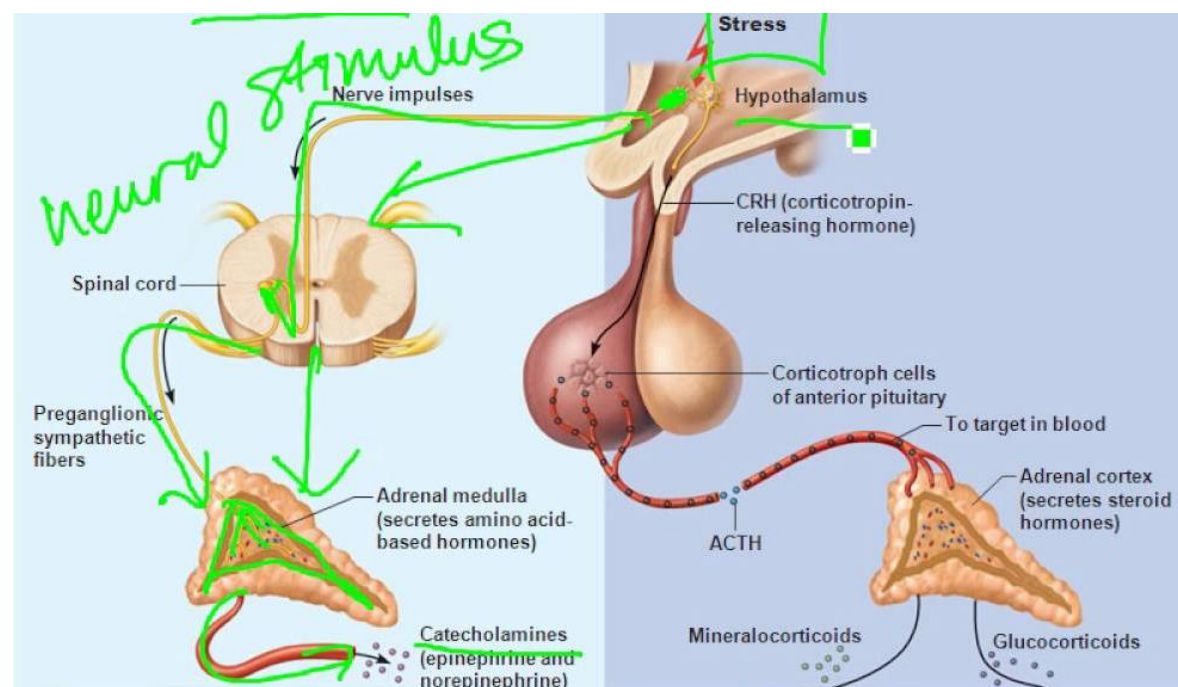
Circulating epinephrine and norepinephrine - almost the same effect as direct sympathetic stimulation, except that the effect is longer (2 – 4 minutes)

Norepinephrine

- constriction of essentially all the blood vessels of the body
- increased activity of the heart
- inhibition of GIT
- dilation of the pupils of the eyes ...

Epinephrine differs in following respects

1. Greater effect in stimulating the beta receptor – greater effect on cardiac stimulation
2. Only weak constriction of the blood vessels in the muscles
3. Greater metabolic effect on tissues





## Value of the Adrenal Medullae to the Function of the Sympathetic Nervous System

1. Organs are stimulated in two ways: directly by symp nerves  
indirectly by the adrenal medullary hormones

One system can substitute for the other

destruction of symp pathway – E, NE in blood indirectly cause stimulation

loss of the two adrenal medullae has little effect (symp pathways still perform necessary duties)

Dual mechanism of sympathetic stimulation provides a safety factor

2. Capability of hormones E, NE to stimulate structures that are not innervated by symp fibers  
metabolic rate of every cell of the body is increased by hormones (epinephrin) even though it is not innervated

# Adrenal gland overview Video

<https://www.youtube.com/watch?v=njUUXiqbcto>

