



# **Physical Activity and Health Promotion**

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Unit of Endocrinology

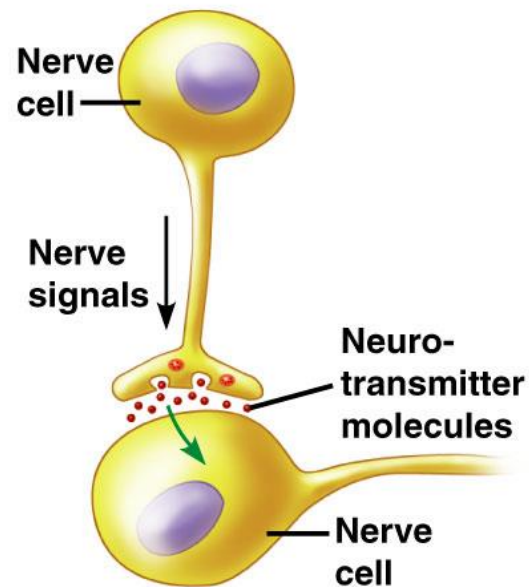
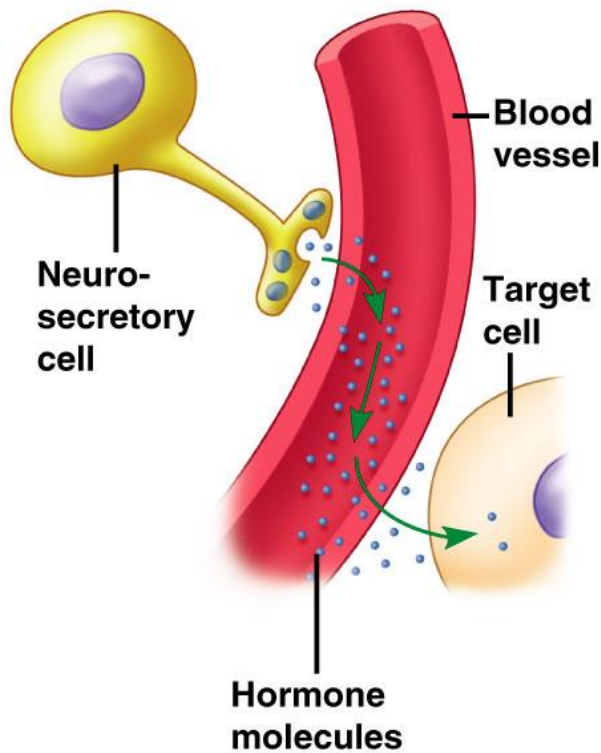
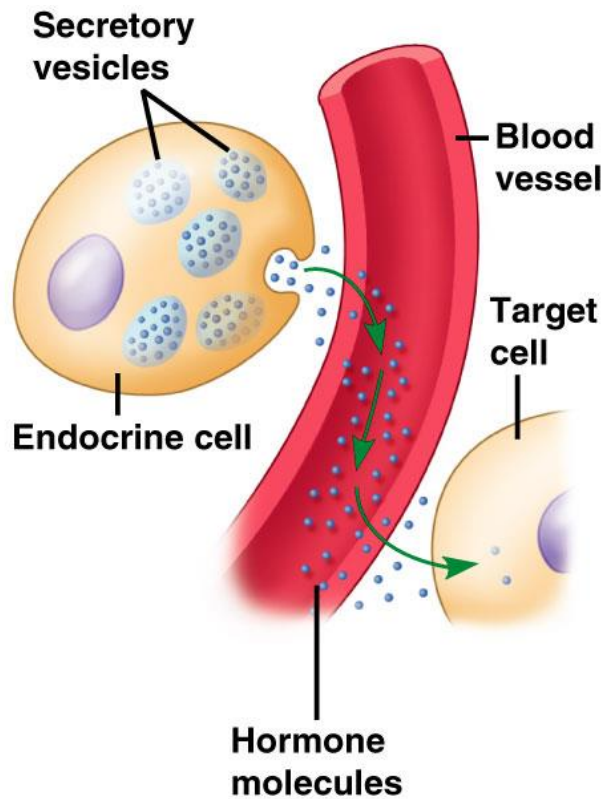
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**Section of Reproductive Endocrinology**

## **Lesson 9**

# **Hormones and physical activity**



## **Hormones**

- **Are chemical substances secreted by cells into the extracellular fluids**
- **Regulate the metabolic function of other cells**
- **Have lag times ranging from seconds to hours**
- **Tend to have prolonged effects**
- **Circulate to all tissues but only activate cells referred to as target cells**
- **Target cells must have specific receptors to which the hormone binds.**
- **These receptors may be intracellular or located on the plasma membrane.**

## **Target Cell Activation**

- **Activation depends on 3 factors:**
  - **Blood levels of the hormone**
  - **Relative number of receptors on the target cell**
  - **Affinity of those receptors for the hormone**
- **Up-regulation – target cells form more receptors in response to the hormone**
- **Down-regulation – target cells lose receptors in response to the hormone**

## **Mechanism of Hormone Action**

- **Hormones produce one or more cellular changes in target cells**
- **Alter plasma membrane permeability**
- **Stimulate protein synthesis**
- **Activate or deactivate enzyme systems**
- **Induce secretory activity**
- **Stimulate mitosis**

## How Hormones Work

In general, hormones can act on a target cell in 1 of 2 ways:

- *Activate Second Messengers* (Involves regulatory G proteins)

(This is how amino acid-derived, peptide, and fatty acid-derived hormones work)

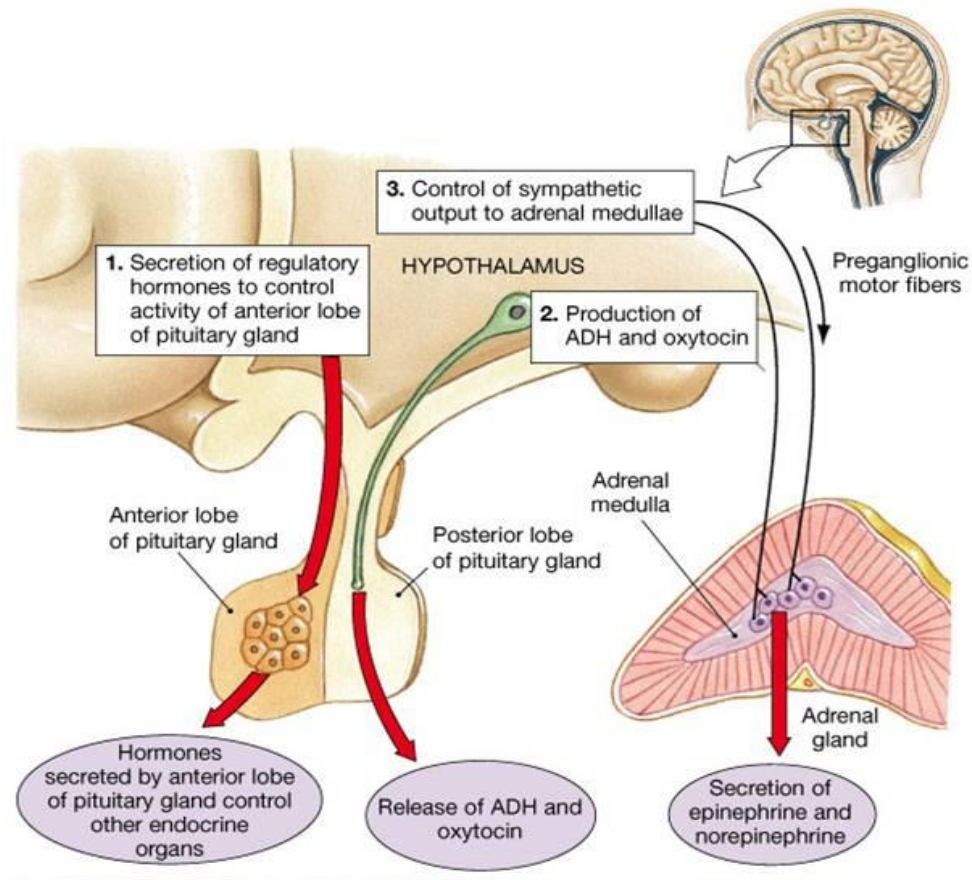
1. The hormone binds to a G protein-linked receptor on the cell membrane; the hormone acts as a first messenger.
2. The binding of the hormone to the G protein-linked receptor activates a second messenger such as cAMP.
3. The second messenger then activates or inactivates enzymes in the cell

- *Activate Genes*

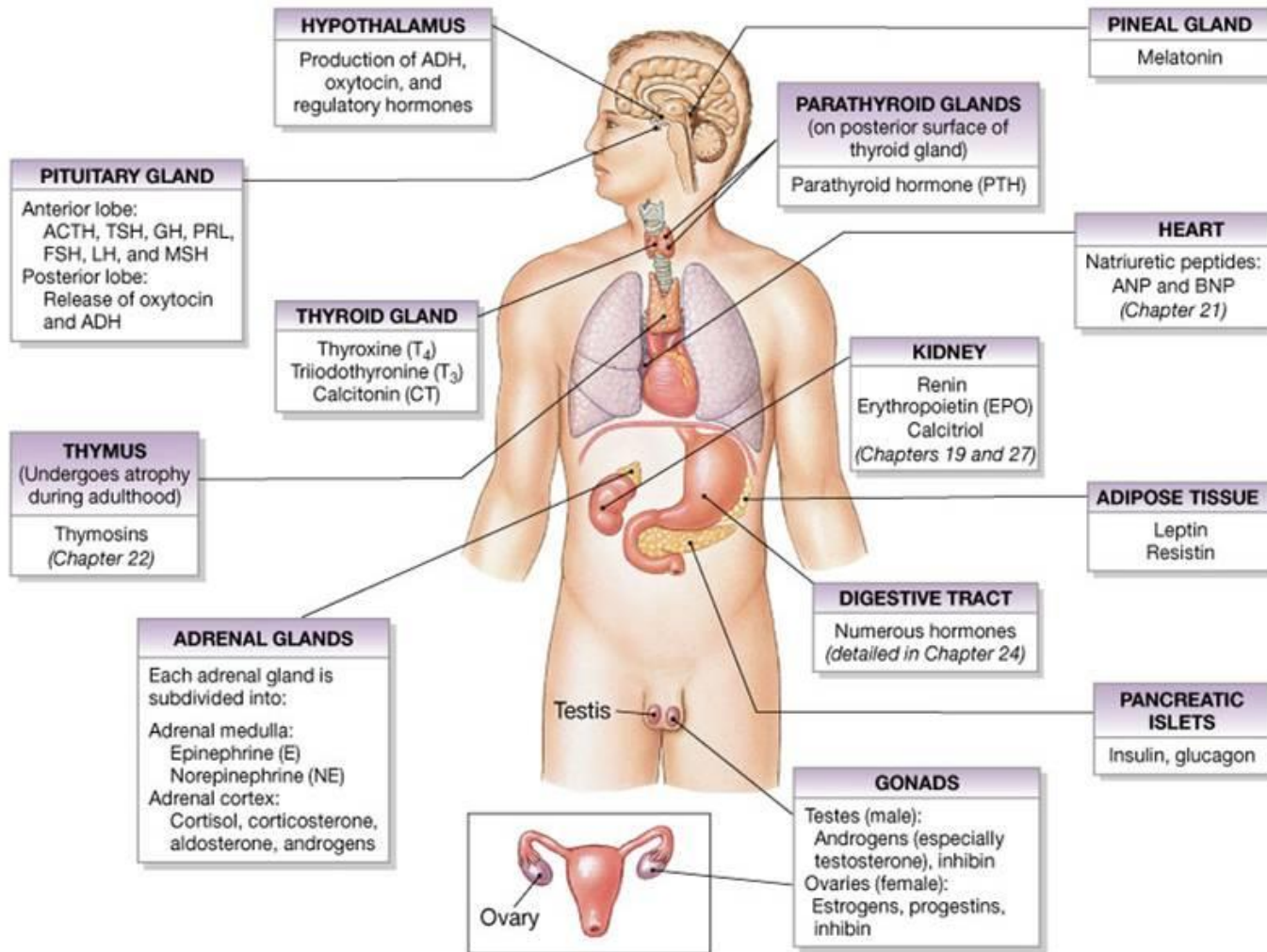
(This is how steroid and thyroid hormones work)

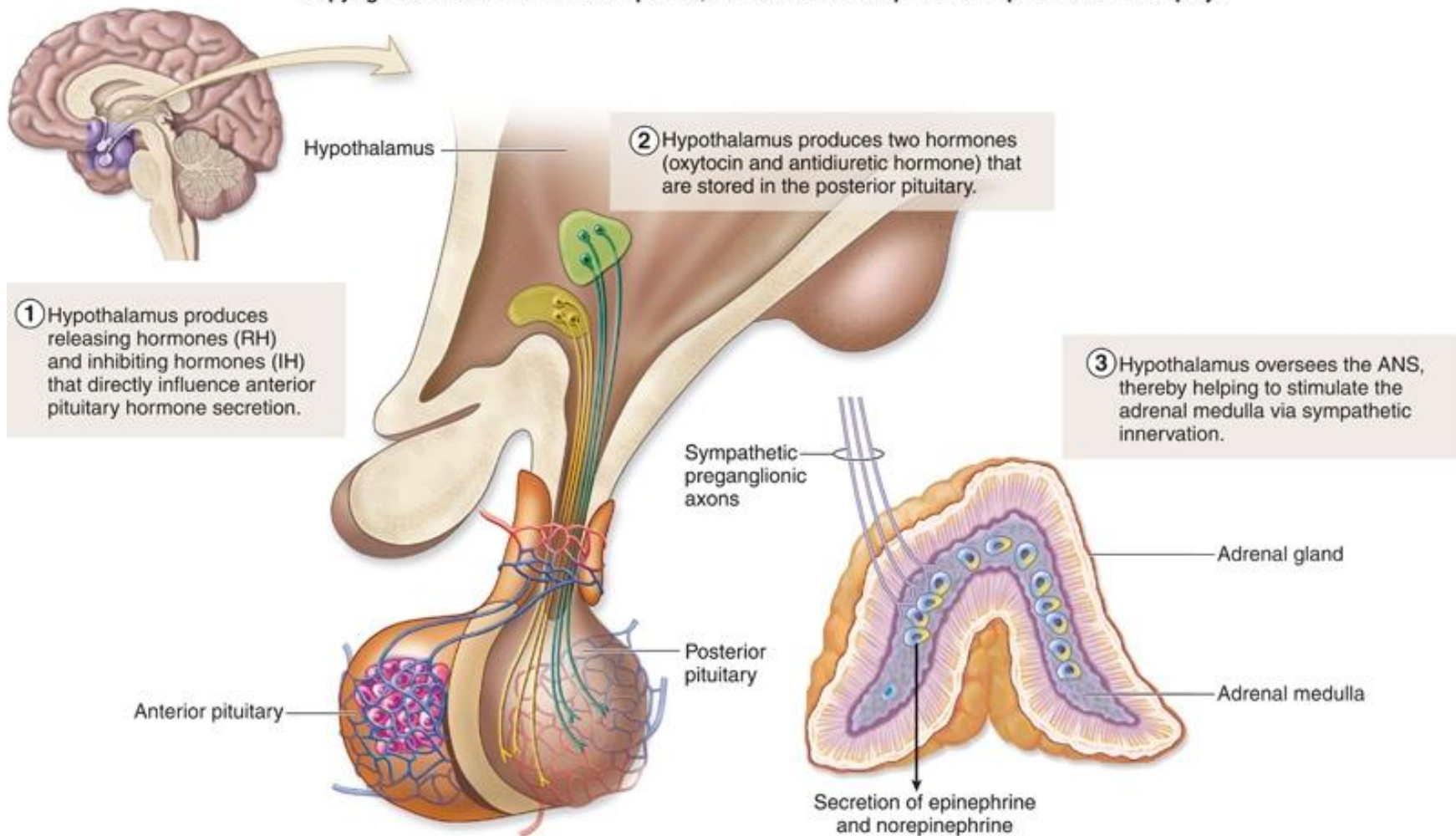
1. Steroid hormones and thyroid hormones pass directly through the cell membrane of target cells.
2. They bind to receptors in the cytoplasm or in the nucleus. (Thyroid hormones also bind to receptors in the mitochondria.)
3. If they bind to receptors in the cytoplasm, the hormone-receptor complex then enters the nucleus.
4. In the nucleus the hormones directly either turn genes “on” or turn genes “off.” That is they either cause the gene to start making a protein by transcription and translation or not.

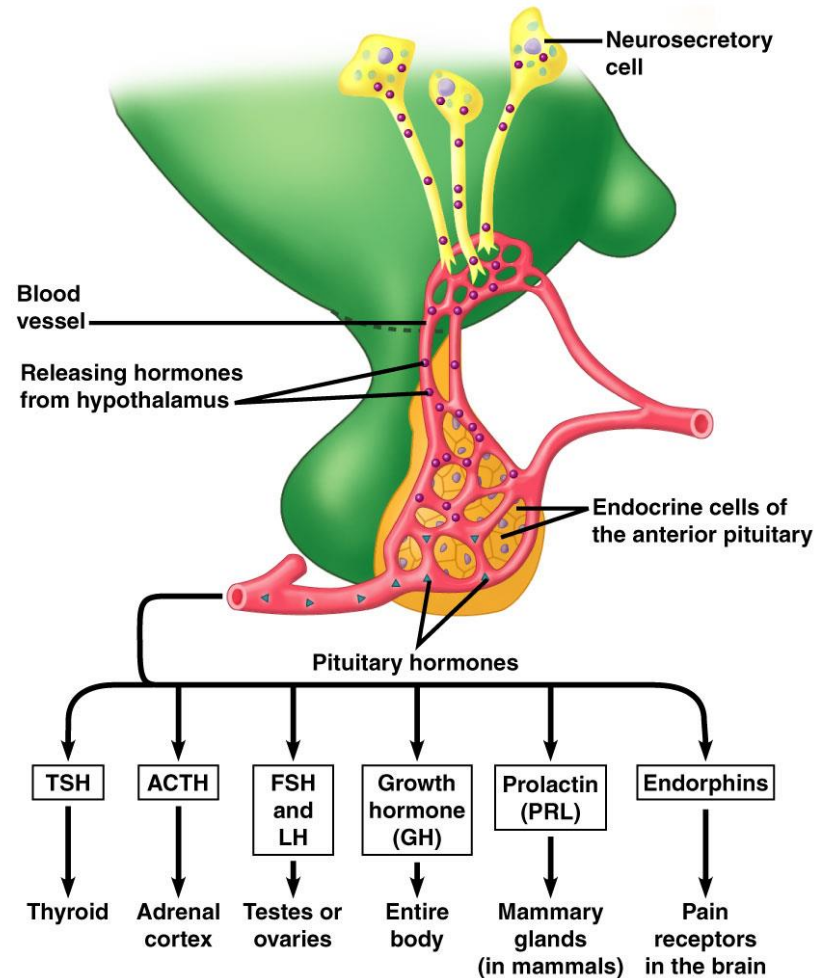
Thyroid hormones that go to the mitochondria increase the rate of ATP production in the cell.

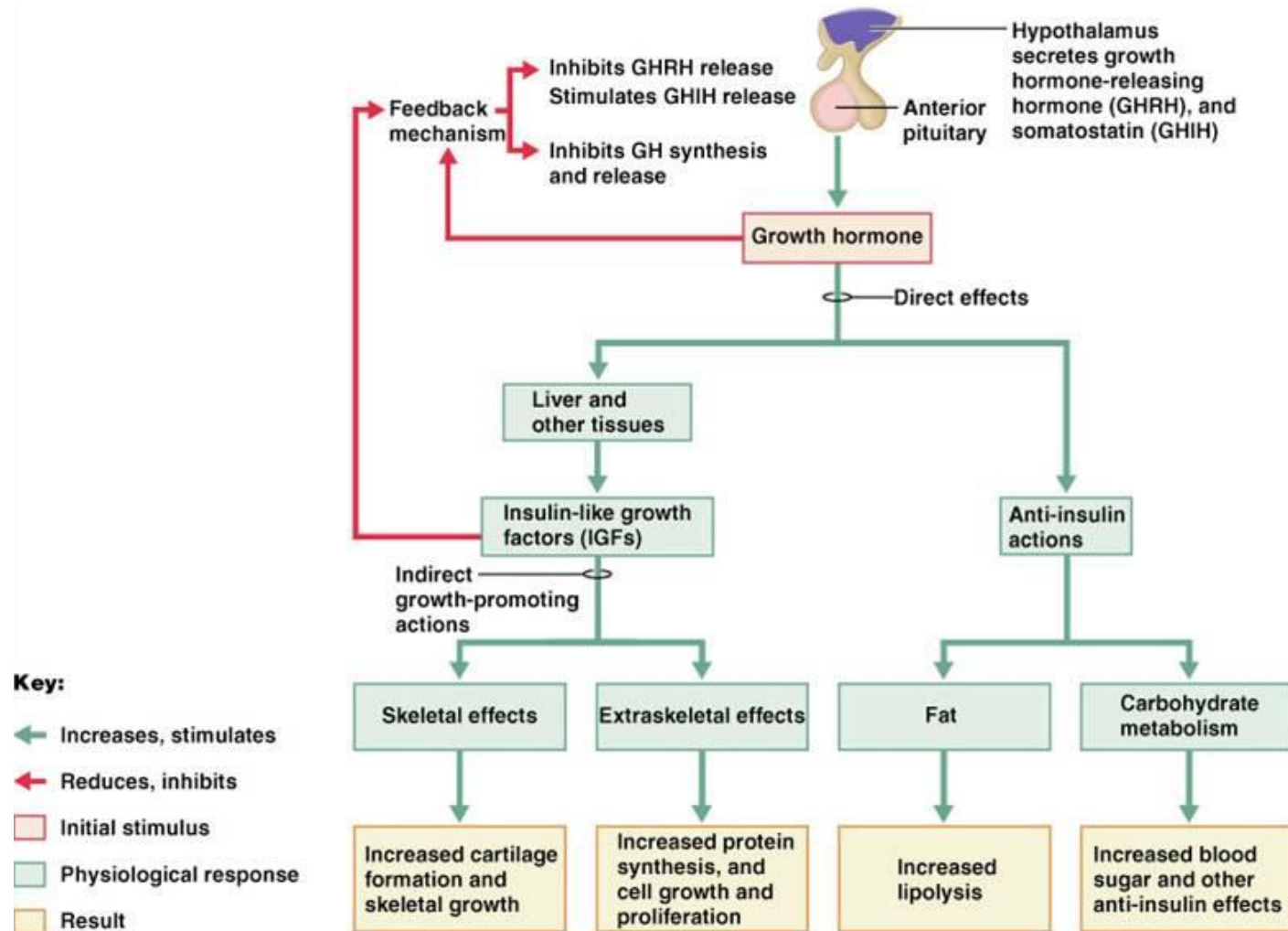


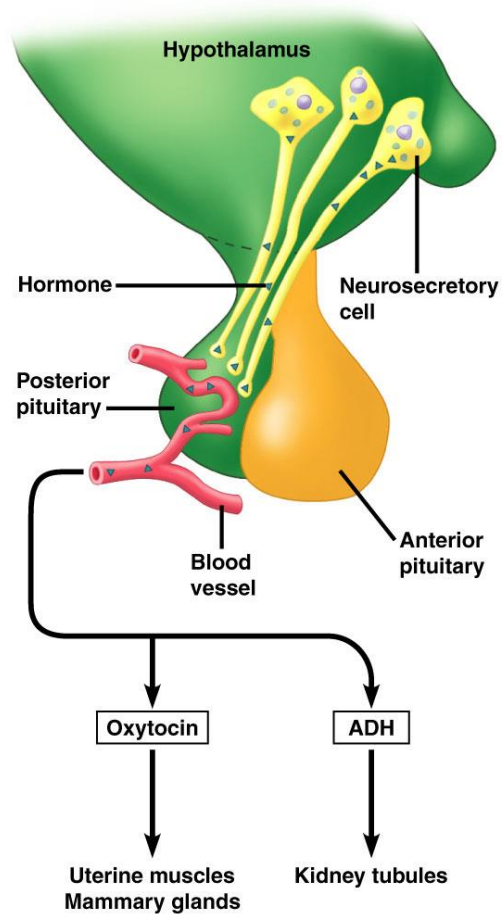














① A stimulus (e.g., low body temperature) causes the hypothalamus to secrete thyrotropin-releasing hormone (TRH), which acts on the anterior pituitary.

② Thyrotropic cells in the anterior pituitary are stimulated to release thyroid-stimulating hormone (TSH).

TSH

TRH

Anterior pituitary

③ TSH acts on cells of the thyroid gland. Follicular cells are stimulated to release thyroid hormone (TH).

TH

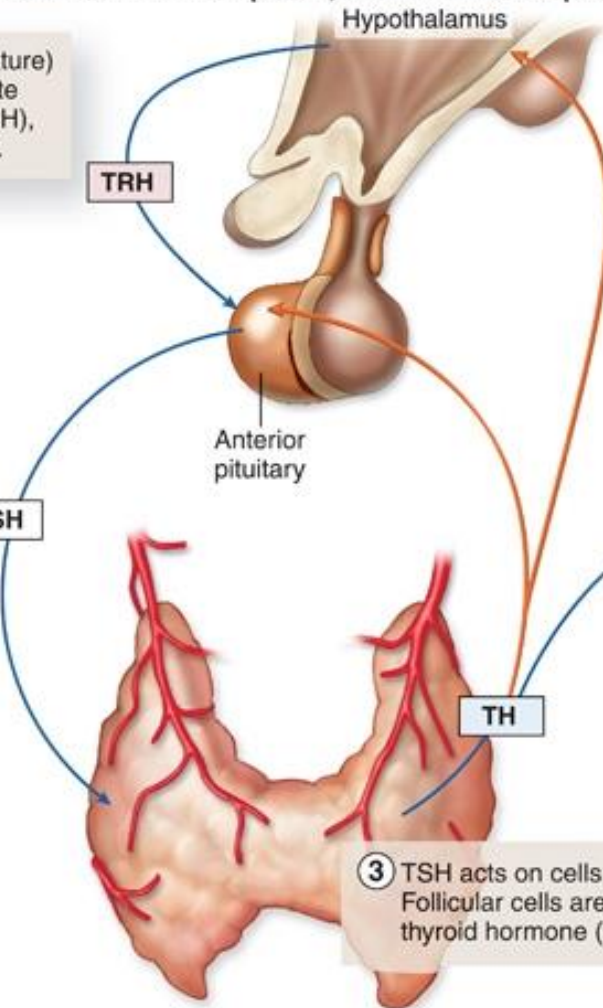
④ TH stimulates target cells to increase metabolic activities, resulting in an increase in basal body temperature.

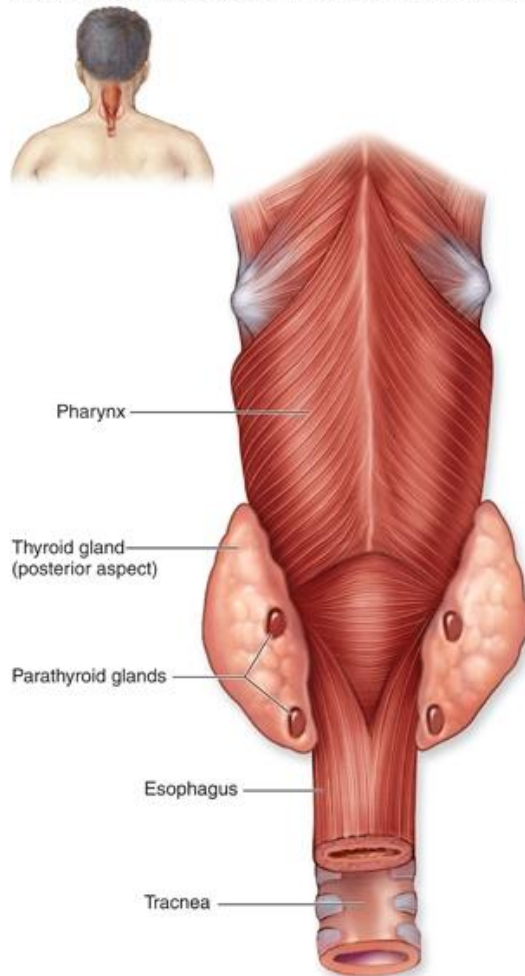
⑤ Increased TH levels cause heat production in target cells; that increase in temperature is detected by the hypothalamus as it monitors blood temperature and inhibits the secretion of TRH by the hypothalamus. TH also blocks the interactions of TRH from the hypothalamus and anterior pituitary to prevent the formation of TSH.

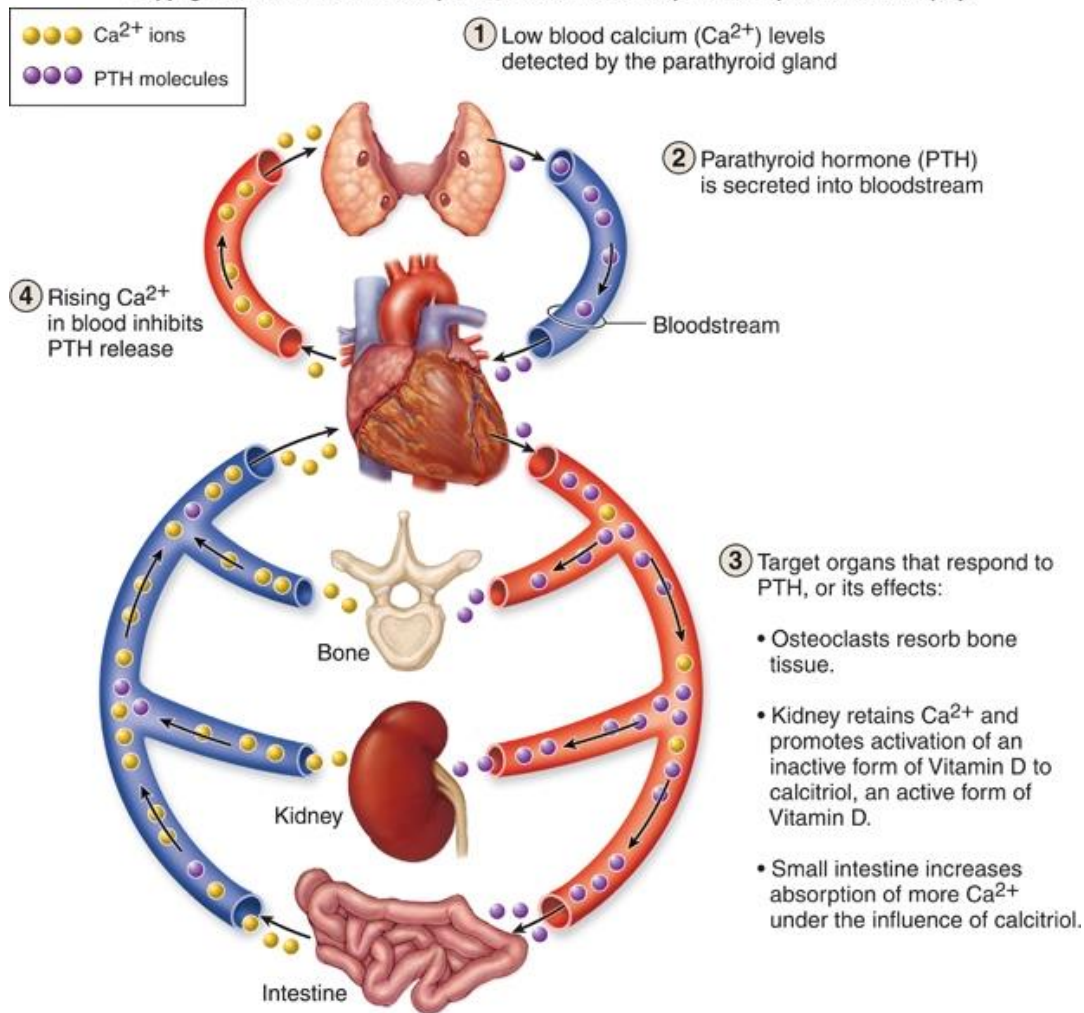
Negative feedback inhibition

→ (blue) stimulatory  
→ (orange) inhibitory

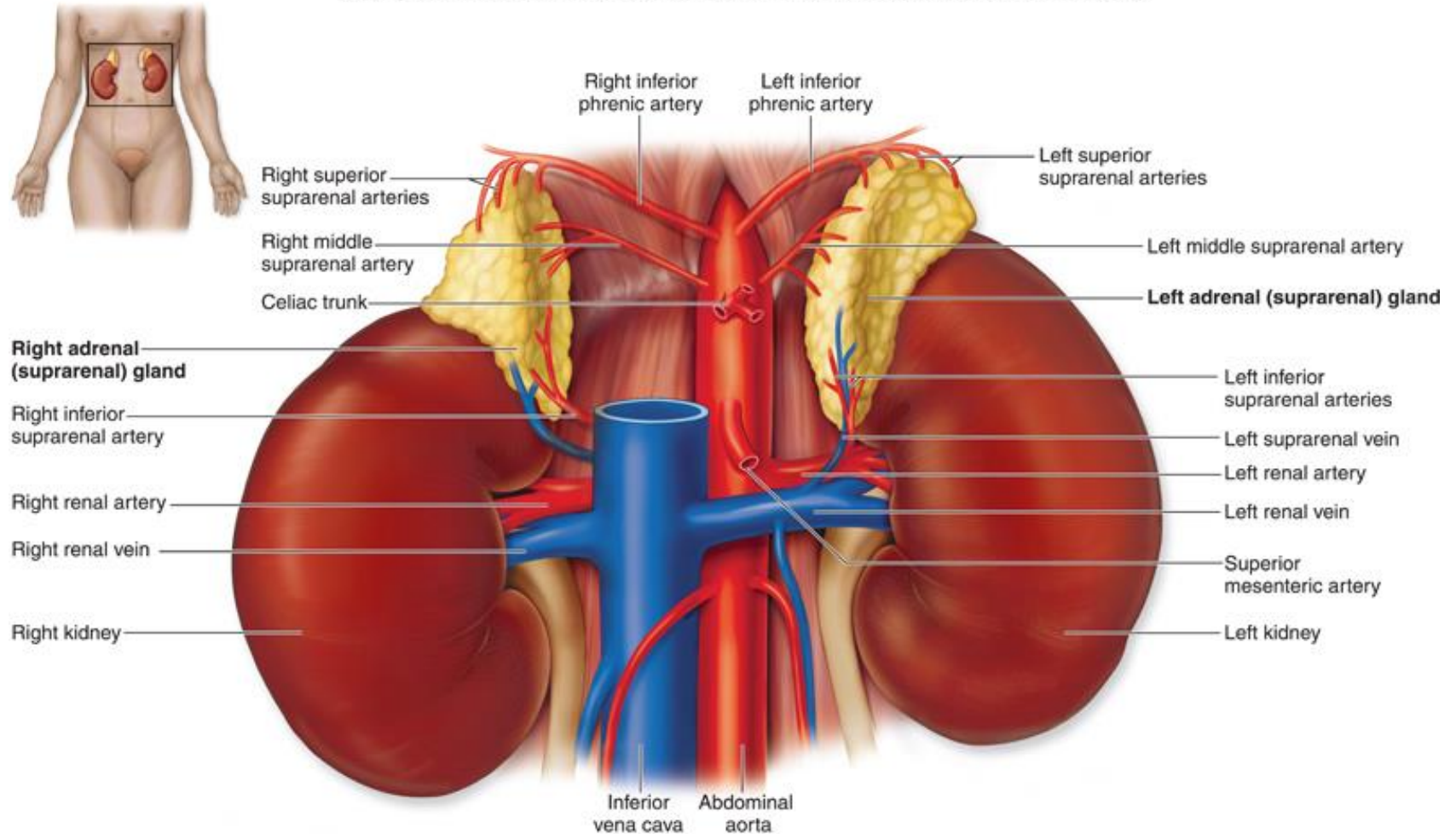
Target organs in body

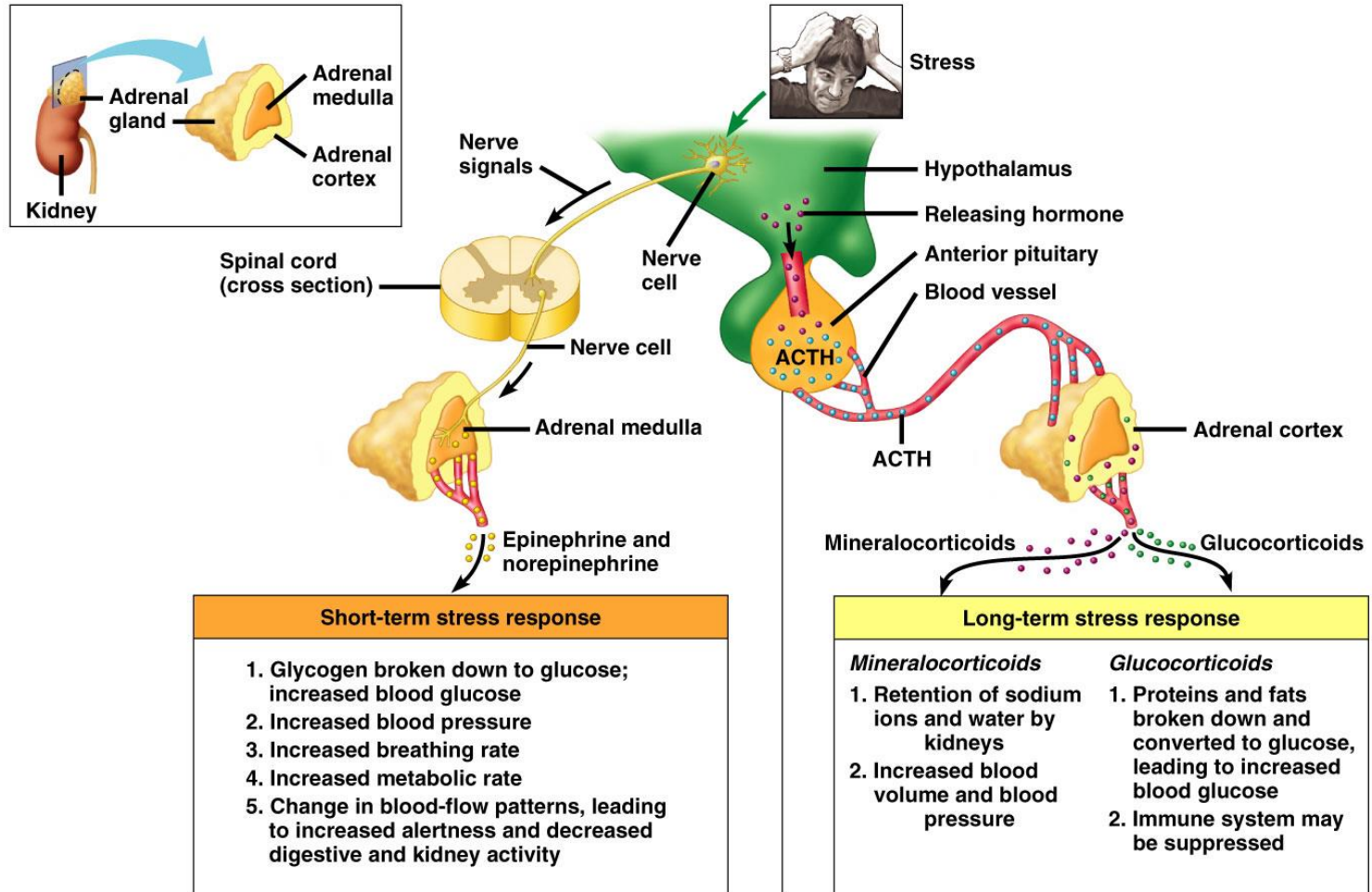


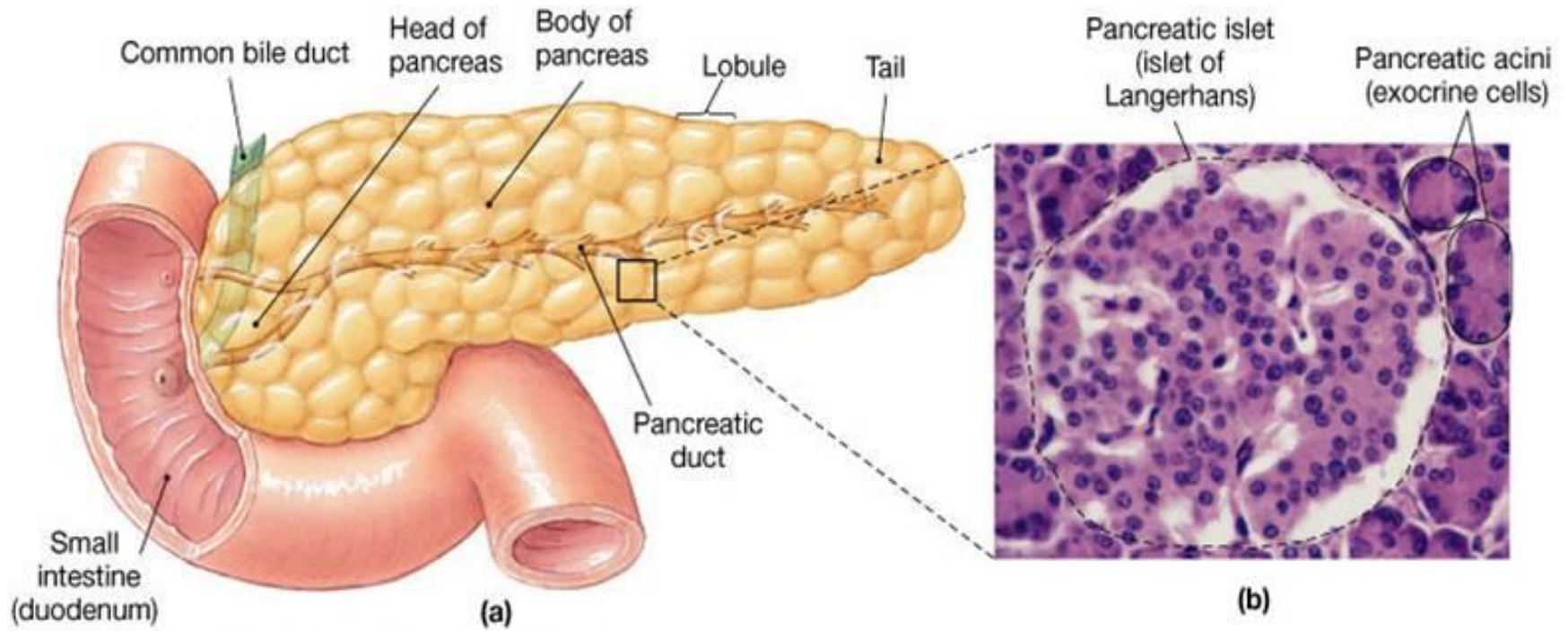


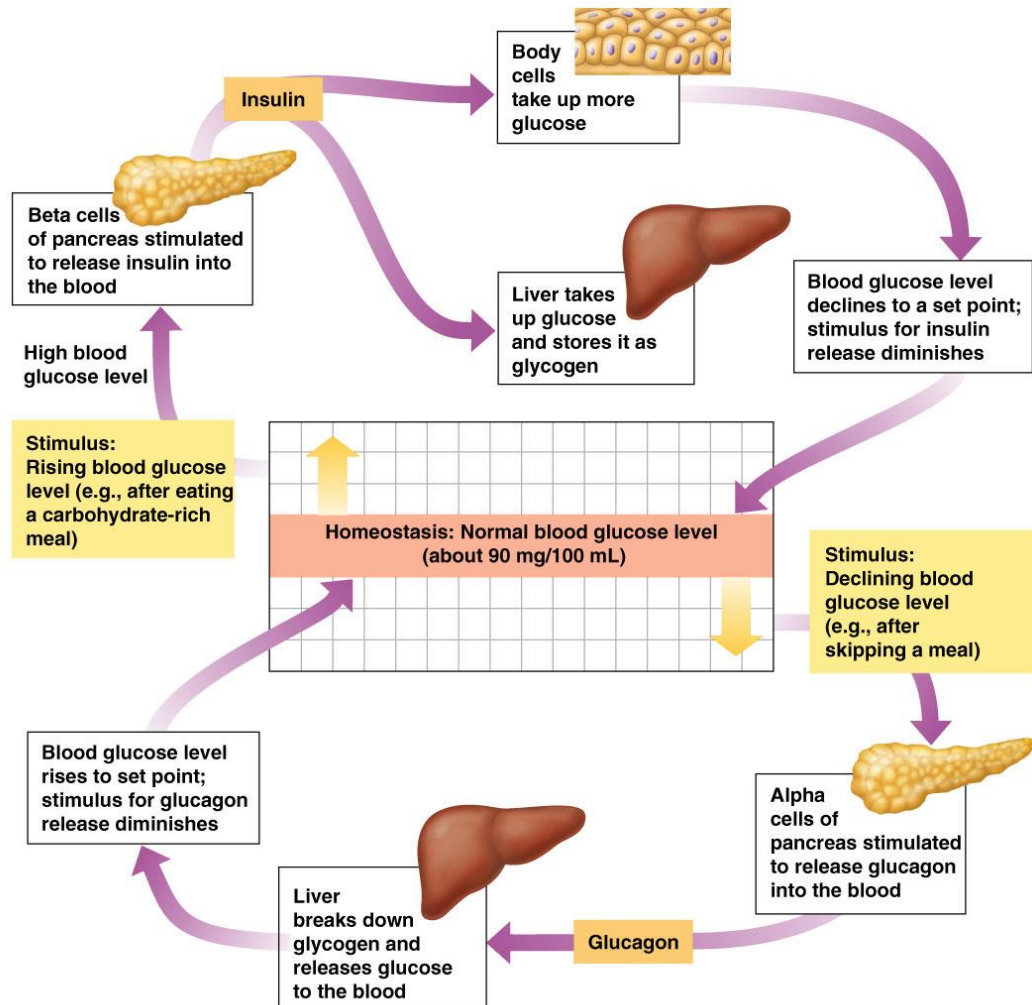






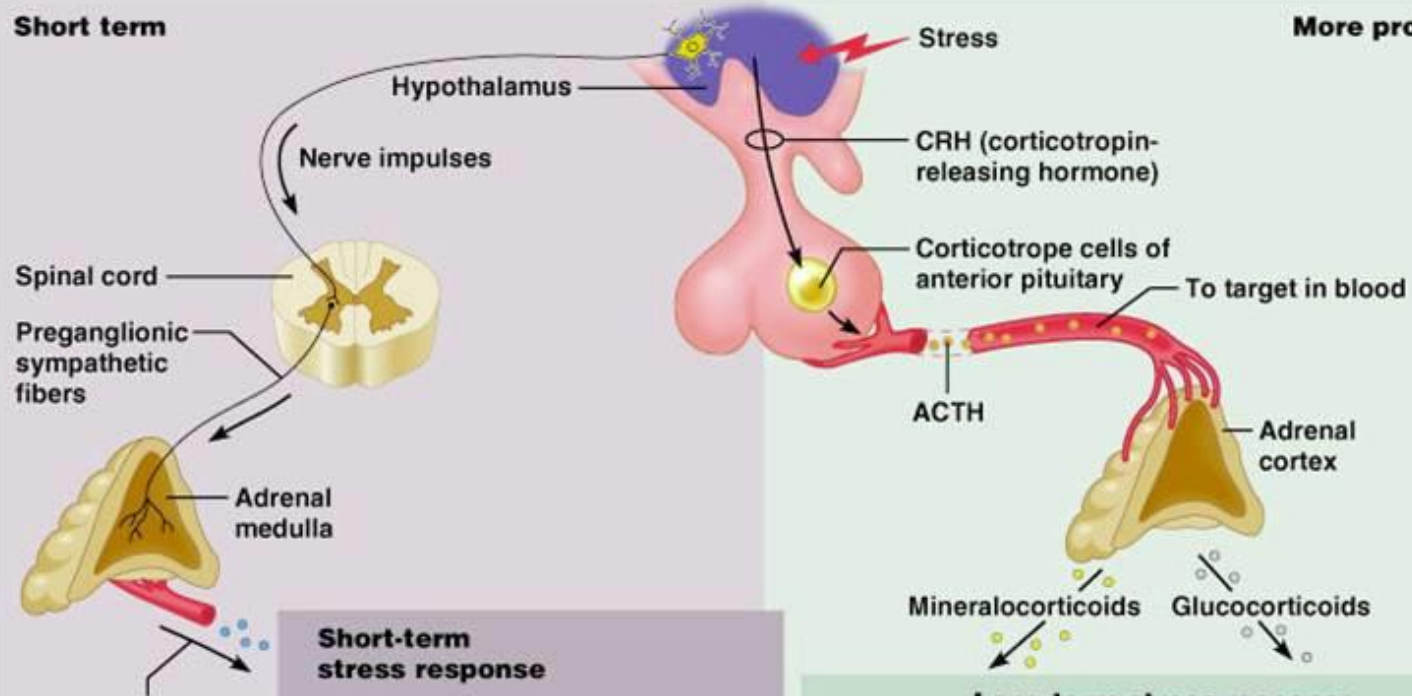








## Short term



### Short-term stress response

1. Increased heart rate
2. Increased blood pressure
3. Liver converts glycogen to glucose and releases glucose to blood
4. Dilation of bronchioles
5. Changes in blood flow patterns leading to increased alertness, decreased digestive system activity, and reduced urine output
6. Increased metabolic rate

## More prolonged

### Long-term stress response

- |  |   |
|--|---|
| 1. Retention of sodium and water by kidneys  | 1. Proteins and fats converted to glucose or broken down for energy |
| 2. Increased blood volume and blood pressure | 2. Increased blood sugar  |
|  | 3. Suppression of immune system                                     |

## Low Intensity



Walking, dance, and other long-duration activities, generally safe but time-consuming with very little effect on fitness

## Moderate Intensity



Activity plus light weight lifting, minimal muscular activation and short lived progress and limited wellness outcomes, safety depends on movement speed and form

## Right Intensity



Optimized muscular activation and scheduling which drives powerful total body results, increased muscle quality, improved cardiovascular vitality, bone health and other vital wellness outcomes

## High Intensity



Will stimulate gains in fitness if over-training does not occur but generally increases risk for over-use and injury

# Benefits of Regular Exercise



## Improves mood

Physical activity stimulates chemicals like serotonin that help you feel more relaxed.



## Harmonizes Hormone Levels

Exercising opens the hormone faucet to release the right amount of hormones that your body NEEDS! This includes endorphins, testosterone, growth hormone and insulin. It regulates metabolic function. You can lose weight too!



## Reduces risk of disease

Exercise boosts good cholesterol and decreases triglycerides in your body. This helps prevent or manage life threatening conditions like diabetes, heart disease, high blood pressure and arthritis.



## Boosts energy

Regular activity improves the ability to deliver oxygen and nutrients throughout the body.



## Increased Fertility

Exercise has a positive impact on fertility. When you work-out, your brain releases endorphins which aid the production of hormones necessary for conception.



## Controls weight

Using up oxygen in the body burns stored fat. This helps to maintain and control weight.

# 7 HEALTH FACTS MEN NEED TO KNOW

Only **30%** of a man's overall health is determined by his genetics.

**70%** is controllable through lifestyle.

Men live **9 years** in poor health - mostly preventable by making small lifestyle changes.



## MENTAL HEALTH

Inactive men are **60%** more likely to suffer from depression than those who are active.



## DRINKING

Those who consume 4 to 10 drinks a week at most have a **lower risk** of developing type 2 diabetes. Drinking more than 10 drinks a week almost **doubles your risk** of type 2 diabetes.

**7-8 HOURS**



## SLEEP

Men who sleep 7-8 hours a night have about **60%** less risk of fatal heart attack than those who sleep 5 hours or less.



## ACTIVITY

Men who climb 50 stairs or walk 5 city blocks a day may lower their risk of heart attack by **25%**.



## NUTRITION

How easy is this? Getting your 5-7 servings of fruit and veggies is as simple as a glass of orange juice, one potato, one big carrot, 1/2 an avocado, and a pear.

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SOURCES:  
[www.statcan.gc.ca/habitude-tableau/sum/sum031/cst031nm67-eng.htm](http://www.statcan.gc.ca/habitude-tableau/sum/sum031/cst031nm67-eng.htm)  
[www.health.gov.bc.ca/library/publications/year/2004/inactivity.pdf](http://www.health.gov.bc.ca/library/publications/year/2004/inactivity.pdf)  
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# YOUR BRAIN LOVES THE GYM

(OR SIDEWALK, BIKE TRAIL, POOL,...)

WHEN YOU EXERCISE....

Norepinephrine is released, improving attention, perception and motivation.

Brain-derived neurotrophic factor (BDNF) is released, protecting and repairing neurons from injury and degeneration.

Hormones combine with BDNF to grow brain cells, regulate mood and provide mental clarity.

The hippocampus, a part of the brain concerned with learning and memory, grows in size with regular exercise over time.

Endorphins are released, dulling the sensation of pain.

Serotonin is released, enhancing mood.

Blood flow to the brain increases, delivering more oxygen and nutrients and improving waste removal.

Dopamine is released, improving motivation, focus and learning.



*Kryski*



# EXERCISE

## Systemic Effects

### Skeletal Muscle

*Hypertrophy  
Hyperplasia  
Fiber Type Switching*

PGC-1 $\alpha$   
MSTN  
IGF-1/IGF1R

### Vascular

$\uparrow$  Flow  
 $\uparrow$  Vasoreactivity  
 $\uparrow$  Angiogenesis

eNOS  
VEGF  
PGC-1 $\alpha$

### Metabolism

$\uparrow$  Insulin Sensitivity  
 $\uparrow$  Ox. Phosphorylation  
 $\uparrow$  Mito. Biogenesis  
 $\uparrow$  Adipose "Browning"

PGC-1 $\alpha$   
AMPK  
Gut/Int. BMT



## Cardiac Effects

### Cardiac Growth

*Hypertrophy  
?Hyperplasia*

IGF1/IGF1R  
C/EBP $\beta$ -CITED4  
Neg. EtsB4

### Cardioprotection

$\downarrow$  Ischemic Injury

IGF1/IGF1R/Pim1  
AMPK  
eNOS/NO

### Function

$\uparrow$  Stroke Volume  
 $\uparrow$  Cardiac Output  
Improved Ca<sup>2+</sup> Handling  
T-tubule Organization

SERCA2a, PLB

### Metabolism

$\uparrow$  Ox. Phosphorylation  
 $\uparrow$  Mito. Biogenesis

PGC-1 $\alpha$   
AMPK

### Vascular

$\uparrow$  Flow  
 $\uparrow$  Vasoreactivity  
 $\uparrow$  Angiogenesis

eNOS  
VEGF  
PGC-1 $\alpha$

## General considerations

The analysis of published data in the scientific literature establish the main traits of **blood hormone responses to exercises**: There are stable changes in hormone levels that are common to all persons, as well as changes which are characterized by a polyphasic pattern and exhibiting inter-individual variability. By the response rate it is possible to discriminate **fast responses, responses of a modest rate and delayed responses**. Accordingly, mechanisms for a rapid and for a delayed activation exist. The changes mediated through the mechanism for a rapid activation depend on the intensity of exercise, revealing the threshold intensity for endocrine response. When a certain amount of exercise is done, the hormonal responses are triggered despite the under-threshold intensity of exercise. Consequently, a threshold duration of exercise also exists. **Through training the threshold intensity of exercise increases and the functional capacities of the endocrine Systems augment**. The former results in the disappearance of hormonal responses during exercise intensity which was previously above the threshold. The latter makes it possible to achieve especially pronounced and long-lasting hormonal changes during extreme exercises. Emotional states as well as environmental conditions, and carbohydrate supply modulate the hormonal changes in exercise.

**1** Muscular activity promotes sweating.

**2** Sweating causes loss of blood plasma, resulting in hemo-concentration and increased blood osmolality.

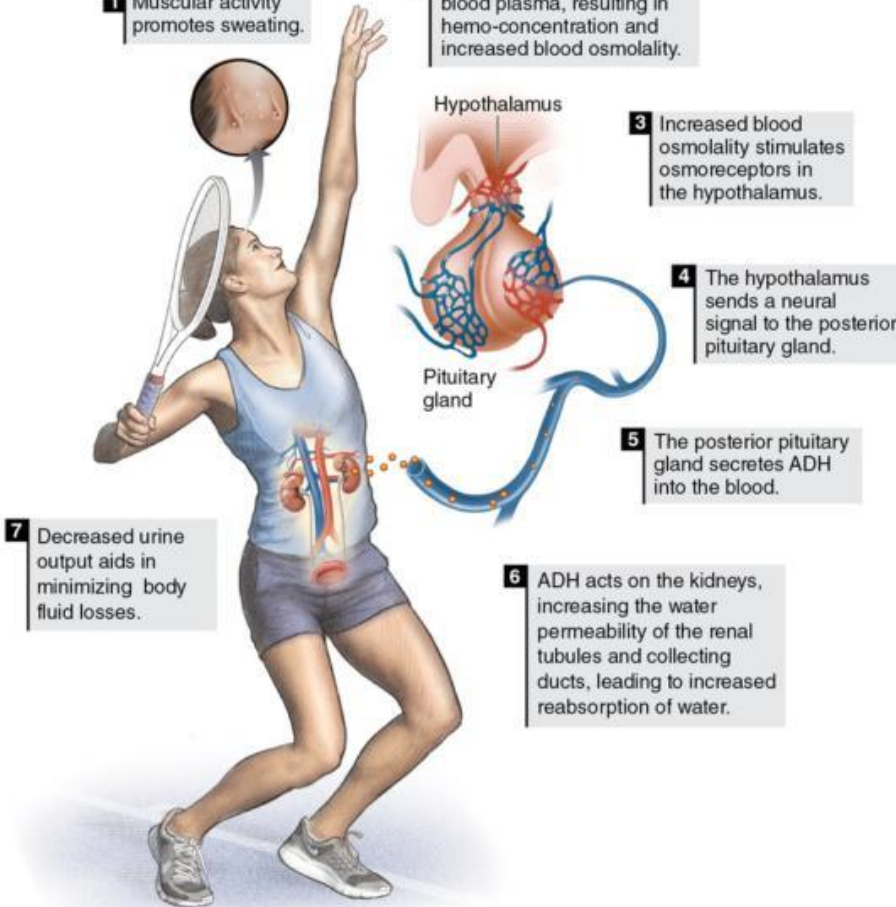
**3** Increased blood osmolality stimulates osmoreceptors in the hypothalamus.

**4** The hypothalamus sends a neural signal to the posterior pituitary gland.

**5** The posterior pituitary gland secretes ADH into the blood.

**6** ADH acts on the kidneys, increasing the water permeability of the renal tubules and collecting ducts, leading to increased reabsorption of water.

**7** Decreased urine output aids in minimizing body fluid losses.



# Hormones and exercise

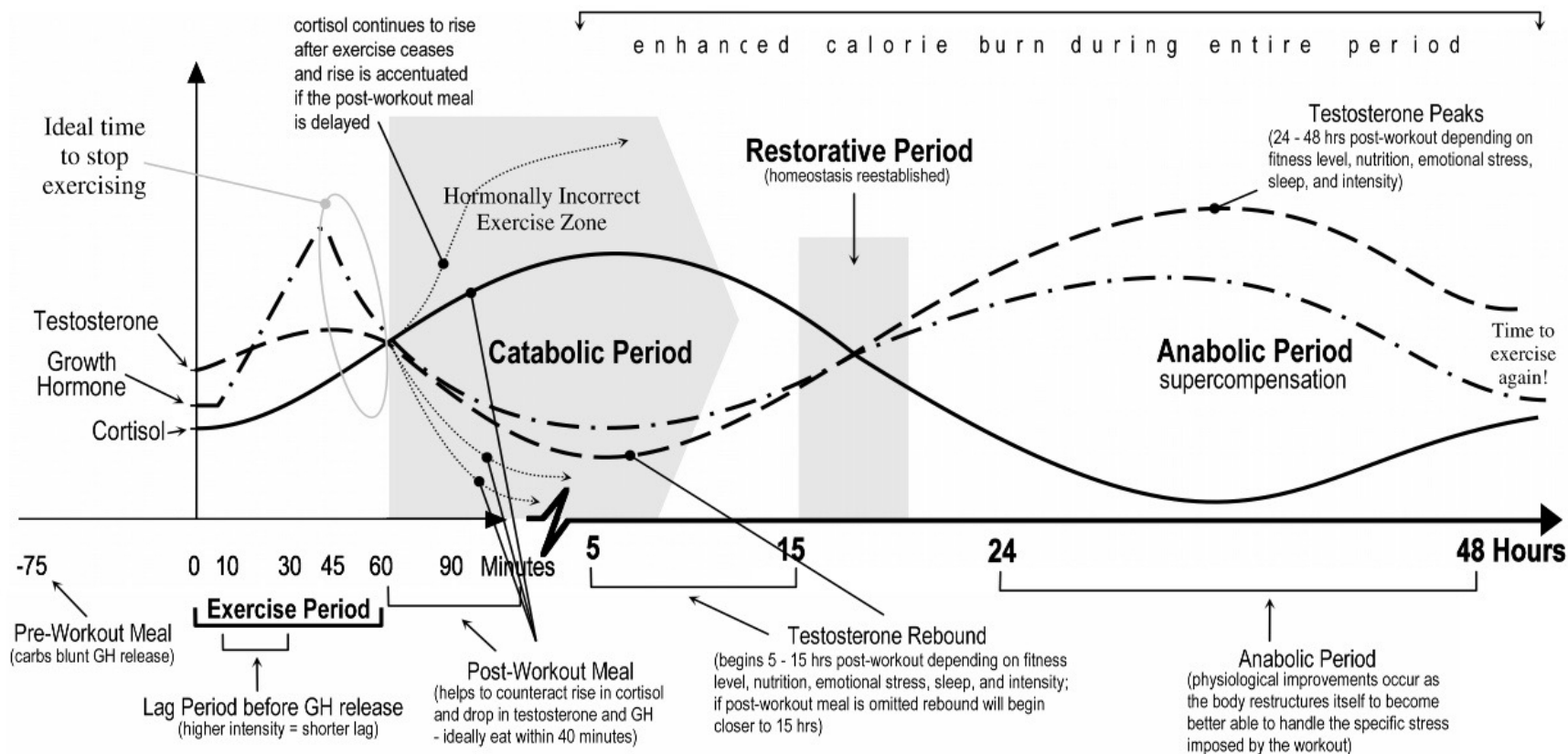
**The endocrine system regulates the production of hormones**, which are chemicals that control cellular functions. Hormones can affect a number of different cells; however, they only influence the ones with specific receptor sites.

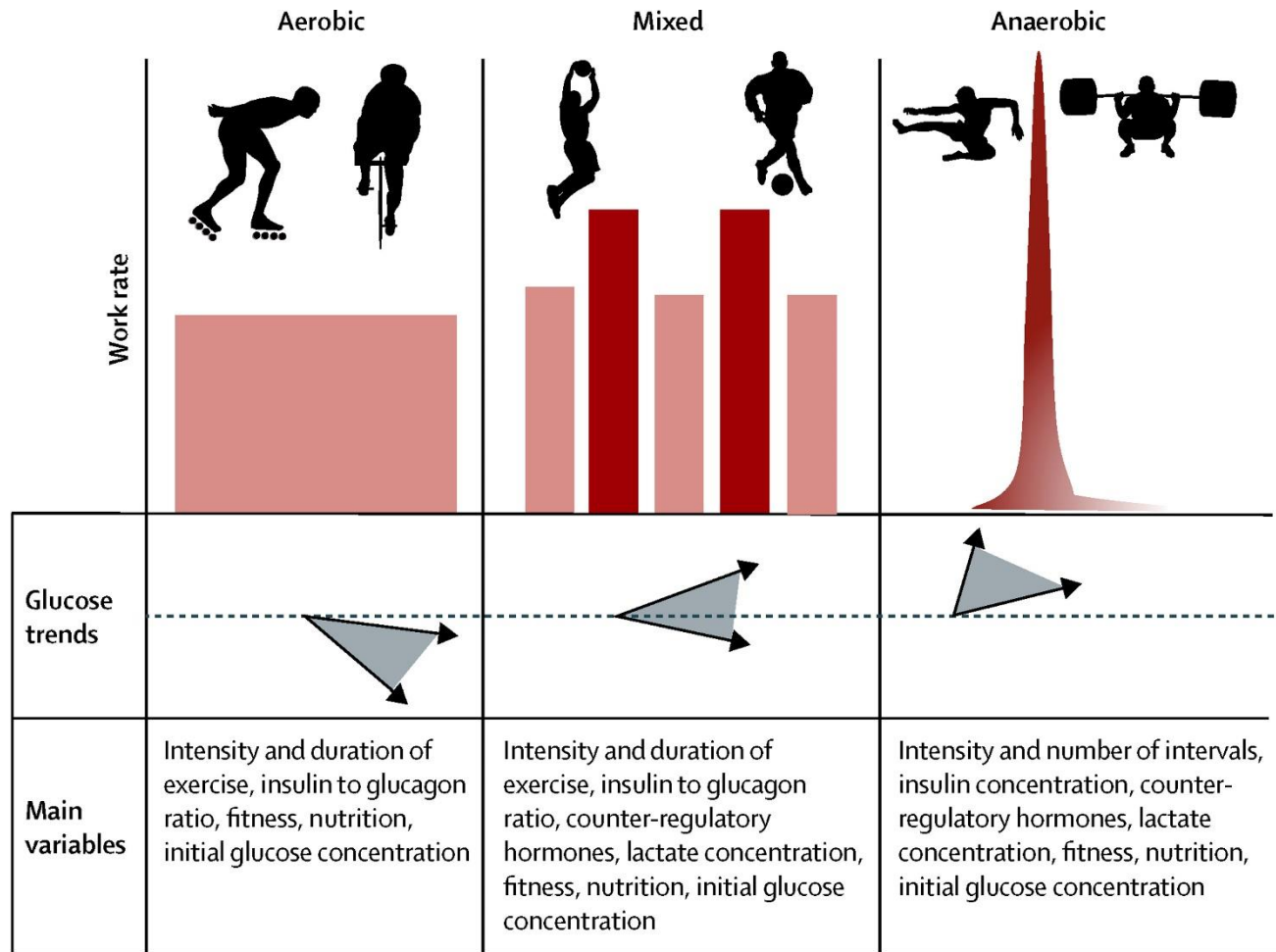
**Hormones control a number of physiological reactions** in the body including energy metabolism, reproductive processes, tissue growth, hydration levels, synthesis and degradation of muscle protein, and mood. Hormones are responsible for both building new muscle and helping to burn fat, so it is important to have an understanding of which ones are released in relation to exercise as well as understanding the physiological functions they influence.

**There are three major classifications of hormones:** steroid, peptide and amines (modified amino acid hormones).

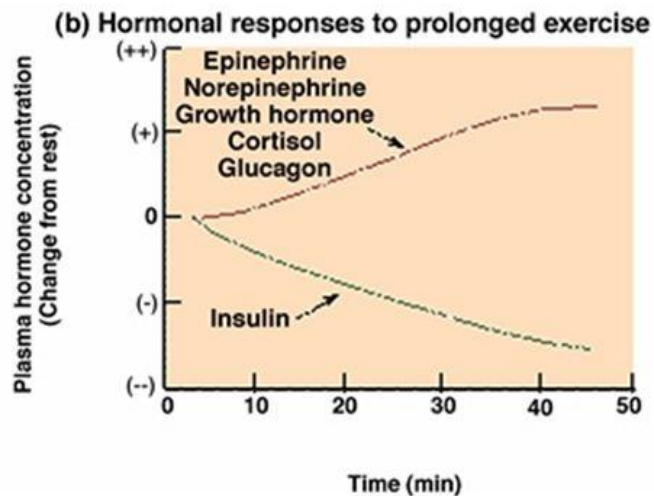
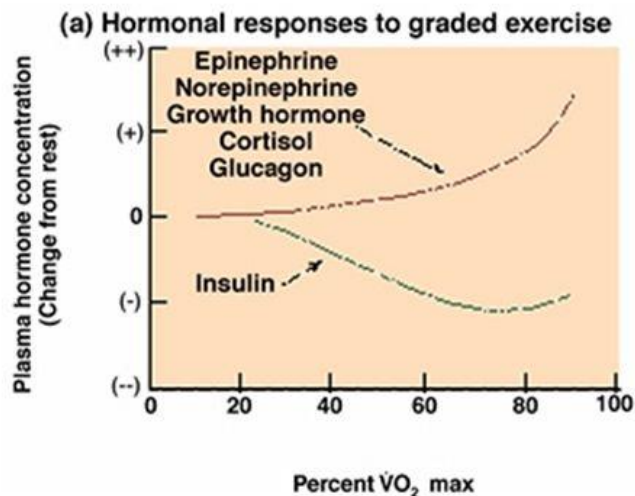
Each class of hormones has a unique **chemical structure** that determines how it interacts with specific receptors. Steroid hormones interact with receptors in the nucleus of a cell, peptide hormones are comprised of amino acids and work with specific receptors sites on the cell membrane, and amines contain nitrogen and influence the sympathetic nervous system.

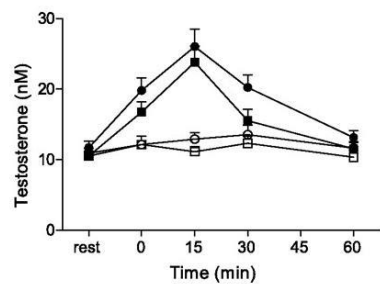
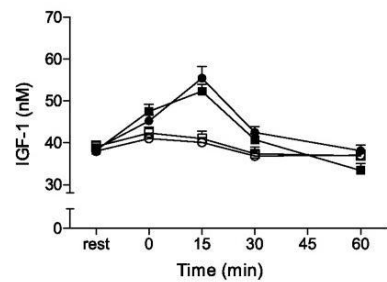
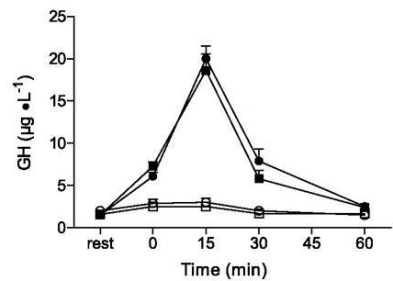
# Acute Hormonal Response to Exercise



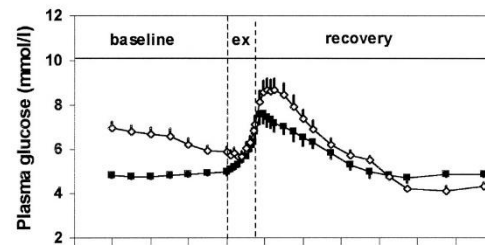


# Hormonal Responses to Exercise

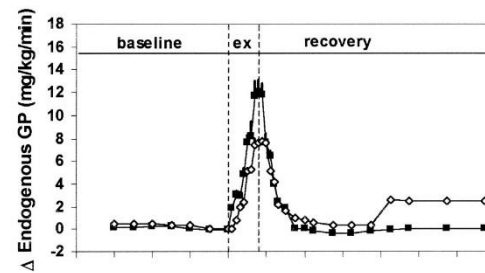




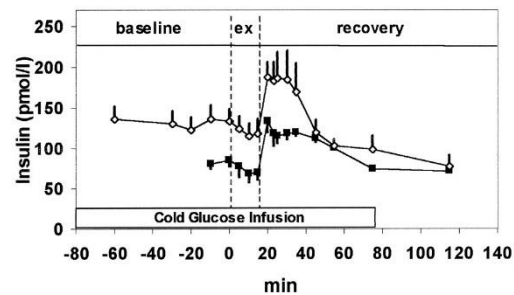
**A**



**B**



**C**

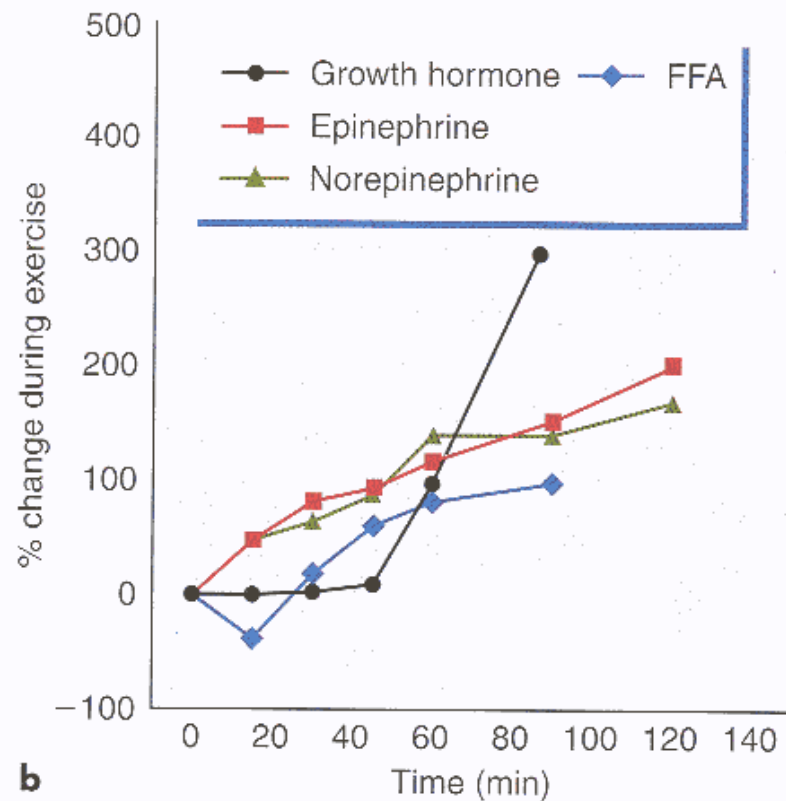
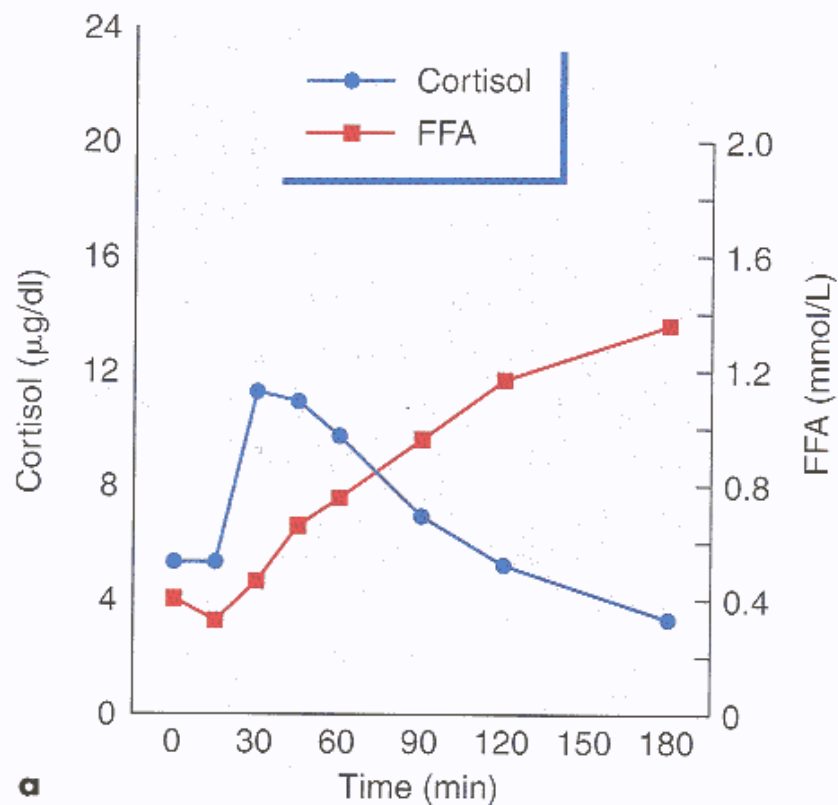




# Hormones and exercise

Hormones can either be anabolic, which means they help build new tissue, or catabolic because they play a role in breaking tissue down. The term “**anabolic steroids**” is often mentioned as a method of cheating used by athletes who want to improve performance; however, anabolic steroids are actually natural chemicals produced by the body that are responsible for promoting tissue growth.

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Changes in plasma levels of (a) free fatty acid (FFA) and cortisol and (b) epinephrine, norepinephrine, growth hormone, and FFA during prolonged exercise.

# Hormones and exercise

## *Insulin*

A peptide hormone produced by the pancreas, insulin regulates carbohydrate and fat metabolism. When blood sugar is elevated, insulin is released to promote the storage and absorption of glycogen and glucose. Insulin helps reduce levels of glucose in the blood by promoting its absorption from the bloodstream to skeletal muscles or fat tissues. It is important to know that insulin can cause fat to be stored in adipose tissue instead of being used to fuel muscle activity. When exercise starts, the sympathetic nervous system suppresses the release of insulin; consequently, it is important to avoid foods with high levels of sugar (including sports drinks) before exercise because it can elevate insulin levels and promote glycogen storage instead of allowing it to be used to fuel physical activity. Wait until the body has started sweating before using any sports drinks or energy gels.

# Hormones and exercise

## ***Human Growth Hormone***

Human growth hormone (HGH) is an anabolic peptide hormone secreted by the anterior pituitary gland that stimulates cellular growth. Like all hormones, HGH works with specific receptor sites and can produce a number of responses, including increasing muscle protein synthesis responsible for muscle growth, increasing bone mineralization, supporting immune system function and promoting lipolysis, or fat metabolism. The body produces HGH during the REM cycles of sleep and is stimulated by high-intensity exercise such as heavy strength training, explosive power training or cardiorespiratory exercise at or above the onset of blood lactate (OBLA, the second ventilatory threshold).

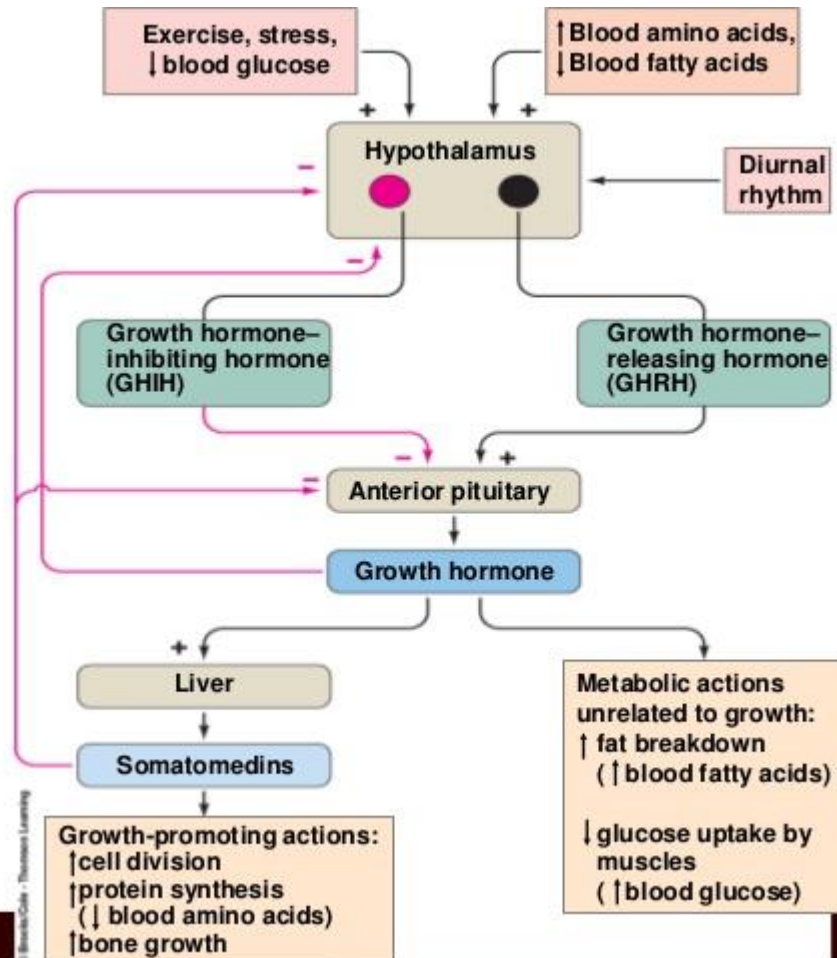
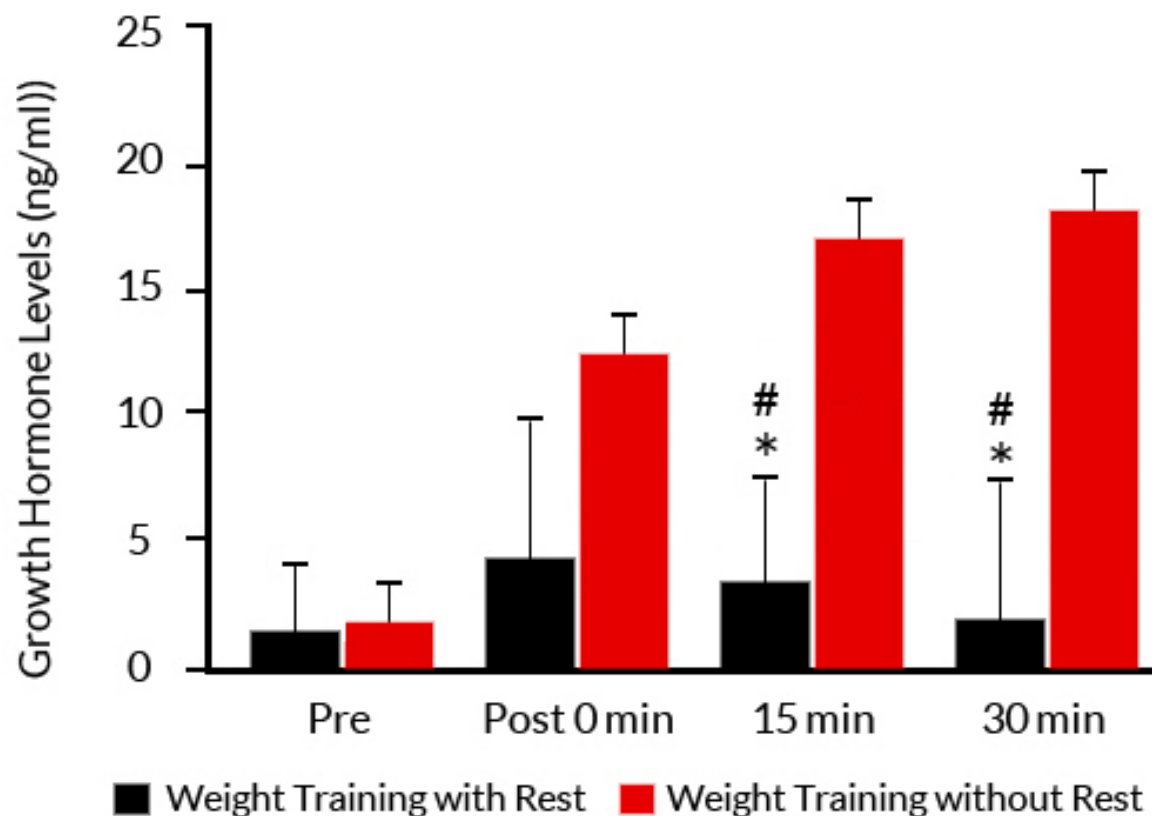


Fig. 17-10, p. 983

Growth Hormone Levels Following Weight Training with Rest Periods or Weight Training with Limited Rest



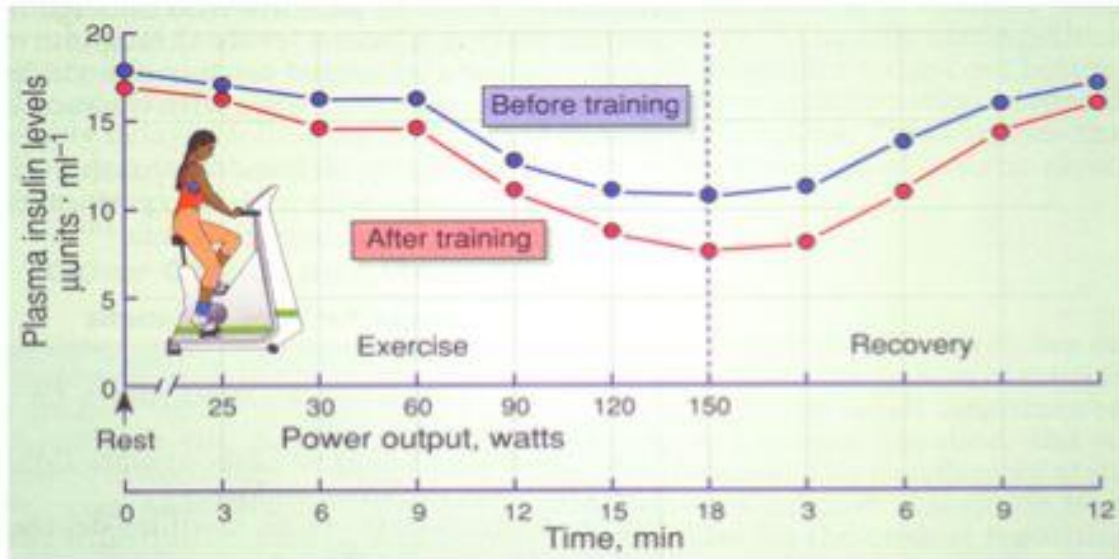
# Hormones and exercise

## ***Insulin-like Growth Factor***

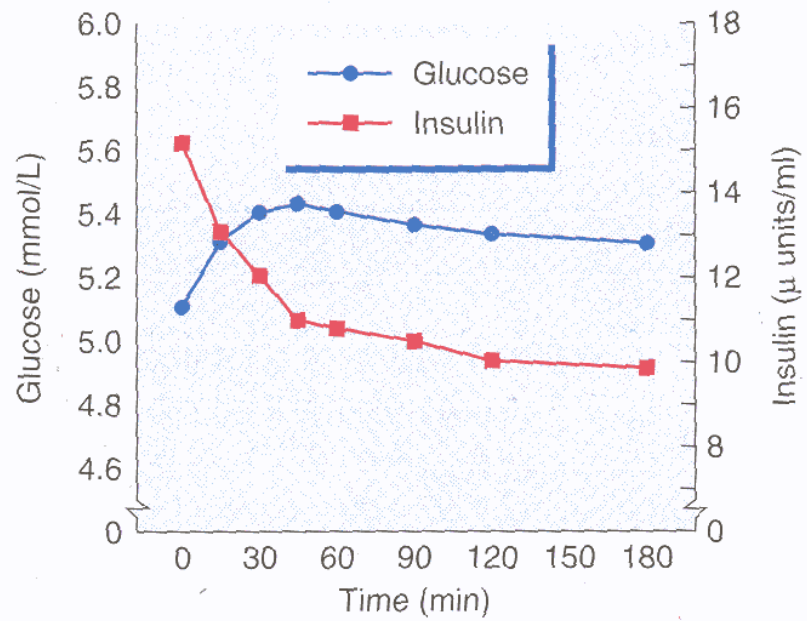
Insulin-like growth factor (IGF) has a similar molecular structure to insulin and is stimulated by the same mechanisms that produce HGH. IGF is a peptide hormone produced in the liver and supports the function of HGH to repair protein damaged during exercise, which makes it an important hormone for promoting muscle growth.

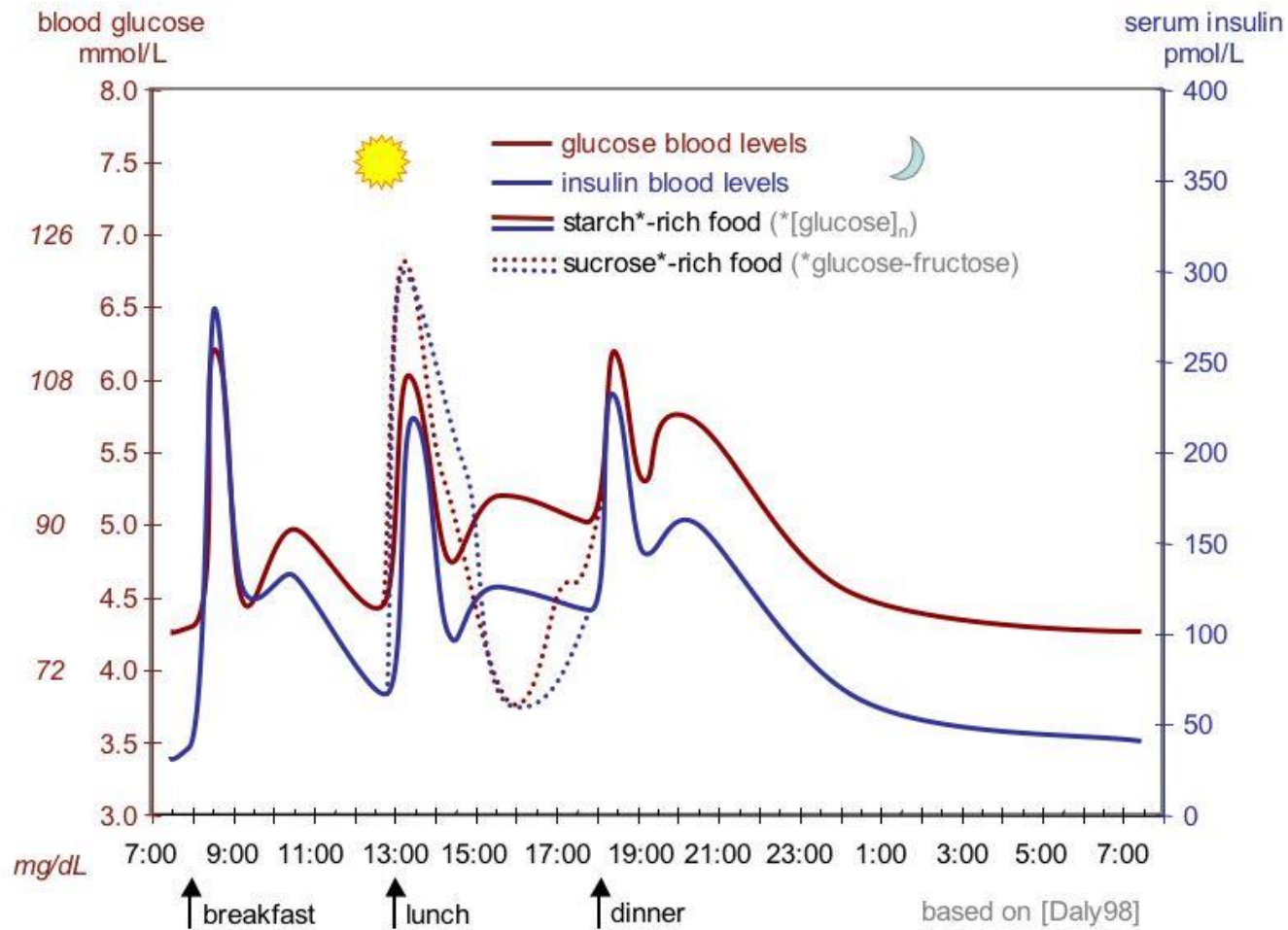
## What about insulin levels during exercise?

Why? 1) GLUT4 transporter  $\uparrow$  glucose uptake  
2) Epinephrine & norepinephrine inhibit insulin release







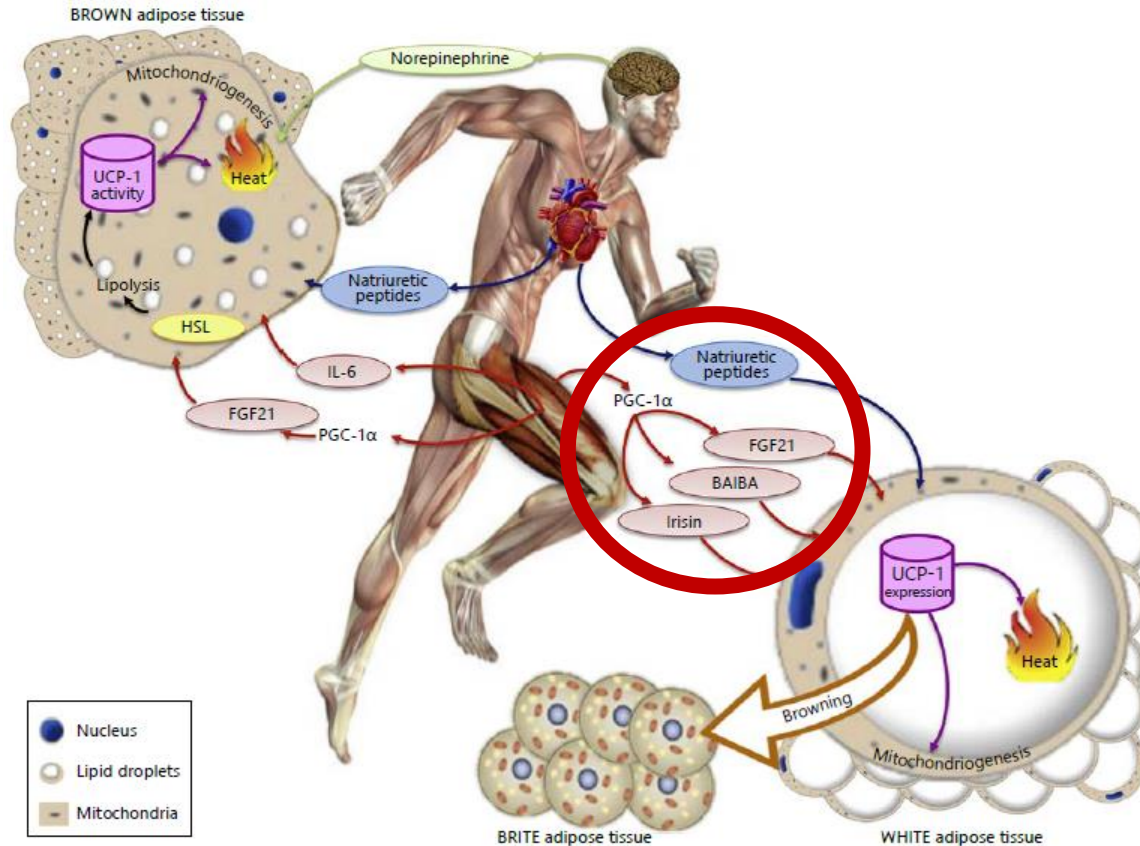


# Hormones and exercise

## ***Brain-derived Neurotrophic Factor***

Brain-derived neurotrophic factor (BDNF) is a neurotransmitter that helps stimulate the production of new cells in the brain. The production of BDNF is closely related to the production of HGH and IGF—the same exercises that elevate levels of those hormones also increase amounts of BDNF. High-intensity exercise can stimulate anabolic hormones for muscle growth while elevating levels of BDNF, which can help improve cognitive function.

# PHYSICAL EXERCISE ACTIVATES BAT



# Hormones and exercise

Understanding how exercise influences the hormones that control physiological functions can assist you in developing effective exercise programs. **Hormones have both short- and long-term responses to exercise.** In the acute phase immediately post-exercise, testosterone (T), HGH and IGF are produced to repair damaged tissue. Over the long-term, there is an increase in the receptor sites and binding proteins, which allow T, HGH and IGF to be used more effectively for tissue repair and muscle growth. For clients who want muscle growth, the levels of T, HGH and IGF are produced in response to the amount of mechanical stress created during resistance-training exercises. Moderate to heavy loads performed until momentary fatigue generate high levels of mechanical force, which creates more damage to muscle protein, which signals the production of T, HGH and IGF to repair protein, which results in muscle growth.

# Hormones and exercise

The increase in serum testosterone levels generally observed with intense, short-term exercise remains unexplained since most investigators have not reported any increase in the levels of luteinizing hormone, the pituitary glycoprotein most responsible for testicular steroidogenesis. Hemoconcentration and decreased metabolic clearance have been suggested as mechanisms to explain the exercise-associated testosterone increase. Such non-specific mechanisms should apply to other steroid hormones as well as to testosterone. To investigate whether the exercise-induced changes in other steroid hormones were similar to that of testosterone, we measured serum levels of testosterone, androstenedione, dehydroepiandrosterone, and cortisol as well as gonadotropins, luteinizing hormone and follicle-stimulating hormone, and prolactin at 5-15 min intervals throughout progressive maximal intensity exercise on a cycle ergometer. Significant increases were observed with all hormones with exercise. The increase in serum testosterone began prior to exercise, peaked at 20 min after the beginning of exercise, and fell to baseline within 10 min. The serum luteinizing hormone increase was synchronous with that of testosterone, suggesting that gonadotropin stimulation was not responsible for the testosterone increment. The increments in serum cortisol, androstenedione, dehydroepiandrosterone, and prolactin levels were simultaneous but began 25-30 min after that of testosterone in all subjects. These findings, therefore, suggest that, contrary to previous evidence, the exercise-associated increase in serum testosterone results predominantly from a specific mechanism, presumably involving increased testicular production without gonadotropin stimulation.