CANADIAN ACADEMY OF SPORTS NUTRITION

Let's Excel Together

Lecture 85:

Endocrine System and Exercise

Hormonal Changes During Exercise and Playing Sports

Part 1

Copyright Protection:

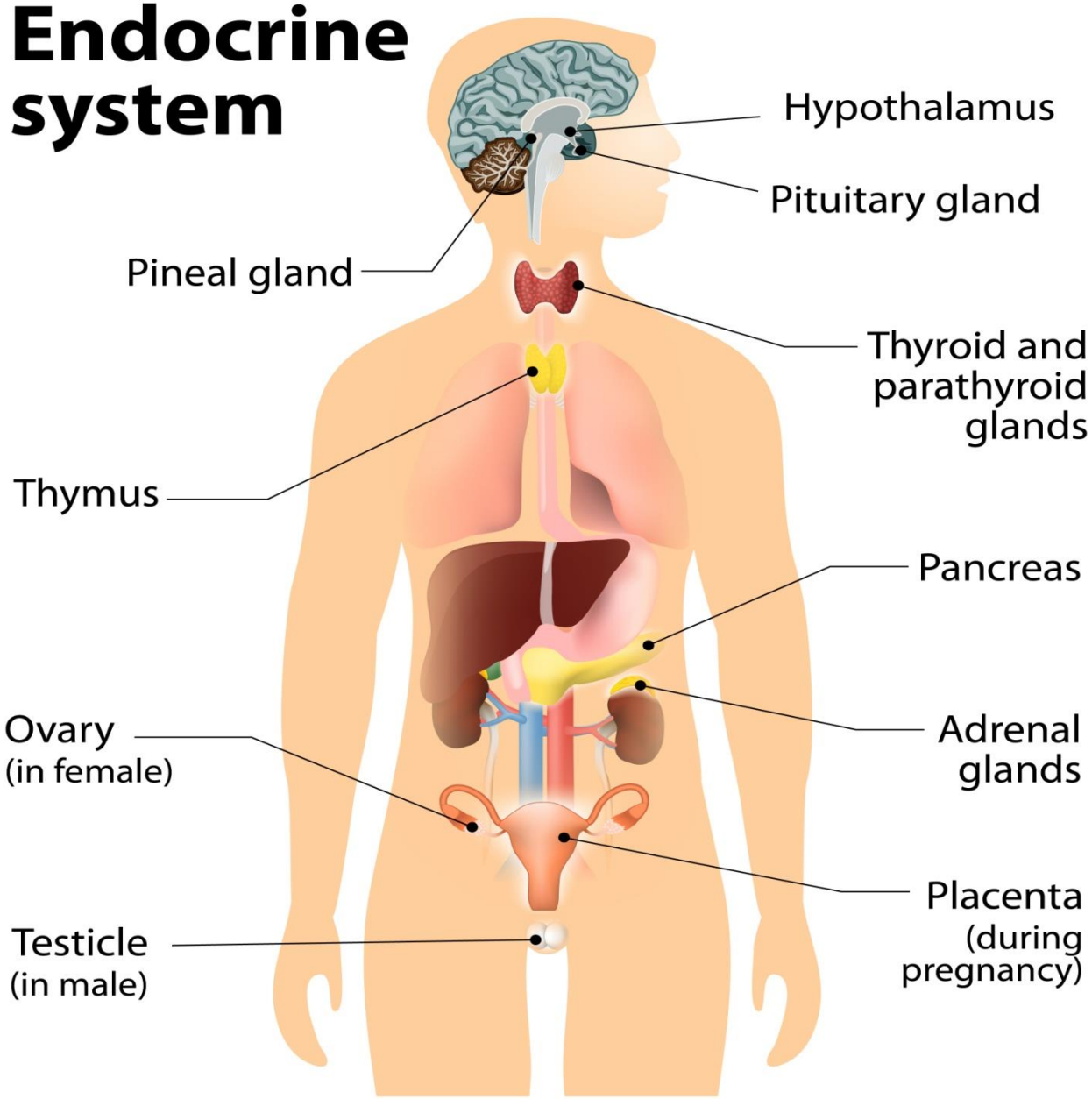
Endocrine System:

- **The endocrine system consists of few glands that integrate and regulate bodily functions to stabilize the internal environment by secreting hormones.**

- **The endocrine system is evaluated primarily by measuring hormone concentrations.**

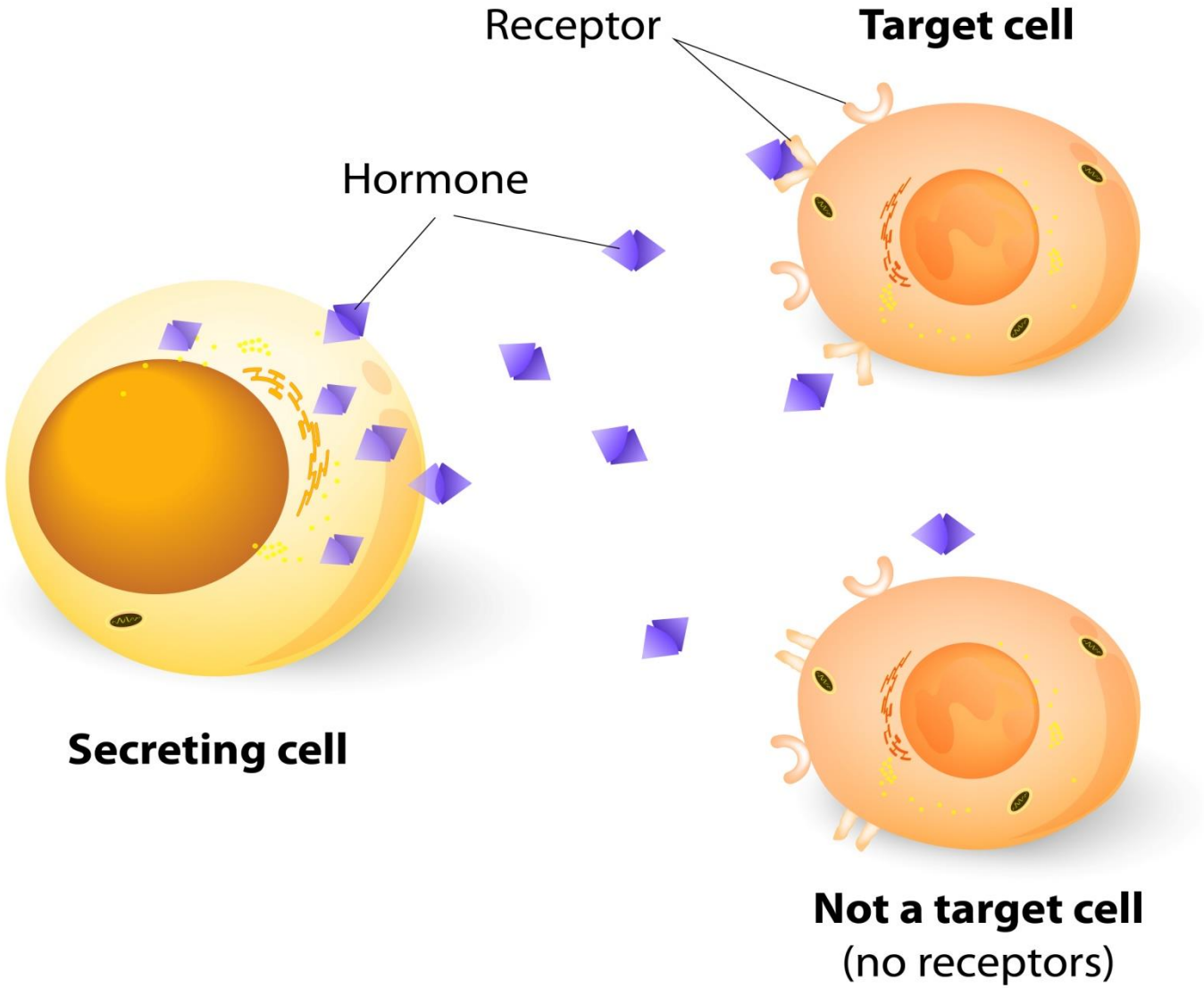
- **This system is in close relationships with the immune and nervous systems.**

Endocrine system

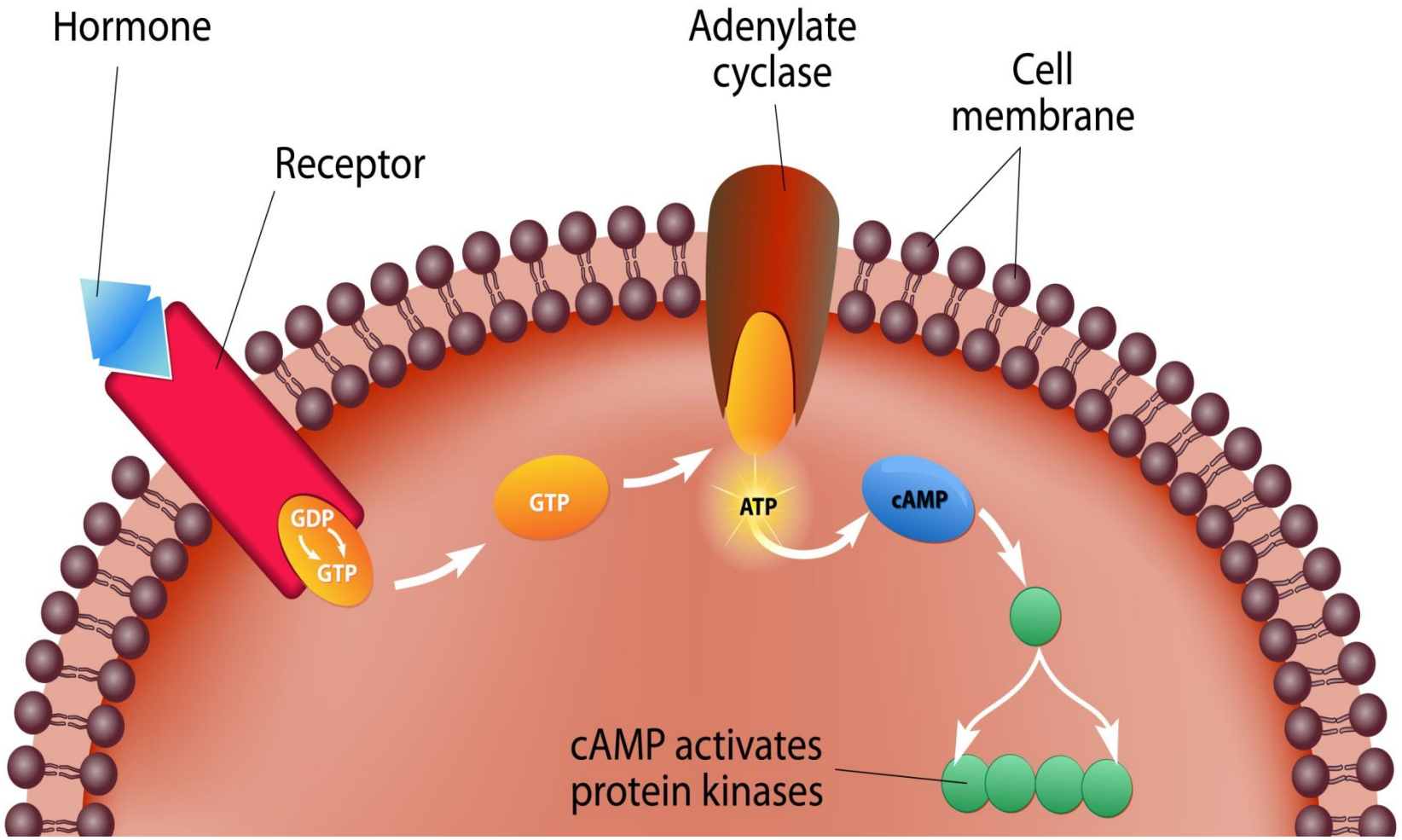


Hormones

- **Hormones are chemical substances that are produced by specific glands, enter the bloodstream for transport throughout the body, target specific cells or organs, and alter their metabolism.**


Receptor
Target cell
Hormone
Secreting cell
Not a target cell
(no receptors)

HORMONE : MECHANISM OF ACTION



Functions of The Hormones:

- **Activate enzyme systems.**
- **Alter cell membrane permeability.**
- **Trigger muscle contraction and relaxation.**
- **Affect metabolism of macronutrients.**
- **Initiate cellular secretion.**
- **Determine how the body respond to physiologic and psychological stresses.**

Glands

Endocrine glands:

- **Have no ducts.**
- **Secret hormones into extracellular spaces. Then hormones diffuse into blood.**

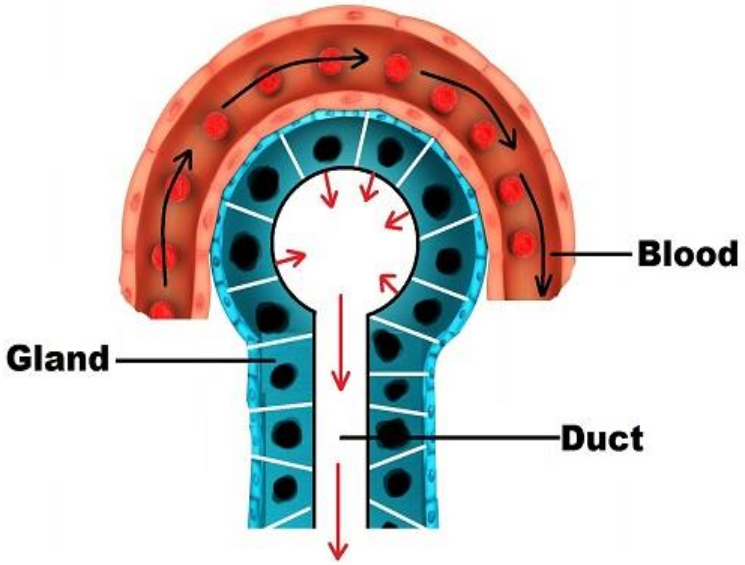
Exocrine glands:

- **Have ducts that carry substances to a specific section or surface.**

Types of Glands:

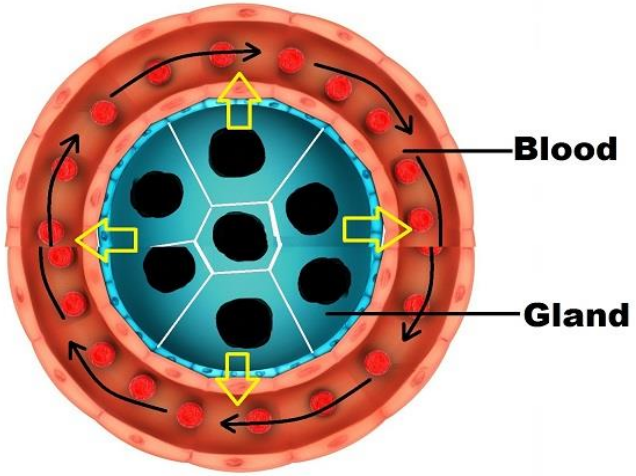
Exocrine:

- Ducts
- Lumen and surface
- Sweat, Sebaceous, Lacrimal, Salivary, Mammary, Pancreas



Endorince:

- No ducts
- Directly to blood.
- Pineal, pituitary, Thyroid, Parathyroid, Testicles, Pancreas



Hormones

Paracrine:

- Secreted into interstitial spaces.
- Have a shorter half life.
- Neurotransmitters and prostaglandins

Telecrine:

- Secreted into blood.
- Have a longer half life.
- Endocrine and GI hormones

Nature of Hormones:

Hormones are divided into five majors classes:

1) Amino acid derivatives: dopamine, catecholamines, and thyroid hormones.

2) Small neuropeptides: GnRH, TRH, somatostatin, and vasopressin.

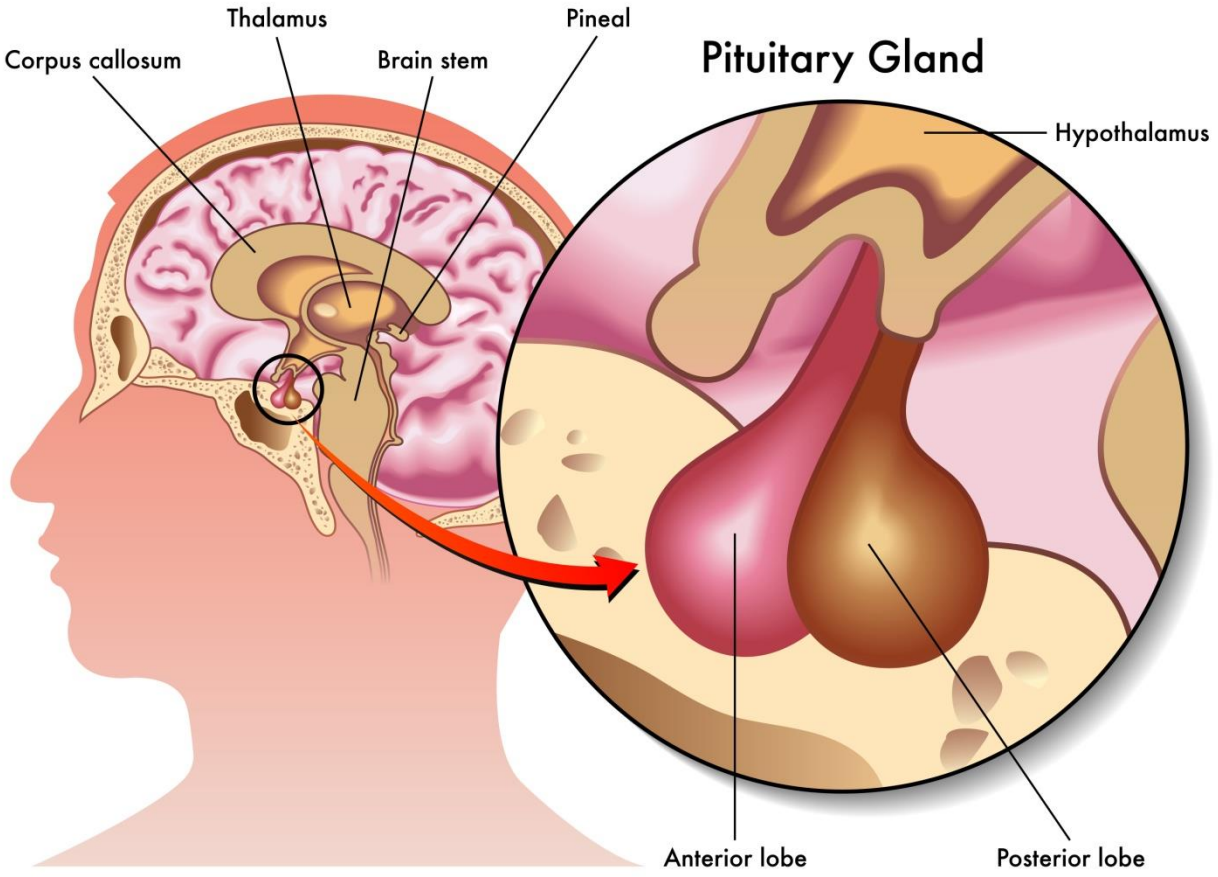
3) Large proteins: insulin, LH, FSH, and PTH.

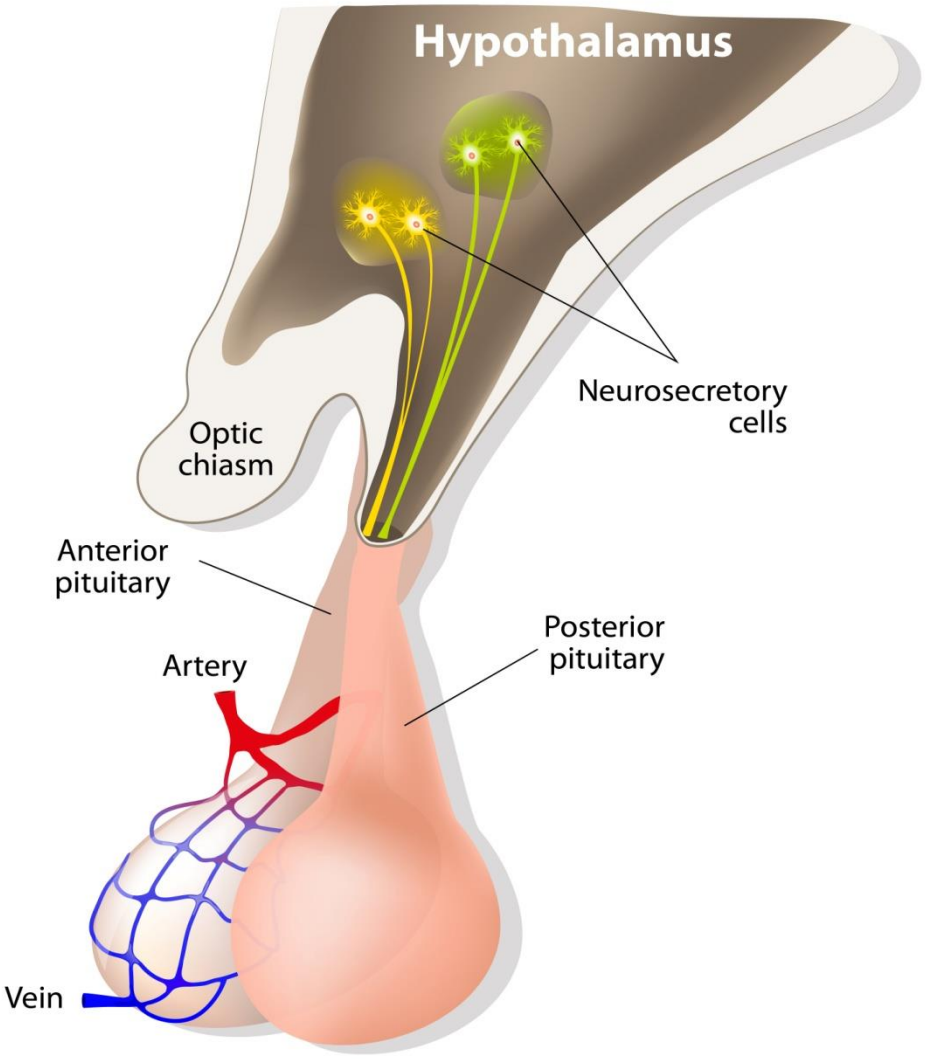
4) **Steroid hormones:** testosterone, estrogen, and cortisol.

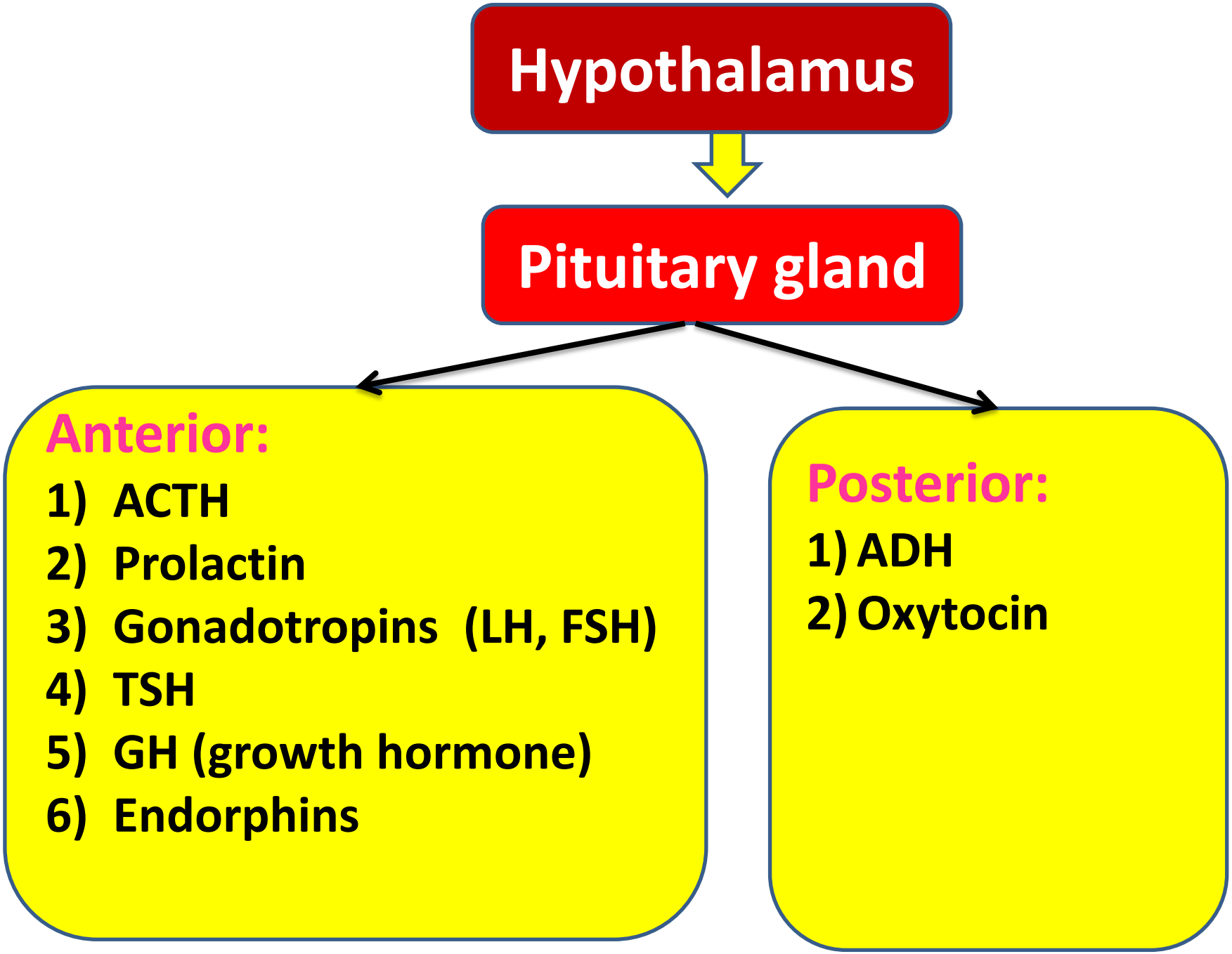
5) **Vitamin derivatives:** vitamin D and vitamin A.

Water Soluble	Lipid Soluble
Receptor in cell membrane	Receptor inside cell
Examples: - Insulin - Glucagon - Catecholamines	Examples: - Steroids. - Calcitriol. - Thyroid hormones. - Vitamins A and D.

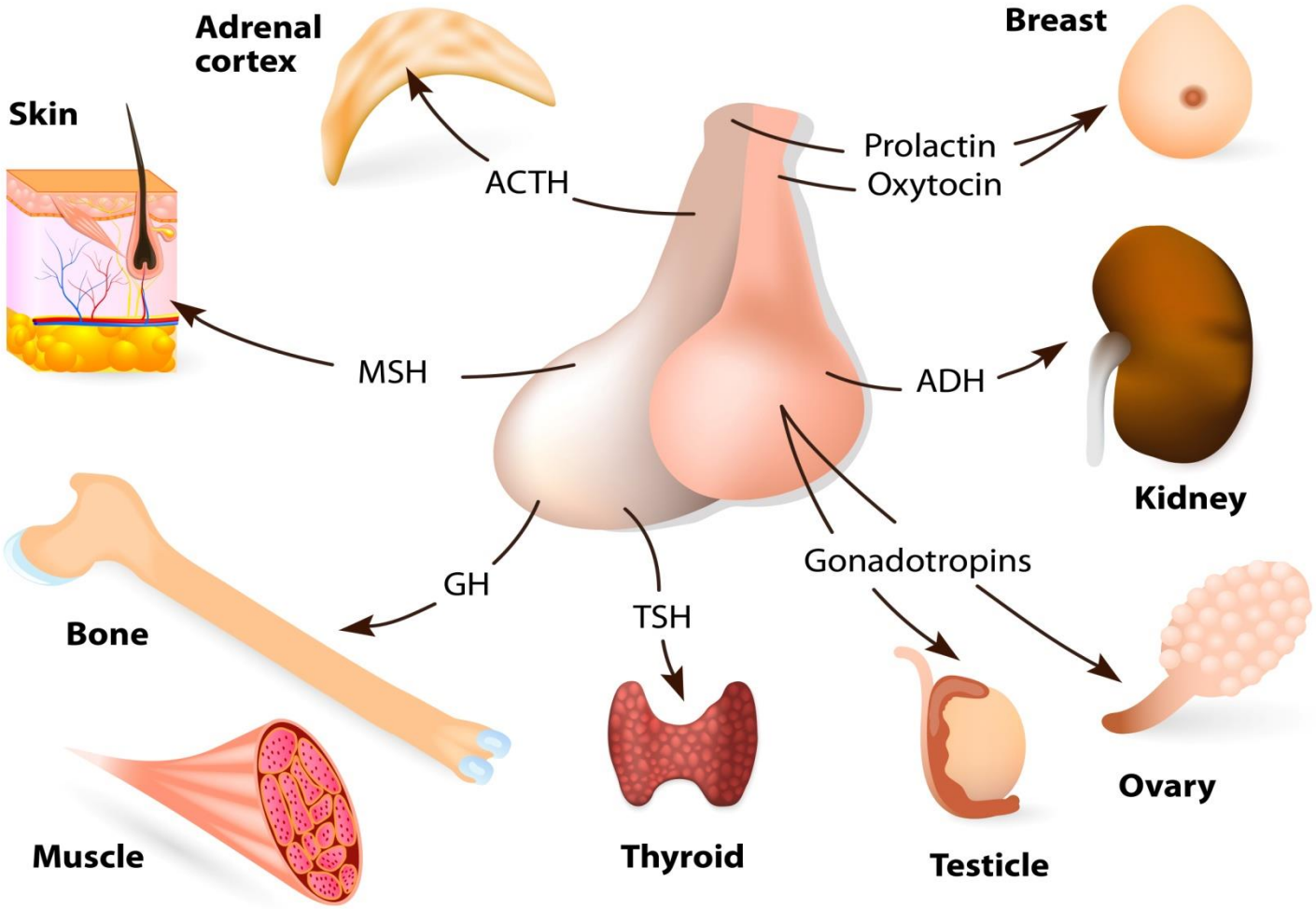
Pituitary Gland:




Hypothalamus
Neurosecretory cells
Optic chiasm
Anterior pituitary
Posterior pituitary
Artery
Vein


Hypothalamus
Pituitary gland
Anterior:
1) ACTH
2) Prolactin
3) Gonadotropins (LH, FSH)
4) TSH
5) GH (growth hormone)
6) Endorphins
Posterior:
1) ADH
2) Oxytocin

PITUITARY GLAND



The following hormones will be discussed during this lecture:

- **Growth Hormone (GH).**
- **TSH.**
- **Testosterone.**
- **Insulin – Like Growth Factors (IGFs).**

Growth Hormone (Somatotropin):

The metabolic effects of GH are biphasic:

- **Insulin – like effects (Indirect actions):**
- **Anti – insulin effects (Direct actions):**

Insulin – Like Effects (via IGF – I):

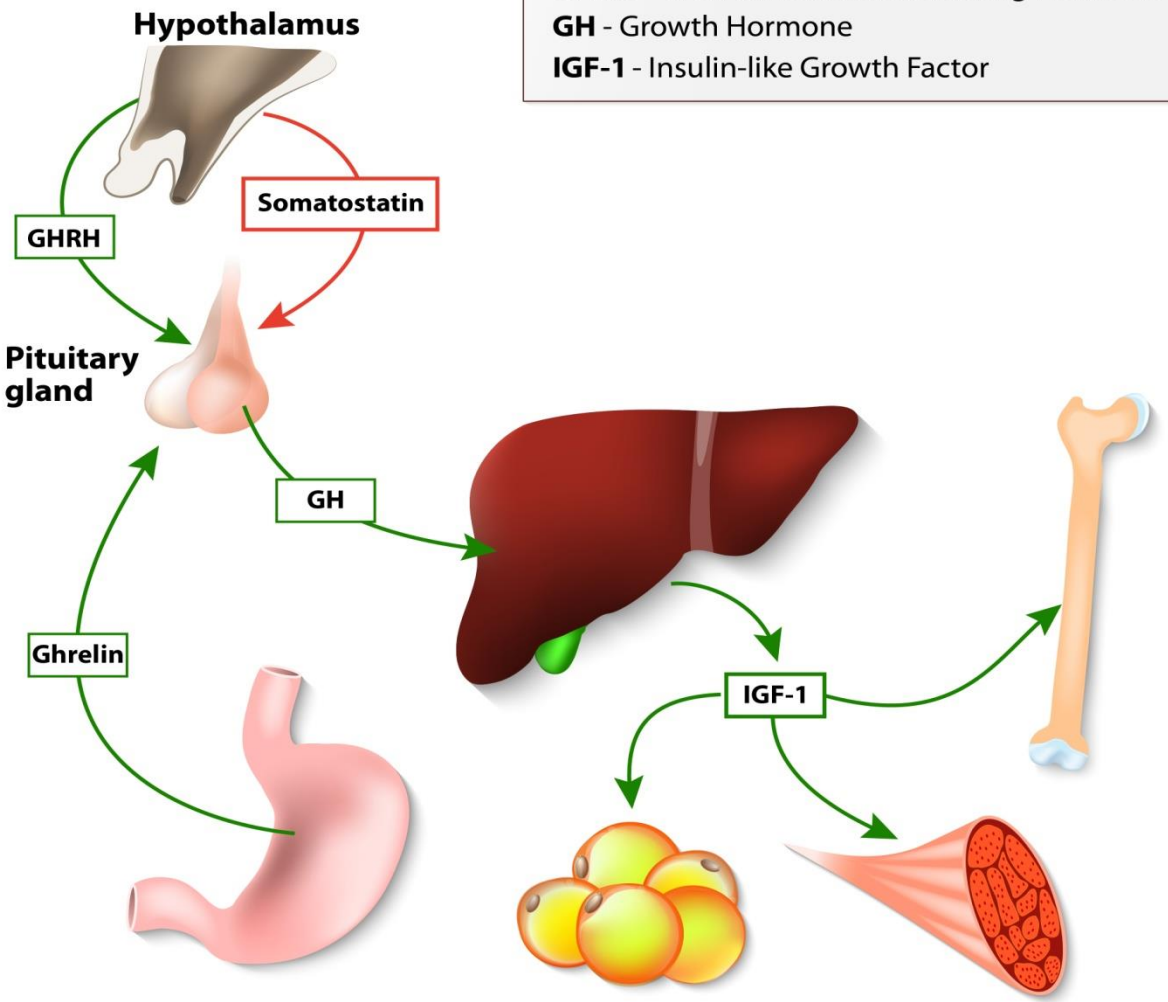
- Increasing glucose uptake in muscles and fat.

- Stimulating amino acids uptake and protein synthesis in the liver and muscles.

- Inhibiting lipolysis in adipose tissues.

GROWTH HORMONE

GHRH - Growth Hormone Releasing Hormone
GH - Growth Hormone
IGF-1 - Insulin-like Growth Factor



- **Anti - Insulin Effects (occur several hours later):**

- Glucose uptake and utilization are inhibited, causing blood glucose to rise.

- Lipolysis increases, causing blood free fatty acids to rise.

GH and Physical Activities:

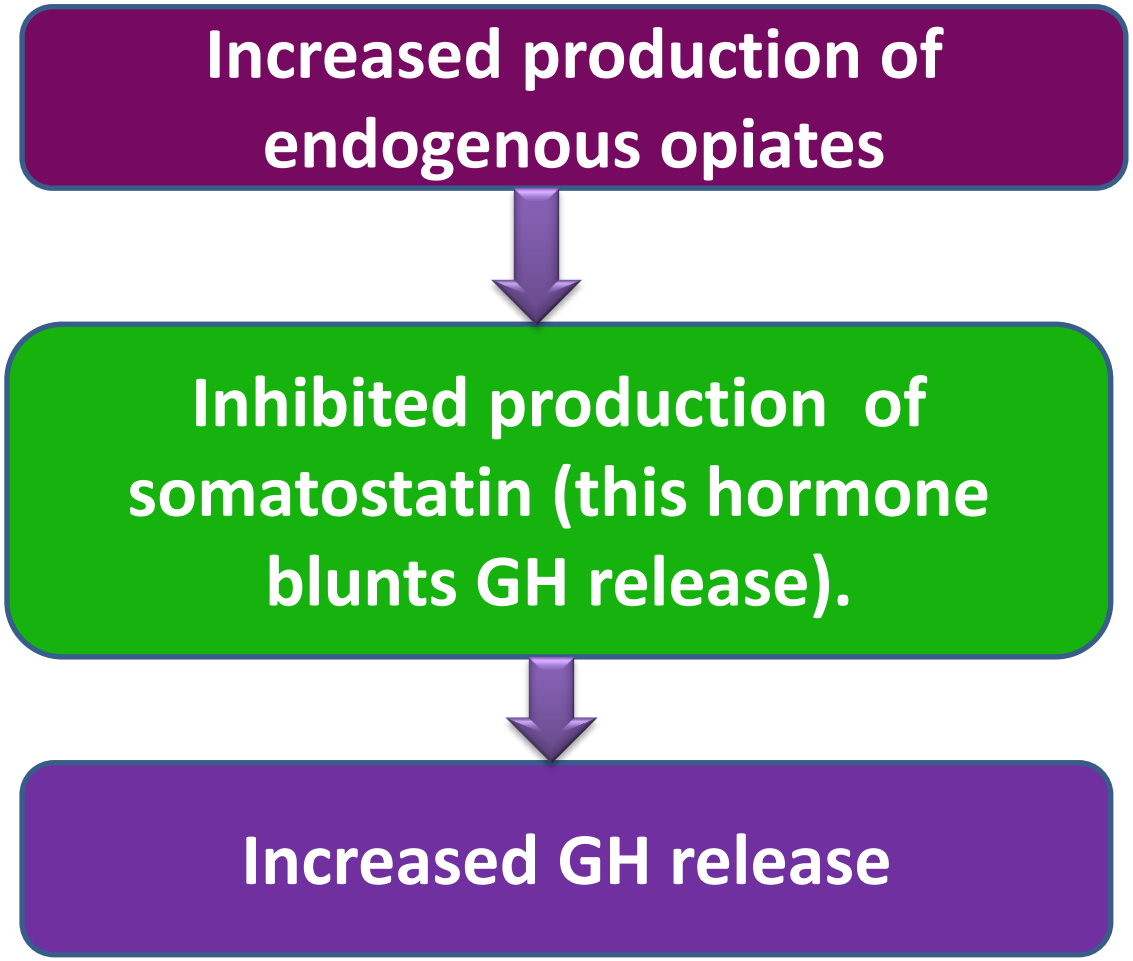
- **Exercise stimulates a sharp rise in GH pulse and the amount of hormone secreted per pulse (GH surge).**

- **This occurs especially within 30 minutes after exercise, which is known as "*anabolic window*".**

How Exercise Increases GH:

- **The exact mechanism is unknown.**
- **Many theories have been suggested.**
- **Blood levels of lactic acid, pyruvate, and alanine and body temperature have no association with GH release.**
- **Two most commonly accepted theories are:**

- **1) Exercise – induced hypoglycemia.**
- **2)**



- **Resistance training affects GH release more than aerobic training.**

- **Few studies show that GH release during a resistance training depends on:**

- **Muscle mass involved.**
- **Type of muscle contraction (greater response during concentric than eccentric muscle contractions).**
- **Intensity of exercise.**
- **Rest between sets.**
- **Total exercise volume (greater response with multiple sets).**

- **When exercising to exhaustion, trained athletes and sedentary individuals show similar response in increasing GH level.**

- **However, GH levels in amateurs and sedentary individuals stay “elevated” much longer than trained athletes.**

- **Recent studies have focused on the association between potassium level and post – exercise GH rise.**

Thyroid Stimulating Hormone (TSH):

- This hormone is released from the pituitary gland and affects the thyroid gland controlling the production of thyroid hormones (T3 and T4).

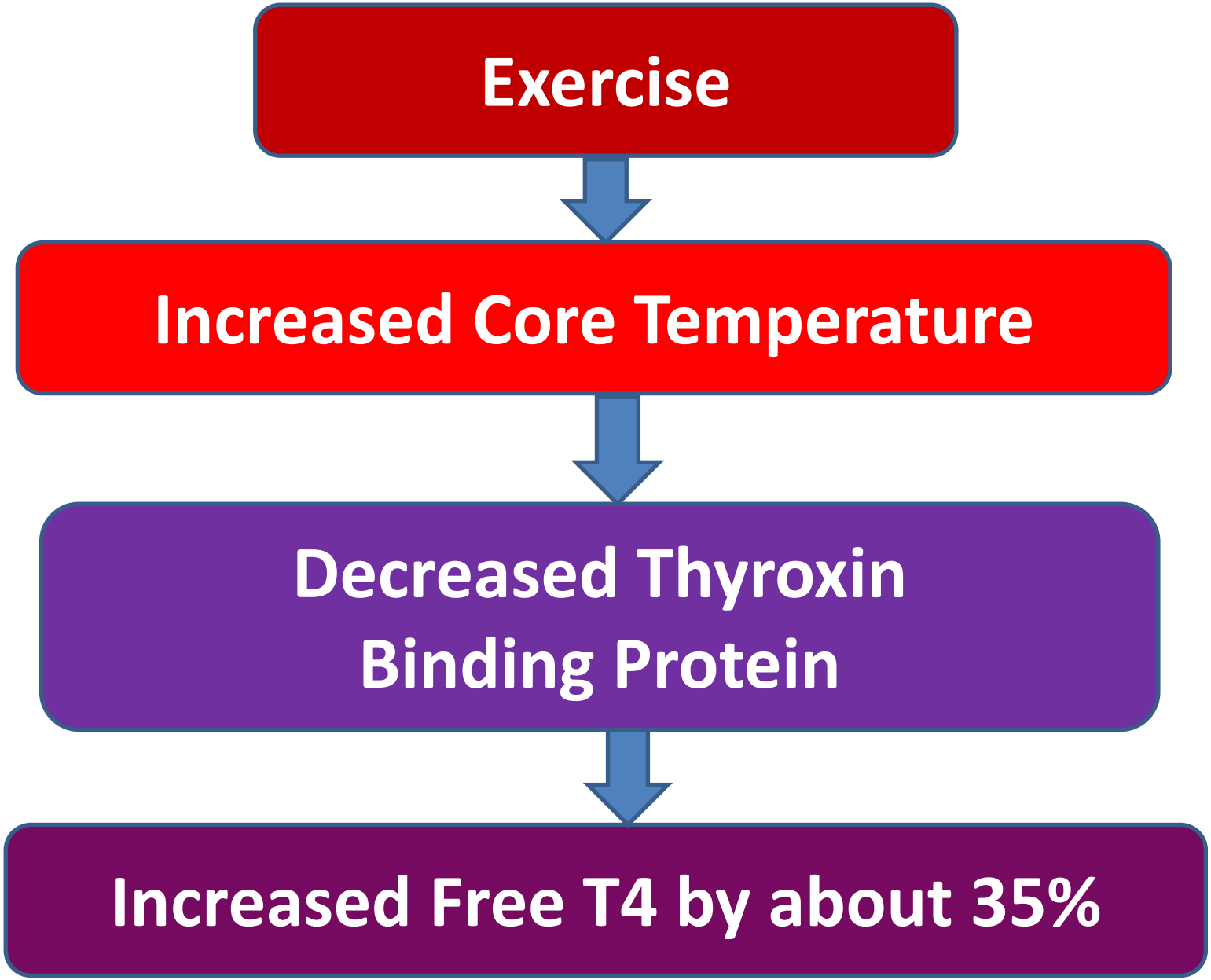
- Calcitonin is another hormone produced by thyroid gland , but not controlled by TSH.

- Thyroid hormones have a key role in body metabolism.

- **T4 raises metabolism of all cells except in the brain, spleen, testicles, uterus, and thyroid gland itself.**

- **Increased production of T4 could increase BMR up to fourfold.**

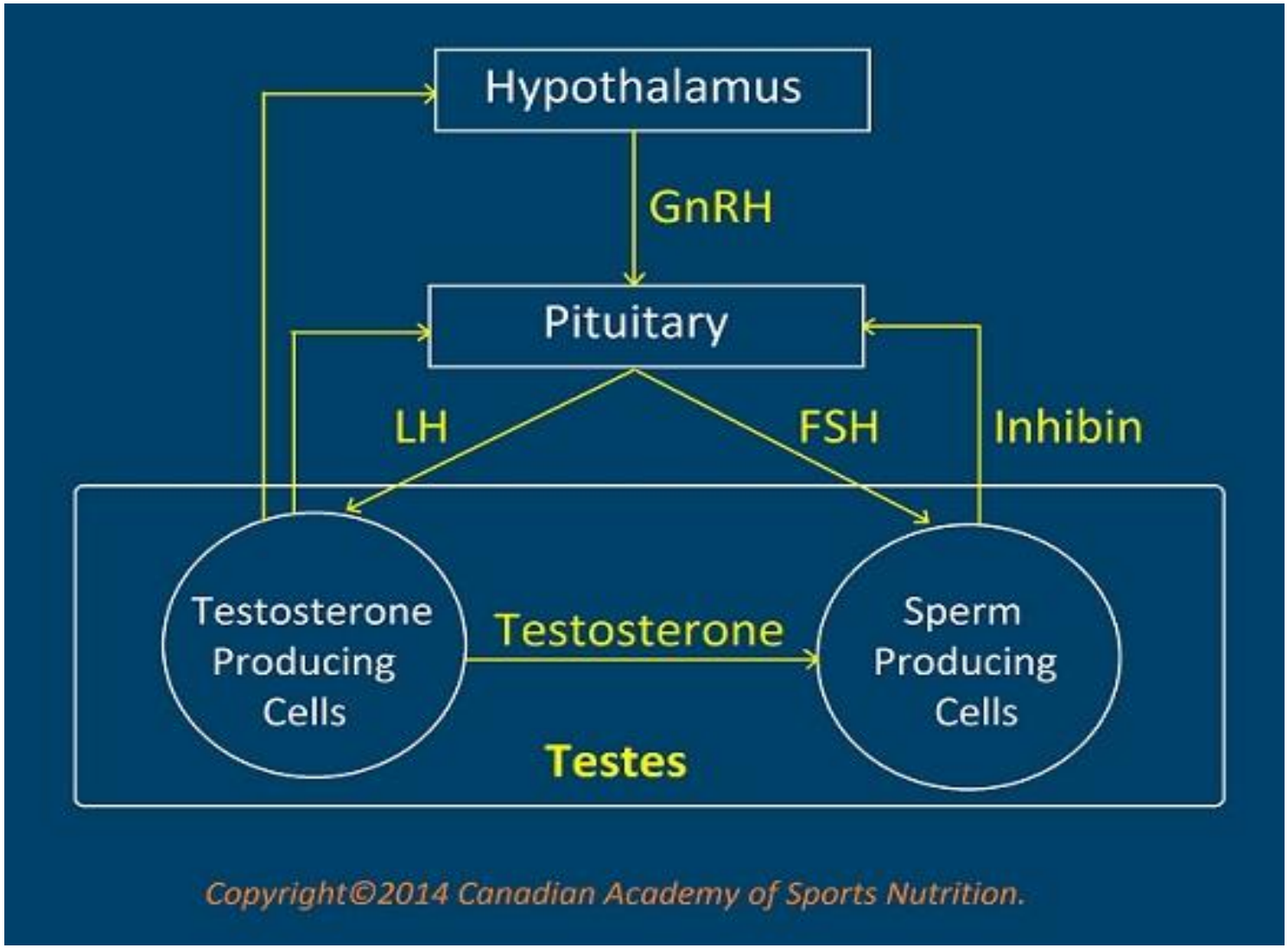
- **What happens to thyroid hormones during exercise?**


Exercise
Increased Core Temperature
Decreased Thyroxin Binding Protein
Increased Free T4 by about 35%

In summary:

- **TSH: no known training effect.**
- **Reduced total T3.**
- **Increased free T4.**
- **Increased turnover of T3**

Testosterone:



- **In general, plasma testosterone concentration increases with physical activity.**

- **The exact mechanism is unknown. Possible mechanism are:**

- **Increased production capacity of Leydig cells.**
- **Increased production of lactic acid.**
- **Increased production of epinephrine.**
- **Increased production of DHEA, a precursor of testosterone.**
- **Alteration in SHBG (sex hormone binding globulin).**

- **Few studies indicate that <u>afternoon exercise</u> sessions generate greater response than those of morning sessions.**

- **Factors that may affect exercise – induced testosterone raise:**

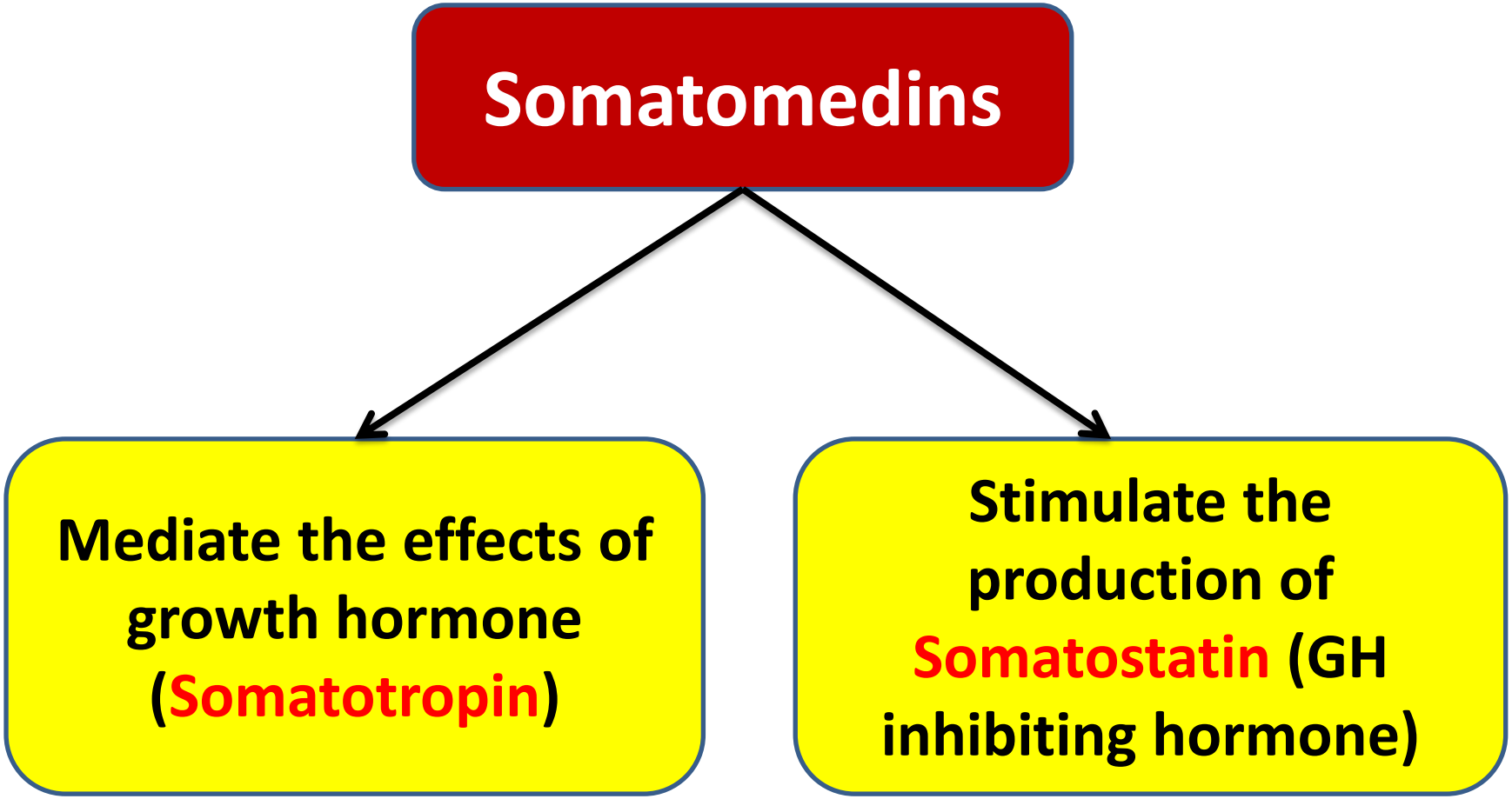
- **Age.**
- **Gender.**
- **Nutritional status.**
- **Type of exercise:**
    - **muscle mass involved.**
    - **intensity and volume of exercise.**

Insulin-Like Growth Factors (Somatomedins):

- They are produced by the liver and mediate the effects of GH.

- In response to GH stimulation, the liver synthesizes IGFs which requires 8 – 30 hours:

- Somatomedin A: IGF - II
- Somatomedin B:
- Somatomedin C: IGF - I


Somatomedins
Mediate the effects of growth hormone (Somatotropin)
Stimulate the production of Somatostatin (GH inhibiting hormone)

- **Produced mostly by the liver, IGF-I is a compound that mediates the effects of growth hormone.**

- **Indirect effects of GH are attributed to IGF-I. It is IGF-I, not GH itself, that promotes growth and development, meaning that growth hormone works through IGF-I.**

- **Thus, IGF-I injections have the same impact as GH.**

- **The two hormones that can elevate the level of IGF-I are growth hormone and DHEA.**

Effects of IGF – I:

- **1) IGF-I regulates the anabolic effects of GH. It goes to the muscles and ligaments where it develops lean tissue.**

- **2) By traveling to the fat cells, IGF-I burns fat. Subsequently, it increases lean body mass and decreases fat—the two most wanted effects by athletes, particularly bodybuilders.**

- **3) The ability of IGF-I to help repair peripheral nerve tissue damaged by injury or illness is under extensive investigation.**

- **4) Because growth hormone secretes in bursts and is rapidly removed by the liver and other tissues, it is medically difficult to measure its level accurately.**

- **5) Compared to GH level, the level of IGF-I is relatively stable. So IGF-I is measured as a screening test for GH deficiency. Also, IGF-I is a good marker of excessive secretion of GH and its level is high almost in all cases.**

Effects of Exercise on IGF – I:

- **Most studies indicate that IGF – I level does not change during or immediately after a resistance training. There is a "*delay*".**
- **Short term resistance training has no impact on IGF – I resting level.**
- **Resting level of IGF – I is higher than normal in long term resistance training.**


Exercise
GH Release
Liver Stimulation
Increased Production of IGF-I
- takes 8 - 30 hours
- peak value is 16 - 26 hours later

Homework:

- **1) Describe the effects of exercise on thyroid.**
- **2) Describe the effects of exercise – induced GH release.**