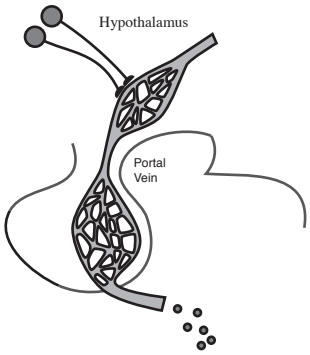
Endocrine Pathways

An Pictorial Guide to Select

Endocrine Control Systems

with examples of both

Negative and Positive Feedback Mechanisms



By Noel Ways

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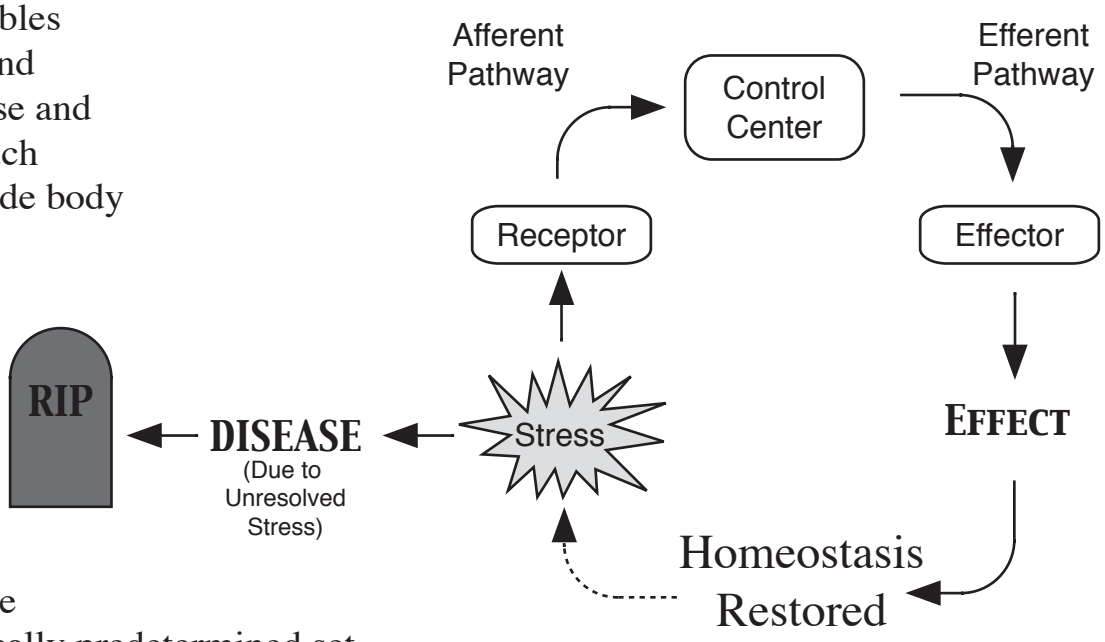
Control Paradigm
(Negative Feedback System)

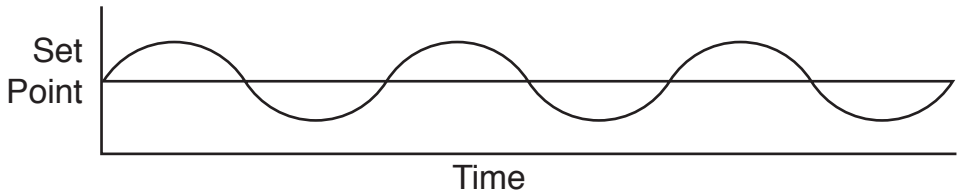


Homeostasis is the ability to control all physiological variables necessary for life and health within precise and optimal ranges. Such variables will include body temperature, blood pressure, ion and mineral concentrations, etc. Here, there will be for each variable a control center that will monitor the variable relative to a genetically predetermined set point. Should be variable be above or below the set point, a state of "stress" will have occurred, and the system will put into effect some action to rectify the "stress", and negate the initial stimulus.

A Disruption of Homeostasis will Activate the System.

System Inactivated Once Homeostasis is Restored

Such a system is called a negative feedback mechanism. And it operates by collecting information via receptors and transmitting this information to a control center by an afferent pathway. Once the information is at the control center, the information will be compared and evaluated relative to a set point. If there is a disruption of homeostasis (stress), then the control center will rectify the problem by sending a message through an efferent pathway to a particular effector that has that specific task of restoring homeostasis. Once the effector does its job, the stress is eliminated and homeostasis is restored. Here the negative feedback mechanisms negated the initial stimulus that set the system in motion.



In the diagram above, note that should the variable exceed the set point, the negative feedback mechanism will restore the variable to the set point. Should the variable go below the set point, the negative feedback mechanism will raise the variable to the set point. In a healthy scenario, each physiological variable will "hover" around the set point.

Negative Feedback Example

In response to elevated levels of Thyroxine, the Hypothalamus secretes less Thyrotropin Releasing Hormone (TRH)

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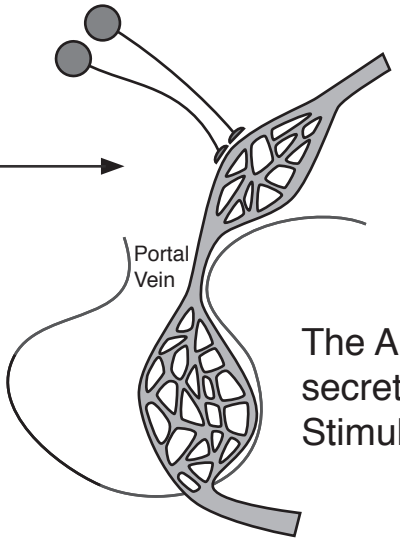
Hypothalamus secretes Thyrotropin Releasing Hormone (TRH)



The Anterior Pituitary Gland secretes less Thyrotropin Stimulating Hormone (TSH)

(-)

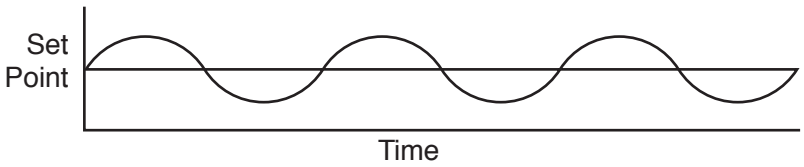
TSH

Thyroid Gland (Follicular Cells)

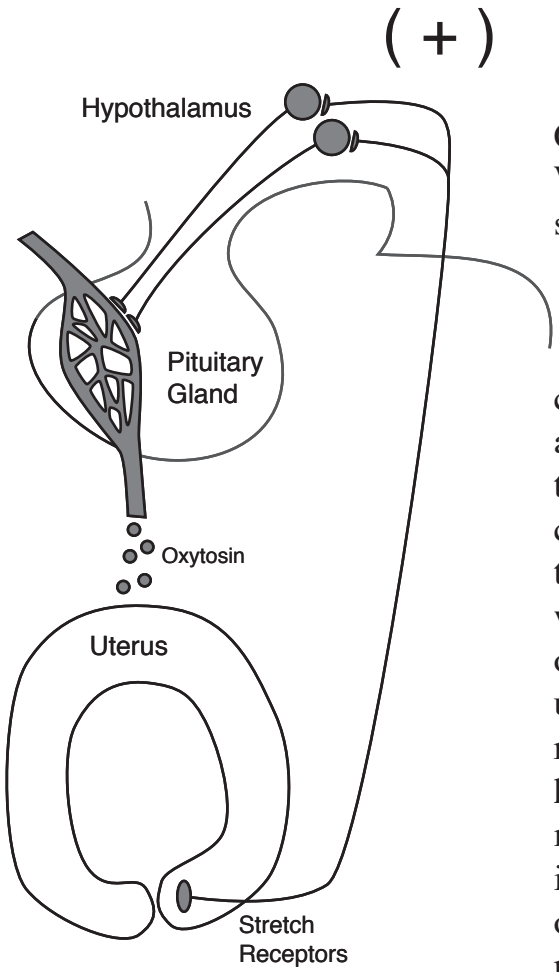
In response to TSH, Follicular Cells of the Thyroid Gland secretes Thyroxine (T4) and Triiodothyronine (T3)

Thyroxine (T4) and Triiodothyronine (T3)

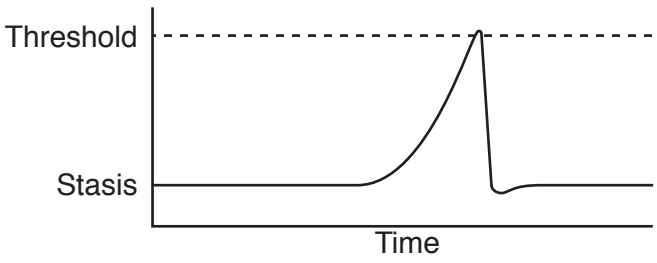
Increase in the Basal Metabolic Rate



Positive Feedback Example



Childbirth: a positive feedback mechanism. Whereas a negative feedback mechanism will serve to reduce or negate the original stimuli, a positive feedback mechanism will enhance and reinforce the original stimuli. The result will be a building process that culminates in an "explosion" or event. It is only after the event occurs that the system ceases. In this case, the initial stretching of the cervix causes local stretch receptors to send an impulse to the hypothalamus where neurosecretory cells will secrete oxytocin into the blood stream. The oxytocin will cause the myometrium of the uterus to contract to result in the stretch receptors sending more stimuli to the hypothalamus, which will yet again secrete more oxytocin. The cycle continues with ever increasing contractions as more and more oxytocin is secreted. Eventually, the pressure reaches such force that the baby is expelled (a "threshold" has been reached), and the system ceases.



Water Balance and Antidiuretic Hormone (ADH)

Thirst Sensation

Osmoreceptors in hypothalamus respond to hypertonic blood and/or decreased blood volume by secreting Antidiuretic Hormone (ADH) into the blood.

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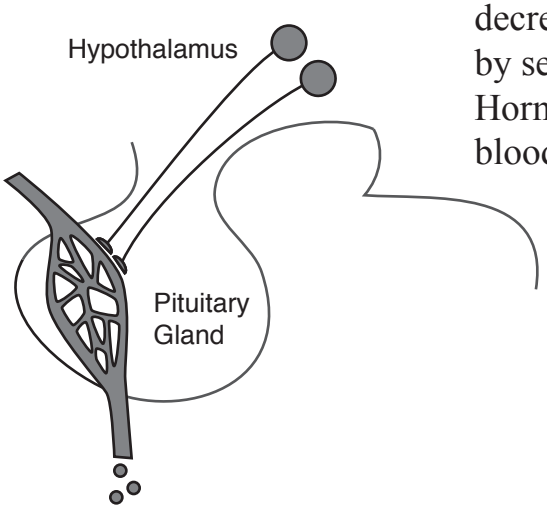
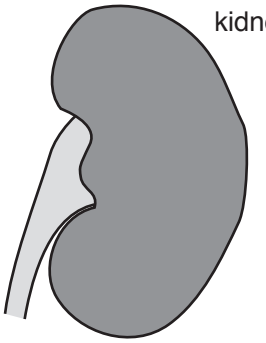
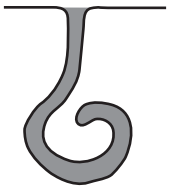




ADH

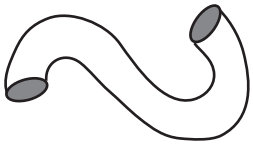
In response to elevated levels of ADH, the Distal Convoluted Tubule and Collecting ducts synthesize proteins that make the tubules permeable to water. As water flows through the tubules embedded within the salty medulla, water is reabsorbed my osmosis.

ADH



Sweat Glands secrete less sweat.

ADH



Vasoconstriction will elevate blood pressure.

Growth Hormone

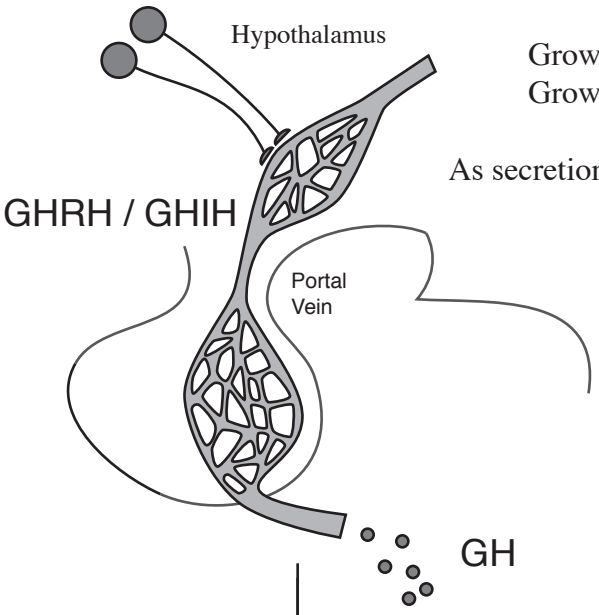
The hypothalamus controls secretion of Growth Hormone (GH) from the Anterior Pituitary by varying concentrations of:

(+ / -)

Growth Hormone Releasing Hormone (GHRH)
Growth Hormone Inhibiting Hormone (GHIH)

As secretion of GHRH increases, and GHIR decreases,

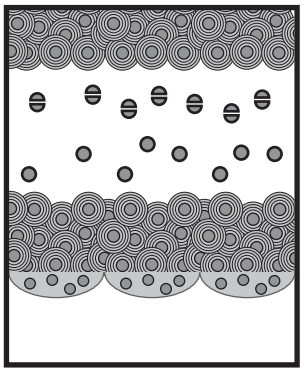
Diet and Body Maturation Process Effect Hypothalamus Control of Growth Hormone Secretion



GH

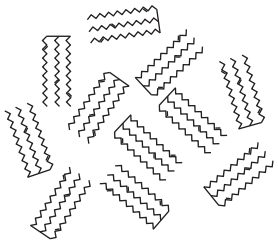
Maintain and Stimulate Growth of Epiphyseal Plates (Growth of Body Frame Occurs).

GH



Lipid metabolism increased for enhanced energy production to support growth processes.

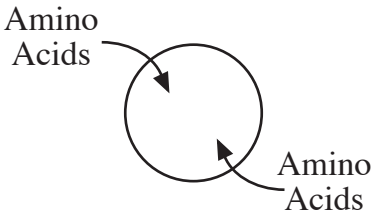
GH



β Oxidation → ATP

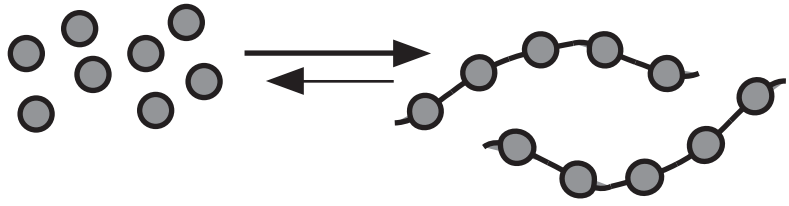
Enhanced Amino Acid Uptake by cells for Anabolism.

GH

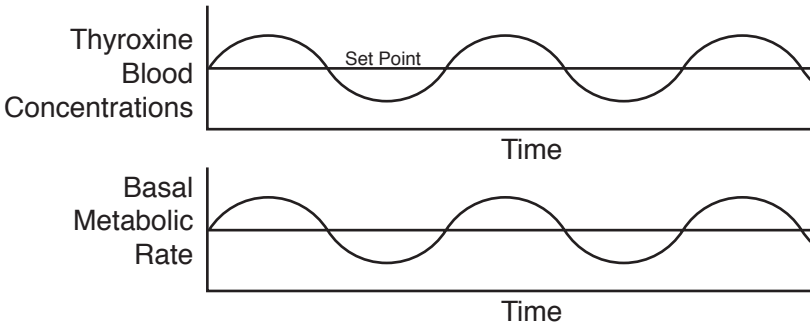


Anabolic Reactions Exceed Catabolic Reactions.

GH



Thyroxine and the Basal Metabolic Rate (BMR)



The Hypothalamus increases secretion of Thyrotropin Releasing Hormone (TRH) as Thyroxine blood concentrations diminish

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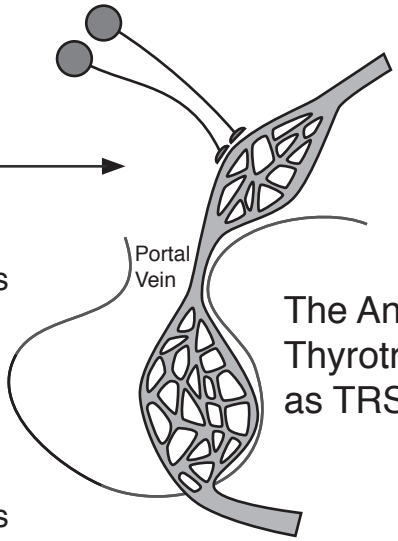
Elevated Thyroxine inhibits secretion of TRH

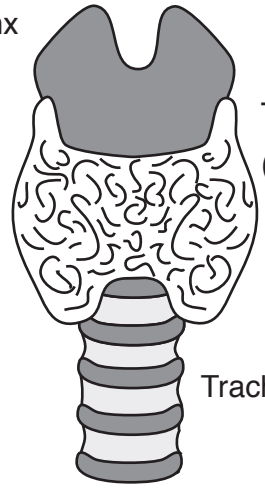
(-)

Elevated Thyroxine inhibits secretion of TSH



The Anterior Pituitary Gland secretes Thyrotropin Stimulating Hormone (TSH) as TRS increases

TSH



Thyroid Gland (Follicular Cells)

In response to TSH, Follicular Cells of the Thyroid Gland secrete Thyroxine (T4) and Triiodothyronine (T3)

Thyroxine (T4) and Triiodothyronine (T3)

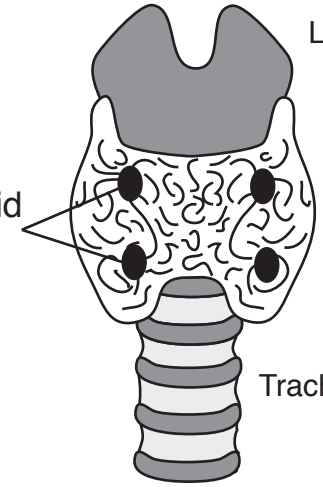
Calorigenic Effect (Increased heat production with a corresponding increase in oxygen consumption)

Increase in the Basal Metabolic Rate

Calcium Regulation in the Blood

Hypocalcemia

Hypercalcemia



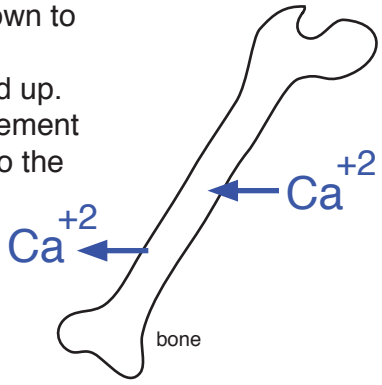
Parathyroid glands

Thyroid Gland (Parafollicular Cells)

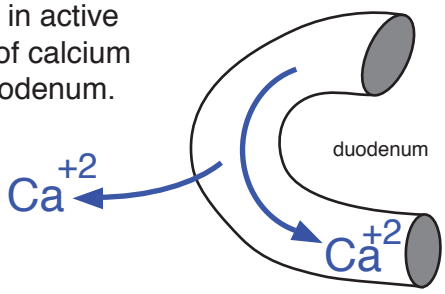
Parathyroid Hormone

Parathyroid Hormone
- stimulates osteoclasts

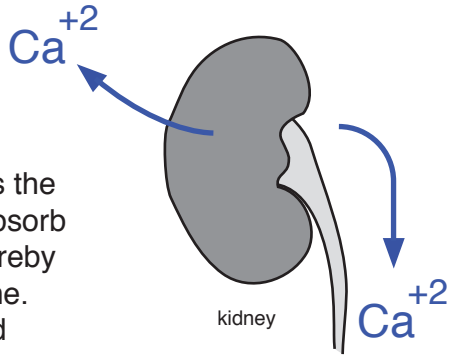
This causes bone breakdown to proceed at a faster pace that bone build up. The result is a movement of calcium from the bone to the blood.



Parathyroid hormone promotes Vitamin D activation by kidneys. This results in active absorption of calcium from the duodenum.



Parathyroid Hormone stimulates the distal convoluted tubules to reabsorb calcium back into the blood, thereby reducing calcium loss in the urine. The above effects of parathyroid hormone help to restore homeostasis!



Calcitonin

Calcitonin
- inhibits osteoclasts
- stiumlates osteoblast longevity

This results in bone buildup proceeding at a faster rate than bone breakdown. As mineralization occurs, calcium is removed from the blood.

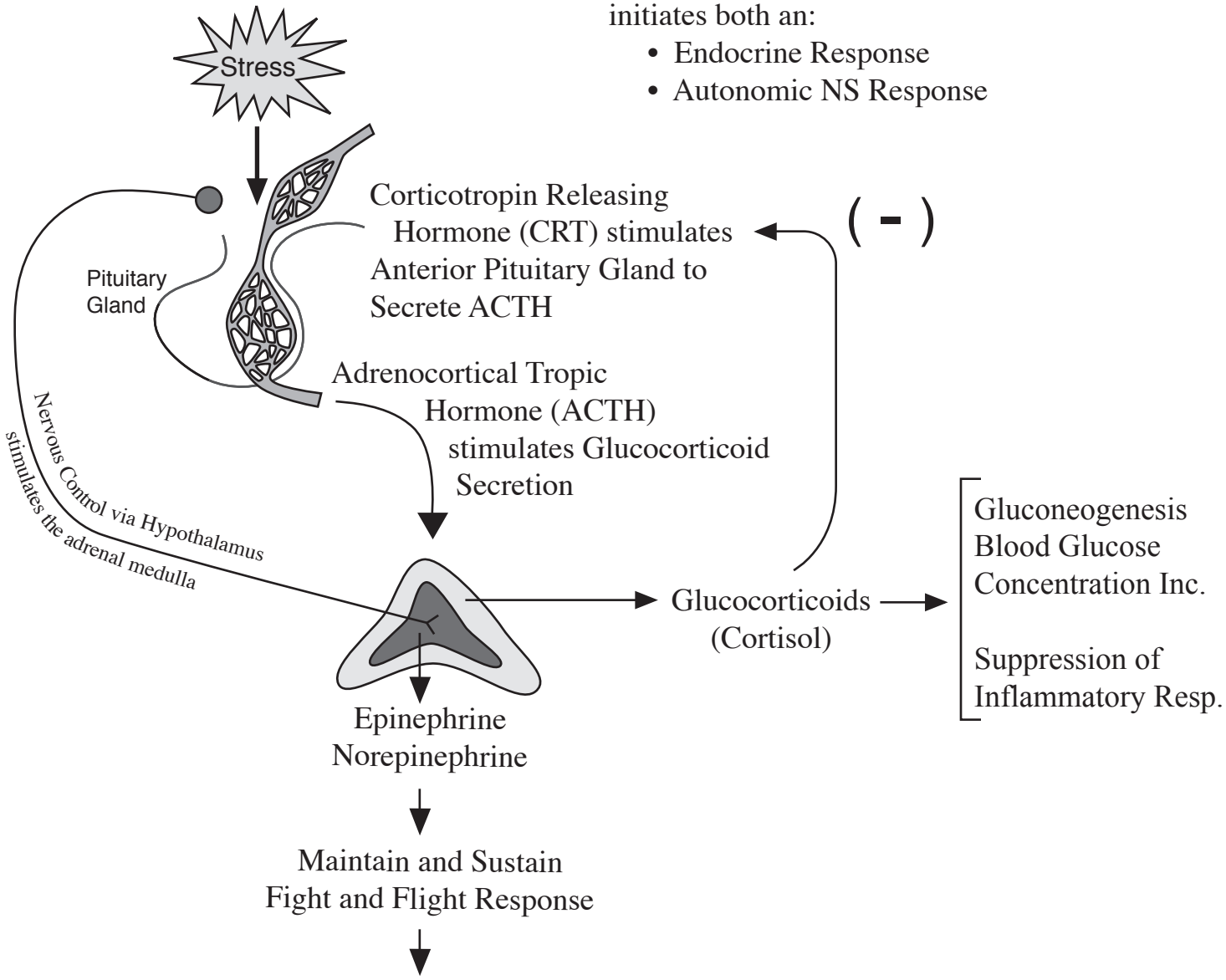
Calcitonin may decrease appetite which may decrease calcium intake indirectly

Calcitonin stimulates the excretion of calcium into the urine by the distal convoluted tubules. Therefore calcium leaves the body, and this helps to restore homeostasis.

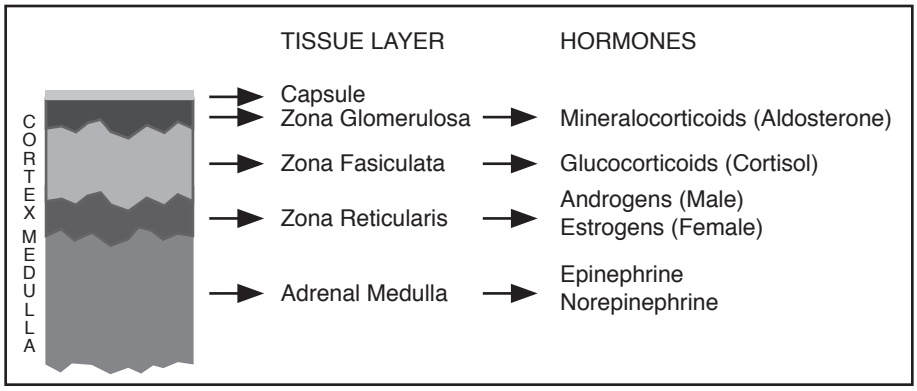
Adrenal Gland and Stress

In response to Stress, The hypothalamus initiates both an:

- Endocrine Response
- Autonomic NS Response



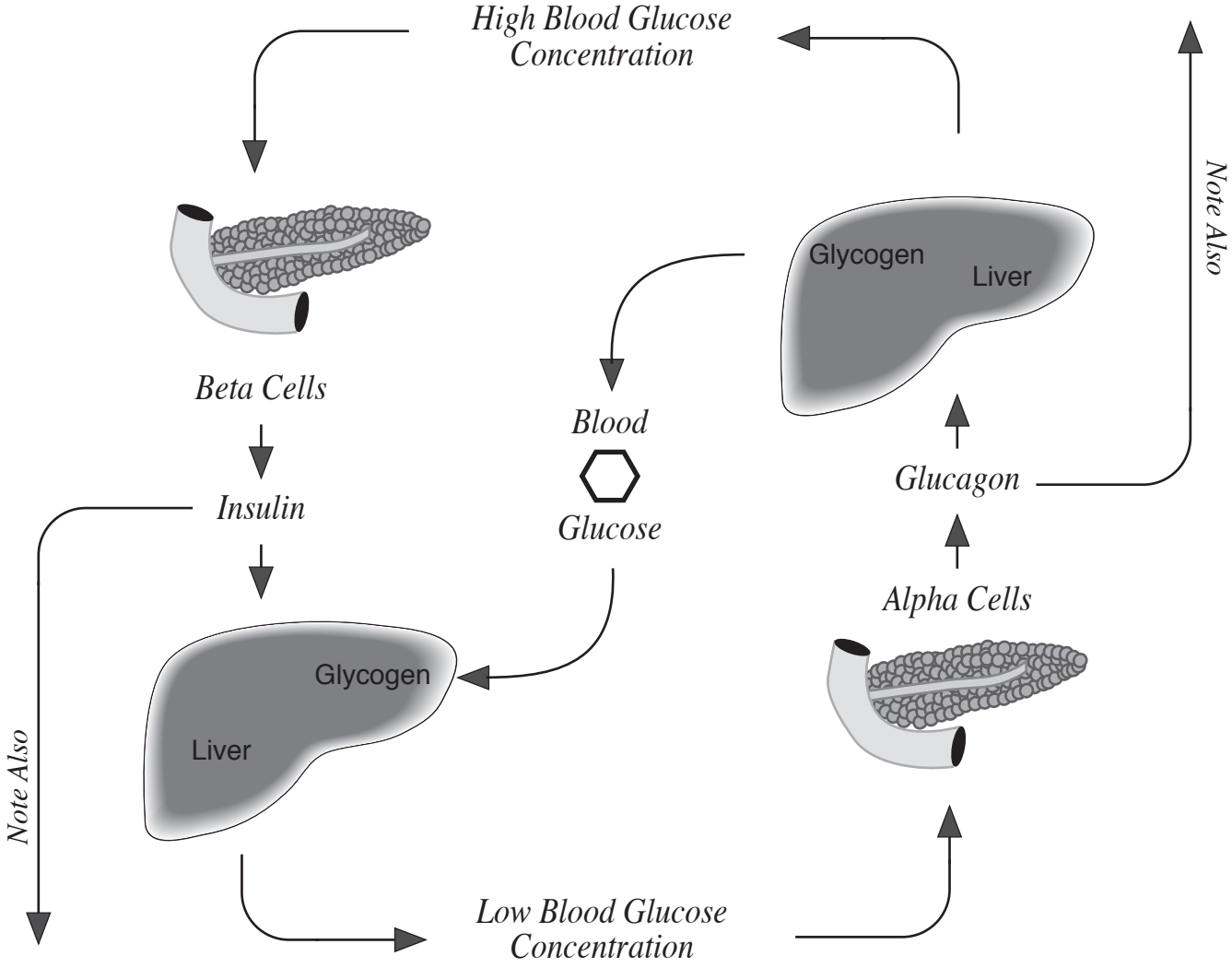
- Vasoconstriction: Increase Blood Pressure
- Cardiac Output increase (both Stroke Volume and Heart rate)
- Blood directed to Brain and Muscles, away from less critical organs
- Ventilation Rate Increase
- Bronchodilation



Glucose Regulation

Glucagon:

- Increases Glucose Production in Liver
- Increases Glycogen Breakdown in Liver and Muscle
- Increases Triglyceride Breakdown in Adipose Connective Tissue



Insulin:

- Increases Glucose uptake among several target tissues
- Increases Cellular Respiration
- Increases Glycogen Formation
- Increases Triglyceride Synthesis in Adipose Connective Tissue

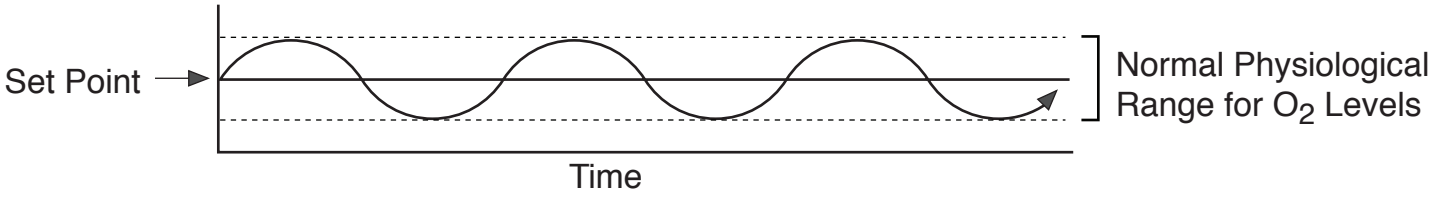
Diabetes Type I

Insufficient Insulin secreted by pancreas, therefore, target tissues do not respond.

Diabetes Type II

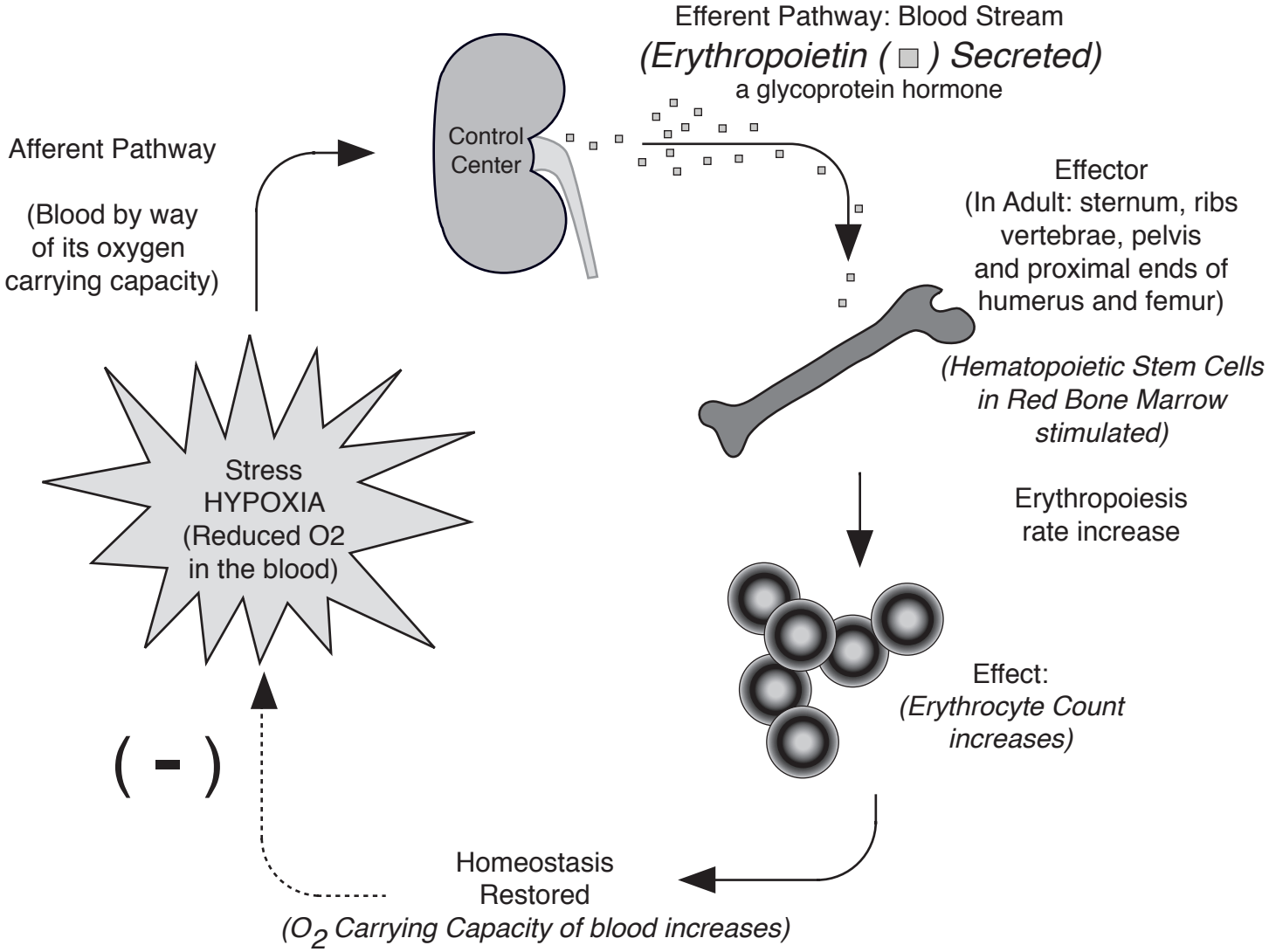
Insulin secreted by the pancreas, but target tissues can not respond.

Regulation of Erythropoiesis



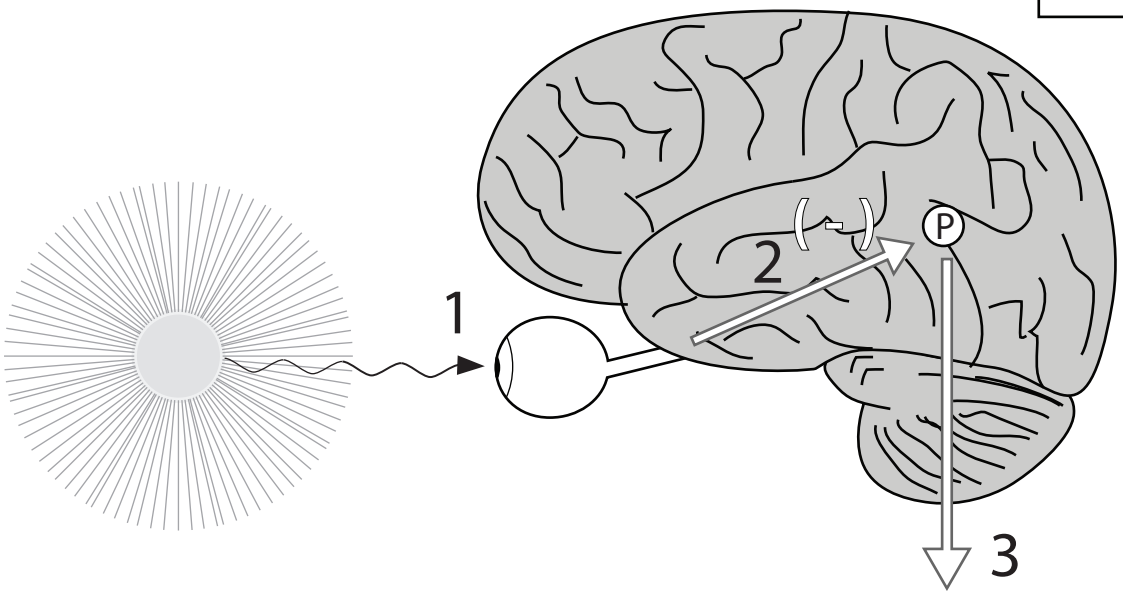
Physiological Stress due to a decreased oxygen carrying capacity of blood may be caused by:

- Reduced O_2 is atmosphere
- Inadequate hemoglobin
- Low red blood cell (erythrocyte) count
- ETC . . .

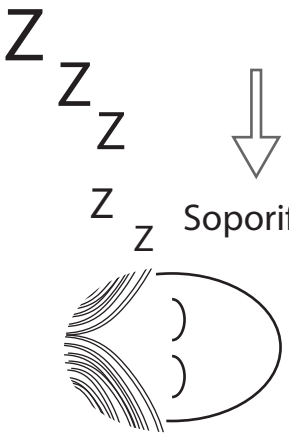


Melatonin and Sleep / Wake Cycles

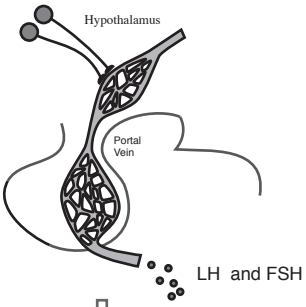
Melatonin, synthesized from tryptophan, secreted into the blood stream



(1) Photoreceptor cells, stimulated by light, communicate via a complex autonomic pathway (2) to the pineal gland where Melatonin production is inhibited.
(3) In the absence of light, melatonin production increases.
(4) May assist in the regulation of sleep/wake cycles. Melatonin is soporific.
(5) Melatonin is some animals regulates reproductive cycles. In humans, it may cause atrophy of reproductive organs. Reproductive development of children is affected by melatonin.



- GnRH (??)



Atrophy of reproductive structures in some animals, maybe humans.