HOMEOSTASIS

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Hyman physiology

First Semester

Week 2

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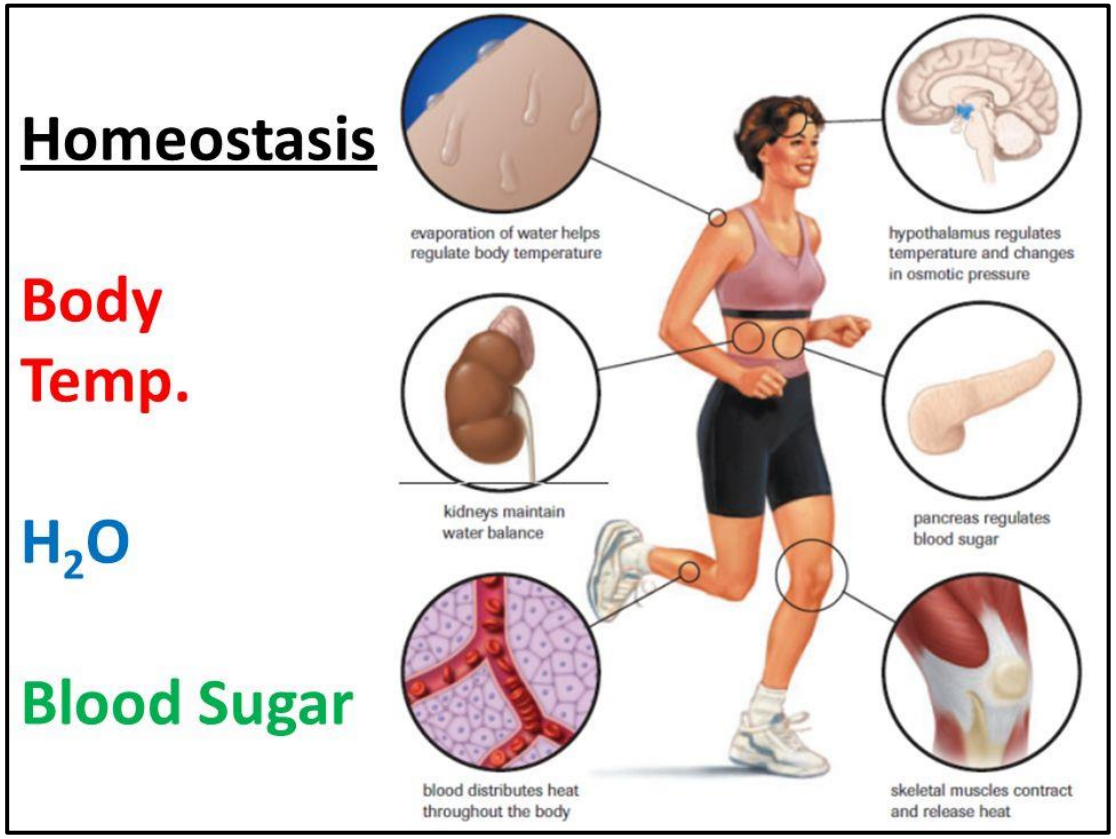
Outline

- Homeostasis
- Important of Homeostasis
- Human controlling systems of Homeostasis
- Feedbacks (Positive and Negative feed]acks)
- Thermoregulation

Objectives

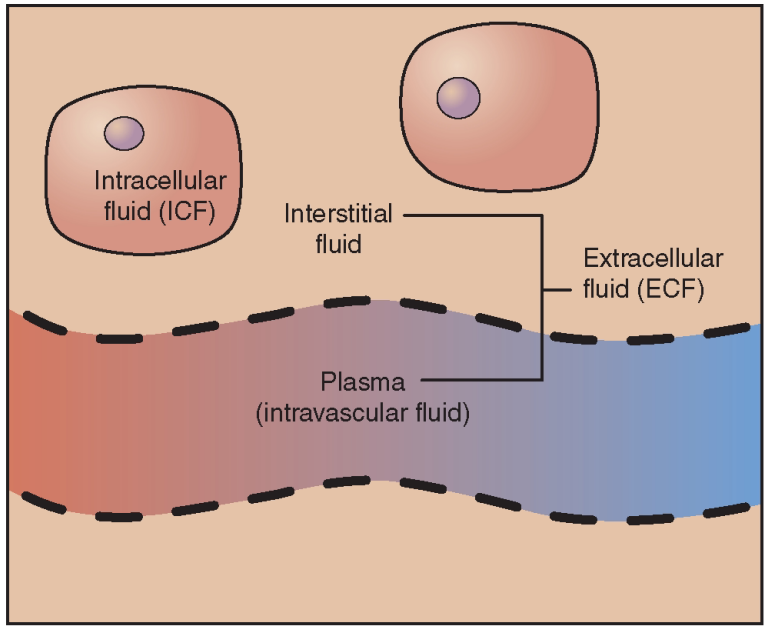
- Define Homeostasis
- Familiarize students with importance of Homeostasis in our live
- Understanding the controlling systems of homeostasis
- Understanding negative and positive feedback lops
- Explaining glucose homoeostasis
- Understanding the Homeostasis of body temperature during Hot and cold stresses

Homeostasis



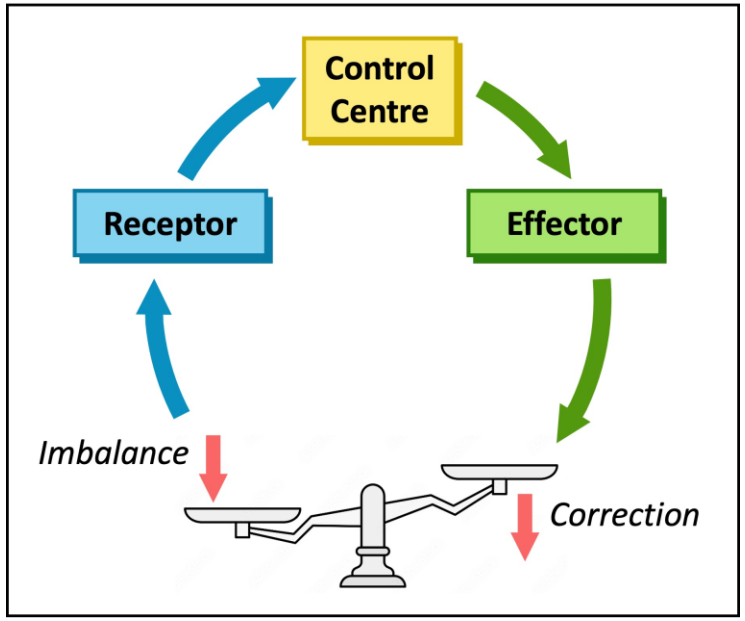
- Cells are capable of living and performing their special functions as long as the **proper** concentrations of **oxygen**, **glucose**, **different ions, amino acids, fatty substances**, and other constituents are available in **internal environment (Extrasellar fluid)**.

- **Internal environment"** refers mainly to the **extracellular fluid (ECF)** — that is, the fluid **surrounding the body's cells**.

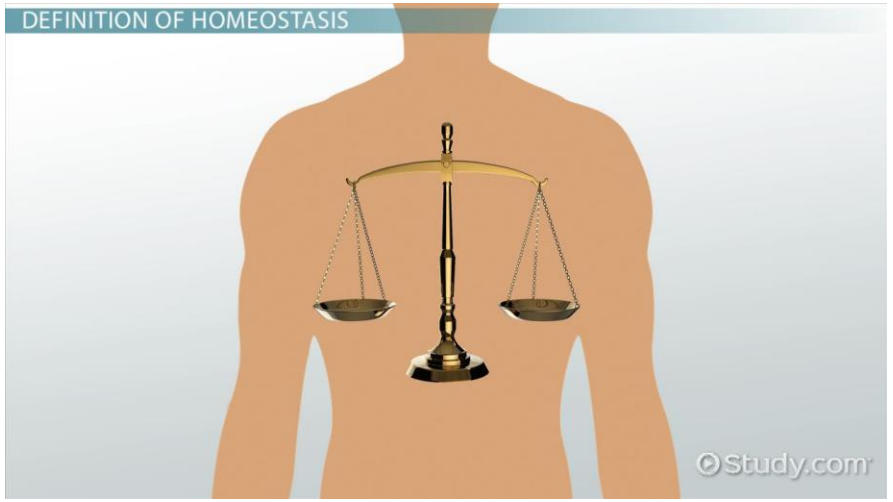


HOMEOSTASIS

- **Homeostasis** is meaning the maintenance of nearly constant (stable) (steady state) in the internal environment (extracellular O_2, electrolyte, pH, temperature, blood pressure ..etc) **regardless of changes in external conditions, to maintain the body healthy .**
- **Homeostasis** is mean the organism maintains relatively stable internal conditions despite of changing in outside environment



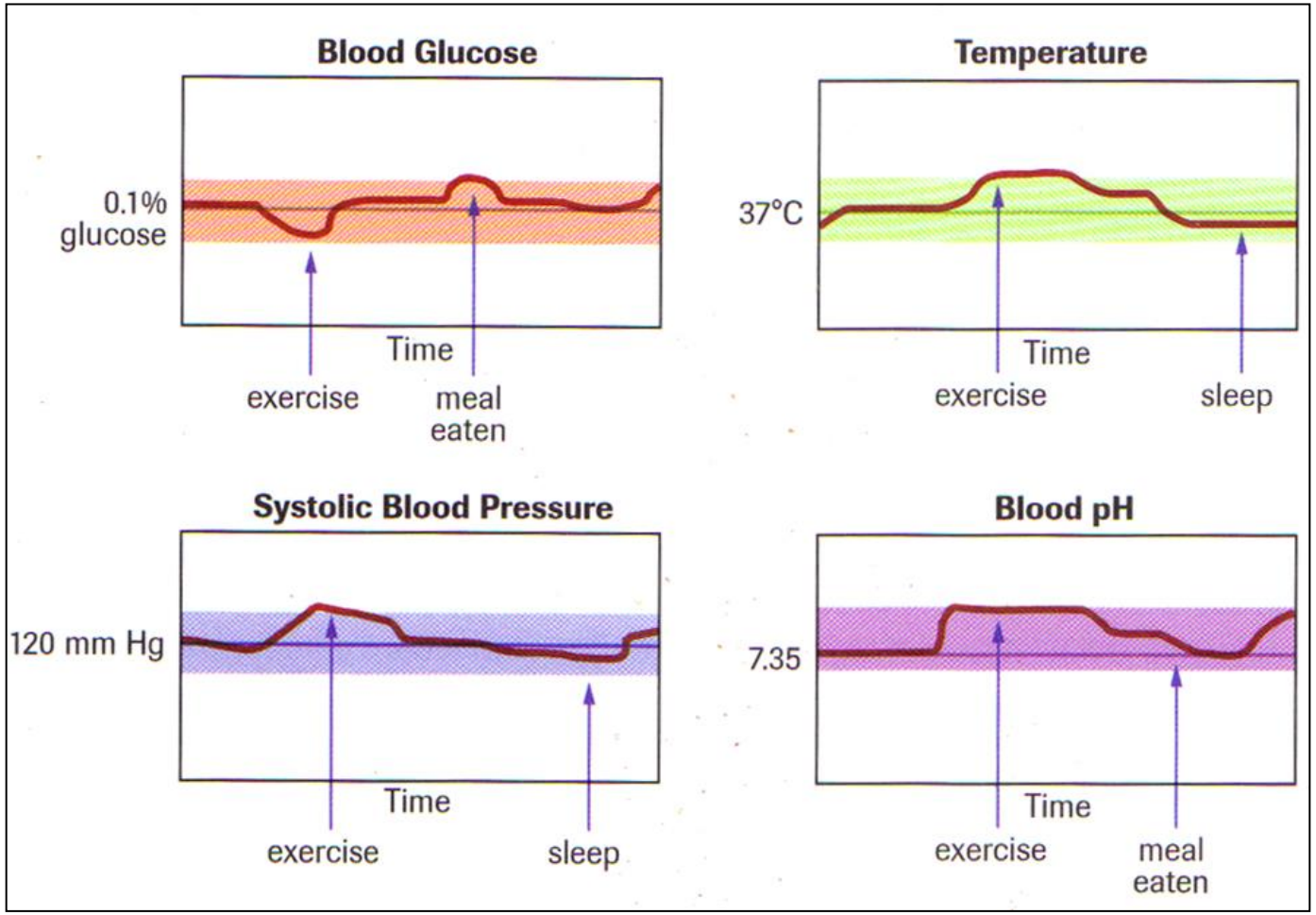
- The steady state is the **optimum level for the body functions**
- Essentially, all organs and tissues of the body perform functions that help maintain these relatively constant conditions.
- For example, **the lungs** provide oxygen to the extracellular fluid to replenish the oxygen used by the cells, the kidneys maintain constant ion concentrations, and the gastrointestinal system provides nutrients while eliminating waste from the body



- We now see **physiology** as largely a group of **mechanisms** for maintaining homeostasis, and the loss of homeostatic control as the cause of illness and death. Pathophysiology is essentially the study of unstable conditions that result when our homeostatic controls go awry.
- Internal conditions aren't absolutely constant but fluctuate within a limited range, such as the range of body temperatures(36° to 37°C)
- The internal state of the body is best described as a **dynamic equilibrium** (balanced change), in which there is a certain **set point** or average value for a given variable (such as 37°C for body temperature) and conditions fluctuate slightly around this point.

Dynamic equilibrium

- Homeostasis is also called **dynamic equilibrium**:



- Conditions *do* fluctuate, but within an acceptable range

Why Homeostasis is important ?

- **Homeostasis** is critically important for the proper functioning and survival of living organisms, including humans. It refers to the body's ability to maintain a stable internal conditions despite external fluctuations. This stability is essential for several reasons:

1. **Optimal Biological Functioning:** Enzymes and physiological processes occur in optical conditions. Homeostasis provide these conditions . Deviations from these optimal conditions can lead to inefficiencies or even dysfunction.

2. **Survival:** Many bodily functions, such as maintaining blood pressure, blood glucose levels, and electrolyte balance, are vital for survival. Homeostasis helps ensure these essential parameters remain within safe limits. For instance, if your blood glucose levels drop too low (hypoglycemia) or rise too high (hyperglycemia), it can have life-threatening consequences.

3. **Cellular Function:** Cells are the basic units of life, and they rely on a stable internal environment to function correctly. Homeostasis helps maintain the right conditions for cellular activities like nutrient uptake, waste removal, and energy production.

4. **Adaptation:** Homeostasis also allows organisms to adapt to changes in their environment. For example, when exposed to extreme cold, your body will work to maintain a core temperature close to 98.6°F (37°C) to prevent hypothermia. In hot weather, it will regulate temperature through mechanisms like sweating and vasodilation.

5. **Preventing Damage:** Homeostasis helps prevent damage to cells and tissues. When a variable, such as blood pH, deviates from the normal range, it can disrupt cellular function and cause harm. Homeostatic mechanisms work to correct these deviations and minimize potential damage.

6. **Disease Prevention:** Many diseases result from the failure of homeostatic mechanisms. Diabetes, for example, occurs when the body cannot regulate blood sugar effectively. Understanding and maintaining homeostasis is crucial for disease prevention and management.

Important variables within the body:

- **Blood sugar**
- **Water balance**
- **Electrolyte balance**
- **Body temperature**
- **Oxygen levels**
- **Blood pressure**
- **Heart rate**
- **pH**

These variables must stay within **certain ranges (cutoff level), To maintain stable internal environment**

Changes in the external environment can cause these variables to change.

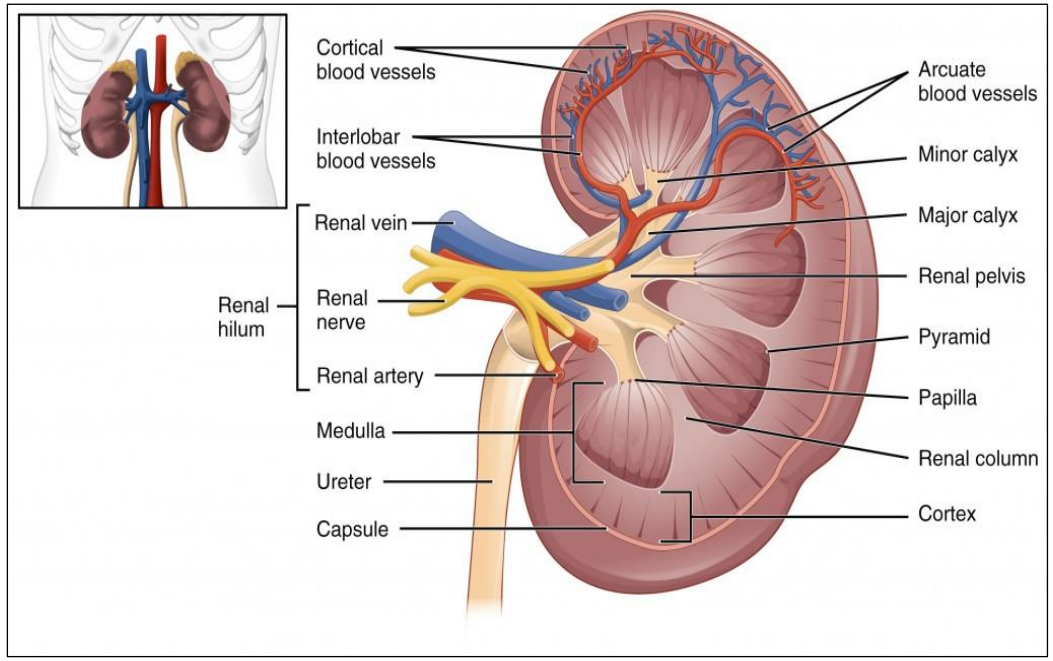
Human controlling systems of Homeostasis

- **The human body has thousands of control systems (regulation systems) diving into two categories**

1. **Autoregulation/ Intrinsic Regulation**
   - Automatic response in a cell, tissue, or organ to some environmental change
2. **Extrinsic regulation**
   - Responses controlled by **nervous** and **endocrine systems**

1-Autoregulation

- Some cell, tissue and organs are responding to environmental changes independent of nervous and hormonal regulation
- Renal autoregulation (Regulation of GFP)



2- Extrinsic regulation

A-Nervous controlling system

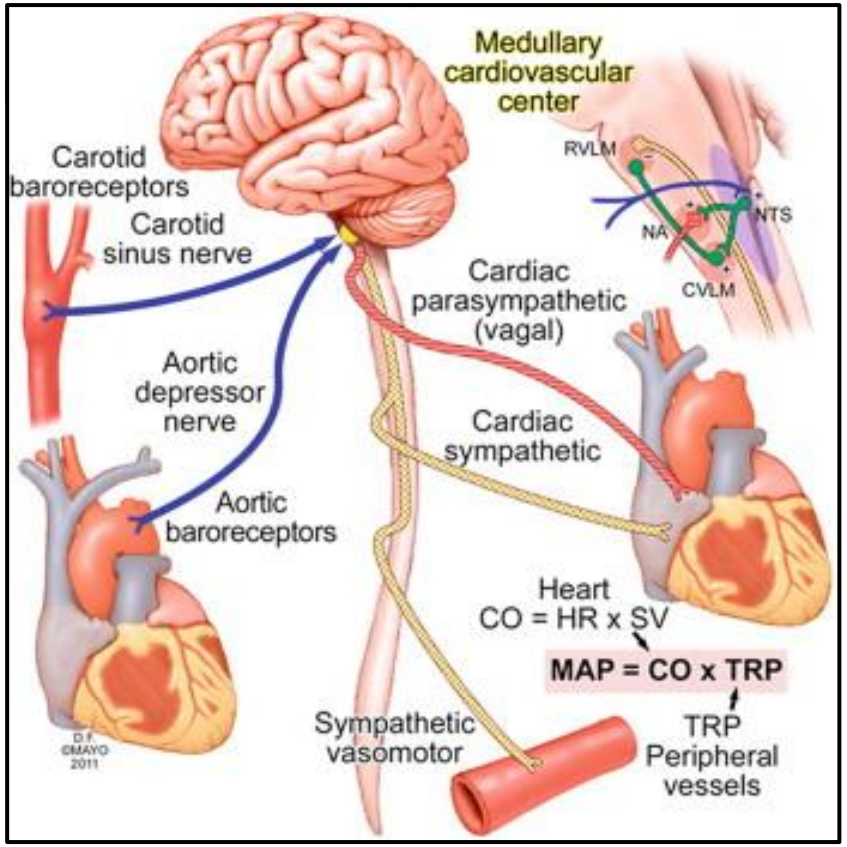
A process in which body functions are controlled by nerve system

Pathway

Example: baroreceptor reflex of arterial blood press

Characteristics:

- Response fast
- Acts exactly or locally
- last for a short time



Hormonal regulation control system

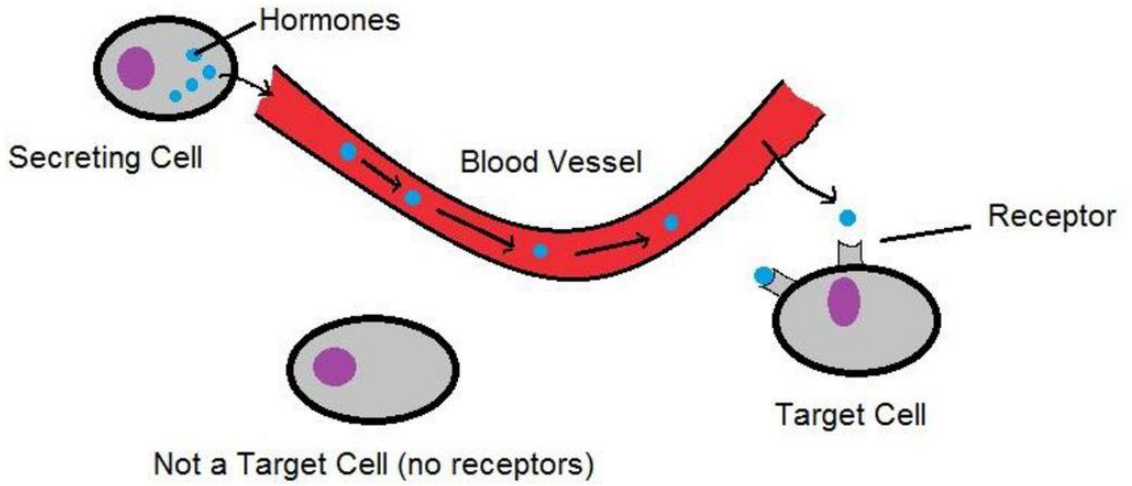
- **Endocrine glands**, organs and tissues that secrete chemical substances called ***hormones***. Hormones are transported in the extracellular fluid to other parts of the body to help regulate cellular function.
- Hormones provide a regulatory system that complements the nervous system.
- The nervous system controls many muscular and secretory activities of the body, whereas the hormonal system regulates many metabolic functions.
- The nervous and hormonal systems normally work together in a coordinated manner to control essentially all the organ systems of the body.

B-Hormonal regulation

Characteristics

- **Response slowly**
- **Acts extensively**
- **Lasts for a long time.**

Hormones affect only target cells that have specific protein receptors

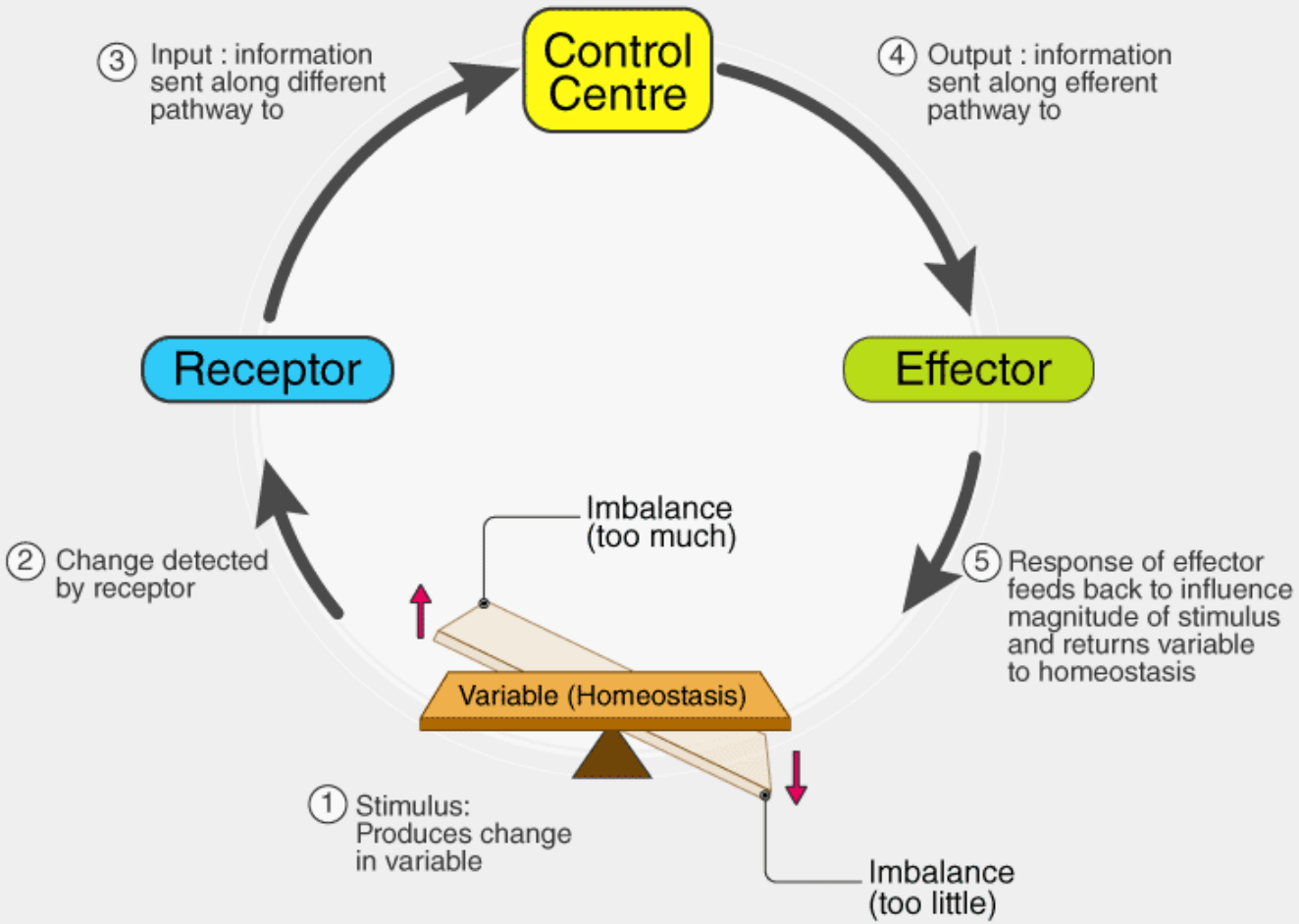


Components of Homeostasis controlling systems

There are five components to a homeostatic system:

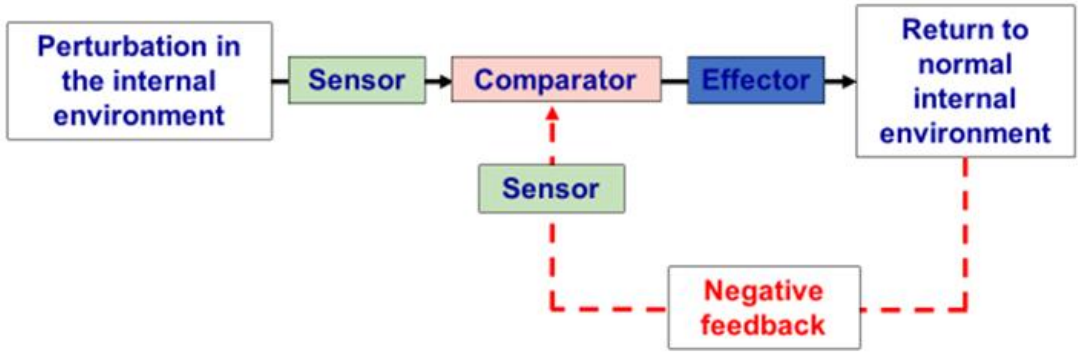
1. **Stimulus**
2. **The Sensor** which detects the stress.
3. **The Control Center** which receives information from the sensor and sends a message to adjust the stress.
4. **The Effector** which receives the message from the control center and produces the response which reestablishes homeostasis
5. **Response** and results

HOMEOSTASIS



Homeostasis is a property of a human biological system where the self-regulating process tends to maintain the balance for the survival. The regulation takes place in a defined internal environment

A system in homeostasis needs



Feedbacks:

Nervous and endocrine system work through two types of feedbacks to regulate Homeostasis.

1. **Negative** feedback control (Most control systems)
   - Common
   - Reverses initial stimulus (decrease output
   - Results in Fluctuations about Set Point
   - Inhibitory of stimulus
   - Examples, Blood glucose

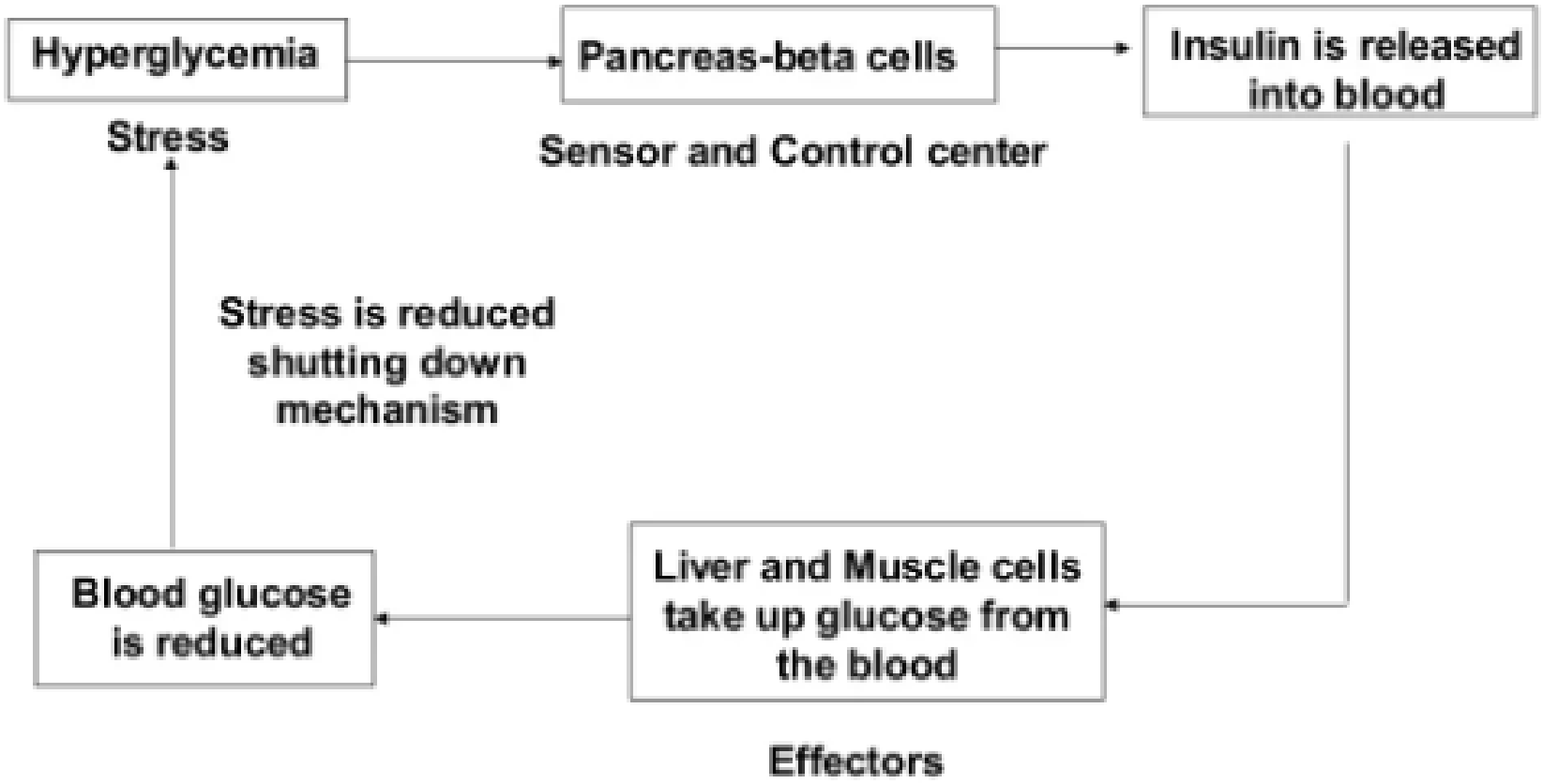
1- Positive feedback control

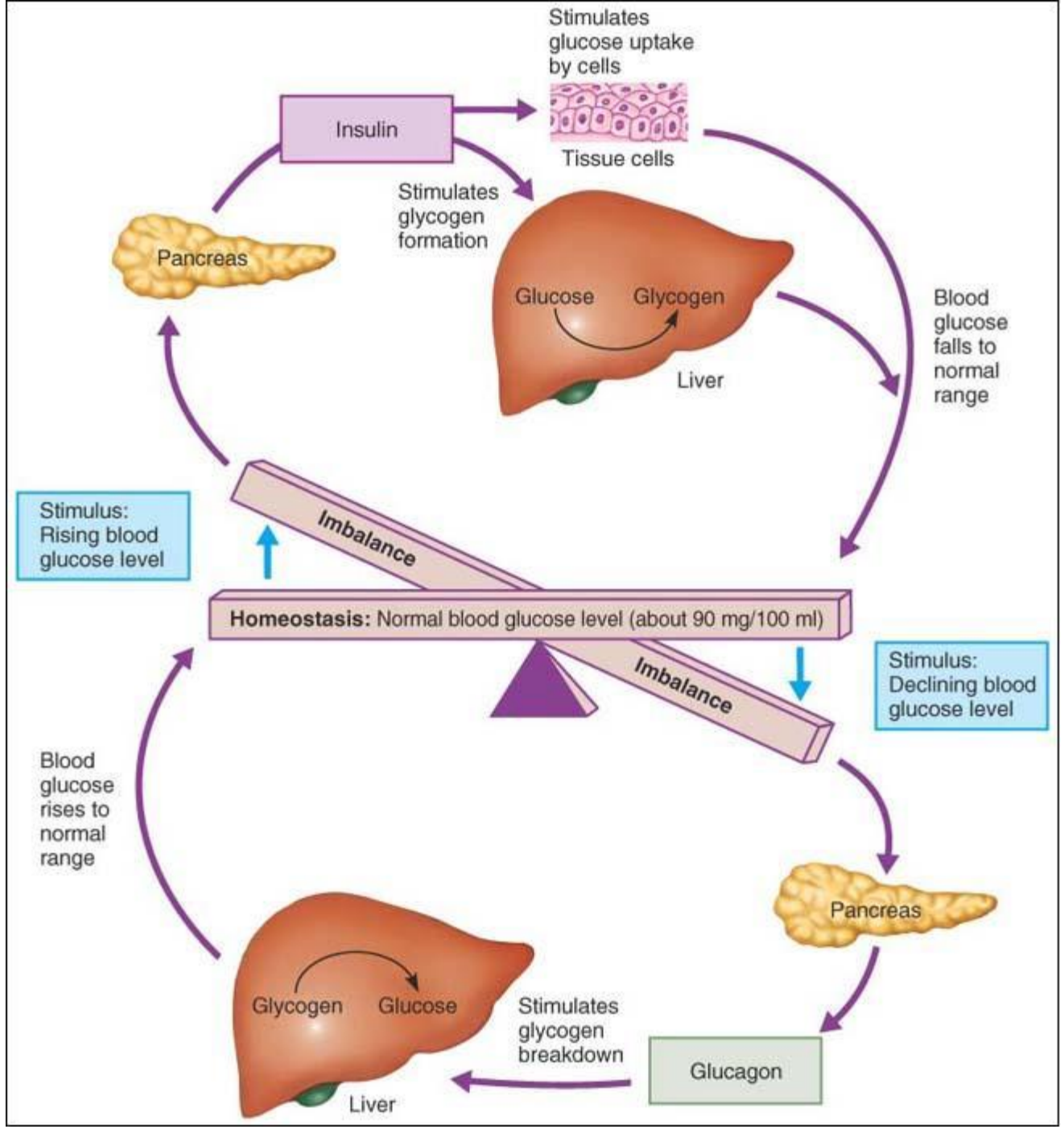
- Less common
- Increase the initial stimulus to increase the variation
- Increase out put of the system
- Amplify the stimulus

Negative Feedback

- **Negative Feedback: Inhibitory.**
- The feedback signals from controlled system produces effect opposite to the action of stimulus.
- Stimulus triggers response to counteract further change in the same direction.
- Negative-feedback mechanisms prevent small changes from becoming too large.

Homeostatic Regulation of Blood Sugar through Negative Feedback




Stimulates glucose uptake by cells
Insulin
Tissue cells
Stimulates glycogen formation
Pancreas
Glucose
Glycogen
Liver
Blood glucose falls to normal range
Stimulus: Rising blood glucose level
Imbalance
Homeostasis: Normal blood glucose level (about 90 mg/100 ml)
Imbalance
Stimulus: Declining blood glucose level
Blood glucose rises to normal range
Pancreas
Glycogen
Glucose
Liver
Stimulates glycogen breakdown
Glucagon

Thermoregulation

Maintaining body temperature

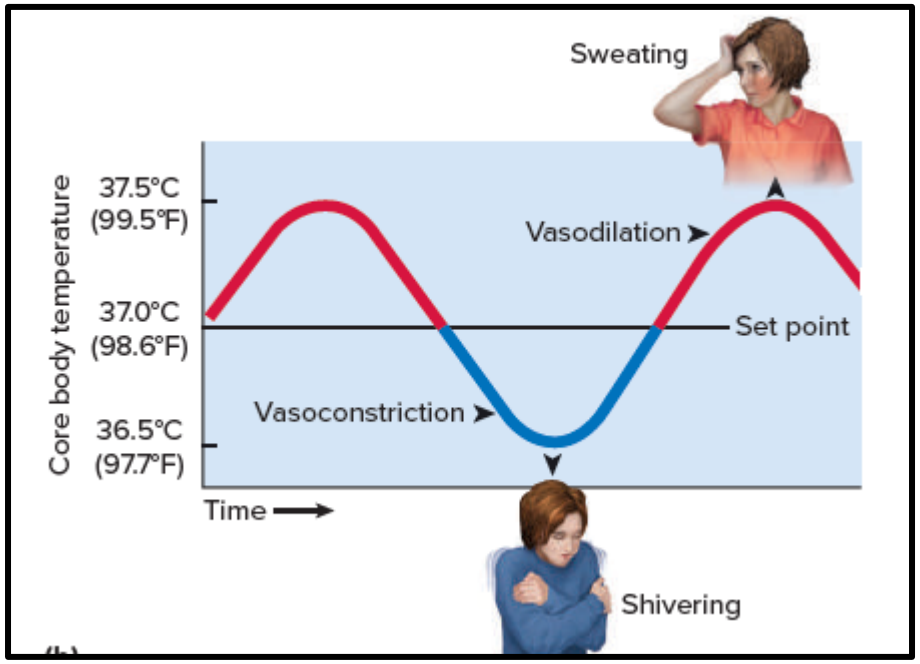
Body temperature

Average human body temperature: 37°C

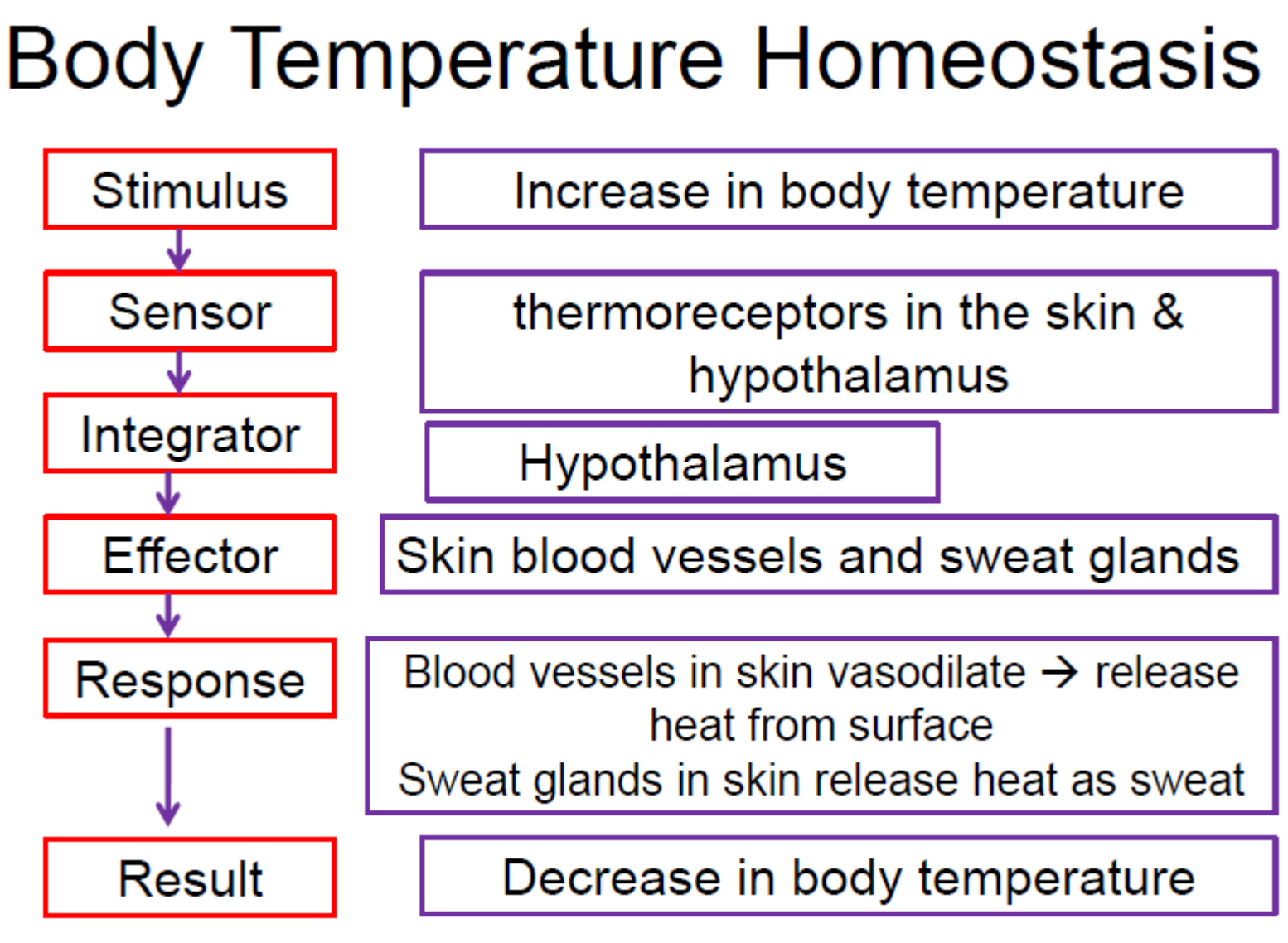
- Core body temperature is slightly higher
- Interindividual variation

Types of temperature stress

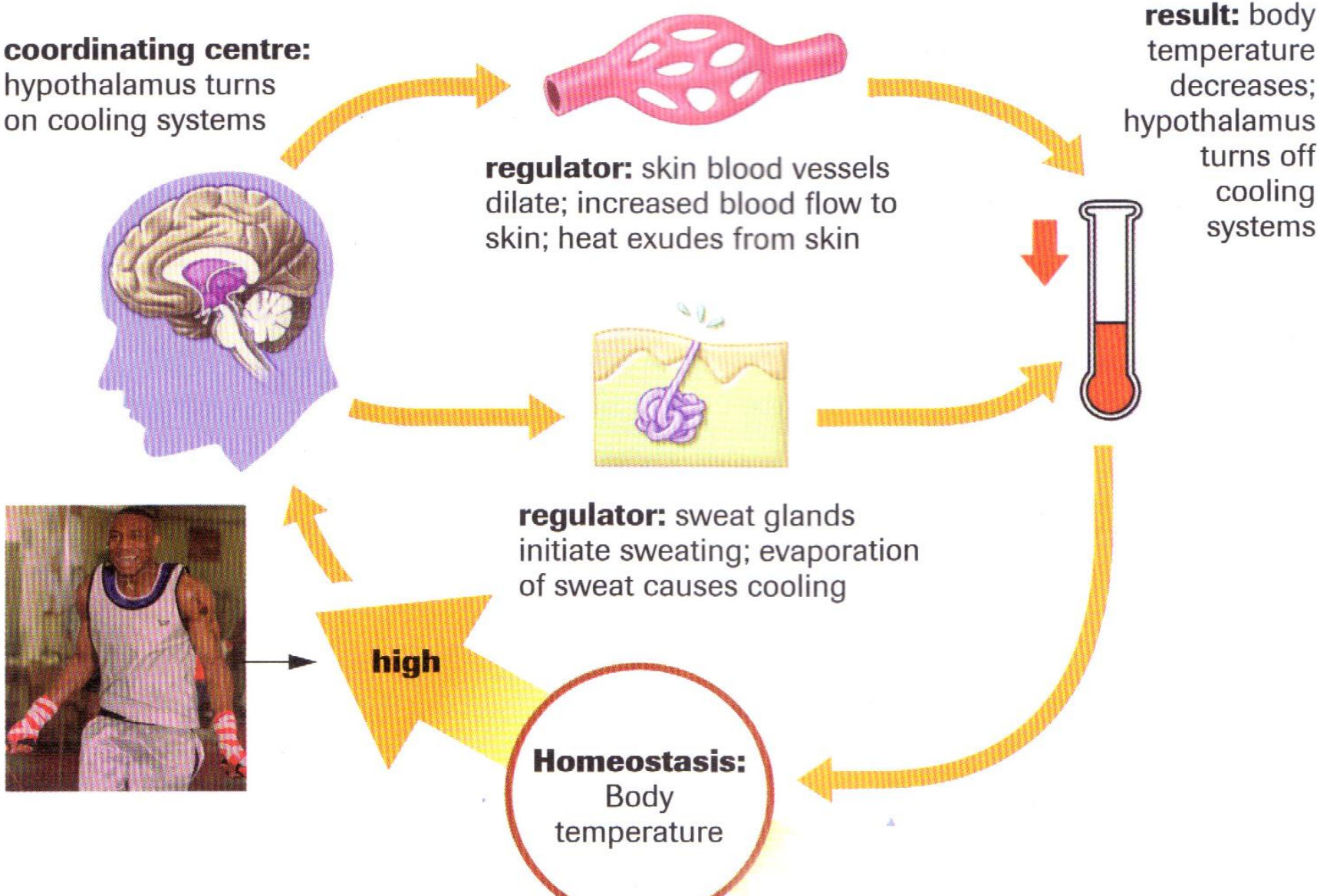
- Heat stress
- Cold stress



Response to Heat Stress



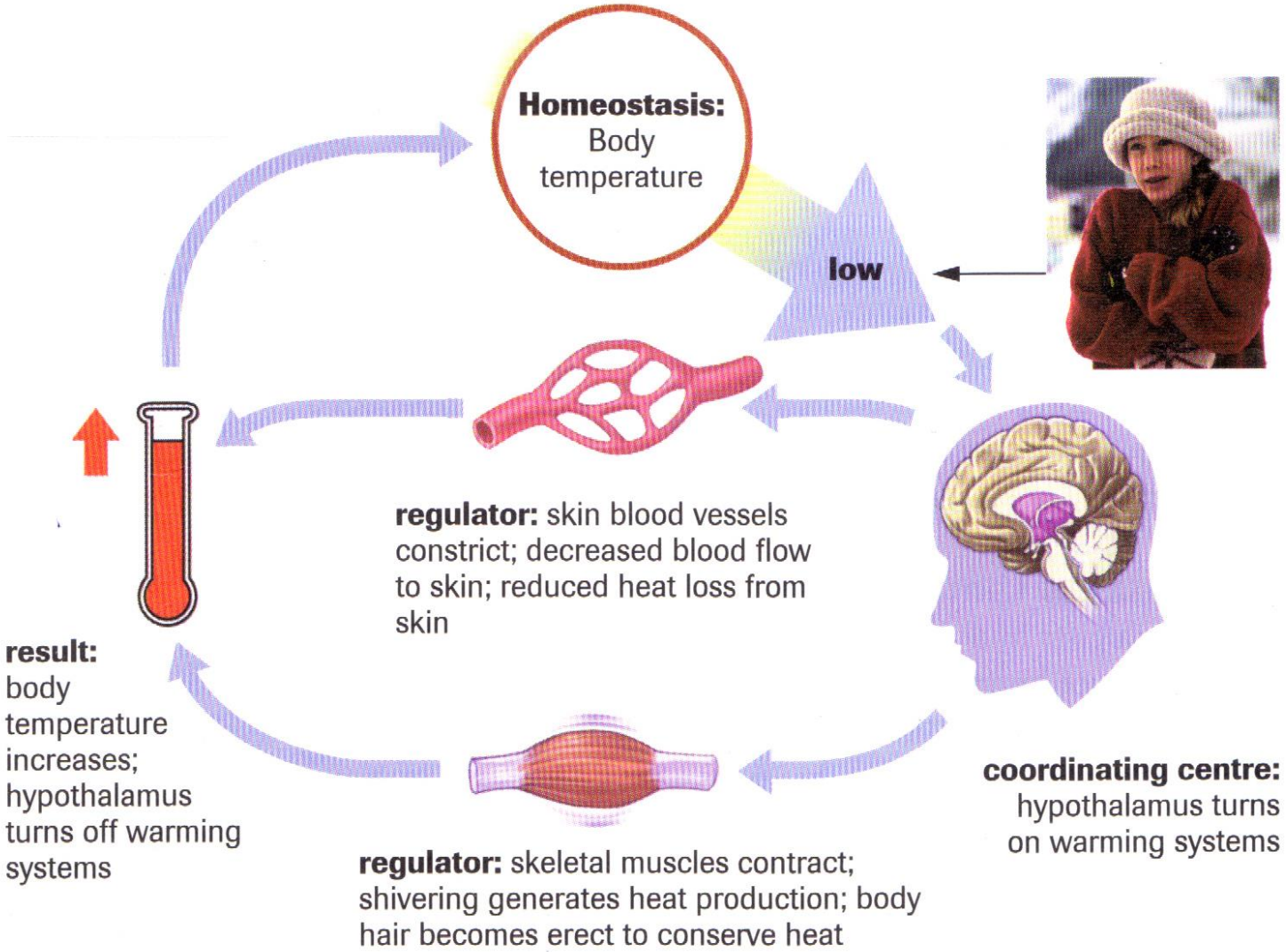
Response to Heat Stress



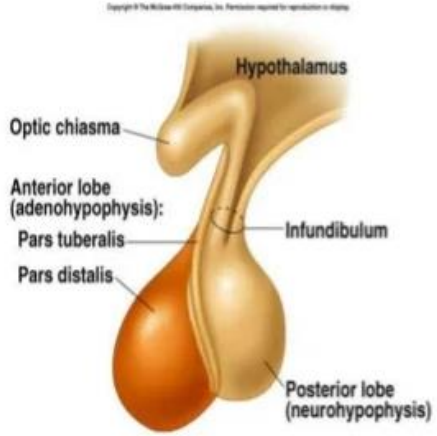
Response to Heat Stress

- Co-ordinating center is the *hypothalamus*
- Responses:
  - Skin blood vessels will dilate
  - Sweat glands will produce perspiration
- Both responses serve to *lower* body temperature → Return to normal range

Response to Cold Stress



Response to Cold Stress



- Co-ordinating center is the *hypothalamus*
- Responses:
  - Skin blood vessels will constrict
  - Skeletal muscle will contract rapidly (shivering), increasing metabolism
  - Smooth muscle around hair follicles will contract, producing goosebumps
- Responses serve to raise body temperature → Return to normal range

Hypothermia: Occurs when core body temperature drops below normal range. Usually results in coma, then death

Summary of thermoregulation

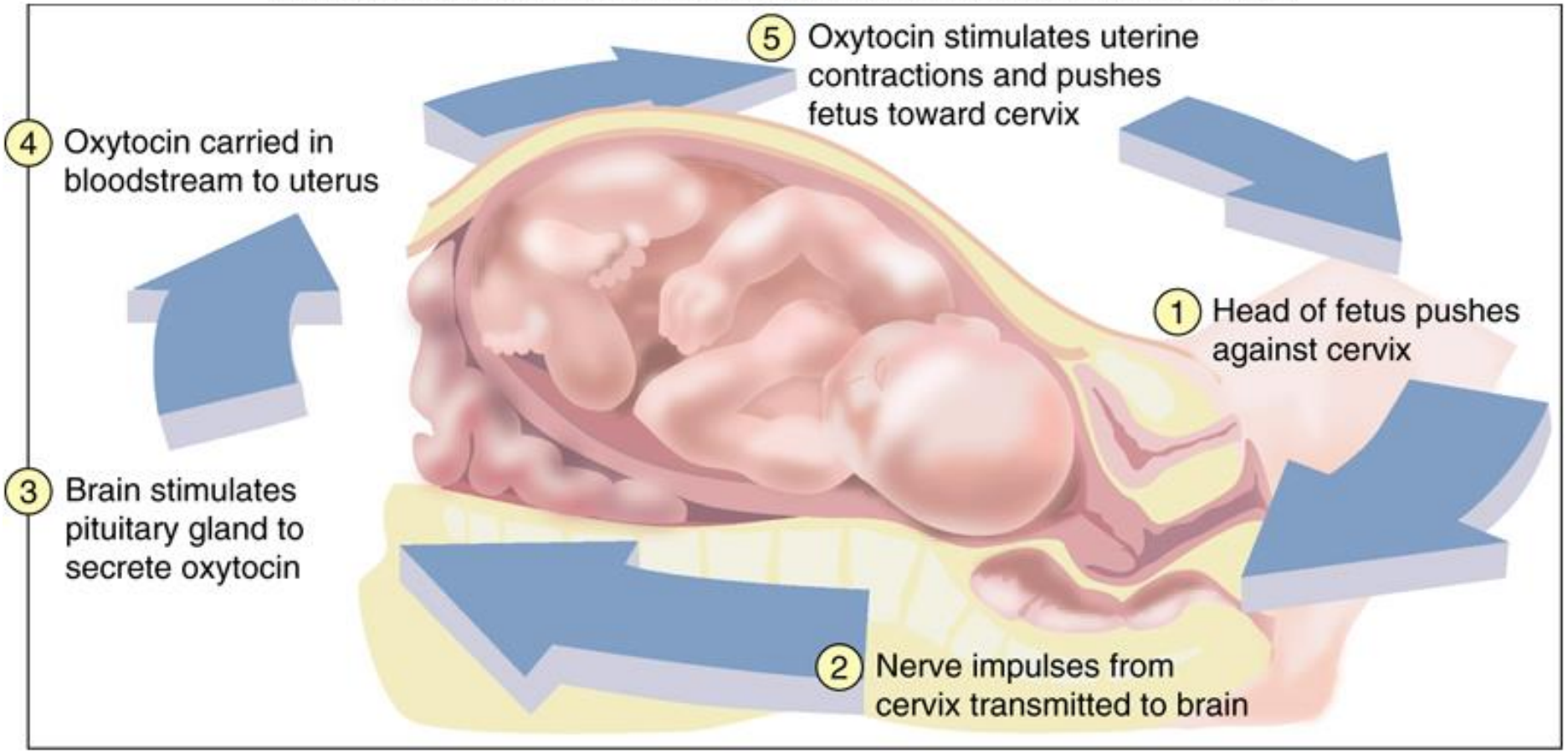
Stimulus	Physiological response	Adjustment
Cold	• Constriction of blood vessels in skin • Hairs on body erect • Shivering	Heat is conserved Heat is generated by increasing metabolism
Heat	• Dilation of blood vessels in skin • Sweating	Heat is released

Positive feedback

The feedback signal or output from the controlled system increases the action of the control system

- The response triggered by changing conditions serves to move the variable even further away from its steady state

- ➢Examples:
- ➢Blood clotting
- ➢Na^+ inflow in genesis of nerve signals
- ➢Contraction of the uterus during childbirth (parturition)



Positive Feedback in Childbirth

- **Frequently**, however, positive feedback is a **harmful** or even life-threatening process. This is because its self-amplifying nature can quickly change the internal state of the body to something far from its homeostatic set point. Consider a high fever, for example.

- A fever triggered by infection is beneficial up to a point, but if the body temperature rises much above 40°C (104°F), it may create a dangerous positive feedback loop. This high temperature raises the metabolic rate, which makes the body produce heat faster than it can get rid of it. Thus, temperature rises still further, increasing the metabolic rate and heat production still more. This “vicious circle” becomes fatal at approximately 45°C (113°F). Thus, positive feedback loops often create dangerously out-of-control situations that require emergency medical treatment.

References

- Hall, J. E., & Hall, M. E. (2020). Guyton and Hall Textbook of Medical Physiology. Elsevier.
- Saladin, K. (2020). Anatomy & Physiology: The Unity of Form and Function. McGraw-Hill Education.