

# Advanced Physiology

531 ZOO

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# Definition

- Physiology (from the Greek *physis* = nature; *logos* = study) is the study of biological structure and function—of how the body works, from molecular mechanisms within cells to the actions of tissues, organs, and systems, and how the organism as a whole accomplishes particular tasks essential for life.

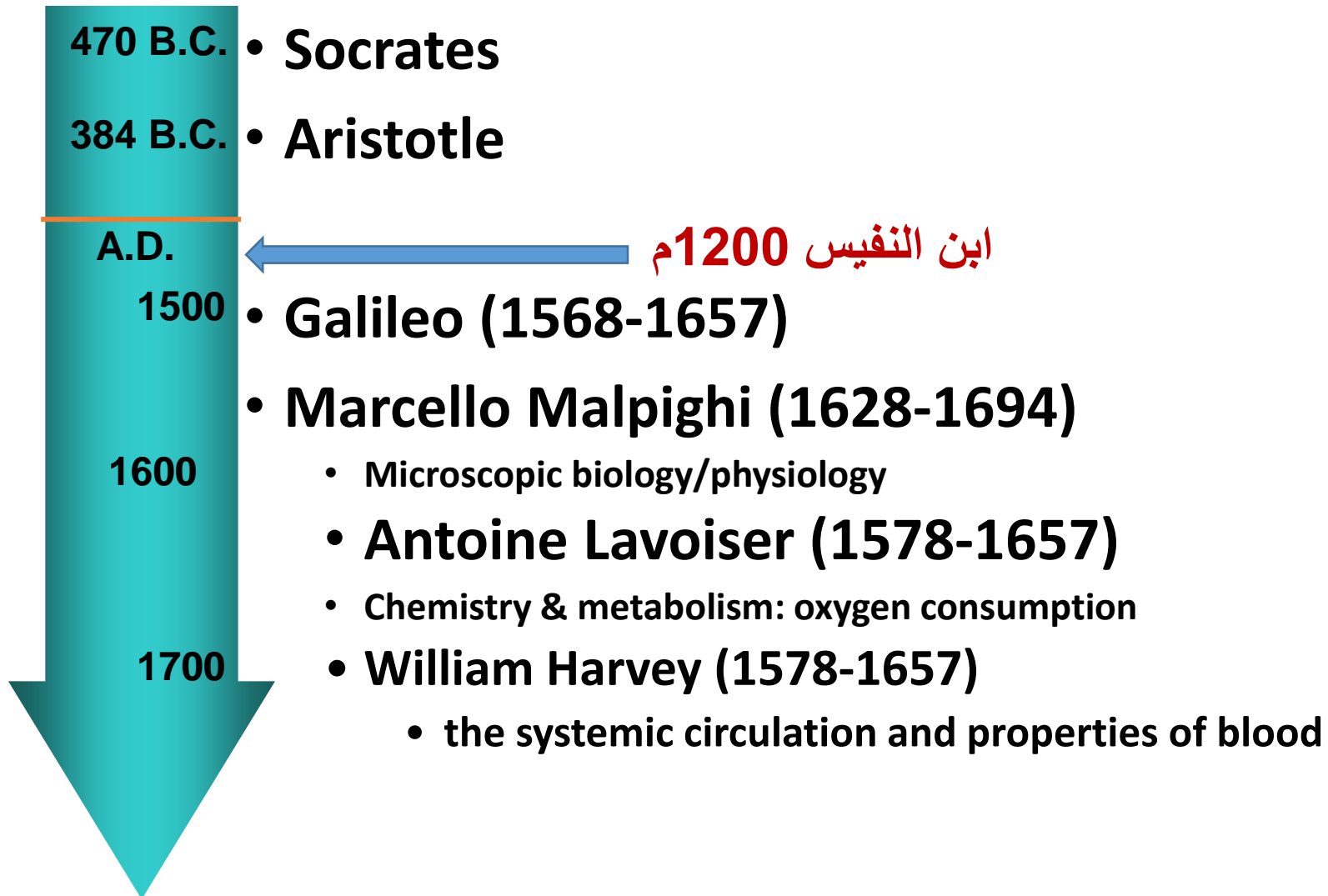
# The History of Physiology

- Aristotle emphasized the relationship between structure and function
- Galen was the first to perform experiments to understand the function of the body; so known to be father of physiology -- Galen ( 216 AD)
- The first “physiologist” of the world, in the modern sense, was William Harvey. In the 17<sup>th</sup> century William Harvey first describes the circulatory system and its interaction with the body
- Claude Bernard (1813-1878) propounded the concept of milieu interieur or internal environment and established physiology as the scientific basis of medicine.

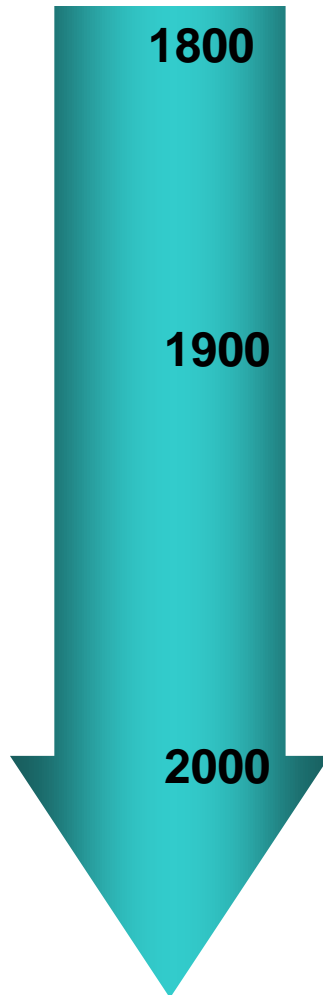
THE FATHER OF MODERN PHYSIOLOGY IS THE FRENCH  
PHYSIOLOGIST CLAUDE BERNARD

أبو الحسن علاء الدين علي بن أبي الحزم الخالدي  
المخزومي [5] القَرَشِيّ الدَّمَشْقِيّ الملقب **بابن  
النفيس** ويعرف أحياناً بالقَرَشِيّ بفتح القاف والراء نسبة إلى  
قبيلة **قريش** العربية [6][7] (607هـ/1213م، **دمشق** -  
1288هـ/687م) هو **عالم موسوعي وطبيب مسلم**، له  
إسهامات كثيرة في **الطب**، ويعتبر مكتشف **الدورة الدموية  
الصغرى**، [8] وأحد رواد علم وظائف الأعضاء في **الإنسان**،  
حيث وضع نظريات يعتمد عليها العلماء إلى الآن. عين  
رئيساً **لأطباء مصر**. [9][10] ويعتبره كثيرون  
أعظم **فيزيولوجي العصور الوسطى**. [11] ظل الغرب يعتمدون  
على نظريته حول الدورة الدموية، حتى اكتشف **ويليام  
هارفي** الدورة الدموية الكبرى.

# Brief History of Physiology

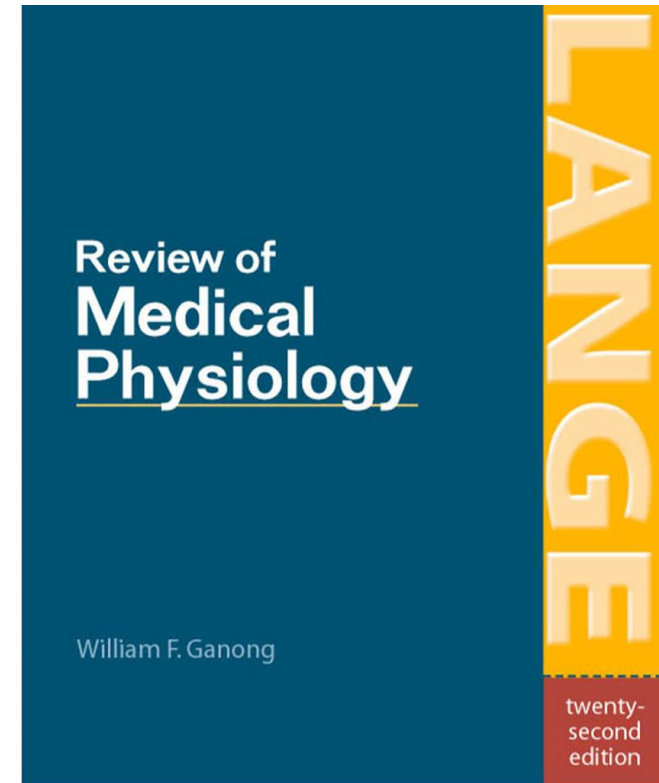
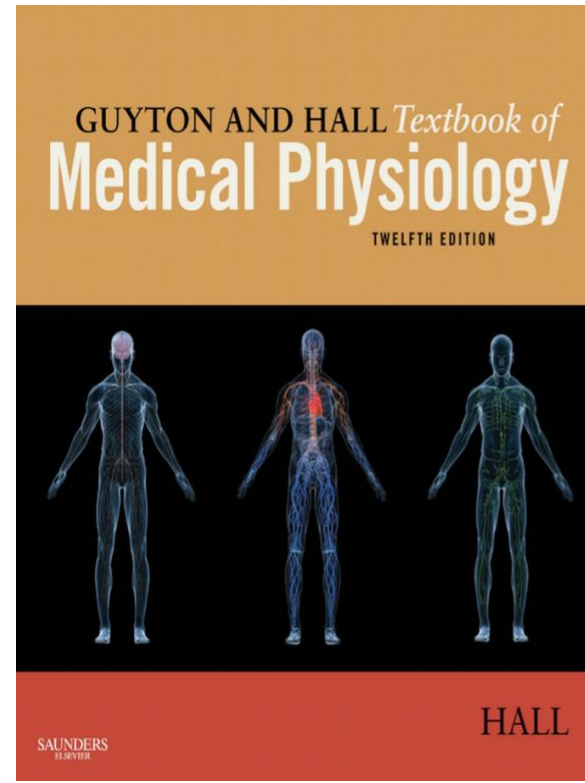
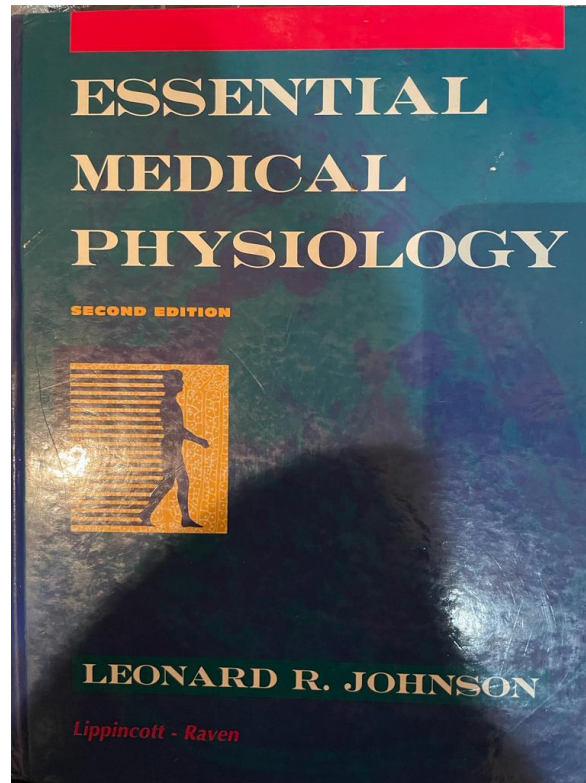
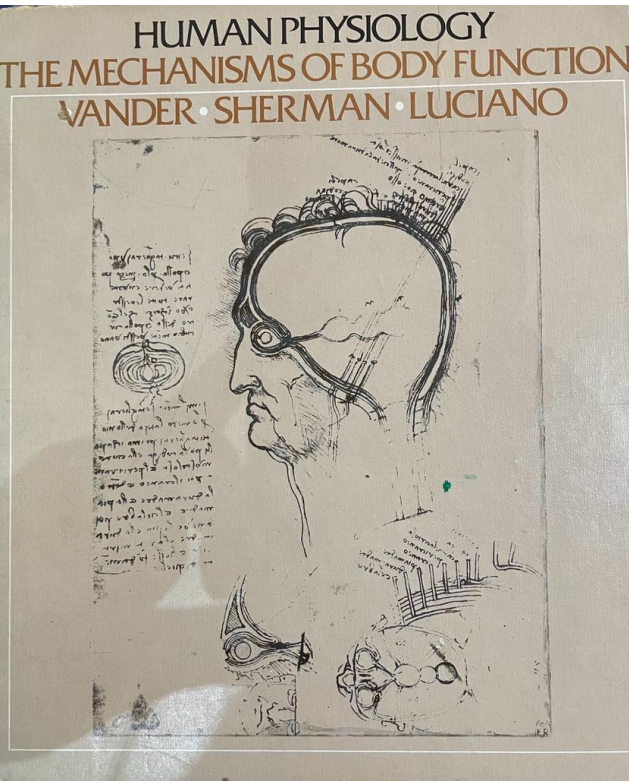


# Brief History of Physiology

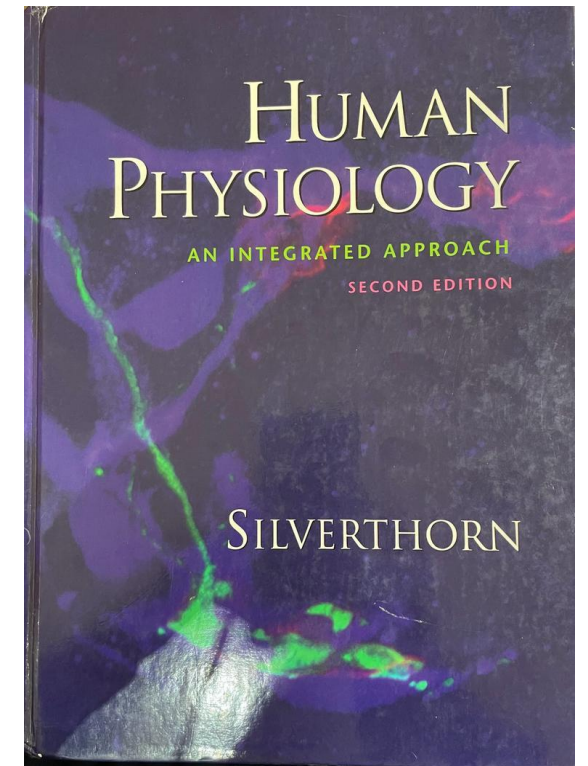
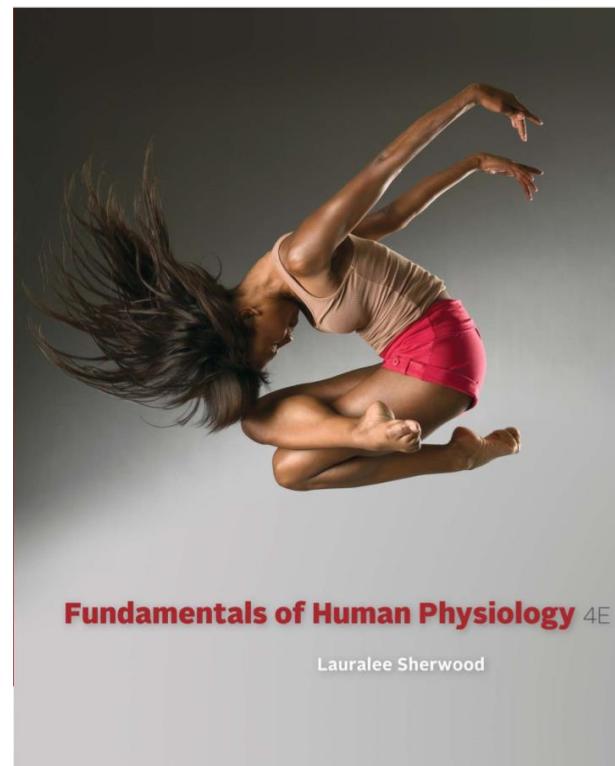
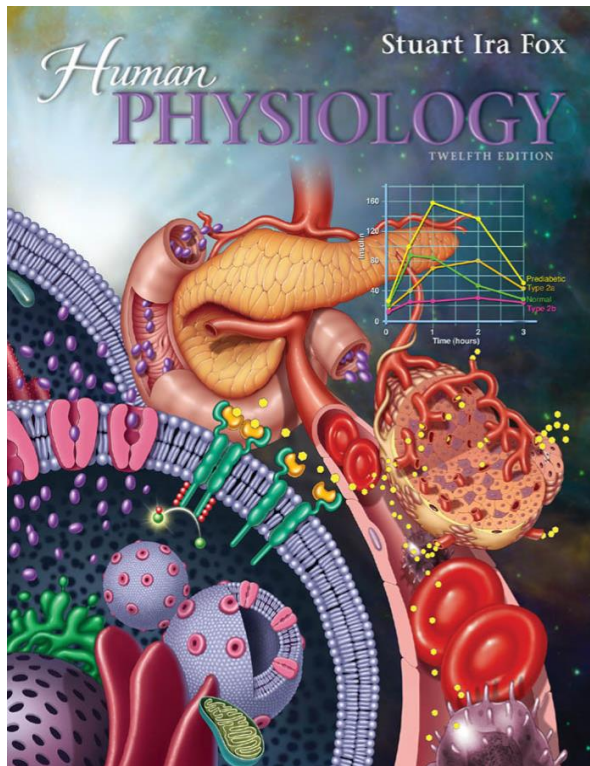


- The rapid expansion of our modern knowledge in physiology began in the late 1800s
- 1920-1950s Phase of classic physiology research
- 1950-1980 Phase of biochemical discoveries: DNA, Enzymes, Receptors, Hormones, etc.
- 1980-present Transgenics, cloning, knock-outs, xenotransplantation, and much more.

# Major Textbook in Physiology



# References



# Physiology is A core Course in Many Disciplines:

- **Medicine**
- **Dentistry**
- **Veterinary medicine**
- **Health Sciences**
- **Cell Physiology/Biology/ zoology**
- **Pharmacy**

# Major Branches of Physiology

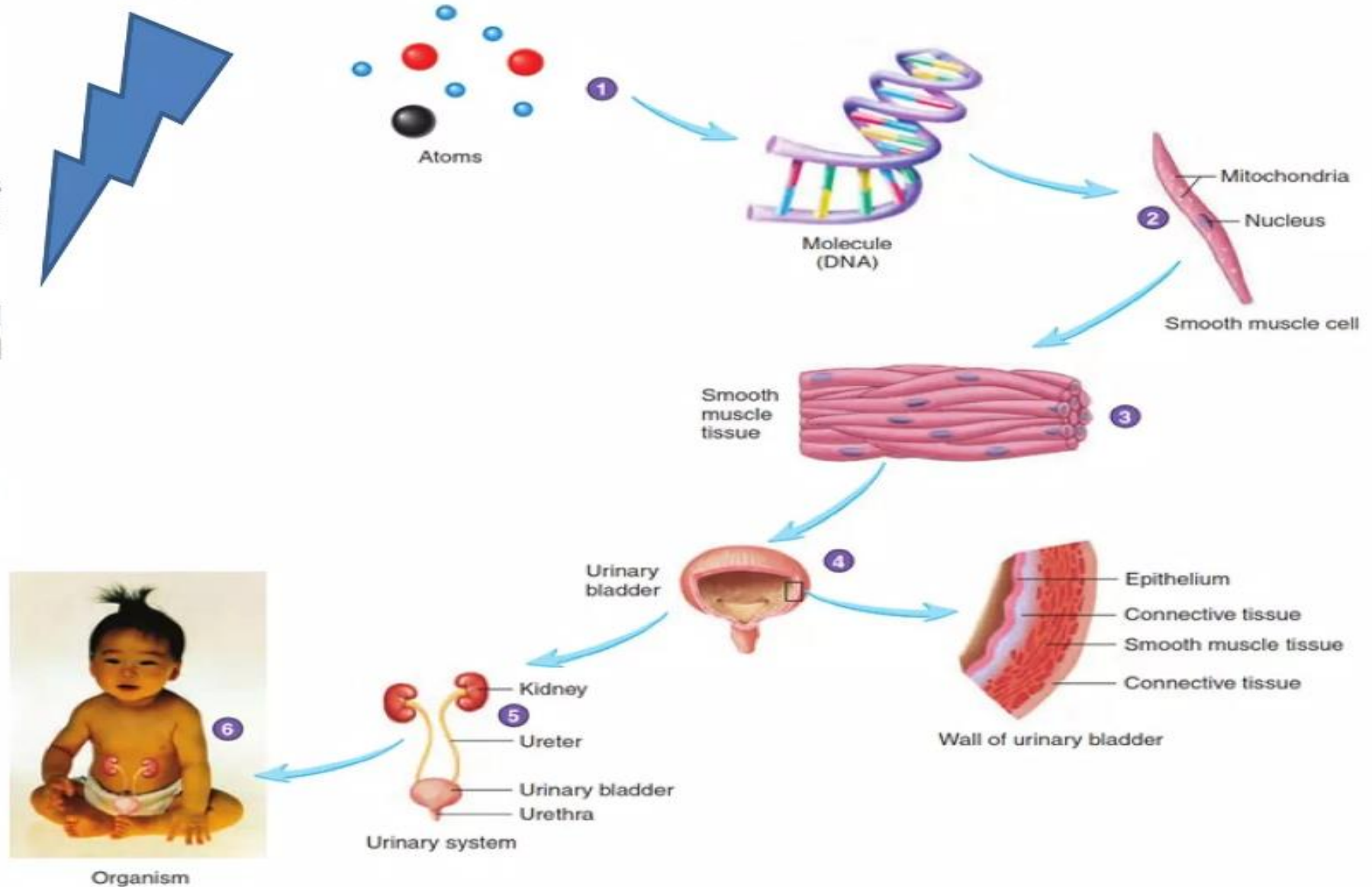
- **Cardiovascular**
- **Renal**
- **Respiratory**
- **Gastrointestinal**
- **Neuroscience**
- **Endocrinology**
- **Reproductive**
- **Orthopedic (Bone and Muscle)**

# Major Branches of Physiology

- **Comparative Physiology**
- **Environmental Physiology**
- **Evolutionary Physiology**
- **Developmental Physiology**
- **Cell Physiology/Biology**
- **Pathophysiology**

# Levels of Structural Organization

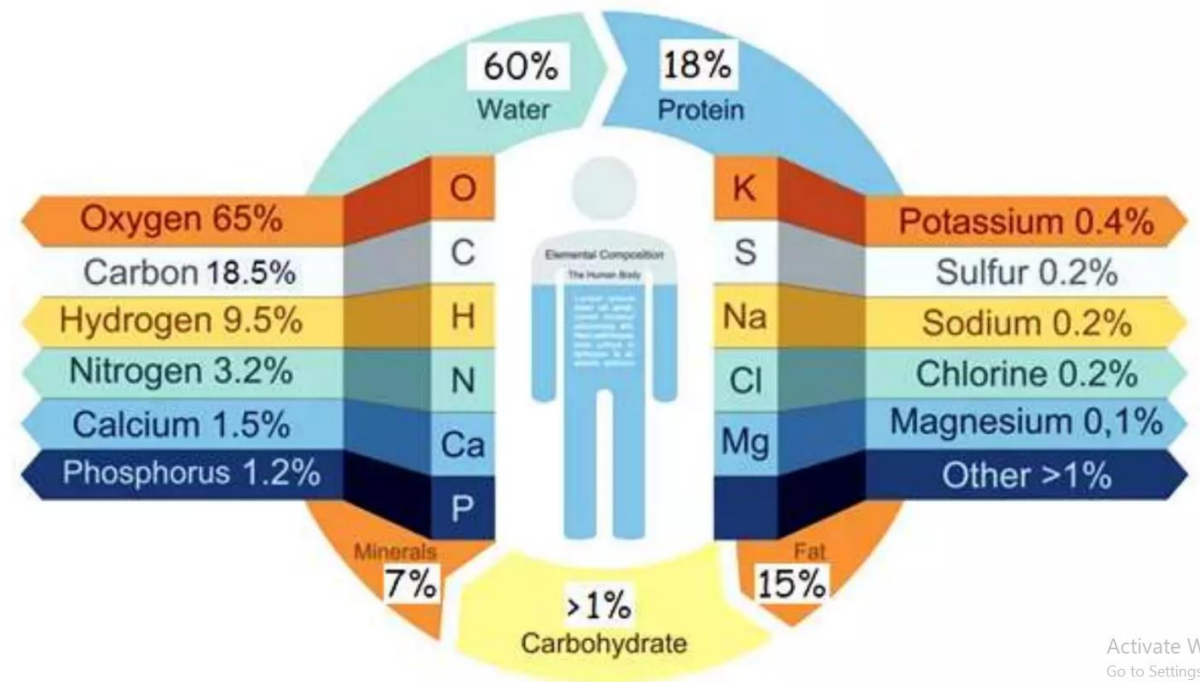
- 1 Chemical level.** Atoms (*colored balls*) combine to form molecules.
- 2 Cell level.** Molecules form organelles, such as the nucleus and mitochondria which make up cells.
- 3 Tissue level.** Similar cell and surrounding material make up tissues.
- 4 Organ level.** Different tissues combine to form organs, such as the urinary bladder.
- 5 Organ system level.** Organs, such as the urinary bladder and kidneys, make up an organ system.
- 6 Organism level.** Organ systems make up an organism.



# Body composition

- In average young adult male:

| Body composition              | % of body weight |
|-------------------------------|------------------|
| Protein, & related substances | 18%              |
| Fat                           | 15%              |
| Mineral                       | 7%               |
| Water                         | 60%              |



## Compartmentalization of total body water in an average 70 kg man

70 kg man



42  
litres

Total body water

Intracellular fluid  
28 litres

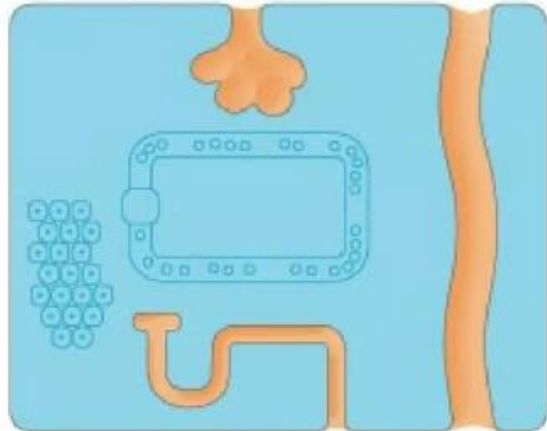
Extracellular fluid  
14 litres

Interstitial  
fluid  
9.5 litres

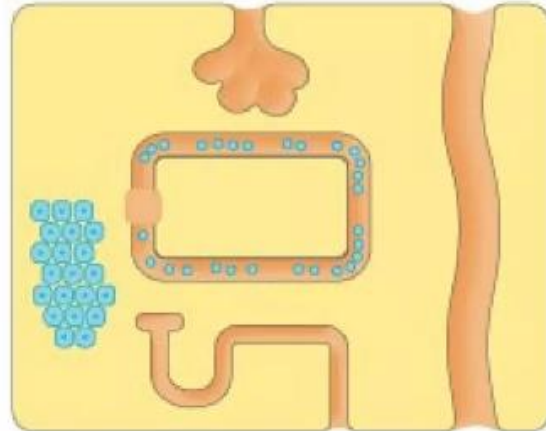
Plasma  
3.5 litres

Transcellular  
fluid  
1 litre

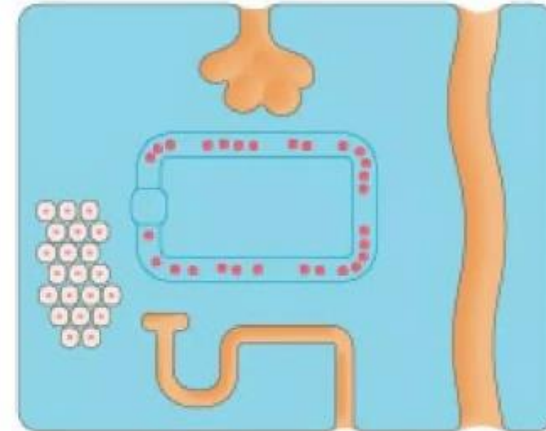
# Body Fluid Compartments



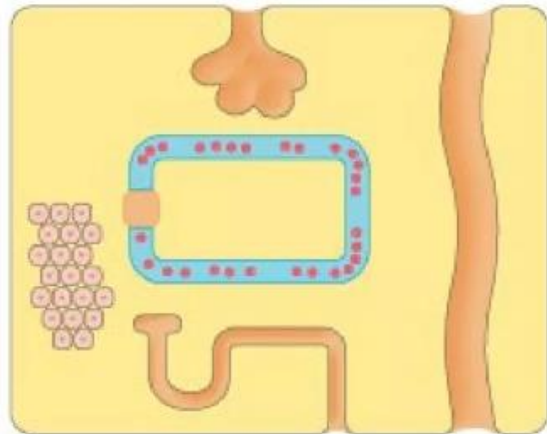
**(a)** Total body water (TBW)



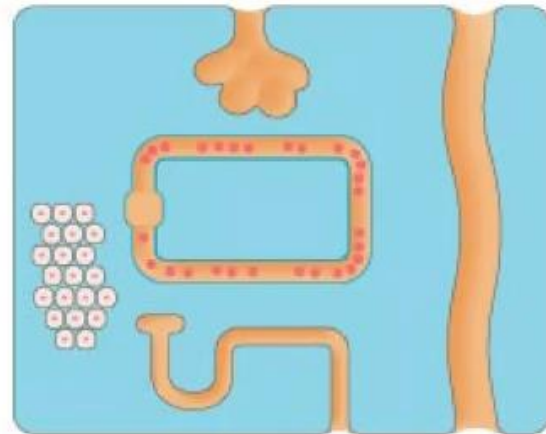
**(b)** Intracellular fluid (ICF)



**(c)** Extracellular fluid (ECF)



**(d)** Plasma



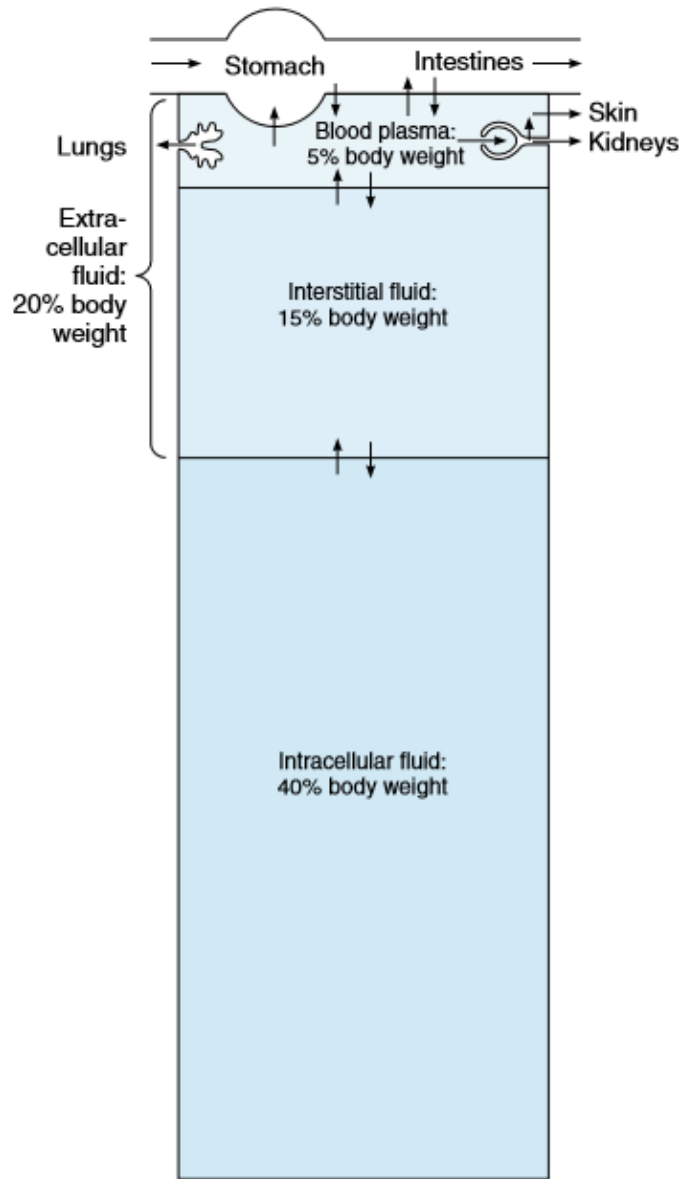
**(e)** Interstitial fluid (ISF)

| Body fluid | Volume (L) |
|------------|------------|
| TBW        | 42         |
| ICF        | 28         |
| ECF        | 14         |
| Plasma     | 3          |
| ISF        | 11         |

**(f)** Distribution of TBW

# GENERAL PRINCIPLES: Organization of the Body

## Body Composition



**Figure 1-1.** Body fluid compartments. Arrows represent fluid movement. Transcellular fluids, which constitute a very small percentage of total body fluids, are not shown.

In the average young adult male, 18% of the body weight is protein and related substances, 7% is mineral, and 15% is fat. The remaining 60% is water. The distribution of this water is shown in Figure 1-1. The intracellular component of the body water accounts for about 40% of body weight and the extracellular component for about 20%. Approximately 25% of the extracellular component is in the vascular system (plasma = 5% of body weight) and 75% outside the blood vessels (interstitial fluid = 15% of body weight). The total blood volume is about 8% of body weight

# WHAT NEEDS TO BE MAINTAINED CONSTANT IN INTERNAL ENVIRONMENT?

1. Concentration of oxygen and carbon dioxide.
2. pH of the internal environment.
3. Concentration of nutrients and waste products.
4. Concentration of salt and other electrolytes.
5. Volume and pressure of extracellular fluid.



# Differences between ECF & ICF

## ECF

### Cations:

**Na<sup>+</sup>** (142<sub>mmol/L</sub>)  
K<sup>+</sup> (4.2)  
Mg<sup>2+</sup> (0.8)

### Anions:

**Cl<sup>-</sup>** (108)  
**HCO<sub>3</sub><sup>-</sup>** (24)

### Nutrients:

O<sub>2</sub>, glucose, fatty acids, &  
amino acids.

### Wastes:

CO<sub>2</sub>, Urea, uric acid,  
excess water, & ions.

## ICF

### Cations:

Na<sup>+</sup> (14)  
**K<sup>+</sup>** (140)  
**Mg<sup>2+</sup>** (20)

### Anions:

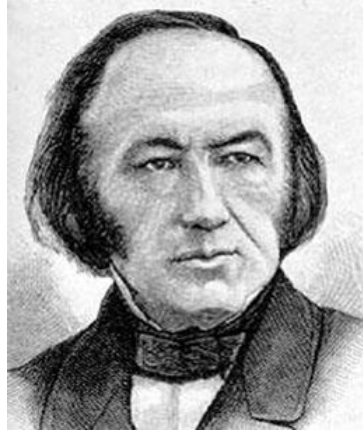
Cl<sup>-</sup> (4)  
HCO<sub>3</sub><sup>-</sup> (10)  
**Phosphate ions**

### Nutrients:

High concentrations of proteins.

# Homeostasis

• **The tendency of organisms to regulate and maintain relative internal stability**



- **Claude Bernard (1872)**
  - The *milieu interieur*
  - “Constancy of the internal environment is the condition of life”

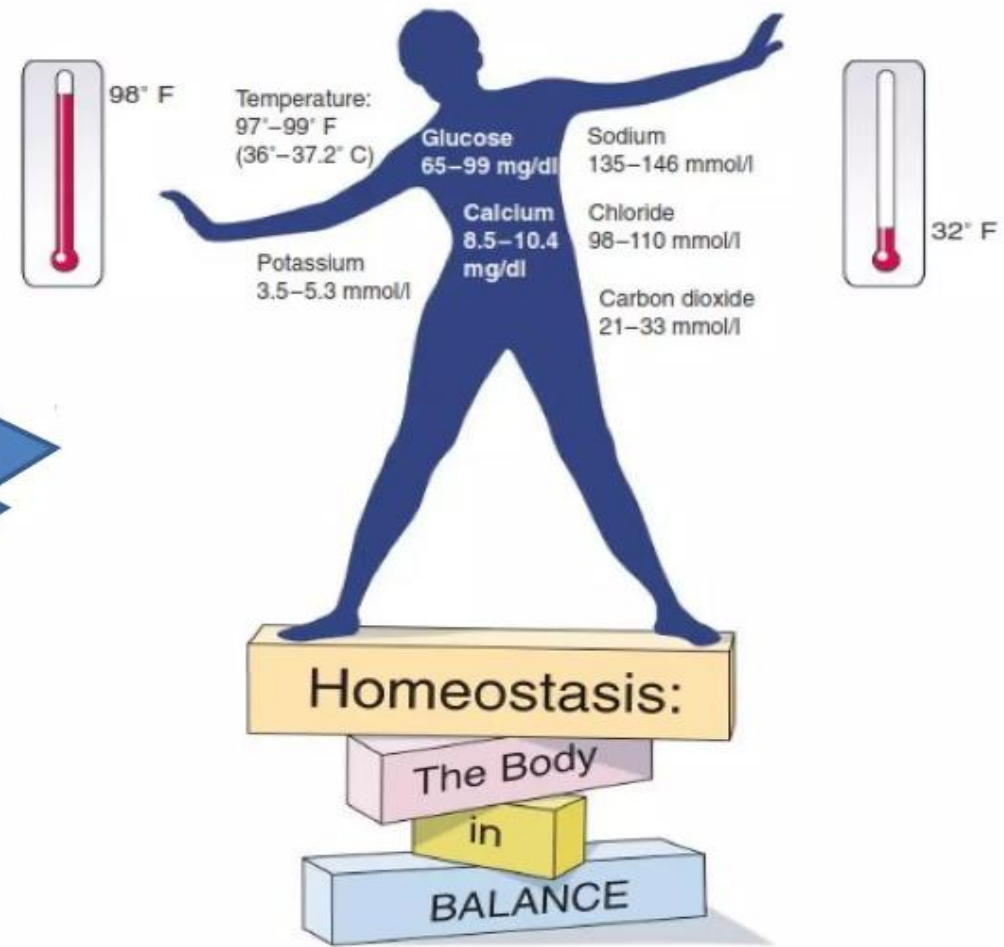


- **Walter B. Cannon (1871-1945)**
  - Sympathetic “flight or fight” response
  - “Homeostasis”

# Homeostasis

Homeostasis (homeo-, the same) is the existence and **maintenance of a relatively constant environment** within the body despite fluctuations in either the external environment or the internal environment.

**Walter Cannon** coined the term "homeostasis" (1929)



# Homeostasis

- Homeostasis is the word derived from the 2 Greek Words 'homeo' meaning 'similar,' and 'stasis' meaning 'stable.' Homeostasis refers to stability, balance, or equilibrium within a cell or the body. Maintaining a stable internal environment which requires adjustments as conditions change inside and outside the cell. The maintenance of systems within a cell is called homeostatic regulation. The continuous adjustments are made to meet the Set Point.
- Homeostasis is regulated by 3 different mechanisms and they are:
  - a) Osmoregulation
  - b) Thermoregulation
  - c) Chemical Regulation

# ALL ORGANS AND ORGAN SYSTEMS OF THE BODY HELP IN MAINTENANCE OF HOMEOSTASIS

- Cardiovascular system.
- Respiratory system.
- Nervous system.
- Endocrine system.
- Gastrointestinal system.
- Excretory system.
- Skeletal system.
- Integumentary system.
- Reproductive system.



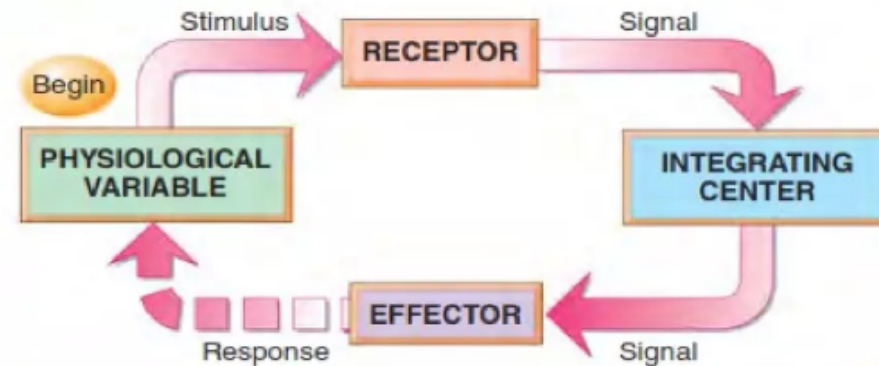
# Homeostatic Regulation

This process of adjustment (called homeostatic regulation) involves:

1. a receptor (which receives information about a change in the environment),
2. a control center (which receives and processes information from the receptor), and
3. an effector (which responds to signals from the control center by either opposing or enhancing the stimulus).



1. Receptor
2. Afferent Pathway
3. Integrating or control center
4. Efferent Pathway
5. Effector



# Feedback

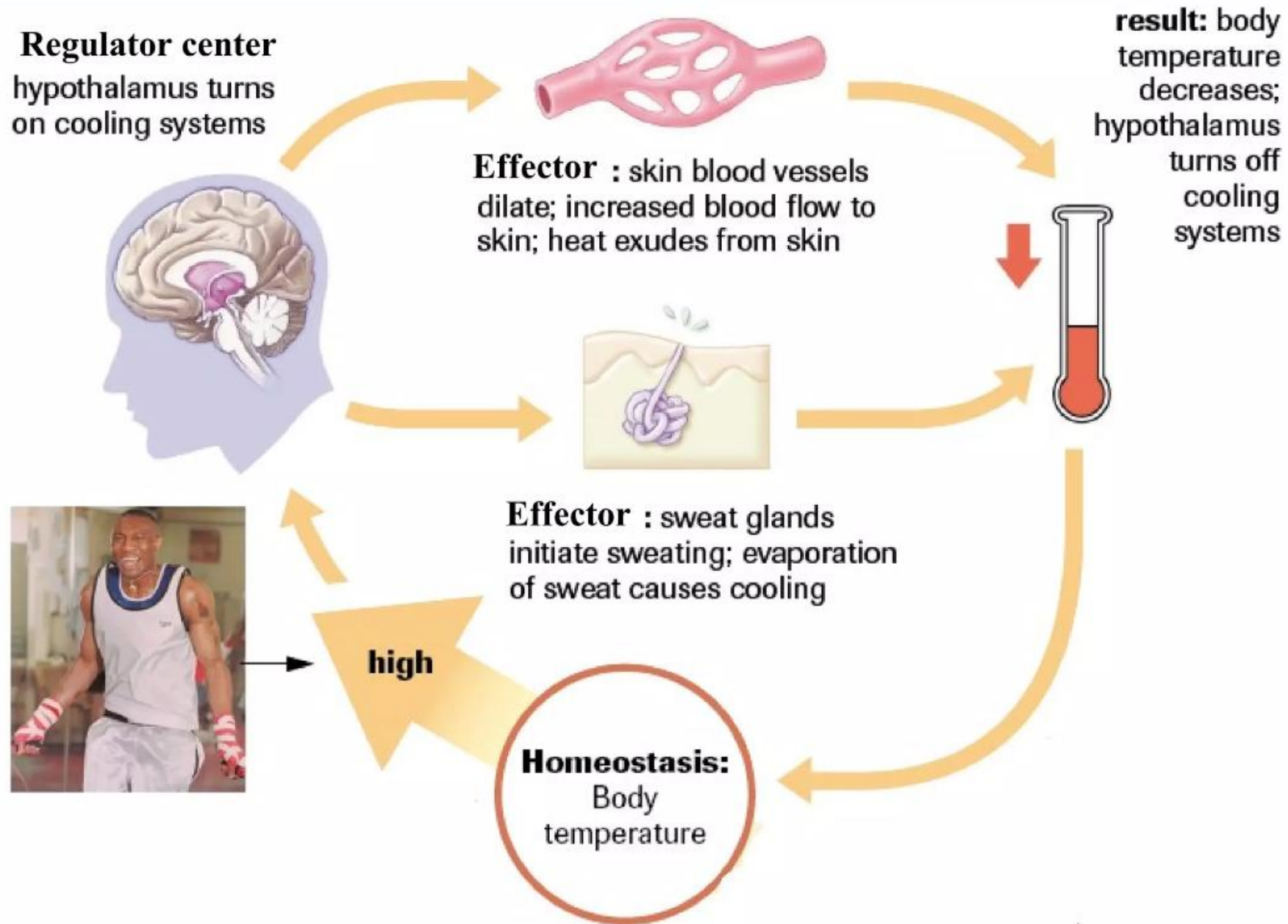
The signal sent by the effector is called feedback; feedback can be either negative or positive.

•**Negative feedback:** when the effector opposes the stimulus (such as a dropping temperature) and reverses the direction of change (causing the temperature to rise). Example: Decrease in Blood Glucose and Blood pressure



•**Positive feedback:** when the effector reinforces the stimulus (such as uterine contractions during childbirth, which trigger the release of the hormone oxytocin) and amplifies the direction of change (causing even greater contractions and further release of oxytocin). Example: Blood clotting, protein digestion, a temperature of 100.2F causes further increase

# Negative Feedback – Temp Regulation



# Negative Feedback – Temp Regulation

## Response to Heat Stress

1. Thermoreceptors in skin detect a rise in body temperature

2. Nervous system in brain sends message to hypothalamus

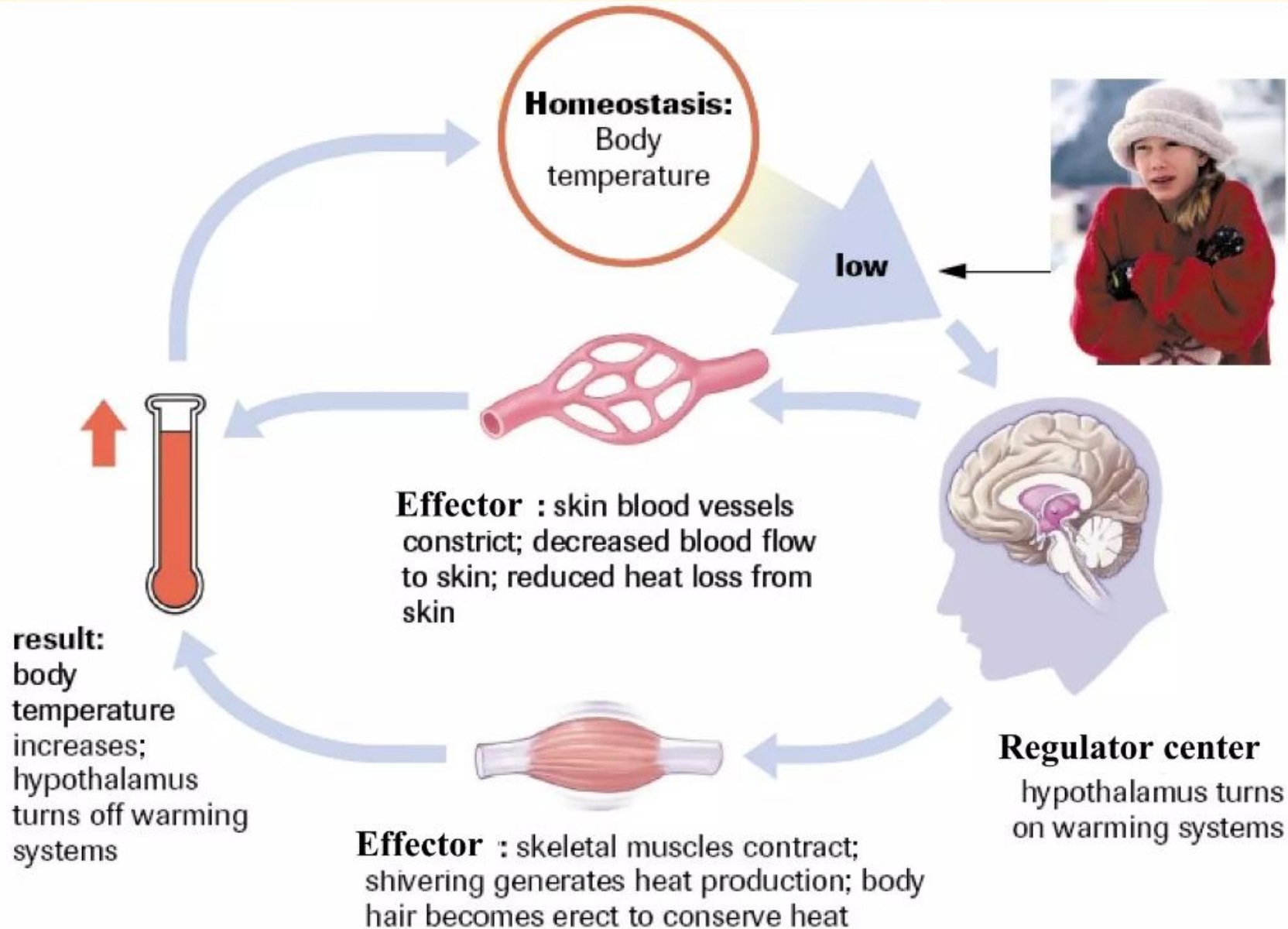


3. Hypothalamus response:

**Sweating:** Sweat glands to initiate sweating – evaporation of sweat cools body

**Vasodilation:** Blood vessels to dilate – more blood flows to skin, which has been cooled by evaporation

# Negative Feedback – Temp Regulation



# Negative Feedback – Temp Regulation

1. Thermoreceptors in the skin send a message to the hypothalamus
2. Hypothalamus response:
  - **Vasoconstriction:** Constricts smooth muscle of arterioles – blood flow is limited, heat loss from skin is reduced
  - **Piloerection:** Constricts smooth muscle around hair follicles, causing hair to stand on end – erect hair traps warm air next to skin
  - **shivering** : Skeletal muscles to initiate rhythmic contractions (10 – 20x per minute)



# Positive Feedback during childbirth

