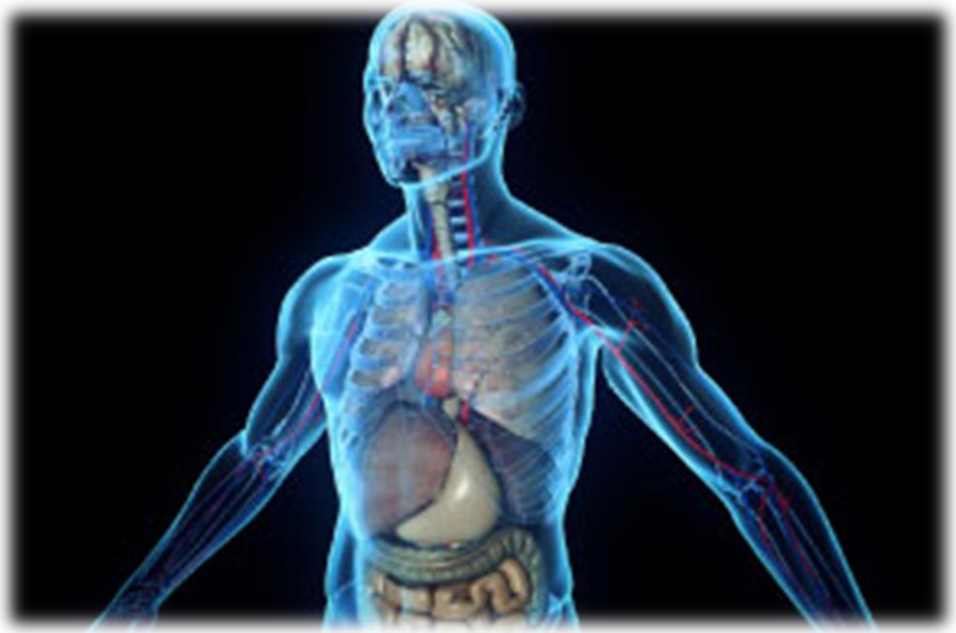

Basic Principles of Physiology

Cell Biology (Year 1 – Semester 1)

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Department of Physiology

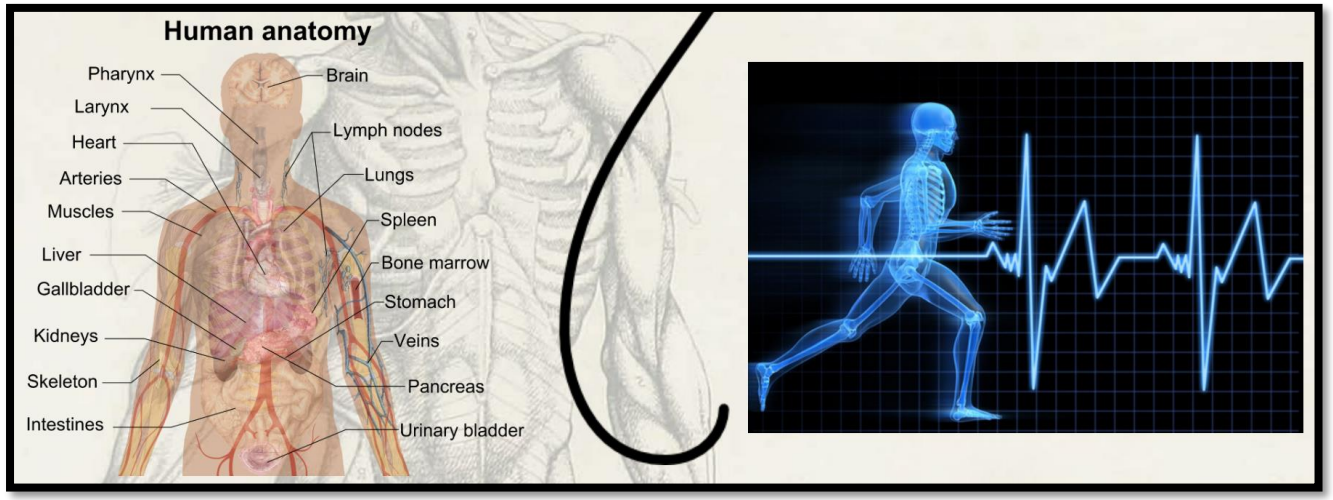
- **Anatomy** is the science of body **structures** and the relationship among them.

  Ana: apart; **tomy:** cut

- **Physiology** is the science of body **function** and the **mechanisms.**

  i.e. *How the body parts work?*

  Physio: nature; **ology:** the study of

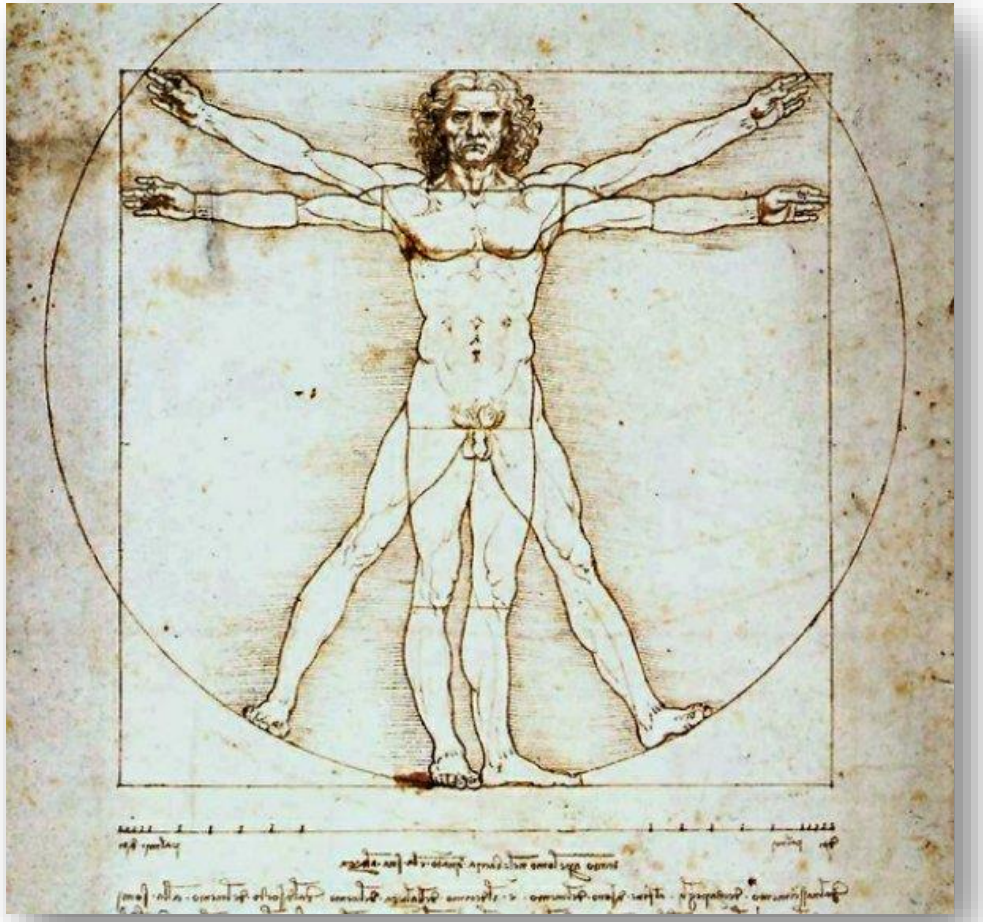


https://edu.glogster.com/glog/anatomy-vs-physiology/1wpsn9lvooo

The goal of Physiology

- To explain the physical and chemical factors that are responsible for the origin, development, and progression of life.

- **Human physiology** attempts to explain the specific characteristics and mechanisms of the human body that make it a living being.



https://en.wikipedia.org/wiki/Vitruvian_Man

Process

How cells divide?

How do we breathe?

How do RBCs transport O_2

Function

Why cells divide?

Why do we breathe?

Why do RBCs transport O_2

- Claude Bernard (1813-1878)

- *“After carrying out an analysis of phenomena, we must . . . always reconstruct our physiological synthesis, so as to see the joint action of all the parts we have isolated. . . .”*
- Physiology as the scientific basis of medicine
- ***milieu interior*:** internal environment

Levels of Organization of the Human Body

- ✓Chemical
- ✓Cellular
- ✓Tissue
- ✓Organ
- ✓System
- ✓Organismal

Levels of Organization: Chemical level

Atoms are the smallest unit of matter

Essential atoms for life: C, H, O, N, P, Ca, S, Mg, etc.

Molecules: Two or more atoms joined together

H_2O, CO_2

Carbohydrates

Lipids

Proteins

Nucleic acids…

Levels of Organization: Cellular level

- ✓**Cells:** Basic structural and functional units of an organism

- ✓~200 different kind of cells

Levels of Organization: Tissue level

- Muscle tissue
- Nervous tissue
- Epithelial tissue
- Connective tissue

Levels of Organization: Organ level

Tissues are joined together to form organs

They have specific function and shape

Levels of Organization: System level

A system consists of related organs with a common function

Major Functional Systems

- Integumentary System
- Cardiovascular System
- Respiratory System
- Digestive System
- Musculoskeletal System
- Urinary System (Renal System)
- Reproductive system

Regulation of Body Functions

- Nervous System
- Endocrine System (Hormones)

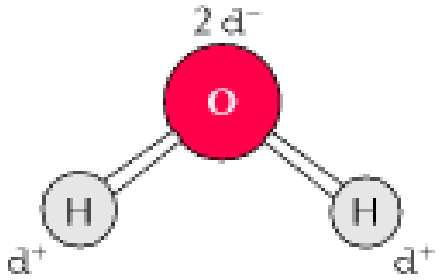
Levels of Organization: Organismal level

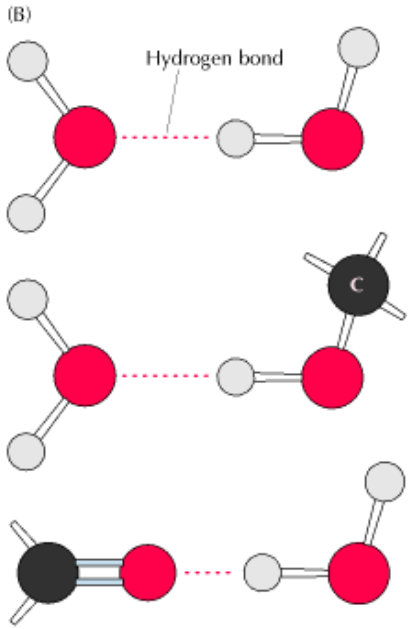
Organ systems work cooperatively to perform necessary life functions.

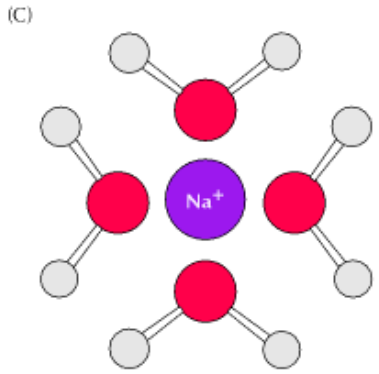
BODY FLUIDS

Body Fluids

- The chemical reactions of life take place in aqueous solutions.
- Human beings are **mostly water**, ranging from about 75% of body mass in infants to about 50–60% in adult men and women.







The total body fluid is distributed mainly between two compartments

1- Intracellular fluid: ICF (inside the cell)
40 % body weight
=28 liters

2- Extracellular fluid: ECF (outside the cell)
20 % body weight
= 14 liters

a) **Interstitial fluid** (Intercellular)
15 % body weight = 10.5 liters

b) **Intravascular fluid** (Blood Plasma)
5 % body weight = 3.5 liters

c) **Transcellular fluid** (synovial, peritoneal, pericardial, CSF, intraocular spaces)

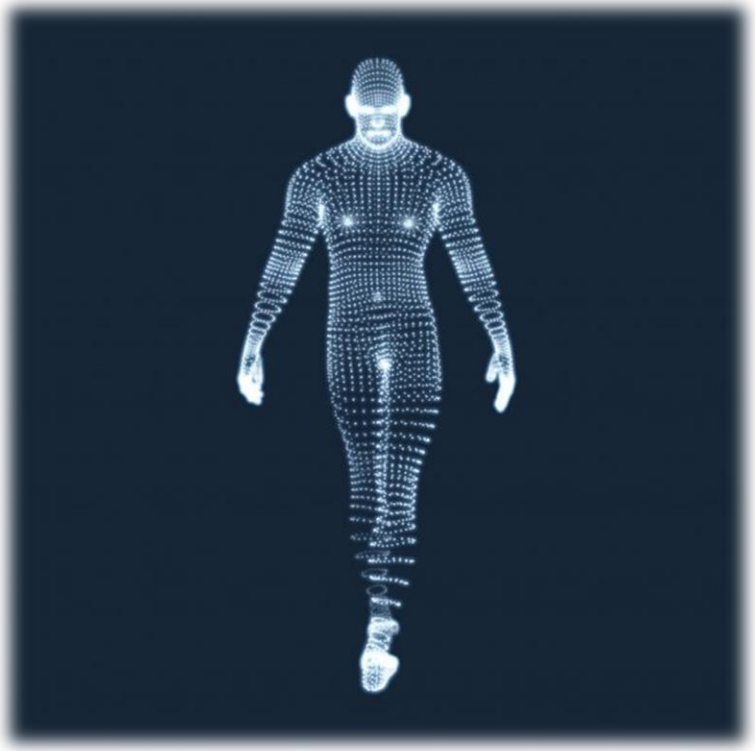
TOTAL BODY FLUID

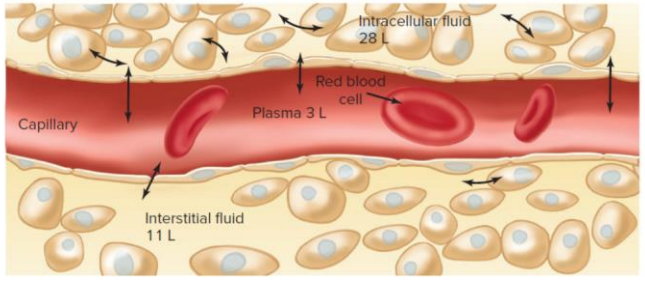
60 % = 42 liters

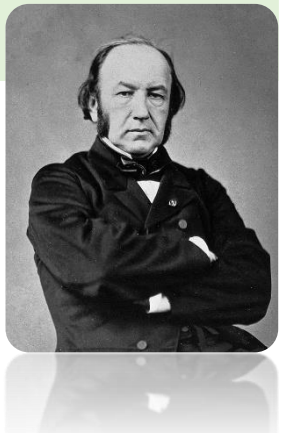
In the extracellular fluid are the **ions and nutrients** needed by the cells to maintain cell life.

The extracellular fluid is also called the "*internal environment of the body*"*(the milieu intérieur).*

The internal environment is made up of the ECF.







Homeostasis

- **Homeostasis** is the maintenance of constant conditions in fluid surrounding cells (extracellular fluid) or internal environment by the integrated actions of various organs within the organism

- **Homeo:** the same; **Stasis:** standing still

- The term *"homeostasis"* is used by physiologists to explain **maintenance of nearly constant conditions in the internal environment** even though the outside world is continuously changing.

- Essentially all organs and tissues of the body perform functions that help maintain these constant (steady state) conditions.

- Dynamic

Homeostasis

DOES NOT mean stopping any changes

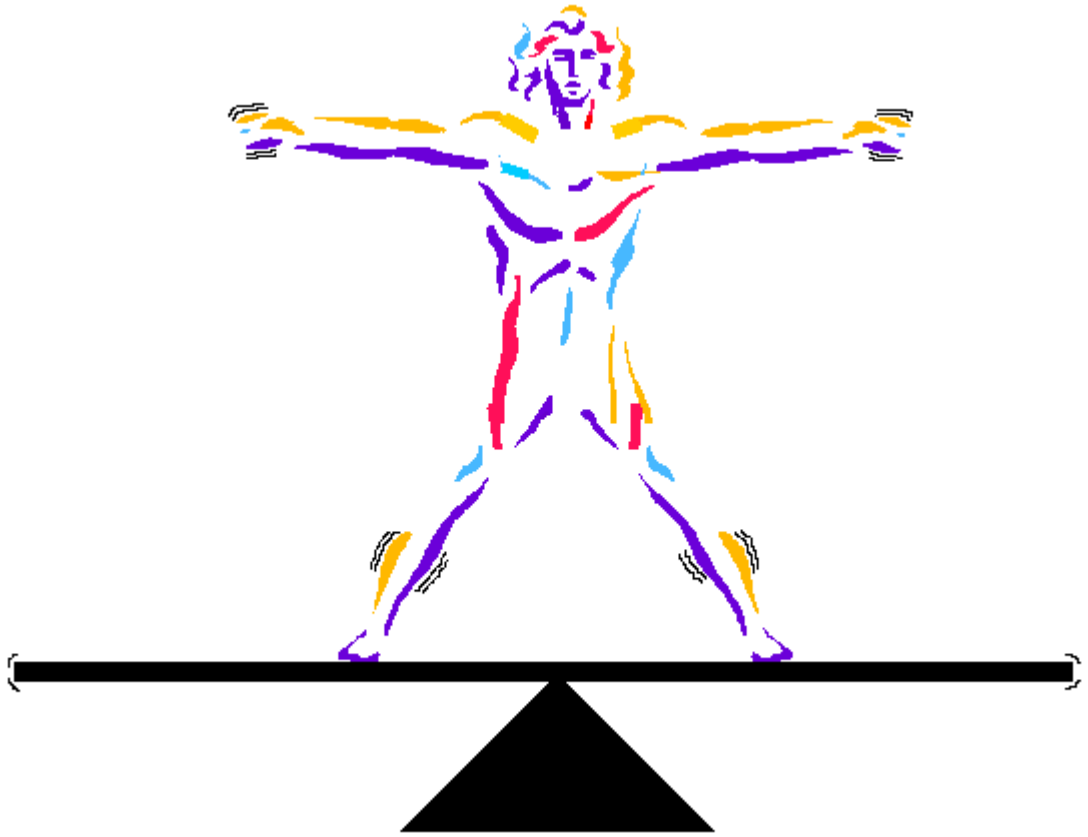
«**Trying to keep it within a normal range**»

A person may be homeostatic for one variable but not homeostatic for another.

Homeostasis must be described differently, therefore, for each variable.

If a variable goes beyond the accepted range, it has **deviated**.

The body must be able to detect variables that have deviated from the **set point**, and perform corrective measures: **Homeostatic regulation**



Homeostatic Control Mechanisms

20°C and moderate humidity

- Heat loss to the external environment because it is at a lower temperature.
- The chemical reactions occurring within the cells of his body are producing heat at a rate equal to the rate of heat loss.
- The body undergoes NO net gain or loss of heat, and the body temperature remains constant.
- **STEADY STATE - SET POINT**

5°C

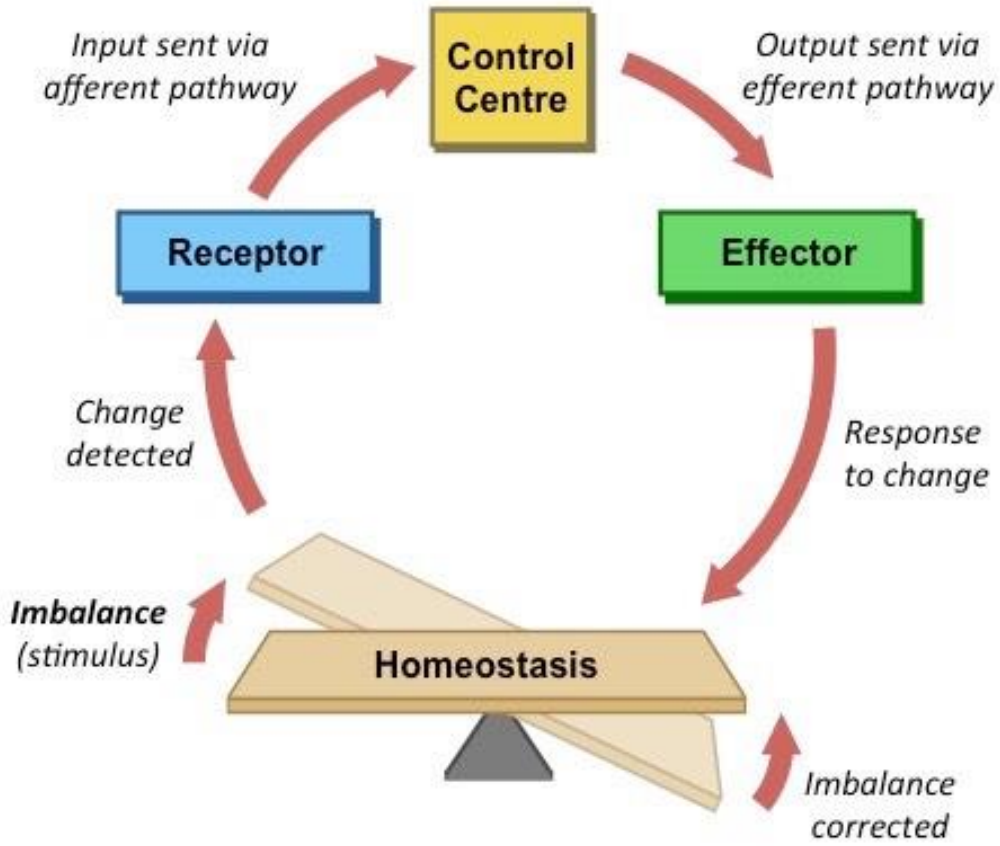
- Increases loss of heat from subject's warm skin, upsetting the balance between heat gain and loss.
- The body temperature starts to decrease. Very rapidly, however, a variety of homeostatic responses occur to limit the decrease.
- Blood vessels to the skin become constricted to reduce the amount of blood flowing through the skin.
- Subject hunches his shoulders and folds his arms in order to reduce the surface area of the skin available for heat loss.
- If excessive heat loss (output) cannot be prevented, the only way of restoring the balance between heat input and output is to increase input.
- Subject begins to shiver, and the chemical reactions responsible for the skeletal muscle contractions that constitute shivering produce large quantities of heat.

Characteristics of Control Systems

- Most control systems of the body act by ***negative feedback***.
- **Negative** → Opposite to the direction of the change
- If some factor becomes excessive or deficient, a control system initiates *negative feedback,* which consists of a series of changes that **return the factor toward a certain mean value**, thus maintaining homeostasis.
- Negative feedback has a vital part in the checks and balances on most physiological variables.

Components of Homeostatic Control System

- Stimulus-Response Sequences: Reflexes
- The pathway mediating a reflex: R**eflex arc,**



Negative Feedback

Example: Regulation of Arterial Blood Pressure

STIMULUS	**INCREASE IN ABP**
Receptor	Baroreceptors
Afferent Pathway	IX. and X. Cranial nerves
Control Center	Medulla Vasomotor Center
Efferent Pathway	Sympathetic nerves
Effector organ	Heart and blood vessels
Response	**Decrease in heart pumping and vasodilation**

“Gain” of a control system

- **Gain of a control system is the degree of effectiveness.**
- The feedback control system has caused a “correction” of –50 mm Hg—that is, from 175 mm Hg to 125 mm Hg.
- There remains an increase in pressure of +25 mm Hg, called the “error,” which means that the control system is not 100 per cent effective in preventing change. The gain of the system is then calculated by the following formula:

$$\text{Gain} = \frac{\text{Correction}}{\text{Error}}$$

- The gain of the person’s baroreceptor system for control of arterial pressure is –2.

- ✓ Barareceptor system is not functioning
- ✓ Large volume of blood transfusion
- ✓ 100 mmHg → 175 mmHg

- ✓ Barareceptor system is functioning
- ✓ Same amount of blood transfusion
- ✓ 100 mmHg → 125 mmHg

Positive Feedback

- *Positive feedback* is a kind of vicious cycle and can't be used as control mechanism.
- Accelerates a process, leading to an "explosive" system which is counter to the general physiological principle of homeostasis .
- Positive feedback can sometimes be useful:
  - Delivery
  - Blood clotting
  - Generation of nerve signals

Adaptive control system: Feed-forward control

- Some adaptive responses of the body occur so rapidly that **there is not enough time** for changing the internal environment.

- Feed forward control, **increases the "net gain" of the control system**

- Example: Sweating and breathing speeds up even before the start of exercise

Clashing Demands

- Because so many properties of the internal environment are closely interrelated, it is often possible to keep one property relatively stable only by moving others away from their usual set point.
- There is a hierarchy of importance, so that certain variables may be altered markedly to maintain others within their normal range.

General Principles of Physiology

Homeostasis is essential for health and survival.

The functions of organ systems are coordinated with each other.

Most physiological functions are controlled by multiple regulatory systems, often working in opposition.

Information flow between cells, tissues, and organs is an essential feature of homeostasis and allows for integration of physiological processes.

Controlled exchange of materials occurs between compartments and across cellular membranes.

Physiological processes are dictated by the laws of chemistry and physics.

Physiological processes require the transfer and balance of matter and energy.

Structure is a determinant of—and has coevolved with—function.

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