

# Course Content Overview

## Module 1: The cell as a functional unit

Structure–function relationship

Organization into levels of complexity

## Module 2: Systems of systemic coordination

Nervous system

Muscular system

Circulatory system

Endocrine system

## Module 3: Body logistics systems

Gastrointestinal system

Respiratory system

Excretory system

Reproductive system

## Assessment

Group project: proposal of an innovative biotechnological application

Written test

## RECOMMENDED TEXTBOOKS:

**Netter's Essential Physiology.** Authors: Mulroney, S. E., & Myers, A. K. (2016). Editor: Elsevier. ISBN : 978-0-323-35819-4. Language: English

**Costanzo Physiology 7th edition.** Authors: Linda S. Costanzo, Editor: Elsevier, ISBN:978-0-323-79333-9. Language: English

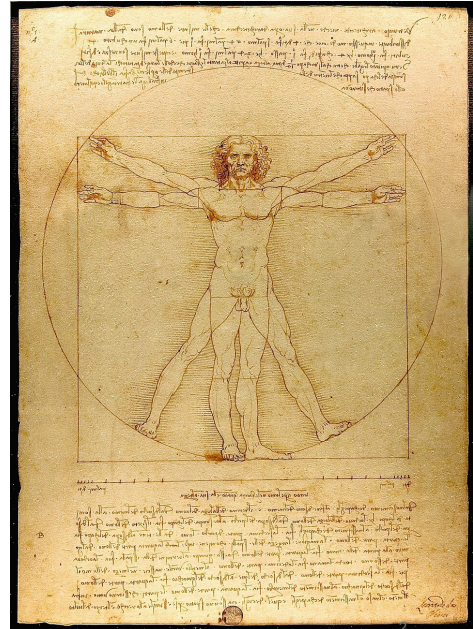
**The Physiology Coloring Book.** Authors: Wynn Kapit , Robert Macey, Esmail Meisami. Editor: Pearson Education. ISBN-13: 978-0321036636, ISBN-10: 0321036638. Language: English

***Physiology is not a science that has exhausted all  
its means... but it grows every day.  
It consolidates... and is destined to absorb arts  
from other sciences.”***

*Gabriele D'Annunzio*

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## Physiology

**Physiology: means “knowledge of nature.”**

**Physiology is the study of the normal functioning of a living organism and of the parts that compose it, including physical and chemical processes.**

*Aristotele (384-322 a.C.) ed Ippocrates (460-377 a.C.) can be considered, respectively, the founding fathers of General Physiology (functioning of all living organisms) and Medical Physiology (study of the “healing power of nature”).*

**The focal point of physiology is the integration of functions across many levels of organization.**

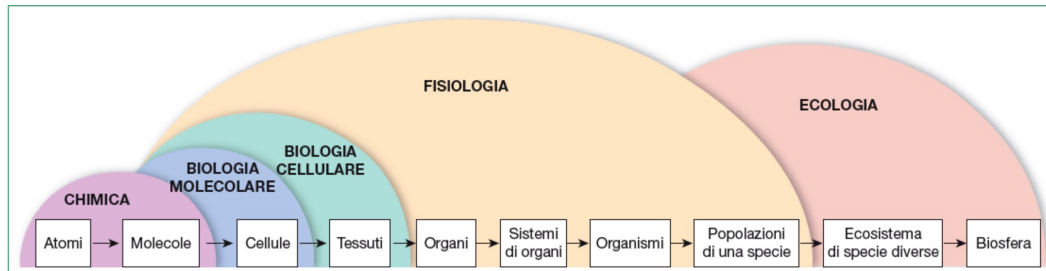
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Physiology is the study of how living organisms normally function.

In simple terms, it is the engineering of life: it explains how cells produce energy, how neurons communicate, how the heart pumps blood, and how the body maintains internal balance.

All these processes occur simultaneously and in a coordinated way.

## Levels of organization of living organisms



↓  
The smallest structural  
unit capable of carrying  
out all processes

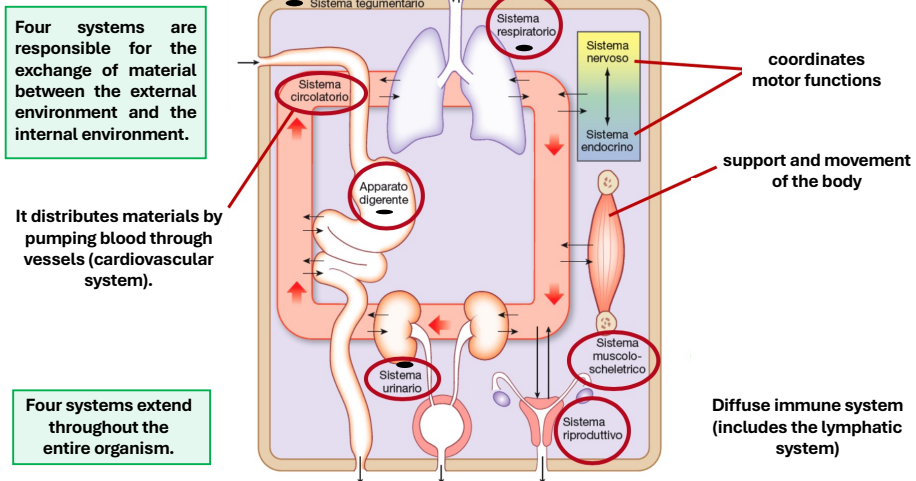
**Physiology cannot be separated from anatomy and physics**

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Here is a fundamental concept for biotechnology students: everything starts from the cell. We can study molecules, proteins, and genes, but the first unit that is truly alive is the cell. And if we understand how a cell works, we can understand everything else: tissues, organs, and systems.

## The main systems of the organism are functionally integrated

(from *integumentum*, covering) composed of the skin



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These are different systems, but they are all working together.  
This is the key point of physiology: nothing functions in isolation.  
Every system exists because it is connected to the others.

## Function and Mechanism

Two related concepts in physiology

The **function** of a system (or of a physiological event) is the “why” of the system or event: **why** does a system exist or why does an event occur? (teleological approach: reasoning about a scientific event in terms of adaptive meaning).

Physiological **processes** (or mechanisms) represent the “how” of a system (mechanistic approach: examines the process).

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In physiology, we always ask two questions:

Why does something happen? And how does it happen?

For example:

Why does heart rate increase when you are afraid?

Because the body prepares for action.

How does it happen?

The nervous system activates the heart through electrical signals and hormones.

So, every physiological phenomenon always has both a function and a mechanism.

## Physiology is an integrated science

### 1. Structure–function relationship

**Molecular interactions:** ability of individual molecules to bind to or react with other molecules

**Mechanical properties of cells, tissues, and organs:** ability to change shape and return to the initial state

**Compartmentalization:** division of a space into separate compartments

### 2. Use of biological energy

### 3. Communication

**Information flow:** chemical and electrical signals; local and long-distance

**Mass flow:** movement of substances within and between compartments; follow gradients

### 4. Homeostasis

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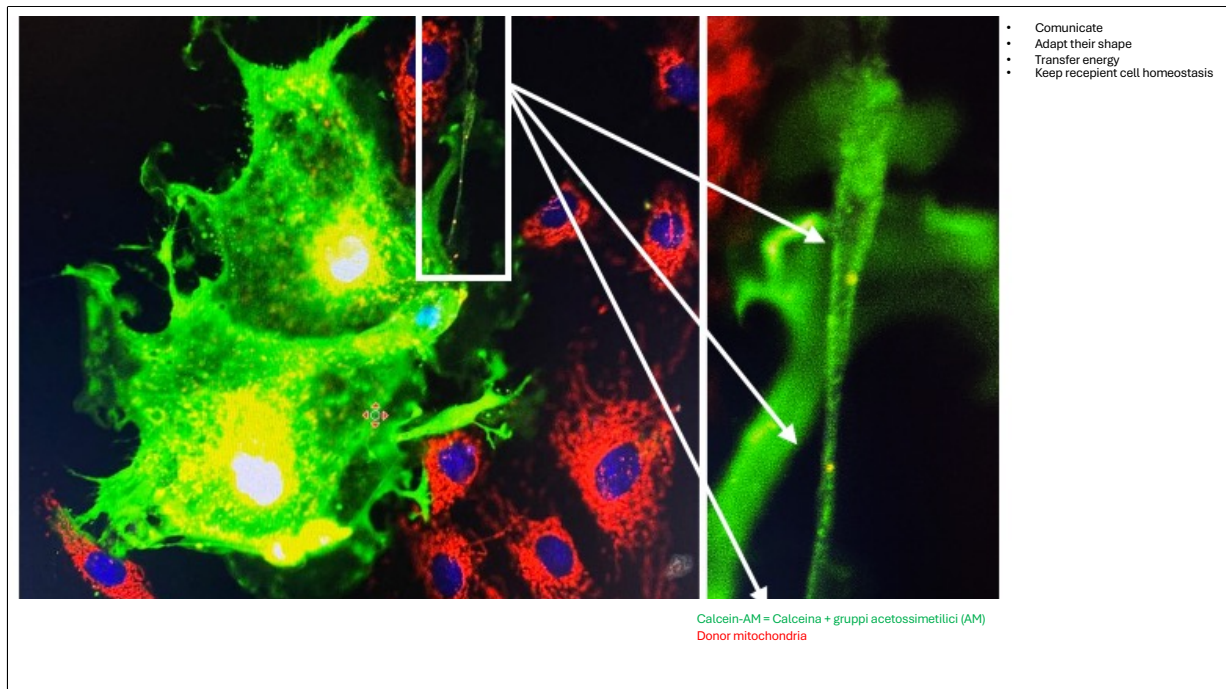
Physiology is based on four key ideas:

Structure and function: shape determines what a structure can do.

Energy: every biological process requires and therefore consumes energy.

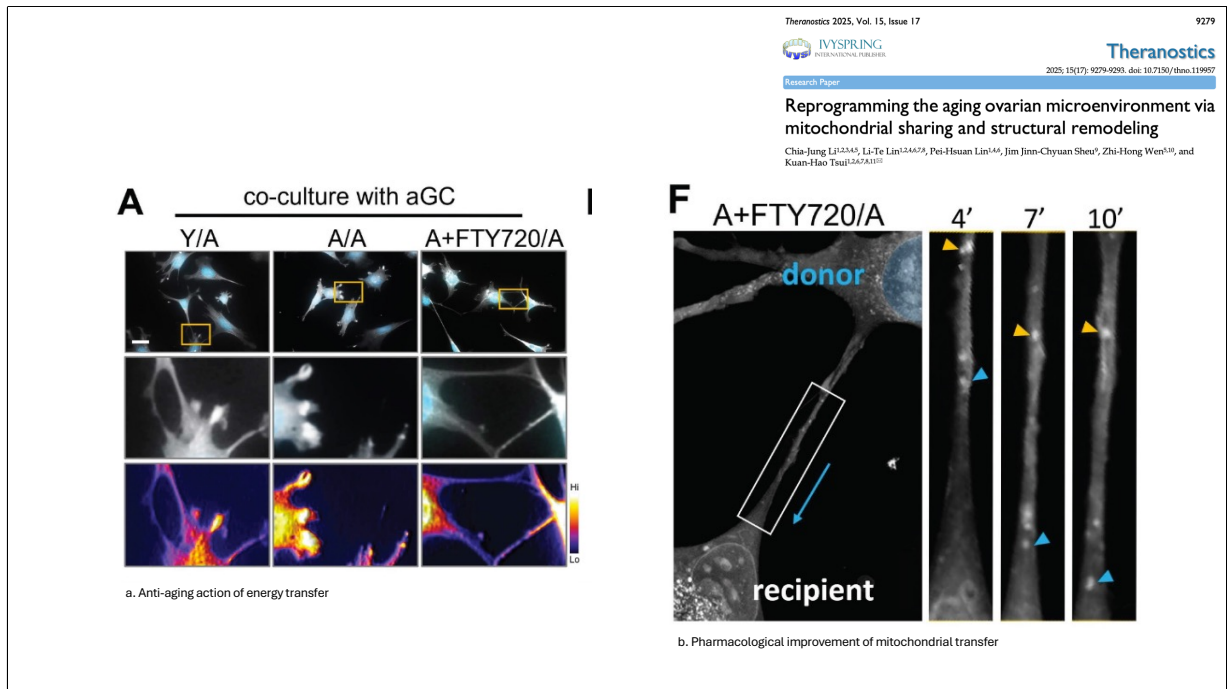
Communication: cells must communicate with each other, using chemical and electrical signals.

Homeostasis: the organism maintains internal balance.



Some examples of integration of the functions previously described:

1. Mesenchymal stem cells (MSCs) act as donor cells, transferring healthy mitochondria and their components to damaged recipient cells via MitoEVs, in order to maintain cellular homeostasis.



2 (a) Mitochondrial transfer from young granulosa cells to aged granulosa cells restores mitochondrial function and represents a potential anti-aging strategy.

(b) Pharmacological treatment with FTY720 in aged granulosa cells promotes the formation of tunneling structures for organelle exchange and therefore energy transfer (enhancing communication and energy balance).

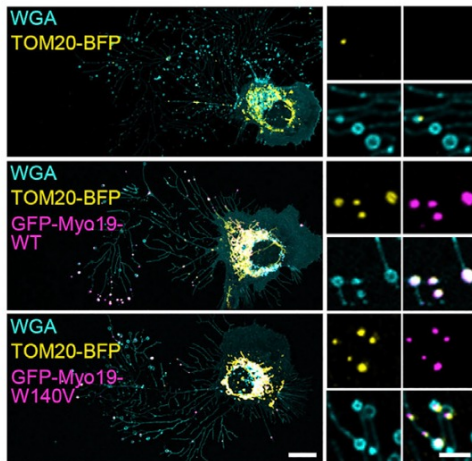
The structure changes according to the message to be sent to the surrounding environment...

CellPress

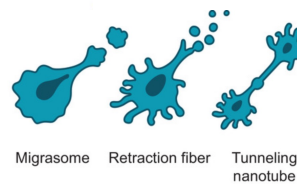
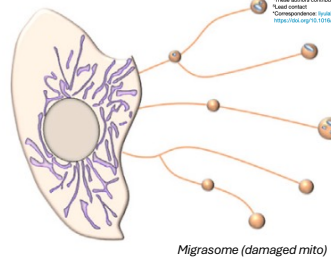
Cell

Article  
**Mitocytosis, a migrasome-mediated  
mitochondrial quality-control process**

Hailong Jiao,<sup>1,2</sup> Dong Jiang,<sup>1,3</sup> Xinyu Hu,<sup>1</sup> Wenqiang Du,<sup>1</sup> Liangfang Ji,<sup>1</sup> Yuhua Yang,<sup>1</sup> Xiaoping Li,<sup>1</sup> Takashi Sato,<sup>4</sup>  
Xuan Wang,<sup>1</sup> Yong Li,<sup>1</sup> Yu-Ting Wu,<sup>1</sup> Yan-Hua Wu,<sup>1</sup> Xinyu Han,<sup>1</sup> and Li Yu<sup>1,5</sup>  
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<https://doi.org/10.1016/j.cel.2021.04.027>



J

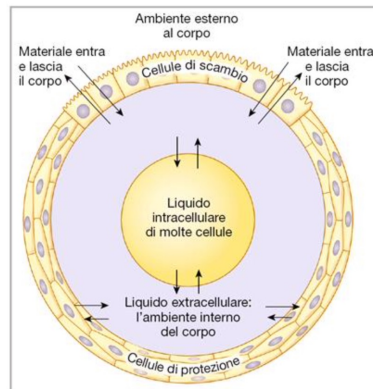


3. Damaged mitochondria are transported into migrasomes and subsequently expelled from the cell, in a process called mitocytosis.

# Homeostasis

*omoios: like Stasis: condition*

Ability of living organisms to maintain their internal environment relatively stable



**Claude Bernard (1850):**  
defines for the first time the  
concept of a “relatively stable  
internal environment” = “la  
fixité du milieu intérieur.”



**Homeostasis and the regulation of the internal environment are fundamental principles of physiology.**

Even if the external environment changes, the internal environment must remain stable.  
This is called homeostasis.  
It is probably the most important concept in physiology.

This idea has deep roots. Around 1850, Claude Bernard made a revolutionary observation.  
He said that life is possible only if the internal environment remains stable, even when the external one changes.  
In other words, we survive not because we are strong, but because we are stable.

Cells function only within very narrow limits.

**If pH changes too much, proteins do not work.**

**If temperature changes, enzymes slow down.**

**If ions change, neurons stop transmitting signals.**

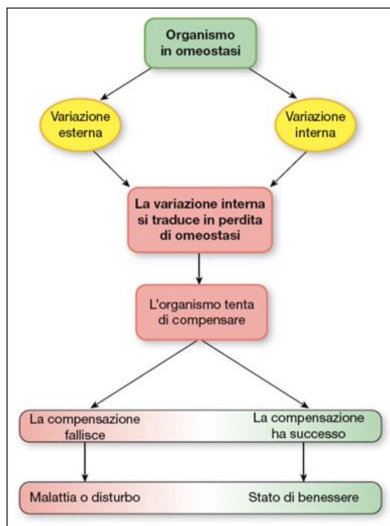
Yet your body keeps all these parameters constant, continuously, without you noticing.  
This is the concept of homeostasis, and it is essential for life.

For example, if blood pH changes by only 0.1 units, some proteins stop functioning.

For example, if your body temperature increases by only 3 degrees, neurological problems begin to appear.

For example, if extracellular potassium slightly increases, the heart can develop arrhythmias.

**The inability to maintain homeostasis:**  
pathology (*pathos*, suffering)



**PATHOPHYSIOLOGY:**  
Studies the loss of balance

**PHYSIOLOGY:**  
Studies the equilibrium

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The body always tries to compensate to maintain homeostasis; when this fails, disease appears.  
Physiology studies balance.  
Pathophysiology studies the loss of balance.