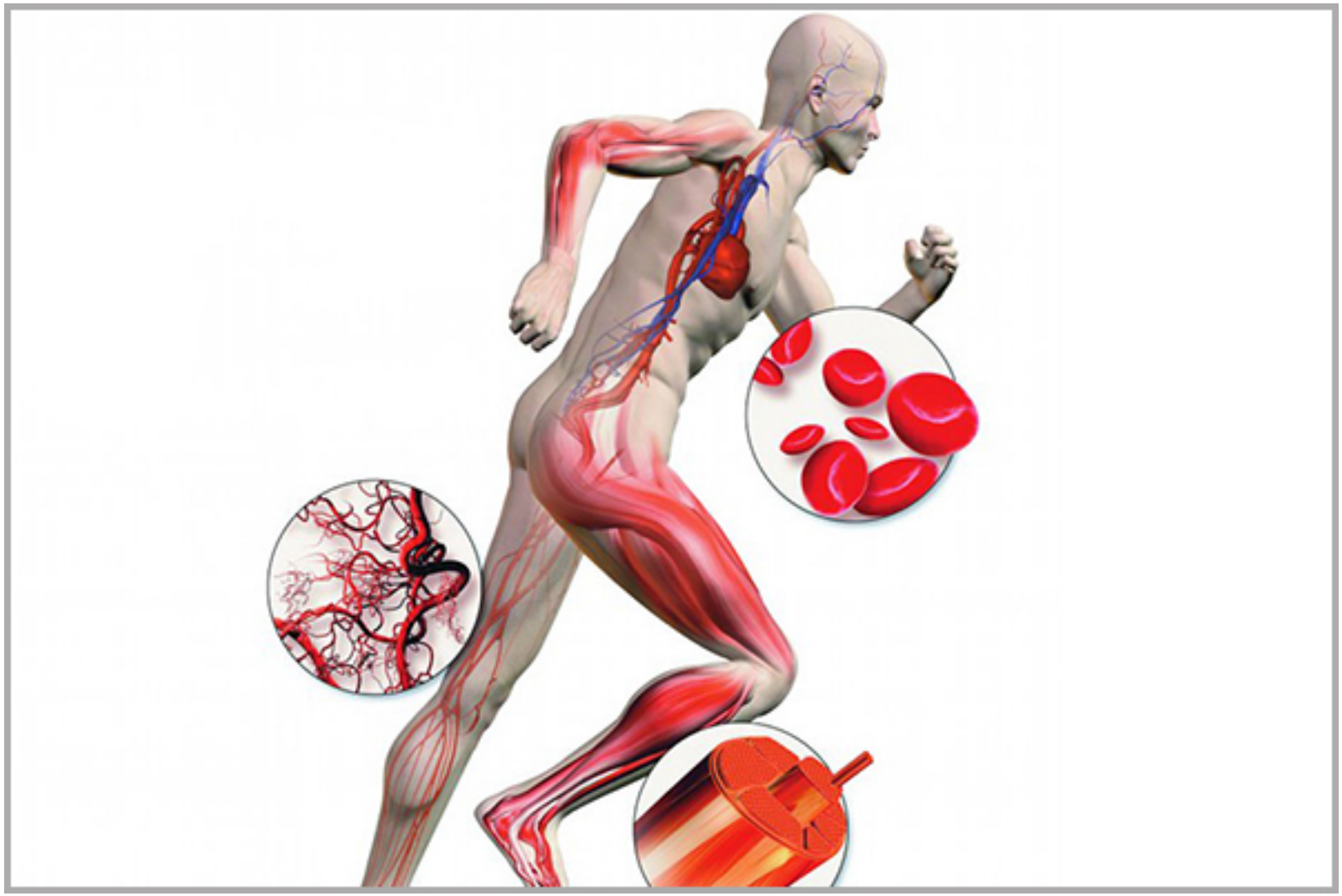


FIZJOLOGIA

dr inż. Magdalena Przybyło

LABORATORIUM

www.lbam.pwr.wroc.pl

Prace inżynierskie w zakresie:

- Hodowli komórkowych pod testowanie kierowanych nośników leków

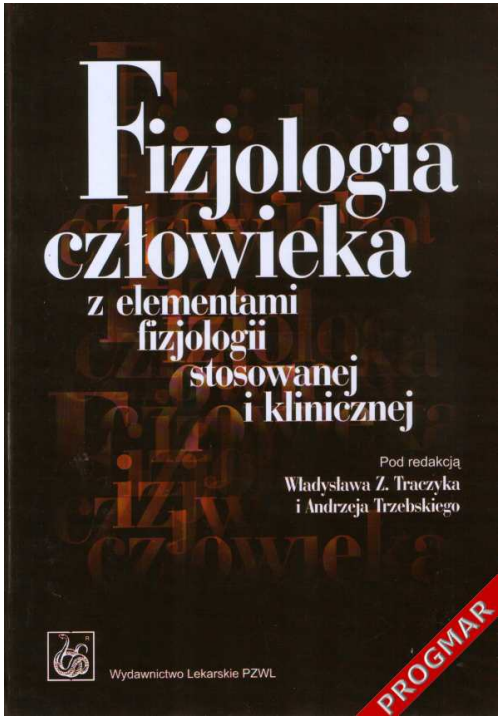
-

- fizykochemii nanoagregatów do zastosowań w farmacji

- analiza nanocząstek i zastosowania w nanomedycynie

- metody diagnostyczne oparte o zjawisko hemolizy

- analiza powierzchni pooperacyjnych implantów kości



magdalena.przybylo@pwr.edu.pl

bud. D1 pok. 02

WAŻNE TERMINY

	PAŹDZIERNIK					LISTOPAD				GRUDZIEŃ				STYCZEŃ					LUTY			
PN	3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30 pnP	6	13	20	27
WT	4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	31 wtP	7	14	21	
ŚR	5	12	19	26	2 śrN	9 ptN	16	23	30	7	14	21	28	4	11	18	25	1 śrP	8	15	22	
CZ	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	2 ptN	9	16	23	
PT	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24	
SO	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18	25	
N	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19	26	
P - PARZYSTY N - NIEPARZYSTY	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N	P	N

TESTY WIELOKROTNEGO WYBORU

TESTY WIELOKROTNEGO WYBORU

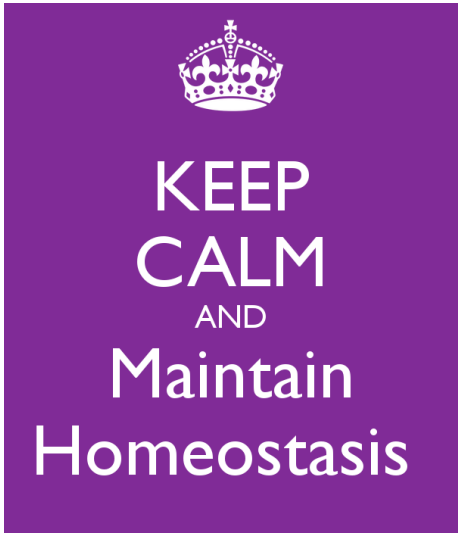
PRZYKŁAD TESTU

W organizmie najwięcej jest płynu:
A) wewnątrzkomórkowego
B) zewnątrzkomórkowego
C) surowicy

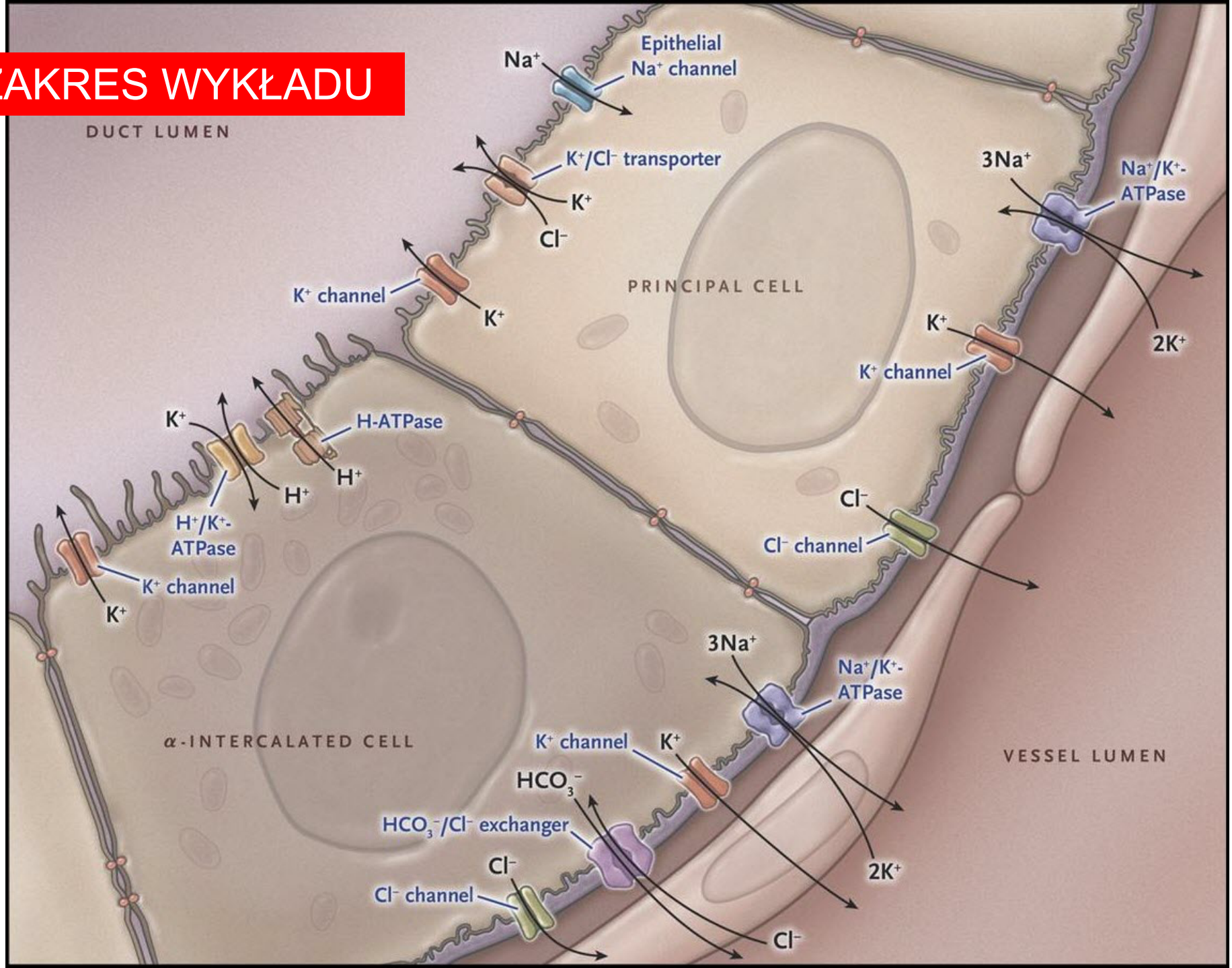
W skład płynu zewnątrzkomórkowego wchodzą:
A) sama surowica
B) surowica i płyn śródmiąższowy
C) sam płyn śródmiąższowy

ZAKRES WYKŁADU

1. HOMEOSTAZA

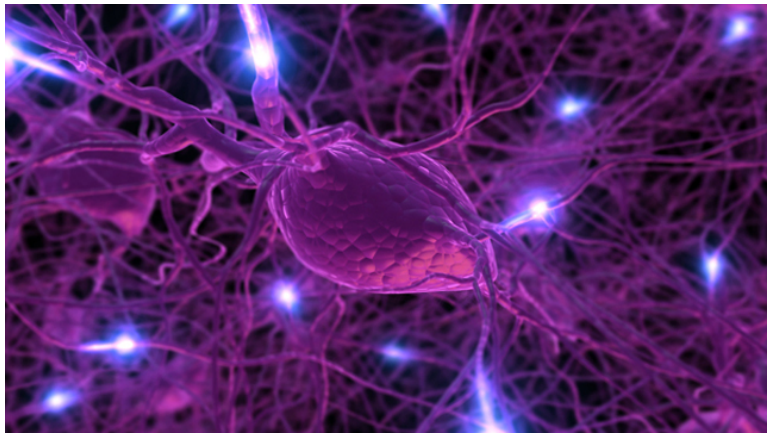


ZAKRES WYKŁADU



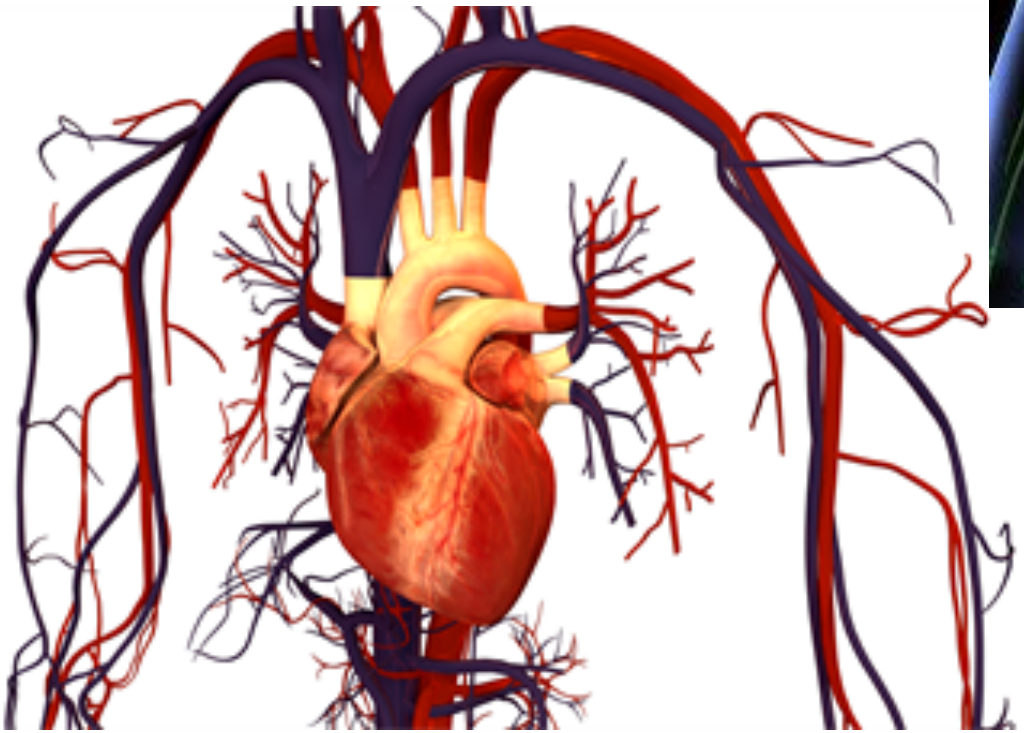
ZAKRES WYKŁADU

2. UKŁAD MOTORYCZNY ORAZ UKŁAD NERWOWY



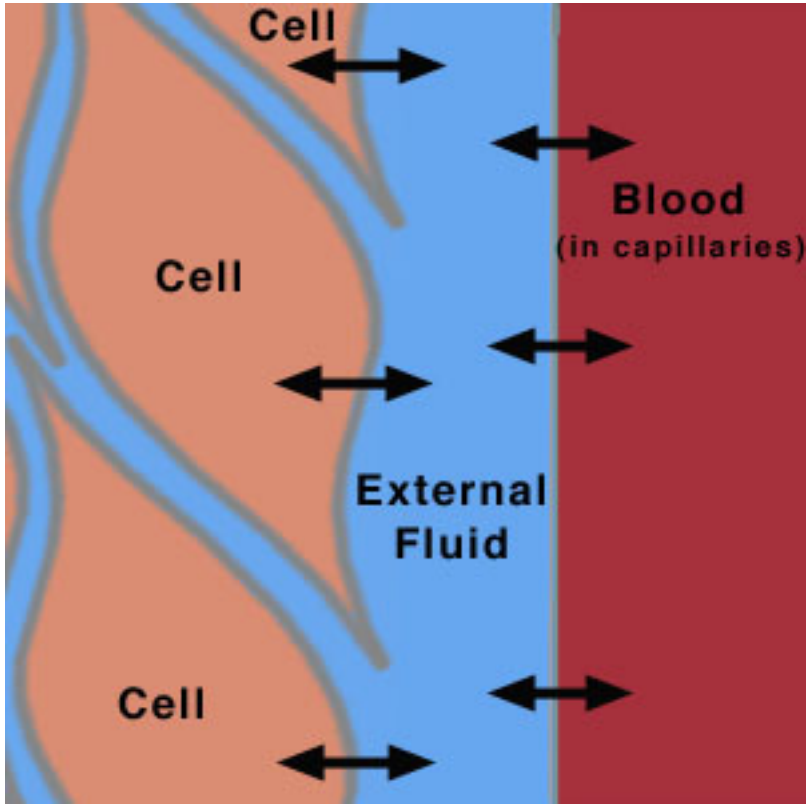
ZAKRES WYKŁADU

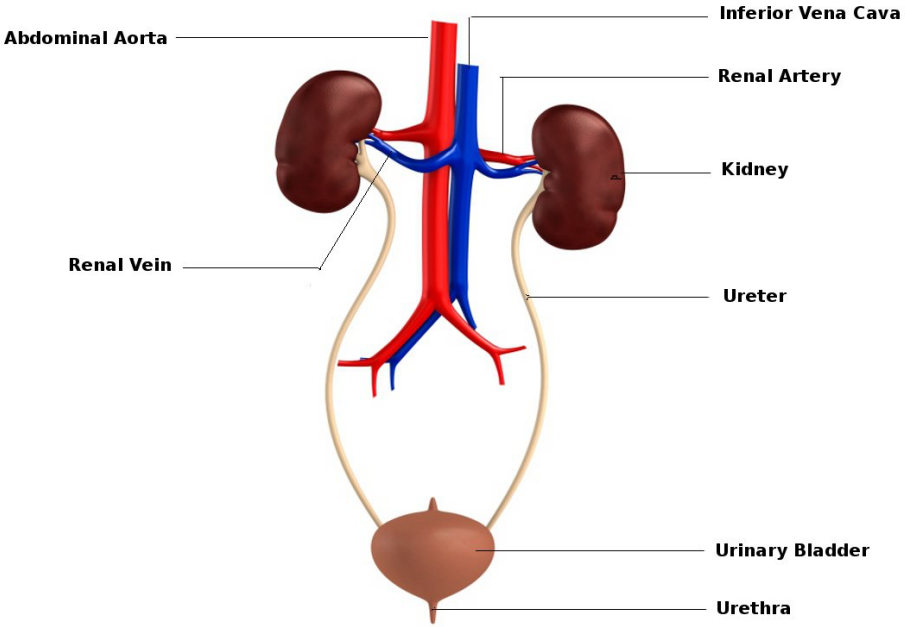
3. UKŁAD KRĄŻENIA ORAZ UKŁAD LIMFATYCZNY



ZAKRES WYKŁADU

4. GOSPODARKA PŁYNÓW



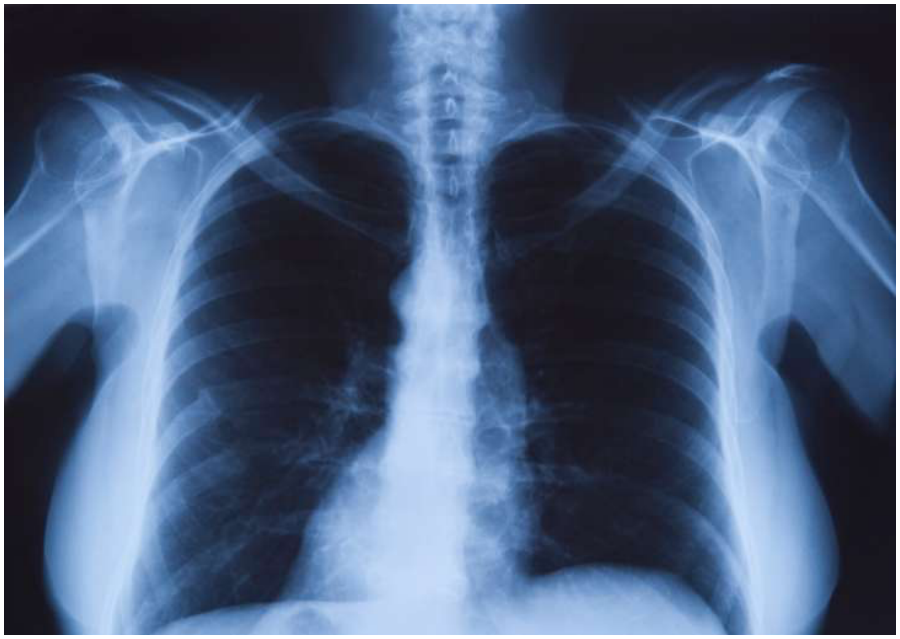


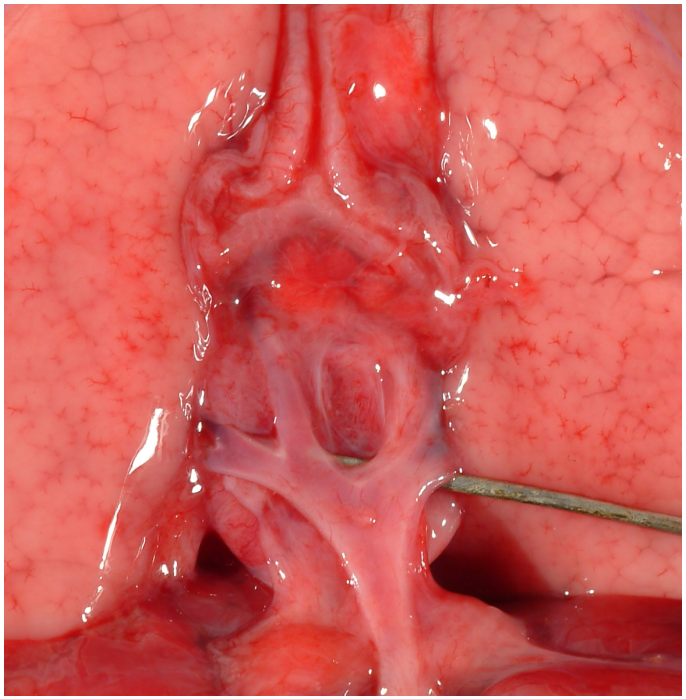
ZAKRES WYKŁADU

5. UKŁAD POKARMOWY

ZAKRES WYKŁADU

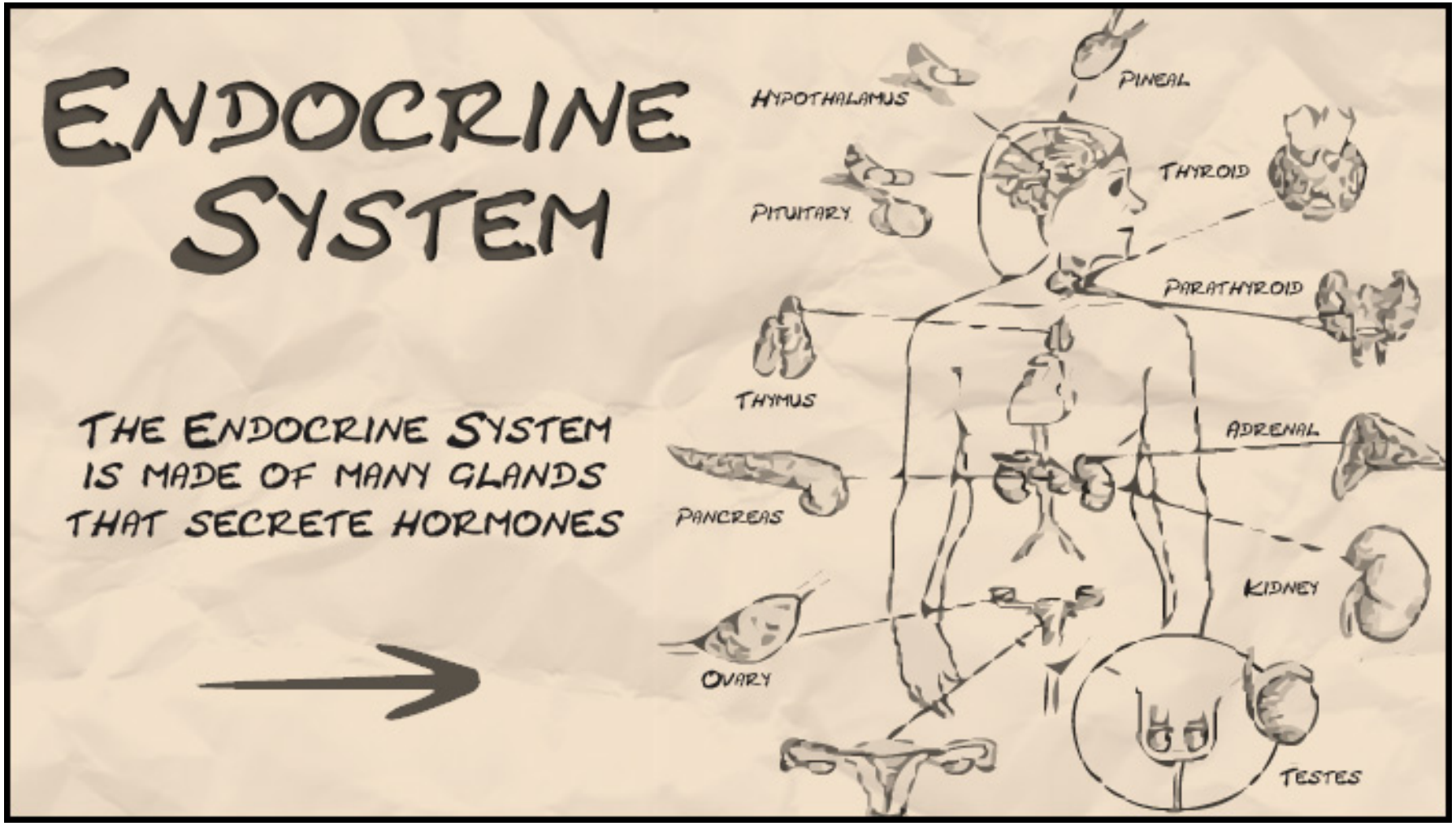
6. UKŁAD ODDECHOWY





ZAKRES WYKŁADU

7. UKŁAD WEWNĄTRZ WYDZIELNICZY



FIZJOLOGIA

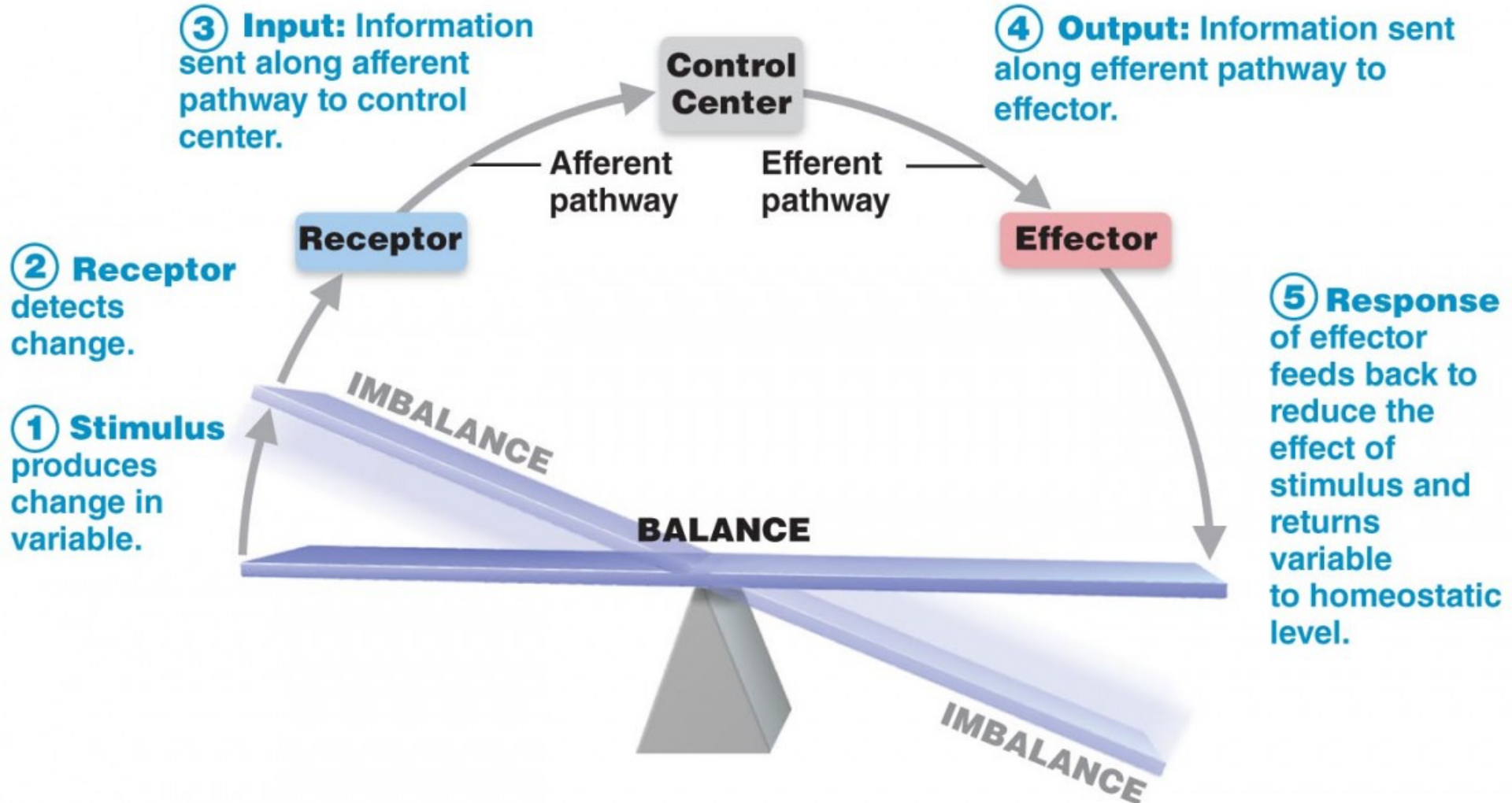
- dotyczy wyjaśniania mechanizmów działania całych organów
  - gospodarka płynów – funkcje nerek
  - neurofizjologia – jak działa układ nerwowy
  - sercowo-naczyniowy – funkcjonowanie naczyń i serca

- Często skupia się na wyjaśnianiu mechanizmów działania na poziomie komórkowym oraz molekularnym

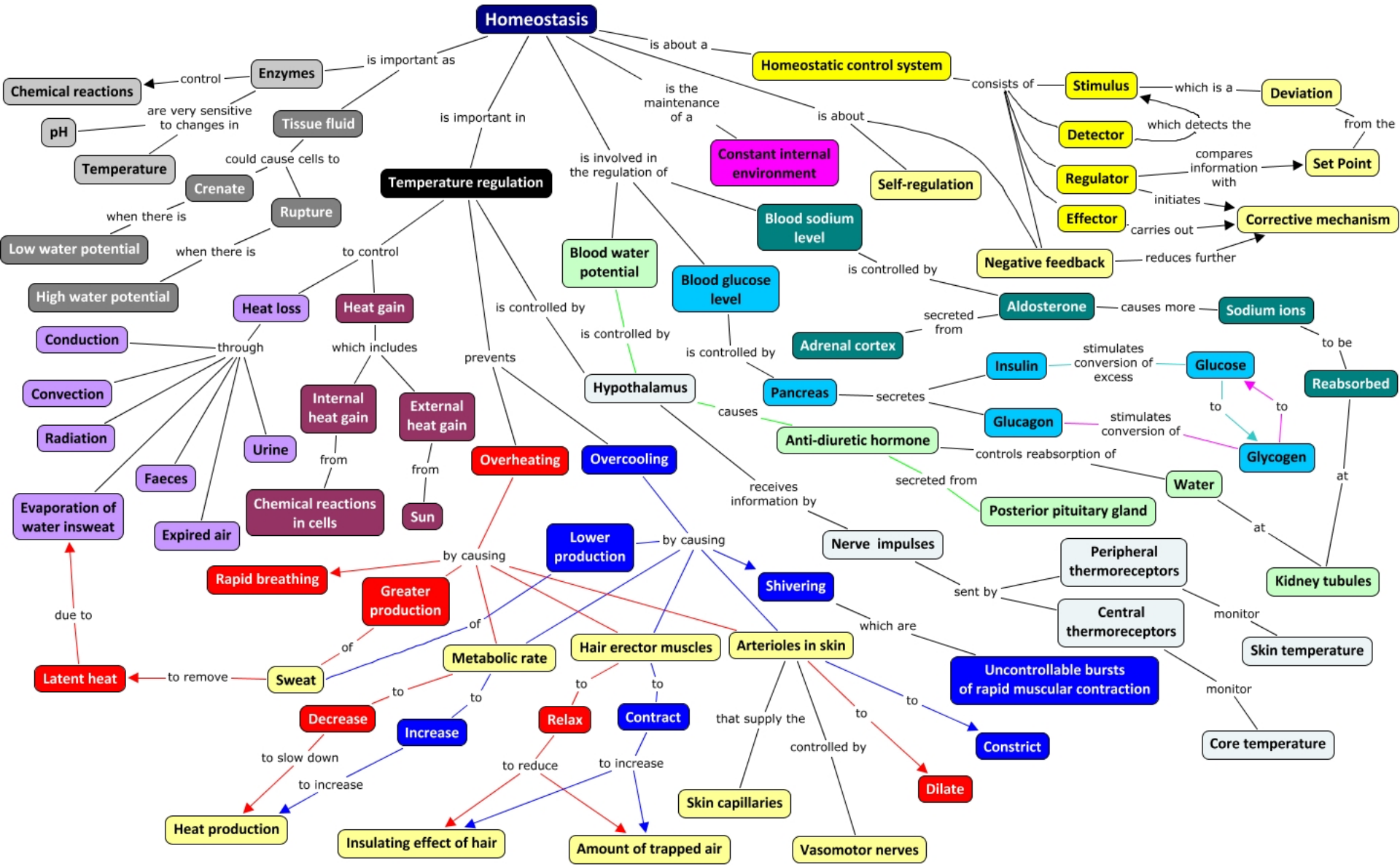
- Zrozumienie fizjologii wymaga wiedzy z fizyki, która pozwala zrozumieć działanie przepływu prądu, ciśnienie krwi, czy sposób w jaki powietrze dostarczane jest z płuc i do płuc

HOMEOSTAZA

DEFINIUJE ISTOTĘ FIZJOLOGII



HOMEOSTAZA


Homeostasis
is about a
Homeostatic control system
consists of
Stimulus
which is a
Deviation
from the
Set Point
Detector
which detects the
Regulator
compares information with
initiates
Effector
carries out
Corrective mechanism
reduces further
Negative feedback
is about
Self-regulation
is the maintenance of a
Constant internal environment
is important as
Enzymes
control
Chemical reactions
are very sensitive to changes in
pH
Temperature
Tissue fluid
could cause cells to
Crenate
Rupture
when there is
Low water potential
when there is
High water potential
is important in
Temperature regulation
to control
Heat loss
Heat gain
Conduction
through
Convection
Radiation
Evaporation of water insweat
Faeces
Urine
Expired air
which includes
Internal heat gain
External heat gain
from
Chemical reactions in cells
from
Sun
is involved in the regulation of
Blood sodium level
is controlled by
Aldosterone
causes more
Sodium ions
to be
Reabsorbed
at
Kidney tubules
secreted from
Adrenal cortex
is controlled by
Blood water potential
is controlled by
Hypothalamus
causes
Anti-diuretic hormone
controls reabsorption of
Water
at
secreted from
Posterior pituitary gland
is controlled by
Blood glucose level
is controlled by
Pancreas
secretes
Insulin
stimulates conversion of excess
Glucose
to
Glucagon
stimulates conversion of
Glycogen
to
prevents
Overheating
Overcooling
receives information by
Nerve impulses
sent by
Peripheral thermoreceptors
Central thermoreceptors
monitor
Skin temperature
monitor
Core temperature
which are
Uncontrollable bursts of rapid muscular contraction
by causing
Lower production
Shivering
by causing
Rapid breathing
Greater production
of
Metabolic rate
of
Sweat
to remove
Latent heat
due to
Hair erector muscles
to
Relax
to
Contract
Arterioles in skin
that supply the
Skin capillaries
controlled by
Vasomotor nerves
to
Constrict
to
Dilate
to
Decrease
to
Increase
to slow down
to increase
Heat production
to reduce
to increase
Insulating effect of hair
Amount of trapped air

HOMEOSTAZA

- Systemy kontrolne homeostazy
- Elementy układów kontrolnych homeostazy
- Chemiczne przekaźniki i transport informacji

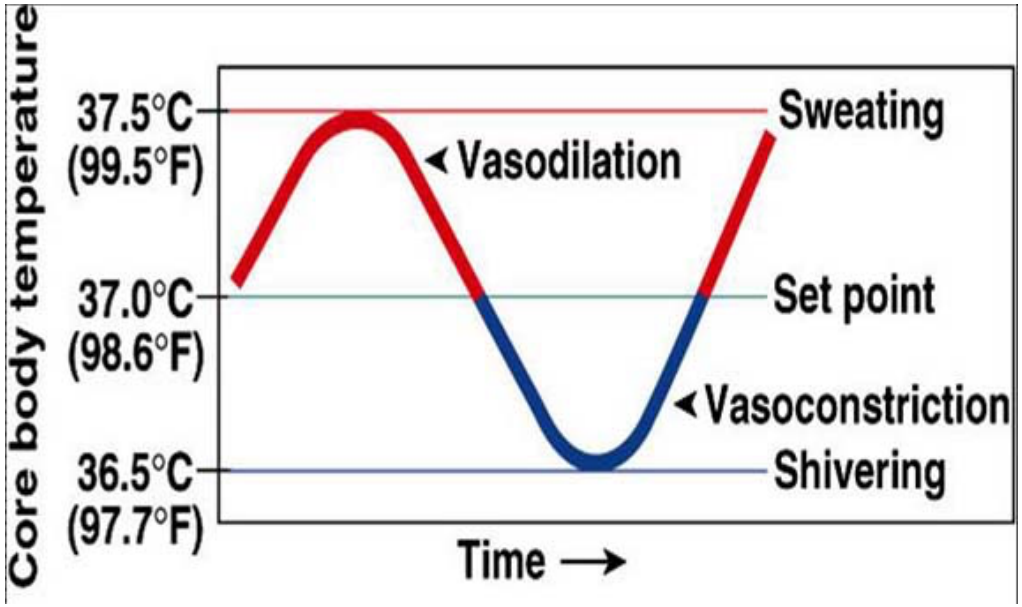
Procesy związane z homeostazą

- - adaptacja
- - aklimatyzacja

Podejścia fizjologiczne

Podejście mechanistyczne - pytanie **“jak”** działa funkcja, tłumaczenie w kontekście przyczyny i skutku procesu fizjologicznego ***Jak czerwone krwinki transportują krew?***

Podejście teleologiczne - pytanie **“dlaczego”** jest dana funkcja ***Dlaczego czerwone krwinki transportują krew?***



Przykład: dreszcze

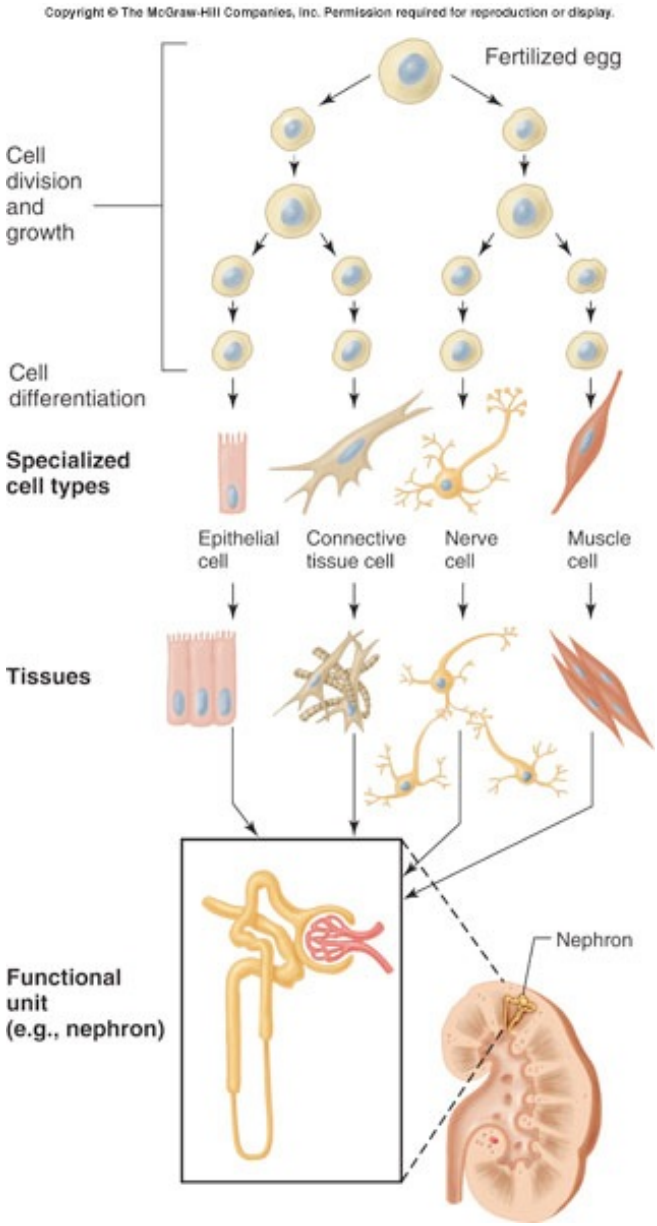
Teleologiczne - dreszcze podnoszą niską temperaturę ciała

Mechanistyczne - gdy temperatura spada poniżej wartości normalnej ruch odruchowy powoduje powstanie bezwiednych skurczy mięśni szkieletowych, które generują ciepło

Poziomy organizacji ciała

•Chemicznie - poziom atomowy i molekularny

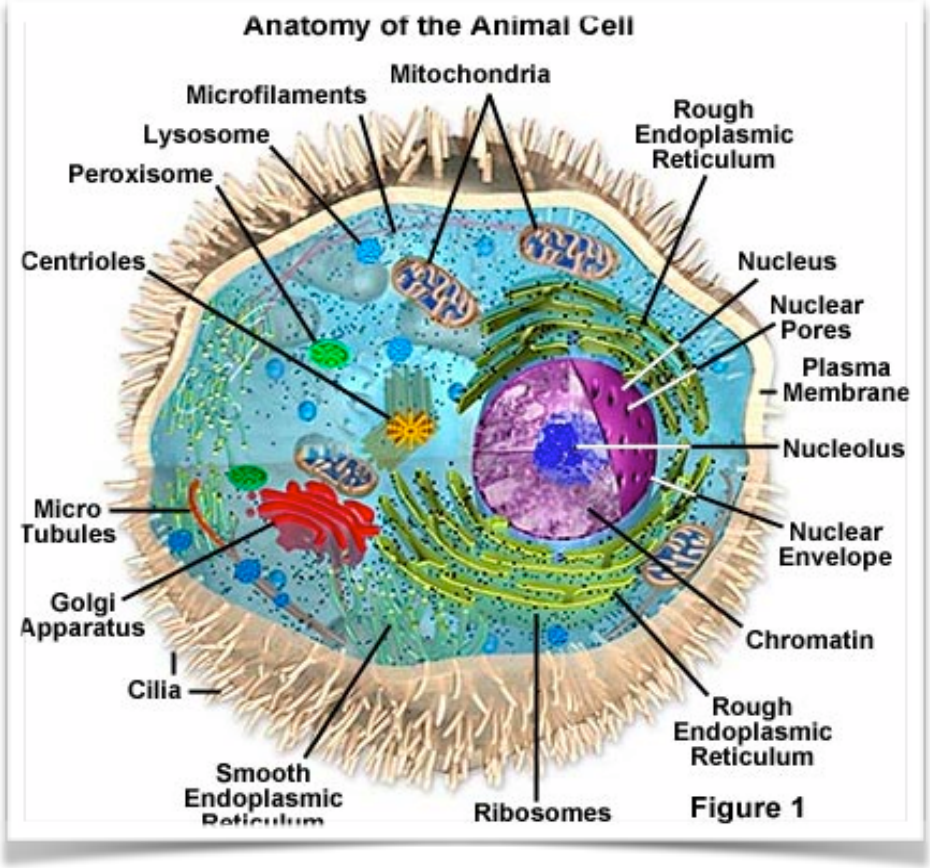
Oxygen 65 %
Carbon 18%
Hydrogen 10%
Nitrogen 3%
Calcium 1.5%
Phosphorus 1.2%
Potassium 0.2%
Sulfur 0.2 %
Chlorine 0.2 %
Sodium 0.1 %
Magnesium 0.05%
Iron, Cobalt, Copper, Zinc, Iodine <0.05 % each
Selenium, Fluorine <0.01 each %

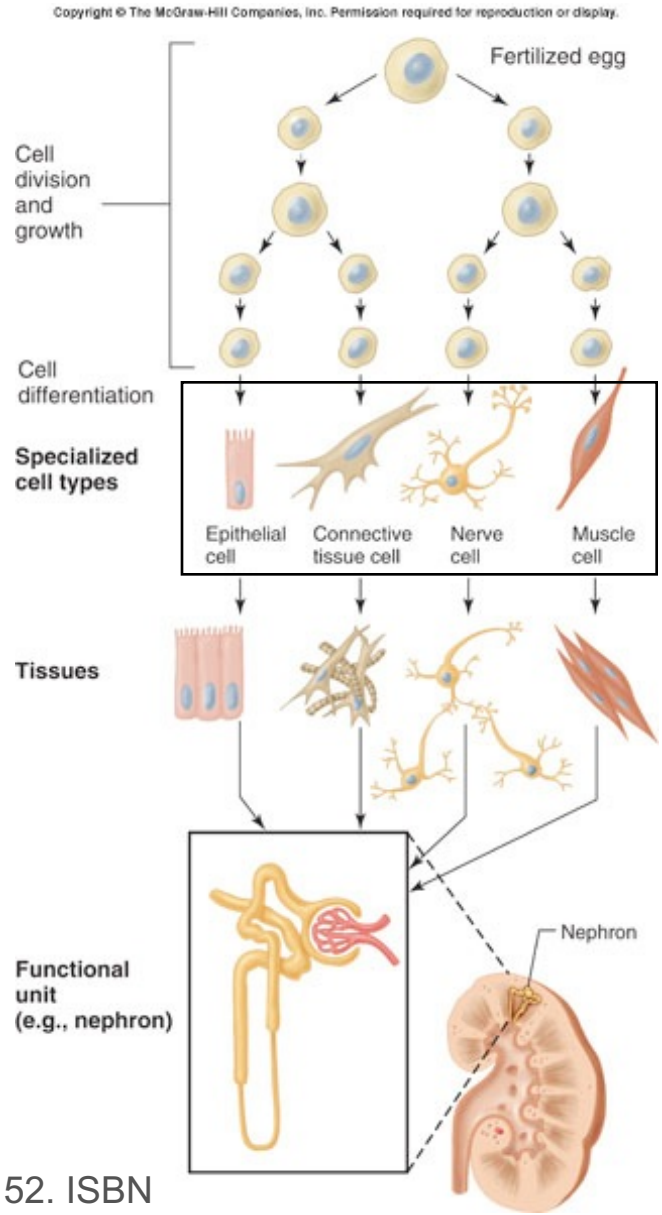


Chang, Raymond (2007). Chemistry, Ninth Edition. McGraw-Hill. pp. 52. ISBN 0-07-110595-6.

Poziomy organizacji ciała

•Komórkowy - najmniejsza jednostka żyjąca w organizmie



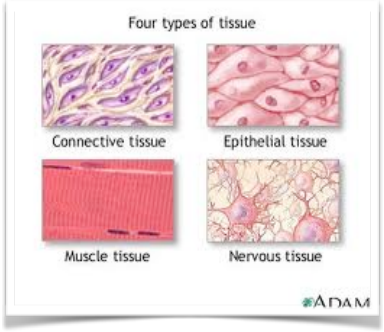


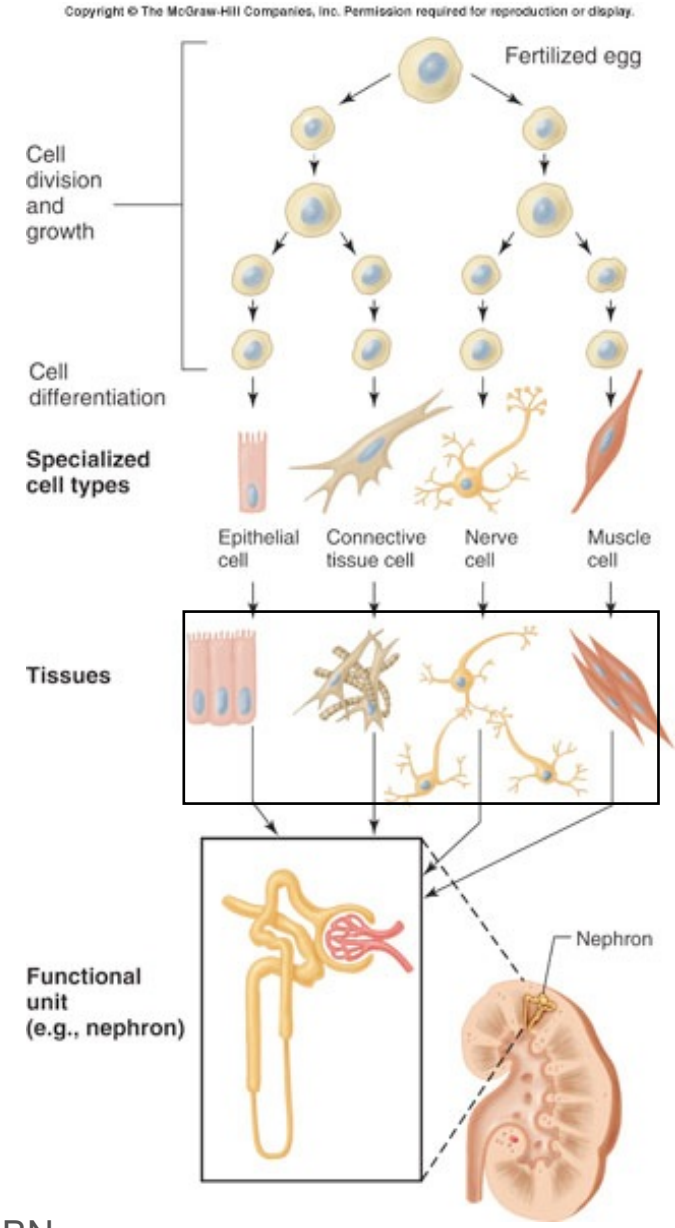
Chang, Raymond (2007). Chemistry, Ninth Edition. McGraw-Hill. pp. 52. ISBN 0-07-110595-6.

Poziomy organizacji ciała

Tkankowy

Grupa komórek i ich ***otoczenia,*** *wyspecjalizowane do realizacji konkretnego zadania*





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Poziomy organizacji ciała

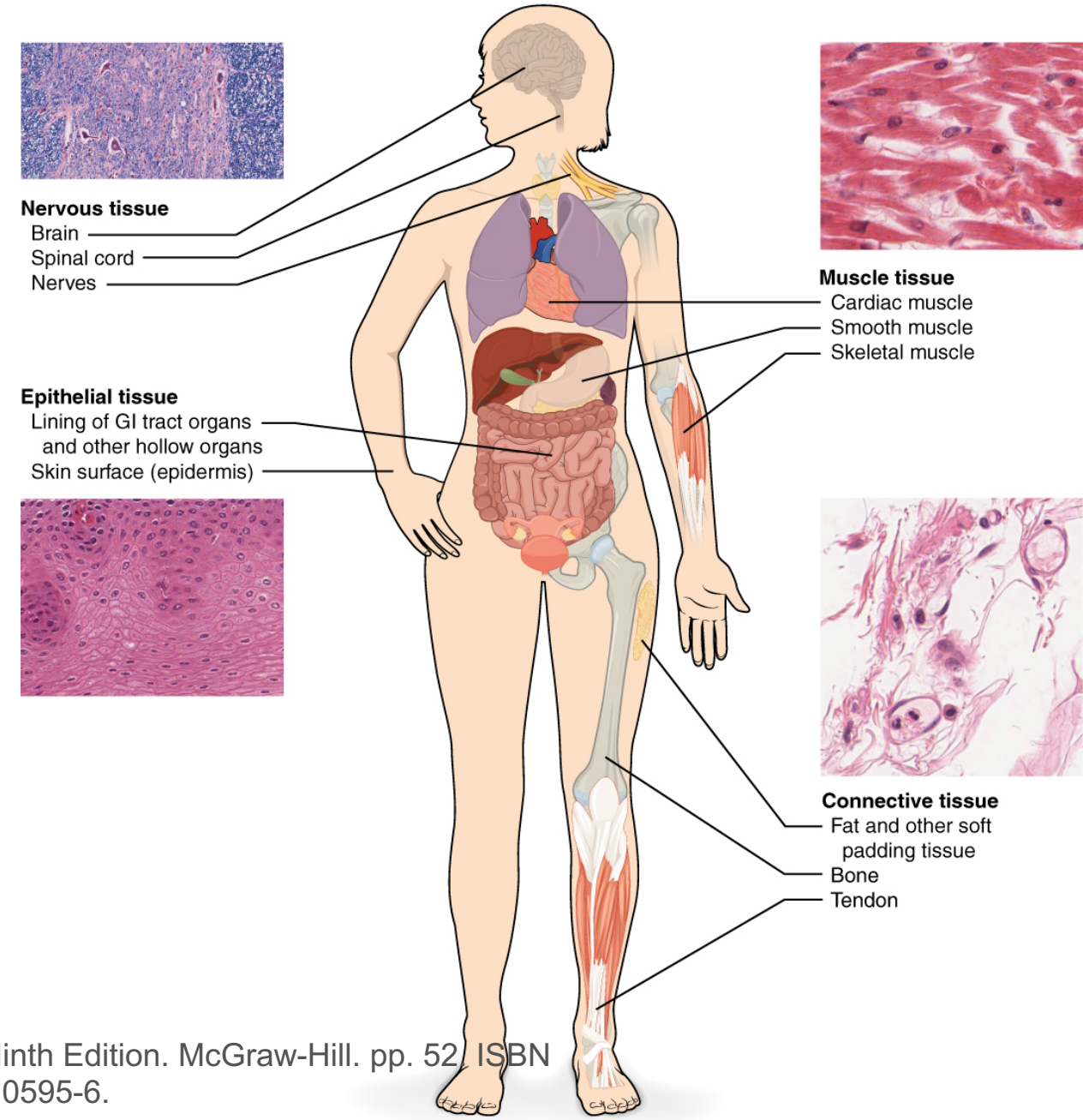
4 podstawowe typy tkanek:

Nabłonek
(epithelium),

Mięśniowa
(muscle),

Tkanka łączna
(connective tissue),

Tkanka nerwowa
(nerve)



Chang, Raymond (2007). Chemistry, Ninth Edition. McGraw-Hill. pp. 52. ISBN 0-07-110595-6.

Organ level - consists of two or more types of primary tissues that function together to perform a particular function or functions

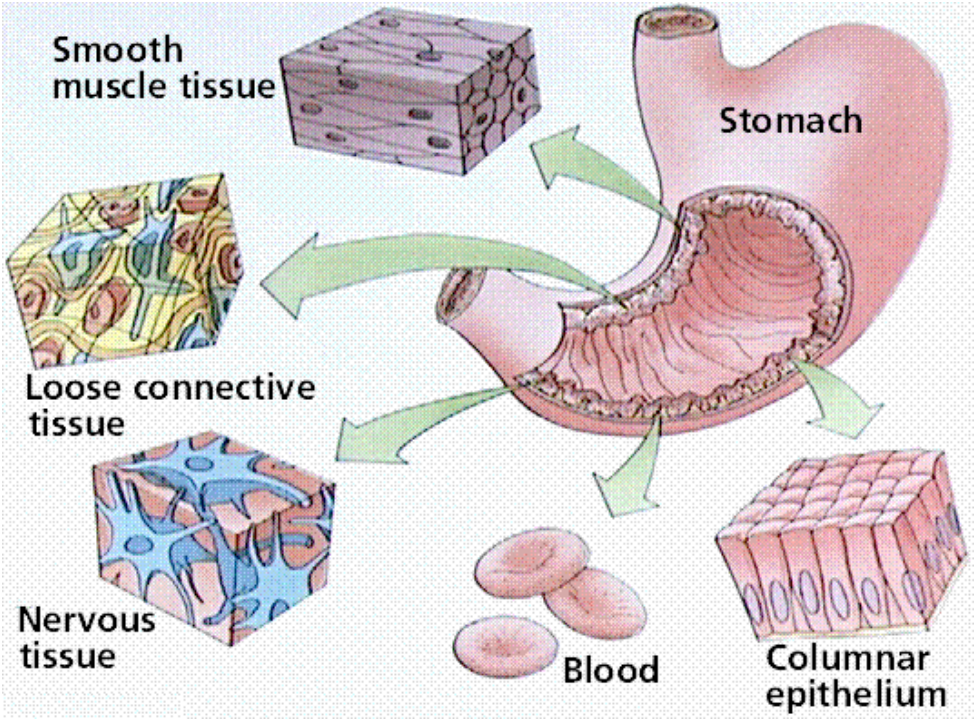
Example: Stomach

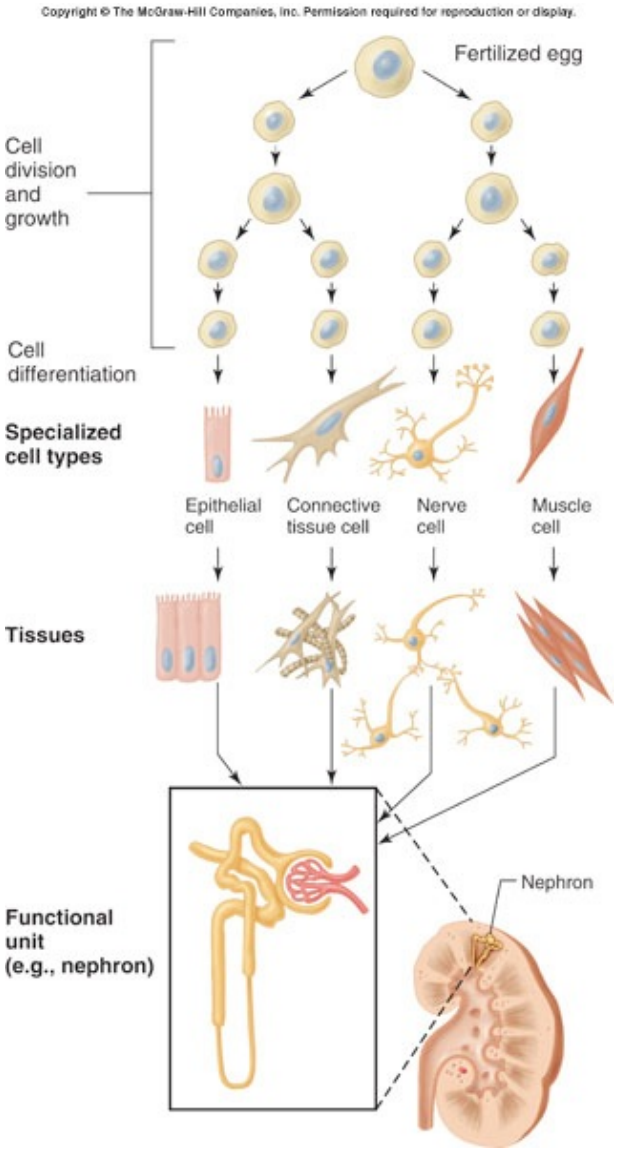
Inside of stomach lined with epithelial tissue

Wall of stomach contains smooth muscle

Nervous tissue in stomach controls muscle contraction and gland secretion

Connective tissue binds all the above tissues together

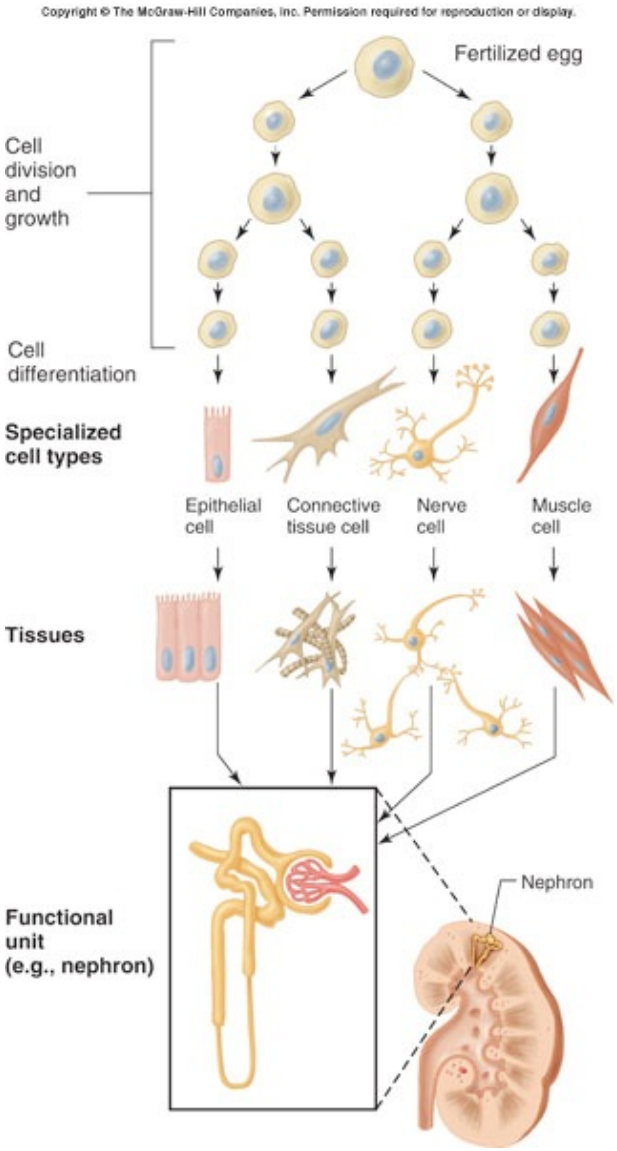




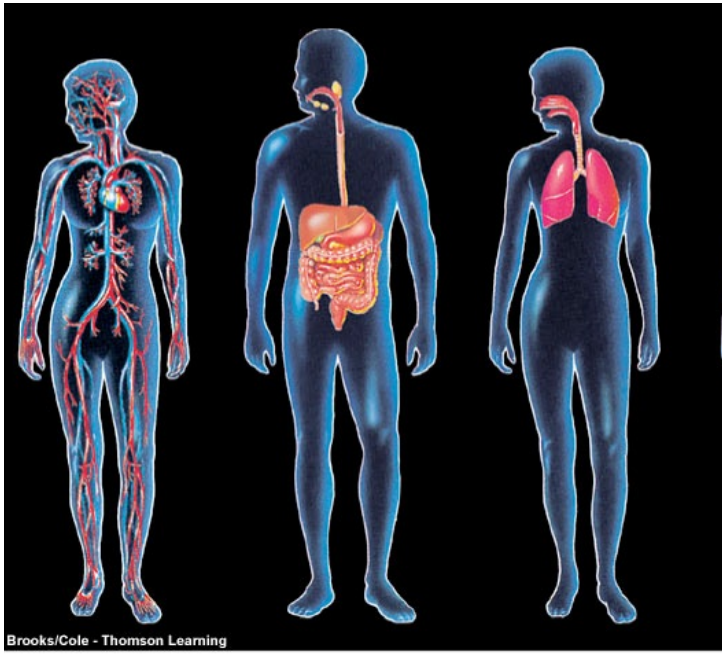
Poziomy organizacji ciała

System - collection of related organs with a common function, sometimes an organ is part of more than one system

Organismic level - one living individual



Groups of organs that perform related functions and interact to accomplish a common activity essential to survival of the whole body. Do not act in isolation from one another.
Human body has 11 systems



Circulatory system
heart, blood, blood vessels

Digestive system
mouth, pharynx, esophagus, stomach, small intestine, large intestine, salivary glands, exocrine pancreas, liver, gallbladder

Respiratory system
Nose, pharynx, larynx, trachea, bronchi, lungs

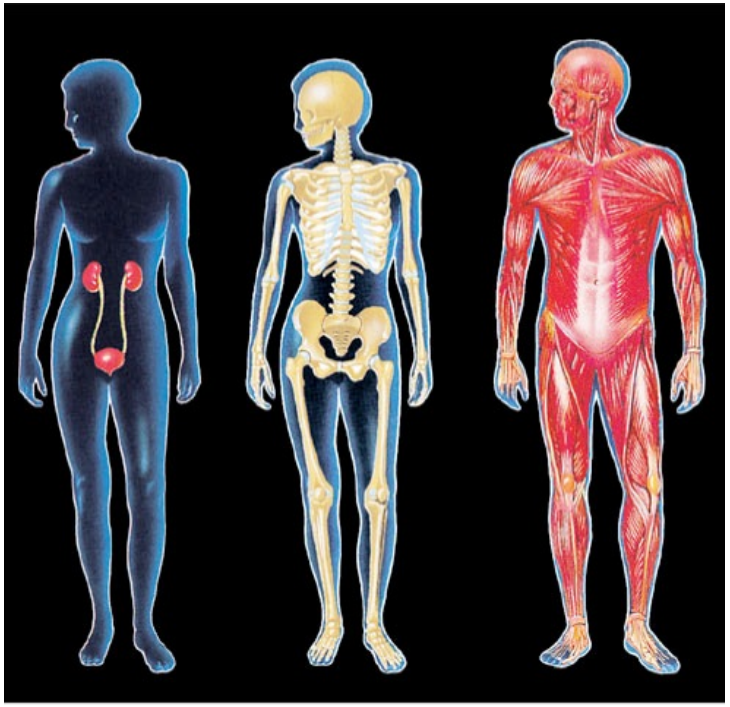
BODY SYSTEMS

Circulatory system
heart, blood, blood vessels

Digestive system
mouth, pharynx, esophagus, stomach, small intestine, large intestine, salivary glands, exocrine pancreas, liver, gallbladder

Respiratory system
Nose, pharynx, larynx, trachea, bronchi, lungs

Groups of organs that perform related functions and interact to accomplish a common activity essential to survival of the whole body. Do not act in isolation from one another. Human body has 11 systems



Urinary system
kidneys, ureters, urinary bladder, urethra

Skeletal system
bones, cartilage, joints

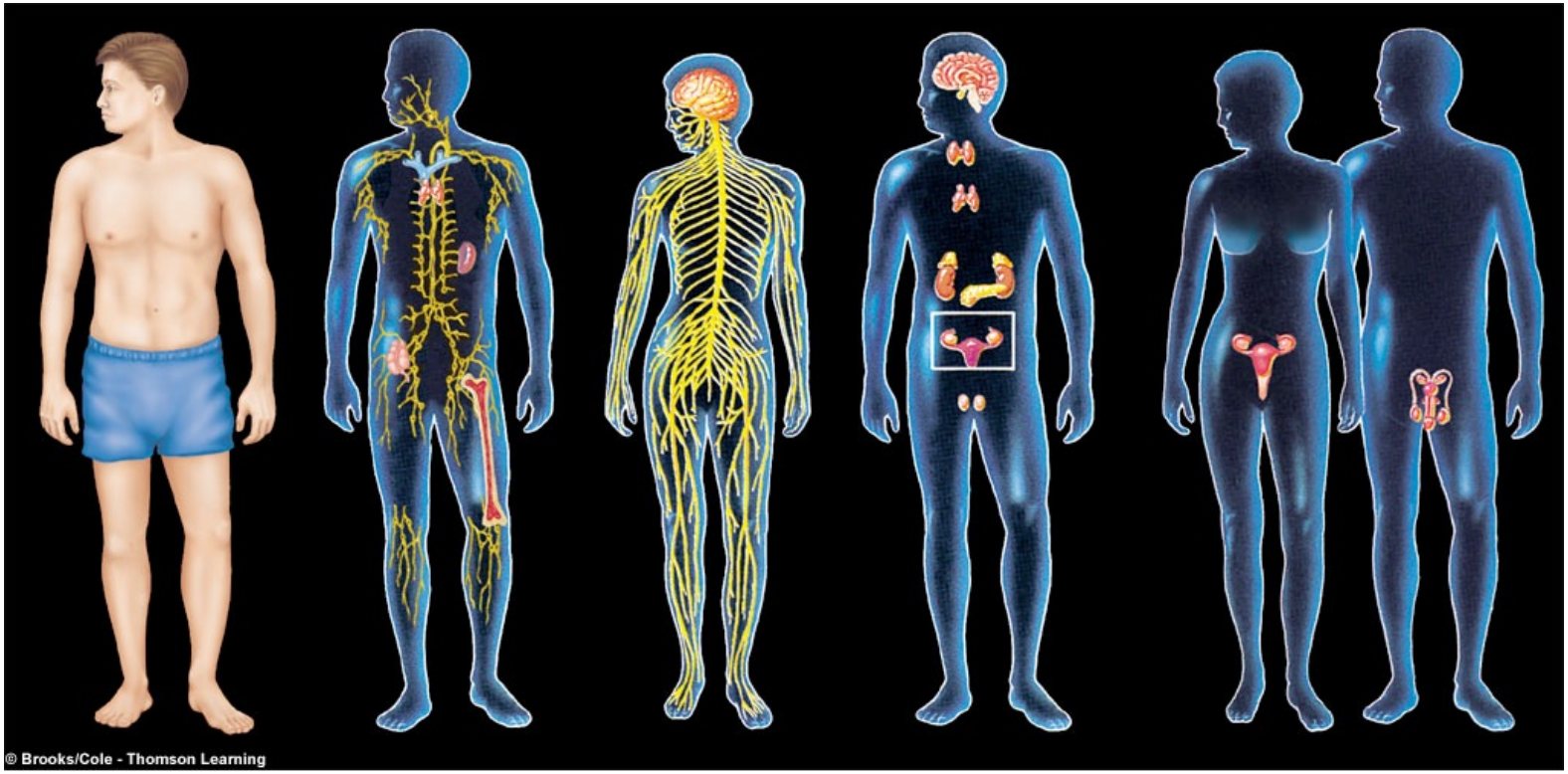
Muscular system
skeletal muscles

<u>Urinary system</u>
kidneys, ureters, urinary bladder, urethra

<u>Skeletal system</u>
bones, cartilage, joints

<u>Muscular system</u>
skeletal muscles

BODY SYSTEMS



Integumentary system
skin, hair, nails

Immune system
lymph nodes, thymus, bone marrow, tonsils, adenoids, spleen, appendix, and, not shown, white blood cells, gut-associated lymphoid tissue, and skin-associated lymphoid tissue

Nervous system
brain, spinal cord, peripheral nerves, and, not shown, special sense organs

Endocrine system
all hormone-secreting tissues, including hypothalamus, pituitary, thyroid, adrenals, endocrine pancreas, gonads, kidneys, pineal, thymus, and, not shown, parathyroids, intestine, heart, and skin

Reproductive system
Male: testes, penis, prostate gland, seminal vesicles, bulbourethral glands, and associated ducts

Female: ovaries, oviducts, uterus, vagina, breasts

BODY SYSTEMS

SYSTEM	MAJOR ORGANS	PRIMARY FUNCTIONS
CIRCULATORY	HEART, BLOOD VESSELS, BLOOD, LYMPHATIC VESSELS, LYMPH	TRANSPORT OF BLOOD THROUGHOUT THE BODY TISSUES
RESPIRATORY	NOSE, PHARYNX, LARYNX, TRACHEA, BRONCHI, LUNGS,	EXCHANGE THE CO_2 O_2; REGULATION OF pH

FIZJOLOGIA – WYKŁAD 1 – HOMEOSTAZA

SYSTEM	MAJOR ORGANS	PRIMERY FUNCTIONS
DIGESTIVE	MOUTH, PHARYNX, ESOPHAGUS, STOMACH,INTESTINES,SALIVARY GLANDS, PANCREAS, LIVER, GALLBLADDER	DIGESTION AND ABSORPTION OF ORGANIC NUTRIENTS, SALTS AND WATER
URINARY	KIDNEYS, URETES, BLADDER, URETHRA	REGULATION OF PLASMA COMPOSITION THROUGH CONTROLLED EXCRECTION OF SALTS, WATER AND ORGANIC WASTES

FIZJOLOGIA – WYKŁAD 1 – HOMEOSTAZA

SYSTEM	MAJOR ORGANS	PRIMARY FUNCTIONS
MUSCULOSKELETAL	CARTILAGE, BONE, LIGAMENTS,TENDONS, JOINTS, SKELETAL MUSCLE	SUPPORT, PROTECTION AND MOVEMENT OF THE BODY; PRODUCTION OF BLOOD
IMMUNE	WHITE BLOOD CELLS, LYMPH VESSELS AND NODES, SPLEEN, THYMUS AND OTHER LYMPHOID TISSUES	DEFENSE AGAINST FOREIGN INVADERS, RETURN OF EXTRACELLULAR FLUID TO BLOOD, FORMATION OF WHITE BLOOD CELLS

SYSTEM	MAJOR ORGANS	PRIMARY FUNCTIONS
NERVOUS	BRAIN, SPINAL CORD, PERIPHERAL NERVES AND GANGLIA, SPECIAL SENSE ORGANS	REGULATION AND COORDINATION OF BODY ACTIVITIES, DETECTION OF CHANGES IN THE INTERNAL AND EXTERNAL ENVIRONMENTS; STATES OF CONSCIOUSNESS LEARNING; COGNITION
ENDOCRINE	ALL GLANDS SECRETING HORMONES; PANCREAS, TESTES, OVARIES, HYPOTHALAMUS, KIDNEYS, PITUITARY, THYROID, PARATHYROID, ADRENAL, INTESTINAL, THYMUS, HEART AND PINEAL, AND ENDOCRINE CELLS IN OTHER LOCATIONS	REGULATION AND COORDINATION OF BODY ACTIVITIES, INCLUDING GROWTH, METABOLISM, REPRODUCTION, BLOOD PRESSURE, ELECTROLYTE BALANCE

SYSTEM	MAJOR ORGANS	PRIMARY FUNCTIONS
REPRODUCTIVE	MALE: TESTES, PENIS AND ASSOCIATED DUCTS AND GLANDS; FEMAL: OVARIES, FALLOPIAN TUBES, UTERUS, VAGINA, MAMMARY GLANDS	PRODUCTION OF SPERM; TRANSFER OF SPERM TO FEMALE; PRODUCTION OF EGGS; PROVISION OF A NUTRITIVE ENVIRONMENT FOR THE DEVELOPING EMBRYO AND FETUS; NUTRITION OF THE INFANT
INTEGUMENTARY	SKIN	PROTECTION AGAINS INJURY AND DEHYDRATION; DEFENSE AGAINST FOREIGN INVADERS; REGULATION OF TEMPERATURE;

- **The underlying principle of physiology is homeostasis**

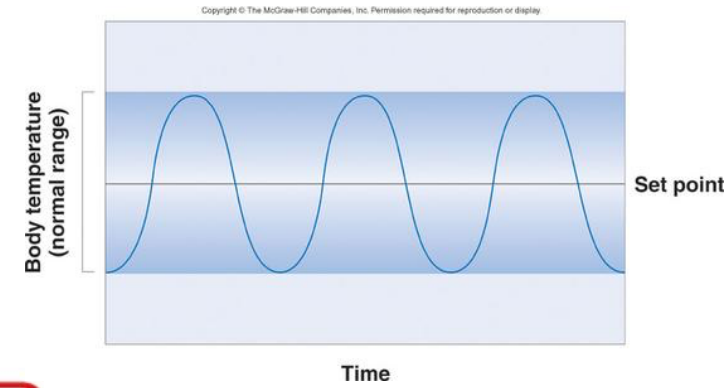
- Homeostasis is the ability to maintain a relatively stable internal environment in an ever-changing outside world

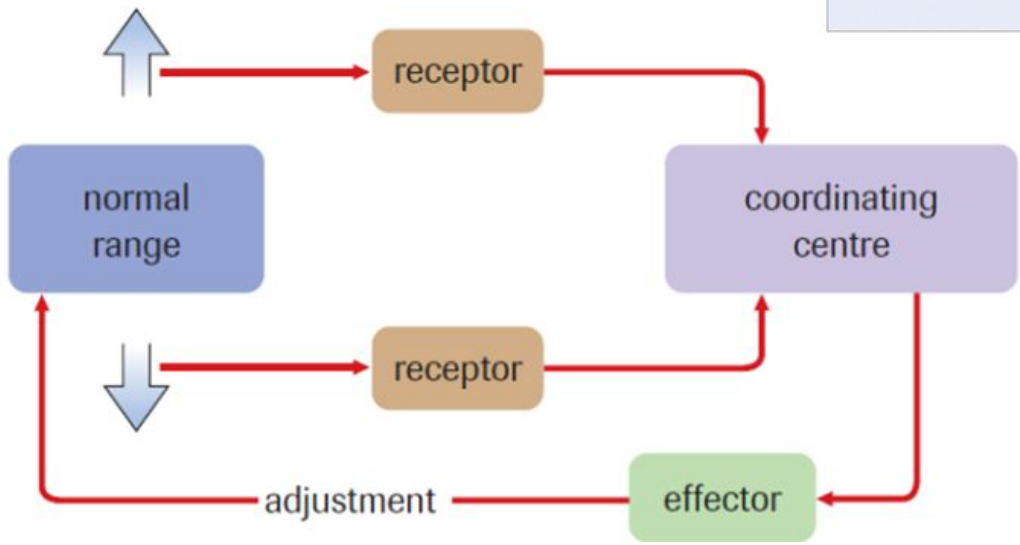
- The internal environment of the body is in a dynamic state of equilibrium (dynamic constancy)

- Chemical, thermal, and neural factors interact to maintain homeostasis
- Loss of homeostasis results in disease or death

Homeostasis refers to the dynamic mechanisms that detect and respond to deviations in physiological variables from their “set point” values by initiating effector responses that restore the variables to the optimal physiological range.

- **Receptors**
- **Coordinating Centre (Modulator)**
- **Effectors**





Defined as maintenance of a relatively stable internal environment

Does not mean that composition, temperature, and other characteristics are absolutely unchanging

Homeostasis is essential for survival and function of all cells

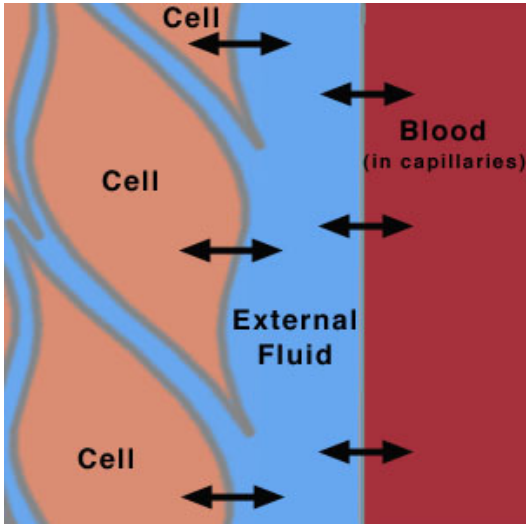
Each cell contributes to maintenance of a relatively stable internal environment

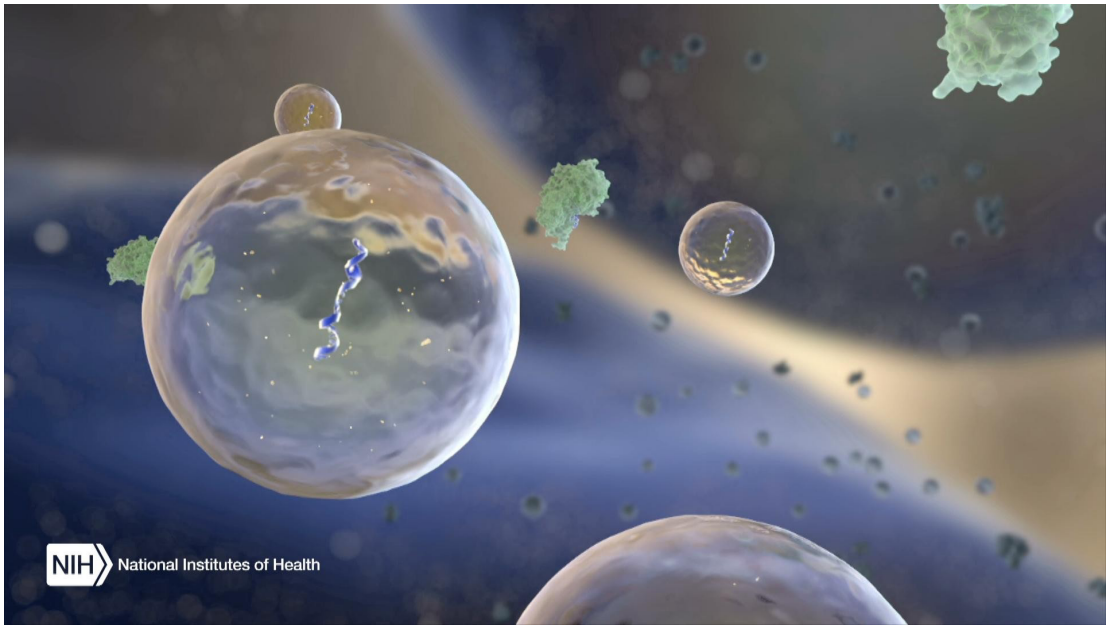
BASIC CELL FUNCTIONS

- Sensing and responding to changes in surrounding environment
- Control exchange of materials between cell and its surrounding environment
- Obtain nutrients and oxygen from surrounding environment
- Eliminate carbon dioxide and other wastes to surrounding environment
- Perform chemical reactions that provide energy for the cell Synthesize needed cellular components

Cells, the fundamental units of life, exchange nutrients and wastes with their surroundings:

The intracellular fluid is “conditioned by”…
the interstitial fluid, which is “conditioned by” …..
the plasma, which is “conditioned by” ……
the organ systems it passes through.

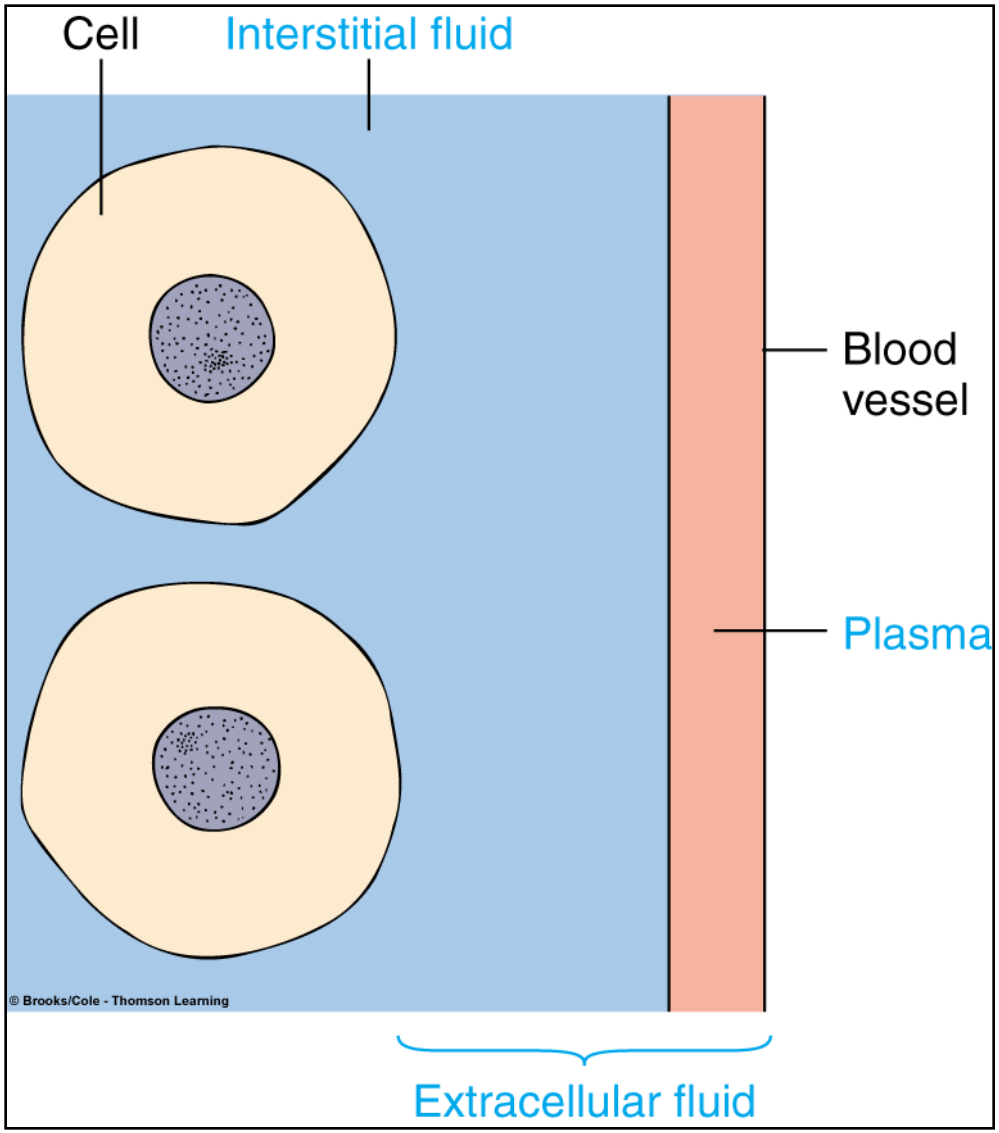




- Body cells are in contained in watery internal environment through which life-sustaining exchanges are made

- **Extracellular fluid (ECF)** - Fluid environment in which the cells live (fluid outside the cells)
  - Two components:
    - Plasma
    - Interstitial fluid

- **Intracellular fluid (ICF)** - Fluid contained within all body cells



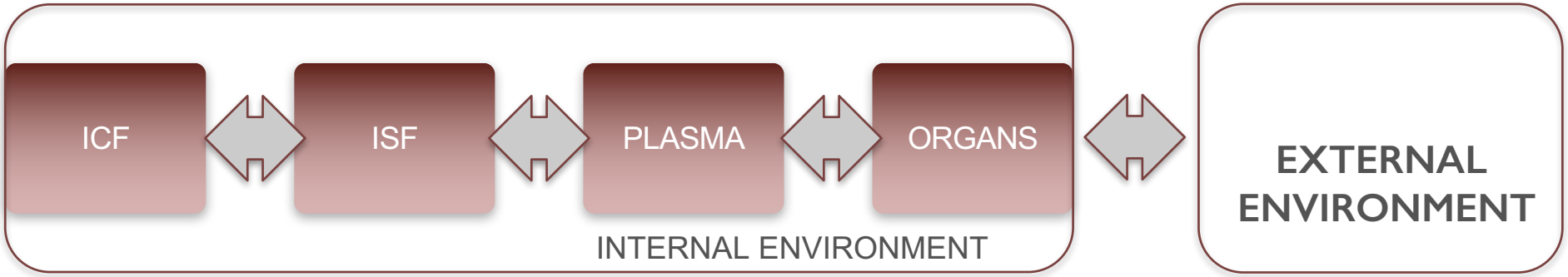
BODY ENVIRONMENTS AND FLUIDS

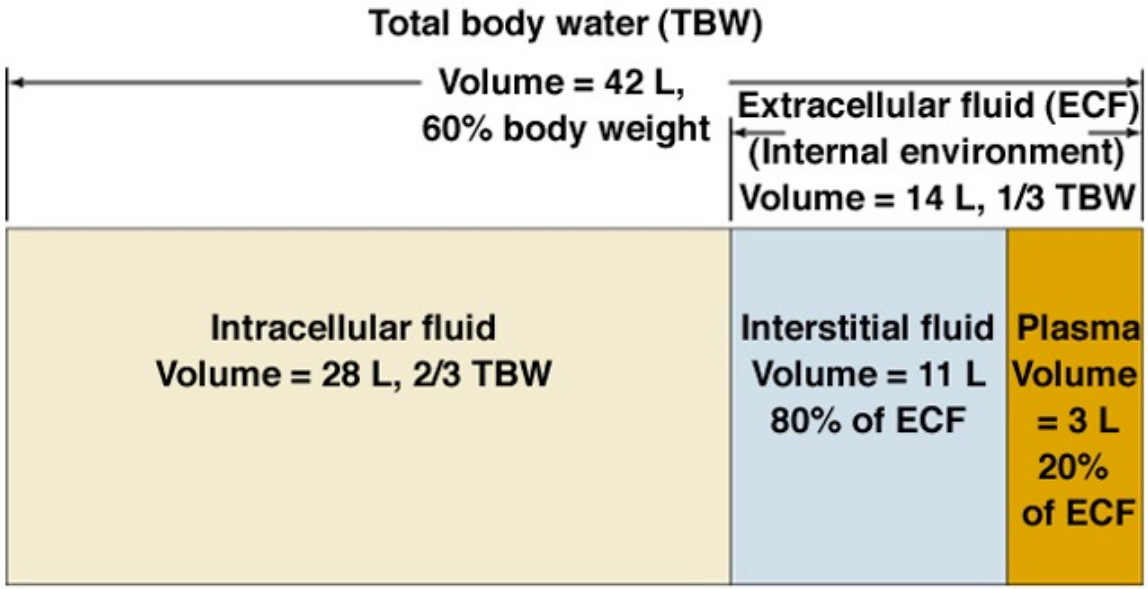
- **External environment**
  - The air in which we live

- Body fluids - two major compartments
  - **Intracellular fluid** - cytosol; fluid within cells (28 L=67%)
  - **Extracellular fluid** - all fluid outside cells of the body
    - Plasma - liquid component of blood (3L=7%)
    - Interstitial fluid - aka, tissue fluid; fluid bathing cells (11L=26%)
    - *Claude Bernard called this the "milieu interieux"; the internal environment.*

  - There is a constant interaction between these 3 fluids
    - They are separated form one another only by cell membranes
    - Therefore, changing one (especially tissue fluid) has effects on the other two

Fluid compartments in the body





Exchange and communication are key concepts for understanding homeostasis.

Cellular Environments

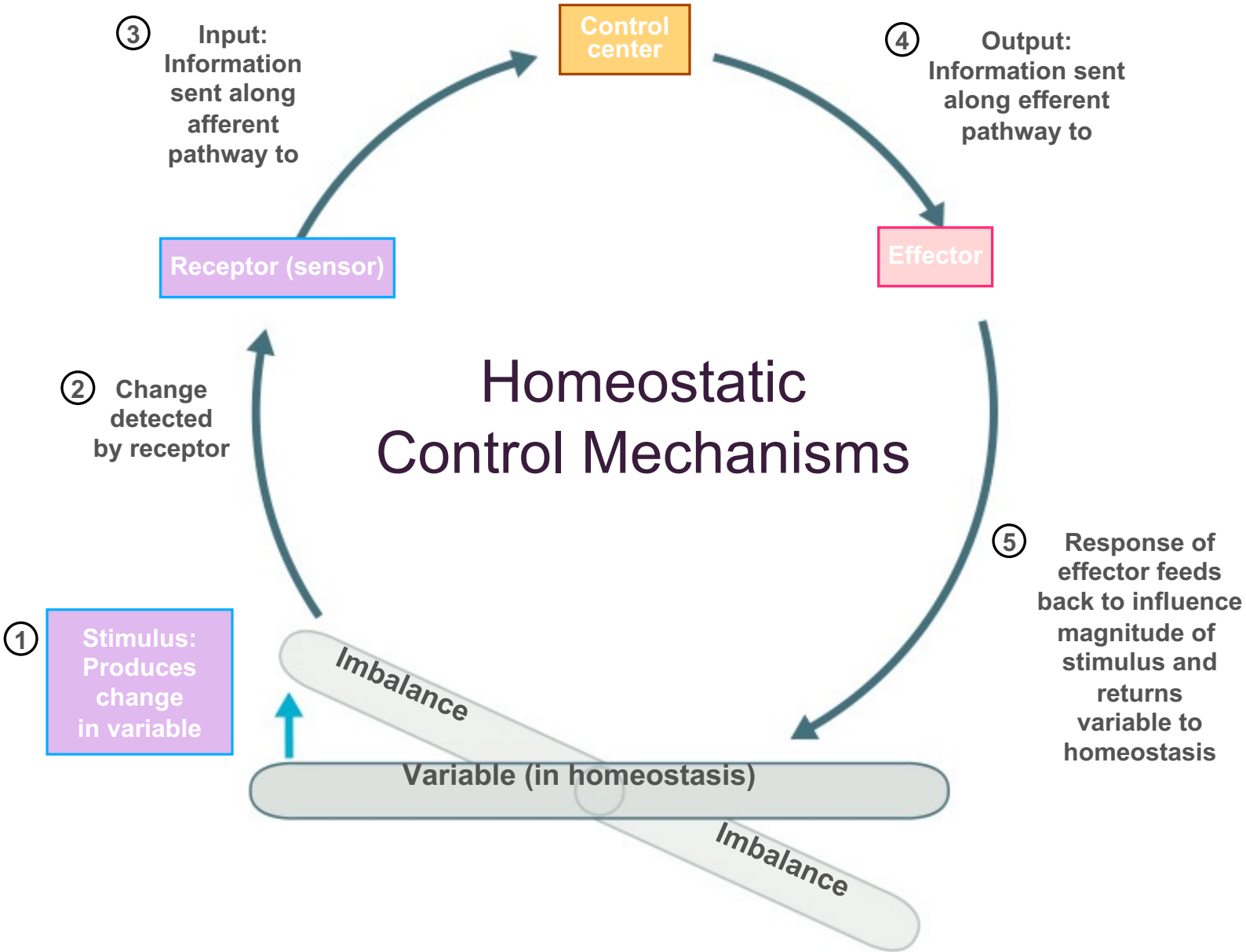
- Extracellular fluids
  - Besides tissue fluid, it also includes all other fluids that are exudates of plasma
  - This would include:
    - **CSF of brain and spinal cord**
    - **Synovial fluid** of joints
    - **Aqueous humor** of eye
    - **Saliva** and other glandular secretions of the GI tract
      - **Pancreatic juice, bile**
    - Exocrine gland secretions
      - ***Sweat, tears, sebum***

Examples of Homeostatically Regulated Variables

- Body Temperature
- Blood Composition (ions, sugars, proteins)
- Concentrations of O_2 and CO_2 in the blood
- Acid-Base balance (pH)
- Blood osmolarity
- Blood pressure, cardiac output, cardiac rate
- Respiratory rate and depth
- Secretions of endocrine glands
- Rate of chemical reactions intracellularly

- Homeostasis is continually being disrupted by:
  - **External stimuli**
    - heat, cold, lack of oxygen, pathogens, toxins
  - **Internal stimuli**
    - Body temperature
    - Blood pressure
    - Concentration of water, glucose, salts, oxygen, etc.
    - Physical and psychological distresses

    - Disruptions can be mild to severe
    - If homeostasis is not maintained, death may result


Homeostatic Control Mechanisms
Control center
③ Input: Information sent along afferent pathway to
④ Output: Information sent along efferent pathway to
Receptor (sensor)
Effector
② Change detected by receptor
⑤ Response of effector feeds back to influence magnitude of stimulus and returns variable to homeostasis
① Stimulus: Produces change in variable
Imbalance
Variable (in homeostasis)
Imbalance

Homeostatic Control Mechanisms

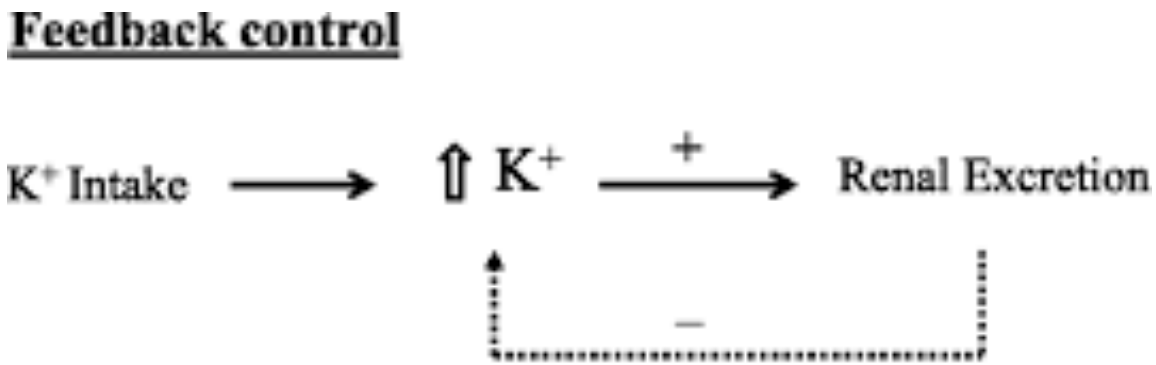
- The variable produces a change in the body
  - E.g. Increase in blood sugar levels or body temperature
- The three interdependent components of control mechanisms are:
  - **Receptor** – monitors the environments and responds to changes (stimuli)
  - **Control center** – determines the set point at which the variable is maintained
  - **Effector** – structures that provide the means to respond to the stimulus and restore the variables to the optimal physiological range.

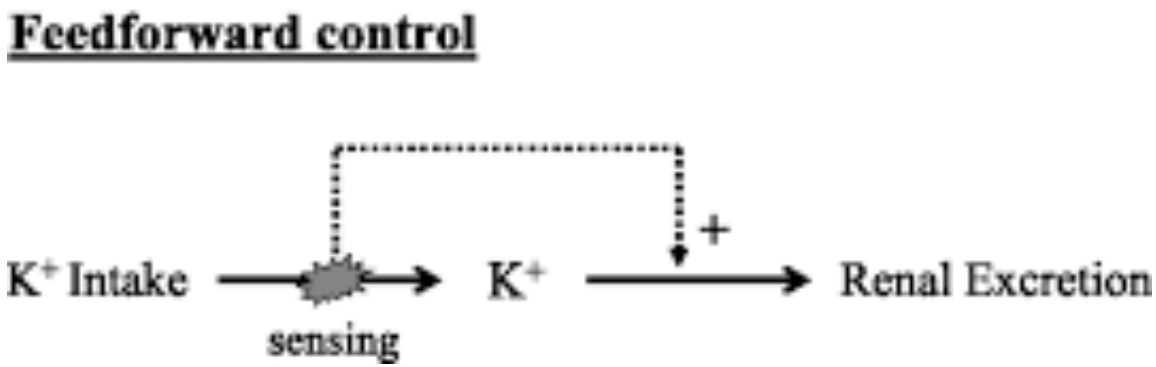
Homeostatic Control Mechanisms

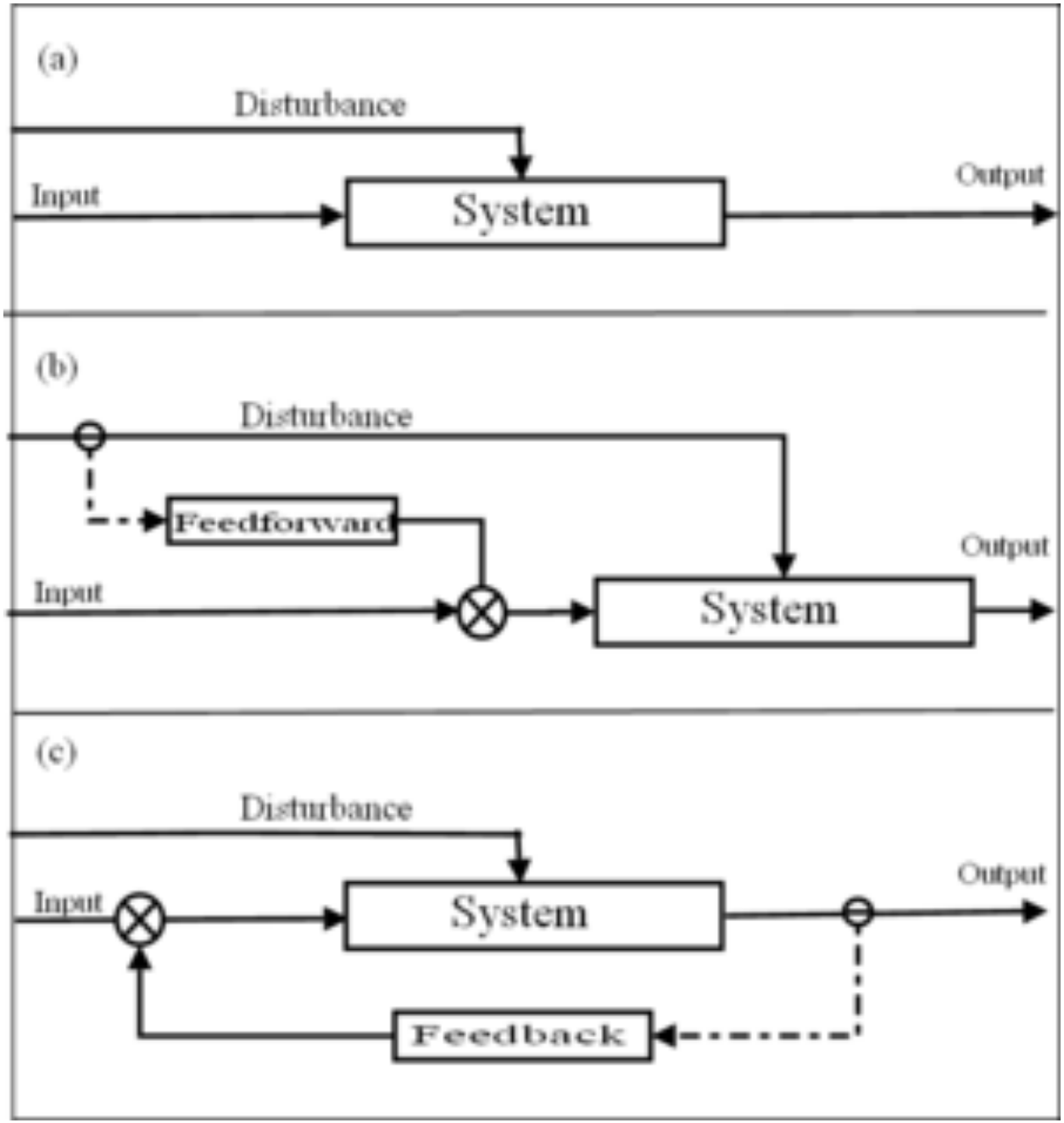
- In order to maintain homeostasis, control system must be able to
  - Detect deviations from normal in the internal environment that need to be held within narrow limits
  - Integrate this information with other relevant information
  - Make appropriate adjustments in order to restore factor to its desired value

- Control systems are grouped into two classes
  - Intrinsic controls
    - Local controls that are inherent in an organ
  - Extrinsic controls
    - Regulatory mechanisms initiated outside an organ
    - Accomplished by nervous and endocrine systems

- **Feedforward** - term used for responses made in anticipation of a change
- **Feedback** - refers to responses made after change has been detected
  - Types of feedback systems
    - Negative
    - Positive






(a)
Disturbance
Input
System
Output
(b)
Disturbance
Feedforward
Input
System
Output
(c)
Disturbance
Input
System
Output
Feedback

Feedback Loops

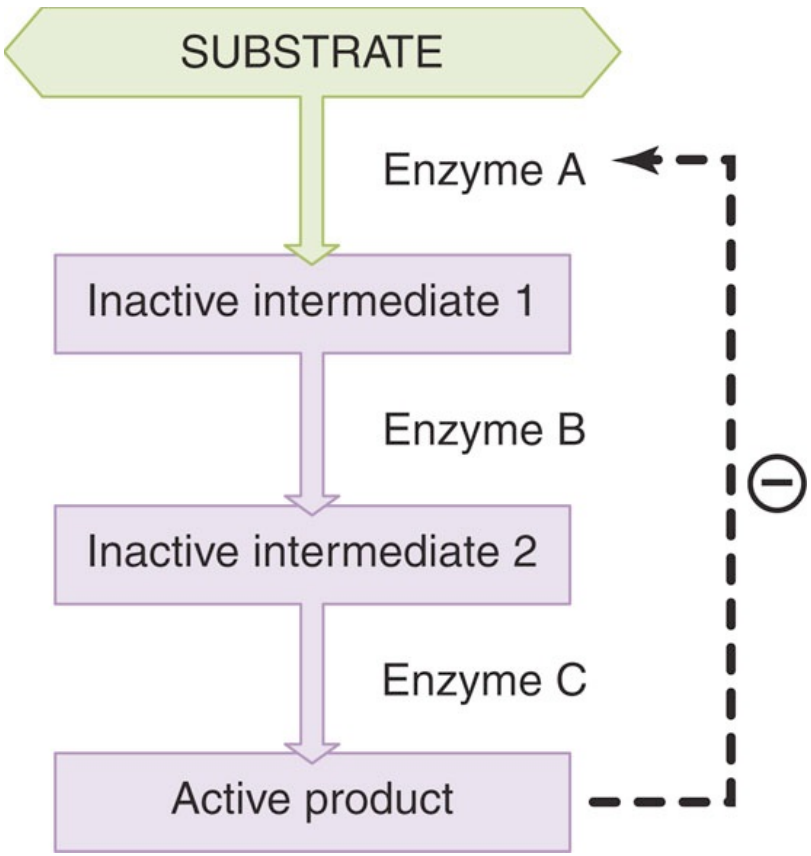
- **Negative Feedback:**

  A body mechanism by which any change from an ideal normal value is made smaller or is resisted. (usually leads to a compensated, healthy state, and maintains homeostasis)

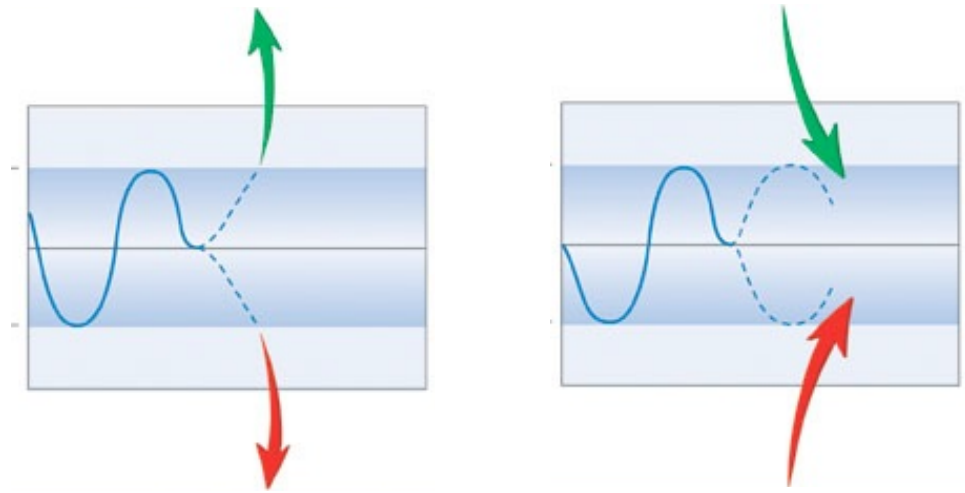
- **Positive Feedback:**

  A body mechanism by which any change from an ideal normal value is made greater. (Usually, but not always, leads to a decompensated, disease state)

FEEDBACK SYSTEMS: EXAMPLES



NEGATIVE FEEDBACKS ARE MORE COMMON



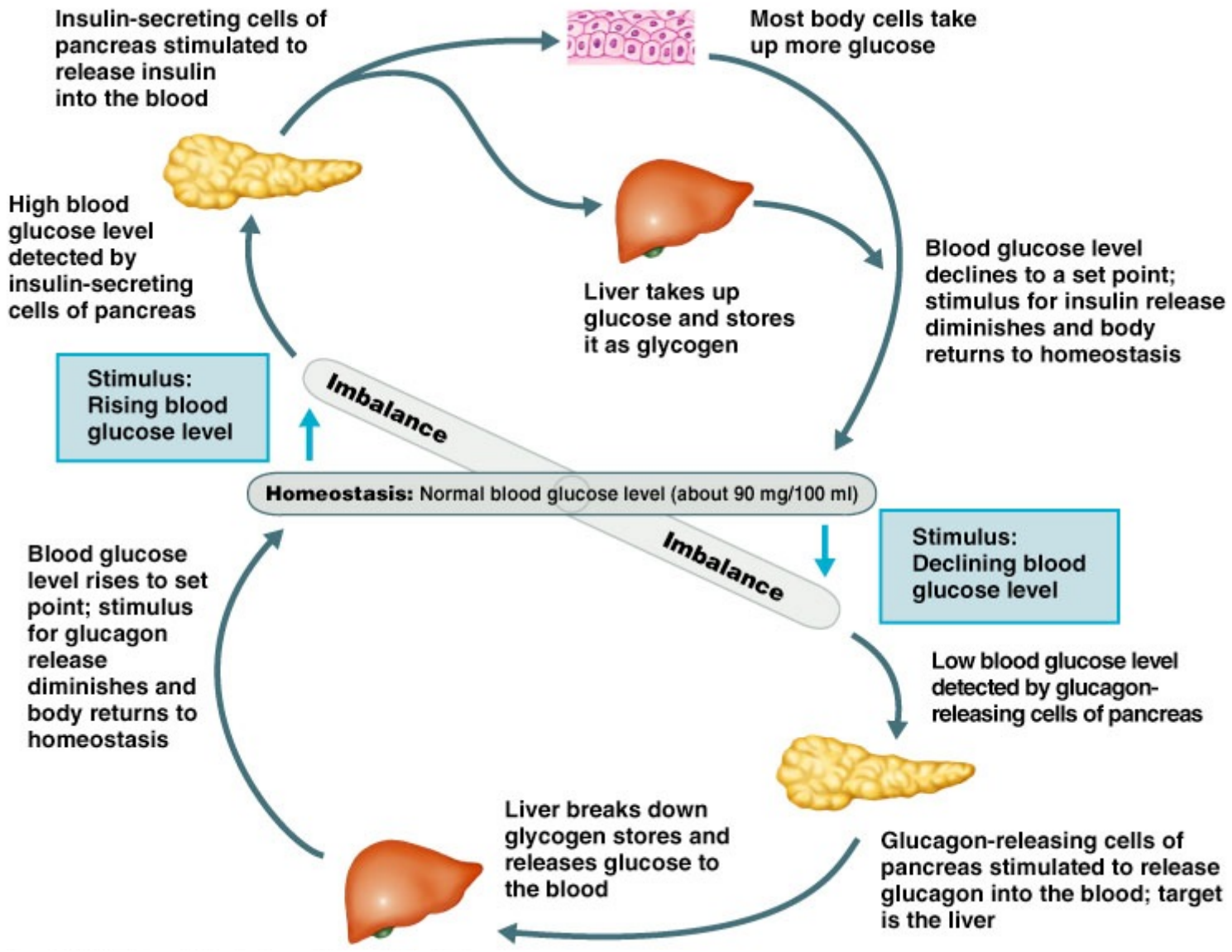
"Active product" controls the sequence of chemical reactions

by inhibiting the sequence's rate-limiting enzyme, "Enzyme A."

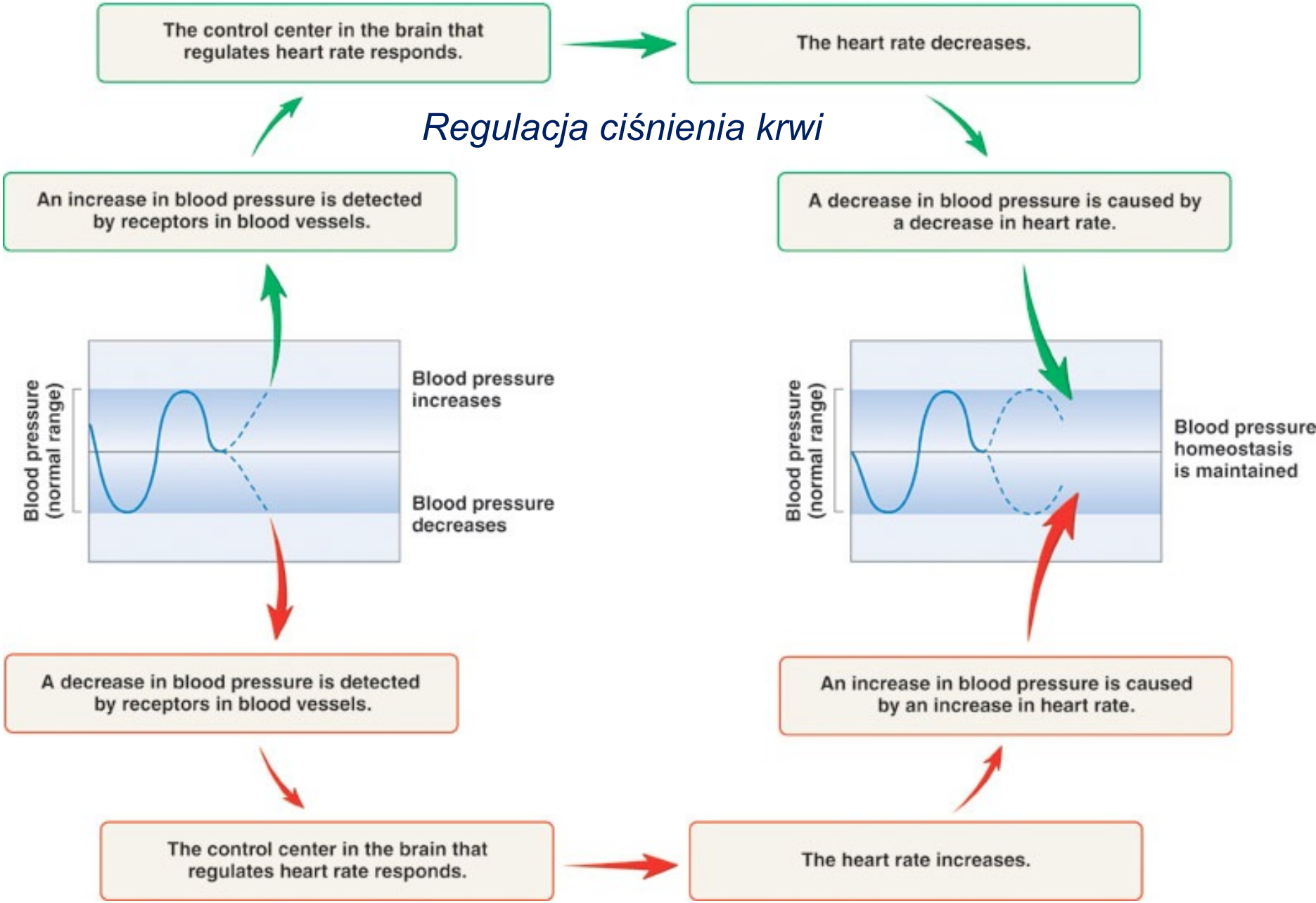
- Example of using negative feedback to control the rate of chemical reactions in a cell

NEGATIVE FEEDBACK

Regulacja poziomu cukru we krwi



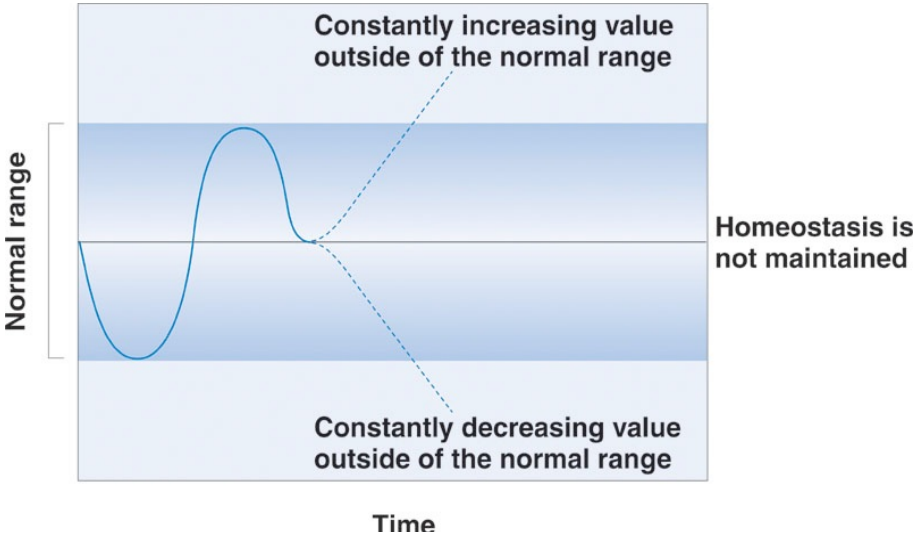
Regulacja ciśnienia krwi



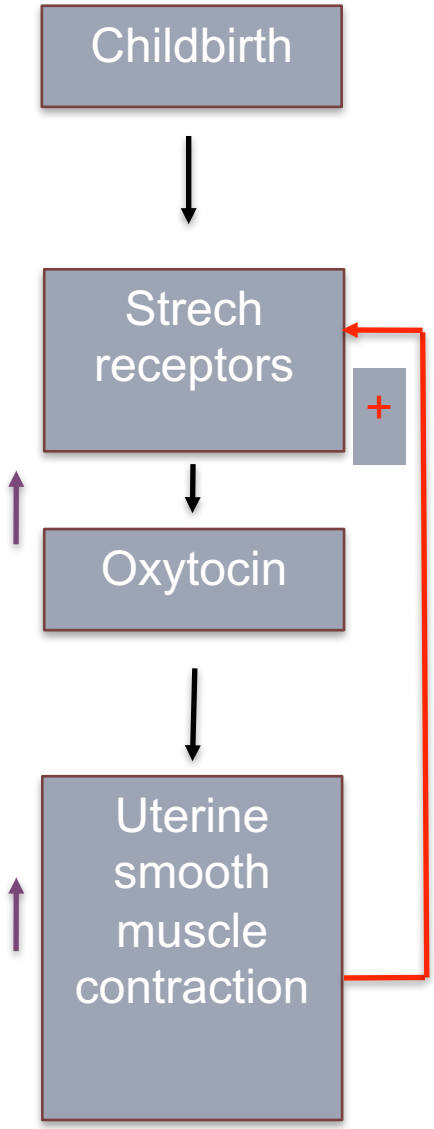
POSITIVE FEEDBACK

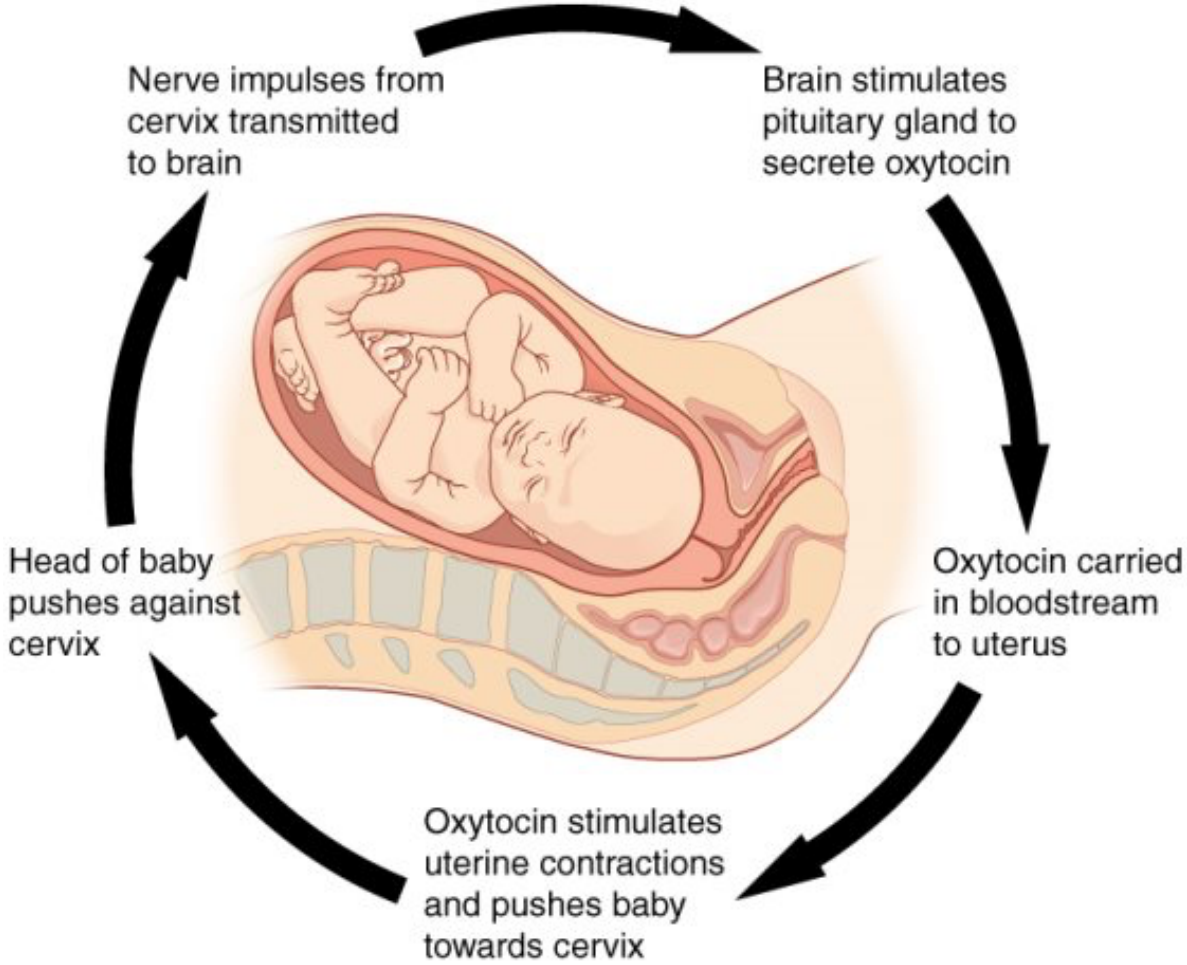
When a deviation occurs, the response is to make the deviation greater

- Unusual in normal, healthy individuals, leads away from homeostasis and can result in death
- Examples of normal positive feedback:
  - childbirth;
  - depolarization of neurons.
- Example of harmful positive feedback: after hemorrhage, blood pressure drops and the heart's ability to pump blood decreases.

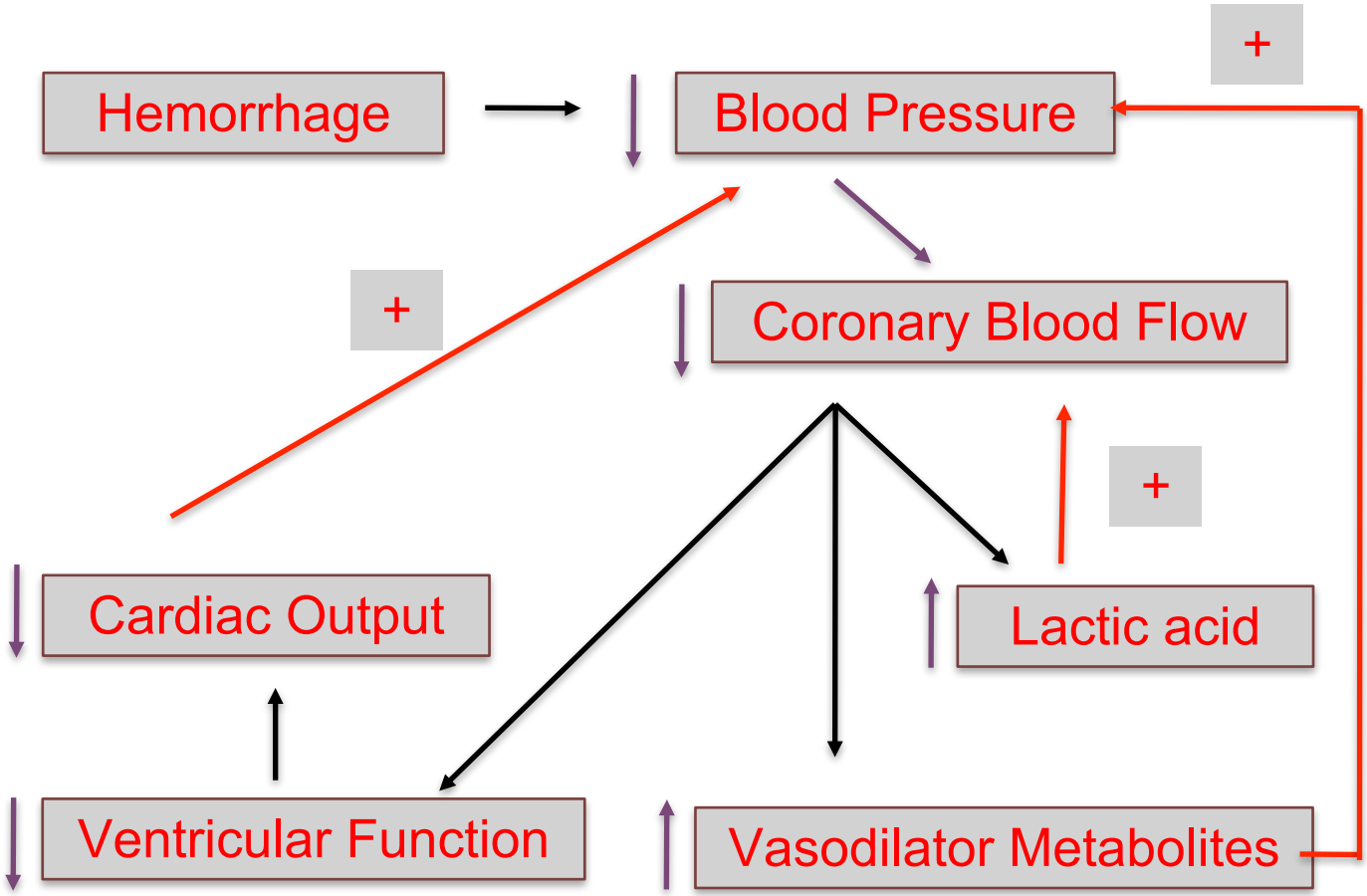


POSITIVE FEEDBACK

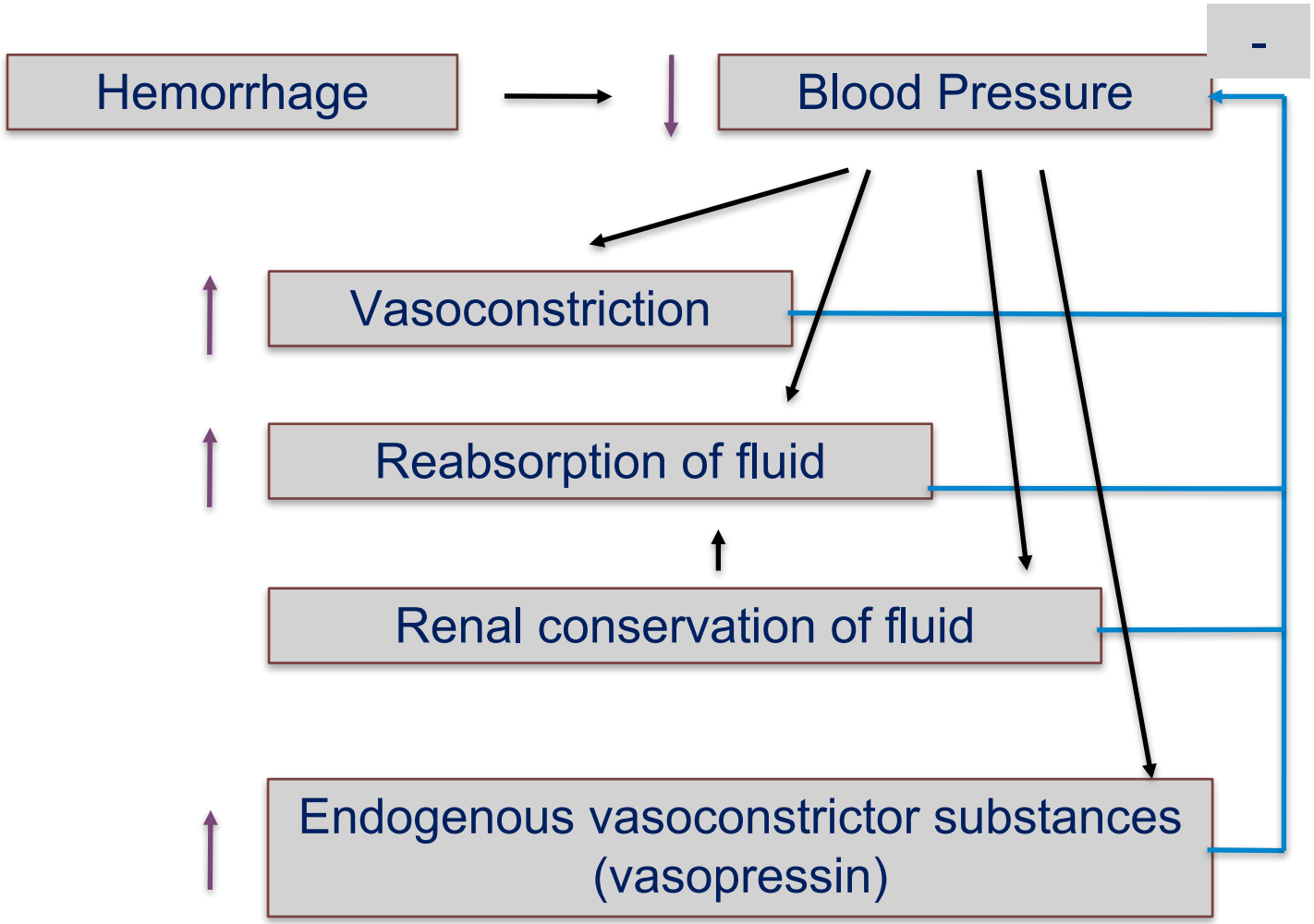




POSITIVE FEEDBACK



NEGATIVE FEEDBACK



A strategy for exploring homeostasis

- Identify the internal environmental variable.

example: concentration of glucose in the blood

- Establish the “set point” value for that variable.

example: 70 to 110 mg glucose/dL of blood

- Identify the inputs and outputs affecting the variable.

example: diet and energy metabolism

A strategy for exploring homeostasis

- Examine the balance between the inputs and outputs.

example: resting versus exercising

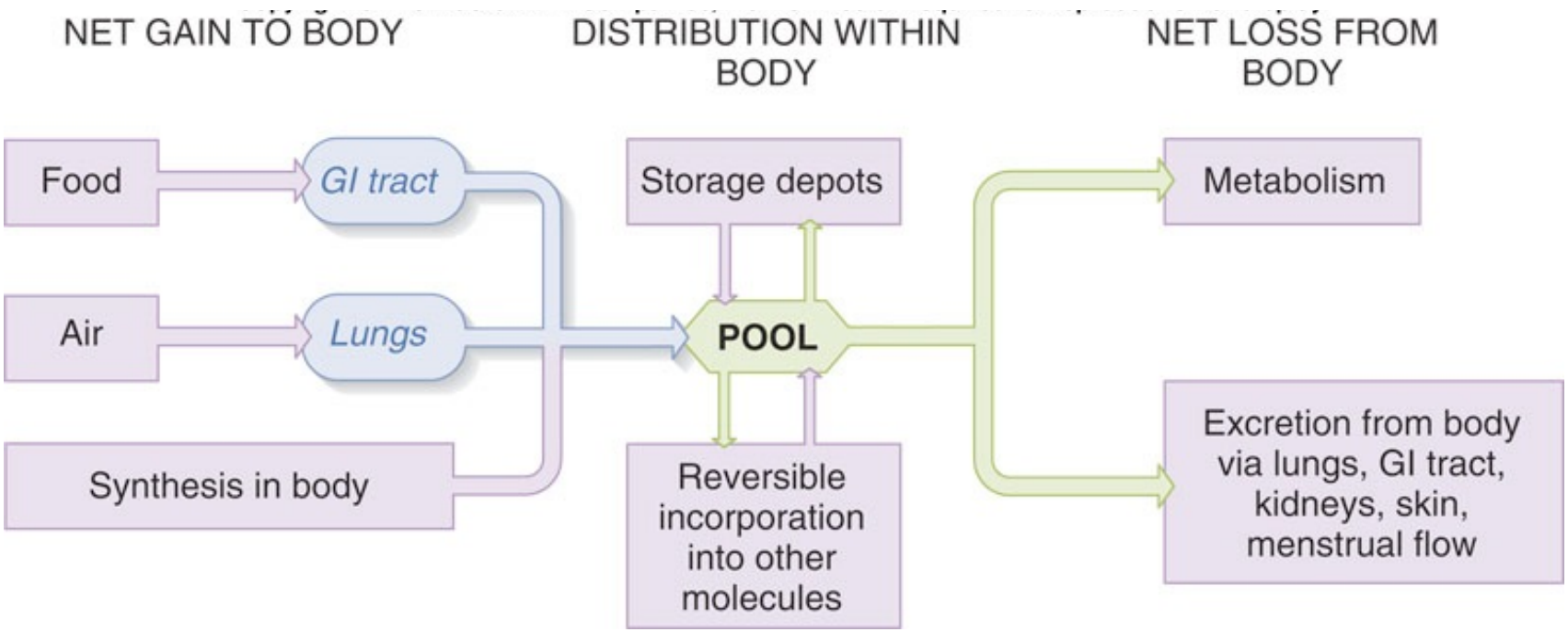
- Determine how the body monitors/senses the variable.

example: certain endocrine cells in the pancreas "sense" changes in glucose levels

- Identify effectors that restore the variable to its set point.

example: a hormone that increases glucose synthesis by the liver

COMPLEXITY

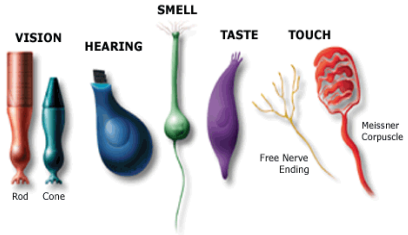


Some of the potential inputs and outputs that can affect the "pool" of a material (like glucose) that is a dynamically regulated physiological variable.

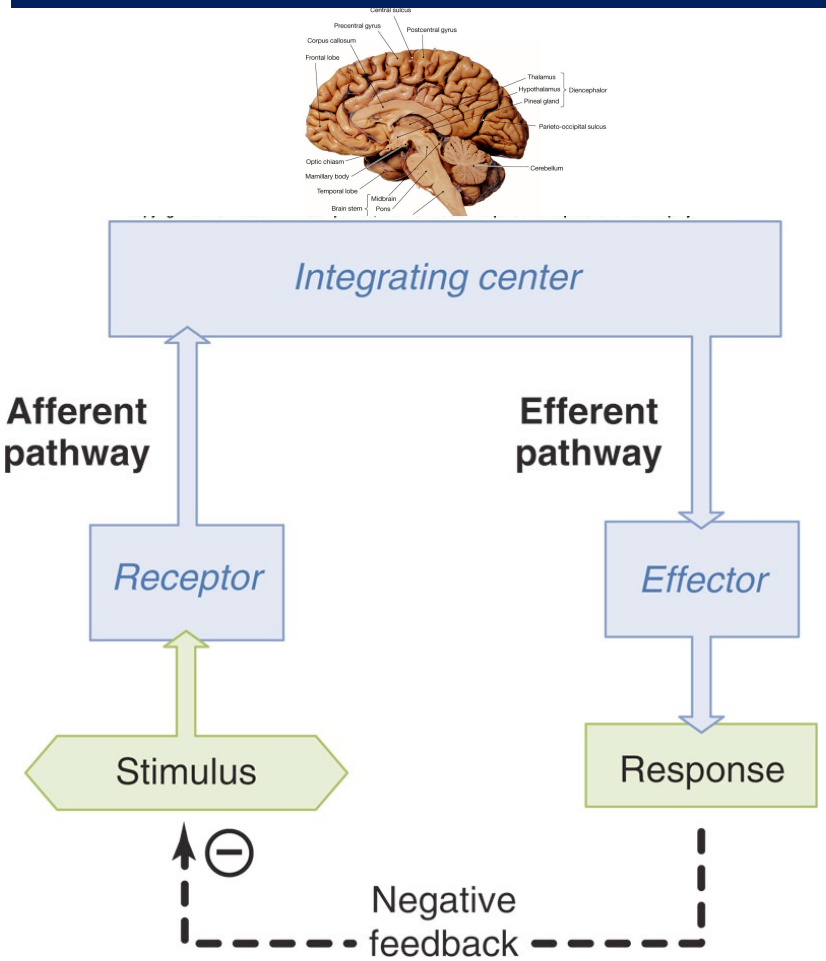
Many homeostatic mechanisms utilize neural communication.

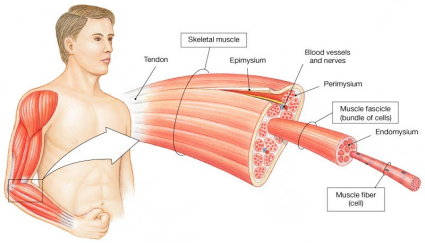
Components of homeostatic control system

- Reflex
- Reflex arc
- Stimulus

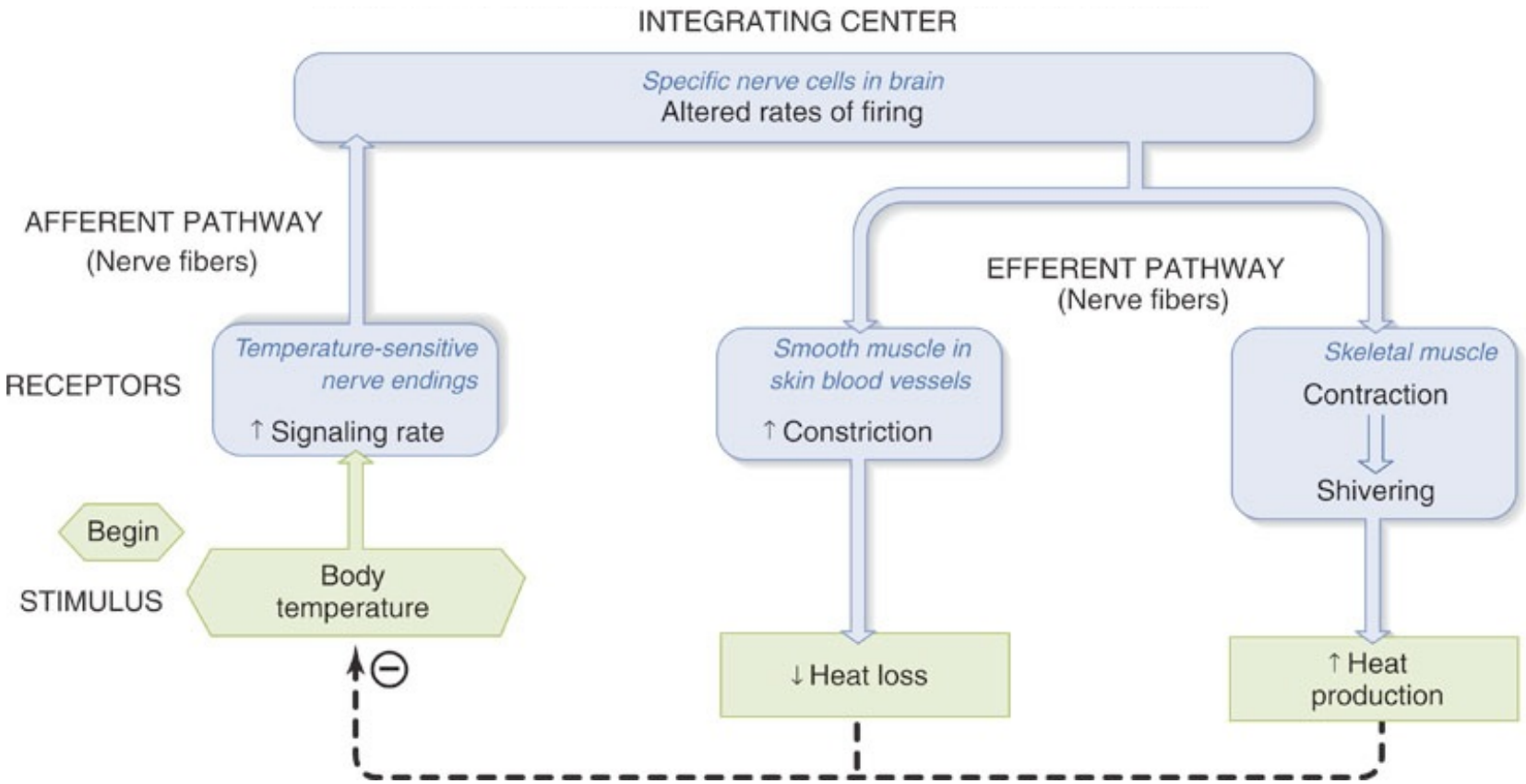


General components of a reflex arc





Example: reflex for minimizing the decrease in body temperature



Intercellular chemical messengers:

Communication systems use molecules that bind to receptors.

Communication signals in three categories:

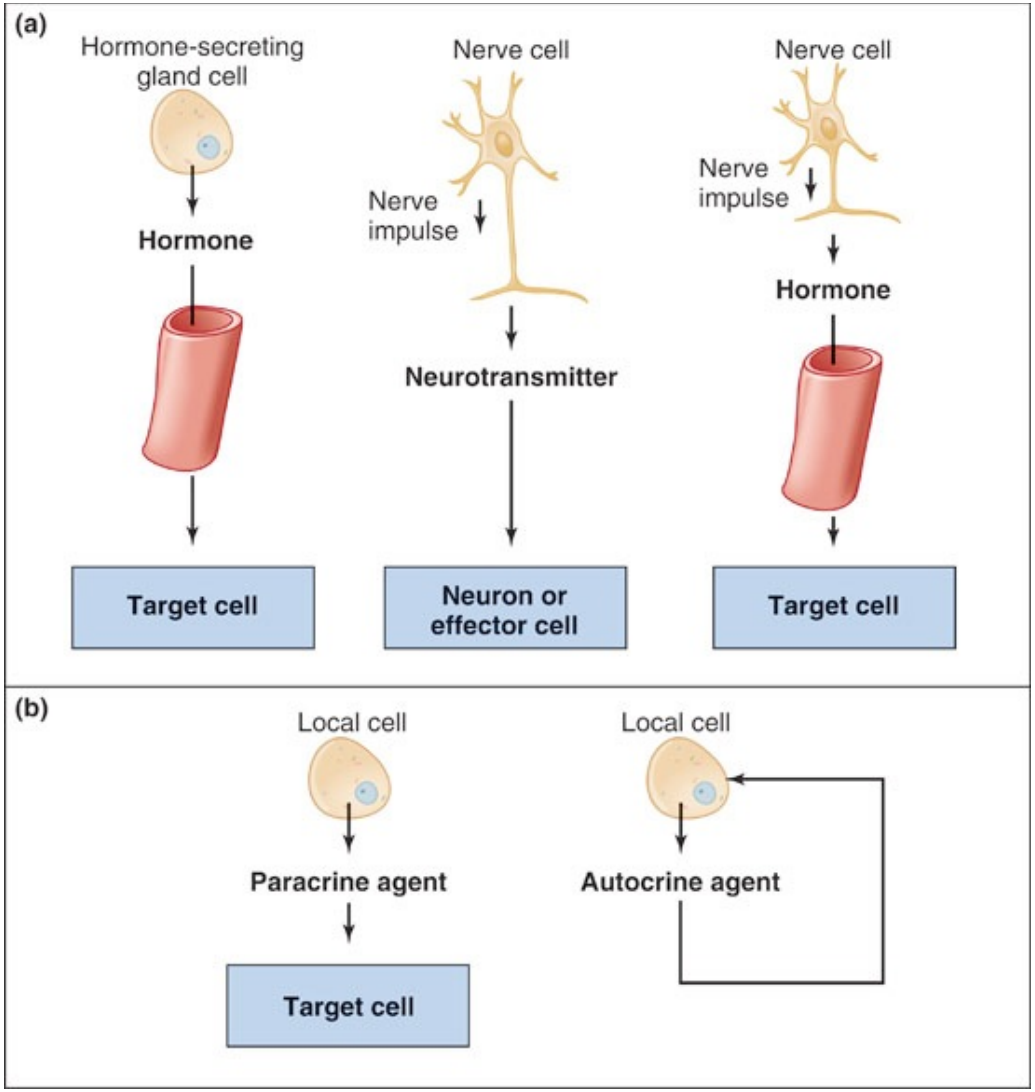
Endocrine: signal reaches often-distant targets after transport in blood.

Paracrine: signal reaches neighboring cells via the ISF.

Autocrine: signal affects the cell that synthesized the signal.

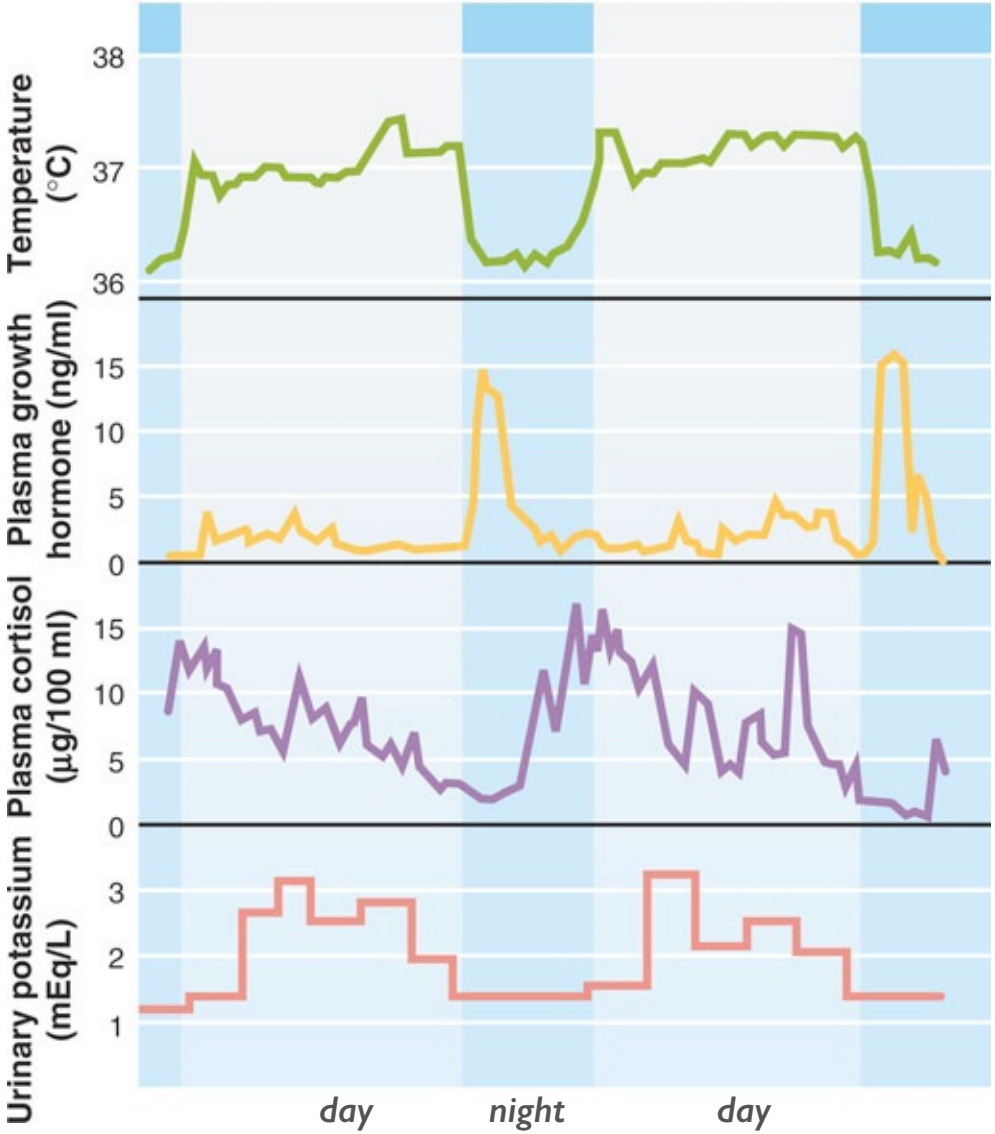
A given signal can fit into all 3 categories:

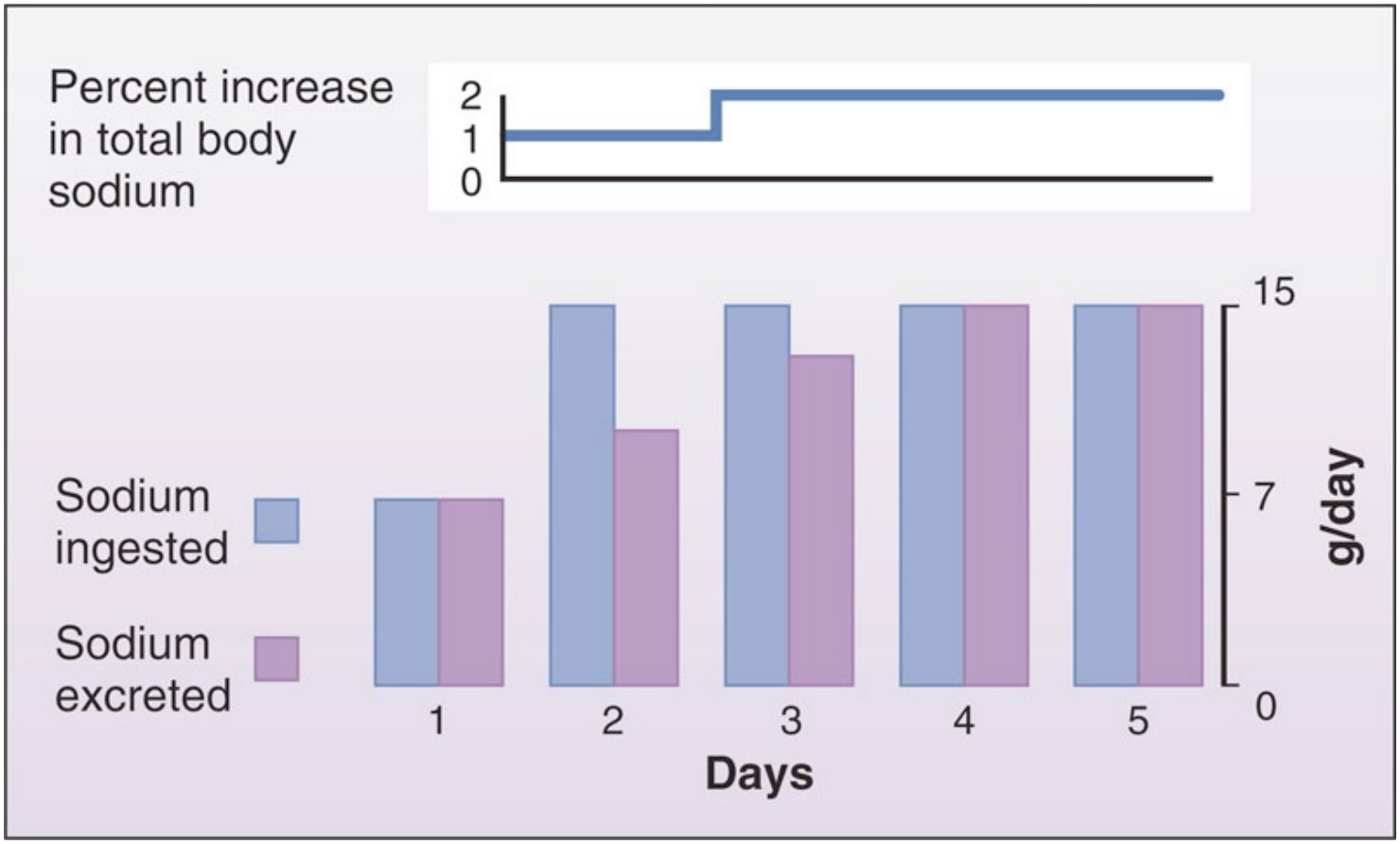
e.g., the steroid hormone cortisol affects the very cells in which it is made, the nearby cells that produce other hormones, and many distant targets, including muscles and liver.



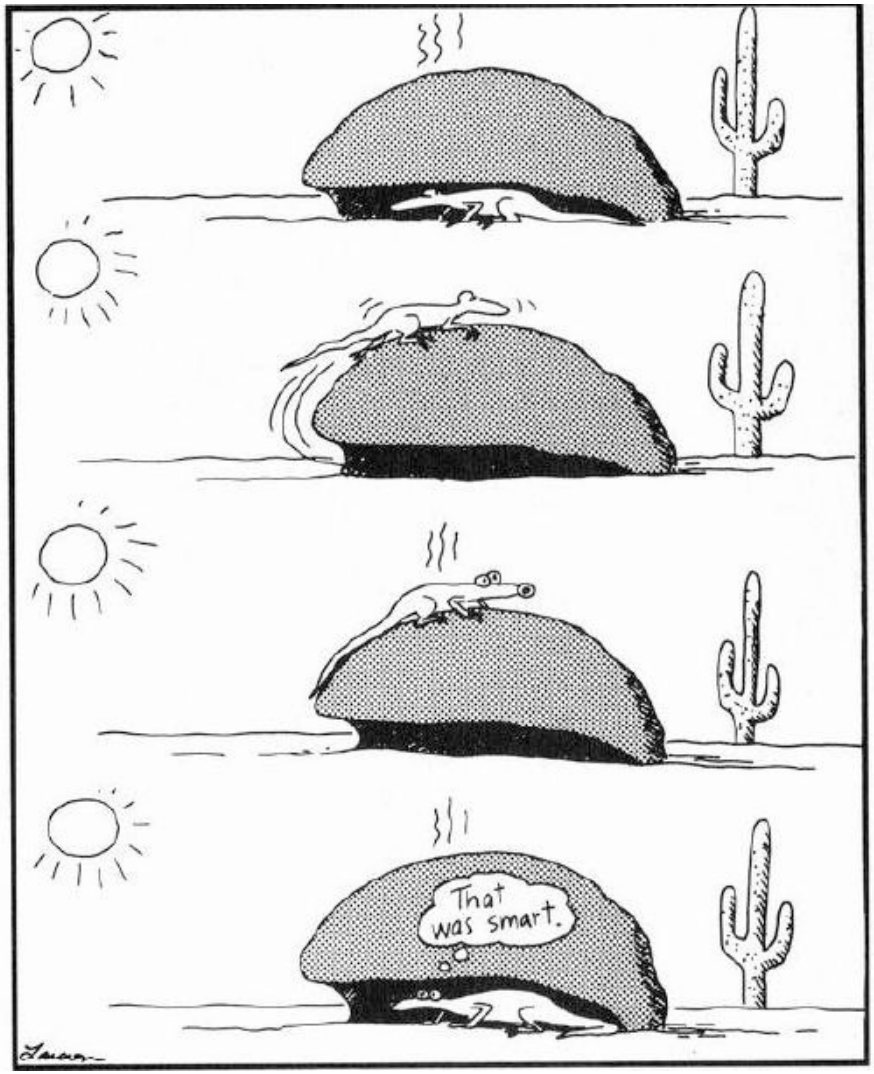
COMPLEXITY

A full analysis of the hormone cortisol requires not only knowledge of the signals that cause its synthesis and secretion but also consideration of biological rhythms.





Sodium homeostasis: Consuming greater amounts of dietary sodium initiates a set of dynamic responses that include greater excretion of sodium in the urine. Though not shown here, the amount excreted would likely exceed the amount ingested until the “set point” is restored.

Some Important Generalizations About Homeostatic Control Systems
1. Stability of an internal environmental variable is achieved by balancing inputs and outputs. It is not the absolute magnitudes of the inputs and outputs that matter but balance between them.
2. In negative feedback systems, a change in the variable being regulated brings about responses that tend to move the variable in the direction opposite the original change – that is, back toward the initial value (set point)
3. Homeostatic control systems cannot maintain complete constancy of any given feature of the internal environment. Therefore, any regulated variable will have more-or-less narrow range of normal values depending on the external environmental conditions.
4. The set point of some variables regulated by homeostatic control systems can be reset – that is, physiologically raised or lowered.
5. It is not always possible for everything to be maintained relatively constant by homeostatic control systems in response to an environmental challenge. There is a hierarchy of importance, such that the constancy of certain variables may be altered markedly to maintain others at relatively constant levels.

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