

REGULATION

Control of living systems.

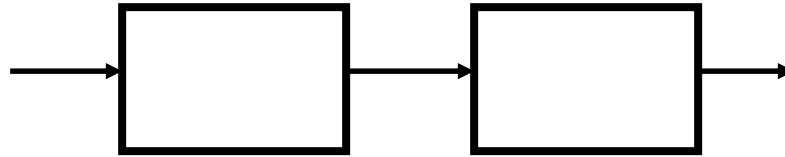
Living systems – open systems; their existence depends on flow of energy, substrates and signaling molecules between organism and environment in both directions.

Appears on all levels of system (cell – whole organism).

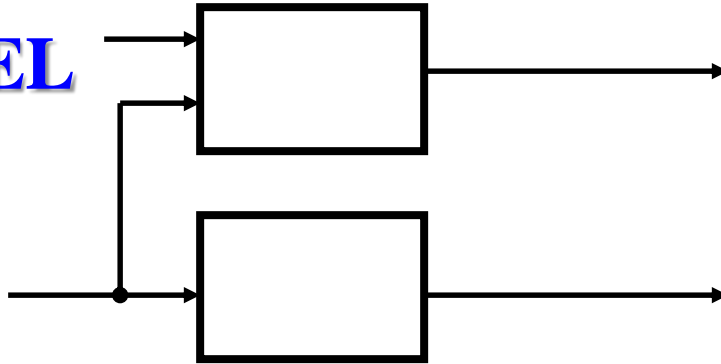
Regulation **nervous vs. Regulation **humoral**.**

BASIC TYPES OF FEEDBACK

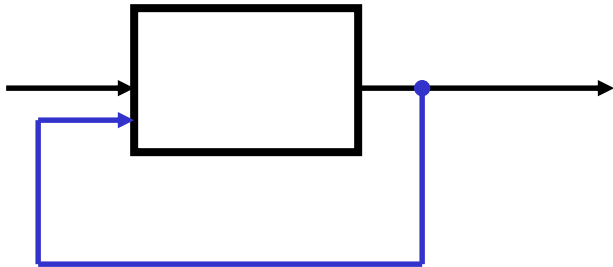
SERIAL



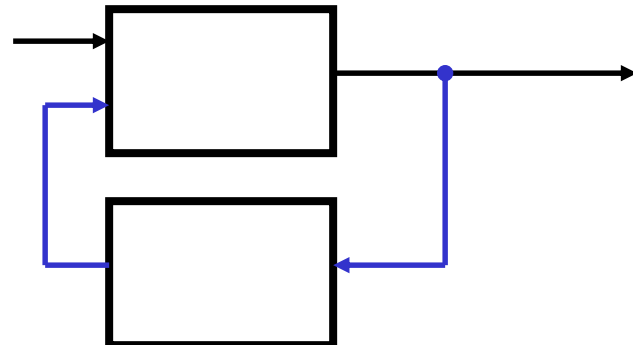
PARALLEL

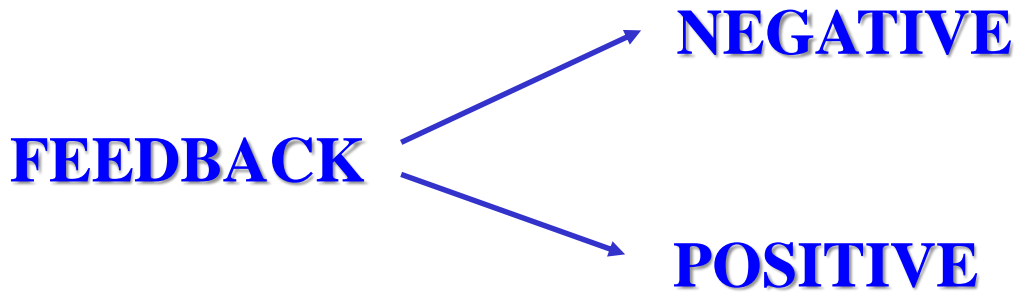


NEGATIVE DIRECT

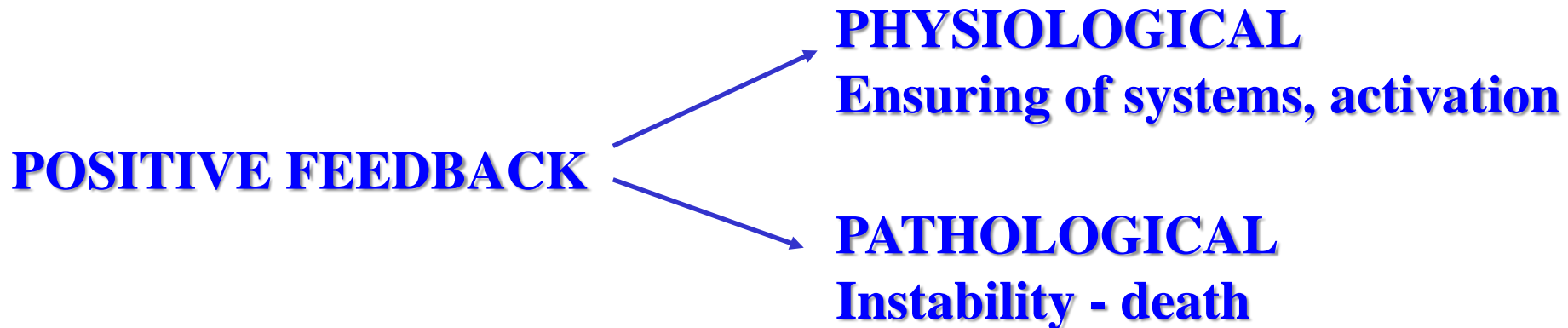


NEGATIVE INDIRECT



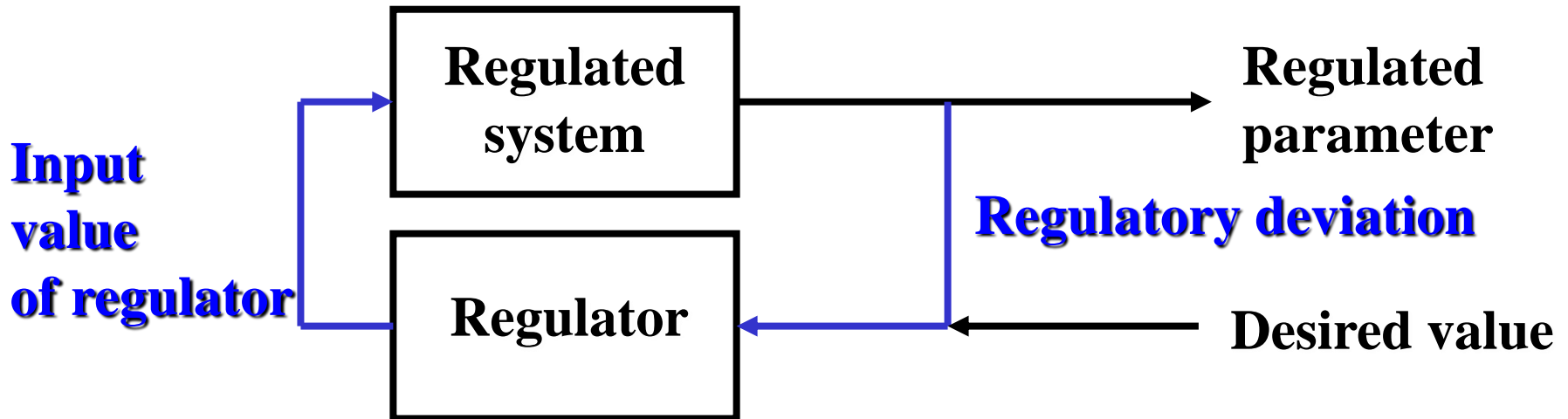


Deviation oscillates or continuously increases.



NEGATIVE FEEDBACK

- plays a role in regulations
- compensates the difference of regulated parameter
- minimizes the difference between real values of regulated parameter and so-called **desired value**



POSITIVE FEEDBACK

- No regulatory effect
- It does not compensate the deviation, but amplifies it

PHYSIOLOGY OF ADAPTATION

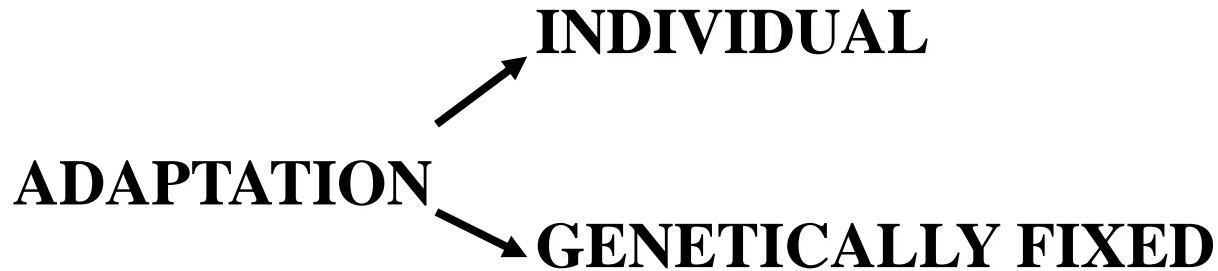
Adaptation or Environmental Physiology

**It examines the influence of environment on living systems
and their ability to adapt to changed conditions**

REACTION (REGULATION): direct, immediate response of organism on environmental changes

ADAPTATION = a complex of biochemical, functional and structural changes in organism caused by long-lasting and repeated environmental changes

REACTION (sec, min) vs. **ADAPTATION** (min, hours, days)



MECHANISMS OF ADAPTATION

= processes which lead to new, functionally better parameters.

Aim is to reach new, more advantageous qualities for surviving of the individual or species.

DURATION OF ADAPTATION:

Minutes - years

CONFORMATION ADAPTATION

Organisms are forced to create new total level of parameters

REGULATORY ADAPTATION

Operation range of function is changed

MECHANISMS OF ADAPTATION

- 1. Changed plasticity of nervous system**
 - **changes at molecular level in CNS**
 - **gene expression changes**
 - **regulation of number of neurites**
 - **changes in neuronal nets (cortical fields)**
- 2) Changes in organ size (adaptation to exercise)**
- 3) Changes of autonomous tonus (athletes)**
- 4) Temporary changes of skin colour (sunbathing)**

CLASSIFICATION OF ADAPTATIONS

a) According to target parameter

- **To cold**
- **To heat**
- **To dietary changes**
- **To high altitude**
- **To changed air composition**
- **To physical exercise**

b) According to output

- **Adaptations at the level of five basic senses**
- **Adaptation changes of behavior**

ACCLIMATION

Reaction of whole organism on change in one changed factor in environment

ACCLIMATISATION

Reaction of whole organism on change in several changed factors in environment

CIVILISATION DISEASES = MALADAPTATIONS

- Gastric ulcer disease
- Hypertension
- CAD
- Psychoses

STUDYING OF ADAPTATION

animal models

human volunteers

ADAPTATION TO COLD

18th century: surviving of sailors in cold water

1887: V. Priesnitz, S. Kneipp

People suffer from low temperatures less in winter than in summer.

ADAPTATION

INSULATIVE

METABOLIC

HYPOTHERMIC

- 1. PROTECTION FROM HEAT LOSS** (feather, vasoconstriction, increased amount of adipose tissue under the skin)
- 2. INCREASE OF HEAT PRODUCTION** (higher metabolic exchange)
- 3. DOWNWARDS SHIFT OF SET-POINT** (opposite to fever, behaviour as in hibernating animals)

Acclimation.

Human: as tropical animals

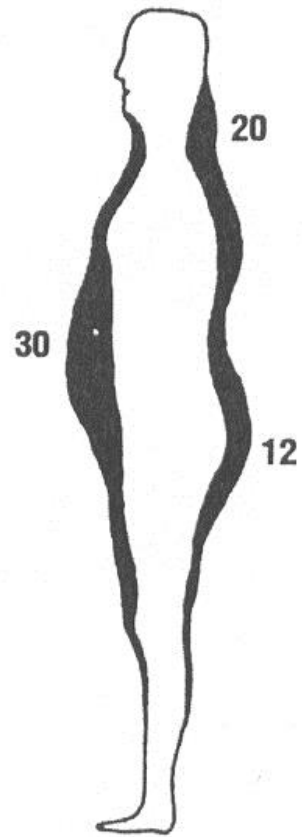
Seal, frog, seagull: arctic animals (thermoneutral zone between 20 – 40°C, thermoregulating below 20°C)

In humans always **all three mechanisms activated at the same time.**

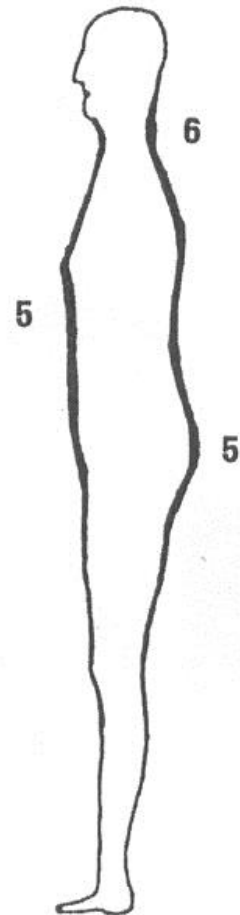
In adapted – O₂ consumption decreases, HR not changed, BP increases (by 20 – 40mmHg), feeling of discomfort is lower (starts at lower temperature), **downward shift of set-point (by 0.75°C)**

ADAPTATION PROCESS

- Mainly **new value of set-point**
- **Changed diet** (higher energy consumption, but **NO** increase of body mass, slowly increases body fat percentage)
- **Cold diuresis** (excretion of Na^+ and K^+) – up to 60x, mediated by ANF, haemoconcentration, increased number of leucocytes and erythrocytes
- **Glycaemia changes**: in non-adapted people decreases (stress), in adapted - increases (no stress)
- Decrease of threshold for pain on skin (total habituation – decreased sensitivity of receptors); **stress analgesia** in the course of adaptation
- **Decrease of threshold for muscle shivering**



J.Z.
Weight 97 kg
Height 1,7 m



G.P.
75 kg
1,8 m

ADAPTATION TO HEAT

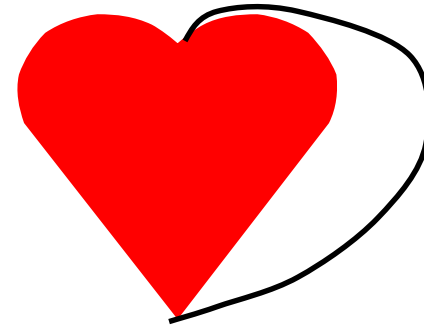
- 1) SWEAT PRODUCTION** may be doubled
 - 2) THRESHOLD FOR SWEATING** decreases to lower temperatures (both core and periphery)
 - 3) DECREASED CONTENT OF ELECTROLYTES IN SWEAT**
 - 4) FEELING OF THIRST** increases
 - 5) HIDROMEIOSIS** (decreased production of sweat in humid hot clima, after the period of profuse sweating; decreases idle dropping of sweat)
 - 6) ADAPTATION OF TOLERANCE TO HEAT** in inhabitants in the tropics, threshold for sweating is increased to higher body temperatures.
- ATTENTION** must be paid to physical exercise !!!

ADAPTATION TO EXERCISE

1. Muscle hypertrophy
2. Athlete's heart

Athlete's heart :

- Hypertrophy → dilatation
- Increased volume reserve (1.5x)
- Increased chronotropic reserve



„Physiological“ hypertrophy

- Prolongation of muscle fibres and increase of their thickness (NOT their number!!!)
- Accompanied by normal or increased contractility (speed of ATP hydrolysis by myosin and maximal speed of muscle shortening are either normal or increased)
- In muscles: increased number of mitochondria, increased activity of oxidative metabolism enzymes, proliferation of capillaries

HIGH ALTITUDE ADAPTATION

FAST RESPONSE (reaction)

(hours)

CARDIOVASCULAR RESPONSE: tachycardia and increased cardiac output at rest, more pronounced during exercise (BP increases during exercise only slightly)

RESPIRATORY RESPONSE: increased minute ventilation, more pronounced during exercise

ACID-BASE BALANCE: respiratory alkalosis ($RQ > 1$)

O₂ TRANSPORTATION: shift of dissociation curve to left

HIGH ALTITUDE ACCLIMATISATION

It takes at least several weeks, fully developed after months or years.

CARDIOVASCULAR RESPONSE: HR and CO are normalized, pulmonary arterioles constrict – pulmonary hypertension

RESPIRATORY RESPONSE: minute ventilation is stabilized (directly proportional to high altitude hypoxia), central chemoreceptors adapt

INCREASED RELEASE OF ERYTHROPOETIN: polyglobulia, transport capacity of blood for O₂ increases, viscosity of blood increases, density of mitochondria increases, myoglobin content increases

ACCLIMATISATION RECOMMENDATION:

After 3 days: A-B balance is restored, Hb concentration increases

After several weeks: it is possible to exercise

GENETIC ADAPTATION IN ALPINE TRIBES:

- **Bigger chest**
- **Higher density of capillary net in lungs**
- **Bigger heart (EDV)**
- **Higher CO**
- **Higher Hb concentration**
- **Bigger bone marrow**

Adaptation from birth ???

PATHOLOGICAL REACTIONS TO HIGH ALTITUDE:

- **Mountain disease (above 3 th. m.a.s.)**
- **Mountain disorientation (disorder - above 5 th. m.a.s.)**
- **Mountain edema**