REGULATION

Control of living systems.

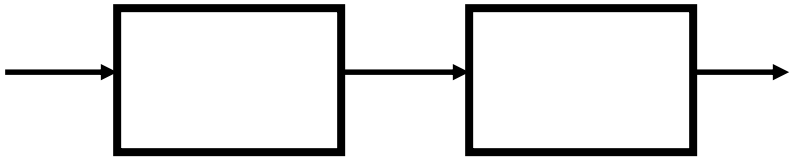
Living systems – open systems; their existence depends on flow of energy, substrates and signaling molecules between organism and environment in both directions.

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

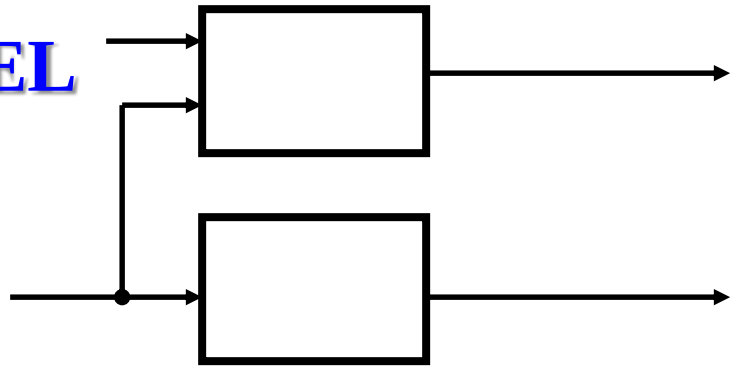
Regulation nervous vs. Regulation humoral.

BASIC TYPES OF FEEDBACK

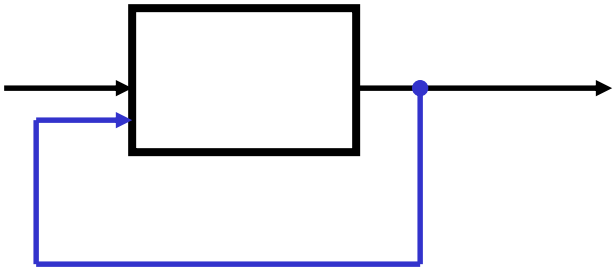
SERIAL



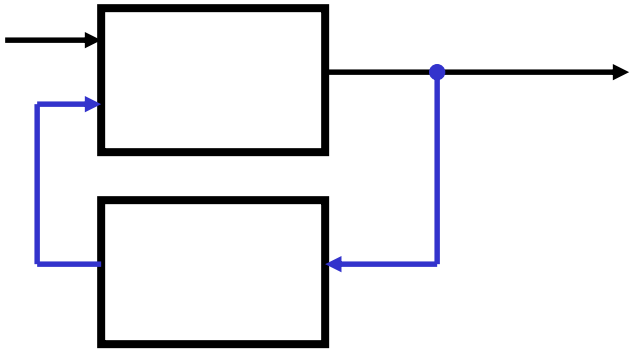
PARALLEL



NEGATIVE DIRECT



NEGATIVE INDIRECT



FEEDBACK → **NEGATIVE**

FEEDBACK → **POSITIVE**

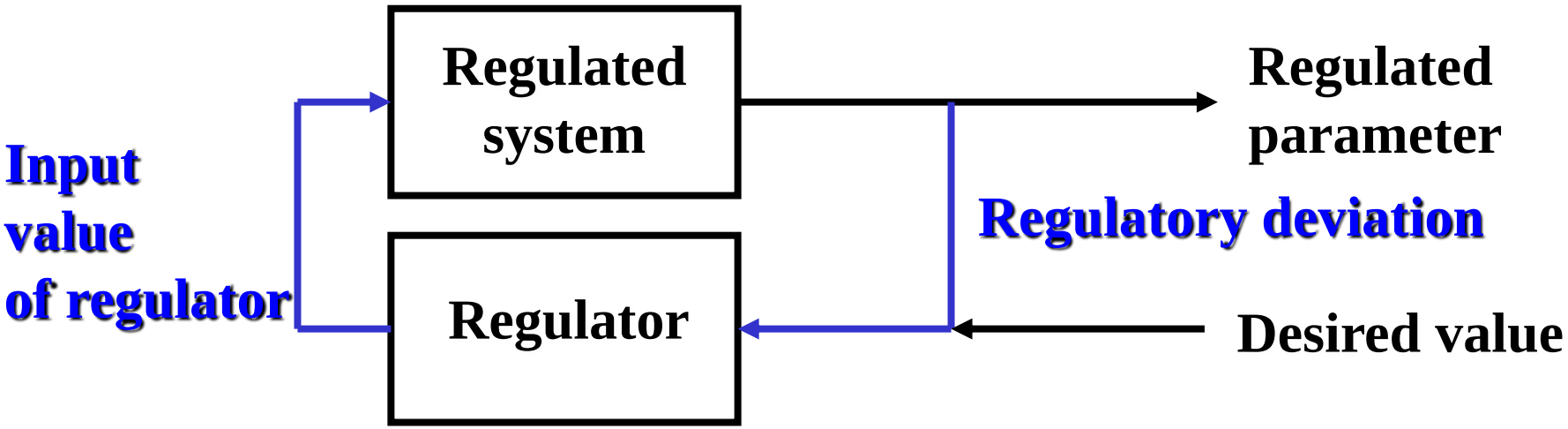
Deviation oscillates or continuously increases.

POSITIVE FEEDBACK → **PHYSIOLOGICAL**
Ensuring of systems, activation

POSITIVE FEEDBACK → **PATHOLOGICAL**
Instability - death

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

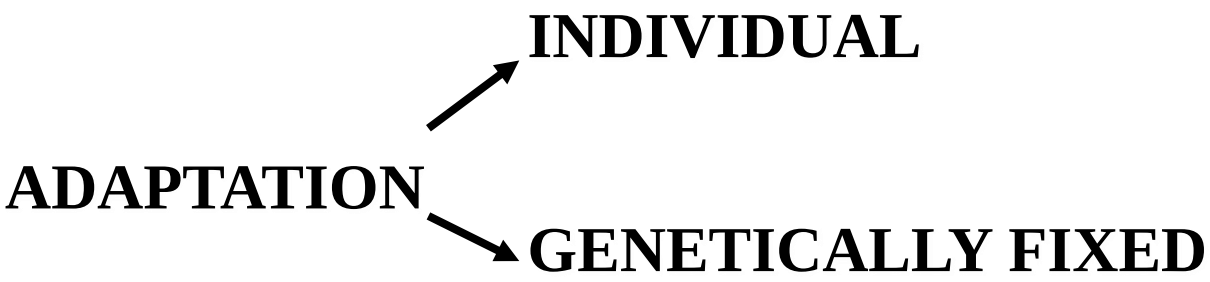
Adaptation or Environmental Physiology

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

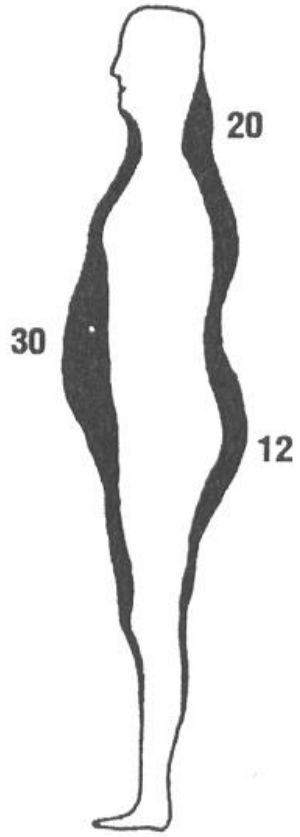
Seal, fog, seagull: arctic animals (thermoneutral zone between 20 – 40°C, thermoregulating below 20°C)

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

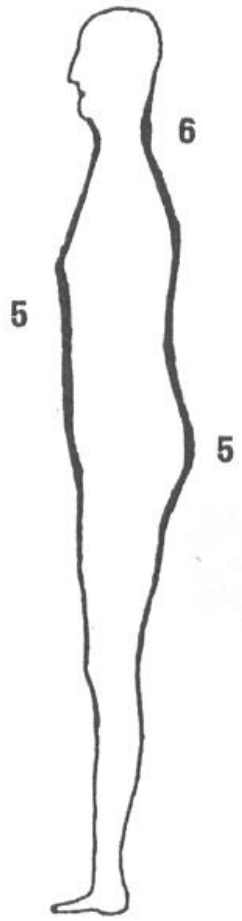
In adapted – O_2 consumption decreases, HR not changed, BP increases (by 20 – 40mmHg), feeling of discomfort is lower (starts at lower temperature), downward shift of set-point (by 0.75°C)

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) THREASHOLD 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 !!!

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)

O_2 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 O_2 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**

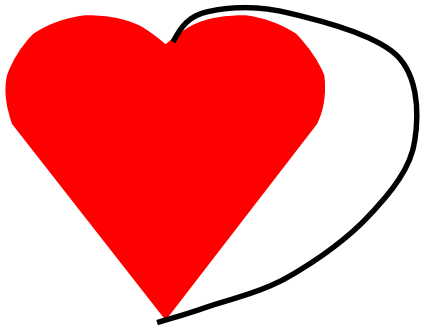
Adaptation from birth ???

PATHOLOGICAL REATIONS TO HIGH ALTITUDE:

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

ADAPTATION TO EXERCISE

1. Muscle hypertrophy
2. Athlete‘s heart

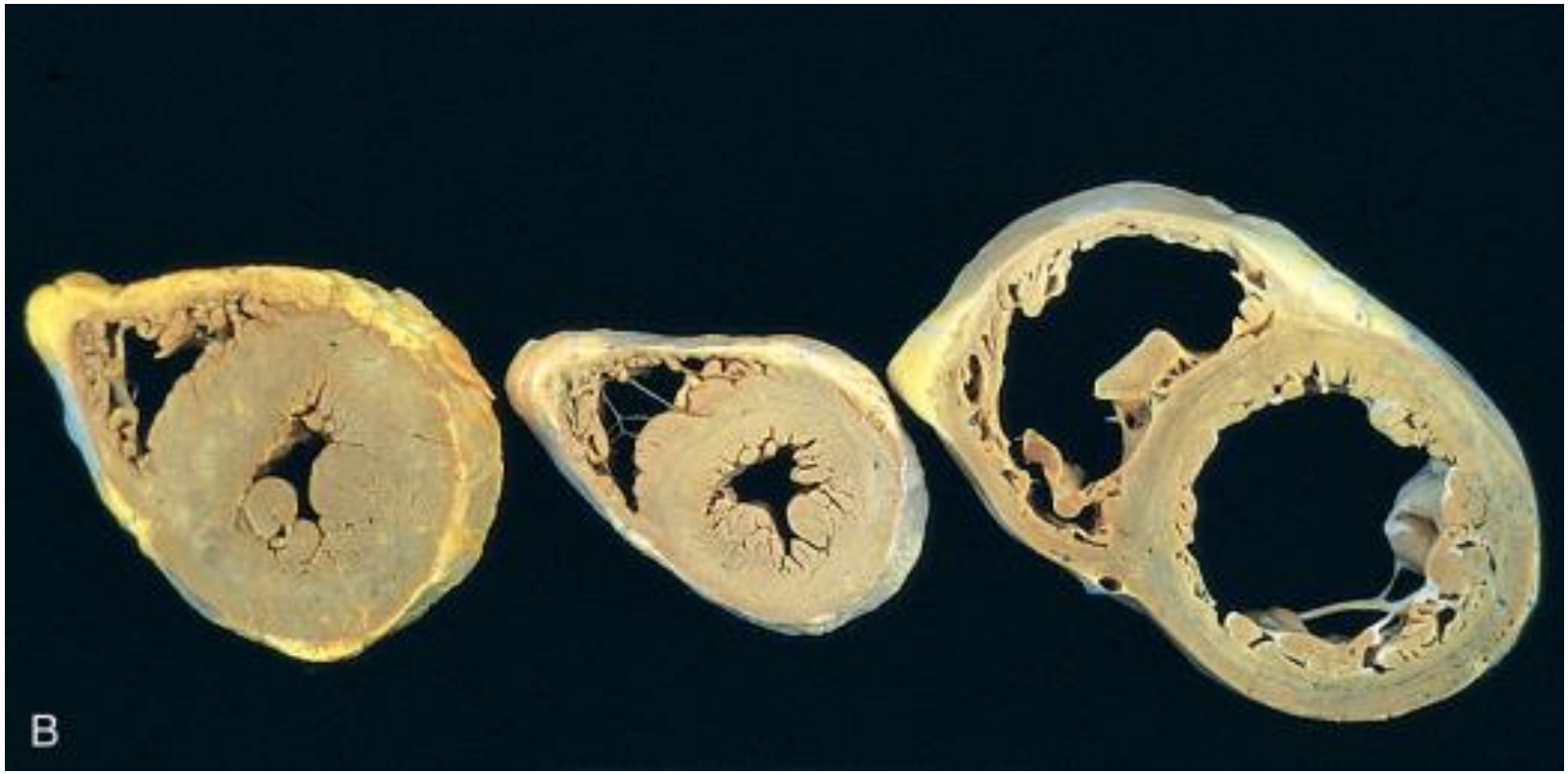


Athlete‘s heart :

- **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**



Transversal heart section:

hypertonic heart with concentric hypertrophy (left)
normal heart (middle)
hypertonic heart with eccentric hypertrophy = hypertrophy + dilation (right)