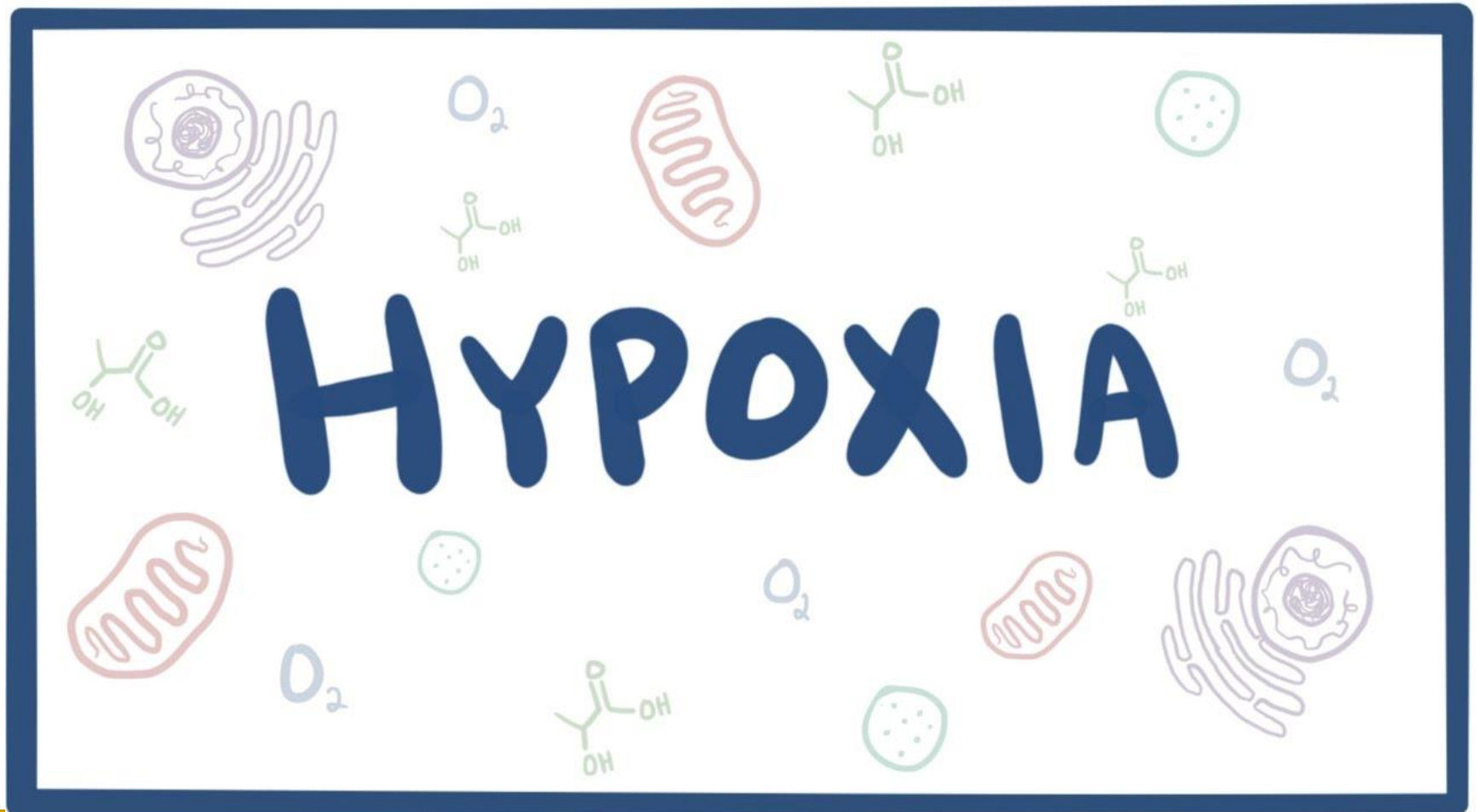


NATIONAL UNIVERSITY OF PHARMACY

DEPARTMENT OF PATHOLOGICAL PHYSIOLOGY



PLAN OF LECTURE

1. Definition, classification of hypoxia.
 2. The concept of hypoxic hypoxia.
 3. Types of endogenous hypoxia.
 4. Urgent and long-term mechanisms of compensation of hypoxia.
-

* **Questions of Independent work**

1. Iso- and hyperbaric oxygenation.
2. Toxic effect of oxygen. Hyperoxia and free radical reactions.

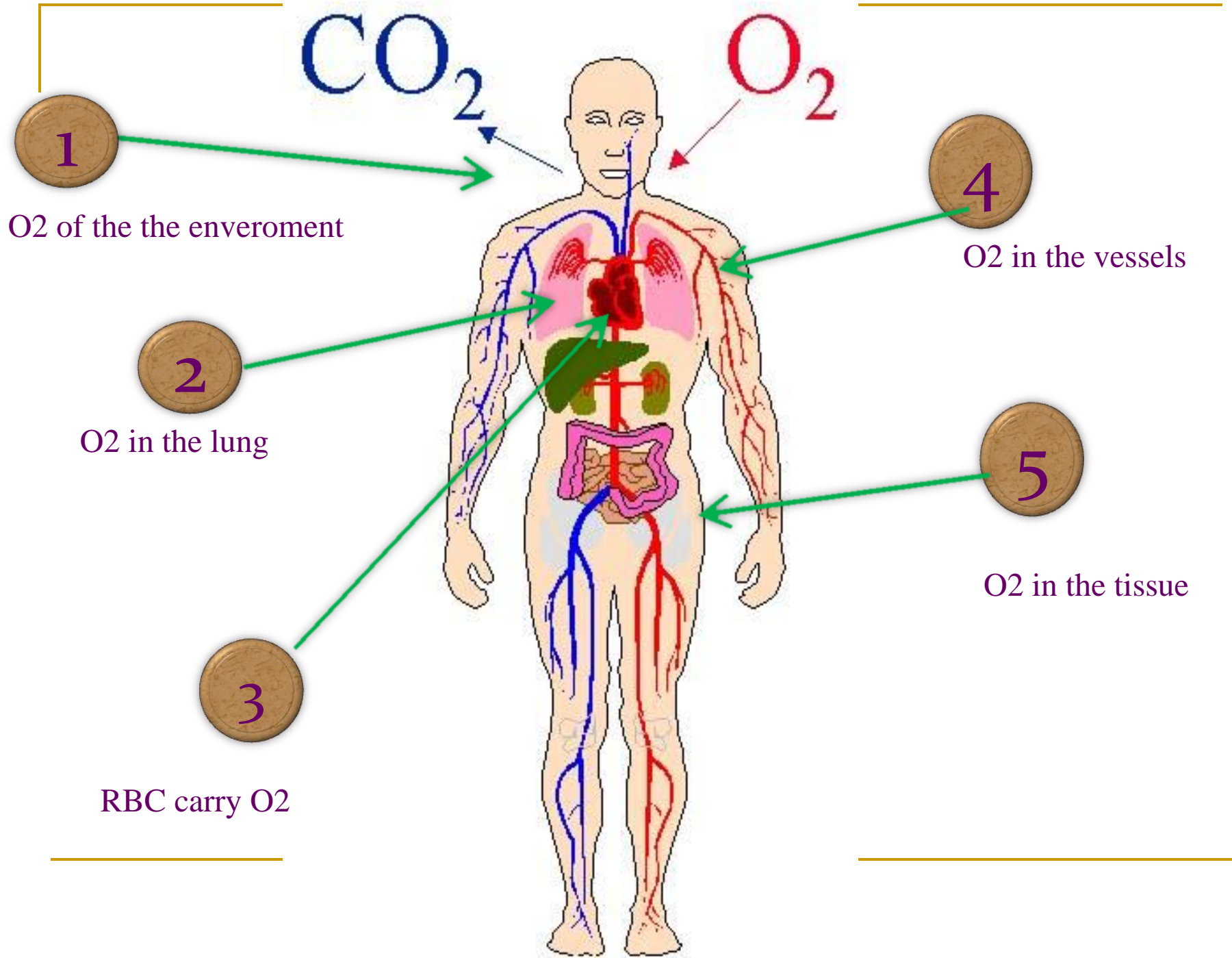
Suggested Reading

■Basic

1. General and clinical pathophysiology/ Editor by Anatoliy V. Kubyshkin. – Vinnytsa : Nova Knyha Publishers, 2016. – 656 p.
2. Lecture notebook pathological physiology. Manual for working in lectures / N.M. Kononenko, S.I. Kryzhna, V.A. Volkovoy et al.; Kh.: NPhaU, 2013. – 99 p.
3. Pathological Physiology: The textbook for the students of higher pharmaceutical educational institutions and pharmaceutical faculties of higher medical educational institutions III-IV levels of accreditation / S/I/ Kryzhna, N.M. Kononenko, I.Yu. Tishenko et al.: under edition of the professor A.I. Bereznyakova. – Kharkiv: NphaU, 2006. – 416 p.

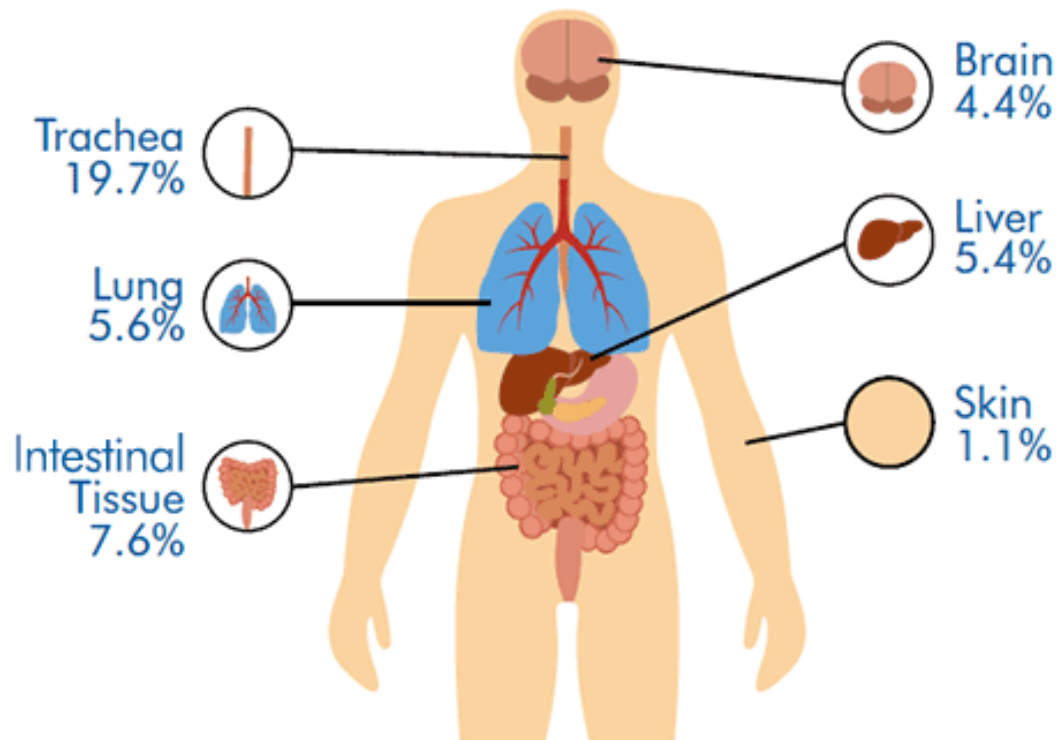
■Auxiliary

1. Professional guide to Pathophysiology / M.H. Birney, C. L. Brady, K.T. Bruchak et al. – Lippincott Williams and Wilkins. – 2002. – 696 p.
2. Crowley L.V. An introduction to human disease: pathology and pathophysiology correlations / L.V. Crowley . – London : Lones and Bartlett Publishers International Bard House. 2001. – 790 p.



Hypoxia is a typical pathologic process, developing as a result of insufficient tissue supply by oxygen or its disturbed use.

Physiologic Median O₂ Levels in Organs and Tissues



Classification by time of appearance and duration of hypoxia features

1. **Fulminant (immediate)** – developing during several seconds (histotoxic hypoxia during cyanide poisoning)
 2. **Acute** – developing during several minutes (shock, cardiac accidents, bronchospasm)
 3. **Subacute** – continues for several hours or day (extreme conditions and pathological states)
 4. **Chronic** – continues for months and years (chronic heart or respiratory failure)
-

Classification by etiology and pathogenesis

1 Hypoxic or exogenous hypoxia develops in the decreased partial pressure of oxygen. The most typical example of it – is a mountain disease.

4 Circulatory hypoxia develops in different disturbances of blood circulation. There are ischemic and congestive forms.

combined forms
of hypoxia.

6

2 Respiratory hypoxia occurs as a result of disturbed external breathing: the disturbance of lung ventilation, lung blood supply or oxygen diffusion.

3 Haemic hypoxia develops in blood disturbances and in particular the decrease of its oxygen capacity.

Tissue hypoxia is a disturbance in oxygen utilization. Tissue supply by oxygen is sufficient, but its biological oxidation is disturbed.

5

PATHOGENESIS OF HYPOXIA

During hypoxia occur metabolism disorders. Violation of carbohydrate metabolism leads to the accumulation of unoxidized products (for example lactic acid). The normal environment of organism $\text{pH}=7.4$ and during hypoxia occurs acidosis (6.8; 6.6; 6.4). Acidic environment or acidosis destroys the cells in the body.

Etiology and pathogenesis

Type of hypoxia	Etiology	Pathogenesis
Hypoxic	Getting to high altitudes, rapid depressurization of the closed aircrafts, quick ascent to high altitude, flying in open planes, when persons are situated in small room with bad ventilation long time, in divers with the problems of aqualung function.	Decreased partial pressure of oxygen in inspired air
Respiratory	Diseases of respiratory system: pneumonia (inflammation of lungs), inflammation of bronchus, bronchial asthma, asphyxia, overdose of narcotic (depressing of respiratory center), tumor of bronchi, pneumosclerosis, bronchial asthma.	Disturbed external breathing: the disturbance of the lung ventilation, the lung blood supply or oxygen diffusion

Etiology and pathogenesis

Type of hypoxia	Etiology	Pathogenesis
Haemic	<p>1) Anemia after hemorrhage (bleeding), as a result of deficiency of vitamins and minerals</p> <p>2) Inactivated forms of hemoglobin:</p> <ul style="list-style-type: none">■ poisoning of carbon monoxide – <i>carboxyhemoglobin</i>■ poisoning of nitrites, by nitrates, dyes - <i>methemoglobin</i>	Decreases of oxygen capacity as a result of decreases of a quantity of erythrocytes (RBC) and hemoglobin)
Circulatory	Diseases of the heart (heart insufficiency, the defects of heart, myocardial infarction) and blood vessels (shock, collapse and disturbed of peripheral blood circulation – ischemia, venous hyperemia)	Disorders of blood circulation

Etiology and pathogenesis

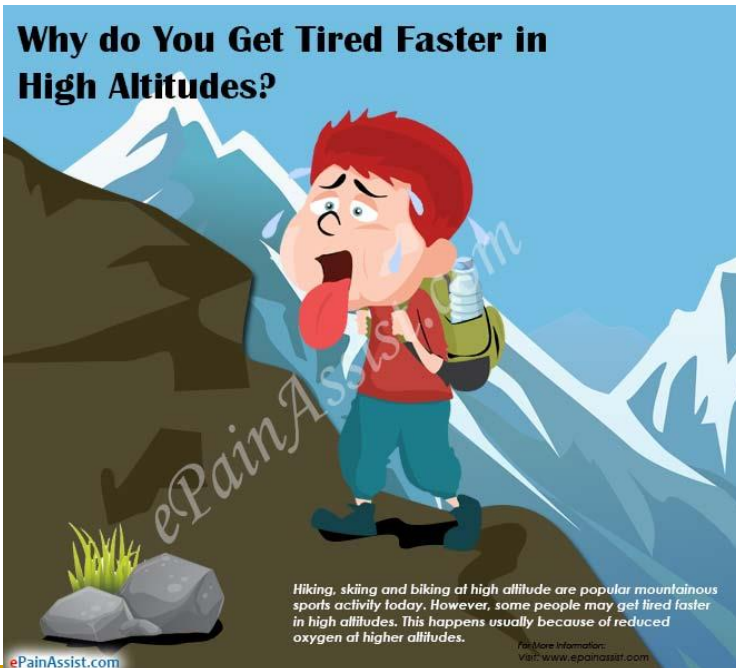
Type of hypoxia	Etiology	Pathogenesis
Tissue (Histotoxic)	<ul style="list-style-type: none">■ poisoning of cyanides, alcohol, barbiturates – inactivation of respiratory enzymes;■ protein starvation, avitaminosis of B₁, B₂, PP – disturbance of the synthesis of respiratory enzymes■ lipid peroxidation products, toxic metabolites in uremia – damage to mitochondrial membranes	Disturbance of the utilization of oxygen by tissue
Mixed	Anaphylactic, traumatic, cardiac shock	Several types of hypoxia
Hypoxia of load	Intensive physical work	deficiency of oxygen

MOUNTAIN SICKNESS

develops after getting to high altitudes in mountains.

Example, hikers, skiers and adventurers hike up a mountain or go skiing.

In this moment your body may not have enough time to adapt for low partial pressure of oxygen in inhaled air.



“Why do I feel this way?”

ELEV.
10,000 FEET

Headache

Fatigue

Nausea

Dizziness

Shortness of Breath

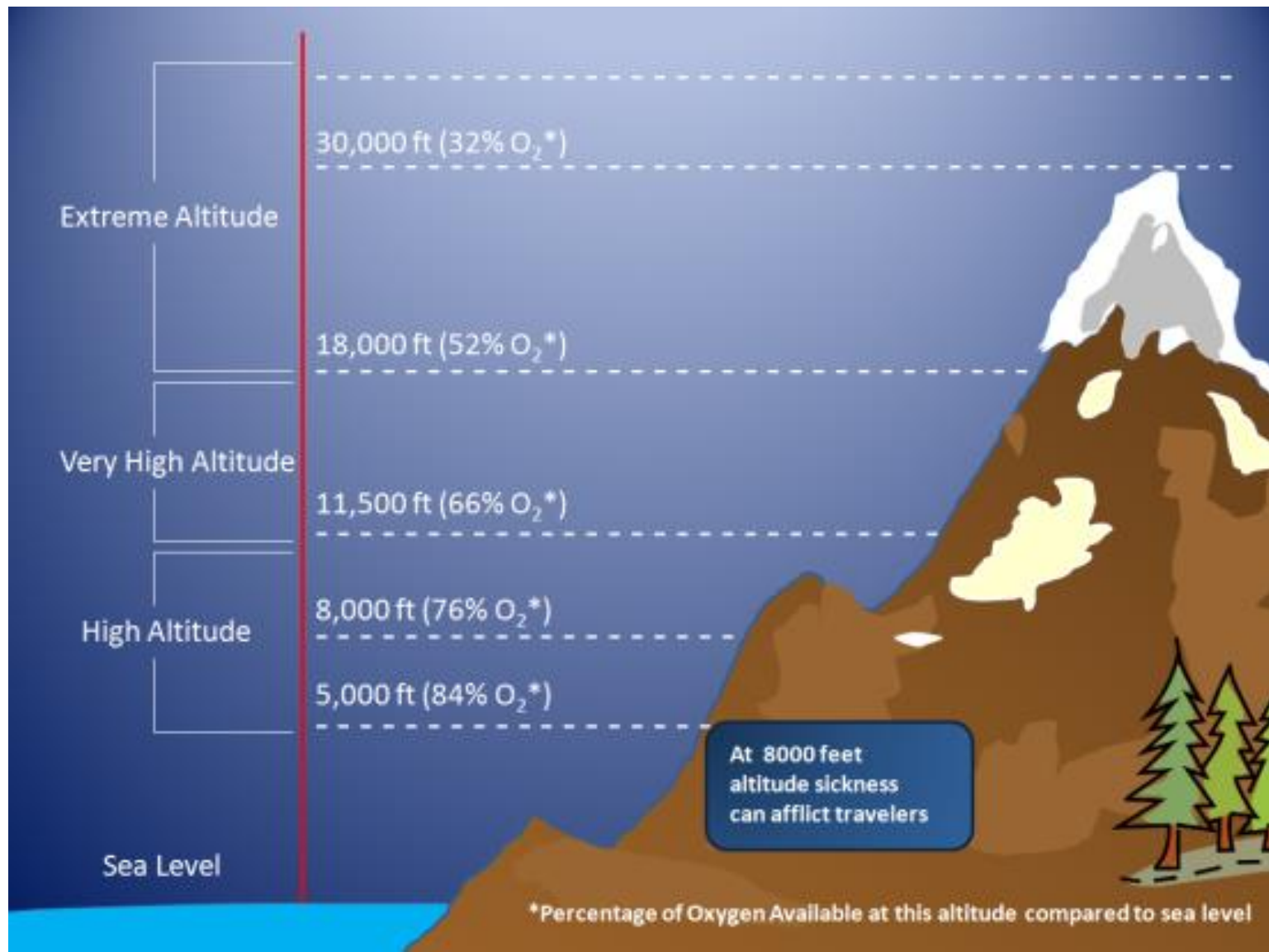
Muscle Aches

Insomnia

ALTITUDE SICKNESS

It develops after rapid depressurization of the closed aircrafts, quick ascent to high altitude, flying in open planes. It is characterized loss of consciousness, gas embolism, explosive decompression.

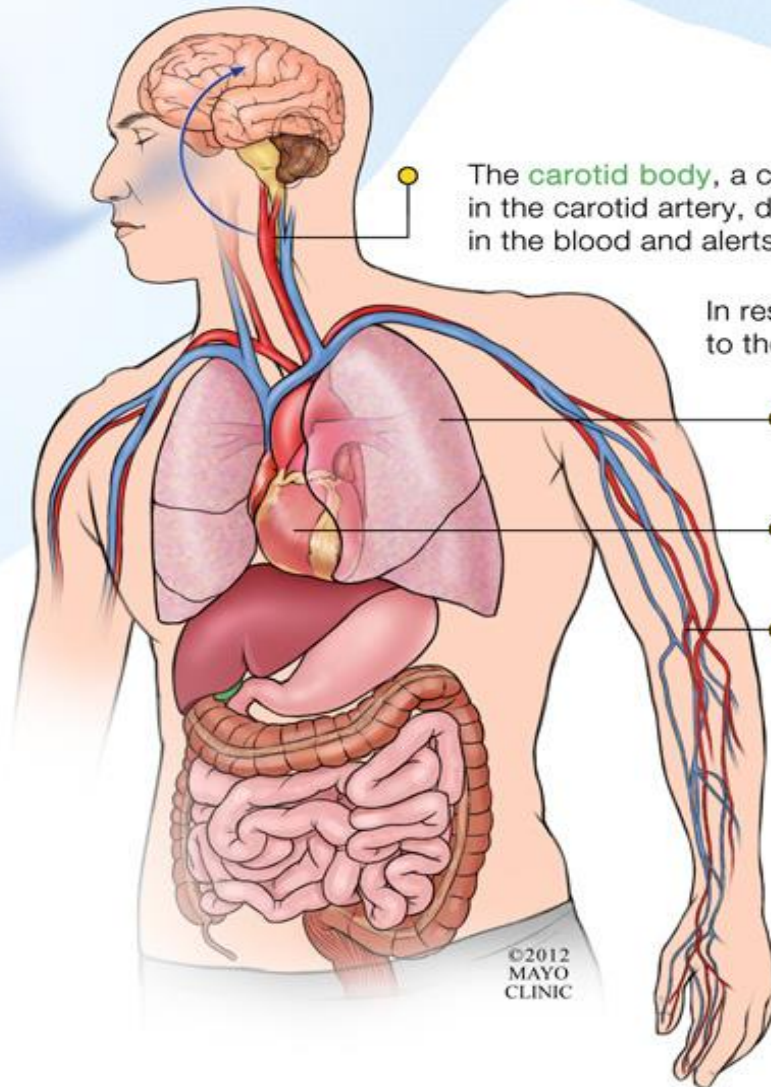




Effects of Hypoxia (hi-pok'se-ah)

; a condition in which the body as a whole or a region of the body is deprived of adequate oxygen supply.
/hy·pox·ia/ - noun

Low oxygen pressure at high altitude



The **carotid body**, a cluster of specialized cells in the carotid artery, detects low oxygen levels in the blood and alerts the brain.

In response, the **brain** sends signals to the rest of the body to...

- increase breathing rate and constrict vessels in the **lung**

- increase **heart** rate

- dilate **peripheral blood vessels** in arms, legs, hands, and feet

Disturbances in the nervous system:
first euphoria occurs (characterized by the emotional & motion excitation, the feeling of one's own power or, on the contrary, the loss of interest to the surroundings, inadequate behavior). Then reflex activity is disturbed, loss of consciousness and convulsions development

Metabolic disturbances in the tissue :
toxic products of incomplete oxidation are accumulated, accumulated lactic acid leads to acidosis. The appearance of products of lipids peroxide oxidation is an important factor of hypoxic injury of the cell.

The diagram features a central horizontal box with the text "Signs of hypoxia". From the top and bottom of this box, two large, light-brown, 3D-style arrows point outwards. The top arrow points towards a box containing text about disturbances in the nervous system and metabolic disturbances in the tissue. The bottom arrow points towards a box containing text about disturbances in the respiratory system and the cardiovascular system.

Signs of hypoxia

Disturbance of the respiratory system:
breathing becomes frequent and superficial, with symptoms of hypoventilation may occur periodic Chein-Stock's breathing

Disturbance of cardiovascular system:
tachycardia, reduced or preserved systolic blood pressure, pulse pressure does not change or increased

Compensatory-adaptation reactions develop in the system of transport and utilization of oxygen.

```
graph TD; A["Compensatory-adaptation reactions develop in the system of transport and utilization of oxygen."] --> B["1. The increase of lung ventilation due to excitation of the respiratory centre by accumulation of CO2."]; A --> C["2. Blood is redistributed to supply the most important organs – lungs, heart, and brain at the decreased blood circulation in the skin, spleen, muscles, and intestines."]; A --> D["3. The increase of erythrocytes and hemoglobin extends oxygen capacity of blood due to ejection of blood from depots."]; A --> E["4. The changes of oxyhemoglobin dissociation curve"];
```

1. The increase of lung ventilation due to excitation of the respiratory centre by accumulation of CO₂.

2. Blood is redistributed to supply the most important organs – lungs, heart, and brain at the decreased blood circulation in the skin, spleen, muscles, and intestines.

3. The increase of erythrocytes and hemoglobin extends oxygen capacity of blood due to ejection of blood from depots.

4. The changes of oxyhemoglobin dissociation curve

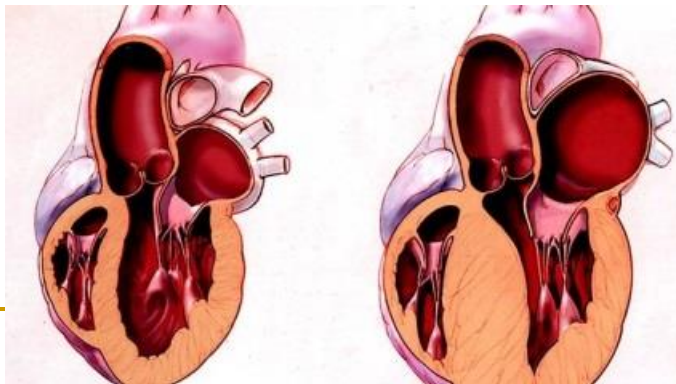
The mechanisms of long-term adaptation to hypoxia: hypertrophy and hyperplasia

The weight of the respiratory muscles, lung alveoli, myocardium, and respiratory neurons is increased. These organs become better supplied with blood at the expense of the increased number of capillaries and their hypertrophy.

The changes in oxygen utilization :

- tissue enzymes utilize oxygen better, support a high level of oxidizing processes and realize normal synthesis of ATP;
- the most effective use of energy.

The other mechanism of adaptation is an increase of the respiratory enzymes and mitochondria.



Thanks for attention!

