MEDICAL CHEMISTRY
GENERAL CHEMISTRY

University Of Fallujah

College Of Medicine

Lecture : Medical Chemistry (3) (Gases)

Stage : 1st Stage

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Learning Objective :

- To learn what is the importance of Gases & Their Medical Relations .
- To understand the role of gases in medical science
- To explore the diffusion process of respiratory gases .
- To examine clinical relevance and medical applications of gases .

GASES

- Introduction
- gases in the human body : The human body relies on various gases to sustain life, facilitate physiological processes, and maintain homeostasis.

- Importance of respiratory gases (oxygen and carbon dioxide).

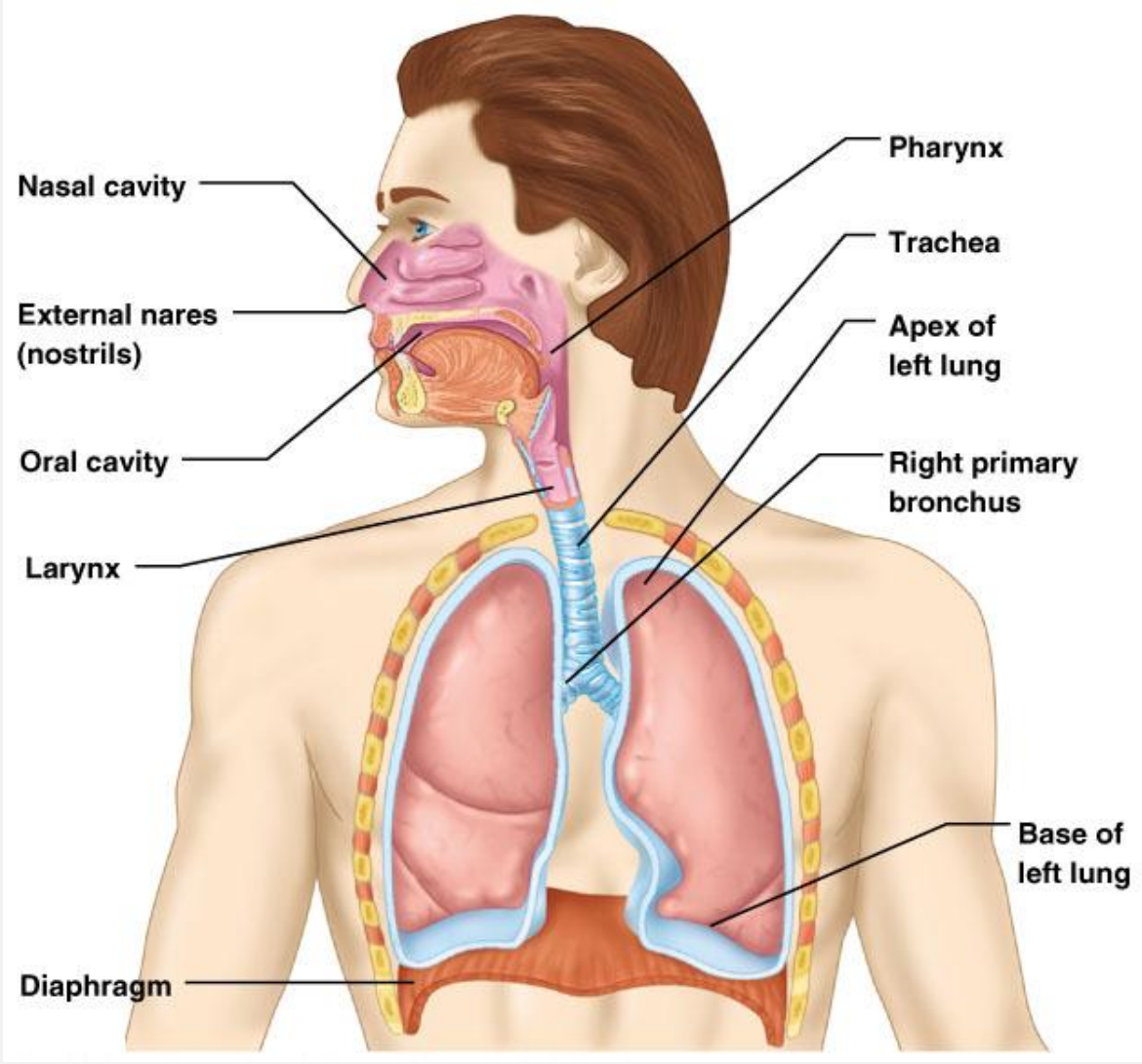
- Medical relevance of gas diffusion in maintaining life.

GASES

- **The Respiratory System**
- Brief anatomy of the respiratory system.
- Highlight structures involved in gas exchange:
  - Lungs
  - Alveoli
  - Capillaries

Organs of the Respiratory system

- Nose
- Pharynx
- Larynx
- Trachea
- Bronchi
- Lungs – alveoli



GASES

- **Gases in the Body**
- **Key Gases:**
  - Oxygen (O_2) : Cellular respiration and energy production.
  - Carbon dioxide (CO_2) : Regulation of pH through bicarbonate buffering.
  - Nitrogen (N_2) : Maintains alveolar stability.
  - Trace gases (e.g., nitric oxide, helium in therapy).
- **Roles in Medical Science:**
  - Oxygen for metabolism.
  - CO_2 in acid-base balance.
  - Nitric oxide as a vasodilator.

GASES

- **Respiratory Gases**
- **Oxygen (O_2):**
  - Carried by hemoglobin.
  - Essential for cellular respiration.
- **Carbon Dioxide (CO_2):**
  - Waste product of metabolism.
  - Transported as bicarbonate, dissolved in plasma, or bound to hemoglobin.

What are medical gases ?

- There are 7 kinds of gases that are commonly used

Uses of medical gases

- It is important to divide what are medical gases, such as oxygen and nitrous oxide, supplied to patients in gaseous form, and gases used as medical devices, for medical care units, as facilitators or adjuncts.
- The difference is that only medicinal gases considered as drugs exert their action by pharmacological, immunological or metabolic means.

Uses of medical gases

1) Nitrogen (*medical liquid nitrogen*):

- Nitrogen is a colorless, odorless, non-toxic, non-flammable gas. It's a medical gas used for the cryosurgical removal of some cancers and skin lesions.
- It is in liquid form and at very low temperatures, so it is also used to store and freeze tissues, cells and blood at cryogenic temperatures to prevent oxidation of samples.
- For example, the pharmaceutical industry uses this medicinal gas in the manufacture of medicines.
- Gaseous nitrogen, the largest component of our atmosphere, is used in medicine mainly to propel surgical tools.

Uses of medical gases

2) Medicinal Oxygen:

- Oxygen is the most basic gas for life, and it is used medically to supplement oxygen to oxygen-deficient patients. Direct inhalation of high purity oxygen is harmful to the human body.
- Odorless, colourless and tasteless, it is used for resuscitation and inhalation therapy.
- It is also used in anaesthesia before any intervention, in the treatment of burns or in hyperbaric therapy to treat numerous diseases.
- Long-term use of oxygen concentration generally does not exceed 30-40%.
- Ordinary patients breathe oxygen through oxygen flowmeter; critically ill patients breathe oxygen through the ventilator.

Uses of medical gases

3) Carbon dioxide:

- Medically, carbon dioxide is used to inflate the abdominal cavity and colon for laparoscopy and colonoscopy. In addition, it is also used for laboratory culture of bacteria (anaerobic bacteria).
- Carbon dioxide can be made into dry is used for cryotherapy to treat cataracts and vascular diseases.

Uses of medical gases

4) Nitrous oxide:

- It is known as "laughing gas".
- Inhalation of a small amount of nitrous oxide has an anesthetic and analgesic effect, but a large amount of inhalation can suffocate people. Medically, a mixture of nitrous oxide and oxygen is used as an anesthetic agent

Uses of medical gases

5) Medicinal air:

- Mainly used in ICU and NICU areas because it allows for the mobilisation of compressed air driven respirations, or as a diluent for administered O2, since O2 in concentrations of 100% is toxic to the body.
- Compressed air is used to deliver power to oral surgical instruments, orthopedic instruments, and ventilators.

Uses of medical gases

6) Helium, Argon

- They are colorless, odorless, non-toxic inert gas. Medically used for argon gas knife, gas knife, and other surgical instruments. its application is focused on the diagnosis of diseases through magnetic resonance imaging, since MRI equipment needs liquid helium to maintain a low temperature that allows the superconductivity of the magnets

Internal Respiration

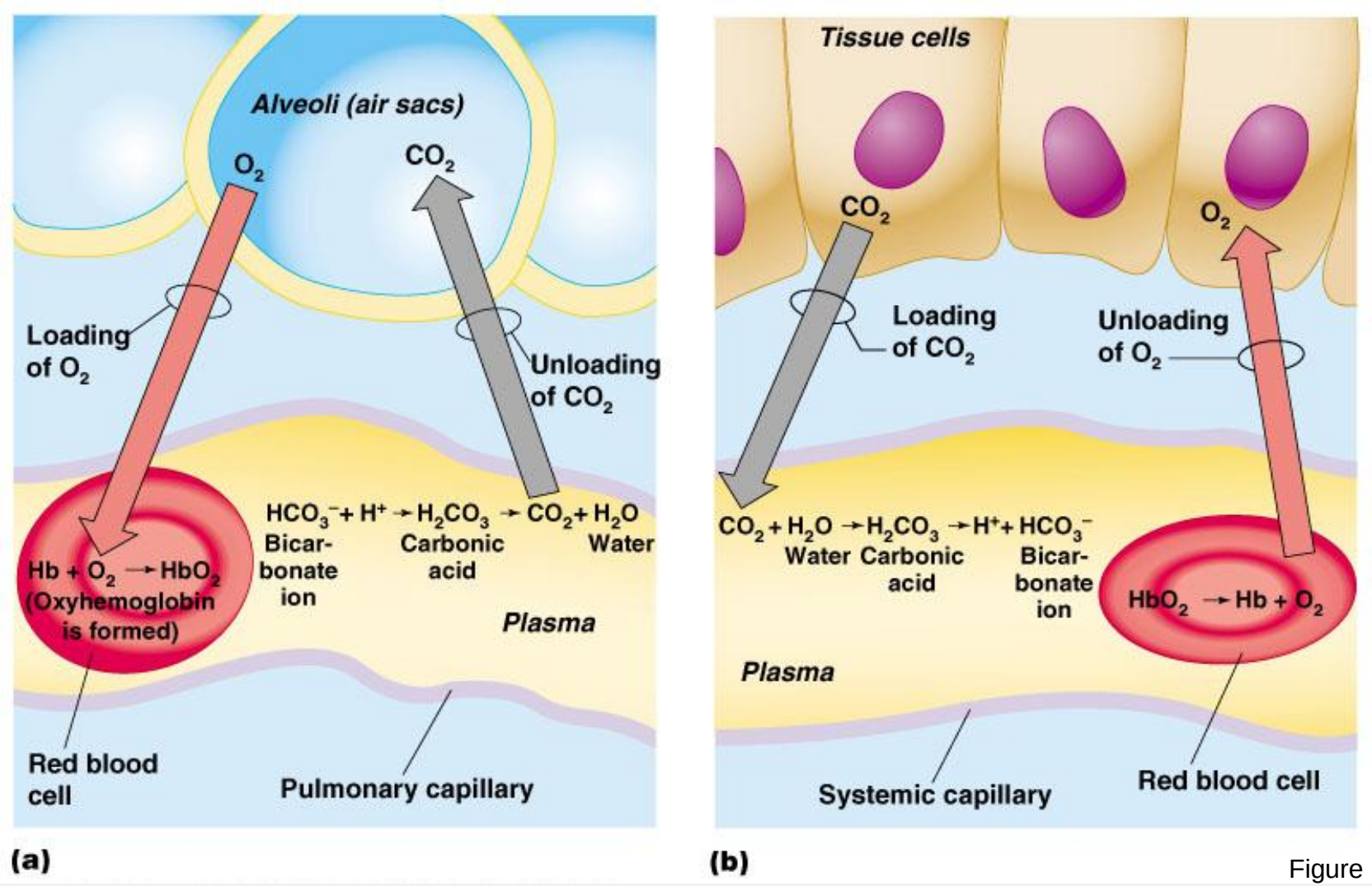


Figure 13.11

External Respiration, Gas Transport, and Internal Respiration Summary

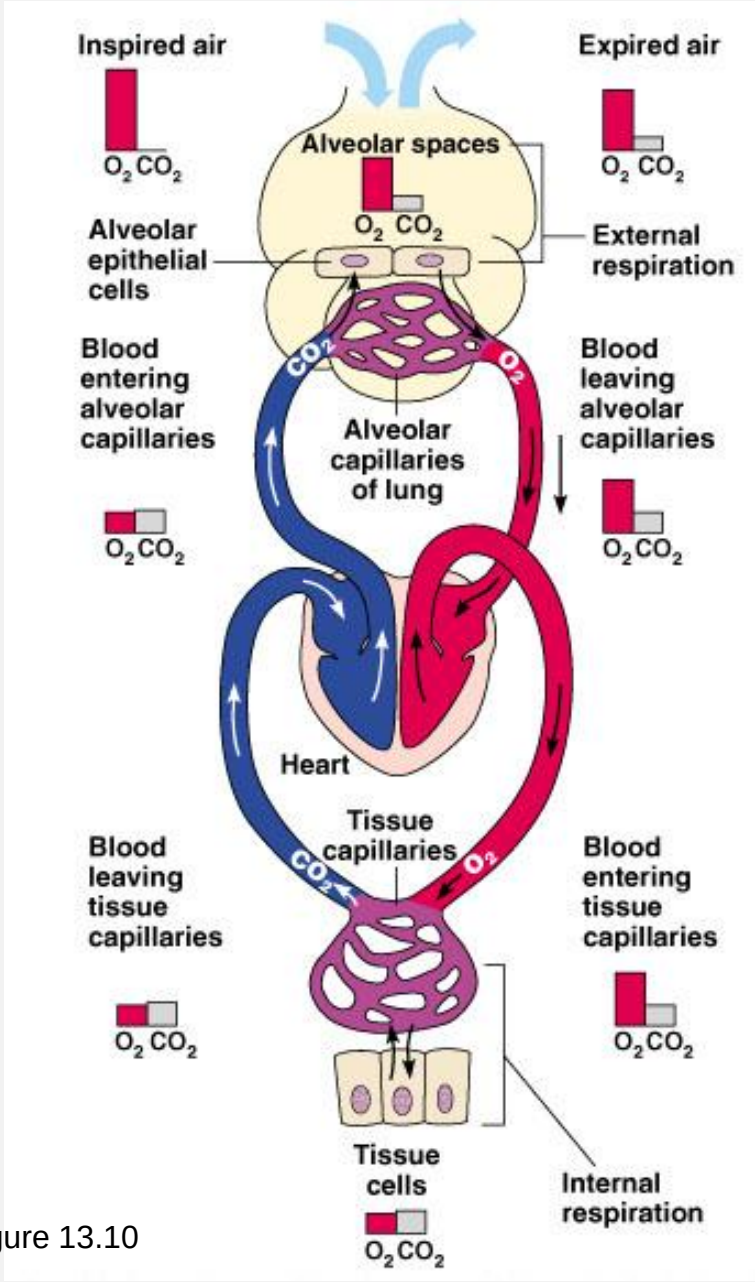


Figure 13.10

GASES

- **Diffusion of Respiratory Gases**
- **Definition:** Movement of gases from areas of higher to lower partial pressure.
- **Mechanism:**
  - Occurs across the alveolar-capillary membrane.
  - Governed by Fick's Law of Diffusion.
- **Key Factors:**
  - Surface area.
  - Membrane thickness.
  - Partial pressure gradient.

DIFFUSION OF OXYGEN ACROSS THE ALVEOLAR WALL

Pulmonary Surfactant

↓ Diffuses/Dissolves

Alveolar Epithelium

↓ Diffuses/Dissolves

Alveolar Interstitium

↓ Diffuses/Dissolves

Capillary Endothelium

↓ Diffuses/Dissolves

Plasma

↓ Diffuses/Dissolves

Red Blood Cell

↓ Binds

Hemoglobin

GASES

- **Clinical Relevance of Gas Diffusion**
- **Hypoxemia:** Reduced oxygen levels due to impaired diffusion.
- **Hypercapnia:** Increased CO_2 levels.
- **Diseases Affecting Diffusion:**
  - Pulmonary fibrosis (thickened membrane).
  - Emphysema (reduced surface area).
  - Pulmonary edema (fluid in alveoli).

GASES

- **Medical Applications of Gases**
- **Oxygen Therapy:**
  - In hypoxemia and respiratory failure.
- **Hyperbaric Oxygen Therapy (HBOT):**
  - For wound healing and decompression sickness.
- **Carbon Dioxide:**
  - Use in surgeries (insufflation in laparoscopic procedures).
- **Nitric Oxide Therapy:**
  - For pulmonary hypertension.

GASES

- **Fick's Law of Diffusion (Detailed)**
- Mathematical formula and explanation.
- Factors affecting diffusion:
  - Surface area (e.g., alveoli).
  - Membrane thickness (e.g., fibrosis).
  - Pressure gradient (e.g., high altitudes).

GASES

- **Carbon Dioxide Transport**
- **Pathways:**
  - Dissolved in plasma (~7%).
  - Bound to hemoglobin (~23%).
  - As bicarbonate ions (~70%).
- CO_2 and pH regulation (buffer system).

GASES

- **Nitrogen and Other Gases**
- **Nitrogen's Role:** Inert gas, contributes to atmospheric pressure.
- **Medical Gases:**
  - Helium: Used in respiratory treatments.
  - Nitric oxide: Vasodilator in pulmonary hypertension.

GASES

- **Oxygen Therapy in Medicine**
- Applications in:
  - Chronic obstructive pulmonary disease (COPD).
  - Respiratory distress syndrome.
  - Post-surgical recovery.
- Delivery methods: Nasal cannula, masks, ventilators.
- Uses:
  - Decompression sickness.
  - Wound healing.
  - Carbon monoxide poisoning.

GASES

- **Nitric Oxide Therapy**
- Mechanism: Relaxation of smooth muscles in blood vessels.
- Use in:
  - Neonatal respiratory distress syndrome.
  - Pulmonary hypertension.

GASES

- **Diffusion of Gases in Tissues**
- **Oxygen Diffusion:** From blood to tissue cells.
- **Carbon Dioxide Diffusion:** From tissue cells to blood.
- Mechanisms in muscle tissues during exercise and rest.
- **Role of Hemoglobin in Gas Transport**
- **Oxygen Binding:** Role of iron in hemoglobin.
- **CO_2 Binding:** Formation of carbaminohemoglobin

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- **Gas Transport Abnormalities**
- **Anemia:** Reduced oxygen-carrying capacity.
- **Carbon Monoxide Poisoning:** Hemoglobin binds CO more readily than O_2.
- **Methemoglobinemia:** Hemoglobin oxidation affecting gas transport.
- **Respiratory Diseases and Gas Exchange**
- **Asthma:** Obstruction reducing airflow.
- **Chronic Bronchitis:** Mucus buildup affecting diffusion.
- **COVID-19:** Alveolar damage impairing oxygenation.

GASES

- **Regulation of Breathing**
- **Respiratory Centers in the Brainstem:** Medulla and pons.
- **Role of Chemoreceptors:**
  - Peripheral: Respond to O_2, CO_2, and pH.
  - Central: Respond to CO_2 levels in cerebrospinal fluid.

- **Acid-Base Balance and Respiratory Gases**
- **CO_2 and pH Regulation:** Bicarbonate buffering system.
- **Respiratory Acidosis:** Due to hypoventilation.
- **Respiratory Alkalosis:** Due to hyperventilation.
- **Gases in Anesthesia**
- Role of gases like nitrous oxide and oxygen in anesthesia.
- Inhalational anesthetics and their mechanisms.
- Monitoring of oxygenation and ventilation during surgery.

Factors Influencing Respiratory Rate and Depth

- **1. Physical factors**
  - Increased body temperature
  - Exercise
  - Talking
  - Coughing
- **2. Volition (conscious control)**
- **3. Emotional factors**

Factors Influencing Respiratory Rate and Depth

- **4. Chemical factors**
  - Carbon dioxide levels
    - Level of carbon dioxide in the blood is the main regulatory chemical for respiration
    - Increased carbon dioxide increases respiration
    - Changes in carbon dioxide act directly on the medulla oblongata

Factors Influencing Respiratory Rate and Depth

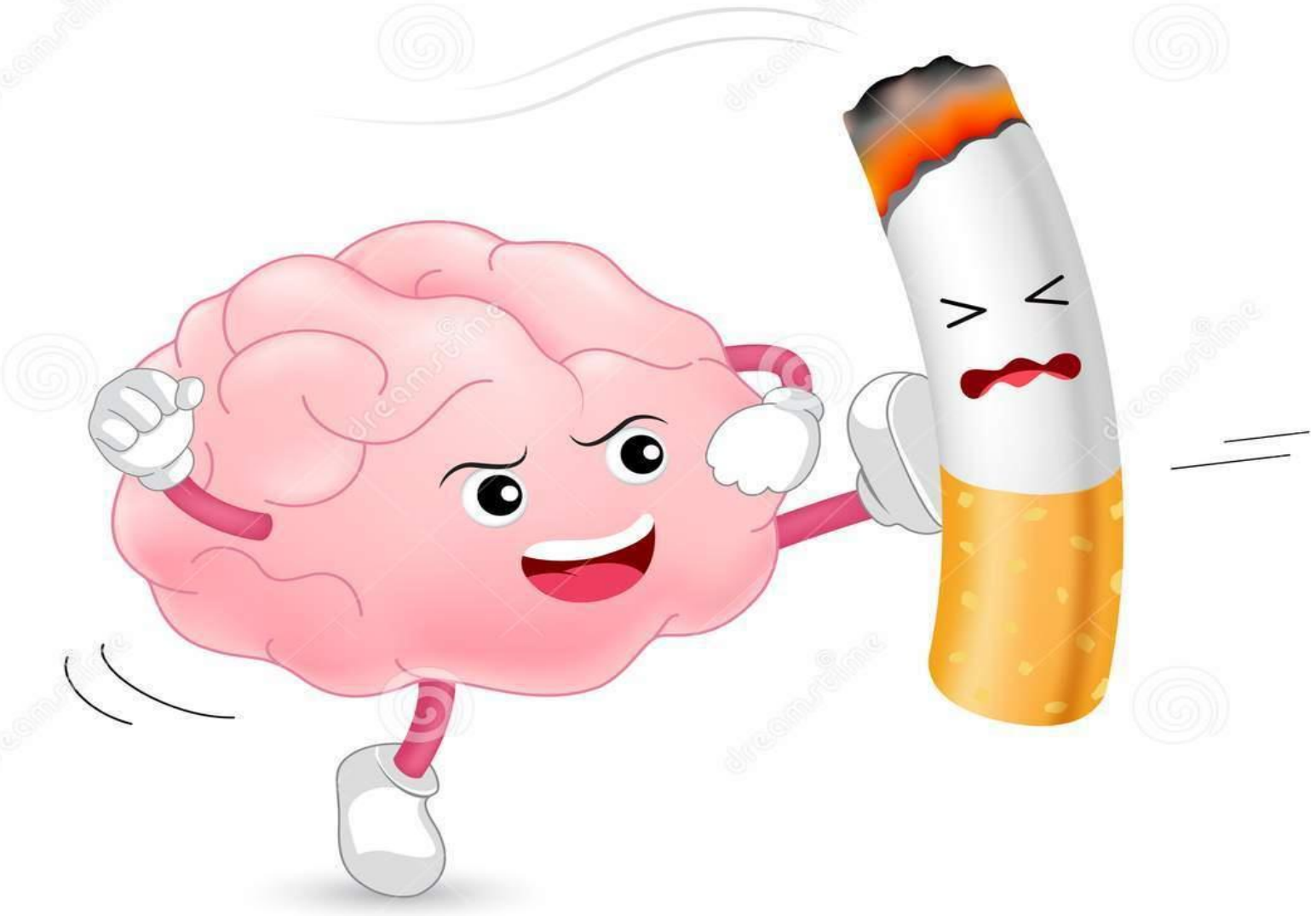
- Chemical factors (continued)
  - Oxygen levels
    - Changes in oxygen concentration in the blood are detected by chemoreceptors in the aorta and carotid artery
    - Information is sent to the medulla oblongata

Aging Effects

- Elasticity of lungs decreases
- Vital capacity decreases
- Blood oxygen levels decrease
- Stimulating effects of carbon dioxide decreases
- More risks of respiratory tract infection

Conclusions

- **1. Why Do We Care About Gases? (Vital Importance)**
  2. How Do We Breathe? (The Respiratory System)
  3. How Do Gases Move? (Diffusion and Transport)
  4. What Happens When the Balance Is Disrupted? (Diseases)
  5. How Do We Treat the Imbalance? (Medical Applications)

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ATTENTION