

Unit 3:

The digestive and respiratory systems



1. The nutrition function

2. Digestive system

- 2.1. The mouth: the beginning of digestion
- 2.2. Stomach: the gastric digestion
- 2.3. Intestinal digestion
- 2.4. Intestinal absorption
- 2.5. The large intestine

3. Respiratory system

- 3.1. Exchange of gases
 - 3.2. Ventilation
-

Think and answer?

- a. What is the function of the digestive system?
And the function of the respiratory system?
- b. Name some organs of the digestive and respiratory systems.
- c. What are digestive enzymes?
- d. How are respiration and cellular respiration different?

UNIT OBJECTIVES

In this unit you will learn:

- The anatomy of the digestive and respiratory systems
- To the processes of transformation that foods undergo within the digestive system.
- To distinguish between the cellular respiration and the processes of ventilation and gas exchange in the lungs.
- To appreciate the importance of healthy habits related to digestive and respiratory systems.
- The main diseases of the digestive and respiratory systems.

1. Nutrition function

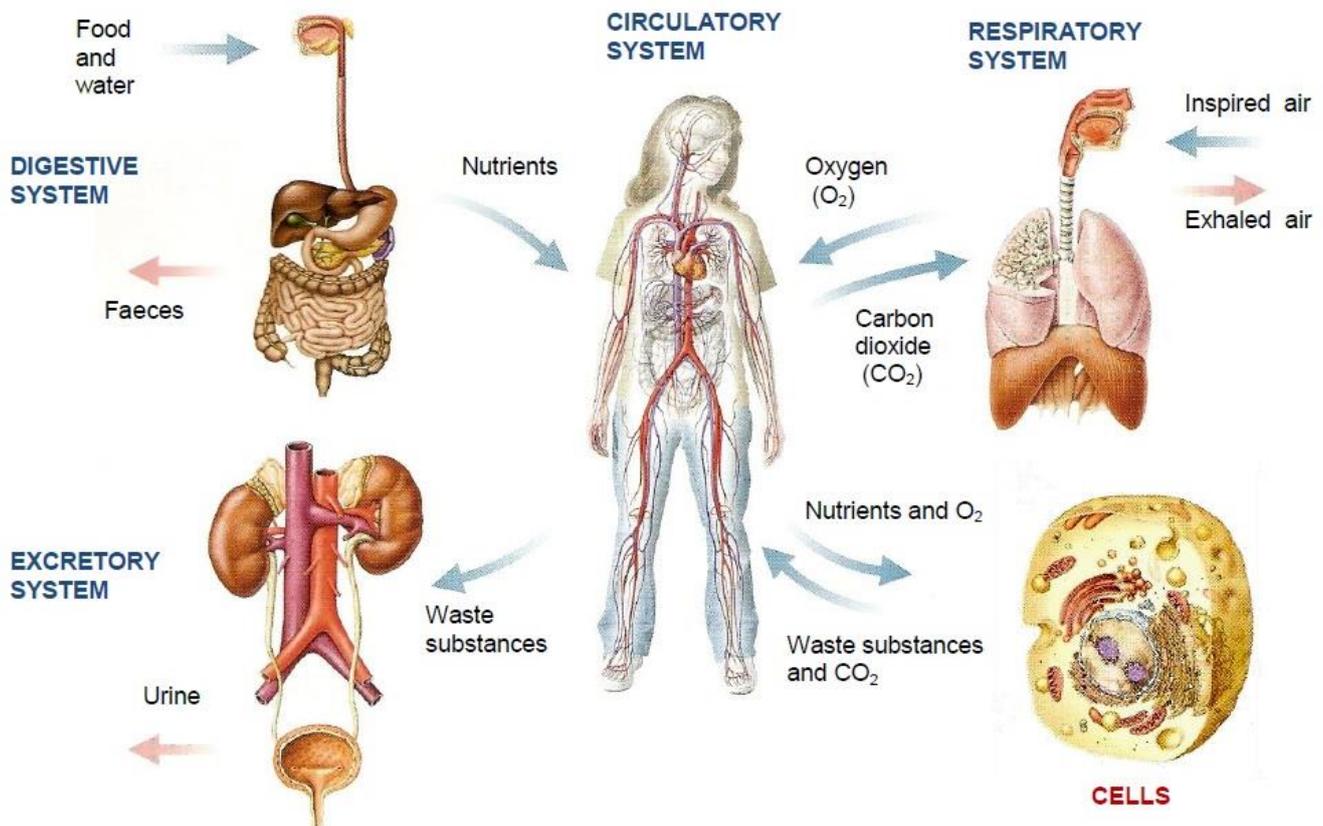
Nutrition is the set of processes, which allow living beings obtain energy and matter to stay alive.

Living means to be able to perform the vital functions (nutrition, interaction and reproduction) and elaborate its own matter in order to replace and repair the damaged parts of the organism.

Nutrition is a complex function in which takes part several organ systems. Each one of them carries out part of the process and they depend on each other to complete it.

These organ systems are:

- **The digestive system.** It processes and transforms food to obtain nutrients which cells are able to assimilate.
- **The respiratory system.** It obtains oxygen from air and expels carbon dioxide from the vital activity.
- **The circulatory system.** Its function is to distribute nutrients and oxygen throughout the body and collects the waste substances and carbon dioxide from cells.
- **The excretory system.** Its function is to expel the waste substances out of the body.



ACTIVITIES

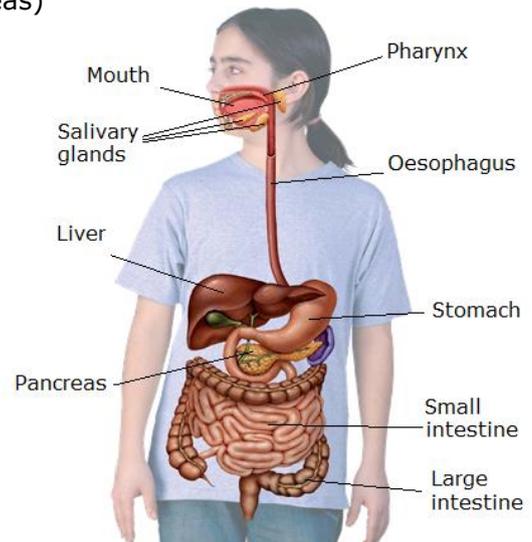
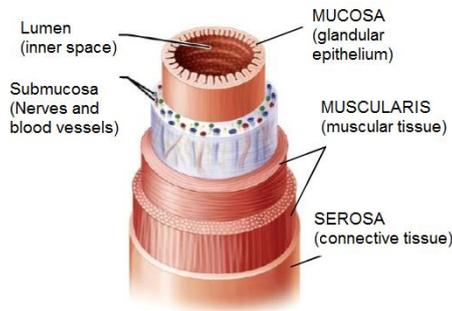
- 1.1. **Nutrients are essential substances which living beings need to stay alive. Where can they find them?**
- 1.2. **What organ systems are involved in carrying oxygen to every cell of the body? And glucose?**
- 1.3. **Listen and indicate what body system related with the nutrition function is described:**
 - a. Digestive system
 - b. Respiratory system
 - c. Circulatory system
 - d. Excretory system

2. Digestive system

a) Parts of the digestive system:

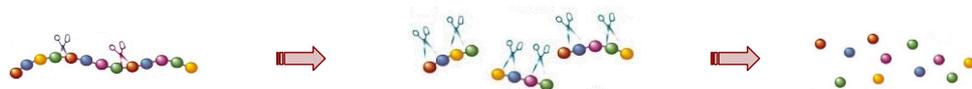
The digestive system is formed by:

- **Digestive tract.** It is a long tube differentiated in several parts: mouth, pharynx, oesophagus, stomach, small intestine, large intestine and anus. It is formed by three layers of tissue: *mucosa* (the internal layer, very folded and lined with glands), *muscularis* (the middle layer formed by two layers of smooth muscle) and *serosa* (the connective tissue layer that joins the digestive tract to other organs)
- **Digestive glands.** They secrete digestive juices into digestive tube (salivary glands, gastric glands, intestinal glands, liver and pancreas)



b) Digestive functions:

- **Ingestion.** It is the entry of food into the digestive tract through the mouth.
- **Digestion.** It is the transformation of food into simple nutrients which can be absorbed and used by cells. We can distinguish two types of processes:
 - **Mechanical digestion.** It includes physical transformations (cutting, crushing, mixing and kneading) to reduce the size and make easier the chemical digestion.
 - **Chemical digestion** It is the transformation of complex nutrients that are contained in food into simple nutrients through a chemical reaction. These transformations are carried out by *enzymes*, which are contained in digestive juices. Enzymes act as chemical scissors to cut the large molecules into small molecules that can be absorbed and used by cells.



- **Absorption.** It is the pass of nutrients from the digestive tract to the blood or to the lymph.
- **Defecation.** It is the expulsion of non-digested or non-usable parts of food (*faeces*).

ACTIVITIES

2.1. Where do different digestive glands secrete their juices?

2.2. Why do you think it is recommendable chew the food well before swallowing it?

2.3. What are the differences between chemical and mechanical digestion?

2.4. Listen and indicate what part of the digestive system is described.

- | | | | |
|----|----|----|----|
| a. | b. | c. | d. |
| e. | f. | g. | h. |

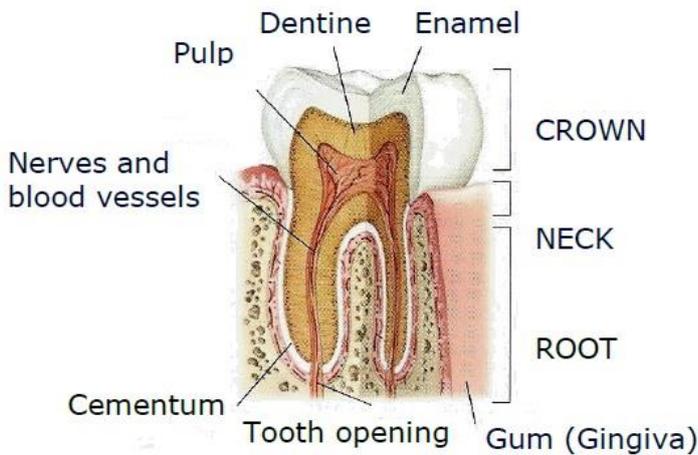
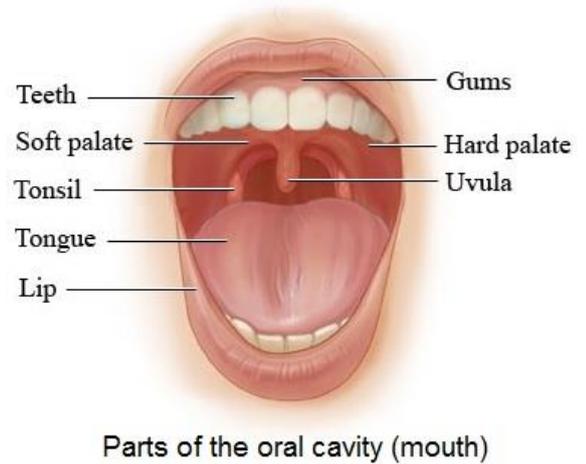
2.1. Mouth: the beginning of digestion

The food digestion begins in the mouth. There, mechanical and chemical processes take place.

a) Mastication (Chewing)

It is the **crushing** of food by teeth, helped by the tongue which changes the food from place to place.

Teeth are hard structures compounded by **calcium** and **fluorine**, which are located within **dental alveolus** (tooth sockets) in the border of both mandibles. Their function is chewing food.



Structure of a tooth

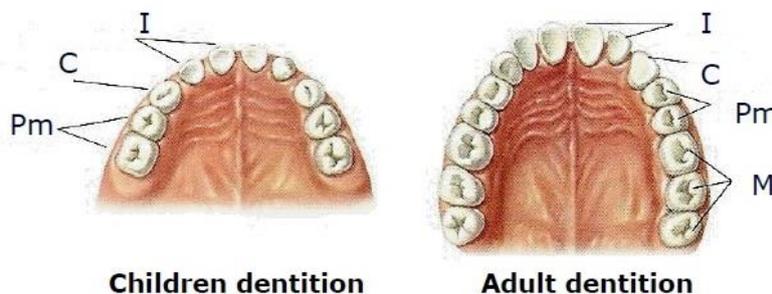


Types of teeth

There are four types of teeth. Each one of them has a particular function and shape. Their characteristics are summarised in the chart below:

| Type of tooth | Crown (shape) | Roots | Function | Number (total) |
|---------------|--------------------------------------|--------|-----------------------|--|
| INCISOR | Flat and sharp | 1 | To cut | 8 |
| CANINE | Conical and pointed | 1 | To tear | 4 |
| PREMOLAR | Wide and flat (2 protuberances) | 1 or 2 | To crush and to grind | 4 |
| MOLAR | Wide and flat (3 or 4 protuberances) | 2 or 3 | To crush and to grind | From 8 to 12 (with <i>wisdom teeth</i>) |

Humans have two **dentitions** along their lives. Children have a set of teeth that fall out and are replaced by adult teeth (beginning at 6). These are called **baby** or **milk teeth**. These teeth are smaller than adult teeth and do not have roots. In addition, in children, molars are missing.



b) Insalivation

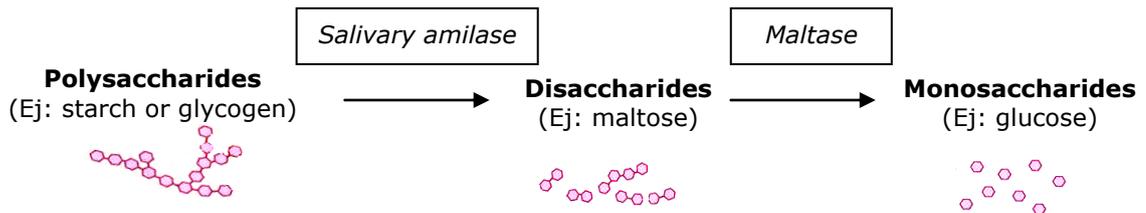
It is the mix of food with **saliva**.

Saliva is a digestive juice secreted by **salivary glands**. Humans have three pairs of them: *parotid*, *submandibular* and *sublingual glands*.

Saliva is a liquid compounded by water, mineral salts, mucin (mucous substance) and enzymes (mainly *salivary amylase* or *ptyalin*, and *maltase*)

The functions of saliva are:

- To start the digestion of glucids (thanks to its enzymes)



- To make easier swallow the food (thanks to its water and mucin)
- To be disinfectant (thanks to its antibacterial compounds)

The **food bolus** is each portion of food chewed, mixed with saliva and prepared to be swallowed.

c) Deglutition (Swallowing)

It is the pass of food bolus from the mouth to the oesophagus and then, to the stomach.

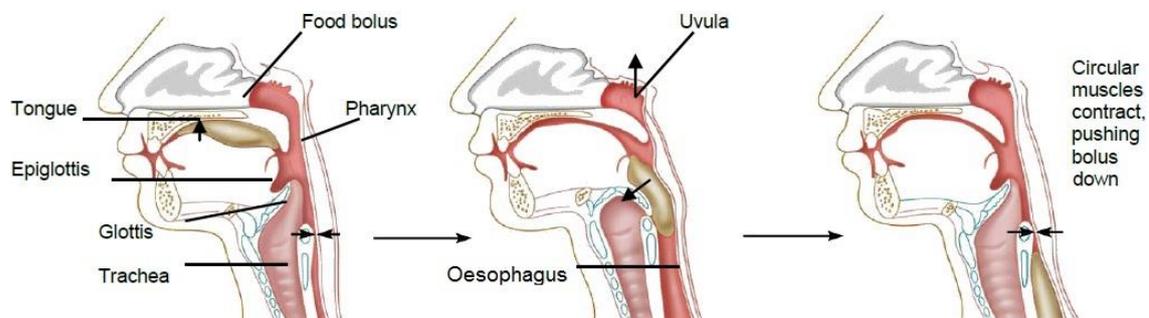
We can distinguish three steps in this process:

1st) The tongue pushes food bolus into the pharynx (voluntary action)

2nd) When food bolus is in the pharynx, it activates a *reflex* (an involuntary action) that:

- o Closes *choanae* (openings that connect the mouth and the nasal passages) with the *uvula*.
- o Closes *glottis* (opening that communicates the pharynx with the larynx) with the *epiglottis*.

3rd) Food bolus passes into the oesophagus. It progresses through it thanks to *peristaltic movements*, circular contraction waves that progress from top to bottom of the oesophagus and force the food bolus into stomach (reflex act).



ACTIVITIES

2.5. How many teeth have a human adult? And a child?

2.6. What is the function of the tongue in chewing?

2.7. Listen and indicate what digestive process carried out in the mouth is described:

a. Mastication (chewing)

b. Insalivation

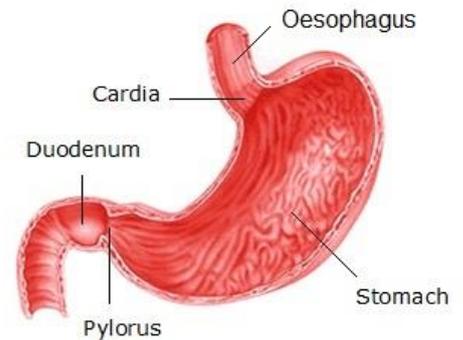
c. Deglutition (swallowing)

2.2. The stomach: the gastric digestion

The stomach is a J-shaped organ, located in the abdominal cavity beneath the diaphragm. The stomach is about 30 cm long and 15 cm wide at its widest point. It is very elastic and it can be up to 2 litres of capacity in an adult.

The stomach has two openings. Both are sphincters. A **sphincter** is a circular muscle that acts as a valve, controlling the pass of substances from one place to another.

- **Cardia** connects with oesophagus and prevents food bolus goes back.
- **Pylorus** separates the stomach from the duodenum and prevents that non-digest food passes into the small intestine.



The structure of the stomach wall is similar to the rest of the digestive tract, but it has three muscular layers (circular, longitudinal and an additional oblique muscle layer).

Gastric digestion includes mechanical and chemical processes:

a) Chemical processes

They are made by **gastric juice**. This juice is produced by *gastric glands* that are located on the stomach mucosa (its innermost layer). The gastric juices contains mainly:

- **Hydrochloric acid (HCl)**
 - It helps to disaggregate the food.
 - It activates *pepsinogen* because reduce the pH (about 2), making the chemical environment very acid. It is transformed in *pepsin* (active enzyme)
 - It destroys any bacteria or germs that could have entered with food.
- **Pepsinogen** (inactive enzyme or precursor of the **pepsin**)
- **Mucin** (protects the stomach from acid)

The main function of gastric digestion is beginning the digestion of **proteins**. **Pepsin** breaks down long chains of amino acids (proteins) into short chains (peptides)

b) Mechanical processes

Stomach wall has peristaltic movements that mix food with gastric juice and grind and move it. The contraction waves close the pylorus when arrive to it. Only when food is very liquid and the gastric chemical digestion has finished, a very small portion of the stomach's content passes into the duodenum in each train of waves.

Chyme is the result of gastric digestion. It is an acid semi-liquid substance, which comes from the mixture of food bolus with saliva and gastric juice, and it is formed by partly digested glucids and proteins.

ACTIVITIES

2.8. Why is pepsin secreted as an inactive enzyme (pepsinogen)?

2.9. What food will be more time in stomach, gherkins in vinegar or natural gherkins? Why?

2.10. Listen and find the six mistakes in the text:

When the food bolus enters the throat, the gastric muscles relax. The food bolus stays there for between three and two hours. Here it mixes with gastric acid. The resulting mixture is called chyle. It is more solid than the food bolus.

2.3. Intestinal digestion

Intestinal digestion takes place in the small intestine thanks to several digestive juices: intestinal juice (produced by intestinal wall glands), pancreatic juice (produced by the pancreas) and bile (produced by the liver)

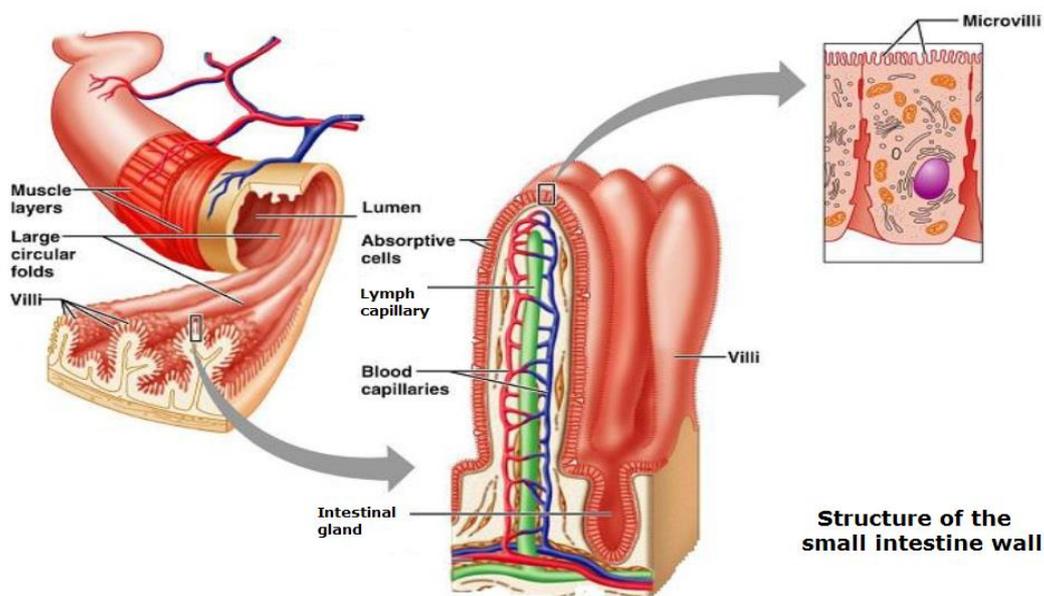
a) Small intestine

The small intestine is a long tube which is located within the abdominal cavity. It is about 7 m long and 2.5 cm in diameter. It is differentiated in three portions:

- **Duodenum.** It is the initial portion, about 25 cm long. It connects with the stomach. The pancreas and the liver pour their secretions into it.
- **Jejunum.** It is the middle portion, about 3 m long.
- **Ileum.** It is the final portion, around 3 m long. It connects with the large intestine.

The structure of the small intestine is similar to the rest of digestive tract but its mucosa has:

- *Intestinal glands* that secrete **intestinal juice**.
- *Villi* which are finger-like projections which increase the absorption surface area.



a) Chemical processes

Intestinal juice contains among other substances, enzymes to digest each type of nutrient (glucids, lipids and proteins)

b) Mechanical processes

The small intestine has also *peristalsis* to mix chyme with digestive juices and make advance food along it.

b) Pancreas

It is an elongated, pinkish and spongy-shaped organ which is located underneath and behind the stomach. It is a gland, which produces two types of secretion:

- Hormones which control the sugar levels in blood (insulin and glucagon).
- **Pancreatic juice** which has digestive function.

Pancreas pours pancreatic juice into the duodenum. This juice contains water and:

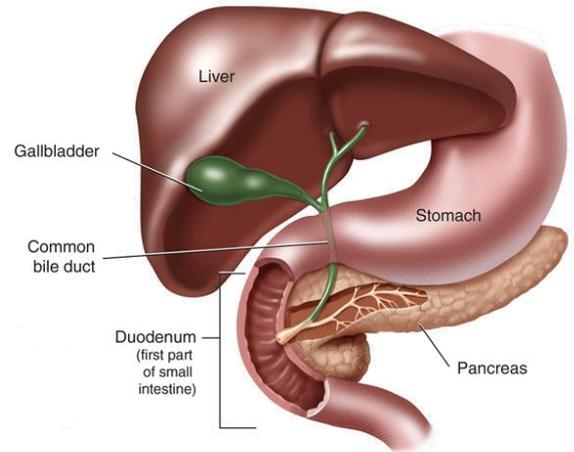
- **Enzymes** to digest every type of nutrient.
- **Sodium bicarbonate** (neutralizes chyme acid and makes pH very alkaline, about 9, providing an optimal environment to enzymes work)

c) Liver

It is the largest gland in the body. The liver is a brown-red organ divided into several lobes which is located on the right side of the stomach within the abdominal cavity.

Liver has several important functions:

- Storage glycogen (polysaccharide formed by many molecules of glucose)
- Recycling of red blood cells which non-useful parts are excreted (bile pigments)
- Detoxify blood.
- Produce **bile** (digestive juice)



It is connected with the **gall bladder** which stores bile. Bile is continuously produced in the liver but it is only poured into the duodenum when chyme is in it.

Bile contains mainly:

- Bile pigments (waste substances which are responsible for faeces colour)
- Bile acids (they emulsify lipids, break down large fat drops into small ones which are easier to attack by enzymes)
- Cholesterol

Chyle is the result of intestinal digestion. It is a very liquid substance, which comes from the mixture of chyme with bile, pancreatic juice and intestinal juice, in which all nutrients are completely digested.

| COMPLEX NUTRIENTS | DIGESTION | | | SIMPLE NUTRIENTS |
|--------------------------------------|-----------|---------|-----------------|-------------------------------------|
| | MOUTH | STOMACH | SMALL INTESTINE | |
| Complex glucids (Polysaccharides) | | | | Simple glucids (Monosaccharides) |
| Lipids (Fats) | | | | Glycerine + fatty acids |
| Proteins | | | | Amino acids |

ACTIVITIES

2.11. Give a reason to explain why:

- a. meals rich in fats usually provoke a heavy digestion.
- b. humans cannot feed only of vegetables and fruits.
- c. intestinal ulcers are produced in duodenum but neither in jejunum nor ileum.

2.12. Listen and complete the text:

The

This is the largest in the body. It performs important functions, for instance, secreting, stored in the, as part of the digestive function. Although bile does not contain digestive, it help us to digest (fats) by acting as a The liver also performs other functions, such as storing, iron and some vitamins, in addition to eliminating toxic substances, such as, from the

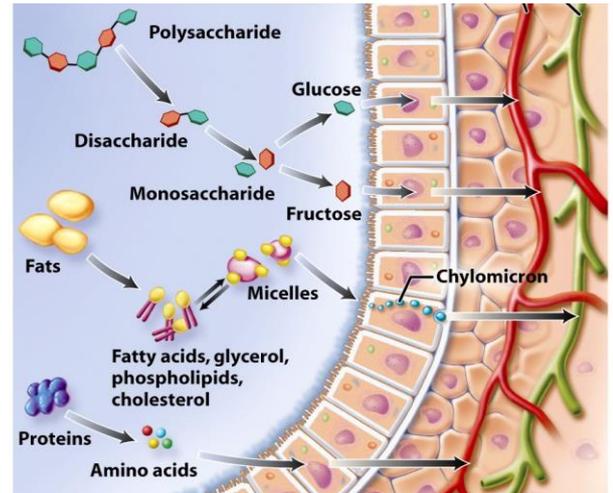
2.4. Intestinal absorption

Once digested, nutrients are in their simplest form and can be absorbed and used by cells.

Absorption is the pass of nutrients from the digestive tract to blood or lymph capillaries, through absorptive cells of intestinal villi.

- Monosaccharides and amino acids, mineral salts, water-soluble vitamins and water pass to **blood**
- Fatty acids and glycerine, and fat-soluble vitamins pass to **lymph**

Anyway, the simplest nutrients absorption, as water, mineral salts or alcohol, begins in the stomach.



ACTIVITIES

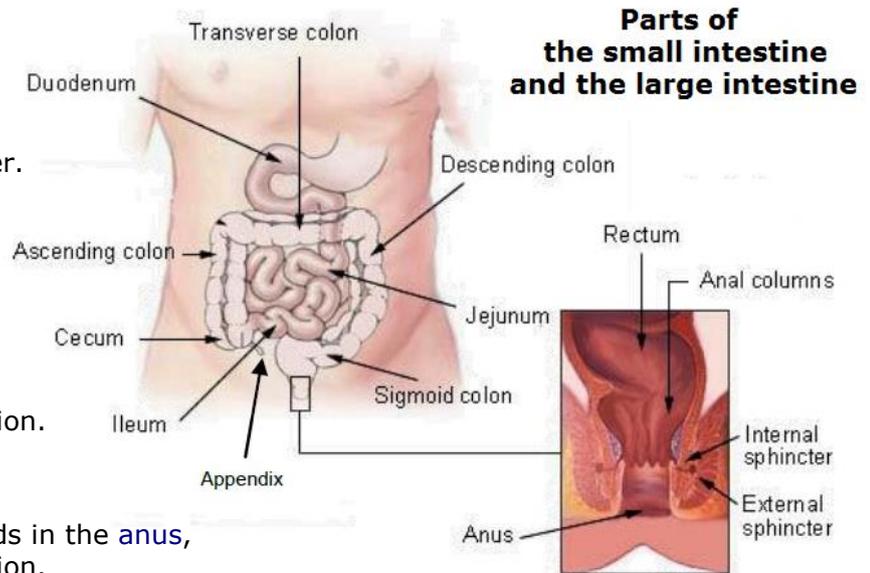
- 2.13. Many sportspeople take glucose before a hard exercise to obtain extra energy. Why do you think they do not take other more energetic food, like bread or potatoes?**
- 2.14. What kind of nutrients does not suffer any kind of transformation along the digestive system? Why?**

2.5. The large intestine

The large intestine is a thick tube which is located into the abdominal cavity, surrounding the small intestine. It is about 1.5 m long and 6 cm in diameter.

It is differentiated in three portions:

- **Cecum.** It is the initial portion, separated from ileum by a valve. Joined to it, there is the **appendix**, a small blind prolongation.
- **Colon.** It is the middle and largest portion. It is divided into: ascending, transverse descending and sigmoid colon.
- **Rectum.** It is the final portion which ends in the **anus**, a double sphincter that controls defecation.



The wall of the large intestine is similar to other parts of the digestive tract but:

- The mucosa has a large number of mucus secreting cells but does not have any villi.
- The longitudinal muscle layer is limited to three bands (**teniae coli**) that create pouches (**haustra**) along the colon.

The remains of chyle which passes to cecum still contains a lot of water and mineral salts. These are absorbed meanwhile the mass goes through the colon forced by peristaltic movements of intestine wall.

As a result, it forms **faeces** by progressive compacting of chyle remains. This process is so efficient thanks to symbiotic bacteria which live in our colon (**gut flora**). They help in the absorption of water and mineral salts and produce vitamins K and B₁₂.

ACTIVITIES

2.15. Why is it not recommendable to take antibiotics orally for a long time?

2.16. Listen and indicate if the following statements are true or false.

a. T / F

b. T / F

c. T / F

d. T / F

3. The respiratory system

In addition to the nutrients obtained by digestive processes, our cells also need **oxygen** to live. This oxygen is used to perform **cellular respiration**, a metabolic reaction that takes place in every one of the body cells.

Cellular respiration is the combustion of organic matter with the help of oxygen to obtain energy to carry out the vital functions. This process occurs in **mitochondria** and produces, as a result, water and carbon dioxide.

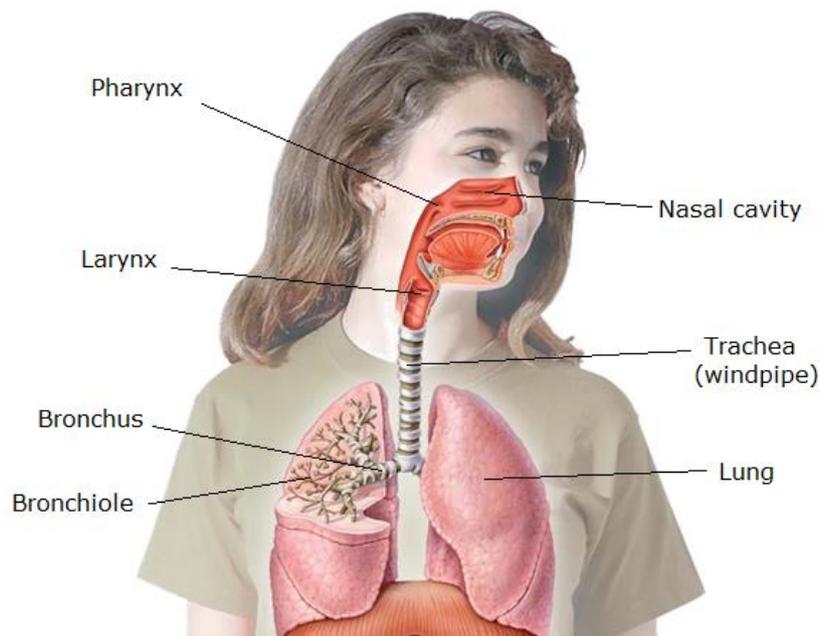


Respiratory system assures that this oxygen goes from the air to the blood that will carry it to every cell, and that the carbon dioxide produced by them, will be expelled. This process is called **ventilation** (breathing).

So that, in fact, **respiration** is the joint of two processes: *ventilation* and *cellular respiration*.

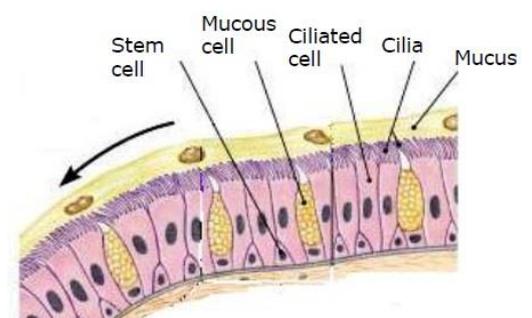
We can distinguish two parts in respiratory system:

- **Airways.** The set of conducts through which air circulates (nasal cavity, pharynx, larynx, trachea, bronchi and bronchioles)
- **Lungs.** Organs where is produced the exchange of gases.



a) Airways:

Airways are covered by an epithelium formed by **ciliated cells** and **mucous cells**. Its function is to humidify the air and to clean it. The mucus traps the strange particles (like dust, pollen or microorganisms) which air can carry, to avoid that they can pass to lungs. The cilia force the mucus to the pharynx and from here it passes to the oesophagus to be digested. In addition mucus has a large amount of water and part of it, is added to the air.



Respiratory passages are:

- **Nasal cavity.** It is divided in two chambers. Every one of them has an external opening (*nostril*) and an internal opening to pharynx (*choane*). The nostrils are covered by the nose. Nasal cavity has many nooks and it is lined by the **pituitary membrane**. This epithelium has a large number of surface blood capillaries. Their function is to warm the air. In the most upper zone of nasal cavity are the **olfactory receptors** which function is to detect the smell.
- **Pharynx.** It is a duct shared with the digestive system. We can find here several openings: *choanae*, *glottis* and *Eustaquian tubes* (that connect with middle ear)
- **Larynx.** It is a short and cartilaginous tube. Its entry (*glottis*) is regulated by the *epiglottis* to avoid the entry of food. Within the lumen of larynx are the **vocal folds** which produce the voice sounds when vibrate.
- **Trachea.** It is a tube about 12 cm long and 2.5 cm. Trachea has a cartilaginous skeleton made of incomplete rings of cartilage which keeps the conduct open and assure the entry and the exit of air.
- **Bronchi.** They are the two branches trachea is divided into. Each bronchus enters in a lung. As trachea, they have a cartilaginous skeleton.
- **Bronchioles.** Every bronchus is divided several times in progressively thinner tubes (bronchioles). The thinnest bronchioles do not have cartilaginous skeleton and end in alveoli.

b) Lungs:

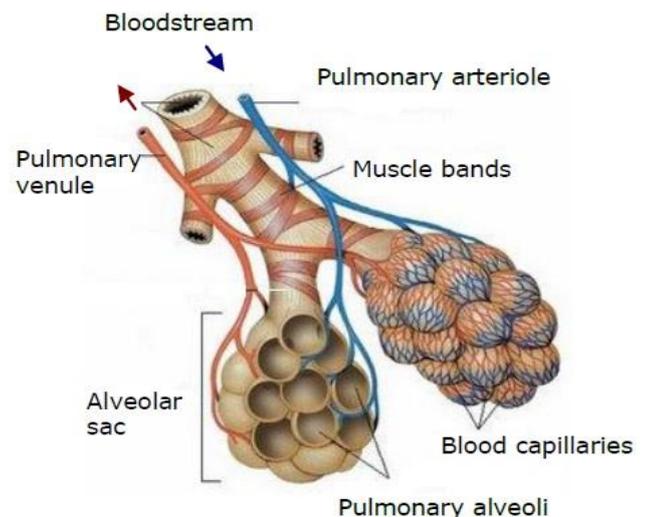
They are two pinkish and soft organs that occupy most of the thoracic cavity.

They are made of **alveoli** and the thinnest **bronchioles**.

Alveoli are very small sac-shaped structures, surrounded by a dense network of blood capillaries. Here is performed the exchange of gases between blood and air.

Each lung is divided in **lobes**. There are three lobes in the right lung and only two in the left one. Surrounding the lungs there are two membranes called **pleurae**.

In the space between them there is a liquid that allow them move one close the other. Functions of pleurae are to protect the lungs from the friction with ribs, and help in ventilation.



ACTIVITIES

3.1. Explain why:

- a. the nasal cavity has so many nooks.
- b. It is recommended breathing through the nose and avoid do it through the mouth.
- c. we produce a large amount of mucus when we catch a cold.
- d. the left lung is smaller than the right lung, and has only two lobes.

3.2 Listen and complete the text. What process is been described?

The cells in our body require..... This is essential for cellular This process uses and turns it into

3.3. Listen and indicate which structure is related each sentence.

- a.
- b.
- c.
- d.
- e.

3.1. The exchange of gases

The **exchange** is the pass of O_2 from the alveolus to the blood and the pass of CO_2 , from the blood to the alveolus.

It is produced by **diffusion**. It can be defined as the tendency that a gas has to pass from the place where it is more concentrated to the place where it is less concentrated, until the concentration in both compartments become equal. Diffusion is a physical process that does not need expend energy.

During inspiration, alveolus is full of air rich in oxygen and poor in carbon dioxide. The situation on blood capillaries is inversed. So that:

- Oxygen tends to pass from the alveolus to the blood.
- Carbon dioxide tends to pass from the blood to the alveolus.

To assure that the concentrations do not equalise, and to keep the continuous gas exchange:

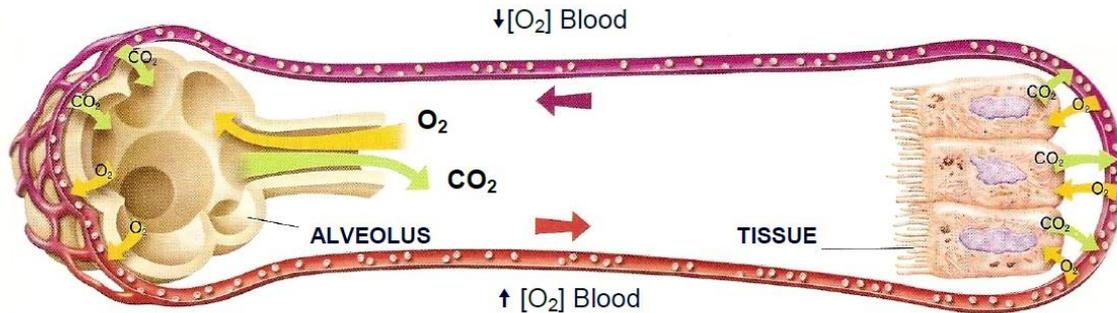
- Alveolus air is continuously renewed ($[O_2]$ is always high and $[CO_2]$ is always low into it)
- Blood flow in capillary is constant. ($[O_2]$ is always low and $[CO_2]$ is always high into it)

Diffusion is optimal when the air is **clean**, **humid** and **warm**. The preparation of air had place previously in airways.

The exchange between the body tissues and the blood follows the same mechanism. In this case:

- Blood is richer in O_2 than cells, so that it tends to pass from capillaries to tissues.
- Blood is poorer in CO_2 than cells, so that it tends to pass from tissues to capillaries.

The exchange is continuous because cells are always consuming oxygen and producing carbon dioxide and the bloodstream flows constantly.



ACTIVITIES

3.4. Indicate where and how the air is prepared to assure an optimal exchange of gases in alveoli.

3.5. The atmospheric air contains about 78% of nitrogen, 21% of oxygen, 0.03% of carbon dioxide and about 1% of argon and other gases. If the inspired air contains carbon dioxide, why this gas does not pass within the bloodstream?

3.6. When the action of mucus to keep clean the air which enters in lungs is insufficient, because the strange particle that has penetrated is too big, the body has other defensive mechanisms. Do you know what they are?

3.7. Listen and find the six mistakes in the text:

Gas exchange

During gas exchange, the oxygen (O_2) in the air passes from the bronchus into the capillary, which collects oxygen around the organism. The carbon dioxide in the air passes into the blood.

3.2. Ventilation

Ventilation is the process of renewing the air of lungs.

a) Accessorial structures:

They are not part of the respiratory system but they are essential to its operation. These structures are:

- Thoracic cage

It is formed by bony box made up by the **ribs**, the **sternum** and the **spinal column**.

- Respiratory muscles

The main one is the **diaphragm**, but there are other muscles implied for example **intercostal muscles** among others. Diaphragm forms the floor of the thoracic cavity and intercostal muscles are attached to ribs.

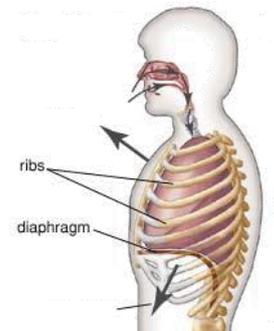
b) Respiratory movements:

It is a reflex act (an involuntary and automatic process). Pulmonary ventilation has place in two phases:

a) Inspiration (inhalation)

It is the **entry** of air into lungs. It is an **active** process (it expends energy)

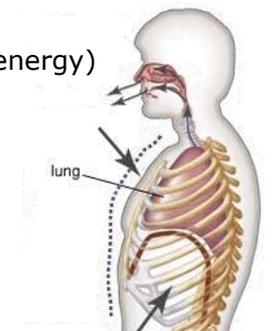
- The diaphragm contracts and goes down and the intercostal muscles contract and ribs go up and out.
- As a result, the volume of thoracic cavity increases and its internal pressure decreases.
- The atmospheric pressure becomes higher than air pressure inside the lungs and air flows into lungs which are filled passively.



b) Expiration (exhalation)

It is the **exit** of air out lungs. It is a **passive** process (it does not expend energy)

- The diaphragm relaxes and goes up and the intercostal muscles relax and ribs go down and in.
- As a result, the volume of thoracic cavity decreases and its internal pressure increases.
- The atmospheric pressure becomes lower than air pressure inside the lungs and air flows out lungs which are emptied passively.



The **respiratory rhythm** is the number of inspirations in a minute. Although it is variable according to sex, age or size, it has an average value about 17 inspirations/minute. Anyway it can adapt to provide an optimal flow of oxygen to cells in every circumstance. For example:

- It increases during the physical exercise and exciting situations (nervousness, fear, danger, etc)
- It decreases during sleep and relaxing situations.

ACTIVITIES

3.8. In a determine moment, the air within the trachea of a person is compounded by 78% of nitrogen, 16.4% of oxygen, 5% of carbon dioxide and 0.6% of other gases. What do you think, is this air entering to lungs or exiting from them? Why?

3.9. What is the difference between respiration and ventilation?

3.10. Listen and indicate what sentences are referred to inspiration and to expiration.

- Inspiration
- Expiration