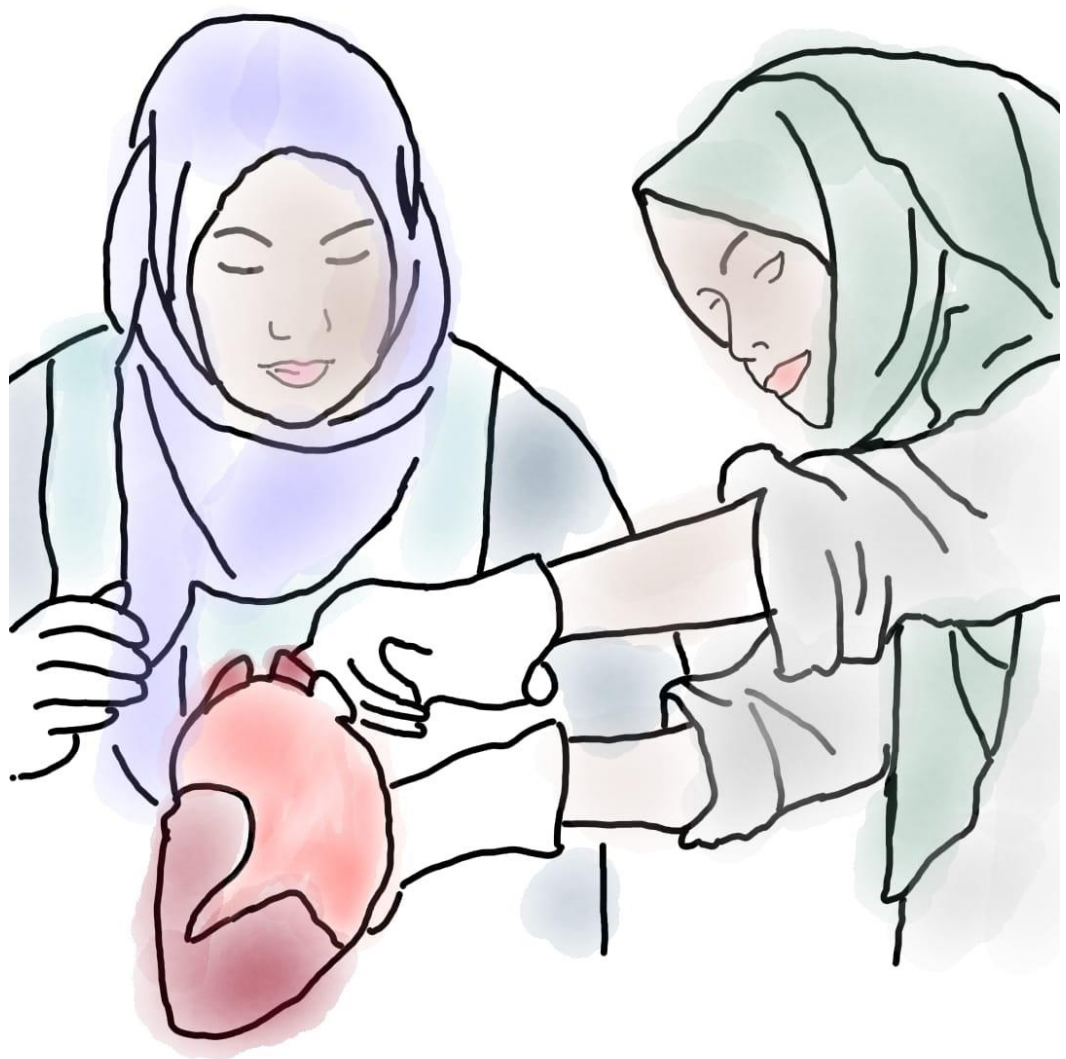


# ANATOMY



<b>ANATOMY.....</b>	<b>3</b>
Skills: .....	3
Learning goals .....	3
<b>Lesson plan .....</b>	<b>3</b>
Class 1: The human body: the different systems. ....	3
What do we need to know?.....	3
What do we need to prepare?.....	4
Class session .....	5
Class 2: Digestive system .....	6
What do we need to know?.....	6
What do we need to prepare?.....	7
Class session .....	7
Class 3: Digestion .....	7
What do we need to know?.....	7
What do we need to prepare?.....	7
Class session .....	8
Class 4: Respiratory system.....	8
What do we need to know?.....	8
What do we need to prepare?.....	10
Class session .....	10
Class 5: Circulatory system, blood: .....	11
What do we need to know?.....	11
What do we need to prepare?.....	12
Class session .....	12
Class 6: Blood types.....	13
What do we need to know?.....	13
What do we need to prepare?.....	14
Class session .....	14
Class 7: The heart.....	15
What do we need to know?.....	15
What do we need to prepare?.....	16
Class session .....	16
Class 8: The nervous system .....	17
What do we need to know?.....	17
What do we need to prepare?.....	18
Class session .....	18
Class 9: Medical measurements.....	19
What do we need to know?.....	19
What do we need to prepare?.....	20
Class session .....	21
Showcase .....	21
Exam.....	21
What do we need to prepare?.....	22
<b>EXTERNAL RESOURCES.....</b>	<b>23</b>

# ANATOMY

Main systems of the human body, their functions and the organs that form them

Anatomy is a very engaging project that focuses on what our students can relate the most with: their own body. Each class mixes theoretical input with practical activities that will help the students fix the knowledge presented. Given that theory needs to be explained, this topic will require translation.

Most of the material needed for this topic are day-to-day objects that can be easily found. However, there are some items more difficult to find. Thus, it would be advisable to try to get everything shipped beforehand to make sure all the material will be available when needed.

## **Skills:**

- Linking theoretical knowledge with the real life
- Doing online research
- Reading information from charts
- Creating PowerPoint presentations
- Presentation skills
- Talking in public
- Doing precise working, by dissecting a heart with a scalpel
- Interconnecting different topics to get a bigger picture

## **Learning goals**

- The digestive system and the absorption of nutrients
- The respiratory system and the absorption of oxygen
- The circulatory system
- Blood: its components and its types
- The nerve system

## **Lesson plan**

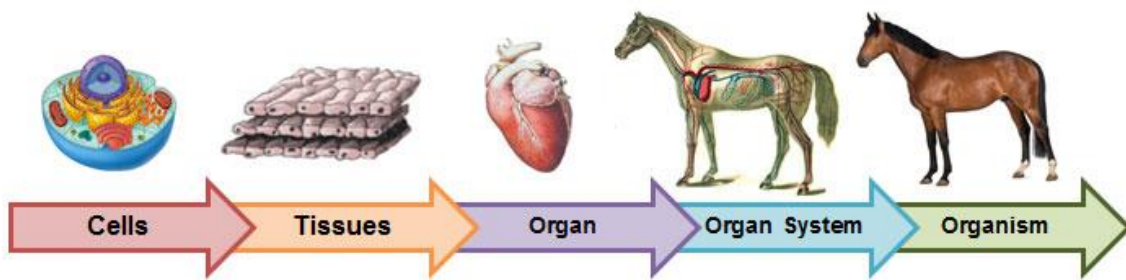
### **Class 1: The human body: the different systems.**

The students will get a first contact with different organs in our body and will share their previous knowledge about them

#### **What do we need to know?**

Everything that is alive is built up by cells. A cell is the basic unit that forms all life. Some living creatures are one independent cell, like bacteria. Others, like us, are a group of billions of cells working together.

A group of similar cells can assemble together. They create a tissue. A group of tissues with similar functions working together is what we call an organ. Different organs work closely in specific processes of the body. Those organs together form an organ system.



Picture 1 From cell to an organism

We can find different categorizations, but in general terms we can say that in our body we can find eleven main organ systems. In the following table you can find their main organs and their most important functions

System	Main organs	Function
<b>Circulatory</b>	Heart, Veins, Arteries	Transport nutrients around the body
<b>Digestive</b>	Teeth, Tongue, Oesophagus, Stomach, Intestines	Absorption of nutrients and excretion of solid waste
<b>Endocrine</b>	Thyroid, Pineal and other hormone glands	Communication between organs. Induction of certain responses
<b>Integumentary</b>	Skin, Hair	External protection of the body
<b>Lymphatic</b>	Spleen, Lymph vessels	Defend the body from intruders
<b>Muscular</b>	Muscles	Movement of the body
<b>Nervous</b>	Brain, Spinal cord, Nerves	Receiving and processing information. Controlling the activity of the body
<b>Reproductive</b>	Female: Ovaries, Uterus, Vagina Males: Testicles, Prostate, Penis	Producing Offspring
<b>Respiratory</b>	Nose, Trachea, Lungs	Exchange O <sub>2</sub> and CO <sub>2</sub>
<b>Skeletal</b>	Bones	Structural support for the body
<b>Urinary</b>	Kidneys, Bladder	Purify blood. Excrete liquid waste

Now we have a wide overview of how living bodies are built and about the specific components of the human body. Let's have a brief look at the processes that every living creature has to perform. Traditionally they are called Vital functions and they are three:

- Nutrition: receiving and processing material from the exterior and releasing the waste
- Interaction: reacting to other living creatures and the environment
- Reproduction: producing offspring

During the project we will focus on nutrition. We will study how food and water are processed by the digestive system and how oxygen is taken through the respiratory system. Once the nutrients are inside we will learn how they are distributed by the circulatory system. Finally, we will briefly see how all this is coordinated by the nerve system.

### What do we need to prepare?

- A piece of paper the size of an adult person
- Markers to outline the person
- A real size sample of one organ per student (or for every group). They should be 3D if possible. Otherwise they can be cut out of paper.

## Class session

In this class we will set up the base for the future sessions, introducing the topic and giving a quick overview about the information that we will be studying. We will begin the class with a real sized outline of a body in the middle of the class. We could have one prepared beforehand or we could pick a volunteer from the students to lay down on a big piece of paper and get his silhouette outlined by the rest of them.

After we present the painting to our class we will ask them what it would need to be alive if it was a person. We want them to come up with “food”, “water” and “oxygen” or “air”. Once they have got to this point, we can test their previous knowledge by asking if they know how we process all those nutrients.

*Most of our students had gone to high school and knew the basics of the digestive and respiratory system. However, even people that have never attended school will have previous knowledge about these. Experiences in doctors or even eating different parts from animals give everybody a brief understanding of the body functions. Many of the ideas they might have will be inaccurate or wrong, but at least there is a base of knowledge. By asking them at the beginning instead of directly introducing information we make them aware of their previous knowledge, what is a way to motivate them into expanding this knowledge.*

*For the last part of the class we will provide a sample of an organ to each student. We did this activity with six students, so it was easy to assign an organ per person. In bigger groups it might make sense to organize the class in groups of two or three.*



Picture 2 3D models of organs placed on an outlined body

The organs can be 3D models or 2D paper cut outs. Ideally they should be real size. The students will have to investigate what their organ is, what is its main function and where in the body it is placed. In this activity students can use their previous knowledge or use their phones to search on the internet in case they don't know something about their organ. This activity is easy to tailor to different levels. Students with a lower level of knowledge or with difficulties to do online research can get easy-to-recognize organs such as the heart, the brain or the lungs, while advanced students can work with organs such as the liver or the intestines, which function is not so easily known.



Picture 3 Student using the VR system

*When we carried out this session, as a last activity we used a VR system to allow each student to enter the organ they had presented. The software we used was YOU, by Sharecare. We are aware that this kind of material is not available in every context, but if the possibility of using it exists, it proved itself, in our case, as a powerful and engaging tool*

## Class 2: Digestive system

The students will make research about the organs that form the digestive system and share their findings with their classmates.

### What do we need to know?

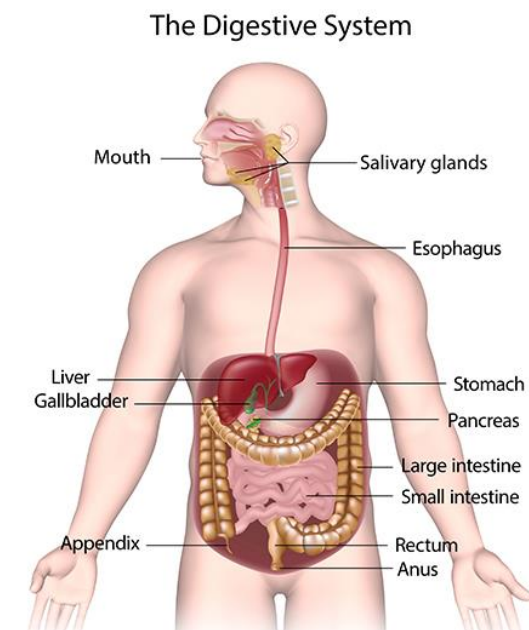
Every day we eat between one and three kilos of food on average. The digestive system turns that food into the nutrients that we need to stay alive. Our body knows how to use carbohydrates, fats, proteins and vitamins, but it doesn't know how to use a hamburger. The job of the digestive system is to break down the hamburger into the elements that the different parts of the body can use and dispose of the rest.

The main organs that form the system are: mouth, that includes tongue and teeth, oesophagus, stomach, liver, pancreas, gallbladder, small intestine, large intestine and rectum. Let's see the functions of each one through the process of digestion:

The digestion starts in the mouth. Food is cut with our front teeth and smashed with our back teeth. The food is mixed with saliva. Saliva contains substances that start breaking down the food and turns it into a moistened mass. Food moves then through the oesophagus, a pipe that connects with the stomach. The food doesn't simply slide down. The oesophagus contracts from top to bottom pushing the moistened mass towards the stomach. When we eat something wrong, the stomach will send a message to the brain and the oesophagus will start contracting in the opposite direction, making food move from the stomach to the mouth and producing a vomit.

When food reaches the stomach, it gets mixed with different acids that dissolve it and break down its proteins. To break down big pieces of food and make them easier to dissolve, the strong muscular walls of the stomach hit them and break them into smaller pieces. The food stays in the stomach for three hours before moving to the next step: the small intestine.

The small intestine is a pipe that can go from three to seven meters long. When the food enters the organ, it gets mixed with liquids coming from the pancreas and the gallbladder that will help to break down completely the different nutrients into pieces that the body can use. The liquid that comes from the gallbladder, the gall, is created in the liver and stored in the gallbladder until it is needed and released. As the food travels around the intestine the nutrients are taken out. Acids coming from fats, amino acids coming from proteins and glucose coming from carbohydrates are filtered through the walls of the intestine, so the more contact there is between the food and the walls, the better use we will make out of the food and the less nutrients will be lost and wasted. This is one of the reasons why the intestine is so long and full of curves.



*Picture 4 Digestive system*

The leftovers from the small intestine pass to the large intestine, a muscular tube that lengths one meter and a half. Here water, minerals and vitamins are taken out, and the leftover material, from which we cannot make any use, is stored in the rectum, the last part of the intestine, until it leaves the body through the anus.

### **What do we need to prepare?**

- An outline of a human body painted on a paper per team. It doesn't need to be real size, but it should be at least one-meter long.
- One bowl per team. This will act as a mouth.
- One pipe per team. It can be a thin PVC pipe, a transparent tube... This will act as an oesophagus
- One zipper bag with vinegar inside per team. This will act as a stomach.
- One stock leggings per team. This will act as a small intestine.
- One small towel per team. This will act as a large intestine.
- One rubbish bag per team. This will act as a rectum.
- One laptop per team, or their own phones.

### **Class session**

At the beginning of the class we will come back to how the body needs nutrients to be alive, and they are taken through the digestive system. We will divide the class into groups and each group will receive a big paper with a body painted and a set of objects, each one labelled with the correspondent organ.

The job of the teams will be to investigate online, using either their phones or computers, where each organ is placed in the body and place the correspondent object in the painted body. Once a team finishes setting the objects, they will be assigned one specific organ for which they will have to do extensive research. If time allows, they can prepare already a small informative poster about their organ. Otherwise, they can just write down the information. It is important that they understand how their organ works, because in the next class they will be the ones explaining it to their classmates.

## **Class 3: Digestion**

Using day-to-day objects as if they were organs, the students will go through the whole process of a digestion.

### **What do we need to know?**

All the theory needed for this class can be already found in the session above

### **What do we need to prepare?**

- An outline of a human body painted on a paper per team. It doesn't need to be real size, but it should be at least one-meter long.
- One bowl per team. This will act as a mouth.
- One pipe per team. It can be a thin PVC pipe, a transparent tube... This will act as an oesophagus
- One zipper bag with vinegar inside per team. This will act as a stomach.
- One stock leggings per team. This will act as a small intestine.

- One small towel per team. This will act as a large intestine.
- One rubbish bag per team. This will act as a rectum.
- A banana and a cookie per team
- A spoon per team
- A bottle of water

### **Class session**

The objective of this class is to deepen the knowledge about the function of each organ that takes part in digestion. Besides, the students will train their presentation skills by explaining the function of the organ that was assigned to them.

We will work with the teams that were formed in the previous class. Every team will take their set of objects and they will be given a banana, a cookie and some water. With all that we are going to reproduce the process of digestion. As soon as the food enters an organ, the correspondent team will take the stage and present, in less than five minutes, its main characteristics and functions.

We can have another set of objects so we can show the steps before they do them.

The digestion will go as follows:

- The food is broken into pieces and put into the bowl. We add water -saliva- and smash everything using a spoon -teeth-
- Food passes to the PVC pipe -oesophagus- that is connected with the inside of the zipper bag -stomach-
- In the zipper bag there are some acids. We close the bag and agitate it strongly, reproducing the movements of the stomach walls
- Once everything is mixed, the mass will be poured into the stock panty -small intestine- We will let the water go through the panty, that we can place on top of the bowl to avoid making a mess. All the matter that goes out of the panty are the nutrients that the body is getting
- After we have made as much mass as possible leave the panty through its small holes, the food can leave the panty and by placed on top of the small towel -large intestine-
- With the towel we will dry out the mass as much as we can. The leftovers are feces that we can put inside the trash bag -rectum-.
- From a small hole in the bag -anus- the waste can leave the body.



*Picture 5 Students building their digestive system*

### **Class 4: Respiratory system**

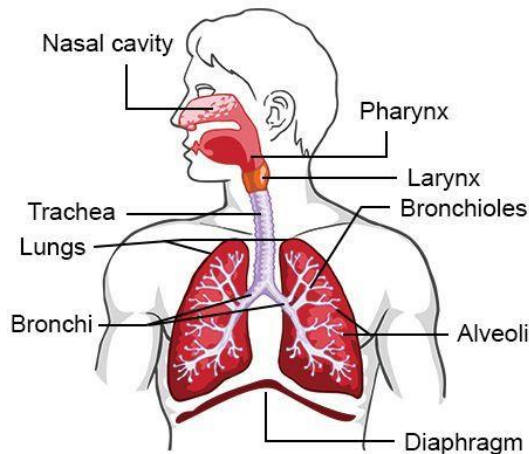
The students will build a model of a lung using a plastic bottle and a balloon to understand the physics behind breathing. Then they will measure the volume of their lungs.

#### **What do we need to know?**

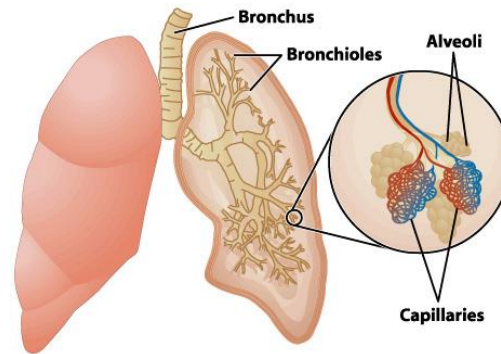
We can spend up to six weeks without eating. When it comes to water time reduces. We can spend five days. Without oxygen, we will be dead in less than five minutes. The oxygen is used by every single cell in our body to take energy out of the nutrients that we ingest. Without

oxygen, cells cannot extract the energy they need, so they cannot work anymore. If our cells stop working, we die.

Then oxygen is taken through the respiratory system when we inhale air. When we exhale, we liberate carbon dioxide, that is the waste material that cells produce after they use the oxygen to create energy.



*Picture 7 Respiratory system*



*Picture 6 Diagram of the alveoli inside the lungs*

The respiration process starts in our nose. It filters the air so big particles and bacteria don't enter our system. From the nose the air travels through the trachea, a pipe that connects our nasal cavities with the lungs. Before reaching the lungs it splits into two branches, the bronchi. Each bronchus enters one lung, and then, splits into many new branches, the bronchioles. At the end of each bronchiole there is an alveolus. When air reaches the alveoli, there is blood carrying  $\text{CO}_2$  waiting. The  $\text{CO}_2$  is exchanged for  $\text{O}_2$  coming from outside, and the air travels back to the trachea to our nose, and is released.

The lungs are the place where the circulatory system meets the alveoli to do the exchange of gasses. It is not a hollow space, because the exchange can only occur if the blood is close to the walls of the lung. This is why the air is distributed through the alveoli, so there is a big contact surface between the air and the blood.

One important element of the system is still unexplained: the diaphragm. It is a muscle located under the lungs. When it contracts it creates space on the thoracic cavity, where the lungs and the heart are. This makes the pressure decrease, and the lungs expand, getting full of air. When it expands, the pressure increases again and the lungs go back to their normal size, pushing the air out.

This is everything that we need to know for the class in terms of the respiratory system. Apart from that, we will measure the volume of our lungs, this is, the amount of air that they can hold. There are different measures in relation with the capacity of our lungs:

- Vital capacity: maximum amount of air that a person can exhale after a maximum inhalation
- Tidal volume: volume of air inhaled or exhaled in a single breath, in resting conditions
- Volume per second: volume of air than can be exhaled in one second

The normal values, in average, for this measurements are:

	Male	Female
<i>Vital capacity</i>	4.75 to 5.5 litres	3.25 to 3.75 litres
<i>Tidal volume</i>	0.5 litres	0.5 litres
<i>Volume per second</i>	3.5 to 4.5 litres	2.5 to 3.25 litres

### What do we need to prepare?

- A bag of balloons.
- One plastic bottle per team. The plastic needs to be hard. Small coke bottles work better than normal water bottles because the plastic is thicker.
- One plastic straw per team
- Hot glue
- Hot glue guns

### Class session

In this class we will introduce the functions of the different organs that take part in respiration, from the nose to the alveoli, using the whiteboard as in a regular class.

*When we had this class we used as an analogy that the trachea could be seen as a tree trunk, the bronchi and bronchioles would be branches and the alveoli, fruits. Then birds, that would be the red cells from the blood could take food from the tree by accessing the fruit.*

Once this is understood, and after solving any questions that might come up, we will split the class into teams and each one will build a small sample of a lung with a diaphragm to see how the change of pressure fills the lungs. The instructions to build one are as follows. There is also a link to an explanatory video in the references of this chapter.

- Take a plastic bottle and cut around 15cm from the top. Keep the top part.
- Make a hole on the lid of the bottle, the size of a plastic straw.
- Introduce a straw on the hole.
- place an empty balloon tightly at the end of the straw, inside the bottle.
- Cut the top of a balloon. Use this balloon to close the bottom part of the bottle
- Seal the hole around the straw with some hot glue so air can only enter through the straw

To test the model, pull from the centre of the balloon. As space is created inside the bottle, the balloon that is inside will inflate with the air that will enter through the straw. This is what happens in our body when we breathe.

*The example in the video that is provided at the end shows how to build a model with two balloons, which is more similar to our respiratory system. We did it with only one to keep the building part easier.*

If time allows, as a last activity we can handle some balloons to our students and use them to compare each other's lung capacities. We don't need tools to measure the volume in litres, we can just see, depending on how much their balloon inflates, who has bigger or smaller lungs.



*Picture 8 Model of the lungs made with a bottle and balloons*

To measure tidal volume everybody needs to breathe normally once into the balloon. For vital capacity, they need to inhale as much as they can and exhale inside the balloon for as long as they can. Finally, for the volume per second, they will have to inhale as much as they can and then exhale in the balloon for only one second, that can be timed by the teachers.



Picture 9 Students having fun measuring their lung capacity

## Class 5: Circulatory system, blood:

The students will learn about the function of the blood, how it travels around the body and the role of its main components.

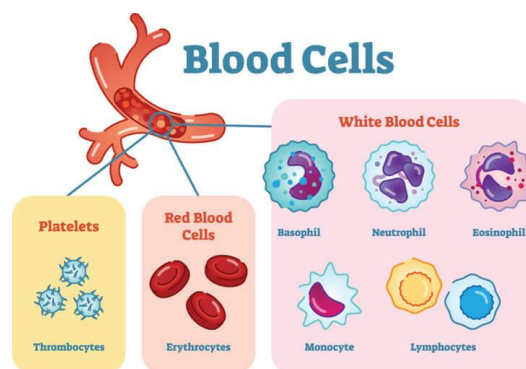
### What do we need to know?

Blood is the substance where all the nutrients travel. It consists of many different cells that have different tasks. The most important ones are:

- Red cells: they carry the oxygen and exchange it for carbon dioxide. They are the most abundant cells in the blood, and give it its red colour
- White cells: they are part of the immune system. They defend the body against intruders or damaged cells. There are different kinds of white cells, each specialized on a different task, but we will not go deeper on this.
- Platelets: if a blood vessel breaks, these cells cover the hole preventing bleeding

Plasma is the liquid where all the blood cells travel. It consists of water, waste products, proteins, hormones and electrolytes.

The circulatory system is the one in charge of transporting and distributing the blood with all the nutrients that we get from outside around the body, so each and every cell on our body gets what they need and can get rid of their waste. It consists of the blood vessels: veins, arteries and capillaries. The arteries carry blood away from the heart and veins carry it back to the heart. The connection among ones and the others, once the blood releases the  $O_2$  and gets  $CO_2$  is done in smaller vessels called capillaries that connect arteries and veins. If we put together all the vessels that form our circulatory system, they would be 100.000km long. Two and a half times the circumference of the Earth.

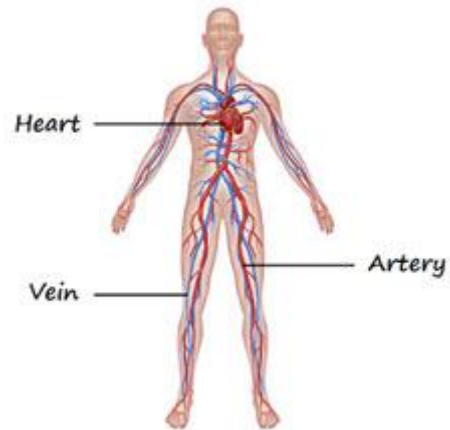


Picture 10 Blood cells

From the moment a drop of blood leaves the heart, it will travel around the body doing two different cycles before arriving back on the starting point. Blood rich in oxygen leaves the heart and is distributed around the body, where the oxygen is exchanged for  $CO_2$ . This blood comes back to the heart, completing the first cycle, and then it is pumped to the lungs. In the lungs it exchanges the  $CO_2$  for new  $O_2$ , and comes back to the starting point completing the second cycle. Information about the different chambers of the heart where the blood is pumped from will be given in following classes, but is not needed for this one.

## What do we need to prepare?

- A jar with small beads, labelled as platelets
- A jar with red beads, bigger than the platelets, labelled as red cells
- A jar with white beads, bigger than the red cells, labelled as white cells
- A jar with water labelled as plasma. If we have yellow food colouring we could add some drops, since plasma is yellow
- One big paper with a body drawn inside per team



Picture 11 Circulatory system

## Class session

We will begin briefly reviewing what we know so far. We have already learnt how we take nutrients and oxygen from the outside world. Now, we will learn how they are distributed around our body. We can ask our students if they know the answer: the circulatory system and the blood.

Simply for visual purposes we will have 4 jars with 4 different elements. Small beads for the platelets, bigger red beads for the red cells, bigger white beads for the white cells and water for the plasma. Using them as a reference we will explain about the four main components of the blood and its main functions.

Now it will be time for the students to deduce the two cycles of the blood. We will make teams and each team will get a paper with a body drawn. Inside the drawing they will paint a heart and the lungs in the correspondent place. We will ask them to use blue to paint the path that they think blood makes when it carries  $\text{CO}_2$ . With red, they will paint the path for oxygenated blood. To make it simple, we will focus on blood circulating to one specific point of the body, for example a foot. Otherwise, they would need to paint the whole system of arteries and veins, and that is not the purpose of the activity.

With our help, if needed, they will deduce that the oxygenated blood goes from the heart to the foot, comes back with  $\text{CO}_2$ , travels to the lung, receives oxygen and comes back to the heart. Like this, they will realize that blood has to make two different cycles, one to the body and one to the lungs. If the number of students is too big, the activity can be done on the whiteboard with the teacher moderating the interventions of the students.

*We decided to let them do it in small groups so everybody had to do the process of reasoning, and no one could simply sit and listen.*

Finally, we will present the teams with three situations on their bodies. They will need to decide which blood cell will act in each situation.

- Somewhere on their blood current a virus has been spotted → white cells will attack the virus
- They have fallen from a bike and have an injury → platelets will cover the injury
- They just took a deep breath and there is a lot of air on their lungs → red cells will exchange the oxygen with  $\text{CO}_2$

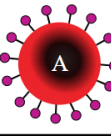
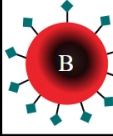
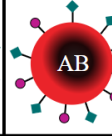
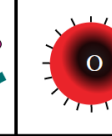






## Class 6: Blood types

The students will learn why there exist different blood types and they will find out their own blood type.

### What do we need to know?

Just as people have different colours on their eyes, we also have different kinds of blood. Unlike the case of the eyes, it is not possible to see it. To know our blood type, we need to get a test. The most common way to categorize the different kinds of blood is to combine two different elements. The red cells can be covered by two different types of antigens. A or B. Antigens are sugars that mark our cells. The red cells can also have both, AB, or none, what we call O. This gives us four possibilities. The second element is the Rh factor. This is a protein that can be found on the surface of the red cells. If our red cells have them, then we are Rh+. Otherwise, we are Rh-.

The combination of the two categorizations gives us the eight possible blood types: AB+, AB-, A+, A-, B+, B-, O+, O-.
























	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in red blood cell	 A antigen	 B antigen	 A and B antigens	None

Picture 12 Presence of antigens and antibodies on each type of blood

If our red cells have a certain type of antigen, our plasma will have antibodies to find and eliminate any antigen that is not ours. Antibodies are elements that protect us from intruders, so if they find something that is not supposed to be in our body they will try to eliminate it. If our blood is A, then our plasma will have antibodies to eliminate the antigens B. If our blood is AB, then our plasma will have no antibodies, since both antigens A and B can be found on our cells. If we are type O, then our plasma will have antibodies to eliminate both A and B.

In the case of the Rh factor, if a person that is Rh- receives blood with the Rheus factor proteins on the red cells, their immune system will realize that something strange has entered the body. Their body will make antibodies to fight the intruder and an immune reaction will start. On the other hand, if someone that is Rh+ receives blood without the Rheus factor proteins their body will not detect anything strange, so there will be no immune response.

Knowing our own blood type is important in case we need a blood transfer. As we saw above, not every type of blood is compatible due to the presence of antibodies in our blood. When a blood transfer is done, it doesn't always mean that all the components of the blood are being transferred. If two people have the same blood type a transfer of

		You can receive type							
		O+	O-	A+	A-	B+	B-	AB+	AB-
If you are type	O+								
	O-								
	A+								
	A-								
	B+								
	B-								
	AB+								
	AB-								

Picture 13 Red cells donation chart

all the blood is feasible, but that is not the case if the types differ. The most common element that is transferred are red blood cells. In this case:

- AB: can get blood from any type, because it does not have antibodies
- A: can only get blood from A and O, as it has antibodies against B
- B: can only get blood from B and O, as it has antibodies against A
- O: can only get blood from O because it has both antibodies, it can however give blood to anyone as they do not have any anti genes

For all those cases, Rh+ types can get from both, positive and negative, while Rh- types can only get blood from negative types. For instance, a person that is AB+ can receive red cells from everybody, while a person that is AB- can receive from AB-, A-, B- or O-.

If we talk now about donating plasma, everything changes. Plasma has the antibodies to fight intruder red cells. Now, the donations go as follow:

- AB: can get blood from only from AB, since it is the only one with no antibodies
- A: can get from A, with antibodies against B, and also from AB
- B: can get from B, with antibodies against A, and also from AB
- O: can get from any other type of blood since its plasma already have antibodies against both A and B

The Rheus factor does not play any role now, since the antibodies against it are not present in the plasma. They are created when red cells that have the protein enter the system. The following chart shows the compatibilities for donating plasma:

### **What do we need to prepare?**

- One blood type test per students

### **Class session**

We will link with the class before, where we already talked about blood, and present the fact that different people have different types of blood. We will ask them about their previous knowledge and if they even know their own type.

After a brief discussion we will introduce the AB0 system by explaining that two different sugars -antigens- can be found in red cells. In the whiteboard we will write a chart for the four types and fill in the types A and B as the cases where either antigens A or B are present. The remaining two cells of the chart can be filled by the students by deducing that cells can still either have both or have none of the antigens.

Once this system is understood we will explain the Rh factor. Then blood can be positive or negative depending on the presence of the Rheus factor protein. We will ask the students to combine both systems, and they will have to come up with eight different types. It might look like a very simple task to ask the students to combine the AB0 and the Rh systems to get the eight types. However, we think that the ability to understand how the two systems interact and to see all the possible combinations is not a given skill for everybody, so it is a good opportunity to train it.

We can make some follow up questions when all the types are present on the whiteboard. For example, "What type has both antigens but has no Rh proteins?" or "What kind of antigens can we find on a 0+ red cell?" With this we will make sure that everyone has fully understood the concepts before we move to donation charts.

The next activity will be to fill in a donation chart for red cells. We will write the chart on the whiteboard, and the students will have to decide for each cell if the type on the left can donate to each of the types on the top.

*We did this activity with all the students at the same time, on the whiteboard. Students, one by one, would tell us what to write in one cell and explain why. The amount of students we had made it possible for everyone to speak at least twice. In a class with too many students it can be a better idea to let them do it individually or in pairs, and after some minutes of working, fill in the one in the whiteboard asking specific students to fill each cell.*

Finally, after all the theory has been learnt, we will hand out a blood test to each student so they can test their blood type. Depending on the setting it might be needed to get a consent form from the parents beforehand, since the students are going to pinch themselves to take a blood sample. The students can work in pairs, one student analysing the blood of their partner, following our instructions. Before ending the class, once everyone knows their blood type, we can make some questions regarding who can donate to who, linking what we learnt today with their reality.



Picture 14 Students testing their blood type

*We did not go into detail regarding the antibodies in plasma and plasma donation. In our case getting the information about red cell donation through was already enough and it took some time. It could be a good idea to talk about it and deduce the plasma donation chart if the class advances very fast understanding the blood types and time allows before performing the blood tests.*

## **Class 7: The heart**

Dissecting a heart, the students will discover the different chambers of the heart and how they are connected with the rest of the circulatory system.

### **What do we need to know?**

The heart is a muscular organ that pumps blood through the blood vessels. It is the central point of the circulatory system. If it doesn't pump, the blood cannot move, so our cells cannot get their nutrients and oxygen, and we die.

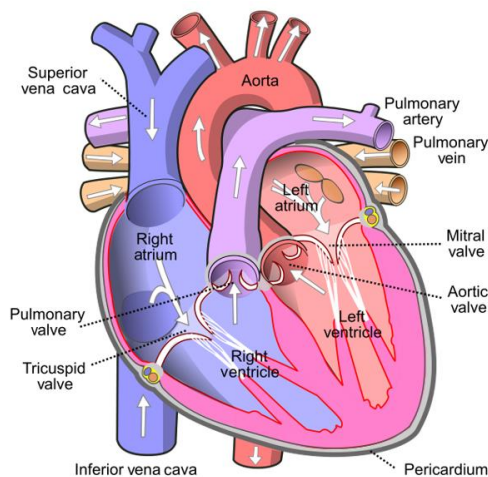
It is formed of four different chambers, connected in pairs. The top ones receive blood, then pass it to the bottom ones that pump it out of the body. Every minute the heart pumps 5 litres of blood. Let's focus on each of the four chambers:

- Right atrium. It is located on the top right. It receives blood from all the body through the superior and the inferior vena cava. This blood has already been used, so it is carrying CO<sub>2</sub>. It connects with the right bottom chamber, the right ventricle through, the

tricuspid valve. This valve consists of three leaflets. They can be pushed down, opening the valve and allowing blood from the atrium to the ventricle. However, they cannot be pushed from the ventricle to open towards the atrium. This prevents blood from being sent back to the atrium

- Right ventricle. It is underneath the right atrium and it sends blood, passing the pulmonary valve, towards the lungs through the pulmonary artery.
- Left atrium. Located on the top left, it receives oxygenated blood coming from the lungs through four pulmonary veins. Then this blood is passed to the left ventricle through the mitral valve. The mitral valve has two leaflets and, as the tricuspid valve, it only opens towards the ventricle, preventing blood to go up again into the atrium.
- Left ventricle. This chamber receives oxygenated blood from the left atrium and sends it, passing the aortic valve, to all the body through the aorta artery. The left ventricle

has to pump blood with much more power than the right one, because it needs to reach the whole body, not only the lungs, that are already close to the heart. For this reason, the walls of the left ventricle are thicker than the ones of the right ventricle.



Picture 15 Diagram of the heart

When we listen to our own heart beat we can identify two sounds. Each of them correspond with the opening of certain valves in our heart, that will allow blood to circulate. The first sound that we hear comes from the closure of the mitral valve and the tricuspid valve. This occurs when the ventricles contract, pushing blood out of the heart. The second one occurs when the aortic and pulmonary valves close, while blood is being pushed from the atriums to the ventricles.

### What do we need to prepare?

One heart for every two students. Pig hearts are the ones that are more similar to humans. Cow hearts are bigger, so it is easier to spot the different elements. We used cow hearts because we were concerned for our students, most of whom were Muslims, to be uncomfortable using pig ones.

- One scalpel for each student
- Plastic gloves
- Newspapers to cover the working tables

### Class session

This is the third class related to the circulatory system. So far we have learnt about the blood, today we will learn how it is pumped around the body. To begin with, we will paint in the whiteboard a big heart, marking the four different chambers. We will start from the right atrium, where blood enters with  $\text{CO}_2$ . We will explain how the valves work to let blood enter the right ventricle and then ask our students where they think blood will go from the ventricle.

We will continue explaining the four chambers and drawing in the whiteboard the whole cycle the blood does until it comes back to the same chamber. We will also explain how the blood

flows through the heart by contracting and relaxing and how each valve can be opened only from one side, preventing blood from going back.

Once everything is understood, we will inform the students about the activity that we are going to do, so if anyone feels uncomfortable working with a heart they can leave. Those staying will be put in pairs and will be given gloves and scalpel for each one, and one heart.

To begin with, we will ask them to locate the right and the left side. To do so, they need to spot where the thicker walls are. That will be the left side. Then, they can try to find each valve and the veins or arteries that the heart connects with. Arteries can be differentiated from veins because they keep their shape and are more rigid than veins.



*Picture 16 Students dissecting cow hearts*

Using their fingers as if they were blood they can enter one atrium and find the valve that passes to the ventricle. After everything is spotted, using the scalps they can carefully open the heart from top to bottom to see the chambers inside. They should try not to break any valve, so they can try to push them from the ventricle to the atrium and see how in that direction they cannot be opened.

In the references at the end of this chapter you can find a video with instructions to perform a dissection of a heart. We recommend having a trial dissection beforehand to be prepared and to know how and where to cut to get a proper look at the insides of the heart.

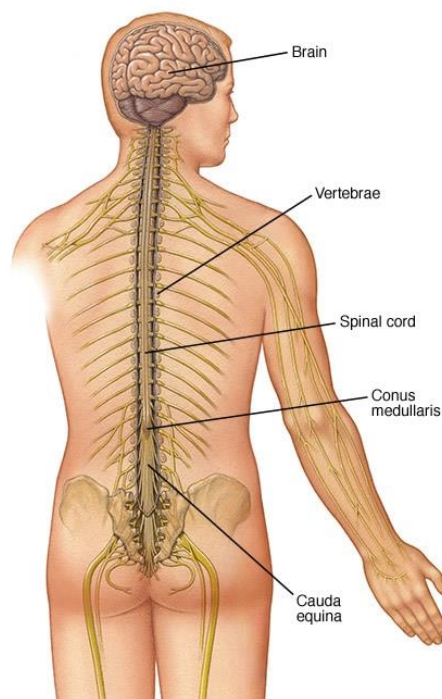
## **Class 8: The nervous system**

Through a game the students will realize the role of the brain in our body, coordinating not only our conscious decisions, but also the normal development of all our body functions.

### **What do we need to know?**

The nervous system coordinates the actions of the body by sending and receiving messages through electric pulses that travel between 5 and 120 m/s. It also collects the information that we get from the outside through our senses. Its centre is the brain, the most complex organ in a vertebrate's body. Among its functions, we have:

- Receive raw data from the exterior and process it.
- Store and access when needed information about the past.
- Coordinate body movement.



*Picture 17 Nervous system*

- Control unintentional processes like salivating, sweating, dilating the pupils...
- Control the correct work of every organ.
- Supervise the right state of the body and initiate a response if something goes wrong.
- Regulate the breathing.

The brain receives information from all the body. This information travels through the spinal cord, that centralizes the information received from the nerves around all the body and carries it to the brain. When the brain wants to send orders, they are sent to the spinal cord and then distributed to the corresponding nerves

This system is one of the most complex in our body, and much is still unknown about how it works. Specially about the functions and ways of working of the brain.

### What do we need to prepare?

- Flexible coloured sticks. This is what we used, but there are countless ways to display the instructions. It can be adapted to the material available
- A set of instructions for the game for each team
- Fabrics or sheets to separate the classroom into two

### Class session

The intention of this class is not to get extensive knowledge of the nervous system, but to have a relaxed fun session after seven classes where a lot of knowledge was transferred. Linking with the previous classes, we already know how we get nutrients and how they are distributed, today, we will see how all these operations are controlled and coordinated.

Drawing it on the whiteboard we will explain how the nervous system looks, the functions of the brain and how it connects with the rest of the body through the nerves. When the students have understood everything, and after some discussion if the students have questions, we will present the activity that we are going to do for the rest of the class.

We will divide our students into groups of three. One person will be a brain, another will be the nerves and the third one will be a body. The brain will be on one side of the sheet that separates the class. The nerves and the body will be on the other side.



*Picture 18 A group of students during the session*

The brain and the nerves will have an instruction

book where different shapes and colours of the stick mean different muscles to move in different ways. For example, a red stick bent 90° could mean lifting the left arm straight up. The instructions will include both conscious decisions, such as moving the limbs and also involuntary actions, such as breathing or blinking.

The brain will have the colour sticks and we will ask them to make their bodies move in certain ways by giving the right instructions under the sheet. The nerves will see the sticks, look up in the instructions book what they mean, and move the body accordingly.

## Class 9: Medical measurements

The students will learn how to measure different indicators, such as the heart speed or the glucose level. Then they will check if their levels are healthy and normal.

### What do we need to know?

We cannot easily access the inside of our body to check if our organs are working properly. Therefore, there are many techniques to get information from outside. We will focus on measurements related to two of the systems that we studied:

#### Respiratory system

- Breathing per minute. The amount of times we breathe in a minute when resting should be between 12 and 20. If our rate is higher we might be having problems bringing oxygen to our system

Normal respiratory rates	
New-borns	44 respirations per minute
Infants	20-40 respirations per minute
Children (1-7 years)	18-30 respirations per minute
Adults	12-20 respirations per minute

Chart 1 Normal respiratory rates per minute by age

- Checking for vibration of the lungs. If we place our hands on the sides of someone's back, covering for the eighth to the tenth ribs and we ask them to pronounce ninety-nine on a deep voice we will feel the lungs vibrating. If the vibration feels too strong it can indicate pneumonia. If it is too weak, it might indicate that there is liquid in the lung area
- Percussing the lungs. If we place our opened hand in the back of a person, where the lungs are, and hit the middle finger with our other middle finger firmly, we will hear a noise. This sound should be resonant, since the lungs are only filled with air. If the sound is dull and not resonant, this can mean that there is liquid inside.
- Auscultation with a stethoscope. If the sound is very low or even inaudible, it may indicate pneumonia. There are also different small sounds that can be worrying. Noises that sound like snores happen when air gets blocked in the airways. Wheezing may indicate the air getting blocked in the trachea or in the back part of the throat

In the references at the end of this chapter you can find a video with an extensive explanation of each test.

#### Circulatory system

- Heartbeat rate. We can measure the beats per minute from our wrist or our neck. The normal values for it are indicated in the following charts:

Age	Heartbeats per minute for men						
	Athlete	Excellent	Good	Above average	Average	Below average	Poor
18-25	49-55	56-61	62-65	66-69	70-73	74-81	82+
26-35	49-54	55-61	62-65	66-70	71-74	75-81	82+
36-45	50-56	57-62	63-66	67-70	71-75	76-82	83+
46-55	50-57	58-63	64-67	68-71	72-76	77-83	84+
56-65	51-56	57-61	62-67	68-71	72-75	76-81	82+
65+	50-55	56-61	62-65	66-69	70-73	74-79	80+

Chart 2 Heartbeat per minute for men

Age	Heartbeats per minute for women						
	Athlete	Excellent	Good	Above average	Average	Below average	Poor
18-25	49-55	56-61	62-65	66-69	70-73	74-81	82+
26-35	54-59	60-64	65-68	69-72	73-76	77-82	83+
36-45	54-59	60-64	65-69	70-73	74-78	79-84	85+
46-55	54-60	61-65	66-69	70-73	74-77	78-83	84+
56-65	54-59	60-64	65-68	69-73	74-77	78-83	84+
65+	54-59	60-64	65-68	69-72	73-76	77-84	84+

Chart 3 Heartbeat per minute for women

- Blood pressure. This is usually indicated by two numbers. One is the lowest pressure applied to our arteries, when the heart is resting. The other is the pressure when the heart pumps blood to the body, the highest pressure applied in the artery. To measure it with a manual pump, we put the armband of the pump around the person's arm and we place a stethoscope in between, so we can hear the blood flow. We apply pressure until we start hearing the blood flow. This sounds indicates that we are disturbing the normal flow of the blood, so we have reached a pressure that is higher than the lowest pressure usually applied to the artery. We continue pumping until the sound disappears again. Now the blood cannot pass. We have stopped the flow because the pressure we are applying is higher than the one provided by the heart. We have found the highest blood pressure.

Blood pressure	Systolic (highest)	Diastolic (lower)
Normal	Under 120	Under 80
Prehypertension	120-139	80-89
Hypertension (stage 1)	140-159	90-99
Hypertension (stage 2)	160-180	100-110
Hypertensive crisis	Above 180	Above 110

Chart 4 Blood pressure level chart

- Blood sugar level. This is the concentration of glucose in our blood. To measure it we need a specific device, a blood sugar test. The normal values are the following:

	Fasting	Just ate	3 hours after eating
Normal	80-100	170-200	120-140
Pre-diabetic	101-125	201-230	141-200
Diabetic	126+	231+	200+

Chart 5 Blood sugar level chart

- Auscultation with a stethoscope. By auscultation we can easily hear the two main sounds of the heart, the first being when the mitral and tricuspid valves close, and the second, when the pulmonary and aortic valves open. Different pathologies can generate extra sounds, or changes in the two main ones. For extra information, we leave a link to an explanatory video about all the possible heart sounds in the references at the end of the chapter.

## What do we need to prepare?

- Stethoscopes.
- One sugar blood test per student.
- Printed charts with the normal values of the different measurements.
- Manual blood pressure meters.

## Class session

In this class we will introduce different measurements that can be checked to look for possible problems in our body. We will start with the respiratory system. For that everyone will measure their breathing per second and compare their results with a chart that shows the normal values for it. Then we will perform two tests: checking for vibration in the lungs and percussing them. We will perform an example, and then the students can work in pairs doing the test to each other. After that, the same pairs can use a stethoscope to hear each other's breathing.

*For this class it may be a good idea to make the pairs non-mixed. Given our context, when we carried out this class we were worried about girls not feeling comfortable not only getting the test done by a boy, but even getting the tests done in front of a boy, in the same space. Depending on the students it might be necessary to separate the class in two areas so the girls can comfortably show parts of their bodies.*

Next we will work with the circulatory system. We will measure our heartbeat rate and compare it with the normal values. Then we will show how to measure blood pressure and sugar level, and we will let the students do it in pairs again. Finally, they can auscultate their partners' hearts or even their own.

Depending on the amount of students it is likely that having materials for everyone to perform the same test at the same time would be impossible. An option is to explain how to perform every test at the beginning, and then ask the students to rotate from one test to another, so everyone is performing a different one at the same time.

## Showcase

The students will be divided into teams, each of which will present one of the systems that they studied. In this case, they will have to prepare a PowerPoint presentation.

## Exam

The exam will be some kind of a treasure hunt. There will be three main locations. The heart, the body and the lungs. The students will know from the beginning where each station is located, they don't need to solve any riddle, but they need to know in what order they need to visit them.

The teams will be a stream of blood, and their purpose is to complete a whole cycle, starting from one chamber of the heart and finishing in the same place. During this process they will be exchanging  $O_2$  with  $CO_2$ . Up to two teams can participate at the same time. If we need to make more teams, we can do it in several rounds.

Within the teams, two students will be red cells and will carry the gases. The remaining student will be a white cell, and will have a shield to defend their peers. Along the way, as they move from one station to another, we will be attacking them with small softballs that will act as viruses. The white cells need to protect the red ones from the viruses. If the red cells get hit, they will have to come back to the last station that they visited.

*We did groups of three for the exam. If the teams would need to be bigger, then the number of red cells should always be bigger than the number of white cells to make the defence a little bit more difficult.*

If two teams start at the same time, one will begin carrying  $O_2$  and the other will carry  $CO_2$ . From now we will focus on the team carrying  $O_2$ . Their first task is to deduce through what chambers

they need to cross the heart to travel to their next destination, that needs to be the body. They will enter the left atrium, pass to the left ventricle and go to the station “body”.

When they reach the station they will need to exchange their O<sub>2</sub> for CO<sub>2</sub>, but in order to do that they will have to pass a challenge:

Challenge 1: Organizing the digestive system

They are bringing blood to the digestive system, but it is messed up. Different objects labelled as each element of the system are in the place, but they are not correctly connected. They need to build the system properly and indicate in which organ the nutrients are taken out and enter the blood flow. The answer is the small intestine

After leaving O<sub>2</sub> in the body and taking CO<sub>2</sub>, they have to enter the heart through the right atrium. There they will face the second challenge:

Challenge 2: Transferring blood.

The students will face the current situation: a person is bleeding to death and needs a transfer. We don't know his blood type and cannot make a test, but we have several bags with blood marked with their blood type. Can we do a safe donation?

There will be a bag marked as O-. They need to choose that one, as O- is a universal donor and in any case the blood will be suitable for the bleeding person

After solving the challenge, the students can move to the right ventricle and from there to the lungs. In the lungs they will have to solve the last task:

Challenge 3: Checking body measurements

A person is feeling sick. He has taken some measurements of his own body: his heartbeat rate, his breathing rate and his blood pressure. The students will have to check on the charts if any of the values is out of the normal range.

*This challenge is not tailored to check hard knowledge about the cycle, but to train the skills of reading tables and understanding ranges. We realized that for our students this was something that was not as easy as we would have expected. With a group of students for which this activity would be too easy, we can ask them to take the measurements themselves, or completely redesign the challenge and focus it on something else.*

Finally, the students can exchange their CO<sub>2</sub> for new O<sub>2</sub> and come back to the heart through the left atrium to conclude the test. They will pass the exam if they manage to complete the cycle in 30 minutes.

### **What do we need to prepare?**

Divide a room in four areas, that will be the four chambers of the heart. We hang curtains in the room to split it into four parts. It could be done marking the ground with tape. Ideally, each chamber should have its own gate to leave or enter.

- Different balls that will be CO<sub>2</sub> and O<sub>2</sub>.
- Softballs that will be viruses.
- Items that could work as shields. We used trash bin lids.
- The same items that were used in sessions 3 and 4 to reproduce the digestive system.
- 4 zipper bags filled with red coloured water. Each will be marked with a blood type. One of them will be O-.
- Charts with the normal values of heartbeat rate, breathing rate and blood pressure.

## EXTERNAL RESOURCES

- More information about tectonic plates and margins.

<https://www.bbc.co.uk/bitesize/guides/z2vjxsg/revision/3>

- Instructions to do a DIY digestive system.

<https://www.youtube.com/watch?v=aeml64NAK08>

- Instructions to do a DIY lung and diaphragm.

<https://www.youtube.com/watch?v=6oMFAMqSlq4>

- How to dissect a heart.

<https://www.youtube.com/watch?v=WBwPhWAP394>

- How to examine a person's lungs.

<https://www.youtube.com/watch?v=zdkYujPkeqo>

- How to use a stethoscope to auscultate lungs

[https://www.youtube.com/watch?v=Egdxicy0c8k&ab\\_channel=EMTprep](https://www.youtube.com/watch?v=Egdxicy0c8k&ab_channel=EMTprep)

- How to use a stethoscope to auscultate heart

[https://www.youtube.com/watch?v=KMYzpJLOF1c&ab\\_channel=SarahParrott](https://www.youtube.com/watch?v=KMYzpJLOF1c&ab_channel=SarahParrott)

- Heart sounds.

<https://www.youtube.com/watch?v=6StYVx6BVLo>