ACCADEMIA MEDICA DI ROMA

A HEALTH SCIENCE EDUCATION PROGRAMME IN PRIMARY SCHOOL

THE SCIESA PROJECT

SECOND YEAR
2014 - 2015

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INTRODUCTION

A five-year project aimed at testing the feasibility and effectiveness of an innovative educational programme dedicated to promoting a health sciences programme (SCIESA, "SCIEnze della SAlute") in Italian primary schools was conceived in 2012 as an initiative of the Accademia Nazionale dei Lincei, in accordance with the Accademia Medica di Roma. This pilot project, with the invaluable collaboration of school authorities (the Regional Superintendency and the Istituto Comprensivo Luigi Settembrini),was started in Rome during school year 2013-2014, in four first-year primary school classes located in two different schools (in Via Asmara and in Via Novara), both part of the Istituto Comprensivo Luigi Settembrini. The project has now completed its second year and is going to continue with the same group of children, until they reach their final 5th year of the primary school cycle. A total of seventy pupils are involved in the project.

Planning of the activities, training of the teachers and monitoring of class activities were undertaken by the SCIESA working group: Mario Stefanini, Antonio Cappelli, Flavia Capozzi, Barbara Muciaccia* of *Sapienza* University of Rome, Silvia Caravita, of the IRPPS-CNR, Rome, and Gregorio Siracusa of the University of Rome *Tor Vergata*. Mario Stefanini is also a member of the Accademia Nazionale dei Lincei. The teaching activity in class was run by the regular school staff, namely, Paola Cherubini, Roberta Corvi, Grazia Cossu, Elena Feliziani, Eleonora Medici, Annarita Pierini, Maria Francesca Scrivo and Grazia Zimbalatti. Teachers,Claudia Regazzini and Angelo Matrone coordinated the activities in the Via Asmara and Via Novara schools, respectively, under the supervision of the headmaster, Massimo La Rocca.

Since its beginning the project has been sponsored by the Accademia Nazionale dei Lincei and the Accademia Medica di Roma. For its first year acivities, the project was funded by the Fondazione Roma-Terzo Settore; for its second year the project received funds from IAP (the global network of science academies) and the InterAcademyMedicalPanel, IAMP. An international workshop on "*Health Science Education in Primary School"*, financially

supported by the IAP, was held in Rome in May 2015 at the Accademia Nazionale dei Lincei. Activities carried out during the first and the second years are reported in publications in Italian and in English, that are available from the Accademia Medica di Roma website at the following link:
http://www.accademiamedicadiroma.it/index.php?option=com_content&view=article&id=573&Itemid=106

*Barbara Muciaccia has been involved in the project until September 2014

THE SCIESA PROJECT

This report covers the activities carried out under the SCIESA *(SCIEnze della SAlute)* project during its second year (2014-2015). SCIESA is a pilot project on Health Sciences education which is ongoing in an Italian primary compulsory school. To ensure a better understanding of the matter addressed it is considered useful to preface the report with the general outline of the project, its timeline and the activities performed at earlier stages.

General outline

Background

The initiative is the result of careful analysis of the Italian epidemiological profile that, as it is in many countries with high social and economic development, is characterized by a progressive increase of demographic and health indicators, such as:

- life expectancy at birth;
- average age of the population;
- prevalence of both endogenous degenerative pathologies and chronic illnesses;
- prevalence of "affluent pathologies" (e.g., metabolic syndrome, obesity, drug dependence, work-related or accidental injury), which are strongly linked to unhealthy lifestyles (e.g., overeating or unbalanced diet, sedentary lifestyle, stress, tobacco dependence, consumption of psychoactive substances).

A consequence of this phenomenon is the increasing lifespan of the Italian population, which, at the same time, is becoming more fragile from a health perspective, with a growing number of people requiring medical attention (e.g., the aged, disabled, chronically ill). Thus, costs incurred by the National Health Service have increased progressively and have reached levels that are difficult to sustain due to the following factors:

- a growing demand for healthcare both in terms of the number of persons requiring healthcare and the quantity of medical interventions requested;

- the complexity of healthcare, which tends to grow in parallel with technological developments in the medical research sector.

The spiralling costs of curative treatments cannot be counterbalanced by a mere reduction in the level, quantity or complexity of the healthcare on offer. The only possible areas of intervention are restructuring the function of the entire healthcare system (e.g., organisational adjustments, elimination of unnecessary expenditure) and implementing preventive measures to meet society's increasing demand for healthcare.

In preventive medicine certain primary measures assume a vital role in avoiding the insurgence of pathologies, and are needed to contain the costs of treatments.Activities to prevent the onset of diseases resulting from unhealthy lifestyles, represent the best strategy to attain a healthy life in the long run.

The promotion of healthy behaviours is generally considered as one of the fundamental components of primary prevention. Many experts agree that this should begin at the earliest possible age to encourage awareness, knowledge and skills that children need to lead a healthy life.

It must be acknowledged that the various initiatives aimed at encouraging healthy behaviours that are currently being carried out in compulsory school, in the form of recommendations and guidelines, have proven to be of quite limited efficacy due to the following reasons:

- initiatives are generally carried out on a sporadic basis and often perceived by the child as imposed rules;
- the school children lack the scientific knowledge that is essential to understanding the educational message, and are thus unable to absorb and retain information in a lasting, comprehensive way.

The aim of the SCIESA project is to introduce a drastic change in the way health education is taught in primary school, from the sheer teaching of healthy practices to an evidence-based health science education, based on the understanding of the human body's basic

structure and essential regulatory processes, although at an elementary level. Such a systematic approach would eventually bring the child to become more aware of him/herself and more receptive to the teaching of healthy practices aimed at promoting "health awareness" and correct lifestyles, thus leading to disease prevention and to adequate psychophysical balance.

In this perspective, compulsory school at the primary level represents a very important opportunity for intervention for the following reasons:

- the fundamentals of knowledge are established at a very early age;
- compulsory school allows entire age segments to benefit from such activities;
- this activity, if conducted efficiently, can also involve the students' families;
- the basis for good health or disease in old age are established in childhood.

On the basis of these considerations, the Accademia Nazionale dei Lincei, in accordance with Accademia Medica di Roma, has developed a project aimed at introducing a health science education programme in compulsory primary schools. This ambitious project, however, requires at the outset an assessment of feasibility to ensure the reliability of the training hypothesis formulated, the possibility of achieving the planned activities and the effectiveness of the activities.

Objectives

Training in health sciences in elementary schools should be aimed at transmitting to students knowledge on the human body structure and function. This knowledge would enable students to acquire and maintain proper health behaviours based on scientific evidence and would serve as an essential component in the prevention of pathologies. Knowledge to be shared, tuned in accordance with the learning abilities for the various elementary grades, should basically cover:

- the relationships with life environment

- the main physiological functions of the human body with specific references to the various organs and apparatuses;
- the most important and common health risk factors for different age groups;
- information useful to help identify healthy lifestyles and to avoid developing health risk behaviours in childhood and adult life.

Methods

Within this setting, the didactic approach is based on two basic strategies: inductive reasoning and interactive teaching. Such approach involves the active participation of students during the training process. The collaboration of families during all of the programme activities is promoted and systematically solicited.

- helping schoolchildren to recall daily experiences
- elaborating detailed teaching Modules
- elaborating and producing teaching support material
- training of the teachers
- presenting the project to the families
- implementing the planned teaching activity
- assessing the results
- presenting the results to the school authorities

The activities envisaged for each phase are indicated below.

Identification of "core experiences"

The training to the inductive reasoning strategy will involve as a preliminary step to identify experiences pertaining to the pupils' lives (scenarios of play, family, school, etc.), to be used to develop a simple yet participative learning programme. This will also include exploring basic elements of the structure, function and, in certain instances, possible pathologies of the main organs of the body. The basic experiences to be chosen will take into account the age and social background of the children; this part will be worked out by the experts of the working group (experts in medical issues, child psychology, etc.), in collaboration with the teachers.

Elaboration of the Modules
Each Module will be articulated around the following guidelines:

- identification of the vital functions, such as movement, nutrition, circulation of the blood, respiration, etc, to be illustrated in relation to the core experiences defined above, making reference, when possible, to healthy life styles;
- identification of the criteria to be applied to assess at each step the results of the learning process.

Elaboration and production of teaching support material
Once the teaching objectives for the programme are established, the material considered to be useful in the teaching and learning process is prepared, as needed for simple experimental activities to be performed in class as well as for dramatization activities. Special attention is paid to the identification of simple techniques to be used for the production of such material, so that it can be autonomously produced by the pupils to further stimulate their active participation in the learning process.

Training of the teachers
In each class the teaching activities pertaining to the programme are run by one or possibly two of the normal teaching staff. Meetings between project working team and teachers will be focused on the following objectives:

- to present and discuss the Modules;
- to adapt the Modules by taking into consideration the previous experience of the teachers;
- to provide teachers with guidelines and documentation.

Presentation of the project to the families
A meeting will be held between teachers and parents at the beginning of the school year and every other month, to stimulate the families' participation in the learning process.
Implementation of the planned teaching activity
The training activity is planned to be run by two members of the regular teaching staff for each class. In addition, the staff will be guaranteed constant monitoring and technical assistance by the

project's working team. A total of approximately 40 hours of teaching activities per school year has been assigned to the project.

Assessment of results
Assessment of the results will be organised as follows:

- assessment of the level of learning achieved by the pupils, based on comments on teaching activities recorded in the log book;
- meta-analytic evaluation of possible improvement of the kids' level of knowledge on the matters covered by the programme and of their abilities to argue, to infer, and to draw conclusions;
- evaluation of the level of appreciation and of any constructive criticism by the teaching staff, the management of the school and by the pupils parents.

Public presentation of results
At the end of the project a meeting is to be held to present to the general public the results obtained.

Project timeline

The programme of the project is going to be developed in three phases during the five years of Primary School:

First phase - Reading the 'book of one's own body' (Years 1 and 2 of compulsory school).
The teaching Modules included in this phase were designed to introduce the children to guided observations of the human body structure and functions (perceptible anatomy and physiology) at an elementary, but scientifically accurate, level. In this phase teaching strategies will be aimed to elicit questions by the pupils based on their everyday experiences, that can be answered with evidence-based arguments. An additional aim is to increase children's awareness of the relationship that links their physical and mental state to the environment where they live.
The programme outline of this phase is as follows.

Year 1

Module 1. Us and The Environment (relationship between the individual and the physical and social environments in which we live)

Module 2. The Human Body and Movement (general configuration of the human body, locomotor apparatus and movement).

Module 3. Relations and Exchange between Man and the Environment (what goes in and what comes out). This module is articulated into sections regarding respectively the journey of air (respiratory apparatus) and the journey of food and drink (digestive system).

Year 2

Module 4: The Heart and Blood Vessels (functional morphology of the circulatory system)

Module 5: The Brain (the journey of nervous signals)

Second phase - Learning through an experimental approach the fundamentals of anatomy and physiology. (Years 3 and 4 of compulsory school).

The program develops new and previously treated topics, taking advantage of the knowledge, the ability to observe and the learning by playing that the children have acquired during the first two years. Teachers will help children in their search for explanations through simple, but "scientific" experiments. Teaching will include, when required, audio-visual media, drama etc.

The programme outline of this phase is as follows.

Year 3

Module 6. The senses

Module 7. The nervous system: the journey towards knowledge, the executive functions

Module 8. From big to small: the cell (part 1)

Year 4

Module 8. From big to small: the cell (part 2)

Module 9. Birth, growth and defence mechanisms of the organism

Third phase - Risk factors to health and how to tackle them. (Year 5 of compulsory school).

The phase that is going to conclude the course will be focused on making the pupils aware of risk factors and behaviours, information that is generally considered as a prerequisite for active health protection and for primary prevention.

The programme outline of this phase is as follows

Module 10. The health risk factors (infectious, degenerative and accidental, toxicological risks). Getting and maintaining a healthy life (risk factors and how to deal with them). Well-being in our physical and social environment.

Activities carried out in previous phases

In a preliminary phase (2011-2012) the following activities were conducted:

- elaboration of a general framework of the project;
- presentation of the project to Italian institutions (Accademia dei Lincei; Accademia Medica di Roma) and to international academic institutions **(**Executive Committee of the Inter Academy Medical Panel - IAMP);
- definition of a protocol agreement with the Lazio Regional Educational Authority (URS Lazio) for the preparation of an experimental project to be delivered in a school in Rome, Istituto Comprensivo Luigi Settembrini;
- definition of a protocol agreement with the school authotities of the Istituto Comprensivo Luigi Settembrini to run the project activities in four Year 1 classes in the institutes in Via Asmara and Via Novara, all pertaining to the same Institute.
- presentation of the project to Fondazione Roma - Terzo Settore that succeded in obtaining the necessary co-funding to run the Year 1 class activities (school year 2013 – 2014);

For the first year of the project (school year 2013-2014) a teaching curriculum was prepared and implemented in four Year 1 primary

school classes. These activities were reported in various documents prepared for the Fondazione Roma-Terzo Settore, and were detailed in a publication (in Italian and English) printed in October 2014 in which the following aspects of the programme were considered:

1. Didactic programme, articulated in the following Modules: *The Environment and Us* (Concept of environment and conditions for environmental well-being); *The Human Body and Movement* (General structure of the human body and the observable functional anatomy of musculo-skeletal apparatus); *Relations and exchange between Man and the Environment* (What goes in and what comes out);
2. Training activities for teachers;
3. Assessment of results;
4. Final Report on all activities completed.

TEACHING CURRICULUM FOR YEAR 2 PRIMARY CLASS

The teaching curriculum for the Year 2 primary class (school year 2014 – 2015) was prepared as a natural continuation of the activities performed during the previous year, and adopting the same didactic methodology.

Continuing the experience of the previous year's activities, teachers again were actively involved in the preparatory phases of the programme. Indeed, their consolidated understanding of the project's methodological approach was invaluable in the preparation of the project.

Regarding contents, it was considered appropriate to continue developing the functional and "perceptible" anatomy, or what is directly observable by the children. This new programme was divided into two teaching Modules respectively concerning the circulation of blood, and general/elementary concepts on the nervous system. The latter Module will be further developed during the third year of the programme.

Two Modules, for a total of 40 working hours per class, were delivered to each of the four classes:

Module 4: *The Heart and Blood Vessels* (functional morphology of the circulatory system)
Module 5: *The Brain* (the journey of nervous signals)

The contents of these two modules are detailed in the following sections.

MODULE 4: THE HEART AND BLOOD VESSELS (functional morphology of the cardiovascular apparatus)

Identification, evaluation, and sharing of common daily experiences of children

The following section lists everyday experiences which can be referred to in the preliminary phase to stimulate the active participation of the children when delivering this module. Additional similar experiences can be identified by the teacher when interacting directly with the children.

The presence of the beating heart and the sight of blood have strong emotional connotations for everyone, especially children. The heartbeat is associated with life and powerful emotions, e.g. falling in love, which in everyday speech and in literature is associated with the heart. In families with elderly persons, the heart is a likely topic of discussion, especially in cases of poor health or persons undergoing medical examinations (electrocardiogram, cardiac echocardiography, blood pressure measurement), or other cases in which special dietary or exercise regimes are followed. Blood is also associated with pain, danger, and death: visible blood is an indicator of an emergency situation. Most children are familiar with bleeding

following a minor injury, which stops by forming a scab or crust. An increased blood flow to the face causing blushing can indicate various emotional states (shame, shyness, anger), symptom of illness (such as a temperature), strenuous physical activity, or a reaction to excessive heat. In everyday language we also hear that certain foods "thicken the blood" or, as a remedy against anaemia "one should take iron" (which is found in the red blood cells).
Before starting the module the teacher should elicit some of these common situations and everyday life experiences which are related both to well-being and to illness.

1. TEACHING OBJECTIVES

Through guided observation of directly observable structures and functions, this Module aims to create an elementary level of awareness in the children of the general conformation of the cardiovascular apparatus, and the functions of the heart, blood vessels and blood.

On completion of the Module, the students will:

- understand that oxygen contained in air is an indispensable element for life, and is transported by the blood to every part of the body;
- be aware that blood is continually in motion and reaches every part of the human body by a system of tubes (blood vessels), through the action of a pump (the heart) which continues its involuntary function during our entire life;
- be aware that blood is present in every part of the human organism as it transports substances vital for life to all tissues (nutrients and oxygen) and eliminates waste products (such as CO_2).

2. SUBJECT MATTER

The subject matter of the various sections of this module are described below (in **bold**, concepts and notions to be transmitted; in *italics*, experiences to be used in the inductive teaching activities).

THE AIR AND OXYGEN

The atmosphere that surrounds us contains substances that we cannot see. These are known as gases. There are different types of gases and they have different weights.

- *Elicit from the students some common knowledge of the gas stove used for cooking. What is it that comes out of the gas ring and can burn? (gas, which cannot be seen, but it is present, since it can burn);*
- *Experiment by comparing a balloon mouth-inflated and another inflated from a helium gas canister (why does one falls to the ground while the other floats? Because they have been inflated with different gases: the first with expired air; the second with helium, which is lighter than air);*
- *Ask the children if they know the names of any other gas.*

Air is found in the space that surrounds us. Even if we cannot see or touch it like a solid object, it is still there.

- *Show the children a picture of someone flying with a hang glider. How does this person manage to slide through the air without falling to the ground? What is it that holds the hang glider up? (air);*
- *Observe a leaf falling from a tree, or a light sheet of paper falling to the ground. Why do these two objects fall slowly towards the ground? (because they are held back by air);*
- *Experiment blocking the tip of a syringe with a finger, which blocks the piston (the syringe is only apparently empty: ~~but~~ the air inside the syringe blocks the movement of the piston).*

Air is impalpable and invisible, and is made of various gases. One of these gases is oxygen, and another is carbon dioxide which is much less abundant.

- *Call the children's attention to some of the concepts acquired in the previous year's module regarding the respiratory apparatus; elicit from them what they know regarding oxygen and carbon dioxide;*
- *Repeat the experiment of the candle which is extinguished under a glass dome (see Module* "What goes in and what comes out" *delivered the previous year, and also Fig. 1*). *Why does the candle go out? (because the flame uses up all the oxygen in the air inside the dome; a flame cannot burn without oxygen). Why does the water in lower container rise up inside the glass? (because it takes the place of the oxygen that has been used up);*
- *Repeat the experiment which demonstrates how water containing a pH indicator changes colour when we blow into it (see Module* "What goes in and what comes out" *delivered in the first year). Why does the colour change? (because the expired air contains carbon dioxide which makes the pH indicator change colour).*

Air is a mixture of various gases, including oxygen. Oxygen is indispensable for the survival of humans and animals. Humans cannot survive in the absence of oxygen.

- *Ask the students to make drawings of astronauts, deep-sea divers, or show them some photographs. Why do astronauts have to wear helmets? (because there is no air on the moon, unlike in the Earth's atmosphere). Why do deep-sea divers have to wear a helmet attached to a tube? (because underwater there is no air, and therefore it has to come from outside). What is in the astronaut's helmet, or in the tube and helmet of the deep-sea diver which lets them survive and work? (air, which contains oxygen, something that is vital for life. Without oxygen animals and plants die);*

- *Show the children some photographs of skindiving underwater hunters. Why do these skindivers stay underwater only for short time and then come to the surface? (Because there is not enough oxygen underwater, and human beings die unless they have enough oxygen);*
- *Ask the children if they think they continue breathing when asleep (respiration is an automatic function which continues even during the sleep phase);*

Fig. 1

- *Ask the children how certain living organisms are able to survive in the sea and rivers (because water contains dissolved oxygen, which allows certain animals and plants that have adapted to the aquatic environments to live there. Due to its conformation, the respiratory passages of human beings are not able to use the oxygen dissolved in water).*

THE JOURNEY OF OXYGEN

Liquids can contain gases. This means that gases can pass from air to liquids, and from liquids, they can return to the air.

- *Experiment showing that by opening or shaking a bottle of sparkling mineral water, gas is liberated, making bubbles;*
- *Experiment of making bubbles by blowing air through a straw into a glass of water. What are these bubbles made of in this experiment? (air – a mixture of gas – which comes out of the water). When a gas is released from water, does it always make bubbles? (No. It makes bubbles only if there is a lot of gas. If there a little gas, then it can be released without making bubbles).*

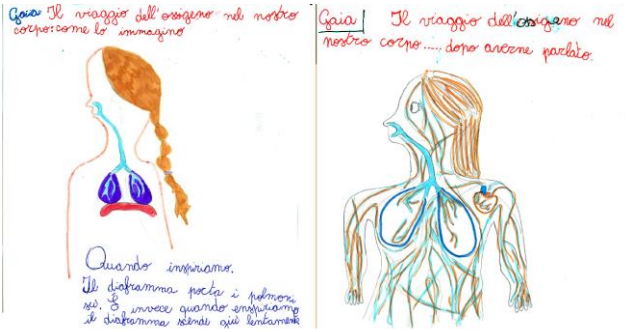


Fig. 2

At the level of the lungs, the oxygen in the air that we breathe passes into the blood, which carries and releases it to the rest of the organism. In the opposite direction, the carbon dioxide from various parts of the body, passes into the blood and is carried to the lungs, where it is released into the air that we breathe out.

- *Show the children a diagram of the gaseous exchange in the lungs, and elicit their ideas regarding the journey of oxygen through our bodies (Fig. 2).*

THE BLOOD VESSELS

The blood vessels are little tubes which are present in every part of our bodies, and are visible to the eye when near the surface.

- *Ask the children to identify blood vessels in the inner part of the forearm, at the fold of the elbow, on the back of the hand, on the sclera, and in the earlobe lit from behind with a handheld torch;*
- *Ask the children to look for other blood vessels on the skin;*
- *Show angiographic images of blood vessels within the body;*
- *Tie a tourniquet around the upper arm to show the veins in the area of the inner elbow;*
- *Likewise, examine a large deciduous leaf against the light to identify the various ramifications of the vessels that transport lymph to the rest of the plant (also plants have vessels which contain liquids).*

Blood vessels contain a red liquid which is known as blood.

- *Ask the children if they can recall any experiences of a change of colour (blushing, paleness) in the faces of others (Fig. 3). What are these changes due to? (To a greater or lesser flow of blood to the face caused by emotional states such as fear or embarrassment, or to particular physical conditions such as temperature or physical exercise);*
- *Ask the children if they have ever seen human or animal blood;*
- *Ask them if they can remember any accident of someone cutting themselves. What happens after the cut? (you can see blood);*

Fig. 3

- *Ask the children where the blood is found within the human body (within the blood vessels, which are present throughout the entire organism);*
- *Ask the children is they have ever seen a nurse taking a blood sample. Where is it taken from? (in the area of the inner elbow). Apply a tourniquet to the upper arm and show the children how the blood vessels become visible in this area. With the needle of the syringe, the nurse perforates the walls of one of these vessels and sucks out the contents.*

The blood contained within the blood vessels is always moving.

- *Ask the children if they think the blood in the human body remain still or is always flowing;*
- *Experiment by listening to the noise made by a liquid flowing rapidly through a tube (and therefore, if blood flows then we should be able to hear a similar noise in blood vessels by listening through a phonendoscope);*
- *When listening to the blood flow with a phonendoscope in a certain area of the wrist, you can hear the noise made by the blood flowing through the radial artery;*
- *Applying a tourniquet around the upper arm (makes the veins swell because the flow of blood toward the heart is blocked).*

THE HEART

The heart is found in the thorax, between the sternum and the vertebral column.

- *Show the children: an animal heart bought from a butcher (e.g., a pig heart which is similar in size to the human heart, Fig. 4), as well as a radiographic image of the cardiac area and a model of the heart;*

Fig. 4

- *Discuss with the children its form and dimensions (similar to that of a clenched fist);*
- *Using the diagram of the human body, ask the children to identify the area of the heart;*
- *Teach the children how to listen to the sound of the heart using a phonendoscope at a point to the left of the sternum and a little below the nipple: the heartbeat is caused by the apex (or lowest part) of the heart beating against the wall of the thorax (Fig. 5).*

- 


Fig. 5

By contracting and relaxing, the heart acts like a pump which makes the blood flow.

- *Ask the children how the heart is able to push blood along the blood vessels (it is able to push the blood because it is a muscle which, when contracted, acts like a pump);*

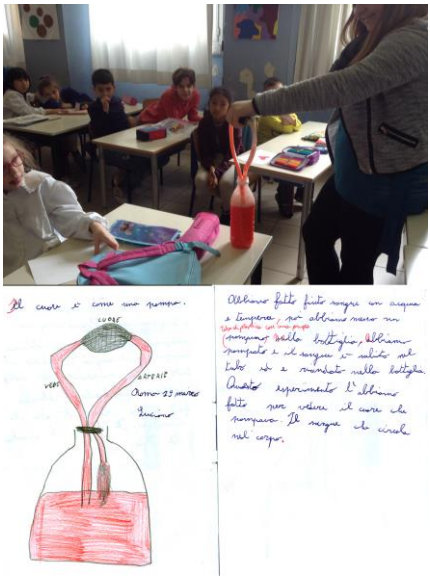


Fig. 6

- *Exemplify the concept of a pump by using a small pump used to pump fuel in small outboard motors* (see, Teaching support materials and Fig. 6).

The blood vessels leave the heart and reach all parts of the body to then return to the heart.

- *Show and comment this concept using an elementary diagram of the vascular tree. Some blood vessels (arteries) start from the heart, and then progressively branch out into smaller and smaller vessels to form the smallest vessels (capillaries) at the level of the organs; as they return to the heart, they join up again to become bigger and bigger (veins)* (see, Teaching support materials).

Pushed by the pumping action of the heart, blood travels through the lungs where it liberates carbon dioxide and is enriched with oxygen, to then return to the heart which then pumps it to the rest of the organism.

- *See if the children can recall information from the previous year Module on the respiratory apparatus: every time we breathe in, the oxygen contained in the air is released into the blood; every time we breathe out, the air takes away the carbon dioxide which is a waste product made by our bodies. After passing through the lungs, the blood - now rich in oxygen and poor in carbon dioxide - returns to the heart to be pumped to the rest of the body. In the peripheral parts of the body, the blood releases oxygen and nutrients to the various organs, and picks up carbon dioxide, and then returns to the heart. Once it reaches the heart, it is pumped to the lungs where it is enriched with oxygen and gives up its carbon dioxide, then it returns to the heart, to be then pumped to the rest of the body once more. The repetition of this process allows our organs to continually receive oxygen from the air and other nutrients from the food that we eat. This allows the organs to be able to function. Burning nutrients received from food with oxygen gives our organs the energy to carry out their specific activities such as*

thinking, running, or digestion. Just like the candle that needs oxygen to function/burn, our bodies also need oxygen for our vital functions. Without oxygen we also stop functioning/die (see, Teaching support materials, role-play: "The journey of blood").

The pumping action of the heart is an involuntary function and it is fundamental for life.

- *Help the children do the following: locate their own hearts, feel the sensation of its beating by placing their hands or a phonendoscope on the chest;*
- *Show the children how the heart's function (making blood to circulate throughout the body) can be felt even at a distance from the heart: help them palpate their radial artery on the inner part of the wrist on the side of the thumb;*
- *While listening within the phonendoscope, ask them to try and voluntarily stop their heartbeat. (it is impossible; the heart continues to beat throughout our life, independently of our volition);*
- *Ask the children what happens if the heart stops (we die immediately);*
- *Ask the children why we die when our heart stops (because blood is no longer pumped throughout the body, and therefore does not circulate. That means that those substances that are vital for life such as nutrients and oxygen, cannot reach our organs).*

The pumping activity of the heart can be accelerated or slowed down depending on the organism's need for nutrients and oxygen.

Carry out some activities to consolidate these experiences using volunteer children by measuring with a chronometer their heartbeat and rate of breathing over a period of 30 seconds. This should be done before and immediately after undertaking some significant physical exercise (physical movement increases the heartbeat and the rate of breathing);

- *Ask the children to interpret this phenomenon: Why does the heart increase its pumping activity when we undertake physical activity (to send more blood to our muscles);*
- *Ask the children why blood has to circulate faster when we undertake physical exercise (because when we work intensively, or muscles need more oxygen and nutrients);*
- *Ask the children why our rate of breathing also increases. (to supply more oxygen to the blood during exercise when it passes through the lungs).*

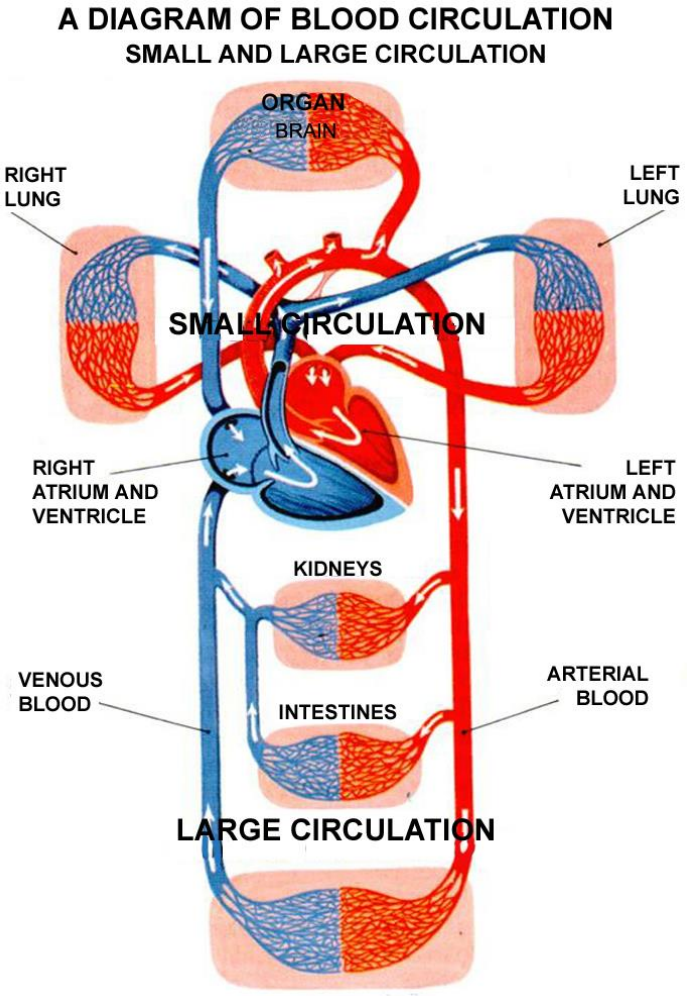
Blood also transports nutrients contained in the food that we eat, and which are absorbed into the blood from the intestines.

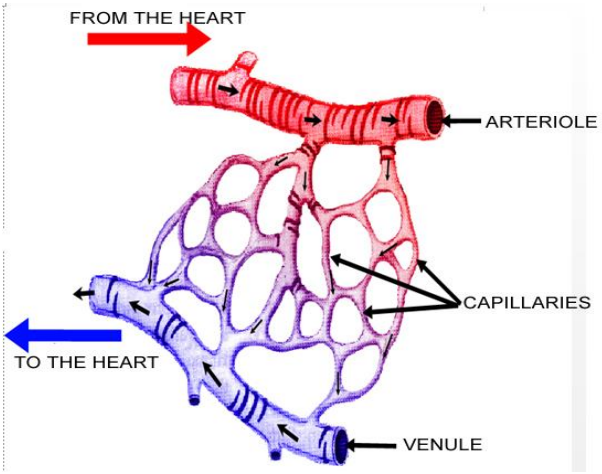
- *Ask the children what other substance apart from oxygen must be carried by the blood to our organs so that these can function correctly (nutrients);*
- *Ask the children where the nutrients contained in blood come from (they come from the food that we eat; these are digested and are absorbed at the level of the intestines);*
- *By interacting with the children, re-elaborate notions acquired from the previous year's module dealing with the gastrointestinal tract "What goes in and what comes out": Nutrients and oxygen are fundamental to allow organs like the brain, kidneys, muscles, respiratory apparatus, digestive system, and many others to grow and carry out their activities. This means that our brain can think, our intestines can digest and absorb the nutrients present in the food we eat, and by contracting, our muscles allow us to move and walk.*

3. TEACHING SUPPORT MATERIAL

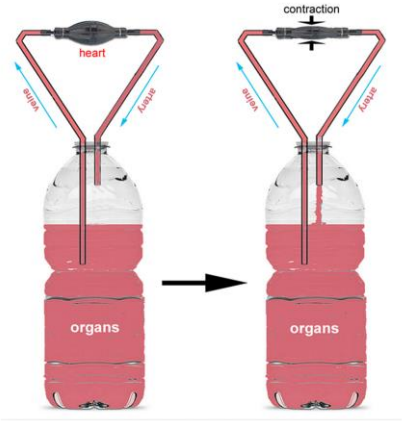
- Plastic 5 ml syringe without needle (five per class)
- Pictures of astronauts and deep-sea divers
- Pictures of underwater skindiver hunters
- Pictures of people flying with hang gliders
- A diagram of gaseous exchanges at the level of the lungs

- Selection of pictures (see following examples) showing the circulation of blood and the branching of the arteries, the progressive reduction of the calibre of the blood vessels down to capillaries





- Angiographic scans
- Mammal heart (preferably a pig, bought from a butcher)
- Three-dimension model of a heart (assemblable)
- Chronometer (a smartphone application is sufficient)
- Portable petrol pump, transparent tubes attached to each extremity, a transparent bottle (partially filled with water coloured with red tempera paint)

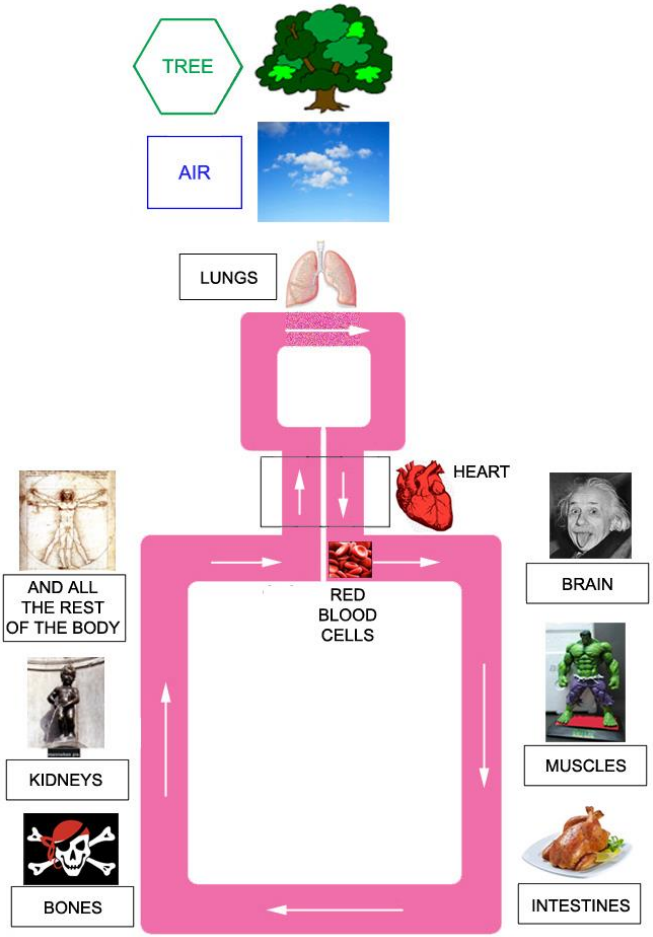


- One electronic phonendoscope for each school, complete with a bottle of non-irritant disinfectant, and swabs to clean the earpieces
- Haemostatic tourniquet
- Balloons
- A solution containing a pH indicator (e.g. a phenol red solution) to reveal the presence of CO_2 present in the expired air
- Handheld torch to experiment the visibility of the capillaries
- Large deciduous leaves
- Radiographic image of thorax showing the outline of the heart
- Sheets of white paper (more than 1 metre length) on which to draw the outline of a child using a thick black marker pen
- 20 ml syringe (without needle), one plastic cup, water (for the experiment "air occupies space")
- Kit for the candle experiment, containing a glass container, six coloured candles, a plastic tray
- Kit to grind and sieve, composed of: mortar with wooden pestle, a metallic sieve with handle
- Kit to make aqueous solutions and composed of: transparent 200 ml plastic cup, a packet of plastic tea spoons, 1 kg of coarse salt, 500 gr. of brown sugar, some tea bags (or camomile).
- some packets of crackers

Material for the role-play "The journey of blood":

- paper masking tape to mark out on the floor the journey of blood
- 8 boxes (shoe boxes or similar), to represent the organs (to contain polystyrene balls)
- 3 different sized boxes to represent the air, a tree, and a store
- about 20 small boxes for the RBC-children (Red Blood Cell) and organ function-children
- about 10 images of RBC and two images of each organ
- at least 150 small white and as many polystyrene balls (diam. ~2,5 cm) (or two different colours), to represent O_2 and CO_2.

- alternatively, these balls can also be made from *papier maché* by the children themselves using pieces of white absorbent paper (15x15 cm), newspaper-type, dampened with glue (Vinavil or wallpaper glue, diluted with water based white or blue colouring), then rolled into a ball and left to dry for a couple of days. Or these can be prepared by the teachers using a paste made of flour, water and salt (e.g. see https://www.youtube.com/watch?v=qUKB5ajIeCU).



Role-play: "THE JOURNEY OF BLOOD THROUGH THE BODY"

The above diagram summarising the activity "THE JOURNEY OF BLOOD THROUGH THE BODY", represents the path of the blood vessels that should be followed by the children. Each child following the pathway plays the role of a RBC.

Preparation

Lay out on the floor (using the paper masking tape) the route that the children will follow.

With safety pins (or a strong two-sided adhesive tape), attach to the chest of each child the image representing the role that they will play in the activity. Some examples are indicated at the end of this document, but the teacher may also find better ones.

Two children representing the HEART are placed at the crossroad of the large and small circles (representing respectively the systemic/large and pulmonary/small loops) and have the role of pushing (with care!) one by one the RBC-children in two opposite directions: one towards the lungs and the other towards the rest of the body. To render this activity clear and useful to the pupils, they should clearly understand the meaning of what they are doing; the activity must be conducted with calm, and the children should progress slowly along the pathway.

Along the route, a series of boxes labelled "LUNGS", "BRAIN", "INTESTINES", etc., are placed (see *diag.)*. A child representing each of these organ stands behind these boxes: the Brain-child reading, the Intestine-child eating crackers, the Muscle-child flexing muscles, etc.). [**n.b**. *1*. Teachers should avoid placing an overweight child to represent the intestines. *2*. Tell the Lung-child to breath normally (without increasing the normal rate), as hyperventilation could create problems for the child. *3*. The AIR box: this is the largest box of all, and is passive or inert. Depending on their needs, both the lungs and the tree exchange gases with this box, therefore no child is needed to represent The Air].

On starting the activity, the LUNGS, AIR and TREE are filled with the balls (mainly white to represent oxygen), while the other boxes will contain mainly blue balls (representing carbon dioxide). All remaining balls (mostly white with a few blue) are placed in the AIR box.
It is important that each child is informed on the general significance of the activity (also the fundamental role that plants play in the cycle of oxygen), and that they understand their individual roles.

Start of Activity:
For each cycle, do not use more than 6 RBC-children: each child will be given a small box to hold, with six oxygen balls (white) and they start their journey from the heart towards the brain. The second child starts out from the heart only when the first child leaves the brain, and so on). To oxygenate the brain, the RBC-child takes from the BRAIN box a blue CO_2 ball and replaces it with a white one (see Note 1 below). The child then continues along the pathway to supply oxygen to all the organs, and then return to the heart with six blue balls. At this point, the same child is pushed by the heart into the pulmonary loop (small circle) towards the lungs, where all CO_2 balls are to be replaced by O_2 balls.

The LUNG-child, by his/her respiratory activity, removes the blue balls from the RBC and exchanges them with six white balls taken from the AIR box.

The TREE-child takes the blue balls from the AIR box and substitutes them with white balls.

NOTE 1: *The RBC-children arriving from the lungs and therefore "oxygenated" progressively exchange their white balls with the blue balls present in the six ORGAN-boxes that they meet during their journey (brain, muscle, intestines, bone, kidney, rest of body)[in other words, they give up their oxygen and pick up carbon dioxide] (one ball at a time, so that they can "fill up" with oxygen all the organs that they come across. They return to the heart loaded with carbon dioxide and are pushed once again by the heart to the lungs where they are oxygenated (= exchange of blue balls with white ones) and then the cycle starts once again (or stops, to be repeated*

with six different children). In any case, before starting the cycle again, the entire system must be reset (blue balls in the organs etc.).

NOTE 2: *This flow of balls as described will cause a progressive accumulation of the blue balls in the tree. The teacher will explain that in nature, trees and to a lesser degree other plants pick up carbon dioxide from the atmosphere and use it for their own vital functions, producing oxygen (and other nutrients for animals and other organisms). Due to the action of trees, the atmosphere is enriched with O_2 and liberated from excess CO_2, which would provoke overheating of the atmosphere (what we call "the greenhouse effect"). So the children will understand that trees are vital for life on our planet, and therefore must be respected and protected. Because of their function, forests are sometimes known as "the lungs" of the earth.*

To ensure a smooth ongoing of the activity, the teacher should carefully monitor the correct flow of the balls.

MODULE 5: THE BRAIN
The Journey of Signals

Identify and discuss common daily experiences, share these between the children.

When teaching this Module, the teacher should make reference to the children's own experiences. What experiences do the children have regarding the brain, and the nervous system? What messages do they receive from adults and the media? "... something done without thinking", "use your brain (when doing something)", "to have your head in the clouds", "to lose your mind".

Point out to the children that in common speech, the word *head* is used as a synonym of *brain* (in the sense of attention, concentration). "Be careful not to hurt your head, because that's where your brain is". "If you stand on your head, blood goes to your brain." Remind the children of sentences regarding their state of well-being: "to be nervous", "to be highly-strung".

Ask the children "What part of our body makes the decision to carry out certain movements?", "What makes our muscles move?", "Who commands our whole body?", "What tells us to do something?", "The brain knows what to do?", "Eyes see, ears hear, but ***I*** see, ***I*** hear… how?", "The brain tells you how".

Elicit from the children their experience with intent, voluntary actions, and their own identity as a person that can be in contrast to the wishes of others, that desires and can achieve what one wishes. "Can one oppose something that one does not agree with?", "Where does this decision come from?", "Am I the same thing as my mind?". Make the children be aware that they can have thoughts, memories and ideas, that "ideas come to mind" and "are kept in the mind, like lots of little drawers", that "I think and can formulate my idea".

1. TEACHING OBJECTIVES

The object of this Module is to create an elementary level of awareness in the children of the general function of the brain and the sense organs, through the guided observation of structures and functions which are directly observable. This module is organised in different phases. The first phase will be delivered to Year 2 primary school pupils and regards ***sensory perception and the brain.*** The second phase will be delivered to Year 3 primary school pupils and deals with *the five senses of the functions of the brain.*

Sensory perception and the brain.

On completion of the module, the pupils will:

- understand that the brain receives signals coming from the external environment (through the sense organs) and the body.
- know that the brain is contained within the cranium and extends caudally in the organism as the spinal cord, which is contained within the vertebral column; know that the brain and the spinal cord are delicate organs, and so are protected respectively by the cranium and the vertebral column;
- know that the brain is composed of various parts responsible for different functions;
- understand that the brain is a command centre which regulates the body's voluntary and involuntary functions (the latter being actions undertaken automatically, without any conscious intervention); comprehend that through the integrated activity of its various parts, the brain permits our bodies to undertake a number of coordinated actions;
- understand that the brain is made up of billions of cells, known as neurons, which are organised in complex networks regulating the various functional activities of our organism;

- comprehend that the brain and rest of the body are connected by bidirectional communication pathways that relay signals between the body and the brain.

1. SUBJECT MATTER

The subject matter of the various sections of this module are described below (in **bold**, concepts and notions to be transmitted; in *italics*, experiences to be elicited in the inductive teaching activity).

Sensorial perceptions

Awareness of the external environment is achieved through the perception of many different signals (visual, acoustic, tactile, olfactory, and gustative) which our bodies receive through our sense organs and other receptors distributed on our skin and in our internal organs. Visual signals found in the external environment such as street signs, warnings, advertisements, etc., also transmit information. Likewise, light, sound, certain chemicals (taste and smell), and mechanical stimuli (such as those from our tendons and muscles, which give us information about our bodies, even when our eyes are shut); our sense of feeling full when having eaten too much; our feeling of needing to go to the toilet, other stimuli caused by temperature or pain (pressure, cold–hot, pain), all reach our brain to give us information on our bodies and make us aware of the environment that surrounds us.

- *Ask the children to concentrate on specific sensory experiences through simple experiments involving single sense organs; this can be done by impeding signals from other organs (blindfolds, earplugs, etc.);*
- *Get them to recognise by touch, without seeing, common objects (a key, a ball), and less common objects (e.g. a*

potato), different materials (wood, metal) and different shapes contained within a paper bag;

- *Get the children to identify one of their classmates simply by touching their head. Get them to recognise a classmate or teacher only by the voice, etc.. Get them to follow a particular pathway using only verbal instructions;*
- *Get the children to experiment how many different types of signals are necessary to correctly identify our surroundings. (being aware of their presence in their own classroom is mainly through visual signals, but in the absence of these – either in the dark, or with the eyes closed – other signals can also help to identify where they are; for example, the voices of the classmates, recognising the desk through the sense of touch, etc.);*
- *Get the children to experiment how multiple and different signals which are perceived simultaneously are normally used to identify our environment;*
- *Ask the children to think of when a signal reaches a specific sense organ, it might not provide sufficient information (e.g. when a voice is not heard because our attention is focused on something else such as a video game, or if we are sleeping. This lack of perception, however, is not due to the non-functioning of the ear. Indeed, if this sound were to become louder or perhaps menacing, then we would be able to hear it: "turn that iPad off immediately, if not I'll get angry";*
- *Ask the children to reason that the world that surround us appears to us not for what it is, but for how we are able to receive and interpret its signals and messages in that particular moment;*
- *Ask the children to think about how experience can influence the interpretation of a signal (the barking of a dog can*

induce fear if, in the past the child has been bitten by a dog, or even pleasure if the child is used to playing with dogs);

- *Let the children explore how the simultaneous perception of more than one signal can help give a more accurate interpretation of the surrounding environment (if in addition to the sound which lets us perceive the presence of a dog, there is also visual input allowing us to see the dog, we may get a more precise interpretation and can understand whether we are dealing with a situation of danger or pleasure);*
- *Simulate with the children how to pay attention to signals that come from inside our bodies which can help us take care of ourselves and to avoid "making mistakes" because we are distracted by what we were doing, or we are thinking or desiring something else.*

What is the brain like?

The brain is a precious organ, vital for life and protected by the cranium which is a bony shell which gives the head its shape. The brain is soft, and is made up to 80% water. As it is so important and fragile, the brain is additionally protected by a layer of liquid and a membrane which act as a cushion between the brain and the bony cranium. The brain extends as the spinal column, which is also very fragile and enclosed within a bony structure—the vertebral column—which can be felt down the centre of the back.

- *Ask the children to imagine where the signals from our sense organs go to ("What is the brain like?, What happens to signals that arrive from the eyes, or the ears?". "Do they stop in the eyes or ears or do they continue their journey through the body? Is it our ears that tell us to cover them with our hands if there is too much noise? Is it perhaps*

another organ that receives these sound signals and tells our hands what to do?"

- *Ask these questions to the children, guiding them towards identifying answers "What do we know about our brains?". "What else would you like to know about your brain?" Make a list of the ideas that they present.*
- *Ask the children: "Where is the brain located?"*
- *Give the children lateral view drawings of a head, a cranium, and a brain of similar dimensions so that they can be placed on top of each other.*
- *Ask the children to touch their heads: "Is it hard or soft? What consistency do you think it has? Is it like wood?*

Fig. 7

- *Let the children touch the brain of a lamb (fig.7). "What does it feel like; a milk pudding? But if it is so soft, why is the head so hard?. Why do we use a crash helmet when we go on a motorbike or bicycle, or when workmen are on a*

building site? Why do we have to protect our brain?" Help children understand that we have to take care of our brain.

- *Ask the children if our brain is heavier than an apple, or a watermelon. (It weighs about the same as a balloon filled with water. Let the children feel how heavy it weighs. Compare the weight of the brains of different animals, e.g. whale). Make them understand that a bigger or heavier brain does not necessarily correspond to greater intelligence. (see Teaching Support Materials).*

The brain is made up of three parts: a) the two hemispheres (one on the right and one on the left) which are joined, and which make up the largest part of the brain; b) the cerebellum, and c) the brainstem which continues as the spinal column.

- *Get the students to assemble and disassemble the three-dimensional model of the brain.*

The surface of the cerebral hemispheres is not smooth and shows many folds (known as gyri).

- *Show the children the brain of a lamb bought from a butcher shop (Fig. 7);*
- *Ask the children to study the form of the hemispheres and how it can it host billions of neurons (they can host so many cells because their surface is increased by multiple pleats, the gyri). Compare two sheets of paper, one with multiple pleats and the other flat. While these two sheets cover the same area, the pleated one will provide a largest surface (see Teaching support materials).*

The hemispheres continue with the brainstem, which in turn continues as the spinal cord which runs along the entire back of our bodies. Being a very delicate organ like the brain, the spinal cord is also protected by a bony casing, the vertebral column which is formed of many little, aligned bones or vertebrae.

- *Ask the children to the feel the vertebral column of a classmate;*

- *Show drawings, and if possible, X-rays images of the vertebral column (see Teaching support materials)*

Each part of the brain has a different function. Introduce the concept of voluntary, and involuntary or automatic activities.

- *Ask the children to hypothesise regarding the functions of the various parts of the brain;*
- *Help the children understand that the brain is also responsible for thought; for the sensations we receive from the external environment, for our voluntary and involuntary movements (give each child a copy of the diagram "The brain" and get them to glue it into their workbooks).*

The largest part of the brain – the hemispheres – which lie directly under your hands when you touch your head, is the part of the brain that "thinks" but it is also responsible for learning, memory, sensations, emotions and it also makes our muscles move when we want them to.

- *Help the children to point with their fingers the hemispheres in the diagram and get them to colour them red.*

The other two parts of the brain regulate the involuntary or automatic activities of the body (such as heartbeat, digestion, respiration, coughing, and sneezing) and the coordination and efficiency of movements (when making complex movements such as swimming, dancing, skating, or trying to keep one's balance).

- *Ask the children if there are movements that they do automatically, without having to think; those things that are not controlled by the "thinking brain" or hemispheres. What are these activities?*
- *Ask the children to try to distinguish between voluntary and automatic activities (give each child a copy of the diagram "Children's Activities". Get them to cut out each of the diagram activities. Ask them to choose the automatic*

activities among those which are represented in the drawings (breathing, sneezing, coughing);

- *Ask them to choose from the cut-out diagrams what activities are connected to the "thinking brain" (reading, writing, speaking, seeing, painting);*
- *Explain to them that they have to associate to the red coloured area (the hemispheres) those activities which are under its voluntary control. Discuss the children's choices and ensure that they have understood that the different parts of the brain have specific functions. Finally get them to stick the pictures representing the various voluntary activities with glue or adhesive tape onto the coloured hemispheres.*

The brain is the command centre of the body. Through the integrated activity of its various parts, the brain lets our bodies carry out various coordinated actions.

- *Get the children to reflect that our daily life is made up of automatic and voluntary activities which are carried out simultaneously (e.g. the complex voluntary and automatic activities involved in running or swimming which involves respectively running and breathing, or swimming and breathing, and the series of single activities involved in a planned action (e.g. walking upstairs whilst holding something in the hands).*

As all of our organs, also the brain is made up of tiny little parts which are invisible to the naked eye and which are called *cells*. The cells that make up the brain are called *neurons*. Neurons are capable of receiving and sending signals and they are connected to each other.

- *Ask the children how a light bulb lights up when we turn on the light switch (the switch activates an electric signal which runs along the power cable to reach the light bulb). The signals generated by neurons can be compared to the*

electric signals which run along a power cable (show the children a piece of a single-wire power cable);

- *Show the children a schematic diagram of a neuron. Discuss why the branched and elongated shape of neurons is useful for them to carry out their function of receiving and transmitting signals, to communicate with other neurons, and with the organs in the body. (e.g., similar to the light bulb and the power cable, the nervous impulses created and transmitted by the neurons also have to reach the target and create a response).*
- *Reason with the children on the fact that a neuron has to reach a muscle to make it contract (just like the power cable which has to reach the light bulb to turn it on); Demonstrate with the battery connected by a piece of electric wire to a light bulb (see Teaching support materials) to show the children that the light bulb has to be reached by the electricity brought by the wire for it to light up.*
- *Explain that the brain is a very complex organ made up of billions of neurons connected with each other to form a network. Each neuron has a large number of connections. In certain areas (synapse) neurons are in contact with each other, and electrical impulses can pass from one neuron to another.*

How does the brain communicate with the rest of the body?

The body and the brain are connected to each other by nerve fibres.

Nerves carry signals from the body to the brain, and in the opposite direction as well, from the brain to the different parts of the body (Fig. 8). These signals travel along the nerve fibres which are bundled together to form nerves which, just like the blood vessels, are present in the entire body.

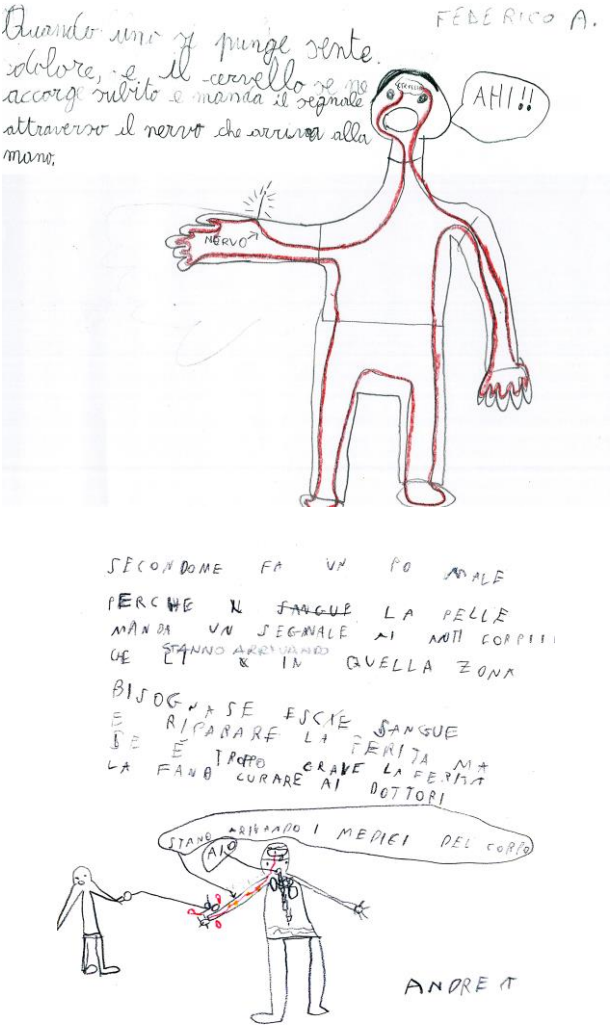


Fig. 8

Nerves carry signals rapidly from the various parts of the body either directly to the brain or indirectly via the spinal cord. Given that there are millions of connections between neurons and a dense nervous

network, an enormous number of signals reaches the brain; the brain receives and coordinates all of these signals and transmits signal to the body via the nerves to activate or inhibit movement or actions. *(give an example of the computer: with the keyboard we send signals to the printer which starts to function).*

Signals from the external environment reach the brain through the nerve fibres. *Develop this concept through the experience activity: "How do signals from the external environment reach the brain?"*

Nerve signals reach those organs that are controlled by the brain, e.g. our muscles are reached by nerve fibres that start in the brain and travel along the spinal cord. Other fibres travel in the opposite direction and transmit signals from the periphery to the brain. *Develop this concept through the Role-play "Voluntary motor activity".*

Background information for the teacher

The following information is given to the teachers with the aim to recall or refresh some basic information on the structure and function of the Central Nervous System (CNS). This information is not intended to be shared in class with the pupils, but to give background information that would give the teacher greater confidence when adopting a didactic methodology based on experimental evidence, as well as when answering questions that may be asked by the pupils.

The greater part of animals have a nervous system which is responsible for coordinating the organism's complex activities. In some more simple organisms such as the jellyfish, the nervous system is not organised in the form of a brain. This elementary structure permits only elementary but important actions which are vital for life and survival such as capturing prey, defence mechanisms and movement. Although plants do not have nervous systems, their cells are able to communicate with each other.

Sensory perception and the brain

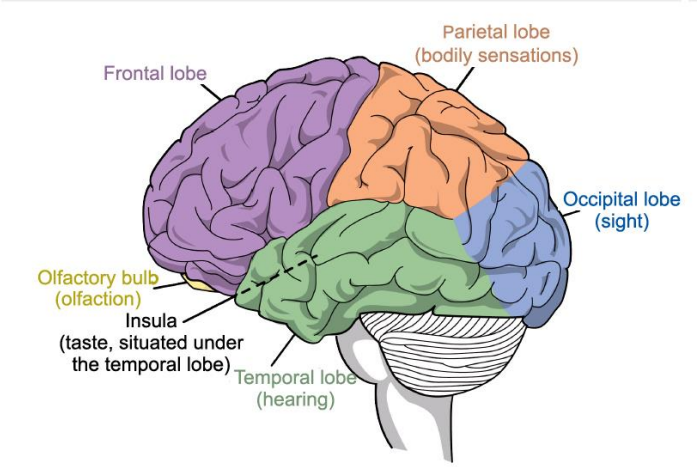
There are five senses: sight, hearing, smell, taste, touch. Signals or stimuli are received by the brain from the external environment to generate sensations. The ability to receive signals from the eternal environment and also from inside our

bodies, however, is not limited to to sense organs, but is diffused to the whole organism, due to the presence of micro sensors [nerve cell terminals or receptor cells]. Micro sensors present in the skin are able to respond to pressure, heat, and pain. Those present in internal organs can perceive tension (e.g. *via* musculotendineous junctions), the variation of acidity in the body fluids, and even other types of signals. Our bodies are therefore able to perceive other senses, such as equilibrium, temperature, and pain. The brain receives these signals, elaborates them and produces a response.

The brain, the most complex organ in our bodies, is part of a network/system**,** known as the Nervous System, which, through the nerves in the spinal cord, receives signals from every part of our bodies and at the same time send signals to different parts of our bodies, and from here to the environment.

What is the brain like?

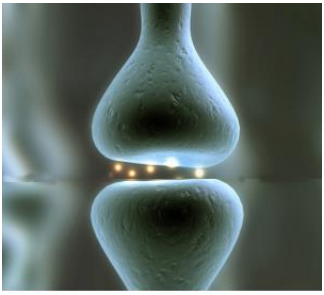
[N.B. the term *brain* is often used to indicate alternatively the entire contents of the skull cavity (which should be more correctly called *the encephalon*) or the brain hemispheres. For the sake of simplicity, we have used here the term brain as a synonym of encephalon].



The brain is the command centre of the body. It is enclosed within the skull and is covered by a bony vault which protects it and gives the head its shape. The brain is also protected by a liquid layer which acts as a cushion, and also by three thin but robust membranes known as the meninges. The brain is part of the nervous system, a cell network which ramifies through the entire body.

The brain is the most complex organ in our body. It can be divided into three parts: the cerebral hemispheres, the brainstem and the cerebellum. The two hemispheres, which form the largest part of the brain in mammals, are responsible for thought processes, learning, memory, language, sensory perception, emotions, and voluntary muscular contraction. The brainstem regulates the automatic functions of the body, such as heartbeat, digestion, respiration, coughing, sneezing. It is connected directly to the spinal cord. The cerebellum is located behind the brainstem. This organ helps muscles work in a coordinated and efficient fashion, and regulates the sequence of movements. It also controls our sense of equilibrium. The surface of the hemispheres (known as grey matter) is covered with a series of folds known as *gyri*, which are separated by furrows, called *sulci*. Such structural organization has the function of increasing the surface area of the hemispheres, allowing it to host more neurons. In various animal species, it has been shown that the greater the folding, the greater the intelligence.

It is important to remember that the brain, together with the rest of the nervous system, is essential to receive and interpret signals that arrive from the external environment and also from inside our bodies, as well as to communicate with the environment. What makes the brain so complex is that these billions of neurons are connected to each other in a network. Each neuron has a large number of connections. Such between-neurons connections occur at an area of contact (called synapse) across which the electric impulse passes to stimulate (or block) the function of the next neuron. At birth, the brain contains approximately 100 billion neurons which are progressively lost during life; this process is faster if these brain cells are not stimulated or used. Differently from other cells and tissues, no new neurons can be formed. Thus during life their numbers are progressively reduced as they die; this reduction in number is compensated by the adaptive capacity of neurons, especially at a younger age, consenting a certain plasticity and remodelling in the functions of the various cerebral areas. Infancy is the period when humans hve the greatest learning capacity.



SYNAPSE

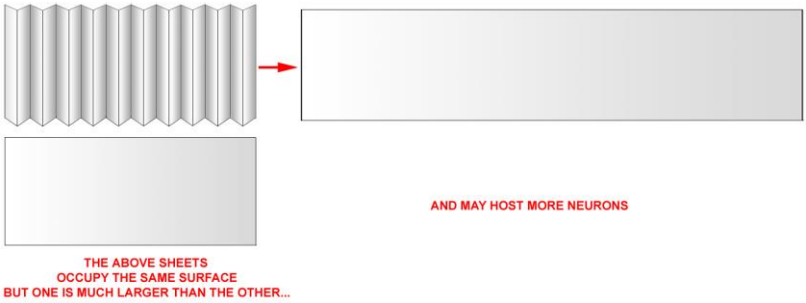
The ability to interpret what happens in our surroundings depends on the presence, in organs such as the eyes or the skin, of specialised cells (“receptors”, that is cells specialized to receive specific signals) and on the brain's capacity to interpret the significance of the information that it receives. To understand something about our sense organs we must first of all understand something about the “central command centre”, or brain. The activities that we are going to describe, to be conducted under the guidance of the teacher, will assist the children in starting to understand about the brain. It is suggested that the children work in pairs, and that each child should have a "HEALTH SCIENCES" workbook to keep all their drawings, collages and observations.

TEACHING SUPPORT MATERIALS

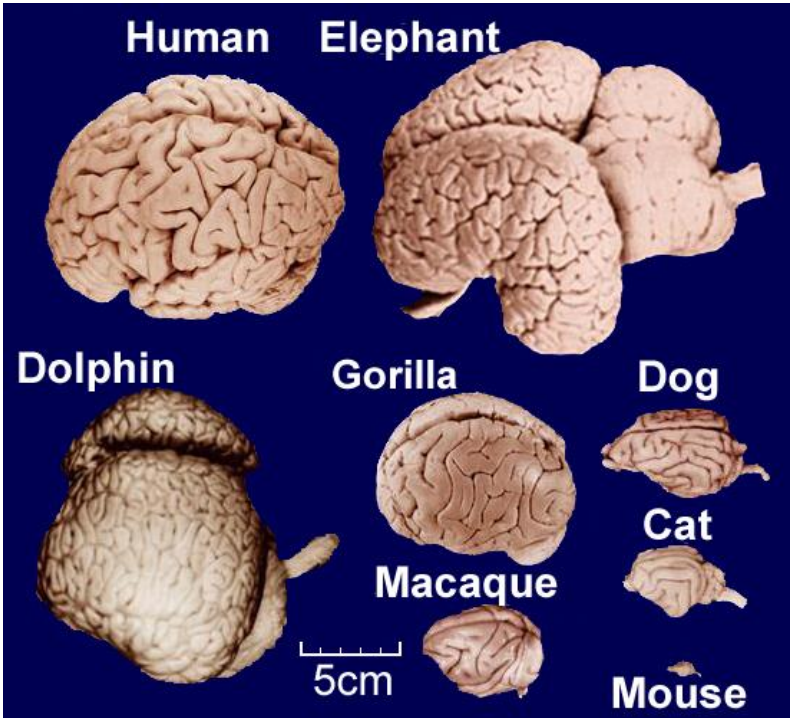
Brain of a lamb

Three-dimensional model of human brain, that can be disassembled in its parts

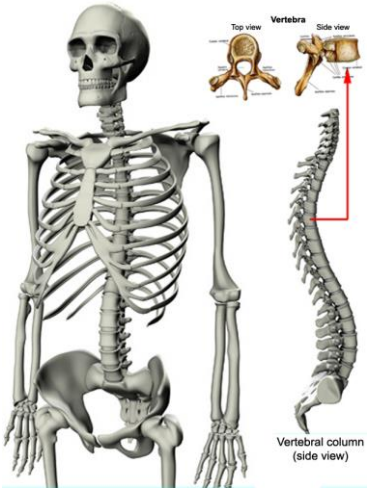
An X-ray of a vertebral column



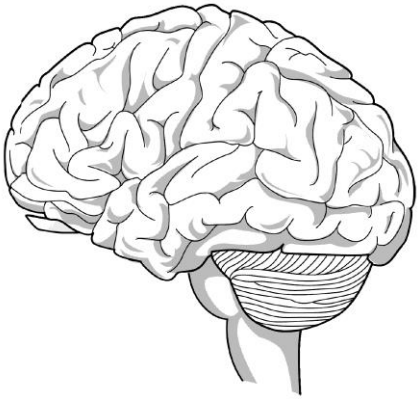
Pleated *vs.* flat sheet



A comparison between the relative dimensions of the brains of some Mammals.



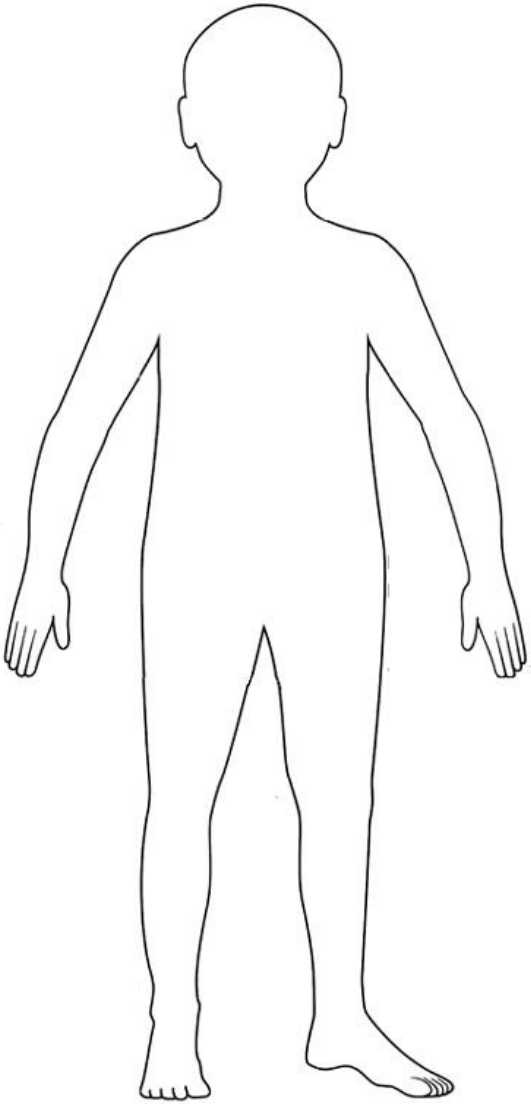
Vertebral column and vertebrae



The brain
(to be cut out and glued on the book)

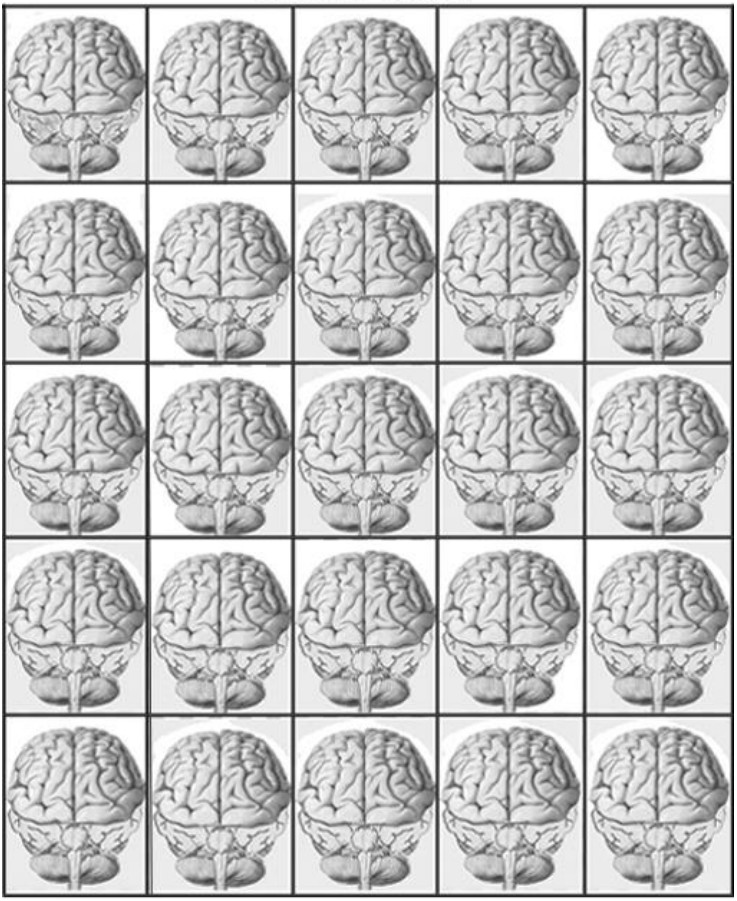
Activities of children

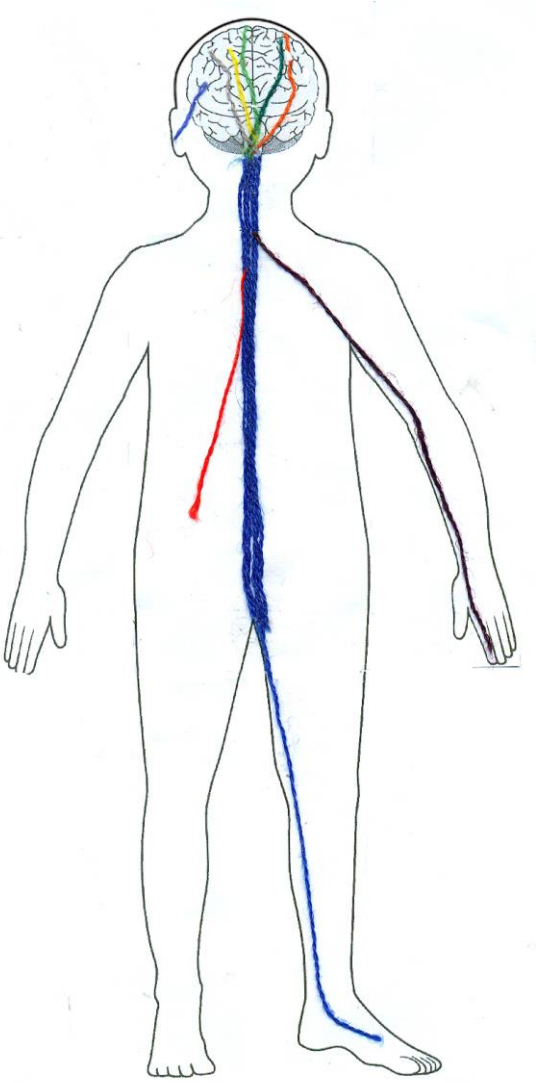
 Reading	 Writing	 Speaking
 Walking	 Dancing	 Skating
 Swimming	 Breathing	 Coughing
 Sneezing	 Painting	 Seeing



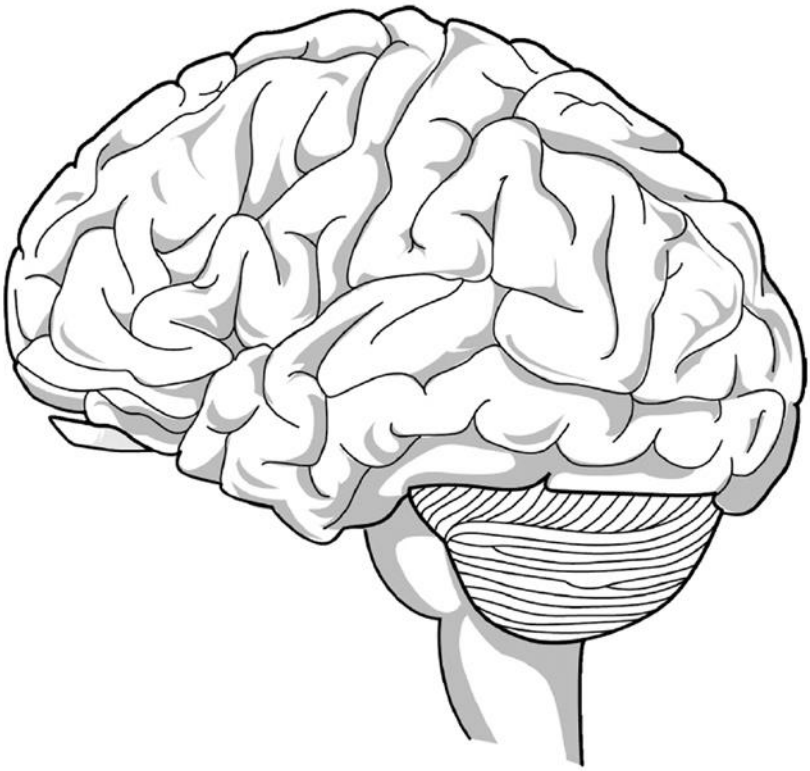
Drawing of the outline of a human body, on which to glue brain (next drawing), spinal cord and nerves (wool strings).

Drawings of brain



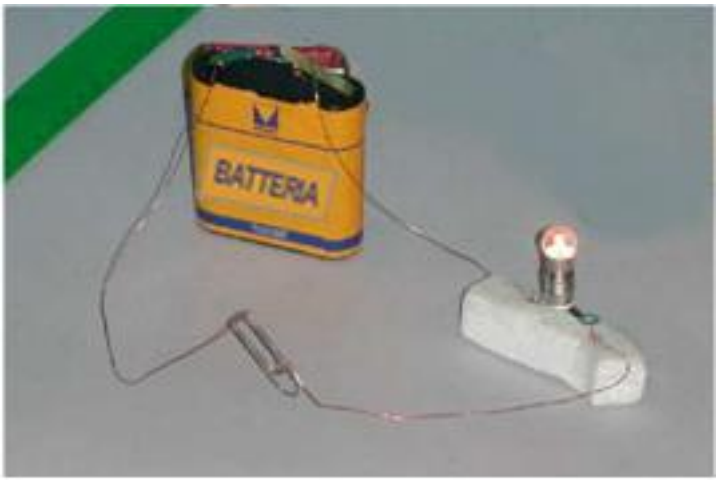


An example of outline of the human body on which brain, spinal cord and nerves have been glued.



Drawing of a brain
(to be used in the following Learning Through Play Experience: "***How do signals from the external environment reach the brain?****")*

Diagram of a neuron



An electrical circuit, to show how a neuron works

LEARNING THROUGH PLAY

How do signals from the external environment reach the brain?

PREPARATION

Before the children enter the classroom, draw the full-size outline of one of the children using a thick black marker pen on a large white sheet of paper. Draw the head in profile, looking towards the left so as to apply the Fig. "Drawing of a Brain". Leave this displayed in class for the entire duration of the module, as during the various classes other information will be added regarding the brain and the sense organs. This activity will be guided by the teacher and will be presented to the entire class as a group.

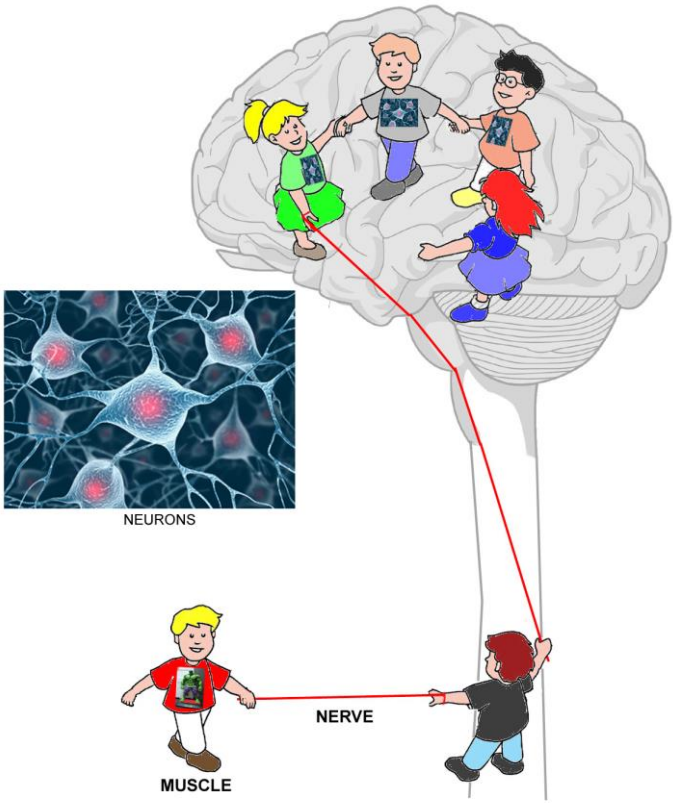
Give each child a copy of the diagram of the body contour and a copy of the brains cut out from the diagram "Drawings of brain".

ACTIVITY

1. *Show the children a copy of the Figure* Drawing of a brain.
2. *Making reference to the full-size diagram of the body contour displayed on the wall, ask the children to indicate the position of the brain. Attach the drawing of the brain in the appropriate position. Then ask: What other parts of the body do you know? Leave time for them to demonstrate their knowledge of the body.*
3. *Ask the children: Have you ever: stubbed your toe against something, cut yourself, fallen? Did it hurt? How do you think you received this information, or how did you feel pain? Give the children time to answer. Clarify the concept that it was the brain that received the message regarding pain, and it told you this! But how does this process work?*
4. *Ask the following: Let's pretend that the child in the drawing hanging on the wall has just stubbed his/her toe. Immediately the child feels pain. How does a person realise so quickly that s/he has hurt his/her foot? Ask a volunteer child to connect the toe with the brain using a piece of wool, in a straight line.*

5. *Ask the following: Do you think this is how it works? Ask them if they think a signal can go through the air from the foot to the brain If not, what other pathway could it take? Are there communication channels between the various part of the body and the brain? Help the children understand that all parts of the body are connected with the brain through nerve fibres.*
6. *By using a long bundle of wool or string, create a spinal cord on the drawing. Ask the children what this could represent. Get them to exchange ideas.*
7. *Place a piece of string between the toes and the spinal cord, and from here to the brain. Explain to the children that nerves are found in every part of the body. (Signals coming from the head and face reach the brain directly without passing through the spinal cord).*
8. *Give the children copies of the outline of the human body and brain and get them to stick them into their workbooks.*
9. *Get the children to stick pieces of coloured wool on this collage to represent the spinal cord, and then ask them to make a connection between the foot and the spinal cord using another piece of wool (see example in Teaching support materials).*
10. *Get the children to create other "nerve" connections between the other parts of the body and the spinal-cord.*
11. *Explain to the children that all sense organs (example, the ears and eyes) are all connected to the brain, and later on they will understand how these various sensory organs receive information from the environment and send signals to the brain.*
12. *Ask if they think the spinal cord needs protection (just like the brain is protected with the skull). Get them to touch their spines and explain that what they can feel are the bones that make up the vertebral column (the vertebrae) which protect the spinal cord.*
13. *Get them to make vertebrae using squares of coloured paper and stick them on to the large diagram hanging on the wall of the classroom.*

VOLUNTARY MOTOR ACTIVITY ROLE-PLAY



Introduction

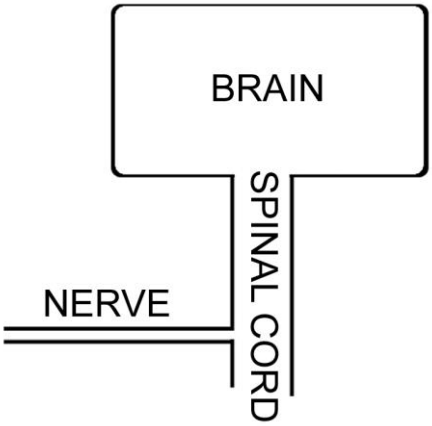
When introducing the "learning through play" activity on how voluntary movement is generated and the role of the brain in this process, using this diagram the teacher will explain that when we decide to carry out voluntary action (e.g. the simple act of raising the arm), a group of neurons in a specific area of our brain are activated and communicate with each by exchanging information through their synapses. This joint action of a group of neurons causes a signal to travel down a long extension of one of these

neurons which is covered with an isolating sheath, known as a *nerve fibre*. This nerve fibre carries the signal along the spinal cord, to finally make a synapse with another neuron. A nerve fibre sprouting from this neuron leaves the spinal cord, joining up with other similar nerve fibres to form *a nerve*. The nerve fibres contained in the nerve reach the muscle making it contract. Let the pupils understand that any movement that we make involves the contraction of some muscles and the relaxation of others (if the other muscles did not relax then they would block the desired movement). Get the children to experiment by contracting simultaneously their biceps and triceps: the forearm can neither extend nor flex.

Required materials

- Paper-based adhesive tape to outline the area
- 5 or more sheets with the drawing of a neuron, 1 sheet with a drawing of a muscle, to be attached to the chests of the neuron/children and muscle/child.
- 4 to 5 m of single-wire electricity cable
- Various sheets of paper on which the teacher will write "*Squeeze the hand of the person next to you: you'll see how your classmate-muscle will raise their arm*" or "*….will raise their leg*" or "*…..will shake his/her head"* etc..

Preparation



Using the adhesive tape, mark out on the floor the parts of the nervous system that will be used, following the above diagram. Position the children as indicated in the diagram *"Voluntary motor activity: Role-play"*.

Explain to the children the significance of these positions. Four of more neuron/children will hold hands to represent a chain of neurons in the brain *(each child will have a drawing of a neuron attached to their chest, with the word NEURON)*. When the brain "makes a decision", not just one but many neurons are involved. The contact between the hands of the neuron/children represents the synapses which connect each neuron and allows signals (nervous impulses) to travel from one neuron to the other. The last child in the chain will have a piece of electric wire 3 to 5 m long attached to their wrist (take care not to tie the wire too tight) to represent the extension of the cell (the nerve fibre) through which the neuron can reach other distant neurons; The wire is attached to the wrist to represent a natural "extension" of the neuron/child. This is one of the many thousands of nerve fibres that travel along the spinal cord [the teacher can also explain that nerve fibres are covered with an isolating sheet, just like the electric wire, because the signals that travel along the nerves are very weak electric impulses]. The electric wire/nerve fibre reaches another neuron/child placed within the spinal cord. This child holds the wire, thus creating a contact through which the signal can pass. Also this neuron/child has a long extension/nerve fibre – together with many other which, for simplicity are not represented in the Role-play – which departs from the spinal-cord and travels along the body to the muscle/child *(who will have on his/her chest a label with the word MUSCLE)*, and representing the final contact (different from others, because the latter represents the contact between a nerve fibre and muscle, rather than between two neurons).

Activity

The teacher will tell the first child to squeeze the hand of the child next in the row– or raise the arm – and makes the child read from a sheet of paper which only this child will see, what the effect produced in the muscle/child will be (e.g. raise an arm, or lift a leg); also the muscle/child will be instructed on how to behave once the signal arrives.

The signal will pass in progression along the chain, until it reaches the last child, just like in the chain of neurons. The last neuron/child of the brain will pull the electric wire, thus transmitting the signal to the neuron/child in the spinal cord. Similarly, this child will transmit the signal along the nerve to the muscle/child, who will respond as indicated above.

The teacher will show all the children the sheets on which what was to be the result of the transfer of each signal from one neuron to the other, and finally to the muscle. This activity can be repeated using another chain of neuron/children which will activate different muscular responses, thus demonstrating how muscular activity is controlled by different groups of neurons.

The teacher will remind the children that the signals transferred between neurons which reach the muscle are very weak electric impulses (they are not fibres that are "pulled" mechanically!).

Reason with the children on what would be the outcome if this chain of signals were interrupted. For example, what would happen if one were to hit one's head violently when diving into a swimming pool? (If the spinal cord is damaged then all muscles that are innervated by the damaged part are paralysed, and there is no feeling in that part of the body. This topic, however, should not be developed now and can be dealt with later, after discussing the sensory organs).

WORKSHOPS WITH TEACHERS

All teachers involved in the project were highly qualified and were able to adopt a pedagogical approach based on active learning rather than on simple transmission of knowledge. The experience and skills acquired by the teachers during the first year of the SCIESA project was invaluable in consolidating the second year's teaching objectives and the implementation of the inductive methodology which characterises this project.

All teachers participated actively in meetings of the SCIESA group and also contributed in the elaboration of the teaching modules. These meetings were mainly focused on contents (knowledge to be transmitted), and the practical approach to be adopted to achieve these goals (organisation of the subject matter, timeframe for delivery of concepts, teaching materials to be used).

On occasions, following specific requests by the teachers, this "working together" methodology was implemented by the presence in class of one or two members of the group of experts. This also helped to standardise different ways of interacting with pupils when carrying out the practical activities and during class discussions. The contribution of teachers was also important in gathering documentation (recording of the children's discussions, observations, photographs, digital acquisition of the children's works).

In the working group experience the teaching methodology adopted is producing quite acceptable results, since the teachers have responded well to the group work approach, and have been able to give contributions concerning both contents and methodology.

One critical issue that came out, not easy to be solved, was the lack of time for this type of activity. Indeed the teachers' teaching loads are substantial and very little space is left for innovative and complex type of activities such as that proposed by the SCIESA project.

ASSESSMENT OF RESULTS

(with specific focus on the methodological aspects of the programme)

1. INTRODUCTION

Lacking an appropriate external body, the assessment of results was entrusted to the teachers actively involved in the programme, who were asked to provide objective and critical analysis of the quality of the work carried out. To assist in this process, a questionnaire was prepared and given to each teacher to be completed on terminating each section of the teaching Modules (*"The heart and the blood vessels"* and *"The brain and the journey of signals"*).

When elaborating the collected data, it was decided to focus on evaluating the methodological aspects of the activities that were completed, leaving out the quantitative assessments (on a 1 to 10 scale) on the results obtained for each section. This evaluation by the teachers (which was consistently positive) was considered not to be independent, thus not objectively reliable.

To try and draw a motivated evaluation regarding the methodological approaches adopted, it was also deemed interesting to take into considerations the materials produced by the children (drawings, papers etc.), in particular for what concerned:

- the effective feasibility and appropriateness (regarding the level of comprehension of the children) for each of the experimental activities proposed in the teaching programme;
- the efficacy of the inductive methodology adopted in the project;
- the degree of participation of the children in the various activities;
- the degree of retention in the learning process (retention of previous knowledge, capacity of reasoning, of inferring, of consolidating previous knowledge with new concepts).

The results of this evaluation process are indicated below and include:

- Critical elements or particularly positive elements identified by teachers regarding the experimental activities (simple experiments, awareness of past experience or observations) proposed by the teaching programme.
- General evaluation on the teaching methodology adopted, not only derived from comments and observation of the teachers but also from the material produced by the students during the delivery of the two teaching Modules.

2. CRITICAL AND POSITIVE ELEMENTS IN THE PROGRAMMED TEACHING EXPERIENCE

The following section contains a summary of the experience recalled, the experiments performed and the relative results (critical and positive elements) derived following the assessment process. Information is presented for each Section of each Module.

MODULE 4: THE HEART AND THE BLOOD VESSELS

SECTION 1: THE AIR AND OXYGEN

Summary of experience and experiments

- Observations on a drawing or on memories of a gas stove, with the flame lit (the gas cannot be seen, but it burns and makes a flame).
- Experiment using a balloon filled with air which does not float, whereas if filled with another gas lighter than air then it does float (there are different gases, and they have different weights).
- Comments regarding the picture of a hang glider (the air makes the flight possible).

- Observing a falling sheet of paper (the air makes the sheet float to the ground).
- Experiment involving blocking the tip of a syringe (air is present, and it occupies space).
- Experiment of the candle under a glass dome (it contains something that is used up: oxygen).
- Experiment of expired air which changes the colour of the aqueous solution containing a pH indicator (presence of CO_2 in the expired air).
- Comments on the pictures of astronauts and deep sea divers (oxygen in the air is needed to survive).
- Experience of trying to hold one's breath (it is impossible to stay for any length of time).
- Observations on the pictures of fish and aquatic plants (there is oxygen in water).

Critical areas identified

Not all children were aware of some of the experiences recalled (that gas that is emitted from the stove and ignites; the flight of the hang glider).

Some children thought that all balloons float, regardless of the gas that is used to inflate them.

While there was a general consensus regarding the presence of air in the environment (also due to the Module delivered the previous year), the understanding that air is composed of various gases was rather limited, and some children did not remember the term "oxygen".

In the experiment with the candle and the glass dome, some children believed that the cause was due to the lack of air and not to oxygen having been burned out.

Carbon dioxide was generally defined as "dirty air".

Positive elements identified

The experiment involving blocking the tip of the syringe was particularly convincing.

Both interest and surprise was shown for the experiment demonstrating the presence of carbon dioxide in expired air.

The experiment involving holding one's breath was very convincing (interpreted by many children as a sort of competition).

SECTION 2: THE JOURNEY OF OXYGEN

Summary of experience and experiments

- The experiment of the bottle of carbonated mineral water that releases gas in the form of bubbles when opened (a liquid can contain gas which can be seen as bubbles when present in large quantities).
- The experiment of blowing through a straw into a glass of water (bubbles are formed by the gas passing through the liquid).
- Observation and discussion with the children on gaseous exchange in the lungs (when breathing, oxygen is introduced into the body and carbon dioxide is eliminated).

Critical areas identified

The process of gaseous exchange in the lungs was hard to understand due to the lack of an appropriate experiment to demonstrate the process.

Positive elements identified

The two experiments that were proposed were effective and easy to execute.
There was a general understanding that breathing takes place through the lungs.

SECTION 3: THE BLOOD VESSELS

Summary of experience and experiments

- Examination of superficial veins (the human body contains tubes that contain blood).
- Highlighting the veins by tying a tourniquet around the arm (presence of tubes that contain blood).
- Examination of angiographic images (blood vessels are also found within the body).
- Recalling episodes of paleness or blushing (blood is everywhere in our bodies).
- Recalling the sight of human blood (bleeding occurs when the skin is cut).
- Observing animal blood in the meat (blood is present in animal bodies as well).
- Experimenting with the tourniquet tied around the arm (blood flows inside blood vessels, when this flow is blocked the veins swell up. When we remove the tourniquet, blood starts to flow again).
- Listening to the noise of water flowing in a tube (a liquid flowing inside the tube makes a noise).
- Listening with a phonendoscope to the flow of blood in the radial artery (blood flows continually inside our blood vessels).

Critical areas identified

There were mixed results regarding the efficacy of the angiographic images, which were understood by some children and were difficult to interpret for others.

Positive elements identified

The experiment involving “discovering” blood vessels in different parts of the body by observing and touching was easy to carry out and fun for the children.

SECTION 4: THE HEART

Summary of experience and experiments

- Observing the heart of a mammal (the form and shape of the heart).
- Examining a model of the heart (form and dimension of the heart).
- Examining radiographic images of the heart (form and dimension of the heart).
- Localisation of the heart in a cut-out image (localisation of the heart).
- Listening to the heartbeat using a phonendoscope (the heart makes a noise, demonstrating that it works continually).
- Experiment with the pump to represent a model (the pump produces a flow of liquid that departs from the pump-heart and returns to it again. This is what happens during every heartbeat).
- Examination of diagrams of the large/systemic and small/pulmonary circulation (circulatory system of blood).
- Examination of images of the journey of blood (blood travels through the circulatory system, reaching all tissues in the body. In the lungs it is enriched with oxygen and gives up its carbon dioxide).
- Role-play: *"The journey of blood"* (the journey of blood in the circulatory system).
- Trying to modify the heartbeat voluntarily (the heartbeat cannot be modified voluntarily).
- Measuring the heartbeat and rate of respiration at rest and following various physical activities (the work of the heart and lungs change in relation to the different needs of the organism).
- Measuring each other's heartbeat and respiration rates at rest and following various physical activities (the heartbeat and breathing rates both increase with greater physical activity).

- Interpreting the cause for the accelerated heartbeat and breathing in conditions of physical stress (physical effort requires a greater quantity of oxygen and this is supplied with an increased rate of respiration and blood flow/heartbeat).
- Recalling information pertaining to the previous year's module regarding the digestive system, and if necessary, repeating some appropriate experiments (recalling knowledge regarding digestion and intestinal absorption of nutrients).
- Identifying signs of cardiac activity in various parts of the body, e.g. chest, radial artery, etc. (the work of the heart reaches every part of the body).

Critical areas identified

Some technical difficulties were encountered in the experiment simulating the pumping action of the heart.
Children had difficulty in understanding the problem of gaseous exchange in the lungs, and the absorption of nutrients in the intestine.

Positive elements identified

Examination of an animal heart was very interesting for the children.
The children were surprised and interested to observe that blood vessels were present on the outer surface of the heart.
The children enjoyed listening to the heartbeat using the phonendoscope, which was a very convincing experience.
Observing the change in heartbeat in relation to physical activity was also very interesting.
Understanding the difference between an artery and a vein was not problematic.
The role-play *"The journey of blood"* was generally considered useful.

MODULE 5: THE BRAIN

SECTION 1: SENSORY PERCEPTION

Summary of experience and experiments

- The experience of identifying objects or environments using only one of the sense organs (using only one appropriate sense organ, it is possible to identify to a certain degree persons, objects, or environments).
- The experience of identifying objects or environments through the normal use of all sense organs (multiple and different types of signals received simultaneously are normally used to identify our surroundings).
- Recalling signals from inside our bodies which let us take care of ourselves and prevent any harmful situations (some signals come from inside our bodies as well, allowing us to pay attention to our bodies and avoid possible health problems).
- Recollection of certain circumstances (sleep; intense concentration in other activity, etc.) when some signals may not be perceived or involuntarily ignored.
- Awareness of the possibility of simultaneously receiving and interpreting various signals (precise interpretation of reality is facilitated by the capacity to receive and interpret different signals).

Critical areas identified

Some children had difficulty in understanding that in certain circumstances (sleep, etc.) some signals may not be perceived.
There was some difficulty in understanding that certain signals come from inside our bodies.

Positive elements identified

The delivery of this subject matter was facilitated by previous study of road awareness/education delivered by the Municipal Police. During this previous activity, attention was given to interpreting road signs.

The children found the identification activity when blindfolded very interesting (this was presented in the form of a game).

SECTION 2: WHAT IS THE BRAIN LIKE

Summary of experience and experiments

- Discussion with the children of their comments regarding where do the signals received by our sense organs go to (all signals are sent to the brain).
- Discussion with the children on their understanding or hypotheses regarding the location, conformation, and functions of the brain (naïve/elementary understanding of the conformation and functions of the brain).
- Positioning by the children of a brain cutout diagram by superimposing it on a drawing of a skull (the brain is located within the skull).
- Children's direct examination and comparison of the consistency of a lamb's brain and the cranium (the brain is a soft and delicate organ which is protected by the hard, bony cranium).
- Observations on protective clothing (motorcycle crash helmets, workmen's helmets) of the cranium (the brain is a precious and delicate organ that needs adequate protection).
- Demonstration of the weight of the brain, like a balloon filled with water (weight of the brain).
- Observation and comments on pictures of brains of different animals (dimension and weight of the brain does not necessarily correspond to a greater level of intelligence).

- Examining, assembling and disassembling the three-dimensional model of the encephalon (identification of the different parts of the encephalon, the right and left hemispheres, the cerebellum, and the brain stem, which is continuous with the spinal cord).
- Examining the brain of a lamb, with particular attention to the gyri (the surface of the brain is not smooth; it contains deep furrows and folds).
- Comparison of two identical sheets of paper, one with multiple pleats and the other not: they occupy very different surfaces (the pleats – i. e. furrows and folds in the brain – increase the surface area of the hemispheres, and thus the space available for the billions of cells present on the brain surface to carry out the work of the brain).
- Reciprocal touching of the vertebral columns by the pupils (the brain continues caudally with the brain stem and the spinal cord, which descends the entire length of the back. The spinal cord is soft and delicate and is protected by a bony casing made of vertebrae, positioned one on top of the other).
- Discussion of children's hypotheses regarding the functions of the brain (the brain carries out many different functions, some voluntary, others automatic or involuntary).
- Colouring in red the hemispheres on a drawing of the brain (the largest part of the brain – the hemispheres – is the thinking part of the brain which is also responsible for learning, memory, sensations, and emotions. This is what makes the muscles move when we want them to).
- Observation of the non-coloured parts the drawing of the brain (the part of the brain not including the hemispheres regulate involuntary functions, and also coordinate complex movements such as dance, swimming and equilibrium).
- Eliciting the children to give some examples of automatic or reflex actions (some activities are not voluntarily controlled, such as the heartbeat, respiration, digestion, coughing, sneezing).

- Activity carried out by children in cutting out copies of various activities, dividing these into voluntary and involuntary activities (distinction between voluntary and involuntary activities).
- Correct positioning of the diagrams representing voluntary actions on the red-coloured hemispheres in the diagram of the brain (the hemispheres regulate all voluntary actions).
- Practical observations by the children on how voluntary actions (writing, speaking, playing, etc.) and involuntary actions (breathing, digestion, sneezing, etc.) are regulated simultaneously by the brain which is able to command the entire body (voluntary actions and automatic involuntary activities can be carried out simultaneously without us realising).
- Observation of a single-wire electric cable (electric signals travel along the nerve fibre, the long extension of the nerve cell, rather like electricity which travels along electric wire).
- Observation and comments regarding the diagram of a neuron (chains of neurons connected to each other are able to transmit signals to every organ in the body).
- Experiment with the battery connected to an electrical wire and a light bulb (just like the light bulb has to be connected through the wire to the battery to light up, also the organs have to be connected to the brain *via* a neuron chain to be stimulated and react).
- Observation and comments of the diagram of a network of neurons (the brain is made up of billions of neurons which are connected to each other to form a network; between one neuron and another is an area of contact, the synapse, across which the electric impulse passes to stimulate the next neuron).

Critical areas identified

Some difficulty was found in positioning the encephalon on the skull by superimposing the cut-out diagrams.

There was some uncertainty distinguishing voluntary and involuntary activities.
There was some difficulty in understanding the significance of comparing the two pieces of paper, one pleated and one flat.

Positive elements identified

The children showed great interest when examining the lamb's brain.
The need to protect the head to safeguard a delicate organ such as the brain was perfectly understood.
The distinction between voluntary and automatic activities recalled some previous knowledge acquired from other modules.
The children appreciated the experiment with the light bulb connected to the battery.

SECTION 3: HOW DOES THE BRAIN COMMUNICATE WITH THE REST OF THE BODY

Summary of experience and experiments

- Example of the computer keyboard being able to send a signal to the printer (the brain sends signals to different parts of the body, and *vice versa*. The signals travel along nerve fibres which are often grouped into bundles, known as nerves. Travelling through the nerves, signals from the external environment reach the brain directly or reach it through the spinal cord. The brain elaborates the signals and again through the nerves, it sends response messages to the different organs).
- Play activity: How do signals from the external environment reach us (signals from the external environment reach the brain through nerve fibres).
- Role-play: Voluntary motor activity (signals reach our organs through nerve fibres which start in the brain and pass through the spinal cord. Other fibres run in the opposite

direction taking signals from the peripheral body towards the brain).

Critical areas identified

Due to lack of experimental evidence, children had some difficulty in understanding the function of neurons and nerve fibres.
The role-play on voluntary motor activity presented some organisation difficulty and also moderate interest by the children.

Positive elements identified

Children seem to understand the bilateral connection between the brain and other parts of the body.

GENERAL ASSESSMENT OF METHODOLOGY

In addition to the above observations regarding the quality of the teaching experience, a large quantity of material was collected and examined in order to evaluate the activity that was delivered (teachers' logbooks, discussions with teachers, work prepared by children). This material was used to formulate interesting observation regarding the methodological approach used, and in particular, some important aspects such as:

a. the efficacy of the inductive approach adopted in this teaching programme project;
b. the degree of participation of the children in the activities delivered;
c. the degree of retention of knowledge acquired through this methodology.

In this teaching programme, the inductive method was based on two fundamental pillars, represented by:

- the participation of young participants in simple experiments gauged to their learning levels;

- the creation of awareness in the children of the nature of daily/routine phenomena (eating, breathing, playing, etc.), through patient and meticulous observation and guided discussion.

This methodological approach creates different relationship between teacher and pupil than a traditional approach, as it is not based on authority or hierarchy, but more on a relationship of trust and mutual collaboration.

The challenge to face was to verify if this approach could produce real and effective results with such young participants, even with children from the first year of primary school. Following the assessment of the results produced by this project, we may say that a markedly positive outcome was obtained. Indeed, after overcoming some initial difficulties at the beginning of the first year of the programme, all teachers confirmed that the children became familiar with the teaching methodology, and collaborated naturally, often showing great enthusiasm, in all the activities that were proposed.

These positive aspects obviously favoured the participation of the pupils in other later activities. As the programme progressed, it was noted that the number of "indifferent" or even "excluded" (due to shyness, language difficulties, etc.) progressively diminished and indeed, towards the end this was practically non-existent. Participation by the children in the activities can now be considered as being total and it was often seen that the greater the participation required, the more active their participation. The "doing together" strategy has proved to be a winning formula when compared to a "listen and do" approach.

Concerning retention of knowledge over time, it is still too early to assess this factor objectively. It was encouraging to observe the numerous notes made by teachers regarding connections made by the children during the year about the teaching concepts examined, and also regarding work done the previous year. With the progressive literacy of the pupils, in the coming years a more precise evaluation

will be possible using more appropriate assessment instruments to evaluate this important aspect of the teaching activity.

Although provisional, these considerations are sufficient to attribute an overall positive evaluation of the feasibility and efficacy of this on-going project. Nevertheless, this does not mean that we can ignore the critical elements that have been identified in the assessment phase.

The most relevant of these elements are:

- The lack of experimental evidence regarding complex phenomena (gaseous exchange, absorption of nutrients, cerebral functions) that can be used in a teaching programme for such young participants;
- The availability of sufficient time for such an innovative and experimental programme, within an overall formal didactic curriculum to be delivered. Indeed, teachers were very busy and sometimes encountered difficulty in dedicating time to conduct these activities, which – due to the innovative subject matter and methodology – required required considerable time in preparation and in implementation;
- The organisation of these contents (functional morphology of the human body) in harmony with the more comprehensive science programme currently being taught in primary schools. This last issue will be a priority item to be addressed in the future development of the project.

LOGBOOK

As previously noticed, the evaluation of didactic Modules carried out in class has been performed by the teachers. They have been asked to write down, during the course of each section of the Modules, an evaluation of the didactic efficacy shown by the experimental items proposed (experiments or experience). To this end, the teachers were provided with a "logbook" in which they were to record, for each experimental item, whether it was fully realized in class (*yes*, *no*, *partially*), the degree of efficacy (rated on a 1 to 10 scale), and possible additional notes.

An example of the logbook that was used for the first section (*The air and the oxygen*) of Module 4 (*Heart and blood vessels*) is given below.

LOGBOOK
(First section of Unit 4: "The air and the oxygen")

1. **Air occupies the space that surrounds us, even if we cannot see it nor grasp it, as we may with an object**

Personal experiences or Experiments	**Realization**			**Efficacy (1-10)**	**Additional notes**
	yes	**no**	**partial**		
Observations on the image of a paraglider (the air supports its flight)					
Observations on the fall of a sheet of paper (the air supports the whirling of the sheet)					
Experiments with a syringe with its tip plugged (the air occupies space)					
General comments					