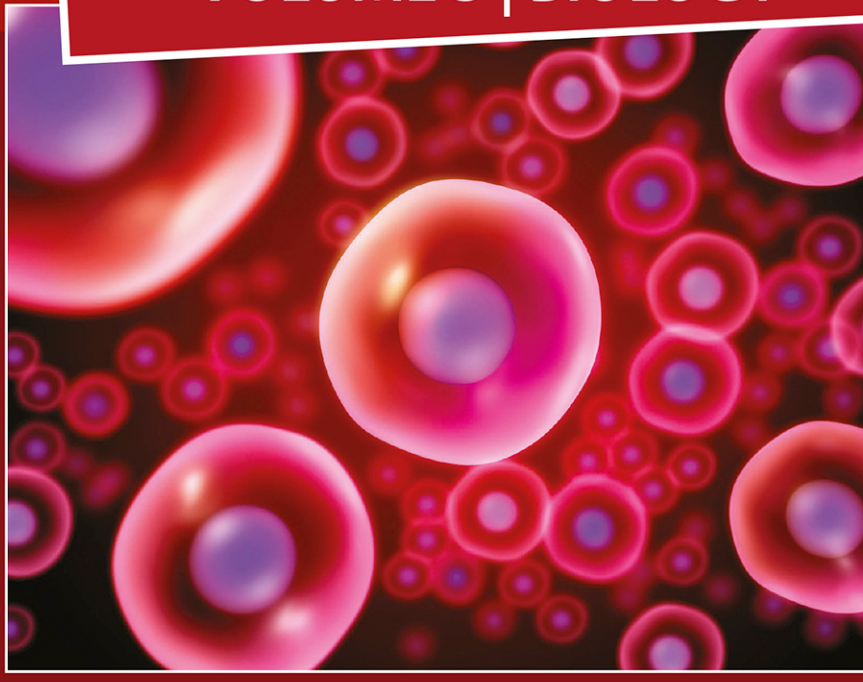
European Science and Technology in Action
Building Links with Industry, Schools and Home

VOLUME 3 | BIOLOGY



ESTABLISH IBSE
Teaching & Learning Units:

Disability
Eco-Biology
Blood Donation
Water in the Life of Man

ESTABLISH IBSE
Teaching & Learning Units

Volume 3

Disability
Eco-Biology
Blood Donation
Water in the Life of Man

European Science and Technology in Action
Building Links with Industry, Schools and Home

SEVENTH FRAMEWORK PROGRAMME | SCIENCE IN SOCEITY
COORDINATION & SUPPORT ACTION | GA N^{o} 244749

www.establish-fp7.eu

European Research Area

This teaching and learning resource is presented in four volumes and has been produced within the scope of the ESTABLISH Project, which has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 244749 (2010-2014).

ISBN: 978-1-873769-23-2

Contact Information:

Project website:
www.establish-fp7.eu
www.castel.ie/establish
Email: castel@dcu.ie

ESTABLISH Project Coordination & Editorial Team:

Dr. Eilish McLoughlin,
Dr. Odilla Finlayson,
Dr. Deirdre McCabe,
Dr. Sarah Brady

ABOUT ESTABLISH

ESTABLISH is a pan-European project funded by the European Union's Seventh Framework Programme (FP7) involving fourteen partners from across eleven countries (Ireland, Sweden, Poland, Czech Republic, Malta, Slovakia, Estonia, Italy, Germany, Netherlands, Cyprus). The aim of the ESTABLISH project is to promote and facilitate the use of inquiry-based approaches in the teaching and learning of science and technology across Europe with second level students (ages 12-18 years).

Through the collaborative efforts of these partners, a series of 18 inquiry-based science education (IBSE) teaching and learning units have been developed through piloting and trialling with teachers in the classroom. These units form the core resource for the implementation of ESTABLISH teacher education programmes. These booklets provide background information for teachers on the ESTABLISH approach to IBSE and presents several of these units which focus on particular biology-related themes selected to be appropriate for the second level science curriculum.

Participating Institution	Country
Dublin City University	Ireland
AG Education Services	Ireland
Umea Universitet	Sweden
Uniwersytet Jagiellonski	Poland
Univerzita Karlova v Praze	Czech Republic
Acrosslimits Limited	Malta
Univerzita Pavla Jozefa Safárika v Košiciach	Slovakia
Tartu Ulikool	Estonia
Universita degli Studi di Palermo	Italy
Malmö University	Sweden
Leibniz-Institut fuer die Paedagogik der Naturwissenschaften und Mathematik an der Universitat Kiel	Germany
Centre for Microcomputer Applications	Netherlands
Martin Luther Universitaet Halle-Wittenberg	Germany
Frederick University	Cyprus

These materials serve as exemplary materials for science teachers and instructors of teacher professional development to experience the benefits of inquiry-based science education approach and are offered openly to inspire, guide and stimulate the further development of IBSE resources and practices. Electronic versions of these units and associated classroom materials are available openly for download from the project website at www.establish-fp7.eu and at www.castel.ie/establish.

The ESTABLISH project (2010-2014) is coordinated by Dr. Eilish McLoughlin, Dr. Odilla Finlayson, Dr. Sarah Brady and Dr. Deirdre McCabe from the Centre for the Advancement of Science and Mathematics Teaching and Learning (CASTeL) at Dublin City University (DCU).

CONTENTS

Volume 1

Volume 2

Volume 3

Volume 4

DISABILITY

The development of this unit has been led by the ESTABLISH partners:

Margareta Ekborg & Maria Sandström.
Malmö University

with

Christina Ottander, Helena Näs & Annika Kjellsson – Lind
Umeå Universitet

UNIT CONTENTS

I. *Unit Description*

When it is working correctly, we can do the most amazing things with our bodies. We can see birds high in the sky, we can recognize the sound of a fly buzzing in the next room and we can climb, run and jump and pick up small things from the ground with our fingers. We can think of clever ideas, invent fantastic stories, sing and make music. We breathe, our hearts beat, we smell, feel and taste. But sometimes there is a part that does not work perfectly; sometimes not at all.

This unit is about the human body when it works and when it does not work perfectly, and what aids there are. The aim is for the students to gain knowledge about the human body and have the chance to learn about, reflect upon and discuss disability.

Photo: Scanpix

- **Student level:** Secondary school
- **Discipline level:** Biology, Physics and Technology
- **Estimated duration:** 10 – 15 lessons

Aim:

Through working on disabilities related to muscles and movement, pupils are given the opportunity to meet people who work professionally with the natural sciences and technology in this field. During the course of the work, the pupils will acquire knowledge of human biology, physics and technology, as well as of the nature and practice of science.

Learning objectives:
We suggest the following learning objectives, if this unit is to be carried through in its entirety. There are also specific learning outcomes specified for each individual activity.
At the completion of this unit, pupils should be able to

- Formulate their own questions and be able to indicate if they can be answered by carrying out an investigation
- Plan, carry out and report on a simple investigation
- Reflect on the relationship between disability and handicap, as well as on the opportunities and obstacles presented by a disability
- Evaluate the school environment and/or its immediate environs with respect to wheelchair access, and suggest ideas for improvements
- Discuss disability in an open manner that is free from prejudice
- Identify some areas of relevance to the unit where technicians and scientists work and be able to describe their work and what educational prerequisites there are for this work
- Describe and explain how one moves: muscles, skeleton, circulation and nerve impulses
- Describe and explain strength and endurance in muscles
- Explain respiration, fitness training and aerobic and anaerobic activity
- Give physiological explanations for some examples of disabilities
- Use competently and correctly the terms lever and torque
- Explain how some aids for disability function physiologically and/or physically
- Develop a simple aid to solve a given problem using their own ideas

It is not the intention that pupils should work on each learning objective in turn, but that the pupils should develop their basic skills in science by carrying out an inquiry-based project.
Human rights § 27:
Everyone has the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits.

II. *IBSE-Inquiry-Based Science Education*

Inquiry-based education, or IBSE, means to identify questions, propose hypotheses, plan investigations, collect data, interpret data and draw conclusions. After this, results are reported and evaluated. All these steps of IBSE are not, perhaps, included in each activity, but rather one or other aspect of IBSE is focused upon. In some activities, the pupils identify questions and make suggestions/propose hypotheses. In other activities they are asked to work in groups to plan, carry out and evaluate investigations of various types. Most activities include a problem that has to be solved, and in most cases a number of solutions are possible. Several activities are rather simple and will lead to a short discussion, while others will lead to more or less independent investigations that are to be reported both verbally and in writing. In order to stimulate interest and engagement, we work with illustrations and with problem-solving. It is possible that new questions can arise in the course of the work on these activities, which gives further opportunities to widen and develop the unit.
Working with IBSE is ideal for the use of laptop computers and other digital resources connected with ICT.

III. *Pedagogical Content Knowledge*

As research has revealed that many pupils do not find that science education in schools has relevance for their lives, we have chosen to work with a unit that elicits an emotional response and that has clear connection to life in our society. This has proven to be a way of increasing the pupils' interest. It is also important to be able to talk about disability and handicap in an open manner and that we are conscious of the fact that conditions in the local environment can make a disability more or less disabling. Most pupils have met people with disabilities – in school, their family or where they live. And many pupils themselves have some kind of disability.
The biology content concerns movement – muscles, skeleton and nervous system. It is possible to broaden the content to include more organic systems as, in principle, all of them are involved in movement. To be able perform movement, at a cellular level glucose and oxygen is required. Multi-cellular organisms have organic systems developed to a greater or lesser extent, which can be seen to provide the logistics of supplying the cells with what they need, as well as disposal of waste products. The physics component concerns energy, strength, torque and rest. The technology component concerns rehabilitation.

Causes for muscular disability can be

- Rheumatism
- Spinal injury (various)
- Neurological illness such as multiple sclerosis and Parkinson's disease
- Inflammation

Common difficulties with concepts that pupils have

Any event in the body can be explained on various levels, ranging from individual to organic systems, on organic, tissue, cellular and molecular levels. Pupils often have difficulty in differentiating between and moving between these levels in thought and explanation. Many pupils do not have a holistic view of the incredibly complex coordination that occurs on various levels. Organic systems in multi-cellular organisms do not work independently of each other. It is common to conceptualize the body as a machine and boys in particular tend to see a disability as a fault in the machinery that can/should be repaired[1].

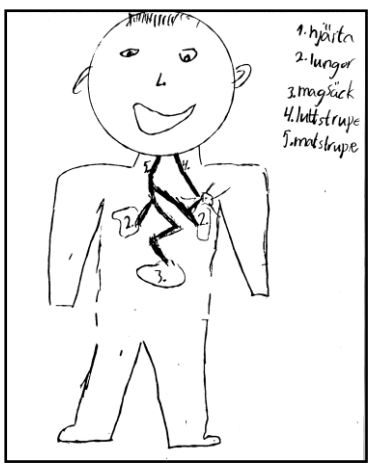
The following pictures show how some children at the middle level of the compulsory school have drawn what is inside themselves. What do you think your own pupils' drawings would look like?

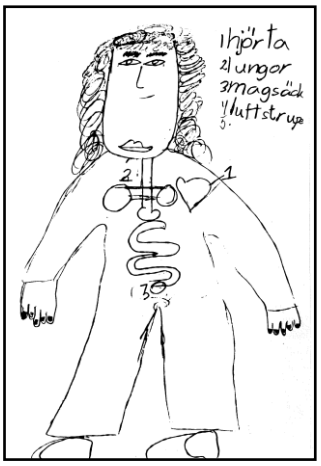
[1] Reiss, M. J., Tunnicliffe, S. D., Möller Andersen, A. M., Bartoszeck, A., Carvalho, G. S., Chen, S.-Y., Jarman, R., Jonsson, S., Manokore, V.,Marchenko, N., Mulemwa, J., Novikova, T., Otuka, J., Teppa, S.& Van Rooy, W. (2002). An international study of young people's drawings of what is inside themselves. Journal of Biological Education, Vol. 36:2, 58-64.

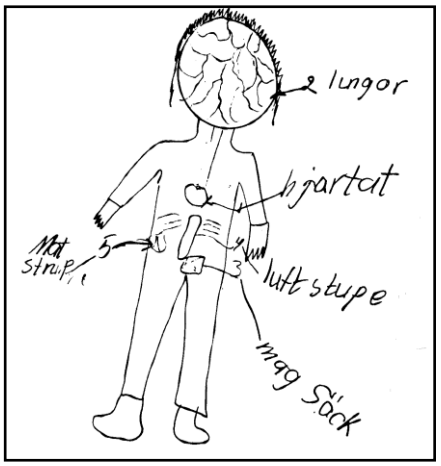
Knippels, M.C.P.J. (2002). *Coping with the abstract and complex nature of genetics in biology education.*

The yo-yo learning and teaching strategy. Utrecht, The Netherlands: CDβ-Press.

Knippels, M.C.P.J., Waarlo, A.J., & Boersma, K. Th. (2005). Design criteria for learning and teaching genetics. *Journal of Biological Education, 39,* 108–112.







IV. *Industrial Content Knowledge*

We define the industry and commercial sectors in broad terms. They include industries, businesses, research and educational institutions as well as the activities of municipal and county government. One can approach the work with these on two levels. On the local level, one can contact centres that work with disability aids and adaptation of these, which have been developed by scientists and technicians. We therefore recommend a study visit at an aid centre or rehabilitation centre – if possible, one concerned with helping children as we believe it is easier for teenagers to relate to children than to old people. The next level is to make contact with those engaged in developing these aids. Although disability aids centres exist in most municipalities, it can be more difficult to organize a study visit to a factory or development research institution. But it is possible to work with both. At aids centres, disabled people can be assisted with suitable aids for their disability and the individual adaptation of these. A study visit and work in the classroom will probably give rise to many questions. Some of these can be answered by doing internet searches and email contact with various businesses. Another alternative is to invite a person working in this field to talk to the class. How do you go about developing a disability aid? What is necessary? If there are chances for the pupils to test and contribute their ideas, this is ideal.

V. *Learning paths*

The table below shows the tasks for pupils that are included in this unit. They are published in the unit document Classroom Materials. Instructions to pupils are included, and we assume that the pupils will write up their activities in their own notebooks.

Activity		Subject
1.	Discussion about body fixation, disabilities and handicaps	ALL
2.	Disability aids	Biology Physics Technology
3.	Study visit to disability aid centre	Biology Physics Technology
4.	Technical aids	Technology
5.	How do muscles work?	Biology
6.	The strength and function of muscles	Biology Physics
7.	Receptors, nerves and nerve impulses	Biology Physics
8.	Why do we breathe?	Biology
9.	How is the pulse and respiratory rate affected by different activities?	Biology
10.	Fitness training	Biology
11.	Can you cope with a wheelchair at your school?	Biology Physics Technology
12.	What does the future hold for the development of disability aids?	Biology Physics Technology

The unit begins with a discussion – Activity 1 – to engage the students in the subject matter and to encourage them to reflect on and discuss a number of important questions. This Activity is designed to make them aware that we are all different and that “handicap” is not a defined concept, but one that is dependent upon how we see ourselves as people, how we define what is “normal” and how we organize our society including our homes, schools and workplaces. This Activity introduces the unit. Questions about disabilities are then present as a continuing theme through the unit. After this introduction, the discussion focuses on disability and movement.

After Activity 1, the work can be continued in a number of ways. Activity 2 is a good one to stimulate thinking about how to alleviate the situation of people with reduced muscle strength. One alternative can be to prepare the study visit (Activity 3) by encouraging the pupils to write the questions they wish to ask. Activity 4 can also function to develop the pupils’ questions and their curiosity. Perhaps they know someone who has personal experience of technology and restricted movement? If it is possible, a number of pupils can interview someone who uses the aids described in Activities 2 and 4, about their daily life.

After that, the unit continues with activities that concern the body – Activities 5 – 10. It is also possible to include here some activities or experiments that are usually included in human biology, but please ensure that the exercises are as investigative as possible. The pupils need to formulate questions, investigate, research and read independently. The concept behind Activity 11 is that the pupils should use their knowledge of movement and technology in order to analyse a situation and present their ideas for improvements. In Activity 12, the pupils are to find out about future developmental work. It is possible to link this section with commercial interests/other institutions through the pupils’ internet searches and contact with researchers/developers to ask questions.

VI. *Assessment*

When working with a unit of this type, it is important that its associated assessment is in line with the stated learning objectives, and of course also with relevant policies. It is also important that the pupils are informed at the beginning of the unit about how they are to report on their work and how they are to be assessed.

VII. *Student learning activities*

Activity 1: Discussion about body fixation, disabilities and handicaps

Learning aims:

The pupils are to become conscious that body fixation is a cultural construction. They are also to become aware that there are no distinguishable borders between a healthy body, disability and handicap, and that the experience to which a handicap is disabling depends upon the existing circumstances and the values held by people. A disability is not necessarily visible. It is also not necessarily permanent, but can be temporary.

Stages of learning cycle	Activity
Engagement	X
Exploration	
Explanation	
Extend – Elaborate	X

Materials:

A number of cards (available in the associated classroom materials) with pictures of people who have clear disabilities, who have disabilities that are not easily seen, and of people without visible disabilities. The pictures are chosen so that it is not clear what the problem is, or if there is a problem. They are contained in a pdf-file. Print the file, laminate it and cut out the pictures so that each group of pupils can have their own set. Naturally you may replace a picture with another if you have a good example. The people in the pictures illustrate the following:

1. Woman in a motor-driven wheelchair
2. Skier with an artificial leg
3. Woman with an artificial brain-controlled right arm
4. Football player with artificial leg
5. Young man with contact lenses, but these are not visible in the picture. He could also have a psychological handicap or no handicap at all
6. Woman with a hearing-aid
7. Mother and son who have both injured their arms and therefore both in plaster
8. Woman in a wheelchair competing in a race for handicapped athletes
9. Celebrity (such as Crownprincess Victoria of Sweden) testing wheelchair basketball

10. Girl with glasses
11. Swimmer. The picture does not show if he has any disabilities

Suggestions for use with possible questions:

Begin by asking the following questions of the pupils.
Do you know anyone who is perfect? What does it mean to be perfect?

You can discuss these questions with the whole class or ask the pupils to talk together in groups of 2 – 3. While discussing the concept of a perfect body, the pupils will almost certainly bring up body fixation. This is not the aim of the exercise, but it is alright to begin in this way so as to challenge their opinions.

What is perfect? Who decides? What criteria to you use? What if you wear glasses? A hearing-aid?

After that, you can distribute the cards showing people with various degrees of disability. The pictures are chosen to show variation. Ask the following question:
When do you have a disability? A handicap?
Think about and discuss who of the people on the various cards have disabilities. *How do you know? What problems do you think they have? How do they cope with their everyday lives? Do they face difficult situations? Are there any disabilities that are not visible? What disability aids do you know about?*

These are to be seen as examples of questions that can be asked.
Choose then one or two of the pictures to discuss with the pupils. Discuss which disability the person has, what can be difficult or problematic and when this can be the case.

What is it like to go for a walk in town, in the forest, to go to the cinema? etc. Are there solutions?
(Disability aids, adaptation and accessibility)

The questions are to be seen as suggestions, and the discussion can take a number of different courses.

Activity 2: Disability Aids

Learning aims:

Using their knowledge of physics, the pupils should be able to explain how/why some disability aids function and which movements are made easier or possible.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials:

Everyday aids for disabled people. Products of various types to assist in everyday tasks such as eating and drinking, getting dressed or opening packages; these can be bought in a shop or on the internet. Make available too some different packages that can be difficult to open, for example plastic bottles, glass jars or tins of food and some paper cartons. It is important to use real packages so that the pupils can test them and understand for themselves the functions and describe the physics behind the activity with their own words.

Suggestions for use:

Divide the class in groups of 3-4 pupils. The task is in three parts.

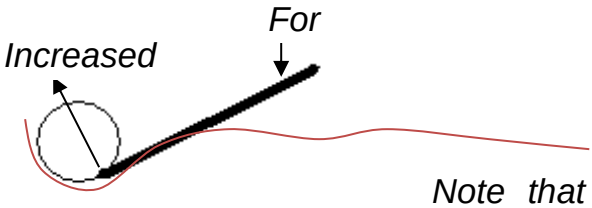
- The first part is about the disability aids
- The second part is about opening a common package
- The third part is about describing the underlying physical principles

Distribute to each group some aids for people with decreased motor skills. The pictures show examples of some aids that can be used. Other pictures are available in the classroom materials:



Ask the pupils to explain what they are and what they are to be used for. What functions do they have? Explain how movement occurs!
After this, each group is given a common package to open. The task is to discover how a person with reduced hand strength can open the package with the help of one or other of the objects. Examples of the packages that can be used are:


Again other examples are available in the classroom materials
To conclude the activity, the pupils are asked to explain and demonstrate the principles for increased hand strength. Theoretically, most cases concern turning around a fixed point. What is to be noticed is that the force used does not work directly at the point at which the result is desired but at some distance from it. The result is dependent upon the degree of force and the distance between the force and the point where the result takes place. This distance is called torque or leverage and is measured at right angles to the force. Note that torque also has a direction – one can turn clockwise or anti-clockwise. This is, therefore, the same principle one uses when a pole or bar is used to lift a stone from a hollow in the ground. The pole functions as a lever; see picture.



Note that the lever always has a fixed point around which the turn occurs
Using a lever is a discovery made in ancient times and is counted – together with the sloping plane, the wedge, the screw and the wheel – amongst the most simple machines. It can be interesting to know that scientists and philosophers in ancient times speculated a great deal about the properties of these simple machines and their use in increasing force.

In order to demonstrate the idea of a lever, you can do the following:
Open a door only about 10cm wide and try pressing against the door close to

the hinge. Note the amount of force required to open the door further. Then try pressing against the edge of the door and compare how much force is required in these two situations. When is least force required? The correct answer is, that least force is required when one presses against the edge of the door. The lever in this case is the complete breadth of the door.

Activity 3: Study visit to a disability aids centre

Learning aims:

The pupils are to learn what reduced motor function can mean and understand and discuss the relationship between reduced movement and handicap. The pupils should also acquire knowledge about which professions are represented at the workplace, what one does within various professions and what educational training is required. They are also to become familiar with some disability aids and be able to explain how these work.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Suggestions for use with possible questions:

The study visit can be carried out with the whole class or in smaller groups. Ideally, try to find more than one place to visit or carry out the visit at various times. Introduce the visit to the class by discussing what the pupils think about, what expectations they have, what disability aids they think they will see and test, what people they think they will meet and what work activities they think these people have. Give the pupils the task of finding out more by doing a search on the internet or by speaking to someone they know who is well-informed on the subject. Ask the pupils to formulate questions to ask during the visit.

Possible Questions:

After the study visit, the pupils are to report using text, pictures or film. Choose a suitable computer program for this work, such as PowerPoint or Photo Story. Suggestions for content:

- What disability aids did I try and how do these help the patients?
- What new things did I learn?
- I would like to know more about…

Hopefully, the pupils will have seen and tried out a wheelchair during their study visit. Present this activity to the pupils:

Adam is a teenage boy confined to a wheelchair. He has a congenital spine injury and cannot move from the waist down. He wants his school and home

life to be fun, to be able to play basketball, compete in wheelchair races, etc.
Activity: Imagine that you work at a disability aids centre and have been given the task of developing a suitable wheelchair for Adam. What do you suggest, based on what you have seen, to help Adam as much as possible? Is one wheelchair enough, or does he need more than one?

This task can be reported on in text and in pictures, together with the report on the study visit.

Activity 4: Technical Aids

Learning aims:

The pupils should be able to explain how technology can assist people with reduced motor function

Stages of learning cycle	Activity
Engagement	X
Exploration	
Explanation	X
Extend – Elaborate	

Materials

Pictures

Suggestions for use with possible questions:

In the first part, the pupils discuss the situation of three people with reduced motor function. During the second part, the pupils make a simple disability aid. The third part consists of a discussion task using an authentic situation.
In Activity 4.1, the pupils are to discuss the problems faced by these three people. Try to imagine what situations they might find difficult to cope with. Some of their problems are eased by the technical aids they have been equipped with. Discuss and give examples of how technology can be of help to people with reduced motor function, in various situations.
In Activity 4.2, a suggestion would be to fasten a torch on a headband and use the lamp to point at different things.
In Activity 4.3 we use the case of a patient who has reduced fine motor skills and therefore has difficulty in pushing small switches on electrical appliances.
The picture on the left shows a large switch available for purchase. The task for the pupils is to build a switch like the one in the picture on the right, which is made of two CD discs. The scientific principle used here is the electrical

circuit.
In Activity 4.4 start from the situation of a handicapped person who needs an adapted car. Let the pupils discuss what adaptations they think might be possible.

Some suggestions:

- A joystick to steer instead of the usual steering wheel
- A specially-adapted air filter for asthmatics
- An individually-fitted driver's seat
- Foot-steering for people with reduced arm function
- Accelerator and brake pedals adapted for use by the left foot if for some reason one cannot use the right one
- Interior heaters so one doesn't need to scrape ice from the windows in winter
- Luggage crane or robot arm for ease of loading/unloading an electric wheelchair

Activity 5: How do muscles work?

Learning aims:

The pupils are to learn that muscles work by contraction and that skeletal muscles work in pairs – one contracts and one lengthens. They work opposite each other. The pupils learn that muscles are fastened to the skeleton at the joints, and learn some of the body's muscles. They are also to learn the distinction between dynamic and static work. Finally, they are to be able to interpret data and draw conclusions. The Activity is an example of how one can work with muscles. Add other exercises you usually use in this area.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	

Materials

Pictures of muscles in the body, from a textbook or from the internet.

Suggestions for use with possible questions:

The pupils are to work in pairs. The task consists of three parts. Gather the pupils together after each part to discuss what they have observed and what they can learn from these observations.

1. Feel the way your muscles work

In this exercise, the pupils feel how the muscle becomes shorter and harder when it is at work. They are also to discover that muscles work in pairs.

2. Which movements?

In this exercise, the pupils work from a picture of the muscles in the human body. They choose some of the larger muscles (for example, the deltoid muscle, back or stomach muscles) and first think about which movement can be the result of the muscle contracting.

The idea is that the pupils are to use their own bodies to be more conscious about it and learn how it works. They work in pairs so that they can discuss their observations. The task is not to investigate each other's bodies.

Gather all the pupils together after 15 minutes and discuss the results all together. Ask them to explain how it feels when the muscles are at work. They have almost certainly observed the movement of the tendons in the arm when they move their fingers. Compare how it feels when a muscle works statically and when it works dynamically. Discuss explanations for this. What is happening to the muscle? (There are more investigations about muscles in Activity 7)

3. Stretching

Discuss stretching with the pupils and ask them if they can think of any exercises one usually does when stretching. Such exercises can be found on the internet. An example:

http://www.musclesprod.com/bodybuilding/bodybuilding-stretching-exercises-for-strength-training/

When muscles are at work, they are thicker and shorter. This is why it is said to be important to stretch after training. Short muscles can lead to deformities in the body. It is also said that stretching prevents muscle pain after training. Both these ideas are disputable and there is no evidence to show that this is truly the case. The best way to avoid muscle pain after training is to warm up properly before the activity, and when finishing exercise, to stop gradually rather than stop suddenly.

Activity 6: The strength and function of muscles

Learning aims:

The pupils are to learn that the skeletal muscles work in pairs with one that contracts and one that relaxes or lengthens. Muscles are fastened to the skeleton on different sides of the joint. Their strength depends on the size of the muscle and the distance between the joint and the point at which the muscle is attached.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials

Diagrams of a muscle, Meccano (or similar) and a dynamometer or steel spring.

Suggestions for use with possible questions:

During the course of this activity, it is highly likely that questions about building up muscles will arise. In that case, it is appropriate to discuss types of training for strength - if one wants to build large, strong muscles or to build up more endurance. To achieve large, strong muscles, one must load the muscles to engage more muscle cells in the exercise. To build big muscles, all the cells in the muscle must become larger. If the goal is to build up more endurance, the muscles must loaded more moderately, but over many exercises. While one is still growing, the best thing is simply to work with one's own body as the load.

Ask the pupils to discuss each of the pictures in terms of strength and function. Which muscle is the strongest? What are the advantages and disadvantages of each of these possible examples?

Muscles work according to the principle of leverage. In figure A, the muscle doesn't work at all, as it is connected to the same bone at both ends. There is no leverage. In principle, Figure C shows the strongest muscle, as the distance between the point of connection and the joint is the greatest. On the other hand, with arm muscles like this, one would be so clumsily built it would be difficult to move with ease.

In order to demonstrate the physics explanations, one can work with Meccano either in metal or in wood. Ask the pupils to construct a model of an arm with the muscles attached according to the picture on the left. Use a dynamometer and compare which of the three examples A – C gives the strongest muscle: that which performs the most work.

Activity 7: Receptors, nerves and nerve impulses

Learning aims:

The pupils are to learn to describe how the nervous system works, and how it reacts to both outer and inner stimuli. They are also to learn that certain disabilities are caused by neurological disorders. The pupils are to understand the difference between the central and the peripheral nervous systems. The pupils should also be able to plan an investigation where both sensory neurons and motor neurons are studied. The pupils should also learn to appreciate that different materials feel differently, even if they have the same temperature, because of the varying heat transferring capacity. The investigations are to include the formulation and testing of hypotheses, the collection of relevant data and the evaluation of its validity, and the drawing of conclusions from the investigation.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials

Time-piece (watch, mobile telephone), ice water, warm water, paper clips, ice cubes.

Suggestions for use with possible questions:

This activity consists of four exercises. The two first exercises concern receptors and the sense of touch, but also the capacity of heat transfer in various materials. The picture of the conversation in the sauna can be used as an introduction to “How does the sense of touch work?”, about receptors in exercise 7.1. Judging temperature using touch is difficult. Exercise 7.2 describes an attempt to show that judging temperature is relative. Exercise 7.2b is included as an example of how one can integrate a task in physics to illustrate further why the feel of temperature is relative. There are advantages

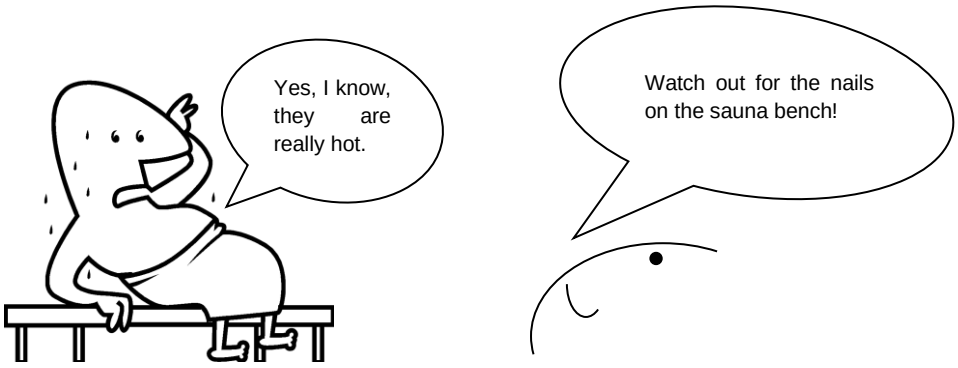
in doing this, as some neurological disorders can be compared to the capacity of different materials to transfer heat, i.e. that certain disorders cause nerve impulses to be transported at a slower rate (and with decreased accuracy). The two last exercises concern nerve impulses and how these and the central nervous system can cause phantom pain, amongst other things.

Activity 7.1: In the first exercise, the pupils plan an investigation where they study various types of sensory cells and if these are evenly distributed on the hand. In order to help the pupils initiate their work, the teacher can ask questions such as:

- Are there different types of receptors to feel heat and cold?
- Where are the sensory cells on the hand?
- Are there areas where sensory cells are more densely situated?

To investigate the distribution of receptors that feel cold and heat, the following can be tried: use a sharp object that is warmed in hot water or chilled in iced water, and draw the object along a line on the hand. Mark where the receptors are found. It is important that the hot/cold object is dry when it is used.

The sauna - How does the sense of temperature work?



The picture above is an example of how difficult it is to judge temperature using touch. We have all been puzzled from time to time about how different it feels to touch objects with different heat transferring capacity. Wood has a lower heat transfer capacity than the metal in the nails. Another way of showing this is to compare the time it takes for ice to melt on a metal tray or on a piece of wood. The different construction of materials and the varying properties this gives them can affect our receptors in different ways.

Activity 7.3. In this exercise, the pupils are to carry out an investigation where they calculate how fast a nerve impulse is. We suggest here that the groups are given various ways of how to go about their work. For example, groups with varying numbers of students can stand in a ring or in a row at arm's length from each other, each with a hand on the shoulder of the pupil in front. A reaction chain is built by squeezing the shoulder of the person in front as soon as it is felt from behind. Ways of varying this are possible. The pupils carry out this investigation, and in order to practice evaluating their results and arguing for alternatives, they present their results to other groups, or similar. They can discuss reasons why the results differ and what might cause this. How much concentration is necessary? Is it better to close your eyes? Each group is to agree on how the investigation can be improved, considering the length of the chain, the number of investigations carried out, the calculations, concentration, etc.

Questions that can be asked of the pupils are:

- Did you get similar results?
- Have the groups carried out the investigation in the same way?
- Which investigation worked best?
- Why?
- Allow the students to plan a new investigation where they take advantage of their experience of the first one.

Activity 7.4: In the fourth exercise, the pupils work with phantom pain. Phantom pain is pain that seems to come from an amputated limb. The pain is real and arises from stimulus to the nerves that have been severed. That the pain is incorrectly attributed to an absent limb is caused by the signals from the remaining fragments of the nerves being interpreted by the central nervous system – i.e. the spinal cord and finally the brain – as coming from the amputated limb. It is not always so that the pain is experienced as common pain, but can present as an irritating itch, heat or cold and can vary between individuals.
Allow the students to investigate how phantom pain can occur and how it feels by asking them to put their elbow in a bucket of ice water for some minutes. Ask the pupils to read an article on the internet or from a journal where the latest research findings on phantom pain are described.

Activity 8: Why do we breathe?

Learning aims:

The pupils are to learn to explain how respiration works, how oxygen is transported in the body and why the cells need oxygen in cell respiration. The pupils are also to learn to critically evaluate various statements, search for information and determine if a statement is scientifically correct. They are also to be able to justify their arguments with the support of scientific knowledge.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	

Materials

A picture of pupils having a discussion, textbook.

Suggestions for use with possible questions:

The pupils are to work in groups. Many pupils have difficulties in seeing the human body as a whole where molecules, cells, organs and organ systems work together. In this task, the pupils discuss how the various parts work together. Give the pupils the worksheet with the transcribed conversation between classmates and ask them to explain why we breathe.

Activity 9: How is the pulse and respiratory rate affected by different activities?

Learning aims:

The pupils are to be able to investigate how the pulse and breathing vary during different activities and to be able to report these results graphically. The pupils are to explain why we need oxygen and realize that we need more oxygen the more work we undertake. They are also to be able to explain the difference between aerobic and anaerobic respiration, and to explain the connection between pulse rate and rate of breathing during and after physical activity.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials

Timepiece (watch, mobile telephone), stairs, computer or graph paper..

Suggestions for use with possible questions:

This task gives the pupils the opportunity to plan an investigation and present the data from their experiment graphically. The task is to identify how the pulse and breathing rate vary during different activities, as well as to explain their results. It would be advantageous to carry out this task with the cooperation of the physical education teacher.

The pupils work in pairs. It can be a good idea to introduce the exercise in a broader context in order to make it more stimulating and to motivate the pupils. For example, one can use a particular sport as a starting point or ask the question “What makes you breathe faster?”

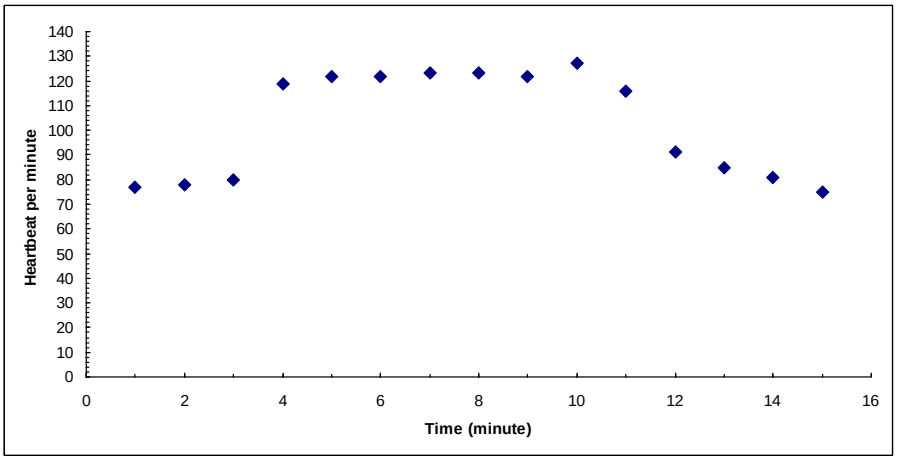
The task consists of several parts:

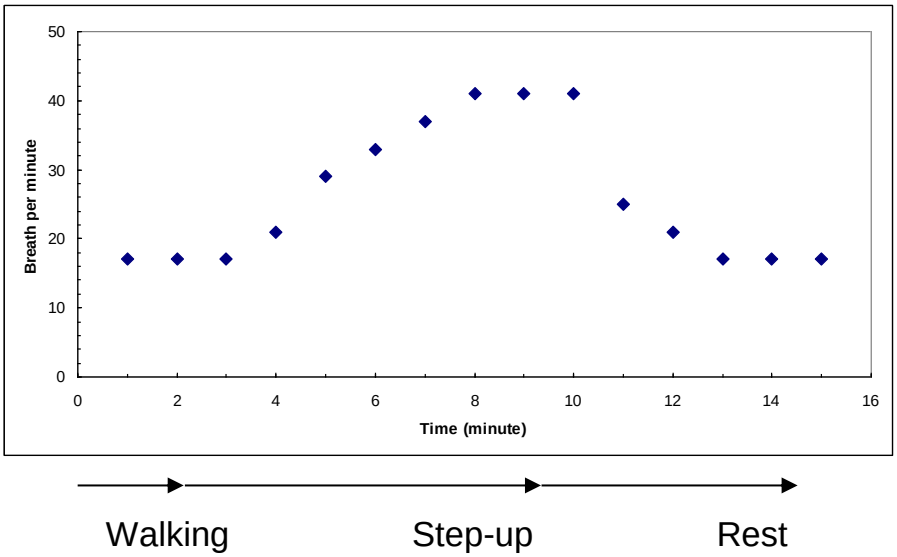
1. Begin by asking the pupils to consider what they think will happen to breathing and the pulse rate during various activities. Is it just the frequency of breathing which changes under stress? The size of each breath? How quickly does one recover after an activity?
2. Discuss how one can measure pulse and the breathing rate. How should one collect data? How long should one keep measuring? How can one present the results so that they are easy to compare?

3. Plan and carry out an investigation.
4. Let the pupils compare each other's results and discuss these with the whole class. Why is there some variation? Discuss the advantages and disadvantages of doing the investigation with a number of participants.

The pupils are to plan and carry out an investigation where they study the connection between pulse and breathing during static muscle activity and dynamic muscle activity and subsequent rest. Dynamic activity is aerobic as the blood circulates through the muscles. Static activity is anaerobic as one hinders the blood supply and the muscles have to work anaerobically when the oxygen supply has expired. Compare, for example, the exercise "step up" with "sit against the wall".

In the diagram below, an example is given of how some pupils have reported the results of the aerobic activity. The diagram shows that the pulse rate and breathing rate changes over time when various activities are carried out. If the heart beats more times per minute, we also take more breaths. This is because the heart pumps the oxygen into the body and when it pumps more oxygen we also need to breathe in more oxygen. This is the case in aerobic activity. When we work at a slower rate, both the pulse and breathing rates decrease as well. During aerobic training, we achieve a stage where the heart is pumping out as much oxygen as the muscles need, and we breathe adequately to ensure that enough oxygen enters the bloodstream. If we increase the activity level above this, the muscles work anaerobically; that is to say the muscles burn glucose without access to oxygen. Carbon dioxide and lactic acid form. We are only able to work this way for a limited amount of time. Describe the connection between the pulse rate and the breathing rate in the example below.





The diagram shows an example of how the pulse and breathing rates change during an activity. The pupil starts by walking for three minutes at a slow pace. After that, the pupil does a step-up exercise for seven minutes, followed by a period of 5 minutes' rest.

Activity 10: Fitness training

Learning aims:

The pupils are to learn to explain what fitness is and the connection between pulse, heart rate, and respiration. They are to be able to make suggestions on how one can engage large groups of muscles so that one increases the pulse rate and thus respiration as well. They are to be able to plan an investigation: formulate hypotheses, test their hypotheses, collect relevant data, interpret data, discuss their data and to present their results and conclusions.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	

Materials

Time piece (watch, mobile telephone).

Suggestions for use with possible questions:

This task requires pupils to plan and carry out an investigation. One can adapt the instructions: the amount of freedom given to the pupils is dependent upon how used they are to working with this type of task. Distribute the worksheet with the story below. The pupils should work in groups of two or three.

Photo:Scanpix

The woman in the picture seems to be very fit. It is obvious that she could not acquire such a good level of fitness by running, which otherwise is a common way to train. What sort of exercise can she do instead to increase her fitness?

When muscles are active the muscle cells need oxygen and glucose which are transported to them when the heart beats. An efficient heart pumps more blood in each heartbeat, thus transporting more oxygen with fewer beats than a heart in the body of an unfit person. If you train regularly, you can perform more work with the same number of heartbeats than if you do not train. In order for the heart to work hard, it is important to engage large muscle groups in fitness training.

1. Firstly, discuss with the pupils what fitness and fitness training is. What is a normal pulse at rest, and how high can the pulse rise? Then discuss what one can do to increase the heartbeat rate - and therefore respiration – without using the muscles in the legs

2. Hypothesis
The pupils write down their hypotheses

3. Planning an investigation
Divide the pupils into groups. Now they need to agree on testing some of their hypotheses. The pupils must decide which activities they are to do, what they are to measure (pulse), how they are to measure it, whereabouts on the body and how many times. It is more interesting if the groups do different types of investigations. Should they do a series of measurements on one person, or should several people do the same thing? It is important that the pupils test only one variable at a time.

4. Data collection
The pupils carry out the measurements they have planned, and record their results

5. Interpreting and discussing the data
Give the pupils sufficient time to discuss their data and the way it has been collected. What did they measure? What differences did they observe and what can have caused these? Where the pulse was measured? The differences between individuals? The differences between the various series of measurements? Differences between the activities? Did they measure the right thing? Did they measure carefully enough?

It is also important to discuss source errors and consider what is and what is not comparable.

6. Reporting of data
Ask the pupils to record their results in the form of tables, graphs, diagrams etc.

7. Conclusions
What is fitness training? What happens to the body in fitness training? What activities do the pupils suggest that the woman in the wheelchair should perform?

Divide the pupils into new groups so that they can cross-reference their investigations and results, and in this way practise communicating and explaining their results.

Additional task:
Find out how handicapped athletes actually train. www.youtube.com

Activity 11: Can you cope with a wheelchair at your school?

Learning aims:

The pupils are to be able to apply their knowledge in order to identify hinders in the school environment for a person confined to a wheelchair. They are to plan and carry out an investigation, draw conclusions from the results and suggest improvements.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials

Worksheet 11. The pupils must themselves think about what materials they need to carry out their investigation.

Suggestions for use with possible questions:

The pupils are to work in groups. The task is to investigate the school's accessibility to a person in a wheelchair.
Start with worksheet 11 containing the description below. Ask the pupils to formulate criteria for good accessibility. Ask them then to describe how they will investigate if these criteria are fulfilled. Discuss this with the whole class, and then allow the groups to carry out their individual investigations. They can investigate various sections of the school and its environs – the classrooms, the sports hall, a nearby shopping centre, bus stop etc.
They are to write a report. In connection with reporting, they are to suggest improvements. A good way to investigate the situation is to borrow one or more wheelchairs and let the pupils test life at their school in a wheelchair for a whole day.

Discussion Assignment: To be young and live with a disability
Many people are forced to live with serious illnesses throughout life. An example of such a disease can be CP, cerebral palsy, an umbrella term for various disorders of muscle control caused during foetal development, during childbirth or during early childhood. CP is the leading cause of disability in children and adolescents. Symptoms vary, but usually the patient in the spastic limbs. Many people believe that people with cerebral palsy are mentally retarded, but only 25 percent are - and these people usually have two diagnoses. CP is not in the head but in the body!

Here the teacher can inspire a discussion based on the story of Alex:
Alex has cerebral palsy and is 23 years old. She is a happy and lively girl, who absolutely do not want her disability to prevent her from living a normal life. She lives in an apartment and has personal assistance around the clock.
Alex says that people she meets often talk over her head and turns to the assistant rather than directly to her. Once they talk to her they scream to make sure that the message gets through.

- Why do you think it is this way?

Alex wants us all to treat a person in a wheelchair the same way as we treat everybody else. You can quickly tell if the person you talk to does not understand.

At school, Alex had a problem, particularly in practical subjects, crafts and home economics. Her teacher felt she did not learn anything because she just watched as assistants did the work. They did not understand that despite the handicap she learned and was interested in learning how to cook and sew. She does need skills of her own to communicate knowledge with her assistants.

- How will she explain this to their teachers?

When it was outdoor activities Alex was liberated and did not participate because the teachers saw all the obstacles her wheelchair could bring.

- What opportunities do you see? What activities could Alex have participated in?
- How would the obstacles be overcome?

The text of the task inspired by article in Biologist 4, 2010: To not only see the wheelchair - to live with disability

Activity 12: What does the future hold for the development of disability aids?

Learning aims:

The pupils are to be able to talk about some of the development work going on in the area of disability aids. They are also to be able to talk about what education people who work in this field have and what their workplaces look like. The pupils are to be able to explain how one can know which websites give relevant information.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Suggestions for use with possible questions:

Following the work with the body, study visit and their own investigations, the pupils are able to pose their own questions about which development projects are underway and how one goes about producing new disability aids. They can find information on the internet. The class can also work together on asking questions before a study visit that the class carries out, or invite someone who works in the field of developing these aids to visit the class to talk about their work and answer questions. In this way the pupils are given the opportunity to discuss their own ideas for development, and to make models.

This task can be given different emphasis, depending on time and interest. It is possible for the pupils to do this as a somewhat larger group task where they formulate questions, describe how they will find answers – for example from literature, the internet, contact with businesses and from interviews – which then form the basis of a report.

ECO-BIOLOGY

The development of this unit has been led by the ESTABLISH partners:

Constantinos Phanis
Cyprus Ministry of Education and Culture, Cyprus

and
Nicos Valanides
University of Cyprus & Frederick University (FU), Cyprus

UNIT CONTENTS

I. *Unit Description*

The proposed activities are designed for an inductive or 'inquiry' field work approach that incorporates the processes of field research. Issues are introduced, key questions raised, and students select methods to investigate and develop possible solutions to these. The teachers act as supervisors and advisors, providing equipment, advice and ensuring safe working.

- Student level: Secondary school
- Discipline level: Biology, Chemistry, Physics and Technology
- Estimated duration:10-15 lessons

Learning objectives:

At the completion of this unit, pupils should be able to:

1. Develop observation and interpretation skills
2. Formulate their own questions and hypothesis
3. Plan, carry out and report on an investigation that can answer their question/ hypothesis
4. Specify the dependent, independent and control variables of their designed experiment
5. Learn how to record and present data in a table and graph format
6. Consider the limitations of the methodology
7. Discuss and evaluate both the validity and the reliability of the outcomes of their designed experiments
8. Consider conservation of endangered plant species
9. Learn relevant ecological terminology
10. Consider safety and ethical issues
11. Estimate the density of an endangered plant species in a named ecosystem
12. Suggest how conservation of specific endangered species can take place.
13. Become able to design and perform an experiment for investigating the effect of temperature or any other specifically selected abiotic factor on the development of seeds of a selected plant or its seedlings that can be find in the ecosystem under investigation
14. Inquire about the construction of a greenhouse
15. Identify living organisms in the local ecosystem
16. Construct keys using common features of organisms
17. Inquire about scientific classification –taxonomy- of organisms
18. Inquire about the life cycle of a living organism
19. Inquire about the role of an organism in the ecosystem

20. Use genetics to identify common features of organisms
21. Discuss the theory of evolution based on DNA homologies
22. Learn how to draw a biological diagram using a flower from their local ecosystem
23. Understand the significance of biological magnification
24. Relate the structure of a flower to seed production, whilst learning relevant terminology, such as, pollination, fertilization. To identify pollen grains using microscopy
25. Understand the structure of seeds
26. Evaluate the methods used by seed banks in the conservation of endangered plants
27. Inquire about the life cycle of a named insect and its role in pollination
28. Collect pollen from flowers and observe it under a microscope
29. Inquire about the effects of Global warming in seasonal flowering, pollination and seed biology
30. Design and perform an experiment to investigate the time that they can store selected seeds
31. Implement an appropriate methodology for safely obtaining a plant extract
32. Investigate the effect of different plant extracts/ antibiotics on bacteria

II. *IBSE-Inquiry-Based Science Education*

The activities elaborate on observations from the European Union Science Olympiad (EUSO), which was organised in Cyprus and took place in May 2008. The proposed activities focus on a lower secondary biology level (student age 12-15), but can be also adapted to higher secondary-level school. The field activities have been carefully planned in order to enhance students' abilities and skills resulting from class and laboratory investigations. From this perspective, field activities put emphasis on stimulating students' curiosity and interest to provide answers to either their own questions or to questions initiated by their teacher. Students are encouraged to be involved in activities targeting the development of their understanding of how science works and on social, moral and ethical issues. Specific attention is drawn to recent technological advances and students have the opportunity to become familiar with new science applications. Students are also guided to gain an appreciation of the ecosystem which is selected for investigation and correctly conceptualize the potential of integrated science and technology for solving or alleviating contemporary environmental issues. The students are guided to record their experimental observations and draw from them tentative generalizations and conclusions that can be verified through continuous experimentation. At the same time, they can also gain an appreciation of the limitations that apply when designing an experiment whilst gaining technical experience.

In an educational context, where there is an increasing need to encourage students to enjoy science, so that they become interested, curious and develop knowledge-building skills, field investigation approaches can be very useful. The field work activities that are presented attempt to promote science, mathematics, and technology and put emphasis on the 7E learning cycle, namely:

- elicit
- engage
- explore
- explain
- elaborate
- evaluate
- extend

"What do you think?" questions can elicit students' prior conceptions, and an ecosystem engages and motivates students by arousing their interest. The

students explore the environment under investigation identify a problem as a result of their observations and make predictions or formulate a hypothesis, design a research methodology, collect, record and analyze data, draw conclusions that result in the acceptance or rejection of the original hypothesis. Various degrees of teacher and student ownership and control are possible. New concepts are introduced and new terms are explained.

III. *Pedagogical Content Knowledge*

The field study inquiry-based activities are designed, so that students who collaborate as a team:

- Are intrigued by field activity.
- Appreciate their experimental observations in order to describe and explain scientific phenomena.
- Appreciate the limitations, which apply when designing an experiment
- Gain technical experience, develop skills of handling simple apparatus through team cooperation and develop initiative
- Gain an appreciation of the ecosystem, which is under investigation.
- Become intrigued to ask and solve questions that arise from their investigations in order to gain knowledge, understanding and critical thinking.
- Plan, carry out and report on investigations
- Develop scientific attitudes and habits of mind that are extremely useful even in usual everyday activities
- Promote their epistemological development life-long learning abilities.

IV. *Industrial Content Knowledge*

In the study of ecology there is now major focus on the increased use of resources and on the impact of humans on the Earth. Classical biology can explain biological phenomena but modern biology must now find new innovative ways to stimulate the intelligent mind and encourage science inquisitiveness. Is it possible to understand human effects on the environment without knowledge of physics, chemistry, mathematics, technology and biology? Eco biology involves industries, businesses, research and educational institutions as well as the activities of municipal and county government. We therefore recommend study visits and the involvement of experts A study visit and field-work will probably give rise to many questions. Some of these can be answered by doing Internet searches and email contact with various businesses, researchers and others. Another alternative is to invite an expert to work in the field or to talk to the class

V. *Learning paths*

The table below shows the tasks for pupils that are included in this unit. They are published in the unit document Classroom Materials. Instructions to pupils are included, and we assume that the pupils will write up their activities in their own notebooks.

Activity		Subject
1.	Estimating the density of an endangered plant species in a named ecosystem	Biology, Physics Maths, Technology
2.	Plant adaptations and effects of global warming on endangered and/or farmed plant species	Biology, Physics Technology, Chemistry
3.	The science of taxonomy	Biology, Chemistry Physics, Technology
4.	Flowering plant reproduction	Biology, Chemistry Technology
5.	Plant extracts and antibiotics	Biology, Technology

VI. *Assessment*

When working with a unit of this type, it is important that its associated assessment is in line with the stated learning objectives, and of course also with relevant policies. It is also important that the pupils are informed at the beginning of the unit about how they are to report on their work and how they are to be assessed. Assessment can also take place in the field when the students are interacting as a group.

VII. *Student learning activities*

Activity 1: Estimating the density of an endangered plant species in a named ecosystem

Learning aims:

- To learn relevant ecological terminology, such as: ecosystem, habitat, abiotic factor, species, population, community, density, endemic organism, adaptation
- To estimate the density of an endangered plant species in a named ecosystem
- To learn how to record and present data in a table and graph format
- To consider the limitations of the methodology
- To consider conservation of endangered plant species
- To consider safety and ethical issues
- To suggest how conservation of specific endangered species can take place.

Stages of learning cycle	Activity
Elicit-Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials:

Calculator , Tape measures, Thermometer, Hygrometer, pH meter, Light meter, Quadrants (1 m^2 or 0.25 m^2), worksheets

Suggestions for use with possible questions:

Introduce the topic: Humans are dependent upon plant life. Plants provide fuel, food, clothing, paper, shelter and yield important medicinal compounds. The International Union for Conservation of Nature and Natural resources (IUCN) report a combined total of 35,319 endangered plant species. Human impact has been the main cause of the rapid destruction of unique ecosystems, thus threatening plant species.

Exercise 1

- To learn relevant ecological terminology, such as: ecosystem, habitat, abiotic factors, species, population, community, density, endemic

organism and adaptation.
- To consider conservation of endangered plant species

The students will be asked to explore a local ecosystem and to select an endangered plant species for their field study. This inquiry-based activity will take place in the field, aiming to stimulate students' interest to raise and investigate relevant scientific questions and connect learning with everyday life and human interest. A class of 20-30 students can be organized by the teacher in 4-6 teams, each team consisting of 5 students. There are many examples of local ecosystems that can be investigated—a pond, a school garden, a forest, an estuary and a grassland. Each team of students can suggest and inquire about a specific plant, which is present in the selected ecosystem. At the end of the field-work the students must search the web in order to find information so that they can write a short passage about the ecosystem under investigation highlighting and/or introducing relevant ecological terminology, such as, ecosystem, habitat, abiotic factor, species, population, community, density, endemic organism, adaptation.

For example in Cyprus, the Athalassa National Park can be the selected ecosystem.

As an example, a short passage follows introducing a Cypriot ecosystem:

> The Cyprus National Park of Athalassa (ecosystem) is the result of afforestation (deliberate planting in an area, which had not recently been a forest land). Thyme is indigenous species in Cyprus, very common to rocky slopes (habitat), disturbed ground and occasionally on sand dunes, in shrub lands and forests. It grows on all types of soils (abiotic factor), as it is a low-demand plant and prevents soil erosion.
>
> Thyme has xerophytic (drought-resistant) adaptations. Thyme has been well known since ancient times as a good source of nectar for honey bees, and for its aromatic and medicinal properties. "Thyme is a source of food for bees" (Aristotle Historia animalium). Shepherds also used it as fuel when making the local goat cheese. Such was the demand for thyme that there was a class of traders called "throumpopoulides" (sellers of thyme).
>
> A Cypriot amateur beekeeper has kept bee hives in his garden for the last three years, but he has not been able to increase their number. Cyprus has had very little rainfall and it faces desertification. The bee hives have not produced swarms and two beehives have perished.

Human impact on the environment has been severe. The bee keeper observed that the number/ population of thyme plants in the Athalassa Park has been declining. It could be that thyme plants are stressed out.

The questions 1 and 2, on worksheet for exercise 1.1 can be used to assess student knowledge of the relevant ecological terminology.

Based on the results of any similar evaluation, the teacher will then design activities or classroom discussion for clarifying or introducing the relevant terms, so that students will have clear understanding and orientation for their activities and tasks.

Exercise 2

- To estimate the density of an endangered plant species in a named ecosystem

The following activity can be used to teach students how to estimate the density of a specific plant that is present in an ecosystem relative to a named abiotic factor such as temperature. The teacher needs to explain to the students that scientists many times cannot possibly count every organism in a population. However, scientists can estimate the size of a population. Students need to learn how to collect data by taking random samples. This activity can first take place in the field without the students knowing the full practical details of the methodology. The students are asked to inquire about how a named abiotic factor may affect the density of the named plant that they have selected. The correct methodology can be provided to the students at the end of their investigation in order to make comparisons and even correct their own designed methodology. The full practical details of random sampling including apparatus to estimate the density of a specific endangered plant in an ecosystem in relation to an abiotic factor, such as, temperature is provided in **worksheet for exercise 1.2.**

Exercise 3:

- To organise and represent data

In order to teach how to record and present data in a table and graph format, the students are asked to record and present their data in a table. The correct format of the table is given below. The table below is given to the students, once they have designed their own table. Of course, the approach should take into consideration students' prior educational level and their abilities, knowledge and skills.
An example is given in **worksheet for exercise 1.3.**

Exercise 4
In order to analyse data from their own investigation, the students will be asked to estimate the mean density of an endangered plant (explain that the mean density equals the average number of endangered plants per m2). A question for further understanding can be: If the area under investigation is 10000 m^2 calculate the number of, e.g., thyme plants in the ecosystem under investigation?
The student teams will be asked to compare how the same abiotic factor affects the density of two different plants (or the same plant, found in a different ecosystem). The investigation is planned accordingly. The students need to plot a bar chart indicating: Mean density of each plant (Y axis) versus (type of plant X axis).

Exercise 5
The students will then be asked to consider the limitations of their experiment. The teacher will explain to the students that limitations in an experimental investigation are factors that they cannot control, no matter what they do. After discussion in their teams, then they can answer the following questions available on **worksheet for exercise 1.5**

Exercise 6

- To consider safety and ethical issues

The students will be also asked to consider any safety and ethical issues, when they are inquiring about the named ecosystem that they will be investigating. The students are expected to search the Internet, to discuss with each other, to answer questions from their teacher and/or to observe a demonstration?

Possible student answers considering safety include:

- Possible risk from indigenous animals / unidentified plants / insect bites / falling branches/ slips and trips.
- Possible student answers considering ethical issues include the following:
- Minimize disturbance to the habitat ……..

A study visit

- To suggest how conservation of specific endangered species can take place.

The activities are designed in such a way that all the answers can be discussed in the field by a team of interacting students and their teacher. The activities could be furthermore extended to technology related topics. A visit to a weather station, either on land or sea, demonstrating how instruments and equipment are used to observe atmospheric conditions can provide information for weather forecasts and for studying the weather and climate. The measurements taken using sensors include temperature, barometric pressure, humidity, wind speed, wind direction, and precipitation amounts. The students can thus understand the need to monitor multiple abiotic factors that can affect plant density over a period of time.

Furthermore, the students can visit a zoo or a University (e.g. a genetics laboratory) and discuss the role of a researcher, a botanist, a zoologist, a microbiologist, a mycologist and a geneticist investigating biodiversity in terms of conservation. Students should become able to suggest how conservation of specific endangered species can take place. The students can study the World Conservation Union (IUCN) Red Data List (http://www.iucnredlist.org) to find species classified as endangered and they can investigate how a specific species is protected in terms of conservation.

Activity 2: Plant adaptations and effects of global warming on endangered and/or farmed plant species

Learning aims:

- To learn relevant plant terminology, such as, xerophytes, hydrophytes, mesophytes, halophytes, and plant adaptations mechanisms, such as: stomata, cuticle, large or small surface area to volume ratio, hairs
- To become able to design and perform an experiment for investigating the effect of temperature or any other specifically selected abiotic factor on the development of Seeds of a selected plant or its seedlings that can be find in the ecosystem under investigation
- To specify the dependent, independent and control variables of their designed experiment
- To discuss and evaluate both the validity and the reliability of the outcomes of their designed experiments
- To inquire about the construction of a greenhouse.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials:

A photo and keys of a known/named plant that grows in the local ecosystem; Calculator; Ruler; Thermometer; Hygrometer; pH meter; Light meter; Soil; Water; Minerals, worksheets.

Suggestions for use:

Introduce the topic: Many scientists are concerned about the effect that climate change could have on the development of organisms and the yield of many important farmed foods, such as, maize, wheat, rice, etc. This activity investigates the effects of global warming on a specific plant found in the local ecosystem under investigation.

Plants are put into categories according to their adaptation to water availability.

- Hydrophytic- adapted to aquatic or semi-aquatic conditions. Rice is semi-aquatic.

- Mesophytic- adapted to middle water conditions, typical temperate terrestrial conditions. An example of a mesophytic habitat would be a rural temperate meadow, which might contain Goldenrod, Clover, Oxeye Daisy, and Rosa multiflora. Mesophytes make up the largest ecological group of terrestrial plants, and usually grow under moderate to hot and humid climatic regions.
- Xerophytic- adapted to conditions of low water availability. This includes plants from a variety of conditions, including sand dunes, high alpine habitats and equatorial deserts. Sorghum is a xerophytic plant. Sorghum is a genus of numerous species of grasses, one of which is raised for grain and many of which are used as fodder plants either cultivated or as part of pasture.
- Halophytic- adapted to high salinity conditions, coming into contact with saline water through its roots or by salt spray, such as. in saline semi-deserts, mangrove swamps, marshes and sloughs, and seashores. An example of a halophyte is the salt marsh grass Spartina alterniflora (smooth cordgrass). Relatively few plant species are halophytes - perhaps only 2% of all plant species

Exercise 1

- To learn relevant plant terminology, such as, xerophytes, hydrophytes, mesophytes, halophytes, and plant adaptations mechanisms, such as: stomata, cuticle, large or small surface area to volume ratio, hairs

The students can be asked to inquire about the adaptations of a named plant, which grows in their local ecosystem. Depending on the ecosystem, the plant can belong to hydrophytes, mesophytes, xerophytes or halophytes.

The teacher may allow a team of students to present adaptations of their plant
High lighting key ecological words and allowing further class discussion in terms of comparison of plant adaptations and plant adaptation mechanisms.

Assess student knowledge relating to adaptations of xerophytes
Read the following passage about the adaptations of Convolvulus oleifolius, which survives in dry conditions, and then write on the dotted lines the most appropriate word to complete the passage available in **worksheet for exercise 2.1.**

Exercise 2

- To become able to design and perform an experiment for investigating the effect of temperature or any other specifically selected abiotic factor on the development of seeds of a selected plant or its seedlings that can be found in the ecosystem under investigation

A team of four to five students can be asked to inquire and write the methodology that they can follow to investigate the effect of temperature, or any other abiotic factor, on the development of a named plant that grows in their selected local ecosystem. The students should have the possibility to repeat observations over time, revisiting the same site and collecting data every day, every week, or even every month (or even every year). There will be a great variety of seedlings or seeds that can be investigated depending on the time of the season and the local ecosystem. The teacher should guide the team to plan their investigation with relevant questions, but without always providing the correct answers. Monitoring germination or growing of the seedling will entirely depend on team effort. This activity can also be linked with a visit to a local greenhouse. The experiment can take place in the greenhouse investigating how a specific temperature affects germination of a stated number of seeds. Students can experience hands-on design and installation projects using professional equipment and materials situated on-site greenhouse, which is dedicated to environmental sustainability. Suggested questions are available on the **worksheet for exercise 2.2.**

Exercise 3

- To discuss and evaluate both the validity and the reliability of the outcomes of the designed experiments

Introduce the topic: The idea behind reliability is that any significant results must be more than a one-off finding and be inherently repeatable. Other researchers must be able to perform exactly the same experiment, under the same conditions, and generate the same results. This can reinforce the findings and ensure that the wider scientific community will accept the conclusions. Without this replication of statistically significant results (this will apply to higher level biology students), the experiment and research cannot fulfil all of the requirements of testability. This prerequisite is essential to a hypothesis establishing itself as a tentatively accepted scientific truth.

A possible question that a teacher may ask the students include:

Describe what effect a non-controlled abiotic factor (variable) could have had on the results, if it had not been controlled.

Activity 3: The science of taxonomy

Learning aims:

- To identify living organisms in the local ecosystem
- To develop observation and interpretation skills
- To construct keys using common features of organisms
- To inquire about scientific classification –taxonomy- of organisms
- To inquire about the life cycle of a living organism
- To inquire about the role of an organism in the ecosystem
- To use genetics to identify common features of organisms
- To discuss the theory of evolution based on DNA homologies.

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials

In the field: Beating Stick and Net; Aspirator; Killing Tube; Light Trap; Keys; Camera; Container

In the lab: Dissecting Microscope; Compound Microscope; Scanning Electron Microscope; DNA Sequencing homologies

Suggestions for use with possible questions:

Introduce the topic: The biodiversity of planet Earth is the total variability of life forms. Currently about 1.9 million species are known, but this is thought to be a significant underestimate of the total number of species. Every year, thousands of new species are discovered. Biologists use characteristics of each newly discovered species to classify organisms having similar characteristics. A classification system is used to assign a single universal name to each organism. Biologists in the field have to use their observation and interpretation skills to make deductions about the organisms they discover. This lets them build up an accurate picture of the role of the organism in its environment, how they interact with their surroundings and what threats they may face now or in the future.

Exercise 1

- Allow a team of five students to observe the environment around them. The students must use a field notebook to sketch the organisms that they discover, and take notes on their features including shape, colouring, and behaviour. The students must write down when and where they found the organism, and any interesting information about its behaviour. They must learn to be as precise as possible. If you can, use a field guide or a specialist (e.g., botanist, forester, zoologist) to identify what kind of organisms they have found. Let the students know that they must keep track of any questions that occur to them.
- Discuss with the team why the organism must be kept alive. If they capture a live insect, and they want to observe it for a short while before setting it free, they must put it in a clear container with enough room for it to fly around and to breathe.
- Return the organism to its natural habitat.
- Allow the students to take a photograph of any interesting organism and to start a photo album.
- Without the right tools, insects can be tricky to catch. Ask the students to search the network for homemade bug-catching devices they can make by themselves.
- Use a stereoscope or a microscope in the laboratory to identify any relevant characteristics.
- Record the characteristics of the organism.

Exercise 2

Construct a dichotomous key device that can be used to easily identify an unknown organism.

Introduction; The word dichotomous comes from two Greek words that together mean, "divided in two parts." A dichotomous key consists of a series of two part statements that describe characteristic of organisms. At each step of a dichotomous key, the user is presented with two choices. As the users make a choice about a particular characteristic of an organism, they are led to a new branch of the key. Eventually the users will be led to the name of the organism that they are trying to identify.

Exercise 3

Ask the students to inquire in the website for information about the role of the organism they have identified in the ecosystem.

- Gather responses and subsequent questions from students with little comment or direction.
- Allow students to collaborate in their team
- Student teams gather data.
- Re-evaluate question based on new data from all the teams
- Students present findings as an oral presentation, a poster presentation or an evaluative write-up.

For questions, see **worksheet for exercise 3.3**

Activity 4: Flowering plant reproduction

Learning aims:

- To learn how to draw a biological diagram using a flower from their local ecosystem
- To understand the significance of biological magnification
- To relate the structure of a flower to seed production, whilst learning relevant terminology, such as, pollination, fertilization. To identify pollen grains using microscopy
- To understand the structure of seeds
- To evaluate the methods used by seed banks in the conservation of endangered plants
- To inquire about the life cycle of a named insect and its role in pollination
- To collect pollen from flowers and observe it under a microscope
- To inquire about the effects of Global warming in seasonal flowering, pollination and seed biology
- To design and perform an experiment to investigate the time that they can store selected seeds

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials:

Hand lens, Pencil, Ruler, Flowers, Seeds, Pollen grains, Microscopes, Stereoscopes, Camera, worksheets

Suggestions for use with possible questions:

Introduce the topic: The floral industry attracts both the artist and the scientist. The floral industry involves flower production, distribution, design, retailing, operations, marketing, publishing, importing, research, teaching, greenhouse design and engineering, climate control systems engineering, soil analysis, sales and pest management. Field-work with a theme of ”wildflower hunting” is a wonderful way to get students to understand how a tiny flower can be such an important part of an entire ecosystem, thus promoting sensitivity to sustainability as well as teaching students about wild flower ethics. Students need to understand that wildflowers are fragile and many wilt and perish soon after being picked. Yet, the loss of an unknown to be endangered flower is not the only reason why wildflowers should not be picked. Students need to realize that wildflowers support entire ecosystems for pollinators, birds, and small animals on a micro scale. Insects, small birds, and animals depend on seeds, nectar, and pollen for their food supply and life support system. It may be a new idea to introduce students to some pollinators which are not very mobile, have very small home ranges, or depend on just one species of plant and die once their habitat has been destroyed.

Basic biology of flower reproduction: Sexual reproduction in plants occurs when the pollen (male sex cell/ gamete) from an anther is transferred to the stigma in a process called pollination. Self-fertilization occurs when pollen fertilizes the egg (female sex cell/ gamete) found inside the ovule of the same flower. The transfer of pollen to the stigma of an entirely different plant, a process called cross-pollination, may lead to cross-fertilization when the pollen fertilizes the egg inside the ovule.
When the egg inside an ovule is fertilized, the ovules will develop into seeds. The petals of the flower fall off leaving only the ovary behind, which will develop into a fruit. There are many different kinds of fruits, including apples and oranges and peaches. A fruit is any structure that encloses and protects a seed, so fruits are also "helicopters" and acorns, and bean pods. When you eat a fruit, you are actually eating the ovary of the flower.

Exercise 1

- To learn how to draw a biological diagram using a flower from their local ecosystem
- To understand the significance of biological magnification
- To relate the structure of a flower to seed production, whilst learning

relevant
- terminology, such as, pollination, fertilization.

The students can be asked to draw a selected flower (magnified approximately 5X) found in their local ecosystem (link with learning aims of activity 3: inquiring for the name of an unknown plant) indicating clearly the reproductive organs. For instructions see **worksheet for exercise 4.1**

Exercise 2
- Collect pollen from flowers and observe it under a microscope

Introduce the topic: Pollen grains produced by different species of plant have a distinctive appearance. This allows us to work out what type of plant they came from, which in turn tells us the plants that used to grow in the area. We can observe the distinctive features of different types of pollen using a microscope. This helps us to identify what they are. Two useful features for identifying pollen are pores and furrows. Pores are holes in the surface of a pollen grain. Furrows are slits in the surface of a pollen grain.

Safety: Be considerate of sensitivity to pollen

Follow the methodology outlined on worksheet for exercise 4.2 about how to collect pollen from flowers and observe it under a microscope

Exercise 3
- To inquire about the life cycle of a named insect and its role in pollination
- To inquire about the effects of Global warming in seasonal flowering, pollination and seed biology

Ask the students to read the passage given on worksheet for exercise 4.3 and answering the subsequent questions.

Exercise 4
- To understand the structure of seeds
- To evaluate the methods used by seed banks in the conservation of endangered plants

Use the web link and the passage outlined on the worksheet for exercise 4.4 to introduce research that takes place in the community such as the Royal Botanic Gardens(RBG) in Australia

Exercise 5
Ask the students to design and perform an experiment to investigate the time that they can store selected seeds (e.g. from a tomato fruit) without loss in the germination rate.

Further information
Seeds are considered viable if they can germinate and produce a radicle (young root), which protrudes through the seed coat (testa). However with time, all seeds lose their ability to germinate. Scientists operating in a seed bank need their seeds to remain viable while in storage. Find the Seed Bank Projects in your country, which conduct research to determine the longevity of the seeds they store. Draw a flow chart to summarize the processes involved in the storage of seeds in a seed bank. Students should realize that seed banks storing seeds have a role in scientific research and in reintroducing species to the wild.

Activity 5: Plant extracts and antibiotics

Learning aims:

- To implement an appropriate methodology for safely obtaining a plant extract
- To investigate the effect of different plant extracts/ antibiotics on bacteria
- To identify safety parameters

Stages of learning cycle	Activity
Engagement	X
Exploration	X
Explanation	X
Extend – Elaborate	X

Materials:

Plant extracts, Agar plate seeded with known bacteria, Sterile Pasteur pipette, Bunsen burner, Beaker of disinfectant, 1%, Virkon or equivalent, Bench spray

of disinfectant, 1%, Virkon or equivalent, Bactericidal soap, Paper towels, Marker pen, Forceps, Plant extract/ antibiotic/ impregnated paper discs, Adhesive tape, Incubator set at 30 °C, worksheets
Suggestions for use with possible questions:
Introduce the topic: Even though pharmacological industries have produced a number of new antibiotics in the last three decades, resistance to these drugs by microorganisms has increased. In general, bacteria have the genetic ability to transmit and acquire resistance to drugs, which are utilized as therapeutic agents. Such a fact is a cause for concern. Therefore, actions must be taken to control the use of antibiotic, develop research to better understand the genetic mechanisms of resistance, and to continue studies to develop new drugs, either synthetic or natural. The ultimate goal is to offer appropriate and efficient antimicrobial drugs to the patient. According to World Health Organization, medicinal plants would be the best source to obtain a variety of drugs. About 80% of individuals from developed countries use traditional medicine, which has compounds derived from medicinal plants. Therefore, such plants should be investigated to better understand their properties, safety and efficiency. In Argentina, a research tested 122 known plant species used for therapeutic treatments. It was documented that among the compounds extracted from these plants, twelve inhibited the growth of Staphylococus aureus, ten inhibited Escherichia coli, and four inhibited Aspergillus niger and also reported that the most potent compound was one extracted from Tabebuia impetiginosa. Hence, more studies pertaining to the use of plants as therapeutic agents should be emphasized, especially those related to the control of antibiotic resistant microbes. *Exercise 1* **Extraction Methods:** Ask the students to inquire about the methodology of preparing safely plant extracts from a plant that they have discovered in their local ecosystem . **Further information:** (it may be used to link chemistry with biology) Advice abounds for the amateur herbalist on how to prepare healing compounds from plants and herbs (reference: Clin Microbiol Rev. 1999 October; 12(4): 564–582. PMCID: PMC88925.Plant Products as Antimicrobial Agents Marjorie Murphy Cowan).

Water is almost universally the solvent used to extract activity. At home, dried plants can be ingested as teas (plants steeped in hot water) or, rarely, tinctures (plants in alcoholic solutions) or inhaled via steam from boiling suspensions of the parts. Dried plant parts can be added to oils or petroleum jelly and applied externally. Poultices can also be made from concentrated teas or tinctures. Scientific analysis of plant components follows a logical pathway. Plants are collected either randomly or by following leads supplied by local healers in geographical areas where the plants are found. Initial screenings of plants for possible antimicrobial activities typically begin by using crude aqueous or alcohol extractions, and can be followed by various organic extraction methods. Since nearly all of the identified components from plants active against microorganisms are aromatic, or saturated organic compounds, they are most often obtained through initial ethanol or methanol extraction. In fact, many studies avoid the use of aqueous fractionation altogether. The exceptional water-soluble compounds, such as polysaccharides (e.g., starch) and polypeptides, including fabatin and various lecitins, are commonly more effective as inhibitors of pathogen (usually virus) adsorption and would not be identified in the screening techniques commonly used. Occasionally tannins and terpenoids will be found in the aqueous phase, but they are more often obtained by treatment with less polar solvents.

Exercise 2

In this activity, the students will be testing the effectiveness of several types of plant extract/ antibiotics/, which they have produced from plants selected from their local ecosystem on bacteria. The standard method of doing this is to put discs of blotting paper soaked in the various extracts / and control antibiotics onto an agar plate that has been inoculated with the bacteria.

Question:

Ask the students to inquire about the safety parameters that they need to apply during this investigation. Safety is an important aspect of this experiment and guidance on microbiology safety is essential.

The students need to investigate the following considerations:

- Eye protection.
- Pathogenic microorganisms
- Aseptic techniques
- Antibacterial disinfectant
- Allergic reactions

- First aid

Exercise 3

Ask the students to perform an experiment, which investigates the effect of different types of antibiotic/ plant extracts (the independent variable) on bacteria. Include details of a suitable dependent variable and how it can be measured. A methodology is suggested on worksheet for exercise 5.3

Possible questions:

1. What factors determine the diameter of the inhibition zones?
2. Suggest how named variables you have could be controlled.
3. Discuss the reliability and validity of the experiment.

BLOOD DONATION

The development of this unit has been led by the ESTABLISH partners:

Katarína Kimáková
Univerzita Pavla Jozefa Šafárika v Košiciach (UPJS), Slovakia

UNIT CONTENTS

I. Unit Description

Blood is a unique organ in which cells are not bonded together but move freely in plasma. Blood plays an important role in the human body: it transfers oxygen and different substances to places of their effect or processing by cells and carries waste products from tissues so that they could be removed from the body. Significant loss of blood, such as occurs in an accident, puts a person in a mortal danger. Additionally, there are diseases in prevent blood from carrying out one or more of its functions. Blood transfusion (the artificial transfer of blood from one person to another) can save a human's life in these situations. Despite much research efforts, there is simply no substitute for blood that has been located or which can be created in the lab.

This unit focuses on blood properties, blood donation and conditions that must be ensured so that transfusion would not endanger patient's life.

Students are given an opportunity to look up information on their own, to process and present this information, work in a team and identify with roles of different experts. They become familiar with aids necessary for taking blood and for its storage. They plan experiments and perform observation.

Photography: Henrieta Kampeová, Slovakia

- **Student level:** 7th grade of lower secondary (elementary) school or upper secondary (grammar) school (13–18 years).
- **Discipline(s) involved:** Biology, Chemistry, Physics and Technology
- **Estimated duration:** 8 -10 hours

Learning Goals

The focus of this unit centres around: human blood properties and blood donation.
Participating students will improve their knowledge of human biology and technologies that help in situations where a human life is endangered by blood loss or disease. They will:

- study facts about blood and blood donation from different aspects;
- get in touch with a transfusion centre staff;
- become familiar with medical products that are used during blood donation, blood storage and transfusion;
- work as a team in variable groups, practise communication and presentation skills;
- be able to convey the acquired information about blood and its donation to others;
- model and get to know properties of blood.

Expected Outcomes:

At the end of this unit, the students should be able to:

- ask questions about blood that can only be answered based on research;
- find out what aids are used by medical staff for handling of blood, where and how these aids are made and why they have to be sterile;
- describe composition of blood;
- explain the blood types and why patient must not be given any blood;
- explain, using an example, how blood types are determined;
- explain, using an example, how blood types are inherited;
- understand who needs blood and who can donate it;
- model sedimentation;
- prepare and carry out presentation in front of their peers at “a scientific conference“ and discuss the presented paper;
- consider the importance of blood donation, prepare a magazine article and a TV interview about the topic in the form of a didactic game.

It occasionally happens that some students of upper secondary or grammar school who meet the requirements for blood donation (age, health condition) decide to donate blood after learning about this topic.

II. IBSE Character

In this unit students are given an opportunity to ask questions, do research on the topic by looking up information (on the Internet, interview with experts), process the information, present the result of their work and answer questions of their peers.

They have an opportunity to organise their work, model a scientific conference, role-play work of experts and that of reporters and journalists. In the interview with haematological centre staff, students become familiar with conditions of blood donation and with necessary instruments.

Reciprocal collaboration of students is required in planning and performing of a short interview. In this interview students have to explain the substance of the issue by asking questions and giving answers in a way that helps to explain the importance of blood donation to common people. They are further required to propose a model of sedimentation and blood type determination, test these models and make conclusions based on their observations.

All proposed activities provide an opportunity to broaden and deepen knowledge of human blood, its properties and its functions. Students are guided to think about and discuss development of biology and technology, possibility of substituting of human blood by artificial blood for medical purposes in the future, and think about completeness of this substituent.

III. Science Content Knowledge

The topic of blood can be seen on four levels which are mutually related.

1. **Composition:** As an organ, blood possesses unique properties and performs several important functions in the human body. It consists of liquid plasma, red and white blood cells and platelets. Changed properties of blood signal a disease, for example changed number of blood cells. That is why doctors do blood tests.
2. **Transfer of substances:** Blood (red blood cells) transfers respiratory gases in the human body, plasma contains inputs and products of metabolism and hormones, which have a regulatory function.
3. **Protection of the body:** White blood cells and antibodies in plasma recognise and destroy antigens and foreign proteins that get into the body. Platelets ensure blood clotting and healing of harmed veins to prevent bleeding to death after injuries.
4. **Blood types:** Human blood has group properties. It is important to be aware of the blood types when saving human life by transfusion and considering possible complications in childbirth. Division of blood into types

based on AB0 system and rhesus factor is best-known. Group properties of blood are inherited based on simple rules. Knowing them makes prediction of blood type before a child is born easier or helps in eliminating of paternity.
The main aim of this unit is to assist students in receiving a complete picture of knowledge about blood by means of practical tasks and situations, blood transfusion being the central motive of the topic. For safe transfusion medical staff has to handle blood in a sterile way. They use plastic aids made of polymers, separator and other equipment. It is also necessary to ensure that blood could be stored for some time in such a way that blood cells would remain alive. The cell damage caused by growing ice crystals during freezing can be prevented by addition of some polymers.

IV. Pedagogical Content Knowledge

Existing previous experience of students is based on the fact, that each of them has been injured, has bled and undergone blood tests. They all are also familiar with the fact that in a hospital blood is not only taken from the patients but there are situations when, in contrary, it has to be added to the body to prevent some patients from dying.
Presenting a topical article or local media news that appeal to people to donate blood can be motivating. Students must think why such an appeal has been published and imagine the situation a person in the need of other people's blood might be in.
Biological content is made up of composition, functions and properties of blood. The topic is related to the activity of circulatory and respiratory systems. We assume that pupils have already learnt about blood circulation in circulatory system, about activity of a heart and about gaseous exchange in lungs and tissues. In this unit they will learn about other properties and functions of blood by means of practical tasks, looking up and interpreting information.

V. Industrial Content Knowledge

Technologies are represented by polymers (plastics) and metals which are used in making aids for taking, processing, transport and storing of blood as well as equipment used to ensure sterility of aids utilized when handling blood. Students also learn about polymers that support long-term storage of blood at very low temperatures by protecting cells from being damaged in the process of ice crystals growth. Also of some interest is the information about efforts of

scientists to develop a blood substitute which could save life in emergency when there is no suitable donor available.

Some useful web pages in Slovak and English:

http://www.ntssr.sk/
http://www.cervenykriz-ke.sk
http://www.redcross.sk
http://www.blood.co.uk/
http://www.coe.int/14-june-world-blood-donor-day
http://www.europarl.europa.eu/news/en/headlines/content/20110610STO21211/html/Blood-donation-saves-lives-needs-more-promotion
http://www.madehow.com/Volume-5/Artificial-Blood.html

VI. Learning Path(s)

Activity		Discipline	E-emphasis
1	Appeal for donating blood	Biology	Engage
2	Looking up information	Biology, Technology	Explore
3	Study visit at a transfusion centre	Biology, Physics, Chemistry, Technology	Explore, Extend
4	Separation of blood constituents	Biology, Physics, Technology	Explore, Extend, Explain
5	Scientific conference	Biology	Engage, Explain
6	Interview	Biology	Engage, Explain
7	Determining blood types	Biology, Chemistry	Engage, Explore, Explain, Extend, Evaluate
8	Is Pavol the father?	Biology	Engage, Explore, Explain, Evaluate
9	Blood as a transporter	Biology, Chemistry	Engage, Explore, Explain, Extend, Evaluate
10	Blood as a guard	Biology	Engage, Explore, Explain, Extend, Evaluate
11	Blood preservation	Biology, Chemistry, Physics	Engage, Explore,

			Extend, Evaluate
12	Is it possible to produce artificial blood?	Biology, Chemistry, Technology	Engage, Explore, Extend, Evaluate

VII. Assessment

A teacher must realise that when carrying out these activities students may be fearful and uncomfortable due to the lack of familiarity both with the content and structure of the teaching and learning environment and so they should be sensitive to this when assessing the progress of the student so as not to lose student engagement and motivation. Possibilities of assessment vary from activity to activity. Much of the feedback will occur through reflective dialogue, perhaps will peers or self-reflection.

In this unit the activities are linked so that the output from one activity is assessed in a subsequent activity so that the assessment is inherently built into the unit. For example: the output of activity 2 is a work text created by a group of pupils and further used in activities 5 “Scientific conference” and 6 “Interview”. Following the activities it is possible to discuss whether the produced work texts contained all the important information, what their quality was and what they lacked.

In activities 4 and 7–10 the concern is to understand relations and to apply the knowledge. The topic should be concluded by reflexion (activity 11, 12) based on which a teacher can assess how students incorporate new information into their own ideas.

The teacher can assess whether students

- adequately interpret concepts, such as blood cell, blood type, antigen, antibody and other;
- can explain what happens after incorrect transfusion;
- can determine child’s possible blood types based on blood types of parents;
- can speak about a protective role of white blood cells and antibodies in plasma;
- are familiar with the ways blood transfers substances from the environment to cells and the other way around.

VIII. Student Learning Activities

The following activities are provided to illustrate opportunities for IBSE in the classroom. The optimal group size of 24 students is suggested. It is recommended that the student work cooperatively either in pairs or small groups. A textbook, the Internet or professional literature can serve as a source of information; digital technologies are an added value.

Activity 1: Appeal to donate blood
Learning aims:
• Introductory presentation from local media or from the Internet appealing to people to donate blood. • Students should be aware of the fact that anyone can get into a situation when their life depends on other people willingness to help. Not everyone, however, can help, even if they wanted. Sometimes complete strangers help us and it is our moral duty to help others when possible. • Students should think about biological properties of blood and technical possibilities of keeping blood suitable for transfer into another body.
Materials:
An article from a local paper, web page or a recording of TV news appeal to people to donate blood.
Suggestions for use:
Pupils get acquainted with the appeal and then talk with the teacher about who and why might need blood transfusion. Further in discussion they are expected to come to a conclusion that if we are to help someone who needs blood transfusion, we need to find out the answers to the following questions: • Who and on what conditions can donate blood? • Can a patient be given blood of any donor? If not, why? • Is it possible to keep a donated blood for later use? Which blood properties must be preserved? Pupils first try to answer these questions on their own but will probably soon realise they do not have enough information to work out a satisfactory answer.

Possible questions:
• What diseases might a patient who needs a blood transfusion have? • How much blood can be taken without endangering the donor? • How long can a blood be stored?

Activity 2: Looking up information
Learning aims:
Students are expected to look up information that will help them answer the questions resulting from Activity 1.
Materials:
The Internet, professional literature
Suggestions for use:
The activity consists of two parts. Students are divided (optimally) into four 6-member groups. Each group is supposed to find different information on blood as well as to look up the answers to the questions of activity 1 on the Internet. At the same time they are given questions that specify what sort of information they should look for. Group 1: – Why do people need blood transfusion? – What is the health condition of people who need blood? – Is blood from one donor enough? Group 2: – What are the conditions for donating blood? – Who may become a blood donor? – How often can one donate blood? Group 3: – Why a patient cannot be saved by blood of any donor? – What does one's blood type depend on? – What blood types are there? Group 4: – What properties does blood have? – What does it consist of? – How can it be stored?

The answers can be found on the website of transfusion centres.
First, each group member looks up the answers to given questions, a pair work can be used alternatively. They are required to write down everything they consider relevant information.
In the second part of this activity the members of each group meet at one desk and work out a collective text containing the answers to the questions (a printed text of approximately 180 words).

Possible questions:

- We heard about donating plasma. How can we donate only plasma without blood cells?
- How is it technically possible to implement?
- Who produces equipment and tools for taking a blood for transfusion?

Activity 3: Study visit at a transfusion centre

Learning aims:

Students should be able to describe where blood is taken, who works at a transfusion centre and what qualifications they are required to have.

Materials:

The Internet, professional literature

Suggestions for use:

Before the study visit, ask students what work they think is done at the centre. Then ask them to write down questions they would like to ask the staff to get complete information (based on their search on the Internet, activity 1 and 2). Each student should prepare at least two questions. The size of group as well as the time of the excursion should be arranged with the staff of the transfusion centre beforehand. The visit can be repeated with small groups.
Alternatively, if the study visit is not possible, a member of the transfusion centre staff and/or a representative of a company producing or selling aids for blood transfusion can be invited to school to demonstrate some aids used in taking and storing blood.
More sophisticated equipment can be presented by means of short video recording.

1. Disposable sterile blood taking set

2. Blood taken with anti-clotting agent

3. Bags with taken blood in a separator

4. Three constituents of blood separated by separator

5. A press for separating individual blood

6. Equipment for separating individual blood constituents

Source of pictures on this page: http://www.ntssr.sk with agreement of National Transfusion Service in SR

Following the meeting with a staff member from the transfusion centre students should be aware of the fact that saving a human life by blood transfusion requires thorough preparation. First of all, there has to be enough blood donors that are healthy and of a specified age. Donated blood is not given directly from one person to another but must be examined, processed and stored until it is used. Blood is a live organ and must not get in contact with the environment. All instruments and aids must be sterile. Material they

are made of must also be sterilised. Blood is not given to a patient as a whole but its constituents are separated. A separator is used to do this. Different constituents are stored by cooling or freezing at very low temperatures.

Photography: Henrieta Kampeová

Also, inviting the mobile transfusion unit to school proved to be an excellent alternative.

Possible questions:

- What qualities must plastic bags for collection of blood have?
- What is anti-clotting agent?
- How does the separator separate the components of blood?
- How to make sure that everything is sterile?

Activity 4: Separating blood constituents

Learning aims:

Students have to design a model by using of which they can show how to count the number of particles in a given volume and propose a model of sedimentation.

Materials:

A photo of blood smear, fine starch (powder), household semolina or corn flour, water, a glass (glass beaker), teaspoon, timer, detergent, worksheet

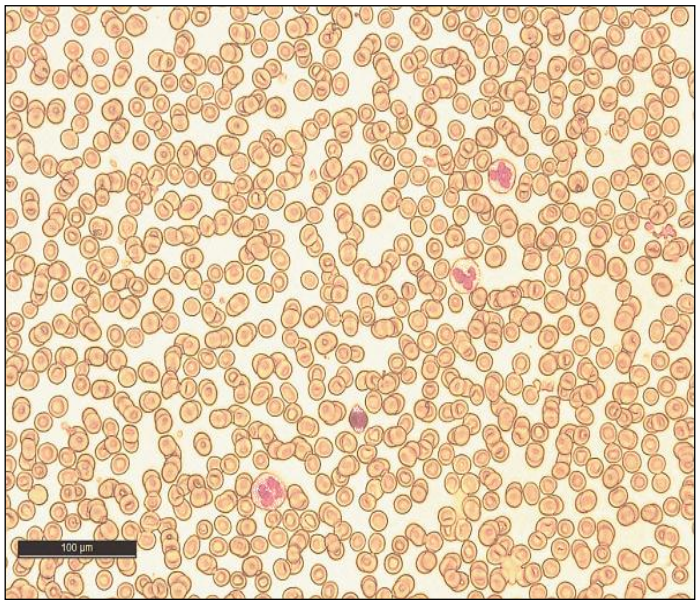
Suggestions for use:

Exercise 1

Blood count

Ask students why doctors want to know patient's blood count.

Students are asked to look at the photo. They are supposed to name different objects they see.



Photography: Edita Pauliková

Let them express their assumption about different objects seen in the photo and what these objects may represent.

Ask students to design a way to determine the number of different blood cells in a given volume of blood. They should invent a model to explain their procedure on. One of the possibilities is to put a grid over the photo, count the

red blood cells in three windows of the grid, make an average and multiply it by the number of windows. In this case, however, we need to know the volume of blood that we see in the field of vision or in one window. White blood cells (leukocytes) can't be counted this way because there are few of them in comparison with red blood cells (erythrocytes).

Students can invent a model in which they substitute blood cells with marbles or small candies and fill a one-litre jar with them. In order not to count all the marbles or candies, it is enough to count them in a smaller jar with the volume of let say 50 ml and work out the number for the whole volume. Ask students how to increase accurateness of the estimate of the small particles number in a large volume. Then they should find out optimal values of blood count on the Internet or in professional literature.

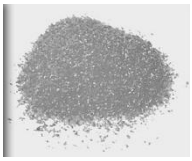
Exercise 2

Sedimentation

Provide students with different aids and the worksheet to plan their experiment. Alternatively, they may use a notebook to write and draw their findings and results.

Ask students to design and carry out an experiment to observe the speed of sedimentation.





Let them try to explain why erythrocytes fall down to the bottom faster when there is an inflammation in the patient's body. The speed of blood cells

sedimentation is determined by viscosity of plasma. Viscosity depends on the ratio of the present plasma proteins. During an illness, representation of proteins in plasma changes as a result of an immune reaction, and thus viscosity changes, too. Students may come to the conclusion about viscosity only based on a new experiment with a sedimentation model after they find out that adding a detergent into water increases speed of sedimentation and they will start to search for the reason of the phenomenon.
Possible questions:
• Why doctors want to know patient's blood count? • Why there are a lot of erythrocytes and a few leukocytes? • What a doctor learns from the speed of red blood cells sedimentation? • Can we speed up the sedimentation of particles?

Activity 5: Scientific conference
Learning aims:
Students have to link information about blood they have acquired so far and interpret it. They have to identify with their roles, speak in front of others, ask questions and answer their classmate‘s questions. They do it by simulating a scientific conference at which apart from experts, media are present. Their knowledge of blood becomes consolidated.
Materials:
Texts prepared by the groups in activity 2 and 3, transparencies, felt tip pens and an overhead projector or a computer for each group and a data projector
Suggestions for use:
Students who worked together on the text in activity 2 meet again. Two new groups will be formed in the following way: one student leaves each group and a new group is created the members of which will get the role of REPORTER. One more student will leave each group and a new group will be created from these students that will get a role of TV STAFF Students of the groups in activity 2 will also be given roles: 1. group - DOCTOR 2. group - TRANSFUSION CENTER STAFF MEMBER 3. group - GENETICS EXPERT 4. group - PHYSIOLOGY EXPERT **The task of groups 1. – 4.** is to prepare a presentation at the conference about blood. Each of groups 1. – 4. appoints a representative who will present their findings. Other group members will help their representative to prepare for the presentation. They can use the text they worked out in activity 2 and all the knowledge acquired during the excursion at the transfusion centre. Together they will prepare notes on transparency or a short digital presentation as if presented by an expert in the appointed role. The length of the presentation should be set ahead of the time. The task of the **group of reporters** is to prepare questions for experts presenting at the conference to get material for writing an article about blood donation in the local paper (school magazine). The task of the **group of TV staff** is to prepare questions for experts presenting at the conference to get prepared for broadcasting an interview with experts about a topical issue of blood donation.

The teacher takes the role of the **conference chair**. Their task is to open the conference, introduce the presenters and open a discussion after each presentation. In the discussion everybody can ask questions – media as well as other experts. A presenter has to give a satisfactory answer or other students take part in the discussion. The teacher will close the conference by informing about the presence of press and TV representatives who will publish the information for the public and will thank all the participants for their contribution.
Possible questions:
• Students will formulate their own questions. There are many possible questions for this activity.

Activity 6: Interview
Learning aims:
To continue interpreting the knowledge about blood, its completing and presentation. Students learn from one another.
Materials:
common classroom furniture and writing aids, camera (not a condition)
Suggestions for use:
Students remain divided in groups 1. – 6. as in activity 5. Students who play the role of reporters meet and agree on working out and publishing an article about blood donation in a local (school) paper, on the Internet or on a school notice board. If they still have doubts they can ask peer-experts (excluding those presenting at the conference, activity 5). They can finish the article at home and have it published by the following lesson. Students who take the role of reporter (TV staff) are supposed to organise a 5-minute interview with a doctor, genetics and physiology experts, and a transfusion center staff member. They can ask experts (excluding those presenting at the conference). Their task is also to arrange the furniture to imitate a TV studio and the rest of the students watch the interview as audience. An interviewer can ask each expert two questions that have to be brief and interesting for the audience – common citizens. They can divide the roles as they want: who will be the chair, who will prepare the scene, who will take the part of the director, who will be in charge of the camera. When the interview is ready, students role-play it. If there is a camera

available, the role-play can be recorded and used as an introduction to the topic related to blood or can be placed on the class web page.
Possible questions:
• Students will formulate their own questions. There are many possible questions for this activity.

Activity 7: Determining blood types
Learning aims:
Students are supposed to learn what the basis of blood types division is. They will also learn about the basic blood types.
Materials:
School set for determining blood type, a picture to explain the antigen – antibody bond, Internet connection, interactive board or computers for pairs of students, plastic tubes, stickers, marker, slides, measuring cup, teaspoon, distilled water, citric acid, washing soda (soda ash, Na_2CO_3), low-fat milk, calcium chloride, starch
Suggestions for use:
The blood type determination and transfusions games, that students can find on Internet, enable them to play roles of medical staff and decide about patient‘s lives by determining their blood type and infusing them with the right blood type*. While doing this they learn that on the surface of red blood cells there are antigens that react with antibodies in blood plasma of a different blood type. *Exercise 1* Student's task is to determine the blood type of unknown blood sample (imitation with the set for school). It is possible to get an educational set designed for this exercise, where students do not work with real blood, but with a model “blood” that works just like real one. If there is no set available, you can use the following alternative model*: Colour all “blood” samples with the red food dye or water paint. ***Blood type A*** Colour the low-fat milk.

Blood type B
Use syrup Calcium chloride (available in a pharmacy).

Blood type AB
Carefully mix the low-fat milk and Calcium chloride in the ratio 1:1

Blood type 0

Boil the distilled water and add a small amount of starch dissolved in water.

Reagent Anti-A
Dissolve 1 small teaspoon of citric acid in 40 ml of distilled water.

Reagent Anti-B
Dissolve 1 small teaspoon of washing soda in 40 ml of distilled water.

Procedure:

On the slide (better with two shallow holes) marked by the letters A and B add two drops of chosen samples (“blood type” unknown to pupils). Add a drop of reagent anti-A to the drop of the sample marked with the letter A, and add a drop of reagent anti-B to the other drop of sample marked with the letter B.

In the real blood the antibody in the reagent anti-A reacts with antigens on the surface of red blood cells of blood types A and AB. The antibody in the reagent anti-B reacts with antigens on the surface of red blood cells of blood types B and AB.

The precipitation in our model occurs in 30 seconds in all cases.

Group A blood does not react with anti-B, group B blood does not react with anti-A, group 0 blood does not react with either anti-A or anti-B. In these cases, no coagulate is observed.

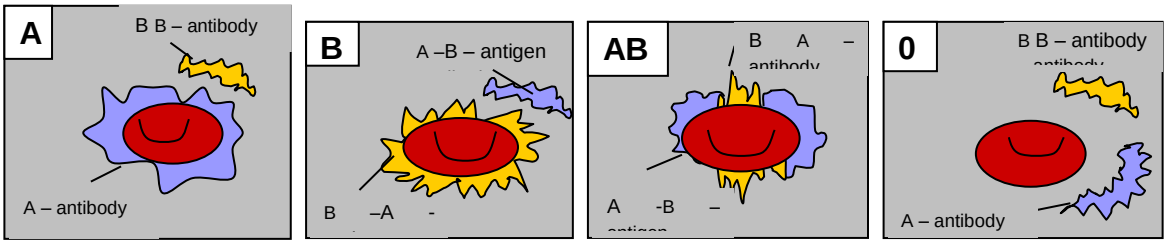
According to the reaction of the tested sample and reagent anti-A and anti-B (clot appears in both or only in one or in none of two drops), blood type of “unknown” sample can be determined.

Important notes

1. Blood'' can be stored in a refrigerator up to one day.
2. Use distilled water for the preparation of reagents and blood type 0.
3. Prepare 20 ml of each blood sample and 40 ml of each reagent (anti-A and anti-B).
4. A drop of blood and a drop of reagent on the slide should be approximately of the same size.

Ask students to explain what they think happened during blood testing.

Why does blood coagulate somewhere but does not somewhere else? How does the test work? Let them describe the situation in the pictures in their own words.



Students have to be able to explain that antigens and antibodies in blood are of two types: A and B. A type blood contains antigens A on the surface of red blood cells and antibodies B in plasma that do not react with each other. Red cells of B type blood carry antigens B and plasma contains antibodies A which react with antigens of group A. Therefore, blood of types A and B coagulates when the two are mixed. Blood cells of group AB do not contain any antibodies but in plasma both types of antigens are present. Blood cells of group 0 do not have antigens but in plasma there are both antibodies A and B. A different type of blood type is a rhesus factor which can be positive if its antigen is present or negative if the antigen is not present in blood.

It can encourage students to design "recipe" for a similar model. As the blood type B they can use, for example, a solution of baking soda (sodium bicarbonate) or an aqueous solution of egg white – (2 parts water and one part of the egg whites; allow the precipitate to settle; collect the clear solution for use). As the reagent in both cases, use 70 % ethanol (alcohol for disinfection, available in a pharmacy).

Exercise 2
Angela was told by her doctor that her newly born baby needs intensive care because he inherited rhesus positive factor from his father.
Look up in your textbook or on the Internet what rhesus factor is.
The doctor did not tell Angela why rhesus positive factor of her child is a problem.
Can you explain it?

Students can find an interactive game for example on following web page:
http://nobelprize.org/

Possible questions:
• Do animals also have blood types like people? • I do not know my blood type. Where can I determine my blood type?

Activity 8: Is Pavol the father?
Learning aims:
Students should understand the laws of heredity of blood types. They should be able to explain that it is the presence of antigens and their antibodies that is inherited. It is inherited from both parents. Each person has two alleles of a blood type gene – one is from the father, the other from the mother when only one of each parent's is randomly given to the child. That is why siblings can have different blood types and blood type of children can be identical with that of their mother or their father but it does not have to be.
Materials:
Calculators for determining possible blood type of a child based on the information about parents' blood types (find on the Internet), matches of 2 colours
Suggestions for use:
Tell the students to open the calculator* and try to design some examples. Then ask them, to explain how heredity of blood types relates to what they have found out about them in connection with transfusion. Ask the students to model genes of blood types using the matches: antigen A present – red head, antigen B present – blue head, no antigen – broken head Every gene consists of two matches – gene parts (called allele). One comes from the mother, the other from the father. In case of blood types both alleles manifest themselves together and the result is a blood type A, B, AB or 0.

What alleles did a man with the blood type AB inherit from his parents?

Ask students to make a table in which they show heredity of blood types by means of AB0 system. They can work individually and then compare their result with others.

Suggested table:

Blood Type	**Genotype**	Alleles
A	dominant homozygote	$I^A I^A$
	heterozygote	$I^A I^0$
B	dominant homozygote	$I^B I^B$
	heterozygote	$I^B I^0$
AB	heterozygote	$I^A I^B$
0	recessive homozygote	$I^0 I^0$

Exercise:

Erika has a blood type A and she has had a baby with a blood type AB. She appointed Pavol, who has a blood type 0, as the father. Can Pavol really be the father of Erika's child?

Students have an opportunity to discover combinations of parents' blood type, when a child is born with blood type 0, and explain why a child may have blood type 0 when both parents have blood type A.

** Calculator examples:*
http://www.babymed.com/tools/blood-type-calculator
http://www.pediatriconcall.com/fordoctor/pedcalc/blood_group_detection.aspx
http://primar.sme.sk/kalkulacky/krvna-skupina-dieta.php (Slovak)

Possible questions:
• How does heredity of blood types relate to what we have found out in connection with transfusion?

Activity 9: Blood as a transporter
Learning aims:
Students are supposed to learn that red blood cells are the transporters of respiratory gases, oxygen and carbon dioxide. They contain haemoglobin that makes temporary bonds with the molecules of the gases. Apart from that, blood carries substances in the body that are vital to cells or which, on the contrary, are excreted by cells. Some of the substances play an important role, for example hormones that regulate different processes in the body.
Materials:
A textbook
Suggestions for use:
Ask pupils to describe their idea of what happens to oxygen on its way from lungs to brain tissue. They can possibly work in pairs or groups. They present their description of oxygen journey and then work on making their ideas more accurate. Different sources of information can be used. Students can propose a procedure to prove carbon dioxide in exhaled air. Talk about other substances blood carries. Ask students to design and make a toy (a puzzle) for younger pupils – to match a source of production of substances carried by blood in the body and target organs where the substances are needed.
Possible questions:
• If there is not enough oxygen in the brain, a brain death occurs. How does oxygen get from lungs to brain? • What other substances blood carries? When and where do these substances go?

Activity 10: Blood as a protector

Learning aims:

Students are supposed to find out that leukocytes protect the body from pathogens. Some of them absorb and digest the pathogens, other produce antibodies that function in a similar way as in the case of blood types.

Materials:

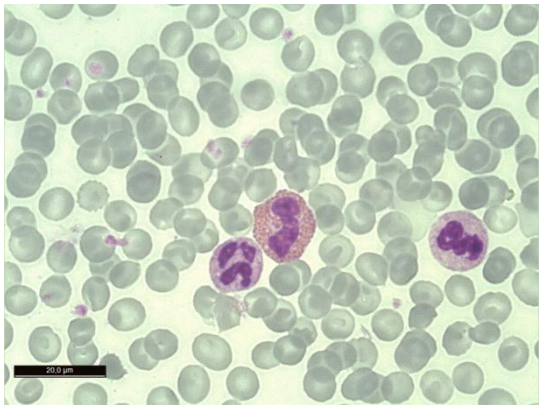
Internet connection, pictures in the textbook, photographs of human blood smear (see in classroom materials)

Suggestions for use:

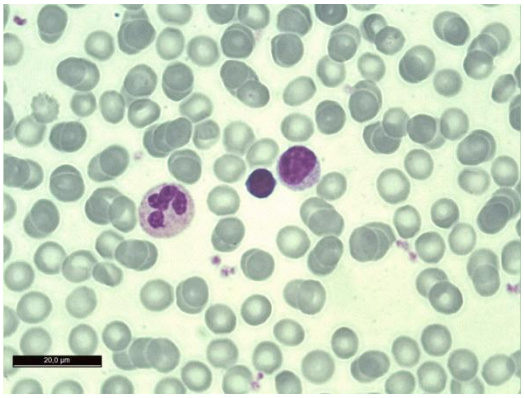
Tell students that they can become experts in recognizing leukocytes. Then let them look at the text and photos in worksheet and ask them: Which types of white leukocytes can you recognise on these photos?

Picture examples (Photography: Edita Pauliková)

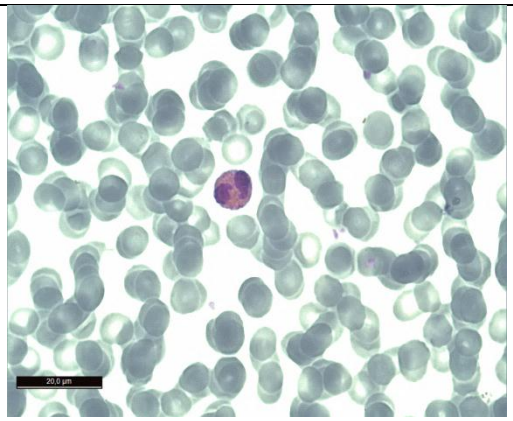
Colour versions are available online



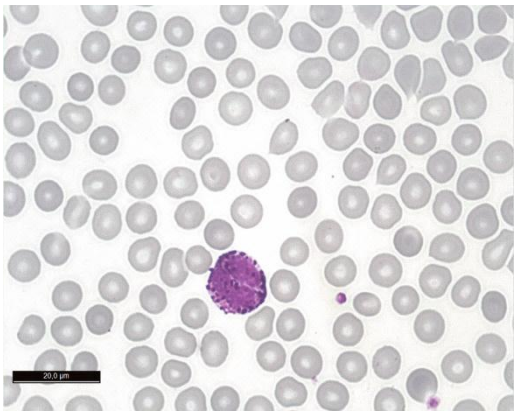
1 – one eozinophil, two neutrophiles



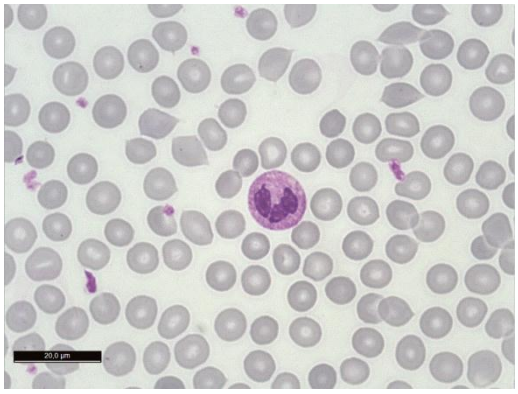
2 – neutrophil, small and larger Lymphocyte



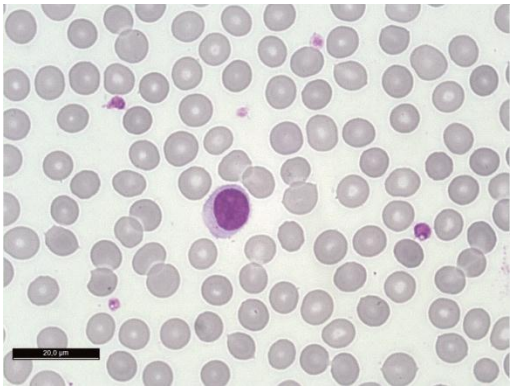
3 – eosinophil



4 – basophil



5 – monocyte



6 - killer

All samples also contain red blood cells and platelets.

Ask students to look up on the Internet (in the textbook) more photos or pictures of humane leukocytes. Students can explore the relationship between the staining of leukocytes and their names.

Talk with the students about the function different types of leukocytes have and what would happen if they were not present in blood or there were too many leukocytes. How do they protect the body from pathogens?

Exercise (task for students): Find on YouTube a blood clotting animation and explain: what is the function of platelets?

Possible questions:

- Why are human erythrocytes without nucleus?
- What happens in the blood during inflammation?
- Why are too many leukocytes in the blood a sign of leukaemia?
- Why a bruising appears after being hit?
- Who needs to receive platelets by transfusion?

Activity 11: Blood preservation

Learning aims:

Students are supposed to link knowledge about blood, water, crystals and polymers. They should understand what damage freezing water causes in cells and how to prevent damages during freezing of the cells.

Materials:

Frozen fruit (strawberries or raspberries), interactive applet on attachment

Suggestions for use:

Let frozen fruit defrost and ask your students meanwhile:

- Why does it not look like fresh?
- What will happen when the fruit defrosts?
- What could have happened to the fruit cells?
- Where does the released water come from?

However, cooling and freezing at very low temperatures in liquid nitrogen is a well-known way to conserve live tissue. There are ways to protect tissues from being damaged during crystal growth. When crystals develop inside a cell or in its neighbourhood, they are very small. But they grow and tear the cell membranes.

Let students plan and carry out an experiment in crystallization of salt. Let them experimentally investigate under what conditions small crystals grow, and when bigger ones are created.

Imagine a crystal of water. It is, in fact, a snowflake with sharp edges.

When working with an interactive applet students should find out optimal conditions – how many polymers and when they should be added to the solution for the best possible protection of cell membranes (during a cooling or before the start of cooling).

Polymers added to tissues wrap the nuclei of crystals and prevent them from growing.

Use the model and explain how the polymer inhibits the growth of crystal.
Possible questions:
• Some parents wish to preserve umbilical cord blood by freezing at birth of child. What is the aim of this? • What could have happened to the frozen blood cells? • What can reduce the water content of cells? • What happens to a cell when we drain it completely?

Activity 12: Is it possible to produce artificial blood?
Learning aims:
Students are supposed to apply their knowledge about blood.
Materials:
worksheet in classroom materials, Internet connection
Suggestions for use:
Ask students to think about what properties artificial blood should have so it would enable to save a human life. Discuss the topic. Start with a story: There has been an accident and the patient has lost a lot of blood. He is threatened with failure of organs and death caused by the lack of oxygen. No blood tin is available to save his life. Ask students: Could an artificial blood save him? It cannot have all the properties of human blood. Which properties must it have so it could help until a donor is found? Let students find on the Internet whether artificial blood has already been made and used for saving a patient. Example of internet source: http://www.madehow.com/Volume-5/Artificial-Blood.html
Possible questions:
• What industry could produce artificial blood? • Which scientists participate in its development?

WATER IN THE LIFE OF MAN

The development of this unit has been led by the ESTABLISH partners:

Vera Čížková, Sabina Radvanova, and Martina Nedomováet
Univerzita Karlova v Praze (Charles University - CUNI), Czech Republic

UNIT CONTENTS

I. Unit Description

The basis of every life is water. It is the main component of most organisms on earth. If there were no water, plants would die, animals would die of thirst. Water affects both living and inanimate nature. Water is really very important. People could not live without water. Today, every home has plenty of water, which is supplied by watermains or pumped from the well. We can buy bottled water. But from where is water taken? How is it that it is clean and drinkable? What would happen if nothing like this existed?
In this unit, we will learn where the clean water is taken from, why it is necessary to hydrate the body and how much we should intake daily as fluids. We will explore what happens to water in our body. We compare which beverages are the most suitable for hydrating the body. Later we will learn what the importance of kidneys for our life is and what would happen if they failed working.

- **Student level:** Students aged 12 – 18 years
- **Discipline(s) involved:** Biology, geography, chemistry, physics, mathematics, technology
- **Estimated duration:** 12 – 14 hours

Learning Goals

In terms of our requirements, the main topic of the unit is fluid intake, a relationship between man and water and importance of kidneys for the life of man. Students will think about their fluid intake and learn about the process the water undergoes before it gets to our house e.g. in the form of Coca Cola. In addition they will learn how our body processes the fluid supplied and what the role of kidneys in this process is. While working, students will gain knowledge of human biology, geography, chemistry, physics and also technology.

Expected Outcomes:

After completing the unit, students should be able to:

- Ask questions and distinguish between those that can be answered on the basis of investigation and those that cannot be answered in this way.
- Plan, perform and evaluate the experiment or verification.
- Apply the obtained knowledge to the issues of everyday life.
- Discuss the given topic.
- Monitor and record their fluid intake, analyse it and draw conclusions.

- Discuss the importance of water and explain where the water is taken from.
- Explain the processes, the result of which is clean water.
- Describe the role of water in the individual human organs.
- Analyse particular types of beverages and decide why the beverage is suitable/unsuitable.
- Summarise the information on the issues obtained from the professional in the given discipline.
- Clarify the production of final urine and verify this assumption.
- Draw schematically the functioning of the artificial kidney.
- Explain the principle of haemodialysis and write a journal paper on this topic.
- Develop good habits of renal care.
- Evaluate the importance of kidneys for the life of man.

II. IBSE Character

In this unit, students have the opportunity to discuss, search the information, ask questions, answer them and evaluate their results. All activities have solutions, but each student can have different results, which leads to discussions among students. Some activities are focused on working with texts and pictures or own experiments. Others include excursions, on the basis of which the students summarise their findings or ask themselves further questions and plan possible solutions.

III. Science Content Knowledge

Topic of water represents four interconnected planes.

1. **Importance of water:** Water in the human body performs many important and unique functions - for example, it is an essential component of cells, an important component of biochemical reactions, solvent of substances and further it serves to transmit the nutrients and other necessary substances (hormones, metabolites, antibodies, ...) or creates the systems equalizing the temperature of the body.
2. **Drinking water:** As drinking water we can consider healthy water, which even through a continuous consumption does not cause diseases or ill health by the presence of microorganisms or substances affecting by acute, chronic or late effects the health of individuals and their offspring. In addition, its sensory properties and quality do not impede its use for drinking and sanitary needs of individuals. Currently, drinking

water is obtained by treatment of surface water in waterworks or water from underground springs or wells.

3. **Absorption of water in the body:** Water taken in beverages and food or formed in metabolic processes is absorbed in the small intestine, and a lesser portion also in the colon. This is done on the basis of different concentration, osmosis, in the presence of minerals of sodium and potassium. Unused, spent, water is excreted from the body through saliva, gastric or pancreatic juice, bile, intestinal secretions and faeces. The main dispensing of water is done through the urine, kidney filtration, vapour in breathing or evaporation and skin sweating.
4. **Haemodialysis:** This method allows removing toxic waste products of metabolism and excess water from the blood using a special dialysis unit popularly known as "artificial kidney". Patients with kidney failure usually come to haemodialysis three times a week to the so-called dialysis centres.

The aim is that students gain a comprehensive view of water as an important component of the human body through practical tasks that require investigation thinking from students. The main topic of the unit is the production of drinking water and haemodialysis. Production of drinking water in the waterworks has several basic phases – sedimentation, trapping of impurities with the use of chemicals, filtration through a sand filter, disinfection. The principle of haemodialysis is the diffusion of solutes through a semipermeable membrane. Opposite direction flow is used when a sterile dialysis solution of mineral ions and glucose flows along the membrane in the direction opposite to blood flowing.

IV. Pedagogical Content Knowledge

Research shows that most of the experience and knowledge that students acquire in biology teaching have no real meaning for their real lives. Therefore, the topic of this unit is focused on sound fluid intake, which concerns every individual any day. This should increase the students' interest. The unit is further complemented by the role of dealing with the structure and function of artificial kidney in an effort to raise awareness among students about the problems of global growth in hidden nephrological diseases and the need for their early diagnosis.

The biological content in the unit is primarily related to the excretory system, circulatory system and digestive system. Actually, the unit may include all organ systems in which there is some form of water. The unit also offers the

activities that require knowledge of chemistry, such as contents of organic or inorganic substances in beverages, pH, and osmotic phenomena in the cell. Further, knowledge of physics, mathematics and geography is also important.

V. Industrial Content Knowledge

The industrial and commercial sectors include mainly industrial plants, research and educational institutions. Establishing a closer co-operation with them can be realised at two levels. At the local level, the centres working with aids for patients with renal impairment can be contacted; these aids have been developed by scientists or technicians. In particular, these are the dialysis centres that work with artificial kidney. Further, it is possible to organize a study visit to waterworks or bottling plants of water or Coca-Cola; the latter enjoys a great popularity among students. The following level is to establish contacts with research institutes and plants that are mainly engaged in the development and production of dialysers as the most important part of the artificial kidney. Another option for establishing cooperation with various plants is to invite the person who works in this area to the class, or at least to make an e-mail contact.

Some important websites:

- http://eagri.cz/public/web/file/130548/VUME_2_UV_2010.pdf.
- http://www.bbraun.com/
- http://www.domaci-dialyza.cz/seznam-dialyzacnich-center?kraj=7
- http://www.coca-cola.cz/onas-vyroba

VI. Learning Path(s)

Activity		Discipline	E-emphasis
1	Discussion over the importance of water	Biology	Engage
2	My water intake	Biology	Explore
3	Which water tastes better, bottled or tap water?	Technology, biology, chemistry	Explore, Extend
4	Waterworks or production of drinking water	Technology, biology, chemistry	Explore, Extend, Explain
5	Can we get drinking water?	Biology, geography	Engage, Explain
6	Analysis of beverages	Technology, biology, mathematics	Engage, Explain
7	How does the water travel through our body after drinking?	Biology	Engage, Explore, Explain, Extend, Evaluate
8	How is finite urine formed?	Biology, chemistry	Engage, Explore, Explain, Evaluate
9	Importance of kidneys for life	Biology	Engage, Explore, Explain, Extend, Evaluate
10	Is it possible to develop an artificial kidney?	Biology, chemistry, physics, technology	Engage, Explore, Explain, Extend, Evaluate
11	A visit to a dialysis centre	Biology, chemistry,	Engage,

	physics, technology	Explore, Extend, Evaluate
12 World Kidney Day	Biology	Engage, Explore, Extend, Evaluate

Activity 1 – The teaching unit will start from the discussion. Students should be aware of the fact that every individual has his/her own water intake and that it can differ from the values referred to in the literature. Discuss how and how much fluid disappears from the body and whether we will really take so much fluid. Think about the impact of the lack of fluid on us, what is related to the availability of beverages and water at all. After this discussion we can move to the following activity.

Activity 2 – From the discussion, the students would like to know their fluid intake, which should be encouraged by this activity. Here the questions are prepared for them; they should be interested in the answers. They themselves will determine for how long it would be good to monitor their fluid intake to get good results.

Activity 3 – In this activity, students are motivated by the introductory text. This is followed by the questions that lead to reflection on how the topic of the introductory text is related to their life.

Activity 4 – This is an excursion to waterworks. Students should agree upon the date of the excursion and accordingly they should prepare themselves for this excursion.

Activity 5 – Students encounter the problem and have a few tools. They should establish a hypothesis and verify it subsequently.

Activity 6 – In this activity, students have beverage packaging (they may bring their own). The aim is to evaluate the appropriateness and inappropriateness of beverages for the human body. And think about whether to incorporate this beverage into the water intake.

Activity 7 – In this activity, students will use their knowledge or the working text or other literature to be able to solve tasks.

Activity 8 - In this activity, students will use their knowledge or scientific literature, or use the Internet to be able to solve tasks. Their findings will subsequently be verified in practice.

Activity 9 – In this activity, students establish a hypothesis, which is then, based on the submitted working text and their present experience, verified. Their findings are factually argued.

Activity 10 and 11 – Students should appreciate the benefits of technology development for human life. In case of excursions to the dialysis centre, students should agree upon the date of the visit and accordingly they should prepare themselves for this visit.

Activity 12 – Students search for the information needed to solve the task, and according to pre-agreed criteria they design promotional materials aimed at the prevention and diagnosis of nephrological diseases.

VII. Assessment

To assess the results of IBSE is not an easy task and it takes a long time. The teacher should be aware that the student learns new things through these activities, and therefore the teacher should not make comments, which could cause a loss of motivation. In addition, the teacher should ensure a safe environment in the classroom; i.e. nobody should laugh when the other student made a mistake. The possibilities of assessment differ from activity to activity. Not only knowledge is assessed, but first of all the skills and attitudes. It is necessary to proceed with students in slow steps through the individual phases of IBSE, always to provide a feedback on their progress through a formative assessment, not grading.

The output of activities 1, 9, 10, 12 is to develop the materials that can be used when working in other activities. After these activities, students can discuss whether the prepared materials contained all the important information, what their quality was and whether anything was missing or was irrelevant, etc. The activities 2, 3, 5, 6 to 8 are related to the application of knowledge and understanding of context. Each activity should be concluded with a feedback, on the basis of which the teacher can assess with the students to what extent the new information on water has been built into their own ideas and knowledge. The teacher can assess whether the student:

- Is able to list the rules that must be followed as for the proper water intake
- Is able to explain how fresh water is obtained
- Is able to explain what is happening to water in different parts of the human body

- Is able to describe how the final urine is formed
- Is able to appreciate the importance of kidneys for life
- Is able to describe the principle of functioning of artificial kidney

VIII. Student Learning Activities

The following activities are provided to illustrate opportunities for IBSE in the classroom. The optimal group size of 25 students is suggested. It is recommended that the student work cooperatively either in pairs or small groups. A textbook, the Internet or professional literature can serve as a source of information; digital technologies are an added value.

Activity 1: Discussion over the importance of water
Learning aims:
• Students explain why each individual has a different fluid intake, which can differ from the values given in literature. • Think about the impact of the lack of fluid on the human organism and explain the general relation between the availability of beverages and water. • Create the rules for proper fluid intake.
Materials:
Worksheet
Suggestions for use:
First the students will be asked the following questions. *Why is it important to drink?* Fluids must be continuously supplied. Enough water ensures the metabolism and excretion of harmful substances arising in the body. The water in our body is in every cell and all biochemical processes are bound to water. Water ensures the absorption of nutrients, their transport to the cells, dissolves and eliminates superfluous products of metabolism, moistens the air we breathe; by evaporation through perspiration it helps the body thermoregulation, regulates the level of the electron and proton in the cells (osmoregulation). Source: http://www.rajec.com/cz/zdravi/voda-a-lidske-telo/voda-v-lidskem-tele

Why is it necessary to continuously supply fluids?

In order to function properly, an adult human body must excrete every day approximately 2.5 litters of water. The body eliminates water in three ways - in the urine (1 - 1.5 litters per day), in faeces (100-200 ml per day; during diarrhoea there occurs up to 1.5 - 5 litre loss), by respiration (in the form of small droplets in the exhaled air the body loses 250 to 300 ml per day) and through skin (normally we sweat out 500 to 700 ml per day). Therefore we have to supply fluid to compensate for water balance (Suchánek, 1999).

What would happen if we did not supply water?

Lack of water or dehydration causes both acute and chronic problems. Acute dehydration represents the loss of 2% of body weight. This acute dehydration is manifested by headache, fatigue, malaise, decline of physical and mental condition. The loss of such amount causes a performance decrease of 20%. Children during this acute dehydration may have reduced ability to concentrate on teaching, and this may affect their school results. Long-term lack of water can cause headaches, constipation as well as serious diseases such as renal disorders, formation of kidney and urinary stones. It also increases the risk of urinary tract inflammation, in the worst cases, occurrence of cancer (rectum or bladder), and cardiovascular diseases (Kožíšek, 2005).

How much fluid should we daily take?

Every day we should get into the body 2 to 3 litres of fluid, but we must not forget that the water entering our body is bound in food, i.e. approximately 900 ml per day. This means that the rest, about 1.5 litres, we have to insert into the body in the form of fluid. This amount should not be drunk at once, but gradually during the day. The need for fluid is an individual matter and depends on many factors, both internal (body weight, activity, composition of food, current health status) and external (temperature and humidity of the ambient environment, the type of clothes ...) (Kožíšek, 2005).

How do I know when to drink?

We are reminded of a lack of fluid by thirst, but do you think that thirst in time points to the need for water? Thirst is a sign that we have already been dehydrated. So to prevent dehydration, we should not follow the sense of thirst. Furthermore, the sense of thirst decreases with age. Another symptom of a lack of fluid is a dry mouth and stale lips (Kožíšek, 2005).

On the basis of discussion, the students create the rules for proper fluid intake:

- It is necessary to drink evenly throughout the day, starting in the morning.
- Every day we should drink at least 1.5 litres of fluid.
- We should not wait for thirst, which is already a manifestation of moderate dehydration.
- Consider which water will be the basis of your fluid intake (it should be tap water or still spring water, the suitability of other beverages vary in relation to the needs of a particular organism, the ongoing activity, health problems, weather, etc.).
- Limit a consumption of larger amount of highly carbonated water.
- If we drink mineral waters, we should try to change them and limit their number.
- Limit the consumption of sweetened soft drinks and Cola drinks.
- Increased load needs also increased consumption of fluids.

Possible questions:

- *How long can we endure without fluids?*

  Two – three days. Everything depends on the actual conditions.
- *Which beverages are the most suitable?*

  The best drink is, of course, clean tap water from waterpipes or a well but also bottled infant and spring water. The appropriate drinks include also fruit and vegetable juice (preferably made from your own fruit and vegetables using a juice extractor) and sugar-free tea, especially green. These stimulate the activities of salivary glands and thus excellently quench thirst, promote secretion of digestive glands and metabolism. Medium and highly mineralized waters are not an appropriate basis for fluid intake and cannot be drunk in worsened state of health, such as kidney stones or high blood pressure. Daily intake of mineral water should not exceed 0.5 litres. It is appropriate to alternate the mineral water. The fluid intake cannot include milk and cocoa; these are rather liquid nutrition (Kožíšek, 2005; Slavíková, 2002).
- *Which beverages are inappropriate?*

  Lemonade, Cola drinks, flavoured mineral waters, energy drinks, etc. The reason for this inappropriateness is the sugar content, which on the contrary increases the sense of thirst. Another undesirable substance is carbon dioxide, which along with organic acids (flavours) damages tooth

enamel, causes stomach and digestive disorders, but the recommended dosage stimulates urine production and encourages the digestive system (such as sipped ice cola helps for nausea). Moreover, cola drinks contain caffeine as coffee does. Caffeine increases urine production, so it takes away even more fluid from the body than we are trying to get by drinking. In addition, caffeine promotes children's tendency to hyperactivity, because it encourages the organism. Inappropriate fluids are definitely alcoholic beverages, which do not belong among fluids suitable for water intake. They can only be a tasty supplement of food and their daily consumption should not exceed 0.5 litre of beer or 0.2 litre of wine (Kožíšek, 2005).

Activity 2: My water intake

Learning aims:

- Students record their water intake, or how much fluid they take daily, which beverages they prefer, how much urine they approximately excrete.
- They will answer the questions in the worksheet.

Materials:

The worksheet with questions and the table, which can be used for data recording.

Suggestions for use:

Before monitoring their water intake, the students will study the questions below and formulate their hypotheses. Then they will suggest the procedure, which would be used to prove or disprove the hypotheses. They should propose monitoring and recording of their water intake. In the worksheet the students will find a prepared table to record their water intake, but they can propose their own table. The students should agree upon the duration of monitoring, but it is good to propose 4 days - 2 working days and 2 weekend days.

Questions:

- How much fluid do you take per day?
- Do you drink regularly during the day?
- How many times per day do you go to the toilet to urinate?
- What amount of urine per day do you approximately excrete considering

the fact that the feeling of urination occurs with the urinary bladder volume of about 300 ml? • Will there be a difference between the volume of water taken and water excreted in urine? If so, what is the cause of this difference? • What fluid do you most often drink during one day? • Questions in conclusion: • What is the difference between your fluid intake and the proper fluid intake? • As for you, do you have any recommendations?
Possible questions:
• How many litres of fluid have you drunk since your birth? • How many litres of fluid will you drink in total during your life provided you live long enough until at least 70 years? • How many swimming pools of 50 m x 15 m x 1.5 m could it be? • Or what can be calculated from the observed data?

Activity 3: Which water tastes better – bottled or tap water?
Learning aims:
• The first objective is to express the opinion on the scientific level of the text searched in the Internet, to formulate the requirements on the subject – field (scientific) text, or to find another text in the literature or in the Internet, which would meet the requirements on the scientific level. • The second objective is to formulate in own words an assumption, which water is preferred by the students and give reasons. At the end of this activity, students compare types of waters, which they either praise or criticise in terms of taste.
Materials:
Worksheet, samples of bottled and tap water, cups
Suggestions for use:
First, the students find in the Internet the text * comparing the quality of bottled and tap water. Then there will be a discussion over the requirements on a scientific text in comparison with a popularizing text. We will ask the students what type of water they prefer and why. We can also ask them what type of water is preferred by their parents. On the basis of discussion and retrieved

text, students will establish a hypothesis, that would, in their opinion, capture the attitudes of consumer public (this can be restricted to the respective class) to bottled water and tap water. They will justify their assumption.
Then we will ask them how to verify the hypothesis and at the same time to find out whether some people really do not like tap water due to its low quality or whether it is just an imposed feeling under the influence of e.g. advertising. Students should also propose a questionnaire investigation and then exploration of taste quality of the respective samples of water (bottled and tap), whose origin would not be known to the students testing them. After the investigation, when the students made notes as for the respective samples or they evaluated them using a scale, they should learn what the type of water it was. They should compare these results with the hypothesis and draw a conclusion. The results of the individuals can be presented in the table or graph in respect of the whole class.
Note: They can work in pairs, when one of the students will be “taster“ and the other “researcher“, who will know the respective samples. Or this investigation can be carried out outside the lesson on another sample than that of the student’s classmates.

*This text can be found for example on the website:
http://www.rozhlas.cz/zpravy/spolecnost/_zprava/637057,
http://www.allaboutwater.org/

Possible questions:

Students formulate their own questions. A large amount of questions arise through this activity.

Activity 4: Waterworks and production of drinking water

Learning aims:

- Students will explain the operation and importance of waterworks for the life of man.
- They will find out how the waterworks operates, which tasks are performed by the employees and what qualification they should have.
- They characterise the individual steps of waterworks operation.
- Students describe the individual phases of water purification, from pumping of water from the source, through its consumption, to its return to the nature.

Materials:

Worksheet

Suggestions for use:

Task 1:

A list of structures for water treatment in the Czech Republic can be found at http://eagri.cz/public/web/file/130548/VUME_2_UV_2010.pdf. (It is also possible to find out a similar website in the respective mother tongue). Students will get information about when the excursion to waterworks will take place. Each student will prepare at least one question for the waterworks guide. Questions should relate to water pumping, both mechanical and chemical purification of water, history and problems of supply, etc.

Task 2:

Students work out the task in the worksheet. They know the answers from the excursion or they will find them out in the Internet.

Phases:

A – monitoring of water quality in the watercourse

B – water meter

C – treated water back to the nature

D – supply

E – waste water

F – pumping of water

G – purification of waste water

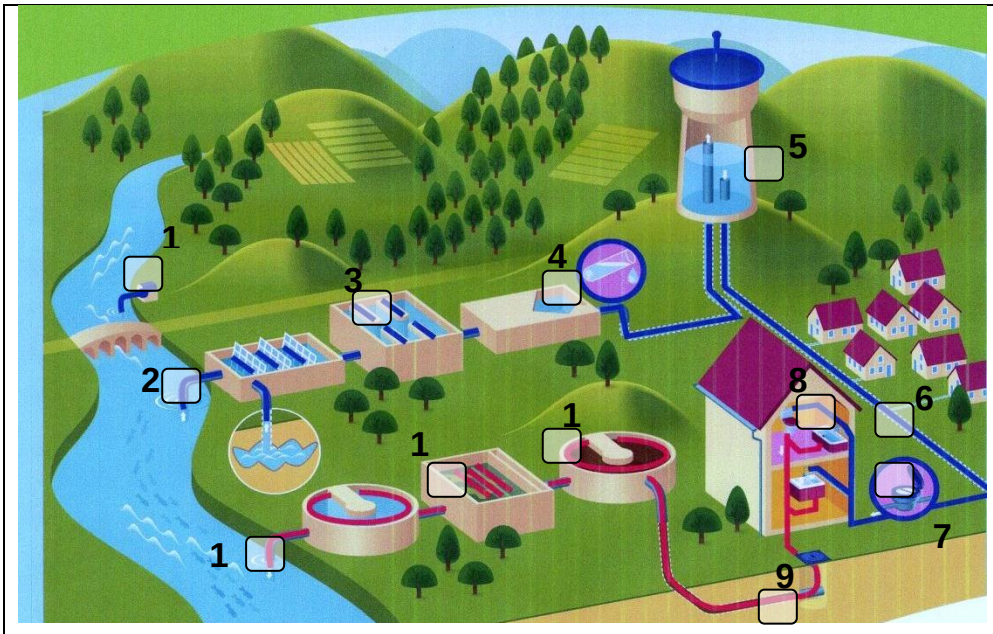
H – waste water in the household

I – storage of drinking water

J – production of drinking water

K – drinking water in the household

L – inspection and chlorination



Source: http://www.pvk.cz/
Key: 1 - A, 2 - F, 3 - J, 4 - L, 5 - I, 6 - D, 7- B, 8 - K, 9 - H, 10 - E, 11 - G, 12 - C.

Possible questions:

- Students formulate their own questions. A large amount of questions arise through this activity.

Activity 5: Can we get drinking water?

Learning aims:

- Students apply the process, which takes place in nature (water filtration through layers of rocks) to the given problem.
- They explain the concept of filtration.

Materials:

Worksheet, PET bottle, sand, hay, crumpled paper, a glass of dirty water (soil with vegetation poured with water), a large empty container, matches, soap, etc.

Suggestions for use:

- **Motivation:** Imagine that you are in South Asia. You are very thirsty and the only water available is muddy water from puddles. How to purify this water to make it drinkable? You have only these things: PET bottle, sand,

hay, crumpled paper, a glass of dirty water, a large empty container (ideally a 3-litre jar), matches and soap (items can be differently replaced or others can be added).

- **Task:** Students work in groups and their task is to build a water purification device using the above items.
- **Solution:** This is rough dirt filtering through the sand filter (emphasize that this process also occurs in the nature). The water that soaks into the ground is naturally cleaned when passing through the rock layers.
- **Question:** Is the water cleaned in this way drinkable? Healthy?
- **Answer:** No!!! A variant how to partially "disinfect" water without chemistry is to leave it in a transparent container in the intense sun. UV light will destroy germs or to boil water over the fire.

or
We will ask the students to propose the way how to find out the (un)safety of filtered water.

Possible questions:

Students formulate their own questions. A large amount of questions arise through this activity.

Activity 6: Analysis of beverages

Learning aims:

- Students analyse the individual beverages, distinguish between appropriate and inappropriate beverages for water intake, and explain why they are advantageous and disadvantageous.
- They will calculate the energy value of their metabolism, which can be compared with their classmates.

Materials:

Worksheet with questions and a table, packaging of various beverages e.g.:

Photo: Martina Nedomová

Suggestions for use:

Task 1:

First, the students will set the questions that would lead to the analysis of the given beverages they were asked to bring. According to their own opinion, they will answer these questions. Thus the hypotheses will be established for the respective questions.

Task 2:

Students will propose the procedure for solution how to verify their hypotheses. They should figure out that they can use the nutritional table for each beverage. Individual information on the composition of the beverages will be supplied into the table. The table will contain the amounts of 100 ml. Some beverages may not show the substances in 100 ml content, so it is important to recognize this fact and to convert them into desired units.

Table: amount to 100 ml

beverage	energy value (kJ)	proteins (g)	saccharides/out of them sugars (g)	fats (g)	fibre(g)	sodium (g)	caffeine (g)

Task 3:

Using these data in the table, students will go back to the questions and compare their answers with the results and draw the conclusion.

Task 4:

The table contains the energy values. Students will write what type of energy it is and why we need it. They will verify their answers in the literature or in the Internet. Further they should be able to estimate how much of this energy they themselves need. The hypothesis will be verified using the formula which can be found e.g. in the Internet.

Questions:

a) What is the energy value? Why do we need this energy?

b) How much energy do you need?

Answers:

Can be found in the Internet or other sources.

a) Refers to the energy, which the given product contains. It is the energy necessary for the functioning of the whole organism.

b) Basal metabolism is the amount of energy needed for functioning of human organs and ensuring of basic life functions. It excludes the energy needed for daily movement. Computation of basal metabolism:

Male: BM = 66 + (13.7 x weight (kg)) + (5 x height (cm)) – (6.8 x age) kcal

Female: BM = 655 + (9.6 x weight (kg)) + (1.85 x height (cm)) – (4.7 x age) kcal

1kcal = 4.2 kJ

In order the body could provide not only basic life functions but also daily activity (walking, running, etc.) it needs to have 30% extra energy of basal metabolism.

Possible questions:

- Which beverage will have the highest energy value?
- Where can you find the highest protein content?
- Which beverage will be the sweetest?
- Will there be a sugar-free beverage?
- Which beverage will be the fattest?
- Will there be any beverage containing antioxidants? If so, which one?
- Which beverages contain caffeine?
- Can a beverage cause allergies?
- What are antioxidants? What do they serve for in our body?

Activity 7: How does the water travel through our body after drinking?
Learning aims:
• Students express in their own words what is going on with water in the picture. • They will propose verification of their answers from the literature or the Internet sources. • They will verify and evaluate their answers
Materials:
Worksheet, working text, or other literature
Suggestions for use:
Students will be provided with worksheet tasks. They will define answers to all tasks. After that they will suggest verifying the accuracy through the answers found in other sources, such as literature or Internet sources. These sources will be offered to them. These could be e.g.: Jelínek, Zicháček – Biologie pro gymnázia, Kočárek – Biologie člověka, Novotný, Hruška – Biologie člověka pro gymnázia in the Czech language or other similar sources in the mother tongue of the students. Solutions to worksheet: What happens to water in this part of the organism? **Picture A** – Food and water are taken through the mouth and continue into the pharynx and oesophagus. **Picture B** – Water is fed into the stomach from the oesophagus, and together with food it continues into the small intestine. **Picture C** – Water is fed from the stomach into the small intestine where it is absorbed. A smaller portion of water is also absorbed in the colon. **Picture D** – Small catheters enter each villus and absorb water and nutrients. Tiny blood vessels then enter the larger vessels and distribute nutrients with water along the body. **Picture E** – The renal artery supplies blood into the kidney where it is cleaned of waste products; nutrients and water are re-absorbed and discharged back into the body by the kidney vein. **Picture F** – Nephron is the basic unit of the kidney. In the glomerulus the primary urine is formed by filtration of blood. From it, in other parts, water and other necessary substances are absorbed and the final urine is produced and

drained from the kidney.
Picture G – Urine is supplied to the bladder by ureters from the kidneys and then it continues through the urethra out of the body.
* The working text, see the worksheet for students.

Possible questions:

Students formulate their own questions. A large amount of questions arise through this activity.

Activity 8: How is final urine formed?

Learning aims:

- Students will propose practical verification of production of final urine and verify the validity of the established hypothesis.
- They will describe the individual pictures showing the gradual production of final urine and express in their own words what happens to the filtrate in each picture.
- They will propose the verification of their answers from literature or Internet sources.

Materials:

Worksheet, scientific literature or the Internet, hay infusion, microscope, slide and cover glass, pipette, two beakers, tap water (distilled water), salt (NaCl)

Suggestions for use:

Task 1:

First, students discuss the osmotic phenomena in the cell. Then they will be provided with worksheet tasks.

Note: The teacher is recommended to prepare a hay infusion.

a) Formulate a research problem about the process of production of final urine.

Research problem:

Will a cell of paramoecium in salty (hypertonic) environment lose or suck water?

b) Establish your hypothesis about the manner of final urine production and

justify your assumption.

Hypothesis:

The cell of paramoecium will lose water in salty (hypertonic) environment and it will shrink.

Justification:

The cell of paramoecium loses water in salty (hypertonic) environment as it tries to dilute it.

c) Propose tools to use during your experiment and justify your selection.

Tools:

hay infusion, microscope, slides and cover glass, pipette, two beakers, tap water (distilled water), salt (NaCl)

Justification:

hay infusion as a source of ciliates, aids for microscopy are necessary for the preparation and observation of microscopic slides, beakers to hold demonstration material and to prepare a saline solution, salt is used to prepare the saline solution, water to prepare aqueous environment

d) Think of the experiment procedure and record it step by step.

Add a small drop of rich culture of paramoecium on the slide glass. Cover with a cover glass and observe. Then add a drop of saline solution (10% solution of NaCl) and observe once more.

Source: http://www.tfsoft.cz/photo/detail.php?a=700&p=1&f=343&rc=6

Now go back to your hypothesis. Has it been proved or disproved by the results of the experiment?

The hypothesis has been proved on the basis of the experiment performed. The cell of paramoecium was losing water after adding the saline solution and it shrank.

Task 2:

Students can find the pictures of the respective parts of nephron in the Internet*.

Students will define the answers to the respective parts of the task in the worksheet. Then they will verify their correctness in the scientific literature or in the Internet, where they search for the correct answers.

a) Proximal tubule

This section is well permeable for both water and salt. Resorption of water is passive after transtubular osmotic gradient that forms active resorptions of sodium and other solutes. Water diffuses through the tubular cells and accumulates in the peritubular area, which increases the hydrostatic pressure in this area; this change in capillary forces then leads to resorption of water into the peritubular capillaries. Absorption of water and solutes in the proximal tubule is proportional, i.e. fluid leaving the proximal tubules is isoosmolar, and creates approximately 70 % of volume filtered in glomeruli.

b) Loop of Henle

The thin descending part of Loop of Henle is permeable to water that is resorbed here in about 15%, but is not permeable to salt. The driving force for again passive resorption of water is hyperosmolarity of kidney marrow. The ascending part of Loop of Henle (thin and thick) is impermeable to water, but, on the contrary, permeable to NaCl. The resorption of salt therefore occurs in the ascending limb of Loop of Henle, i.e. passively in the thin part and actively in the thick part where the sodium is resorbed along with potassium and chlorides. Salt re - absorption in the ascending loop reaches 20% of the total amount of ultrafiltrate. The fluid leaving the Loop of Henle is hypoosmolar because the resorption of solutes in this section prevails over resorption of

water.

c) Distal tubule and collecting duct

A coiled portion of the distal tubule is impermeable to water; the resorption of salt here is active. The end of the distal tubule is the place where both water and salt may or may not undergo resorption; this part is under the hormonal control. A usual amount of water and salt resorbed through distal tubules is about 5 %. Urine leaving the distal tubule remains hypoosmolar.

A collecting duct is responsible for final treatment of urine according to the needs of the organism. Backward resorption of water is here under the hormonal control of ADH, which opens for water the aqua channels (aquaporins) in the apical membrane. Without ADH, the collecting duct is impermeable to water. Backward resorption of sodium in the collecting ducts is under the hormonal control of aldosterone, which stimulates its re-absorption via epithelial sodium channel. The collecting ducts usually resorb about 4 % of filtered sodium and about 9 % of filtered water.

Source: http://pfyziollfup.upol.cz/castwiki2/?p=5063

*These pictures can be found on the website such as: http://pfyziollfup.upol.cz/castwiki2/?p=3695, http://science.kennesaw.edu/~jdirnber/Bio2108/Lecture/LecPhysio/PhysioExcretory.html, http://www.engin.umich.edu/~cre/web_mod/viper/kidney_function.htm

Possible questions:

Students formulate their own questions. A large amount of questions arise through this activity.

Activity 9: Importance of kidneys for life

Learning aims:

Students will appreciate the indispensability of kidneys for life and defend their standpoints in the group on the basis of presented arguments.

Materials:

Worksheet, working text

Suggestions for use:

We will begin with the discussion over the advertisement where a man in material poverty sells one of his kidneys. We will ask the students how much they value this organ and whether they would act in a similar manner in such a situation. We try to highlight the ethical aspect of the example. A discussion over trafficking in human organs is possible. Then they will be provided with a worksheet with the introductory text and questions that will be worked out independently and the findings will be discussed in a group.

Advertisement:

Sale of organs or the kidney under the Christmas tree to every (rich) family

Subject: Sale of kidney

Description of goods sold: I am a thirty year old man, do not drink, smoke and I regularly practise sports - I am in good health. Blood group 0, vaccinated against common diseases, I have never had a serious illness. For financial reasons, one of my kidneys is offered for sale.

Price: 1 500 000 CZK, in the case of multiple bids the highest wins

RE: Rushing, I and my wife live with my mother in law - I really NEED to live on my own!

Source: http://tomassoukup.blog.idnes.cz/c/19442/Prodej-organu-aneb-ledvina-pod-stromecek-do-kazde-bohate-rodiny.html

Possible questions:

- Is the price of kidney undervalued or vice versa overpaid? (in terms of who provides and in terms of who may or may not buy it)

Activity 10: Is it possible to develop an artificial kidney?

Learning aims:

Students apply their knowledge about the function and structure of kidneys to the given problem.

Materials:

Worksheet, scientific literature or the Internet

Suggestions for use:

Students will be first motivated by a short story informing briefly about the development of artificial kidney and this topic will be discussed with them. Then they will be asked to supply the worksheet table with the properties that the artificial kidney should have in order to save human life and their answer will be justified.

Which properties should it have in order to save human life?

Properties	**Justification**
Removal of excess fluid (water)	Incidence of oedema
Removal of waste products of metabolism (urea, creatinine)	Flooding the organism with waste products and consequently apathy, weakness, headache, shortness of breath, vomiting, diarrhoea, chest and bone pain, pale itchy skin

Subsequently, students complement their existing knowledge about kidney function and structure of the retrieved information on the operating principle of artificial kidneys from scientific literature or the Internet. Based on the information obtained, they will draw a diagram of functioning of artificial kidney.

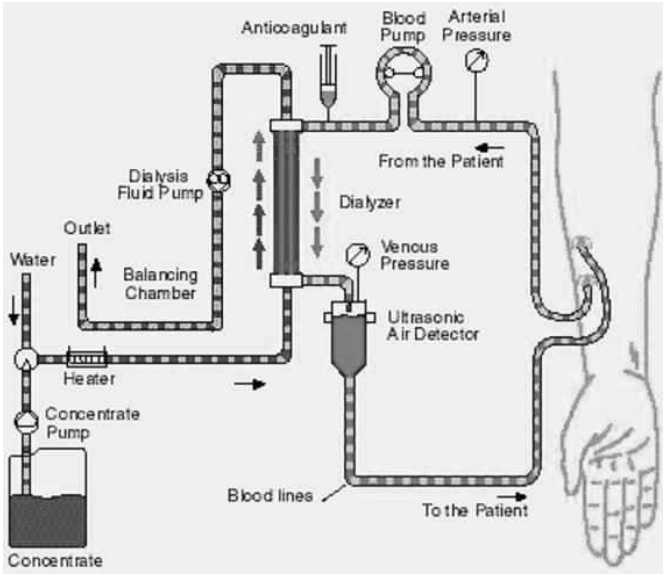
On what principle should it operate?

During dialysis, a dialysis unit (artificial kidney) provides an extracorporeal circulation and produces a dialysis solution. This solution must have the exact composition and temperature. The solution a mixture of water and its solutes

(sodium, potassium, calcium, magnesium, chlorine, bicarbonate anion, glucose). For central water treatment in the dialysis centre, a water treatment plant is used, which is based on the principle of reverse osmosis. It is a water filtration through membranes under high pressure. In addition to the dialysis unit itself, a dialyzer is necessary for dialysis. It consists of a semipermeable membrane that separates blood from the dialysis solution. This membrane allows the passage of substances with small molecules (urea, creatinine, etc.) as well as of excess fluid from the bloodstream of the patient. These components are transferred to the dialysis solution and with it they then leave the dialysis unit as waste. Today, capillary dialyzers are used, where the membrane consists of a hollow fibre. Several tens of thousands of these fibres are connected in parallel. Blood flows through the cavity of each fibre and a dialysis solution flows around the outer wall of each fibre in the opposite direction. Based on the gain of patient weight, the operator sets the size of ultrafiltration on the dialysis unit. Then the unit, depending on blood pressure on the dialyzer membrane and the volume of ultrafiltration, calculates and sets the appropriate pressure for the dialysate. This ensures that the patient leaves the dialysis with optimal weight. In order to reduce blood clotting, heparin is dosed into the blood during dialysis.

Source: http://www.inmed.cz/index.php?page=princip_dialyzy

Draw the scheme.



Source: http://www.gml-dialyza.cz/index.php?multi=dialyza&parent=1

Finally they will search the scientific literature or the Internet for where and how to make dialyzers* and where, in their neighbourhood, a closest dialysis centre is located. Their findings will be supplied into the worksheet.

Search the Internet or the scientific literature for details of where and how to make dialyzers, the most important part of the artificial kidney.

The main element of the dialyzer is a semipermeable membrane that partially replaces the renal function. This membrane consists of a bundle of polysulphonic hollow fibres, capillaries. Polysulfone dissolved in dimethylacetamide is pushed through more than a thousand of subtle circular nozzles in the centres of which there are smaller nozzles for injecting precipitate solution. Behind the mouth of the nozzle a porous hollow fibre, membrane, is created; this enters the coagulation bath. In the coagulation bath, solid stable capillaries are formed by precipitation and chemical conversion. After that the fibres travel to the washer consisting of several separate baths of specially treated (ultraclean) water. Here, the capillaries are flushed, thereby removing undesirable residues (e.g. solvents) from the previous chemical reactions. Fibres are then dried in hot air.
We are constantly monitoring the quality of water in the washing baths and air temperature in the drying chambers. Each fibre is examined using a microscope for a corresponding diameter, wall thickness and porosity. Chromatography examination is also performed to confirm the correct composition of mixtures used.
The individual parts of dialyzers are assembled under perfectly clean conditions on automated lines, with partial service of personnel. Finally, all dialyzers are subjected to strict tests, such as membrane integrity test.

Find in your neighbourhood the closest dialysis centre.

* This text can be found for example on the website: http://braunoviny.bbraun.cz/, http://www.bbraun.com/

Possible questions:

Students formulate their own questions. A large amount of questions arise through this activity.

Activity 11: A visit to a dialysis centre
Learning aims:
• Students will explain what events are performed in the dialysis centre, what rules must be followed during the dialysis, who works here and what education the person has to have. • They will complement the information on the functioning of artificial kidney.
Materials:
Worksheet
Suggestions for use:
Students will be informed about the date of the excursion. We will let them write down the questions that they would like to ask the medical staff to supplement the missing information on the matter. As the output of the excursion, students can write an article for the school magazine about the operation of dialysis centre, complemented with their own photographs taken during the excursion or the interviews with patients or the experience of medical staff.
Possible questions:
• How does haemodialysis work? • Where, who and when is it carried out? • What can I do during these 4-5 hours of dialysis? • How does each respective haemodialysis go on? • How to prepare for it before it starts? • Who is eligible for haemodialysis? • Who is ineligible for haemodialysis? • What are its advantages over abdominal dialysis? • What are the disadvantages? What will limit me? • What can be a complication of haemodialysis? How do I know? • If I decide for haemodialysis, can I change my decision in future? • What will happen if I undergo transplantation in future? * This text can be found for example on the website: http://www.nefrologie.eu/cgi-bin/main/read.cgi?page=hemodialyza, http://kidney.niddk.nih.gov/, http://www.kidney.org/

Activity 12: World Kidney Day

Learning aims:

- Students will explain what are the causes, manifestations and possibilities of treatment of chronic disease (failure) of kidneys.
- They will evaluate the incidence of disease worldwide and possibilities of prevention.
- They will propose and prepare promotional materials according to the agreed criteria.

Materials:

Worksheet, scientific literature or the Internet, markers, crayons, drawing tools

Suggestions for use:

First, students will be introduced to the problem by discussing with them the fact that most people do not know about their disease because the chronic kidney disease usually does not hurt. Then we will ask them how they would ensure an early diagnosis of the kidney disease with the affected persons so that the treatment was easier and thus there was also a lower risk of other diseases. Then we will let the students search from relevant sources for information about kidney function, causes and manifestations of chronic disease (failure) of kidney, prevention and treatments, disease incidence in the world's population. Based on this information the students agree upon a uniform and pre-arranged target of advertising campaign and suggest possible forms and design of advertisement. Their works along with the informative article can be then published in the school magazine or they can hold discussions with classmates where they present their findings on the given topic.

Note: We recommend downloading a couple of current flyers from the World Kidney Day from the Internet, printing them out and at the beginning of the activity handing them out among the students

Causes, manifestations and treatment

Chronic renal insufficiency is characterized by progressive loss of renal

function due to renal disease or renal damage with a system disease of organism (diabetes, obesity, high blood pressure). Such damage often runs for a long time without obvious symptoms causing serious problems to the patient.

However, damage to kidneys caused by any chronic disease, leading to a reduction in their function, can be very accurately measured. It is expressed as glomerular filtration rate or amount of filtered urine, which occurs in the kidneys. According to the degree of reduction in glomerular filtration, the chronic disease can be divided into five stages.

Stage	**Description**	**GF ml/min**	**GF ml/s**
1	Damage to kidneys with normal or higher GF	>90	>1.5
2	Damage to kidneys with moderate reduction in GF	60–89	1–1.49
3	Moderate reduction in GF	30–59	0.5–0.99
4	Severe reduction in GF	15–29	0.25–0.49
5	Failure of kidneys	<15 or dialysis	<0.25 dialysis

A current stage of renal impairment is also reflected in the selected treatment - from medication, diet and regime measures in mild manifestations to a dialysis or transplantation with function loss greater than 80-90%.

Renal insufficiency after its discovery usually accompanies the patient throughout the rest of his/her life and often tends to spontaneously worsen despite the provided treatment. Therefore, patients are under close supervision of professional nephrology outpatient clinics, where they undergo a regular physical examination, blood pressure checks, and blood and urine tests.

Rate of deterioration of renal function is dependent on the nature of underlying

disease, the effectiveness of therapeutic measures, but also on the approach of the patient to the therapy. Renal failure (the last stage of chronic kidney disease, when it is vitally necessary to artificially replace the kidney function) may therefore occur within a year, as well as after several decades.

The first clinical symptoms appear only when the kidney function drops to 35 - 40% of its original capacity, but unfortunately, very often even much later. These include headache, weakness, rapid onset of fatigue, anorexia, recurrent vomiting, frequent urination (especially at night), increased thirst, pale skin, high blood pressure, growth failure in children.

Should the renal function worsen until the stage of their failure, we can also observe the apathy, weakness, headache, shortness of breath, vomiting, diarrhoea, oedema, chest pain, bone pain, pallor, and itchy skin. At this point the start of dialysis treatment is clearly necessary. Even so it applies that each patient should be assessed individually with regard to the renal function and overall condition of the patient.

Prevention

Do not smoke, avoid being overweight, regular exercise, healthy diet, stick to water intake, reasonable consumption of alcohol, regular preventive examinations

The incidence in the world's population is about 10%.

Source: http://www.ledviny.cz/nemoci-ledvin

Proposal of advertisement:

Television advertising, radio advertising, walking advertisement, flyer, poster, billboard, banner, etc.

Possible questions:

- Students formulate their own questions. A large amount of questions arise through this activity.

ISBN 978-1-873769-23-2

These teaching and learning materials have been produced within the scope of the European ESTABLISH project. They serve as exemplary materials for science teachers and educators to experience the benefits of Inquiry-Based Science Education (IBSE) and are offered openly to inspire, guide and stimulate the further development of IBSE resources and practices.

Electronic versions of these units and associated classroom materials are available for download from the project website at:
www.establish-fp7.eu
and
www.castel.ie/establish

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 244749 (2010-2014). This publication reflects only the authors' views and the European Union is not liable for any use that may be made of the information contained therein.

The ESTABLISH project has been coordinated by: Dr. Eilish McLoughlin, Dr. Odilla Finlayson, Dr. Deirdre McCabe and Dr. Sarah Brady from the Centre for the Advancement of Science and Mathematics Teaching and Learning (CASTeL) at Dublin City University (DCU).

www.establish-fp7.eu

VOLUME 3 | BIOLOGY

ESTABLISH IBSE - Teaching & Learning Units