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Light Intensity

Objective

- To study limitations of human senses.
- To investigate if the light intensity of a bulb is constant or fluctuates.

Modules and Sensors

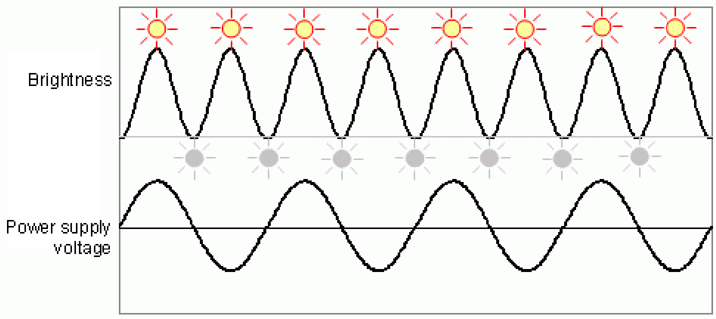
- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Light Sensor: S98242-20ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Discussion

The incandescent light bulb is a source of electric light that works by incandescence (a general term for heat-driven light emissions, which includes the simple case of black body radiation). An electric current passes through a thin filament, heating it to a temperature that produces light. The enclosing glass bulb contains either a vacuum or an inert gas to prevent oxidation of the hot filament.

Incandescent bulbs are also sometimes called electric lamps, a term also applied to the original arc lamps. Incandescent light bulbs are gradually being replaced in many applications by other types of electric light such as (compact) fluorescent lamps, high-intensity discharge lamps, light-emitting diodes (LEDs), and other devices. These newer technologies give more visible light and less heat for the same amount of electrical energy input.



Relationship Between Power Supply Voltage and Brightness

Some jurisdictions, such as the European Union, are in the process of phasing out the use of incandescent light bulbs in favor of more energy-efficient lighting. In the United States, federal law has scheduled incandescent light bulbs to be phased out by 2014 to be replaced with more energy efficient light bulbs. In this activity we will use a light sensor to study light intensity dependence on time.

Procedure

Sensor setup

1. Connect the USB module  to the computer's USB port.

2. Connect the light sensor  to the USB module using the data cable.

3. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

4. Notice the sensor's module box on the left side of the screen. Click on the 'Module Setup' icon  to open a dialogue box:

Set the sensor's range by selecting the radio button next 1,000 Lux. Your screen should look as follows:

Note: the lowest sensor's range is used for this activity since we are working indoors.

Testing and Measurements

5. Click the 'On Line Experiment' icon  in the main icon bar.

6. Direct the sensor towards a light bulb and click on the 'Run Experiment' icon  to start a measurement. The measurement will continue by default for ten seconds.

7. Observe the graph.

Analysis: You should see a relatively stable horizontal line, which is how our eyes perceive the light. You will now perform a fast measurement which will allow you to see how the

8. Click on the 'Experiment Set Up' icon  in the sub icons bar. This opens a dialogue box:

Set the Experiment duration to 50 milliseconds.
Set the sampling rate to 3,000 per second on the drop down menu.

9. Close the dialogue box.

10. Direct the sensor toward the light bulb and click on the 'Run Experiment' icon  to start a new measurement.

11. Observe the graph.

Analysis: This new graph shows the real behavior of light produced by an A.C. voltage, i.e. light intensity changes with time in a periodic way (the frequency is twice the one of the power supply).

12. Click on the 'Zoom Fit' icon  to see the graph better.

Summary Questions

1. Count the wave peaks (either up or down) in the screen and divide the number by 0.050 (experiment duration). This is the frequency of the light in number of waves per second (Hertz).

2. Compare the frequency obtained with the frequency of the electrical current supplied by the local company.

Properties of Light

Objective

- To understand what happens when light hits different surfaces.
- To study the properties of light in terms of reflection and absorption.
- To measure the reflectivity of various colored surfaces through a Light Sensor.
- To measure the energy absorbed by various colored surfaces, through a Temperature Sensor.

Modules and Sensors

- Computer with NeuLog™ Software
- 2 Data Cables, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Light Sensor: S98242-20ND 
- Temperature Sensor: S98242-31ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- A lamp with a 100 W bulb
- Ring stand
- Utility clamp

Materials

- Aluminum foil
- White paper or cloth
- Black paper or cloth
- Tape
- Ruler

Discussion

A light wave consists of energy in the form of electric and magnetic fields. Light waves are seen by the human eye as different colors and they are characterized by their wavelength**,** which is the distance between any two corresponding points on successive waves.

What happens to light when it hits different surfaces? In this activity you will study that light is both waves and energy, part of it will be reflected and part will be absorbed. The amount of light absorbed or reflected depends on the color and surface quality of the object. Usually, dark colors absorb most of the light and reflect less, compared to light colors which tend to reflect more and absorb less. People try to adapt their color of clothes, cars and the paint of their homes according to the climate they live in.

In this experiment, you will illuminate different surfaces and measure the reflectivity of various colors as well as the temperature change due to energy absorption. You will use a light sensor to measure the amount of light reflected from papers of different colors and calculate the percentage of reflectivity. You will also measure the temperature change of the air under the paper due to energy absorption by the paper, through a temperature sensor. These measurements will allow you to study the relationship between reflection and absorption energy.

You will explore the reflection and absorption of radiation from different surfaces. Following the instructions, you will design an experiment of your own to either test the reflectivity of sand, soils, water and other materials or investigate the effect of different surface textures on reflectivity.

Procedure

<u>Experiment setup</u>

1. Place the Temperature Sensor  on the table with a piece of paper on top.

2. Attach the Light Sensor  about 10 cm above the white paper to the ring stand using a utility clamp as show in the following picture.

3. Put the lamp in front of the assembled system, as in the picture.

Sensor setup

4. Connect the USB Module to the USB port of your computer.

5. Connect the Light and Temperature Sensors to the USB Module using the Data Cables.

6. Run the NeuLog™ software and check that the sensors are identified. If the software is already running, click the 'Search for Sensors' icon .

7. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar , click on the 'Load Configuration' icon .

8. This sets up the experiment parameters as follows:
Experiment duration to 7 minutes
Sampling rate to 5 per second
Sensor's range: 6,000 Lux.

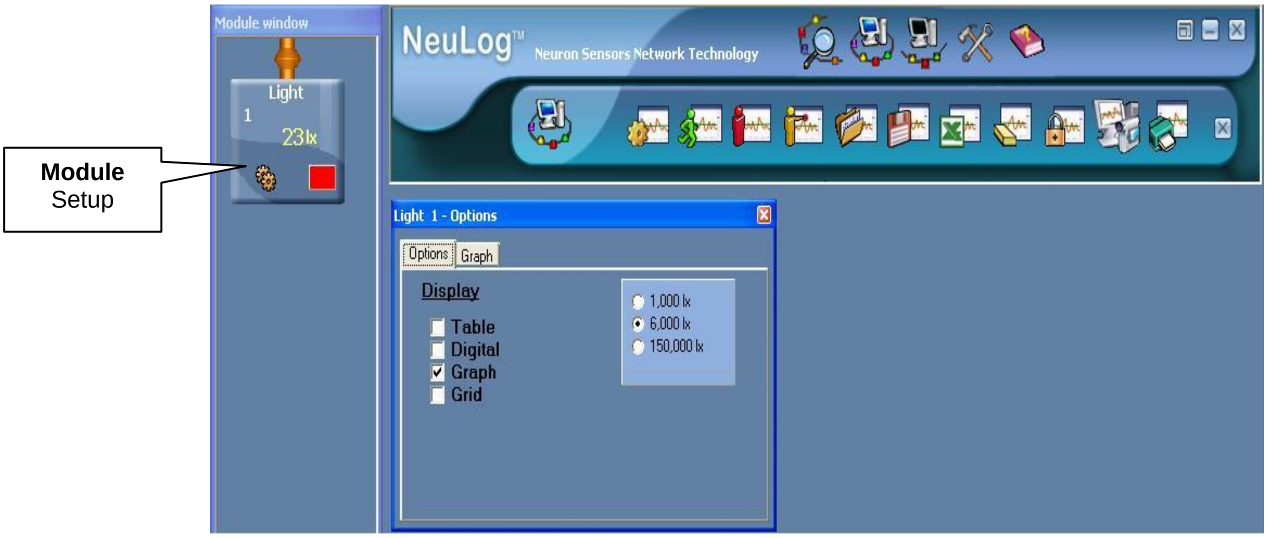
9. If you did not use the Load Configuration function , click the 'On Line Experiment' icon in the main icon bar.

10. Click on the 'Experiment Setup' icon . This opens a dialogue box:
Set the experiment duration to 7 minutes
Set the sampling rate to 5 per second on the drop down menu.

11. Close the dialogue box.

12. Click on the 'Module Setup' icon to open a dialogue window. Set the sensor's range by selecting the radio button next to 6,000 Lux.

13. Your screen should look as follows:



14. Close the module setup dialogue box.

Testing and measurements

15. Switch on the light bulb.

16. Click on the 'Run Experiment'  icon to start the measurement.

17. At the end of the measurement, click the 'Show Functions' icon . Click the Statistics tab and select Light from the drop down menu. Click the 'Calculate Statistics' icon . Observe the Maximum, Minimum and Average values of the illumination. Record the mean light reflection value (in lux). The lux is the SI unit for light illumination.

18. Press the 'Show Functions' icon  again, then click on the Statistics tab and select temperature. Click the 'Calculate Statistics' icon . Observe the Maximum, Minimum and Average values of the temperature. Use the minimum and maximum values to fill the table.

19. Repeat Steps 4 to 7 with a black paper and then with aluminum foil. If time allows, make and record readings for two additional colors of paper.

20. When the tests are completed, measure the total radiation as a reference:
First measure the distance of the light source from the table;
Place the light sensor facing the light directly at that distance;
Measure the intensity;
Repeat steps 5 and 6.

Object	Minimum Temperature (°C)	Maximum Temperature (°C)	ΔT	Reflection value (lux)	%Reflectivity
White Color					
Black Color					
Aluminum					

Summary Questions

1. Does the change in temperature differ when illuminating different colors?

2. Calculate relative reflectivity of each colored surface using the relationship:
% of Reflectivity = (reflection measured/total radiation measured in step 11) × 100. Write the result in your table.

3. Make a list of all the colored surfaces you have measured. Begin from the largest temperature increase to the smallest.

4. Does color affect reflectivity? If so, in what way?

5. Is the correlation between the reflection and the color the same as in temperature?

Challenge

1. In order to study the effect of surface textures on reflectivity, design and perform an experiment to test the reflectivity of sand, water and other materials.

2. Could you mention situations from daily life where the effect of color and energy is used? How? (For example, solar collectors, etc.)

Measurements of Visible Light and UV Radiation During the Day

Objectives

- To study visible light and UV radiation intensity differences at different times of the day.
- To analyze its implications to our health.

Modules and Sensors

- Computer with NeuLog™ Software
- 3 Data Cables, 30cm: S98242 – 49ND
- USB Module: S98242 – 45ND 
- Light Sensor: S98242 – 20ND 
- UVA Radiation Sensor: S98242 – 36ND 

- UVB Radiation Sensor: S98242 – 37ND 

- Battery Module: S98242 – 44ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Base 6" x 4"
- Rod 500mm
- Boss head
- Clamp

NOTE: **The Effectiveness of Sunscreen Kit** is available – S02143. This kit contains an activity guide and the materials needed to conduct a variation of this activity and allows you to analyze the difference in sunscreens and discover if SPF 15 is really different than SPF 30.

Discussion

Ultraviolet (**UV**) light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays. The Sun emits ultraviolet radiation which we divide as follows: UVA, UVB and UVC. The ultraviolet A, long wave, is UVA, with wavelengths of 400nm-320nm; ultraviolet B or medium wave, is UVB with wavelengths of 320nm-290nm; ultraviolet C, short wave, UVC with wavelengths of 290nm-200nm.

Oxygen and Ozone in the atmosphere absorb most of the UVC and UVB radiation which are considered harmful. Out of the UV reaching the Earth's surface, 10% is in the range of 290-320nm. The remaining 90% of the UV radiation, mainly the UVA that is not affected by the Ozone, reach the Earth in the range of 320-400nm.

Many skin problems such as sunburn, tanning and some skin cancers are a result of the interaction of UVB radiation with the human skin. Therefore, we can understand the importance of conserving the Ozone layer in the atmosphere.

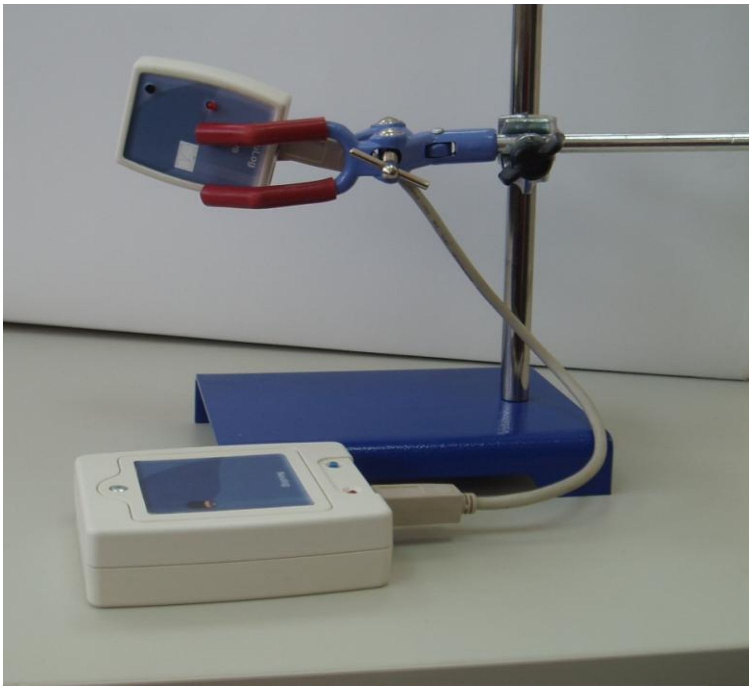
The purpose of this experiment is to measure visible light, UVA and UVB radiation outdoors in order to study it as a function of the time during the day.

As mentioned, ultraviolet radiation could be harmful. Therefore, it is very important to be aware of the peak hours during the day in order to take precautions such as wearing protective clothes, sun glasses and sun protection cream. You should even try to avoid or minimize outside activities during these hours.

Procedure

Experiment setup

1. Assemble a simple outdoor radiation measurement system, as in the following



You will have to change the sensor module for each measurement, i.e. start with the Light Sensor, perform a measurement, then switch to the UVA Sensor and then to the UVB Sensor.

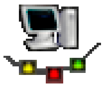
Sensor setup

2. Connect the USB Module  to the USB port on your computer.

3. Connect the Light Sensor  to the USB Module using one of the Data Cables.

4. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

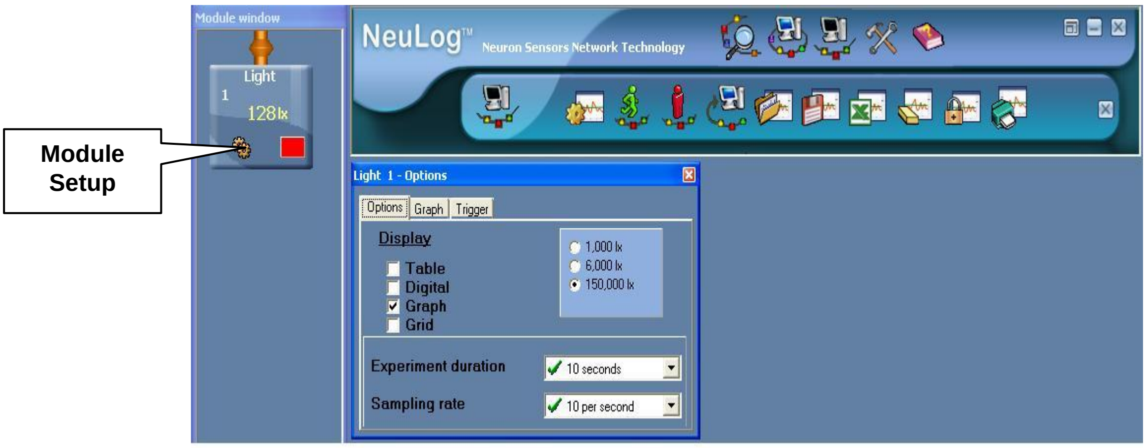
5. We will work in the Off Line Mode of the NeuLog software to program the measurement conditions for the sensor to work disconnected from the computer (outside).

6. Click the 'Off Line Experiment'  icon in NeuLog's main icon bar.

7. Since the measurement will be performed outside, you will work with the sensor's lowest sensitivity. Click the 'Module Setup' icon  in the sensors module box to open a dialogue box.

a. Verify that the range of the sensor is set to 150,000 Lx.
b. If necessary, set the sensor's range, selecting the radio button next to 150,000 lx.
c. Set the experiment duration to 10 seconds
d. Set the sampling rate to 10 per second.

Your screen should look like the one below:



This procedure downloads the measurement conditions to the sensor and these are stored in its memory.

8. Close the module setup dialogue box.

9. Disconnect the Light Sensor  from the USB Module  and connect the UVA Sensor 

to the USB Module.

10. Set experiment duration and sampling rate as in step 7.

11. Repeat steps 9 and 10 for the UVB Sensor 

.

12. Connect the Light Sensor  to the Battery Module  using a Data Cable

Testing and measurements

The goal of this activity is to measure light, UVA and UVB radiation intensity during the day. Since each sensor can store 5 measurements in off line mode, divide your measurement time by five. For example, perform your first measurement with the three sensors at 8 a.m. Then repeat at 10 a.m., 12 p.m., 14 p.m. and 16 p.m.

13. Take your equipment outside.

14. Use a ring stand and a clamp to hold the light sensor facing the Sun directly.

Caution:
Do not stare directly at the Sun while aiming the sensor.

Note:
Make sure that the sensor is facing the Sun by moving it and at the same time looking at its shadow; the smallest shadow indicates that the sensor is facing the Sun. If you have a monitor display unit, connect it to the sensor and vary the position and angle of the sensor to get the highest intensity reading.

15. Begin the measurement by pressing the sensor's start/stop button.

The red LED should turn on.

Note:
You should see the sensor's red LED On during the measurement. When the LED turns Off, it means the experiment time is over. The measured data is stored in the sensor's memory.

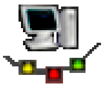
16. Repeat steps 14 and 14 but this time, use the UVA Sensor.

17. Repeat steps 14 and 15 again for the UVB Sensor.

18. Repeat measurements four more times, as apart from each other as possible during day time.

19. When all measurements are completed (at the end of the day you should have 5 measurements with each sensor), disconnect the last sensor used from the Battery module.

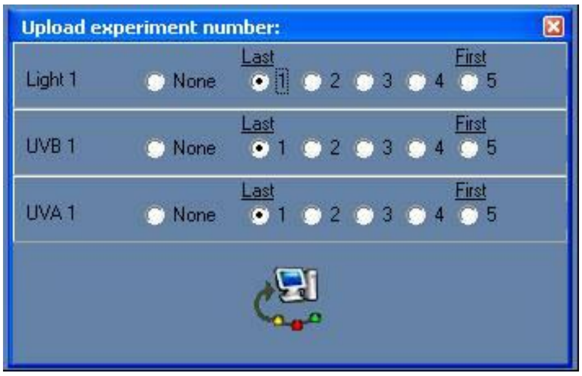
20. Using the Data Cables, create a chain with the three sensors and connect them to the USB Module.

21. Download the data to the computer as follows: click the 'Search for Sensors' icon , then click the 'Off Line Experiment'  icon in NeuLog's main icon bar.

22. Click on the 'Load Data from Sensors' icon  in the sub-icons bar to reveal a box with options:

All (last experiments)
Light 1
UVB 1
UVA 1
Experiments

23. Select **Experiments**. This will open the window: "upload experiment number". See following picture:

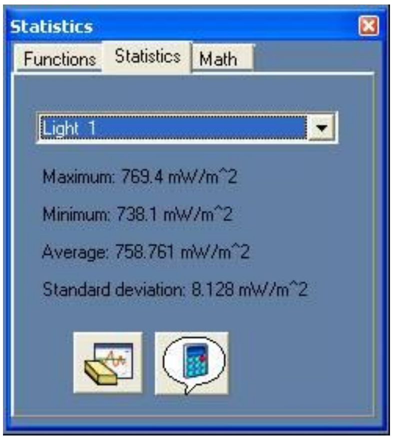


24. Upload the measurements which were saved in the sensor's memory to your computer:

Select the three radio buttons next to the number 5 (one for each sensor).
This way, you are selecting the first measurements to be uploaded.

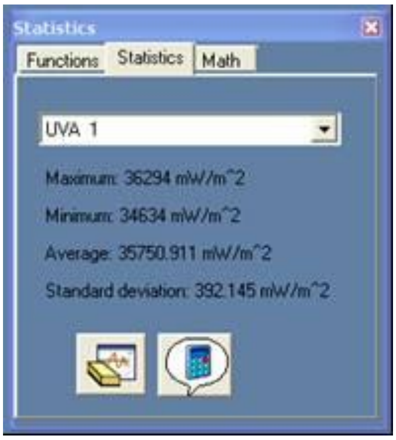
25. Click on the icon  inside the "upload experiment number" window to load the selected experiment. Observe the graphs.

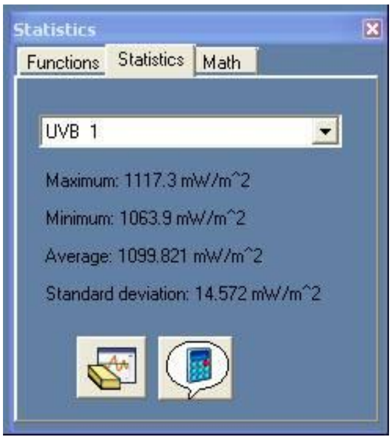
26. You can use the statistics tools in NeuLog software to get the average measurement. Click the 'Show Functions'  icon in the upper left corner of the graph window and select the statistics tab in the dialogue box that opens.



27. Click the 'Calculate Statistics' icon  and write down the average values in the table in the next page.

28. Click the scroll down menu in the dialogue box to select the other two sensors, one at a time, and repeat steps 28 and 29.





29. Continue to upload the measured data from each measurement for the three sensors, as described in step 26 and write down the results in the table.

Sensor	First Measurement 08:00 a.m. ------------------	Second Measurement 10:00 a.m. ----------------	Third Measurement 12:00 p.m. ----------------	Fourth Measurement 14:00 p.m. ---------------	Fifth Measurement 16:00 p.m. ----------------
Light (lx)					
UVA (mW/m^2)					
UVB (mW/m^2)					

Summary Questions

1. Describe the time of the day and the location where you recorded your measurements.

2. Analyze your results and conclude. Does the intensity of the measured radiation behaves similarly as a function of time for the light, UVA and UVB?

3. From your experimental results, explain why there are such big differences in the dependence of the intensity on time of day for the three radiation categories (visible light, UVA and UVB). As a clue, investigate why the horizon looks red during sunrise and sunset.

Testing the Quality of Sunglasses Using Visible Light and UV Sensors

Objectives

- To study the effect of sunglasses on visible light and UV radiation.
- To compare the level of protection (UV absorption) of different types of sunglasses.

Modules and Sensors

- Computer with NeuLog™ Software
- 3 Data Cables, 30cm: S98242 – 49ND
- USB Module: S98242 – 45ND 
- Light Sensor: S98242 – 20ND 
- UVA Radiation Sensor: S98242 – 36ND 

- UVB Radiation Sensor: S98242 – 37ND 

- Battery Module: S98242 – 44ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Base 6" x 4"
- Rod 500mm
- Boss head
- Clamp

Discussion

Ultraviolet (**UV**) light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays. The Sun emits ultraviolet radiation which we divide as follows: UVA, UVB and UVC. The ultraviolet A, long wave, is UVA, with wavelengths of 400nm-320nm; ultraviolet B or medium wave, is UVB with wavelengths of 320nm-290nm; ultraviolet C, short wave, UVC with wavelengths of 290nm-200nm.

Oxygen and Ozone in the atmosphere absorb most of the UVC and UVB radiation which are considered harmful. Of the UV reaching the Earth's surface, 10% is in the range of 290-320nm. The remaining 90% of the UV radiation, mainly the UVA that is not affected by the Ozone, reach the Earth in the range of 320-400nm.

Everyone is at risk of eye problems caused by the Sun, UV radiation in particular. Even children face damaging their eyesight; in fact they are more at risk as a child's eyes are usually less protected against UV radiation than adults'. Those most at risk are people who spend a lot of time in the sun, people who have had cataract surgery or have cataract or retina disorders and people who are taking certain drugs, such as tetracycline, birth control pills and tranquilizers that increase the sensitivity of the eyes to light.

Evidence is increasingly available linking exposure to UV rays to eye damage. Long-term exposure to UV radiation can cause cataracts, macular degeneration or even skin cancer around the eyelids. It is therefore recommended to wear a pair of good quality sunglasses when outdoors in order to protect your eyes from these harmful rays.

Of the three types of UV radiation, UVC is not a problem as UVC rays are absorbed by the atmosphere and never reach the Earth's surface. UVA rays are absorbed by the lens in the human eye. Although there have been no documented accounts of ill effects from UVA rays, this area is still much debated and a lot of research is still ongoing into whether any harm can be caused by UVA rays.

UVB rays however can be very dangerous. UVB rays burn the skin, damage the eyes and cause snow blindness - a temporary but very painful affliction that can last up to two days. Daily exposure to UVB rays is also thought to be a primary cause of cataracts, which causes a clouding of the lens and significantly hampers vision. Many experts also suspect that UVB rays are responsible for eye growths such as pingueculae or pterygia.

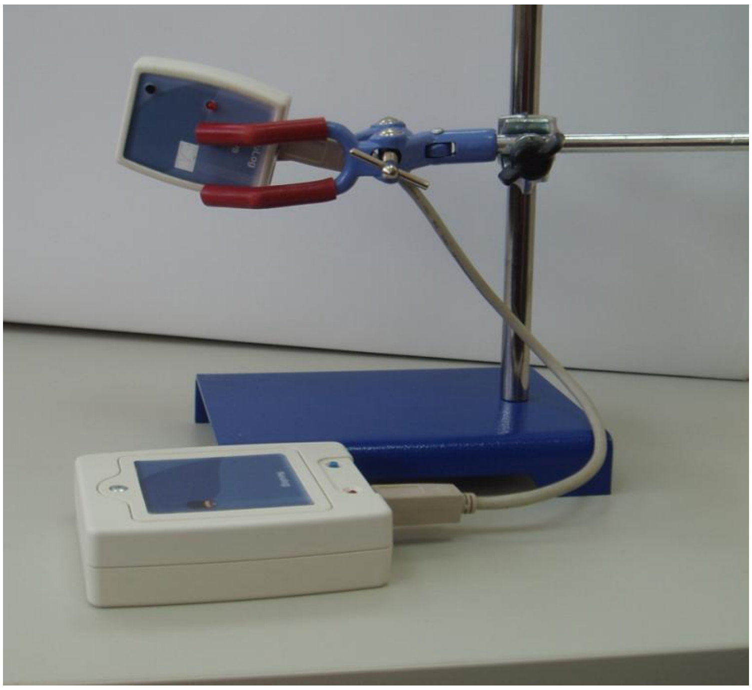
Wearing good quality sunglasses can filter out most if not all UV radiation and therefore reduce risks of eye damage and other potential eye problems.

The purpose of this experiment is to measure visible light, UVA and UVB radiation outdoors through different sunglasses. If possible, compare low cost with expensive types or sunglasses.

Procedure

Experiment setup

1. Assemble a simple outdoor radiation measurement system, as in the following picture:



You will have to change the sensor module for each measurement, i.e. start with the Light Sensor, perform a measurement, then switch to the UVA Sensor and then to the UVB Sensor.

Sensor setup

2. Connect the USB Module  to the USB port on your computer.

3. Connect the Light Sensor  to the USB Module using a Data Cable.

4. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

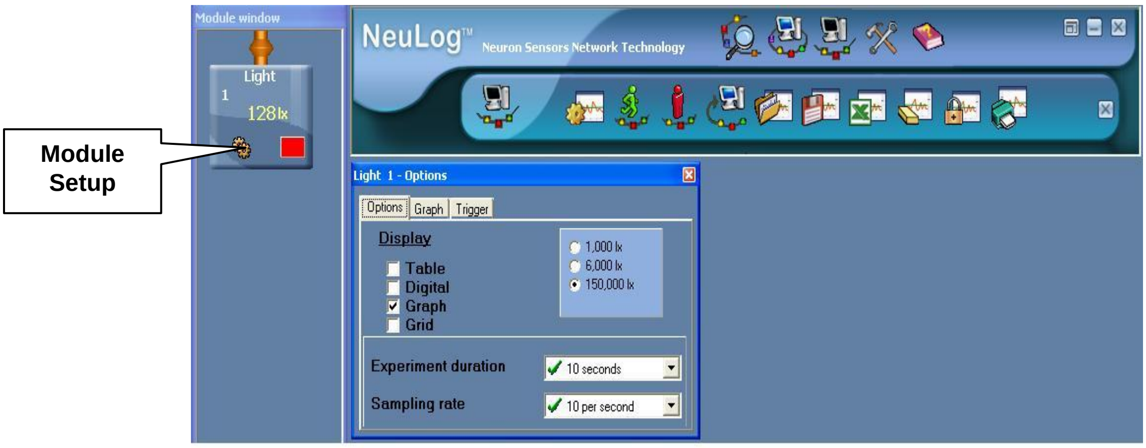
5. You will work in the 'Off Line Mode' of the NeuLog software to program the measurement conditions for the sensor to work disconnected from the computer (outside).

6. Click the 'Off Line Experiment' icon in NeuLog's main icon bar.

7. Since the measurement will be performed outside, you will work with the sensor's lowest sensitivity. Click the 'Module Setup' icon in the sensors module box to open a dialogue box.

- **a.** Verify that the range of the sensor is set to 150,000 Lx.
- **b.** If necessary, set the sensor's range, selecting the radio button next to 150,000 lx.
- **c.** Set the experiment duration to 10 seconds
- **d.** Set the sampling rate to 10 per second.

Your screen should look like the one below:



This procedure downloads the measurement conditions to the sensor and these are stored in its memory.

8. Close the module setup dialogue box.

9. Disconnect the Light Sensor from the USB Module and connect the UVA Sensor to the USB Module.

10. Set experiment duration and sampling rate as in step 7.

11. Repeat steps 9 and 10 for the UVB Sensor.

12. Connect the Light Sensor to the Battery Unit using a Data Cable.

Testing and measurements

The goal of this activity is to measure light, UVA and UVB radiation intensity through different types of sunglasses. Remember that each sensor can store 5 measurements in Off Line Mode.

13. Take your equipment outside.

14. Use a ring stand and a clamp to hold the Light Sensor facing the Sun directly.

Caution:
Do not stare directly at the Sun while aiming the sensor.

Note:
Make sure that the sensor is facing the Sun by moving it and at the same time looking at its shadow; the smallest shadow indicates that the sensor is facing the Sun. If you have a monitor display unit, connect it to the sensor and vary the position and angle of the sensor to get the highest intensity reading.

15. Begin the measurement by pressing the sensor's start/stop button.

The red LED should turn on.

Note:

You should see the sensor's red LED On during the measurement. When the LED turns Off, it means the experiment time is over. The measured data is stored in the sensor's memory.

16. Put one pair of sunglasses in front of the Light Sensor. Begin a new measurement by pressing the sensor's start/stop button.

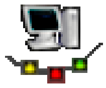
17. Repeat this procedure with up to 4 different types of sunglasses. Remember that each sensor can store up to five measurements in Off Line Mode. Since the first measurement is of the direct irradiation of the Sun you can test four different types of sunglasses before downloading the data to the computer.

18. Repeat steps 14 through 17 but this time, use the UVA Sensor.

19. Repeat steps 14 through 17 again for the UVB Sensor.

20. When all measurements are completed, disconnect the last sensor used from the Battery module.

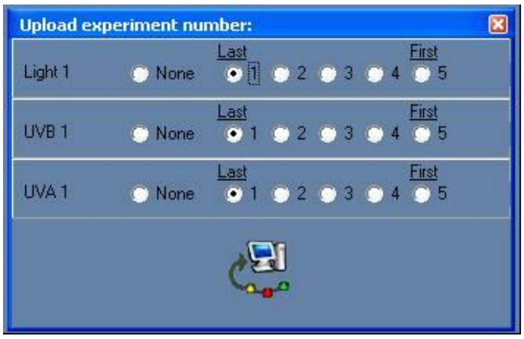
21. Create a chain with the three sensors and connect them to the USB Module using the Data Cables.

22. Download the data to the computer as follows: click the 'Search for Sensors' icon , then click the 'Off Line Experiment;  icon in NeuLog's main icon bar.

23. Click on the Load data from 'Sensors' icon  in the sub-icons bar to reveal a box with options:

All (last experiments
Light 1
UVB 1
UVA 1
Experiments

24. Select **Experiments.** This will open the window: "upload experiment number". See following picture:

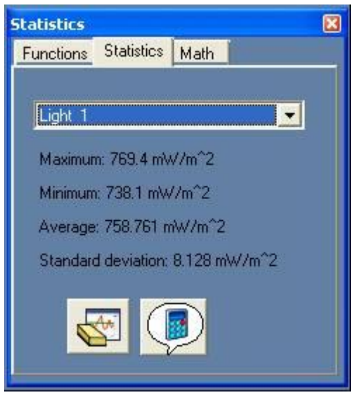


25. Upload the measurements to the computer which were saved in the sensor's memory:

a. Select the three radio buttons next to the number 5 (one for each sensor).

b. In this way, you are selecting the first measurements to be uploaded (direct sun irradiation).

26. Click on the 'Load Data from Sensors' icon  inside the "upload experiment number" window to load the selected experiment. Observe the graphs.

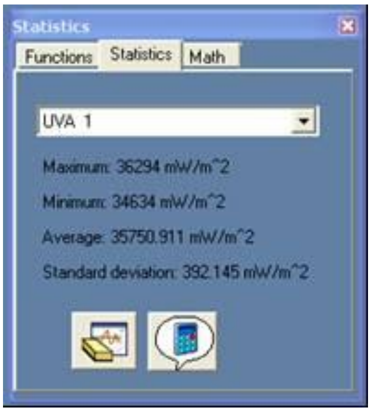


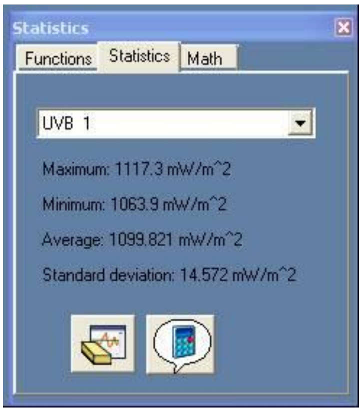
You can use the statistics tools in NeuLog software to get the average measurement.

Click the 'Show Functions' icon  in the upper left corner of the graph window and select the statistics tab in the dialogue box that

27. Click the 'Calculate Statistics' icon  and write down the average values in the table below.

28. Click the scroll down menu in the dialogue box to select the other two sensors, one at a time, and repeat steps 29 and 30.





Sensor	Direct Measurement	Sun Glasses No. 1	Sun Glasses No. 2	Sun Glasses No. 3	Sun Glasses No. 4
Light (lx)					
UVA (mW/m^2)					
UVB (mW/m^2)					

29. Continue to upload the measured data from each measurement for the three sensors, as described in step 27 and write down the results in the table.

Summary Questions

1. Describe the light absorbance differences for the various sunglasses evaluated.

2. Describe the UVA absorbance differences for the various sunglasses evaluated.

3. Describe the UVB absorbance differences for the various sunglasses evaluated.

4. Correlate the cost of the sunglasses to the degree of eye protection.

5. Is it worth paying more money in order to get better eye protection?

Challenge

1. Repeat your measurements with regular reading glasses and conclude.

Effectiveness of Sunscreen Protection

Objectives

- To study the effect of sunscreen protection on UV radiation.
- To compare the level of protection (UV absorption) of different sunscreens.
- Understand the SPF concept.

Modules and Sensors

- Computer with NeuLog™ Software
- 3 Data Cables, 30cm: S98242 – 49ND
- USB Module: S98242 – 45ND
- Light Sensor: S98242 – 20ND
- UVA Radiation Sensor: S98242 – 36ND
- UVB Radiation Sensor: S98242 – 37ND
- Battery Module: S98242 – 44ND

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Base 6" x 4"
- Rod 500mm
- Boss head
- Clamp

NOTE: **The Effectiveness of Sunscreen Kit** is available – S02143. This kit contains an activity guide and the materials needed to conduct a variation of this activity and allows you to analyze the difference in sunscreens and discover if SPF 15 is really different than SPF 30.

Materials

- Microscope slides (or any strong but thin transparent surface)
- Different sunscreens: SPF15, SPF30, with and without UVA screening.

Discussion

UVA (ultraviolet-A): long- wave solar rays of 320-400 nanometers (billionths of a meter). Although less likely than UVB to cause sunburn, UVA penetrates the skin more deeply, and is considered the chief culprit behind wrinkling, leathering, and other aspects of "photoaging" The latest studies show that UVA not only increases UVB's cancer-causing effects, but may directly cause some skin cancers, including melanomas.

UVB (ultraviolet-B): short-wave solar rays of 290-320 nanometers. More potent than UVA in producing sunburn, these rays are considered the main cause of basal and squamous cell carcinomas as well as a significant cause of melanoma.

Sun blocks and sunscreens: Sunscreens chemically absorb UV rays, sun blocks physically deflect them. Sunscreens have long blocked UVB effectively, but until recently, provided less UVA protection. Sun blocks have also markedly improved.

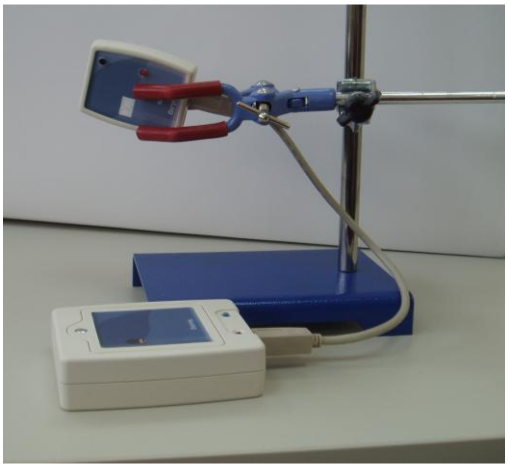
SPF (sun protection factor): measures the length of time a product protects against skin reddening from UVB, compared to how long the skin takes to redden without protection. If it takes 20 minutes without protection to begin reddening, using an SPF 15 sunscreen theoretically prevents reddening 15 times longer -- about 5 hours. To maintain the SPF, sunscreen should be reapplied every two hours and right after swimming.

The Skin Cancer Foundation recommends SPF's of at least 15, which block 93 percent of UVB. While SPF's higher than 30 block only 4 percent more UVB, they may be advisable for sun-sensitive individuals, skin cancer patients, and people at high risk of developing skin cancer. While SPF is the universal measurement of UVB protection, no comparable standard exists for UVA. Scientists worldwide are working to develop a standardized testing and certification method to measure UVA protection.

Procedure

<u>Experiment setup</u>

1. Assemble a simple outdoor radiation measurement system, as in the following picture:



2. Prepare microscope slides with sunscreen; spread a very small amount thinly and evenly.

3. Repeat this procedure for up to three sunscreens with different SPF. You will also need a microscope slide without sunscreen for control.

4. You will first perform all the measurements with one sensor module and then with the other.

Sensor setup

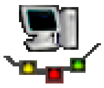
5. Connect the USB Module  to the USB port on your computer.

6. Connect the UVA Sensor 

to the USB Module using a Data Cable.

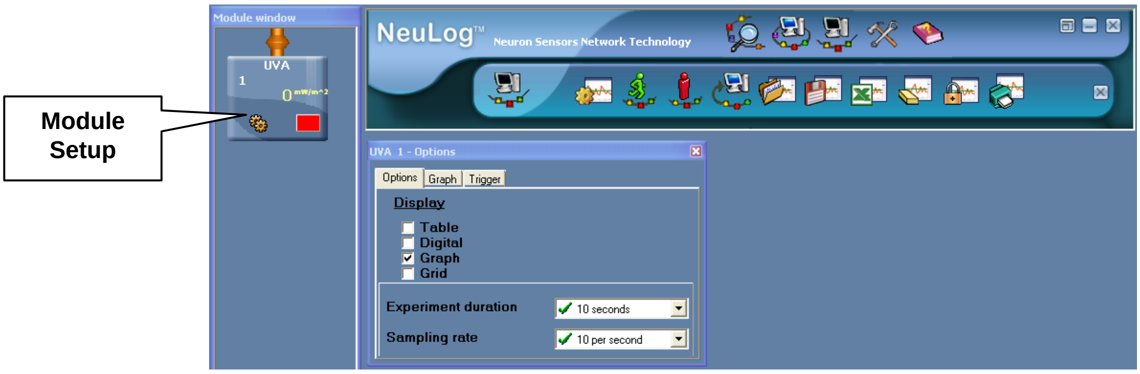
7. Run the NeuLogTM software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

8. You will work in the Off Line Mode of the NeuLog software to program the measurement conditions for the sensor to work disconnected from the computer (outside).

9. Click the 'Off Line Experiment'  icon in NeuLog's main icon bar.

10. Click the 'Module Setup' icon  in the sensors module box to open a dialogue box:
Set the experiment duration to 10 seconds
Set the sampling rate to 10 per second.

Your screen should look like the one below:



This procedure downloads the measurement conditions to the sensor and these are stored in its memory.

11. Close the module setup dialogue box.

12. Disconnect the UVA Sensor 

from the USB Module  and connect the UVB Sensor 

.

13. Set experiment duration and sampling rate as in steps 10, 11 and 12.

14. Connect the UVA Sensor 

to the Battery Unit  using a Data Cable.

Testing and measurements

The goal of this activity is to measure UVA and UVB radiation intensity through different sunscreen protectors. Remember that each sensor can store 5 measurements in the Off Line Mode.

15. Use a ring stand and a clamp to hold the UVA Sensor facing the Sun directly.

Caution:

Do not stare directly at the Sun while aiming the sensor.

Note:

Make sure that the sensor is facing the Sun by moving it and at the same time looking at its shadow; the smallest shadow indicates that the sensor is facing the Sun. If you have a monitor display unit, connect it to the sensor and vary the position and angle of the sensor to get the highest intensity reading. You will first measure UVA radiation directly from the Sun, without protection.

16. Begin the measurement by pressing the sensor's start/stop button.

The red LED should turn on.

Note:

You should see the sensor's red LED On during the measurement. When the LED turns Off, it means the experiment time is over. The measured data is stored in the sensor's memory.

17. Now put the control microscope slide (the slide without sunscreen) in front of the sensor. Begin the measurement by pressing the sensor's start/stop button.

18. Repeat this procedure with the microscope slides you prepared with sunscreen. Remember that each sensor can store up to five measurements in Off Line Mode. Since the first measurement is of the direct irradiation of the sun and the second of the control microscope slide you can test up to three sunscreens before downloading the data to the computer.

Note:

If you prefer, you can skip the first measurement of direct radiation. This one is to measure how much UV radiation is absorbed by the microscope slide.

19. Repeat steps 16 through 19 but this time, use the UVB Sensor.

20. When all measurements are completed, disconnect the last sensor used from the Battery Module.

21. Create a chain with the two sensors and connect them to the USB Module using the Data Cables.

22. Download the data to the computer as follows:

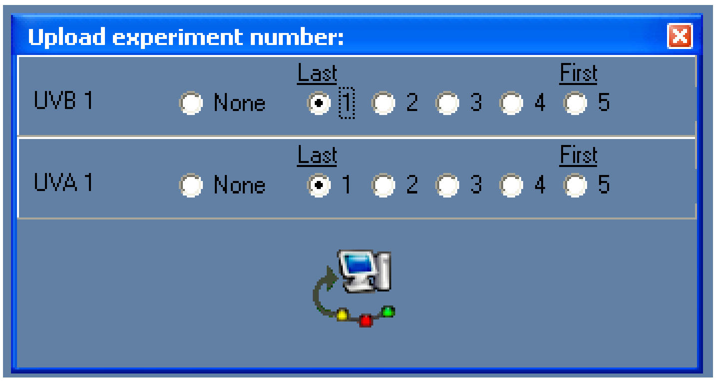
a. Click the ‘Search for Sensors’ icon ,

b. then click the ‘Off Line Experiment’ icon in NeuLog’s main icon bar.

23. Click on the ‘Load data from Sensors’ icon in the sub-icons bar to reveal a box with options:

All (last experiments)
UVB1
UVA1
Experiments

24. Select **Experiments**. This will open the window: "Upload experiment number". See following picture:

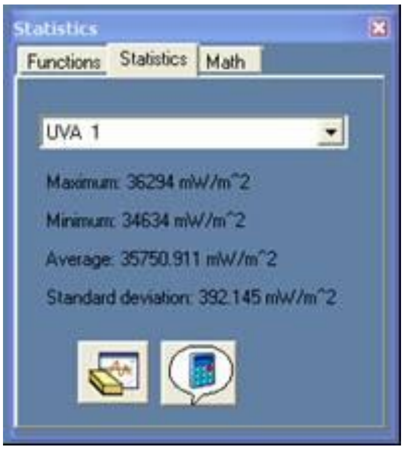


25. Upload the measurements to your computer. The measurements were saved in the sensor's memory:

26. Select the two radio buttons next to the number 5 (one for each sensor). In this way, you are selecting the first measurements to be uploaded (direct sun irradiation).

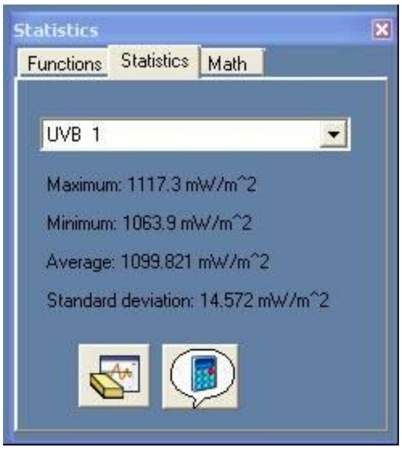
27. Click on the 'Load data from Sensors' icon  inside the "upload experiment number" window to load the selected experiment. Observe the graphs.

28. You can use the statistics tools in NeuLog software to get the average measurement. Click the 'Show Functions'  icon in the upper left corner of the graph window and select the statistics tab in the dialogue box that opens.



29. Click the 'Calculate Statistics' icon  and write down the average values in the table below.

30. Click the scroll down menu in the dialogue box to select the other sensor, UVB, and repeat steps 28 and 29.



31. Continue to upload the measured data from each measurement for both sensors, as described in step 26 and write down the results in the table.

Sensor	Direct Measurement	Microscope slide Control	Sunscreen 1	Sunscreen 2	Sunscreen 3
UVA (mW/m^2)					
UVB (mW/m^2)					

Summary Questions

1. Describe the UVA and UVB absorbance of the microscope slide (compare the measured value with the direct value measured).

2. Describe the UVA absorbance differences for the various sunscreens evaluated.

3. Describe the UVB absorbance differences for the various sunscreens evaluated.

4. Correlate the SPF factor with the degree of UVB absorbance of each sunscreen.

5. Analyze the UVA absorbance of each sunscreen and check if the printed information in each container refers to UVA. Check if it suits your results.

Challenge

1. Use a moisturizing cream and see if it has any UV protection.

UV Radiation and Clothes

Objectives

- To study the degree of protection clothes give from UV radiation.
- To understand if different fabrics give more or less protection from UV radiation.

Modules and Sensors

- Computer with NeuLog™ Software
- 3 Data Cables, 30cm: S98242 – 49ND
- USB Module: S98242 – 45ND 
- Light Sensor: S98242 - 20ND 
- UVA Radiation Sensor: S98242 – 36ND 

- UVB Radiation Sensor: S98242 - 37ND 

- Battery Module: S98242 – 44ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Base 6" x 4"
- Rod 500mm
- Boss head
- Clamp

Materials

- Different kinds of fabrics. For best results select different materials such as cotton, polyester, etc. Also different colors, dark and light.

Discussion

UVA (ultraviolet-A): long-wave solar rays of 320-400 nanometers (billionths of a meter). Although less likely than UVB to cause sunburn, UVA penetrates the skin more deeply, and is considered the chief culprit behind wrinkling, leathering, and other aspects of "photoaging" The latest studies show that UVA not only increases UVB's cancer-causing effects, but may directly cause some skin cancers, including melanomas.

UVB (ultraviolet-B): short-wave solar rays of 290-320 nanometers. More potent than UVA in producing sunburn, these rays are considered the main cause of basal and squamous cell carcinomas as well as a significant cause of melanoma.

Clothes and UV radiation

Clothes can protect your skin against the Sun's harmful ultraviolet (UV) rays, but not all clothing is created equal. The tightness of the weave, the weight, type of fiber, color and amount of skin covered all affect the amount of protection they provide.

What a UPF rating really means

UPF stands for Ultraviolet Protection Factor and indicates how much of the sun's UV radiation is absorbed. A fabric with a rating of 50 will allow only 1/50th of the Sun's UV rays to pass through. This means the fabric will reduce your skin's UV radiation exposure significantly, because only 2 percent of the UV rays will get through.

What's the difference between UPF and SPF?

SPF stands for Sun Protection Factor and is the rating you're familiar with for sunscreens and other sun-protective products. It measures the amount of time it takes for sun-exposed skin to redden, while UPF measures the amount of UV radiation that penetrates a fabric and reaches the skin.

Which fabrics are best?

As a rule, light-colored, lightweight and loosely-woven fabrics do not offer much protection from the sun. That white T-shirt you slip on at the beach when you feel your skin burning provides only moderate protection from sunburn, with an average ultraviolet protection factor (UPF) of 7. At the other end of the spectrum, a long-sleeved dark denim shirt offers an estimated UPF of 1,700 – which amounts to a complete sun block. In general, clothing made of tightly-woven fabric best protects skin from the Sun. The easiest way to test if a fabric can protect your skin is to hold it up to the light. If you can see through it, then UV radiation can penetrate it – and your skin.

The color of the fabric also plays a role. Darker-colored fabrics are more effective than lighter at blocking out the Sun. For instance, the UPF of a green cotton T-shirt is 10 versus 7 for white cotton, and a thicker fabric such as velvet in black, blue or dark green has an approximate UPF of 50.

Fabric content and the wearer's activity make a difference

What the clothing is made of matters. Fabrics such as unbleached cotton contain special pigments called lignins that act as UV absorbers. High-luster polyesters and even thin, satiny silk can be highly protective because they reflect radiation.

Even if the piece of clothing has a good UPF, what you do while wearing it can make a difference. If the fabric gets stretched, it will lose some of its protective ability, because the fabric becomes thinner and more transparent to light. And once it gets wet, it can lose up to 50 percent of its UPF. In Florida, it is a common practice for parents to put a white T-shirt on their children to protect them from the sun while swimming. But when that T-shirt gets wet, it provides a UPF of only 3.

Consider High-Tech Clothing

When selecting clothes for sun protection, consider fabrics that have been specially treated with chemical UV absorbers, known as colorless dyes. These prevent some penetration of both UVB and UVA rays. A number of manufacturers are now making special sun-protective clothing that has been treated with a chemical sun block during the manufacturing process. In addition, they use fabrics of the weave and colors that provide protection best. The garments are designed to cover as much of the skin as possible.

New standards for sun-protective fabrics in the US were unveiled in January, 2001. UPF is similar to SPF, in that they both measure protection.

Only clothes with a UPF of 15-50+ may be labeled as sun-protective. Clothes that are marketed with a sun-protective claim are usually UPF 50+. Also, like regular clothing, sun-protective clothing may lose its effectiveness if pulled too tight or stretched out, if it becomes damp or wet, or if it is washed and worn repeatedly.

Wash Sun protection into your clothes

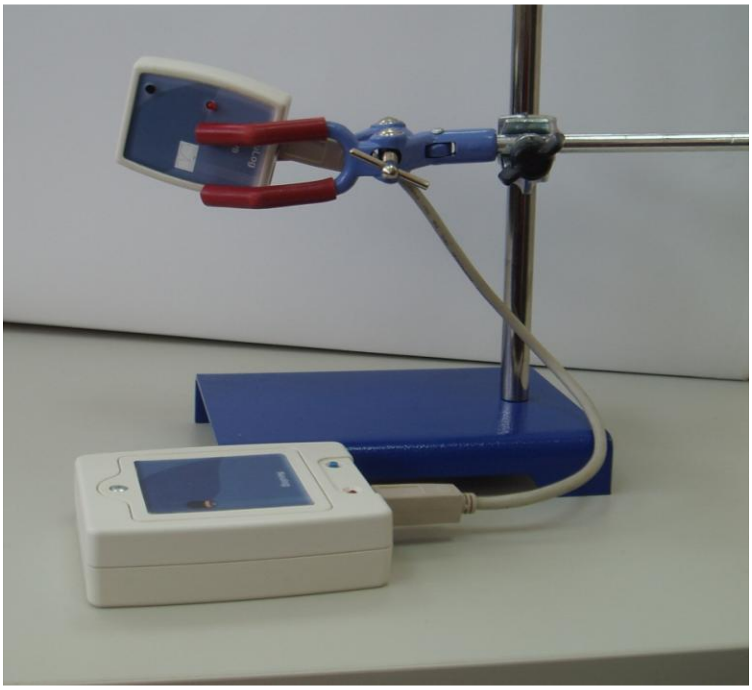
A laundry additive, Sun Guard, contains the sunscreen Tinosorb(R)FD. When added to a detergent, it increases the UPF of the clothing, and this protection lasts through 20 washings.

In this activity we will use the UVA and UVB sensors to evaluate the degree of protection that different fabrics give to our body.

Procedure

Experiment setup

1. Assemble a simple outdoor radiation measurement system, as in the following picture:
2. Perform measurements with one sensor module and then change it to repeat



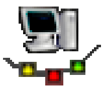
measurements with the other sensor module, i.e. start with the UVA Sensor, perform measurements and then switch to the UVB Sensor to the USB Module  with a Data Cable.

3. Connect the UVA Sensor 

to the USB Module using a Data Cable. The USB Module should be connected to your computer through the USB port.

4. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

5. You will work in the Off Line mode of the NeuLog software to program the measurement conditions for the sensor to work disconnected from the computer (outside).

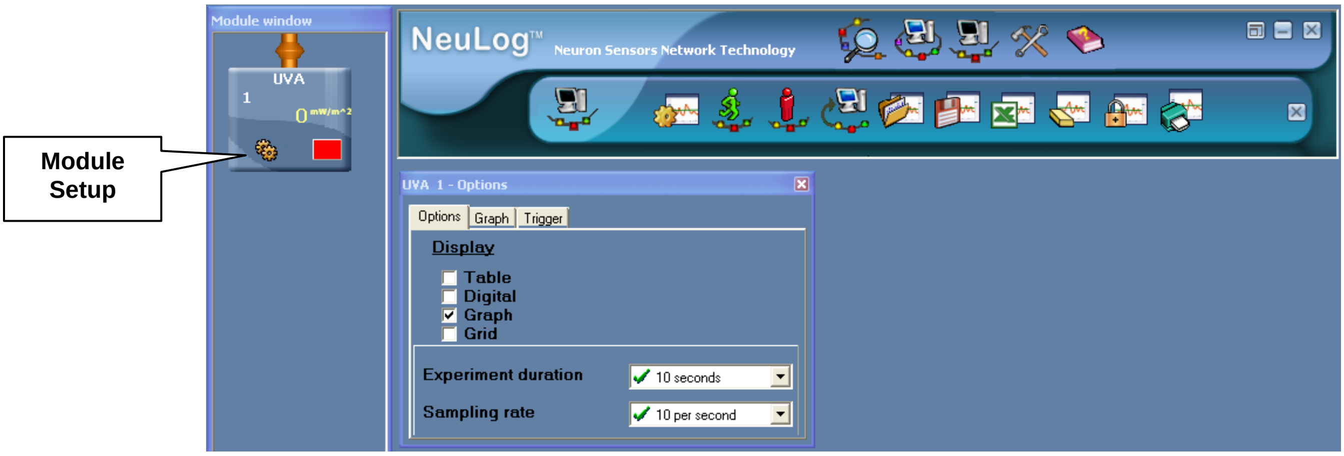
6. Click the 'Off Line Experiment'  icon in NeuLog's main icon bar.

7. Click the 'Module Setup' icon  in the sensors module box to open a dialogue box:

Set the experiment duration to 10 seconds

Set the sampling rate to 10 per second.

Your screen should look like the one below:



This procedure downloads the measurement conditions to the sensor and these are stored in its memory.

8. Close the Module Setup dialogue box.

9. Disconnect the UVA Sensor  from the USB Module  and connect the UVB Sensor .

10. Set experiment duration and sampling rate as in step 7. Then disconnect the sensor.

11. Connect the UVA Sensor  to the Battery Module 

Testing and measurements

The goal of this activity is to measure UVA and UVB radiation intensity through different fabrics. Remember that each sensor can store 5 measurements in off line mode.

12. Take your equipment outside.

13. Use a ring stand and a clamp to hold the UVA Sensor facing the Sun directly.

Caution:
Do not stare directly at the Sun while aiming the sensor.

Note:

Make sure that the sensor is facing the Sun by moving it and at the same time looking at its shadow; the smallest shadow indicates that the sensor is facing the Sun. If you have a monitor display unit, connect it to the sensor and vary the position and angle of the sensor to get the highest intensity reading. You will first measure UVA radiation directly from the Sun, without protection.

14. Begin the measurement by pressing the sensor's start/stop button.

The red LED should turn on.

Note:

You should see the sensor's red LED On during the measurement. When the LED turns Off, it means the experiment time is over. The measured data is stored in the sensor's memory.

15. Put the first fabric you want to evaluate in front of the sensor. Begin the measurement by pressing the sensor's start/stop button.

16. Repeat this procedure with up to four different fabrics. Remember that each sensor can store up to five measurements in off line mode. Since the first measurement is of the direct irradiation of the Sun you can test four fabrics before downloading the data to the computer.

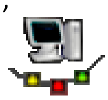
17. Repeat steps 13 thru 16 but this time, use the UVB Sensor.

18. When all measurements are completed, disconnect the last sensor used from the Battery Module.

19. Create a chain with the two sensors and connect them to the USB Module using the Data Cables.

20. Download the data to the computer as follows:

a. Click the 'Search for Sensors' icon ;

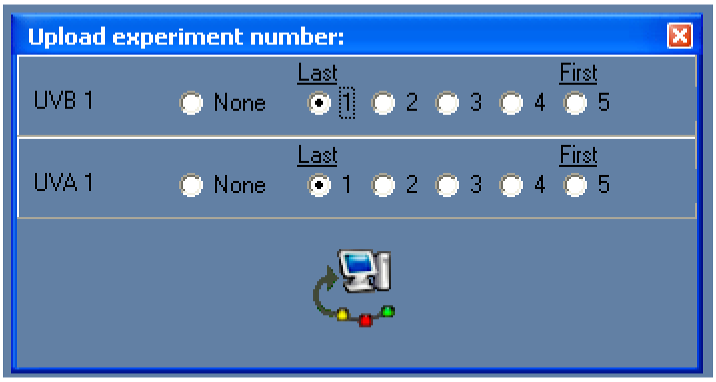
b. Then click the "Off Line Experiment"  icon in NeuLog's main icon bar.

21. Click on the ‘Load Data from Sensors’ icon  in the sub-icons bar to reveal a box with options:

All (last experiments)
UVB 1
UVA 1
Experiments

22. Select **Experiments**.

23. This will open the window: "Upload experiment number". See following picture:



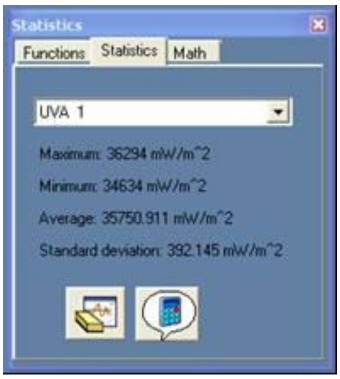
24. Upload the measurements to your computer. The measurements were saved in the sensor's memory.

25. Select the two radio buttons next to the number 5 (one for each sensor). In this way, you are selecting the first measurements to be uploaded (direct sun irradiation).

26. Click on the ‘Load Data from Sensors’ icon  inside the "upload experiment number" window to load the selected experiment. Observe the graphs.

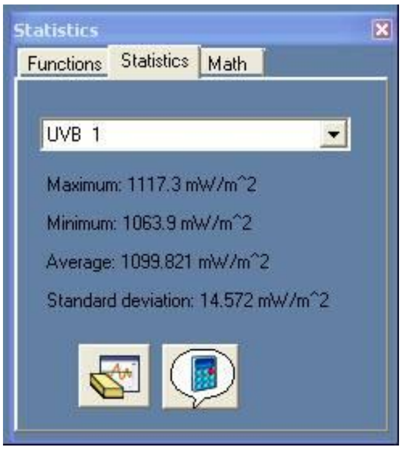
27. You can use the statistics tools in NeuLog software to get the average measurement.

28. Click the ‘Show Functions’  icon in the upper left corner of the graph window and select the statistics tab in the dialogue box that opens.



29. Click the 'Calculate Statistics' icon  and write down the average values in the table in the next page.

30. Click the scroll down menu in the dialogue box to select the other sensor, UVB, and repeat steps 26 and 27.



31. Continue to upload the measured data from each measurement for both sensors, as described in step 24 and write down the results in the table.

Sensor	**Direct Measurement**	**Fabric 1**	**Fabric 2**	**Fabric 3**	**Fabric 4**
UVA (mW/m²)					
UVB (mW/m²)					

Summary Questions

1. Calculate the percentage of radiation that passes through the fabric and the UPF values of UVA and UVB for the different fabrics evaluated. Register the values in the following table. The first two lines are sample results.

Sensor	**Direct Values**	**Fabric 1**	**%**	**UPF**	**Fabric 2**	**%**	**UPF**	**Fabric 3**	**%**	**UPF**
UVA (mW/m²)	34000	1700	5	34,000/ 1,700= **20**	12,000	35	**2.8**	1800	5.3	**19**
UVB (mW/m²)	1060	30	2.8	**35**	230	21	**4.6**	30	2.8	**35**
UVA (mW/m²)										
UVB (mW/m²)										

2. Describe the UVA absorbance differences for the various fabrics evaluated.

3. Describe the UVB absorbance differences for the various sunscreens evaluated.

4. To receive The Skin Cancer Foundation's Seal of Recommendation, sun-protective fabrics must have a minimum UPF of 30. We consider a UPF rating of 30-49 to offer very good protection, and 50+ excellent protection. Study your UPF results and conclude to which of the three categories each fabric belongs.

Challenge

1. Wet the fabric and see how this affects the protection.

2. Try to obtain "UV protective cloths" and evaluate their protection.

3. Try to wash some of the evaluated cloths with "wash sun protection" and evaluate the effect in their protection.

Respiration

Objective

- To determine the percentage of Oxygen in exhaled air.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Oxygen Sensor: S98242-8ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Materials

- A balloon

Discussion

Respiration is the process by which an organism provides its cells with oxygen for metabolism and removes carbon dioxide produced as a waste gas.

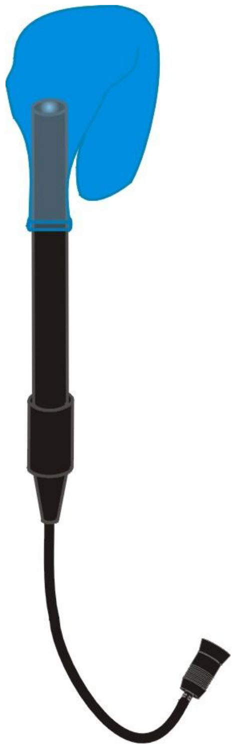
All living organisms respire. In fact, respiration is one of the basic characteristics of living organisms so that if an object does not respire, it is considered non-living such as a rock or a piece of wood.

Our cells would die if blood did not supply them with the oxygen it acquires in the lungs. An adult needs about 600 liters of oxygen a day and eliminates about 480 liters of CO_2. The Oxygen and Carbon Dioxide concentration in the lungs changes through the respiration process. Inhaled air contains 20.9% O_2 and 0.04 CO_2.

The CO_2 percentage in exhaled air is 4.5%. Through this activity, you will investigate the percentage of oxygen in the gas exhaled during respiration.

Procedure

Experiment setup



1. Remove the rubber protection from the Oxygen Sensor's cap. Unscrew the cap, fill half of it with the included liquid and screw it back.

2. **Sensor setup**

3. Connect the USB Module to the USB port on your computer.

4. Connect the Oxygen Sensor to the USB Module using the Data Cable.

Note:

You must wait at least 5 minutes after connecting the sensor to the USB Module before beginning calibration and measurements.

5. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

6. If this experiment was opened through the 'Load Activity' icon located in the 'Tools' sub icon bar , click the 'Load Configuration' icon .

7. This sets up the experiment parameters as follows:

   Experiment duration to 1 minute
   Sampling rate to 10 per second
   Sensor mode: % in air

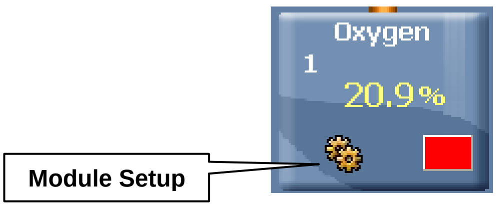
8. If you did not use the Load Configuration function , click the 'On Line Experiment' icon in the main icon bar.

9. Click on the 'Experiment Setup' icon . This opens a dialogue box:

   Set the Experiment duration to 1 minute
   Set the sampling rate to 10 per second on the drop down menu

10. Close the dialogue box.

11. Click the 'Sensor Setup' icon in the sensors module box on the left side of the screen to open a dialogue box. Verify the mode is '% in air'.



12. Whether you used the Load Configuration function or not, click on the 'Calibration' icon . This will calibrate the sensor to a value of 20.9%.

13. Close the module setup dialogue box.

Testing and measurements

14. Perform an initial measurement to calibrate the Oxygen Sensor by clicking on the 'Run Experiment'  icon. Observe the oxygen measurement on the screen. You are measuring oxygen in air; when the measurement stabilizes, press the 'Stop Experiment' icon .

15. Insert the sensor in the deflated balloon (observe the left illustration).

16. Click the 'Run Experiment' icon  again, and observe the percentage of oxygen measured inside the deflated balloon. Record the value.

17. Inflate the balloon and, keeping the air inside, insert the sensor (see the right illustration).

18. Click the 'Run Experiment' icon  to perform a new measurement of the percentage of oxygen inside the inflated balloon.

Summary Questions

1. What is the percentage of oxygen inside the deflated balloon?
2. How do you explain the result?
3. What is the percentage of oxygen inside the inflated balloon?
4. How do you explain this?

Challenge

1. Perform simple physical exercise and then inflate the balloon. Measure the percentage of oxygen to see if it has changed.

Aerobic Respiration

Objective

- To qualify and quantify carbon dioxide generated during the respiration process.
- To determine the acidity change during the process.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm – S98242-48ND
- USB Module - S98242-45ND 
- pH Sensor - S98242-24ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- A ring stand with utility clamp
- A 50 ml beaker or a cup
- NaOH 0.01 M
- A straw
- A 10 ml burette

Materials

- NaOH 0.01 M

Discussion

Respiration is a process that takes place in living beings. Chemical energy is created during this process. Through a series of chemical reactions, carbon dioxide and water are produced.

Aerobic respiration is comprised of a series of reactions through which the organic substances are reduced to CO_2 and H_2O in the presence of molecular oxygen. The process takes place in the cytoplasm and mitochondria through respiratory enzymes; it is called cellular or internal respiration. This process supplies energy for all the chemical activities of the cell.

If glucose is used as the base of respiration, the following reaction is obtained:

$$C_6H_{12}O_6 + 6O_2 \Rightarrow 6CO_2 + 6H_2O + Energy$$

In this experiment the carbon dioxide generated during the respiration process will be measured to determine the quantity by using titration with NaOH.

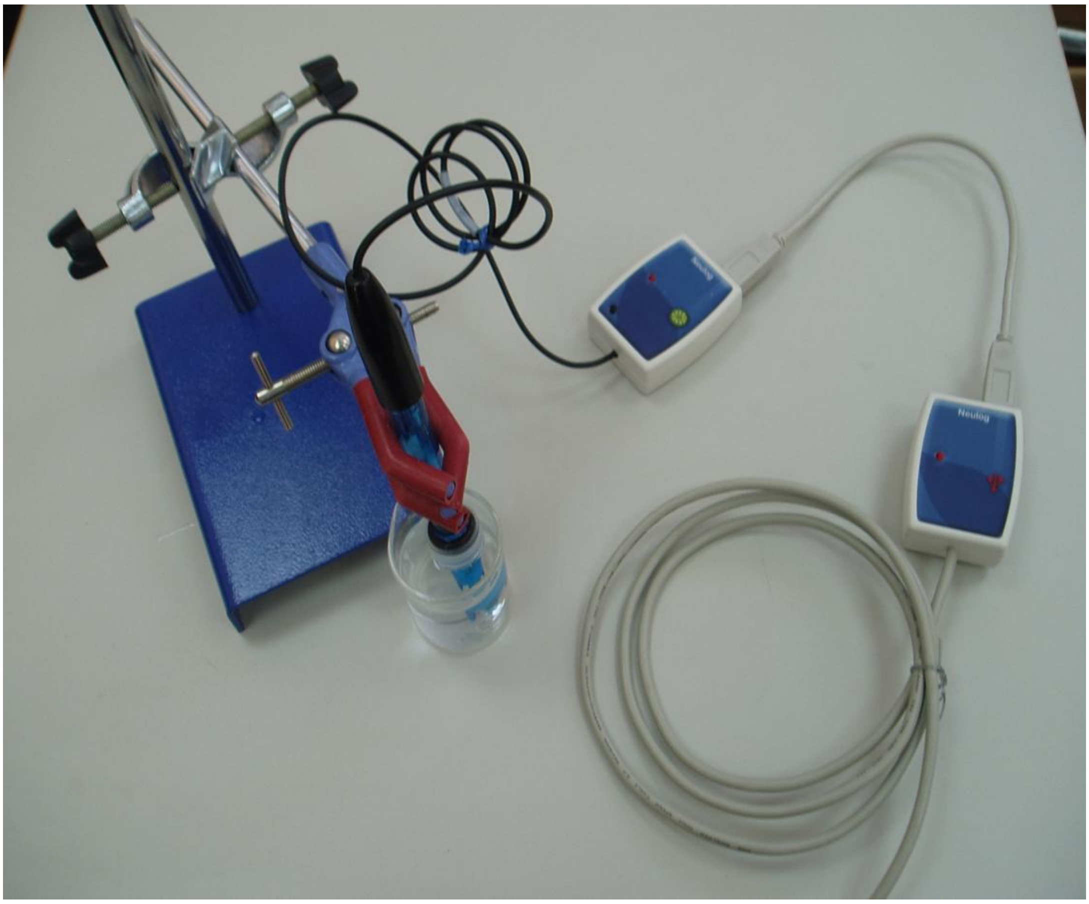
Procedure

Experiment setup

Warning: Please note that the bottom part of the pH sensor consists of a fragile crystal sphere. Even though it has a plastic protection, be careful not to break it.

Note: For the third part, you will need sodium hydroxide 0.01M. Since the original solution is 1M, take 1 ml from it and add 99 ml water.

1. Assemble the first part of the experiment (qualitative part). Prepare the sample: Pour 20 ml of water into a 50 ml beaker.



Sensor setup

2. Connect the USB Module  to the USB port on your computer.

3. Connect the pH Sensor  to the USB Module.

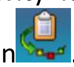
4. Unscrew the cap of the storage solution and take out the sensor. Raise the cap to the top of the sensor. Put the solution aside.

5. Introduce the pH Sensor into the water and stir carefully to remove the soaking solution.

6. Put the sensor in the tube holder on the stand. Work with the pH Sensor with care its tip is fragile.

7. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

8. Observe the sensor's module box on the left side of the screen. Allow the pH value to stabilize.

9. If this experiment was opened through the 'Load Activity' icon  located in the Tools sub icon bar , click on the 'Load Configuration' icon .

10. This sets up the experiment parameters as follows:

Experiment duration to 3 minutes
Sampling rate to 10 per second

11. If you did not use the Load Configuration function , click the 'On Line Experiment' icon  in the main icon bar.

12. Click on the 'Experiment Setup' icon . This opens a dialogue box:

Set the Experiment duration to 3 minutes
Set the sampling rate to 10 per second on the drop down menu.

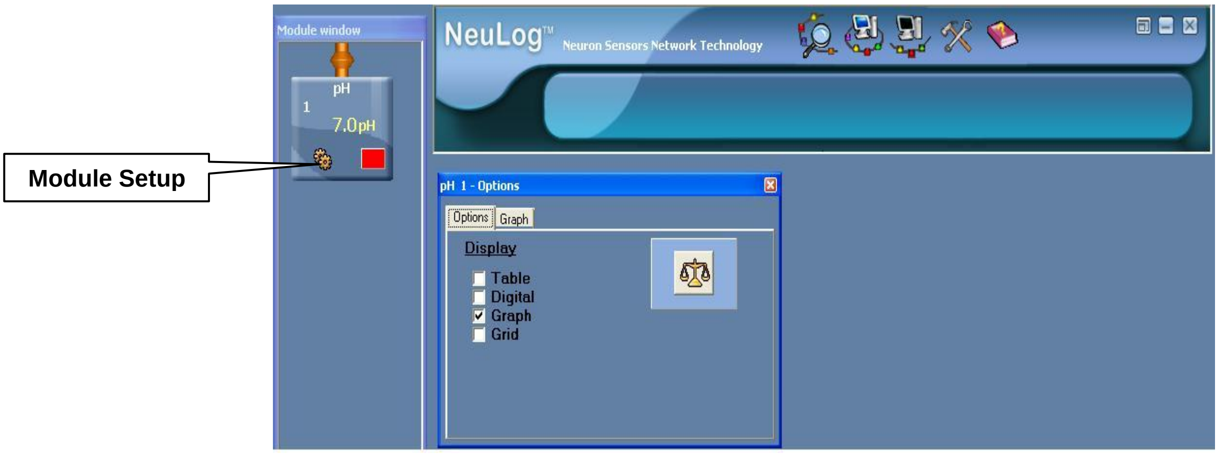
13. Close the dialogue box.

14. Insert the pH electrode into the beaker.

15. Whether you used the Load Configuration function or not, click on the 'Module Setup' icon  in the sensor module box to open a dialogue box.

16. Click on the 'Calibration' icon  to set the value at 7. (For a more accurate calibration, a buffer solution pH = 7 should be used).

17. Note that the measured pH appears in the sensor's module box.



18. Close the module setup dialogue box.

Testing and measurements

Qualitative test:

19. When the reading has stabilized, click on the 'Run Experiment' icon  to start the measurement.

20. Without stopping the measurement, blow bubbles into your sample by exhaling through a straw for a minute (try to breathe normally).

21. Observe the changes of the pH.

22. Allow the pH to stabilize.

23. Save the data.

Quantitative part:

24. For the titration you can start a new measurement or follow the pH reading in the sensor's module box. Start the titration in the solution used for the qualitative test.

- **a.** Fill the 10 ml burette with sodium hydroxide at 0.01M.
- **b.** Allow the sodium hydroxide to fall, drop by drop, into the solution in the beaker, stirring gently and constantly.
- **c.** Use the pH sensor to verify that the solution is neutralized.

25. Write down how many milliliters of sodium hydroxide were used in the titration.

Transform the amount of of sodium hydroxide milliliters into micromoles of CO_2/min. Each milliliter of NaOH at 0.01M is equivalent to approximately 5 micromoles of CO_2. Stoichiometric relation of the equivalence between milliliters of NaOH and micromoles of CO_2:

a. $2NaOH(aq) + CO_2 \rightarrow Na_2CO_3 + H_2O$

b. The chemical equation indicates a relation 2 (NaOH) a 1 (CO_2).

c. The concentration of NaOH is 0.01M in 1000 ml (1 liter of solution, therefore 1 ml of the solution is equivalent to $0.01 \cdot 10^{-3}$ moles.

Concentration of NaOH 0.01M → 1000 ml of solution
X → 1 ml of solution

$$X = 0.01 \cdot 10^{-3} \text{M in 1 ml of solution}$$

d. 2 molecules of NaOH are equal to 1 of CO_2 therefore:

2 molecules of NaOH → 1 molecule of CO_2
$0.01 \cdot 10^{-3}$ moles → X

$$X = 0.005 \cdot 10^{-3} \text{ or } 5\ 1 \text{ micromoles of } CO_2$$

Summary Questions

1. Repeat the experiment after running continually for 10 minutes.

2. Analyze and conclude.

Challenge

1. Develop and explain the chemical equation of aerobic respiration.

2. What is the difference between aerobic and anaerobic respiration?

3. What chemical compound was created by blowing bubbles into the water? Write the chemical equation.

4. What was the pH of the sample after exhaling continually?

5. Develop the chemical reaction after the neutralization.

Diffusion in Biology

Objective

- To measure the ionic concentration of different salt solutions by monitoring their conductivity.
- To study the effect of concentration gradients on the rate of diffusion through a membrane.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Conductivity Sensor: S98242-5ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Ring stand
- Utility clamp
- Syringe
- Scissors

Materials

- 1%, 5%, and 10% salt water
- 4 disposable cups
- Dialysis tubing (2.5 cm x 10 cm)
- Dental floss

Discussion

Diffusion is one process by which matter (ions or molecules), heat or momentum moves freely in liquids or gases from one place to another to fill the space available. The direction of the motion is from the high concentration to less concentration.

Understanding diffusion through membranes is a major process in biology in which cells acquire food and exchange waste products. Diffusion is a process that accounts for the movement of many small molecules across a cell membrane and it can be either a passive process that does not require any additional energy or active.

The rate of diffusion of particles might be affected by the following parameters:

- The concentration gradient
- The temperature
- The size of the particles: large particles move slower than small particles.
- Other different, neighboring particles that can affect either by blocking or enhancing the diffusion rate.

In this experiment you will use a dialysis tube to simulate the membrane in a cell. You will use three different concentrations of a salt solution, place each in a dialysis tube and then place the tube in a cup with water.

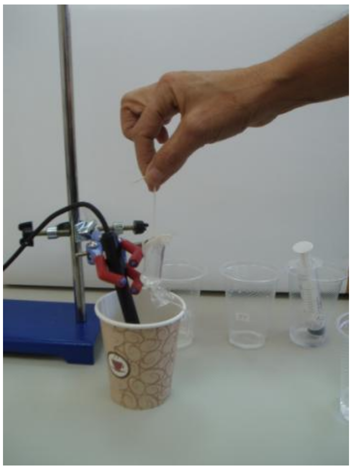
The salt, sodium chloride, produce ions when it dissolves in water. The salt ion diffuses through the porosity of the tube into the water in the cup. Since ions are electrically charged, water solutions containing ions conduct electricity. A conductivity sensor will be used to monitor the conductivity of the water in the cup, as a function of time and the salt concentration. From your measurement you could obtain the rate of diffusion.

Procedure

Experiment setup

In order to test the effect of different concentration gradients on the rate of diffusion, you will prepare three solutions of different salt concentrations (1%, 5% and 10%) in water. You will then pour one salt solution in a dialysis tube and allow it to diffuse into the surrounding water.

The conductivity of the water in the cup will increase because of the diffusion of salt. Do the same with the other two salt solutions with different concentration.



What do you think will happen in this experiment?

1. Wet a piece of dialysis tube by pouring a few drops of water on it. Take a short piece of dental floss. Tie one end of the tube with it about 1 cm from the end.

2. Prepare the salt solutions:

    a. For the 10% solution, pour 15 ml of water into a cup and add about half a tea spoon of salt; mix well.
    b. For the 5% solution, pour 5 ml of the 10% solution into a second cup and add 5 ml of water.
    c. For the 1% solution, pour 1 ml of the 10% solution into a third cup and add 9 ml of water.

3. Open the dialysis tubing with your fingers on the untied side. Use the syringe to fill it with 1% salt solution;

4. Tie firmly the other side of the dialysis tubing with a new piece of dental floss without letting any air into the dialysis tubing.

5. Wash the outside of the tubing with water to rinse any salt water adhering to it.

Sensor setup

6. Connect the USB Module to the USB port on your computer.

7. Connect the Conductivity Sensor to the USB Module using the Data Cable.

8. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon.

9. If this experiment was opened through the 'Load Activity' icon located in the 'Tools' sub icon bar, click on the Load Configuration icon.

10. This sets up the experiment parameters as follows:
    Experiment duration to 5 minutes
    Sampling rate to 5 per second
    Sensor's units: **µs/cm**.

11. If you did not use the Load Configuration function, click the 'On Line Experiment' icon in the main icon bar.

12. Click on the 'Experiment Setup' icon.

2. This opens a dialogue box:
   Set the Experiment Duration to 5 minutes
   Set the sampling rate to 5 per second on the drop down menu.

3. Close the dialogue box.

4. Click on the 'Module Setup' icon to open a dialogue box.

   Set the sensor's units by selecting the radio button next to **µs/cm**.

5. Close the 'Module Setup' dialogue box.

Testing and measurements

6. Pour 100 ml tap water into a cup.

7. Insert the Conductivity Sensor into the water cup as shown in the picture.

8. Introduce the dialysis tubing into the same cup of water. Make sure the tubing is completely covered by the water.

   Note: Keep the Conductivity Sensor and dialysis tubing at the same distance apart from each other during experiments.

9. Stir the solution for 30 seconds and then click the 'Run Activity' icon to start the measurement. Stir the solution slowly and continuously throughout the measurement. Save the data.

10. Use the 'Show Cursors' icon to determine the rate of diffusion. Move the two cursors so that you put the first when the increase begins and the second at the end of the measurement.

11. Click the 'Show Functions' icon and then click the functions tab. Select the 'Linear Fit Between Cursors' option from the second drop down menu.

12. Click the 'Calculate Function' icon. Observe the formula with the best fit line. The slope of the conductivity vs. time graph is the rate of diffusion.

Salt concentration (%)	Rate of diffusion (mg/L/s)
1	
5	
10	

13. To reuse the dialysis tubing, carefully cut the dental floss to open one of its sides. If you accidentally make a cut in the tubing, replace it with a new one.

14. Throw all the liquid out of the tubing, squeezing out the excess.

15. Repeat the experiment, using this time the 5% solution.

16. Repeat again the experiment, using the 10% solution.

Summary Questions

1. Observe the results of the different rates as a function of concentration. What could you conclude?

2. What other parameters could affect the diffusion of salt? How was your prediction compared to the experimental results?

3. How many times will the diffusion rate of the 10% and 5% solutions be higher than that of the 1% solution?

Challenge

1. Make a graph of rate of diffusion vs. salt concentration. Observe the graph and predict the rate of diffusion for a 7% salt solution. Could you make a prediction for a 15% solution?

2. What other parameters could affect the diffusion of salt?

Enzyme Activity

Objective

- To measure the change in pressure due to enzyme activity.
- Determine the initial rate of enzyme activity at different temperatures and concentrations.

Modules and Sensors

- Computer with NeuLog™ Software
- 2 Data Cables, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Pressure Sensor: S98242-13ND 
- Temperature Sensor: S98242-31ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Test tube 18 x 150 mm
- Ring stand
- Utility clamp
- Syringe
- Perforated cap, (1-hole rubber stopper)

Materials

- Yeast suspension
- H_2O_2 3%.
- Disposable cup
- Warm water
- Cool water

Discussion

Catalase is a common enzyme found in nearly all living organisms exposed to oxygen. Its function is to catalyze the decomposition of hydrogen peroxide to water and oxygen.

The greatest majority of these biochemical reactions do not take place spontaneously. Enzymes act as catalysts, and catalysis is defined as the acceleration of a chemical reaction. The catalysts itself does not undergo any chemical change during the process.

Enzymes are responsible almost for all the chemical reactions in living organisms; the reactions take place faster while the enzymes can be used over and over again. The important parameters that affect enzyme activity are temperature and pH. Most of the enzyme – biochemical reactions will function best only within a narrow range of pH and temperature values.

Hydrogen peroxide is a harmful by-product of many normal metabolic processes. To prevent damage, it must be quickly converted into other, less dangerous substances. Catalase is frequently used by cells to rapidly catalyze the decomposition of hydrogen peroxide into oxygen and water molecules, as follows:

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

The enzyme activity rate can be studied by following the pressure change due to the increase in the production of O_2; when the reaction begins the pressure is equal to the atmospheric pressure.

As the reaction evolves oxygen starts to accumulate linearly at a constant rate at the initial stage of the reaction and the slope of the curve at point is called *initial rate*. The rate of O_2 production starts to decrease when the concentration of peroxide decreases..

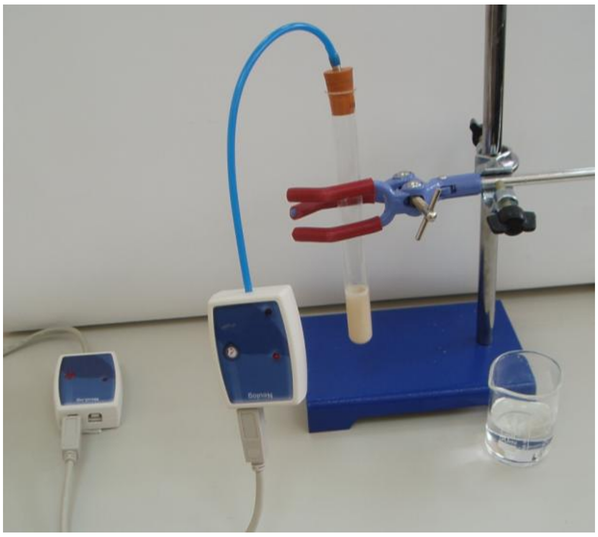
In this experiment, you will measure the rate of enzyme activity through different enzyme concentrations and temperatures.

Procedure

Experiment setup

1. Add 3 ml of water and 3 ml of 3% H_2O_2 to the test tube.

2. Prepare the enzyme suspension; dissolve half a teaspoon of yeast into 20 ml of water. Gently swirl the yeast suspension to mix what settles at the bottom.



Sensor setup

1. Connect the USB Module to the USB port on your computer.

2. Connect the Pressure and the Temperature Sensors to the USB Module using the Data Cables.

3. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

4. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar, click on the 'Load Configuration' icon .

5. This sets up the experiment parameters as follows:

Experiment duration to 5 minutes
Sampling rate to 60 per minute

6. If you did not use the Load Configuration function, click the 'On Line Experiment' icon in the main icon bar.

7. Click on the 'Experiment Setup' icon . This opens a dialogue box:

Set the Experiment duration to 5 minutes
Set the sampling rate to 60 per minute on the drop down menu.

8. Close the dialogue box.

9. Note that the measured pressure appears in the sensor's module box.

Testing and Measurements

10. Use a clean syringe to add three drops of the enzyme suspension to the test tube. Do not let the enzyme fall against the sides of the test tube.

11. Put the perforated cap on the test tube and insert the pressure sensor's inlet connector into the perforated cap, as shown in the picture. Shake the tube to mix its contents.

12. Click the 'Run Experiment' icon to start the measurement.

13. Observe the pressure readings displayed in the meter. (If the pressure reaches 1.3 atmospheres or more, then the pressure inside the test tube is too great. Remove the cap from the tube so that it does not jump by itself and click on the 'Stop Experiment' icon.)

14. At the end of the experiment, remove the cap, throw away the contents of the test tube and rinse it with water. Save the data.

15. Find the initial rate of enzyme activity: click the 'Show Cursors" icon and move the two cursors, one to the beginning of the experiment when the increase starts to be linear and the second before the rate starts to slow down.

16. Click the 'Show Functions' icon and then click the functions tabulator. Select the "Linear Fit between cursors" from the second drop down menu and click the 'Calculate Statistic' icon; observe the formula with the best fit line. The slope of the graph is the initial rate of enzyme activity. Record the result in your table.

17. Add 3 ml of water and 3 ml of 3% H_2O_2 to the test tube. Repeat the experiment but this time, add 5 drops of the enzyme suspension to the test tube.

18. Add 3 ml of water and 3 ml of 3% H_2O_2 to the test tube. Repeat the experiment adding this time 7 drops of enzyme suspension to the test tube.

Table 1:

Number of enzyme drops	Initial rate of enzyme activity
3	
5	
7	

Test the effect of temperature:

19. Read the room temperature on the temperature sensor's module box. For the first point, use the result you obtained when you added 3 drops of enzyme suspension recorded in table 1 and copy it to table 2.

20. Pour water at a temperature range of 30-35 ^{o}C into a disposable cup. Keep the temperature in this range throughout this measurement.

21. Add 3 ml of water and 3 ml of 3% H_2O_2 to the test tube. Introduce the test tube into the warm water, insert the temperature sensor in the test tube and wait till the mixture reaches a temperature in the range of 30-35 ^{o}C. Record the temperature in your data table 2.

22. Use the syringe to add 3 drops of enzyme suspension to the test tube. Repeat steps 6-10. Discard the contents of the test tube and rinse it with water.

23. Pour water at a temperature range of 50-55 ^{o}C into a disposable cup. Keep the temperature in this range throughout this measurement.

24. Add 3 ml of water and 3 ml of 3% H_2O_2 to the test tube. Introduce the test tube in the warm water, insert the temperature sensor in the test tube and wait till the mixture reaches a temperature in the range of 50-55 ^oC. Record the temperature in your data table 2.

25. Use the syringe to add 3 drops of enzyme suspension to the test tube. Repeat steps 6-10. Discard the contents of the test tube and rinse it with water.

Table 2:

Temperature range	Initial rate of enzyme activity
Room Temp.	

Summary Questions

1. Did changing the concentration of the enzyme affect the rate of the decomposition reaction? In what way? Explain.

2. Plot a graph of the reaction rate as a function of the enzyme concentration. From the slop of the graph predict the rate value for a different enzyme concentration such as 10 drops

3. Describe how the different temperatures tested affected the rate of enzyme activity in the reaction.

Challenge

1. Carry out the experiment at a cold temperature, in the range of 10-5 ^oC. How does it affect the enzyme activity?

2. What do you think will happen to the enzyme activity at very high temperatures?

Enzymatic Activity of Catalase

Objective

- To determine the catalytic activity of the catalase enzyme.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm – S98242-48ND
- USB Module - S98242-45ND
- Oxygen Sensor - S98242-8ND

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- 50 ml Erlenmeyer

Materials

- H_2O_2 3%, oxygen peroxide
- A potato
- Yeast

Discussion

Catalase is a common enzyme found in nearly all living organisms which are exposed to oxygen. Its function is to catalyze the decomposition of hydrogen peroxide to water and oxygen.

Catalase is used in the food industry for removing hydrogen peroxide from milk prior to cheese production. Another use is in food wrappers, where it prevents food from oxidizing. Catalase is also used in the textile industry, removing hydrogen peroxide from fabrics to make sure the material is peroxide-free.

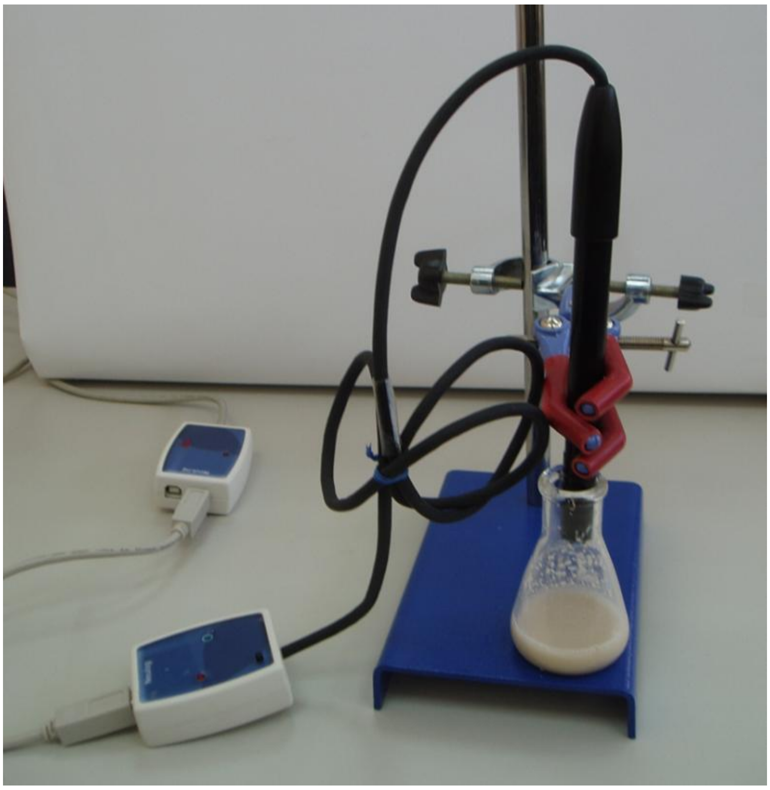
Hydrogen peroxide is a harmful by-product of many normal metabolic processes. To prevent damage, it must be quickly converted into other, less dangerous substances. To this end, catalase is frequently used by cells to rapidly catalyze the decomposition of hydrogen peroxide into less reactive gaseous oxygen and water molecules. In the human body, hydrogen peroxide is toxic; it accumulates in the cells as a result of metabolic activity.

Procedure

Experiment setup

1. Cut the potato into small pieces and place them in the Erlenmeyer.

2. Remove the rubber protection from the Oxygen Sensor's cap. Unscrew the cap, fill half of it with the included liquid and replace the cap.



Sensor setup

3. Connect the USB Module to the USB port on your computer.

4. Connect the Oxygen Sensor to the USB Module.

> **Note:**
>
> **You must wait at least 5 minutes after connecting the sensor to the USB Module before beginning calibration and measurements.**

5. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

6. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar, click on the 'Load Configuration' icon.

7. This sets up the experiment parameters as follows:

Experiment duration to 5 minutes
Sampling rate to 5 per second
Sensor Mode: % in air

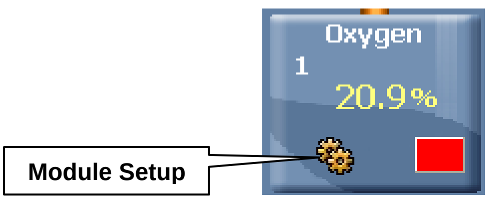
8. If you did not use the Load Configuration function, Click the 'On Line Experiment' icon in the main icon bar.

9. Click on the Experiment set up icon in the On line sub icon bar. This opens a dialogue box:

Set the Experiment duration to 5 minutes
Set the sampling rate to 5 per second on the drop down menu

10. Close the dialogue box.

11. Click on the 'Module Setup' icon in the sensor's module box to open a dialogue box.



12. Click the radio button next to % in air.

13. Whether you used the Load Configuration function or not, you should click on the 'Calibration' icon. This will calibrate the sensor to a value of 20.9%.

14. Close the module setup dialogue box.

Testing and measurements

15. Insert the oxygen sensor into the Erlenmeyer and hold it above the sample.

16. Click on the 'Run Experiment' icon  to start the measurement.

17. When the oxygen measurement stabilizes (actually, you are measuring the oxygen content before the reaction), take out the sensor momentarily, add 1 ml of oxygen peroxide to the potato pieces and immediately return the sensor to its place on top of the sample. Do not touch the potatoes with the sensor.

18. Follow the oxygen changes on the computer screen. Save the data.

19. Wash the Erlenmeyer and repeat the procedure, steps 13-16, this time with yeast in 5 ml water.

Summary Questions

1. Observe the graphs and explain the behavior of the oxygen.

2. What does the release of oxygen indicate?

3. Compare the results of the two measurements and state which sample produced more oxygen. Explain.

4. Determine which chemical reaction took place in the experiments.

5. How could you demonstrate, without using a sensor, that the liberated gas is oxygen?

6. Investigate what is the role of paroxysms in the chemical reaction with hydrogen peroxide.

7. Investigate the importance of catalase for the human body.

8. How could you explain the concept of an enzyme using everyday ideas?

Challenge

1. Repeat the experiments with other samples of vegetal tissue such as celery or animal tissue such as kidney. Compare the results.

2. Quantify the amount of liberated oxygen when you change variables like the quantity of the tissue used, the size of the pieces, the quantity of oxygen peroxide used, etc.

Osmotic Pressure

Objective

- To investigate osmotic pressure.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Pressure Sensor: S98242-13ND 

- Battery Module: S98242-44ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Osmotic Pressure Kit - S02167

Discussion

Osmosis is the diffusion (or spreading) of water molecules across a semi-permeable membrane from a region of high concentration to a region of low concentration until a state of dynamic equilibrium is reached.

Net movement of solvent is from the less-concentrated (hypotonic) to the more-concentrated (hypertonic) solution, which tends to reduce the difference in concentrations. This effect can be countered by increasing the pressure of the hypertonic solution, with respect to the hypotonic. The osmotic pressure is defined to be the pressure required to maintain equilibrium, with no net movement of solvent. Osmotic pressure is a colligative property, meaning that the osmotic pressure depends on the molar concentration of the solute but not on its identity.

Osmosis is important in biological systems, as many biological membranes are semi permeable. In general, these membranes are impermeable to organic solutes with large molecules, such as polysaccharides, while permeable to water and small, uncharged solutes.

Permeability may depend on solubility properties, charge, or chemistry, as well as solute size. Water molecules travel through the plasma cell wall, tonoplast (vacuole) or protoplast in two ways, either by diffusing across the phospholipids' bilayer directly, or via aquaporins (small transmembrane proteins similar to those in facilitated diffusion and in creating ion channels).

Osmosis provides the primary means by which water is transported into and out of cells. The turgor pressure of a cell is largely maintained by osmosis, across the cell membrane, between the cell interior and its relatively hypotonic environment.

In this activity we will use a pressure sensor to measure dependence of the pressure developed as a result of the entrance of water to a container with high concentration of solution through a semi permeable membrane on time.

Procedure

<u>Experiment setup</u>

Assemble the osmosis device from the kit as follows:

1. Take the plastic container from the Osmosis kit and add tap water up to the height of about 8 cm.

2. Carefully introduce the pipette in the rubber hole of the Osmosis device.

3. Close the other small opening with the rubber stopper.

4. Soak one membrane in the water for one minute.

5. Unscrew the lid of the Osmosis device, cover the opening with the membrane and screw the lid back tightly.

6. Dip the device in the water so that it is completely covered and gently blow through the tube to test that the device is airtight.

7. If bubbles appear, remove the device from the water and readjust or change the membrane.

8. Take out the Osmosis device from the container.

9. Prepare 100ml of 50% sugar solution as follows: pour 100 ml of water to the plastic cup and add ten teaspoons of sugar (sugar dissolves faster in warm water).

10. Add 10 drops of the dye solution and stir until all the sugar dissolves.

11. Remove the rubber stopper form the device and use the syringe to fill it completely with the sugar solution.

12. Firmly insert the stopper and observe the level of the liquid in the tube.

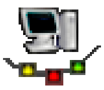
<u>Sensor setup</u>

13. Connect the USB Module  to the USB port on your computer.

14. Connect the Pressure Sensor  to the USB Module using a Data Cable.

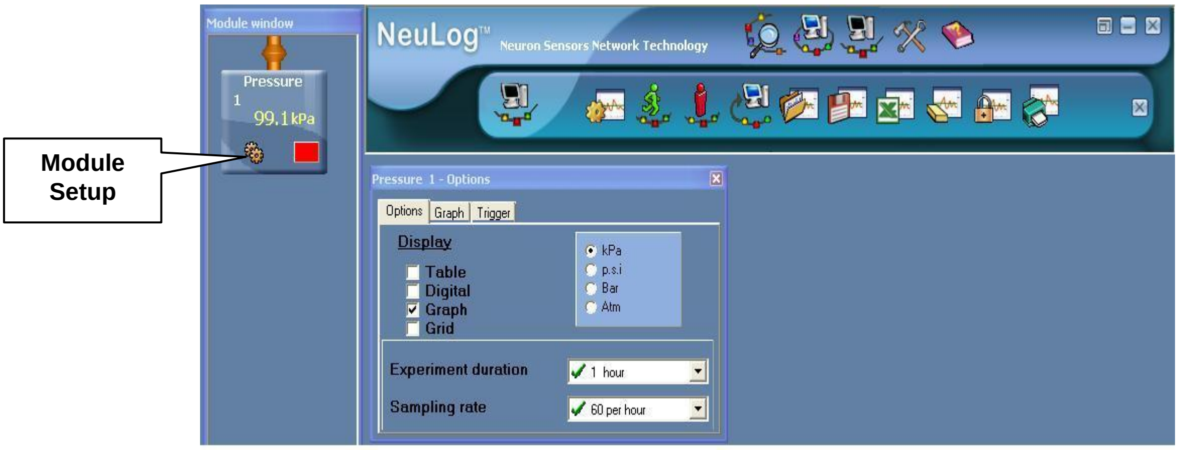
15. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the search for 'Sensors' icon .

16. We will work in the off line mode of the NeuLog software to program the measurement conditions for the sensor to work disconnected from the computer.

17. Click the 'Off Line Experiment'  icon in NeuLog's main icon bar.

18. Click the 'Setup' icon  on the sensors module box to open a dialogue box.
    Set the sensor's units, selecting the radio button next to kPa (if not already selected).
    Set the experiment duration to 1 hour
    Set the sampling rate to 60 per hour.

Your screen should look like the one below:

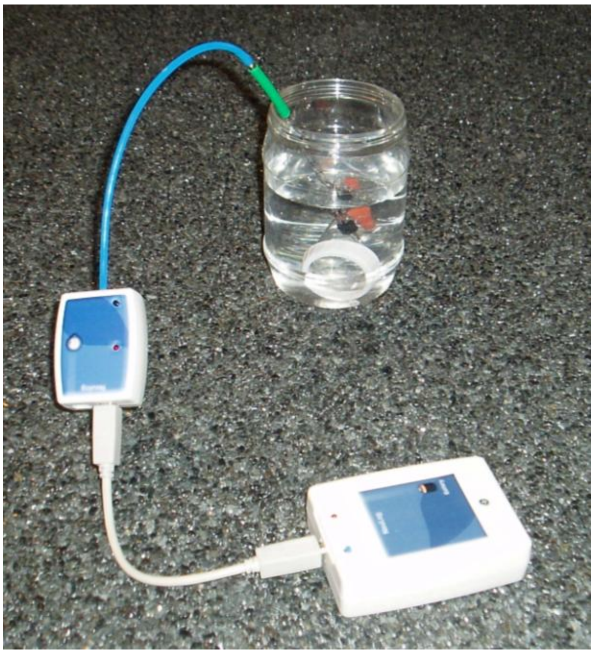


This procedure downloads the measurement conditions to the sensor and these are stored in its memory.

19. Close the module setup dialogue box.

20. Disconnect the Pressure Sensor  from the USB Module  and connect its blue tube to the green tube in the pipette of the Osmosis device.

21. Connect the sensor to the Battery Module . Be careful not to press the sensor's Start/Stop button until you are ready to begin the measurement. Observe the picture below.



Testing and measurements

22. Begin the measurement by pressing the sensor's Start/stop button. The red LED should blink. Wait one minute to verify that the LED blinks again, which indicates the sensor is measuring.

23. The measurement will be saved automatically in the sensor's memory.

24. After one hour, check that the LED is not blinking anymore and disconnect the sensor from the battery unit .

25. Connect the sensor to the USB Module to download the data to the computer as follows: click the search for 'Sensors' icon , then click the 'Off Line Experiment' icon in NeuLog's main icon bar. Click on the Load data from 'Sensors' icon in the sub-icons bar to reveal a box with options. Select pressure. Notice the box with the comment "upload completed".

26. Observe the graph of the measurement.

27. In order to view the graph better, click the 'Zoom Fit' icon .

28. Click the 'Show Functions' icon . The functions dialogue box will open. Click on the 'Calculate Function' icon . Observe the linear fit in the graph. Also, the straight line equation in the dialogue box. Conclude if the increasing pressure behaves as a straight line.

Challenge

1. Perform the experiment with different sugar concentrations.

2. Perform the experiment for longer periods of time.

Solar Oven

Objective

- To compare and quantify temperature changes with the use of a solar oven.

Modules and Sensors

- Computer with NeuLog™ Software
- 2 Data Cables, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Battery Module: S98242-44ND 
- 2 Temperature Sensors: S98242-31ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Materials

- A carton box
- Black color or black plastic bag
- Aluminum foil

Discussion

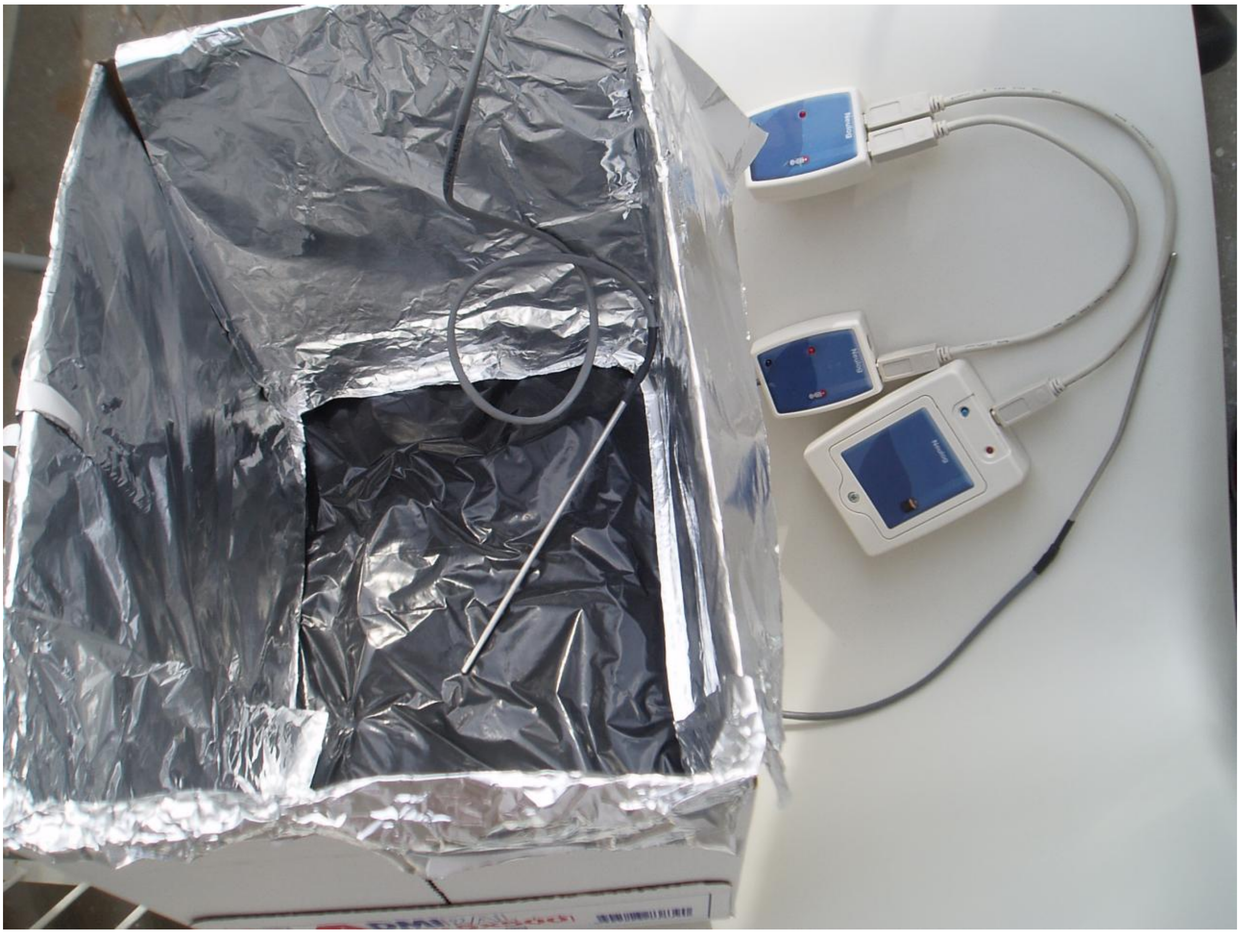
A solar oven or solar cooker is a device which uses sunlight as its energy source. Because it uses no fuel and it costs nothing to run, humanitarian organizations are promoting the use of solar ovens worldwide to help slow deforestation and desertification, caused by using wood as fuel for cooking. Solar cookers are also sometimes used in outdoor cooking, especially in situations where minimum fuel consumption or fire risks are considered highly important.

Life on the biosphere is based on the use of solar energy. In plants, for example, photosynthesis uses carbon dioxide and water, releasing oxygen as a waste product. Photosynthesis is crucially important for life on Earth, since it maintains the normal level of oxygen in the atmosphere and nearly all life either depends on it directly as a source of energy or indirectly as the ultimate source of the energy in their food.

The Sun constantly provides light and heat. These two types of energy are products of nuclear reactions, which convert the Sun's hydrogen into helium. Today we have cells that transform solar energy into electricity. Solar energy does not pollute, lasts and is free. A direct way of using solar energy is through heaters.

Procedure

Experiment setup



1. Build a solar heater

a. Paint the bottom of a carton box black or put a black plastic bag at the bottom of the box.
b. Cover the inner walls of the box with aluminum foil.

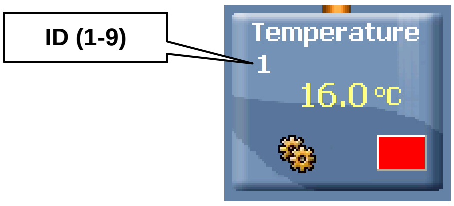
Sensor setup

2. Connect the USB Module  to the USB port on your computer.

3. Connect one Temperature Sensor  to the USB Module using a Data Cable.

4. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon.

5. Click the Tools icon in the NeuLog software main icons bar to reveal the tools-icon bar. Bring the cursor to "set sensor ID number" icon. Select number to 2 and click the icon. A new sensors search will start automatically; your sensor should appear now with ID = 2 (you will see the number 2 appear in the upper left part of the sensor's module box).



6. Connect the second temperature sensor to the USB Module. Click the 'Search for Sensors' icon. You should now see two temperature sensors' module boxes, one with ID 1 and another with ID 2.

7. We will work in the off line mode of the NeuLog software to program the measurement conditions for the sensor to work disconnected from the computer (outside).

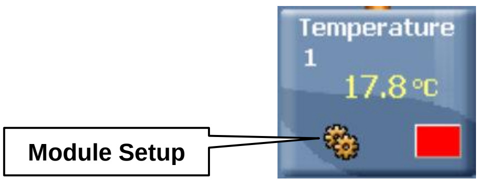
8. Click the 'Off Line Experiment' icon in NeuLog's main icon bar.

9. Click the 'Module Setup' icon in the sensors module box to open a dialogue box:

Set the experiment duration to 10 minutes
Set the sampling rate to 30 per minute.
This procedure downloads the measurement conditions to the sensor and these are stored in its memory.

10. Close the module setup dialogue box.

11. Repeat steps 9 and 10 for the second sensor.



12. Disconnect both sensors from the USB Module.

13. Connect both sensors to the Battery Module using the Data Cables.

Testing and measurements

14. Take the solar oven you prepared outside to a sunny area. If this is not possible, you could use artificial light (a reflector).

15. Put one Temperature Sensor in the box and the second outside the box exposed to sunlight.

16. Begin measurements by pressing both sensors' Start/stop buttons.

Note:

You should see the sensors' red LED On during the measurement. When the LED turns Off, it means the experiment time is over.

The measured data is stored in the sensors' memory.

17. At the end of the experiment outside, create a chain with the two sensors and connect them to the USB Module to down load the data into the computer as follows:

18. Click the 'Search for Sensors' icon , then click the 'Off Line Experiment' icon in NeuLog's main icon bar.

19. Click on the Load Data from sensors icon in the sub-icons bar to reveal a box with options:

All (last experiments)
Temperature 1
Temperature 2
Experiments

20. Select All (last experiments).

21. This uploads the measurements to your computer which were saved in the sensors' memory.

22. Observe the graphs and save them.

23. You could improve the display of the readings by using the 'Zoom Fit' icon on the left upper part of the graph window.

Summary Questions

1. What temperature did the oven reach? Use the 'Show Cursors' icon  to move the two cursors and record the difference in temperature from initial to final measurements; chose the sensor that was in the box (look at the sensor's ID number).

2. What temperature did the external sensor reach? Use the 'Show Cursors' icon  to move the two cursors and record the difference in temperature from initial to final measurements, chose the sensor that was out of the box (look at the sensor's ID number).

3. Observe the change in temperature inside the solar oven and outside.

4. Compare your different observations. Analyze and conclude.

5. What was the function of the outside temperature sensor?

Challenge

1. Investigate how heat is transmitted and relate it to the material used for building the solar oven.

2. Investigate why solar energy is important for an ecosystem.

3. Build a solar oven and give cooking time for different types of food, considering the temperature it reaches.

Photosynthesis

Objective

- To study the processes of photosynthesis and respiration of a plant.
- To measure the level of carbon dioxide in a closed cell, during respiration and photosynthesis of a plant.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- CO2 Sensor: S98242-3ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- A lamp
- A glass
- Special glass bottle for the Carbon Dioxide sensor.

Materials

- About 20-30 green leaves from a plant
- Aluminum foil

Discussion

Photosynthesis occurs in the chloroplasts of plants as a means of turning solar energy into chemical energy in the form of glucose, the primary food/energy source of cells. Through a series of biochemical reactions, sunlight energy transforms carbon dioxide and water into glucose and oxygen. The photosynthesis process is defined as follows:

$$6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$$

Respiration releases the chemical energy stored in glucose and turns it into energy that can be used by the cell in the form of ATP (adenosine triphosphate). Nearly all cellular processes depend on ATP as their energy source. The chemical equation for respiration using glucose is the mirror image of the chemical equation for photosynthesis:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + energy$$

In this experiment, we will follow the respiration of plant leaves with and without light.

Procedure

Experiment setup

1. Take green leaves from a plant. (The leaves should be dry so if damp, dry them.)

2. Wrap the special bottle with aluminum foil so that no light can get in.

3. Place the leaves in the bottle.

Sensor setup

4. Connect the USB Module  to the USB port in your computer.

5. Connect the Carbon Dioxide Sensor to the USB Module using a Data Cable.

6. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon.

7. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar, click the 'Load Configuration' icon.

8. This sets up the experiment parameters as follows:

Experiment duration to 15 minute
Sampling rate to 60 per minute

9. If you did not use the Load Configuration function, click the 'On Line Experiment' icon in the main icon bar.

10. Click on the 'Experiment Setup' icon. This opens a dialogue box:
Set the Experiment duration to 15 minute
Set the sampling rate to 60 per minute on the drop down menu.

11. Close the dialogue box.

12. Whether you used the Load Configuration function or not, click the sensor's 'Setup' icon in the sensors module box on the left side of the screen to open a dialogue box and then click the 'Calibration' icon. This will calibrate the sensor to a value of 380 ppm. An alternative way of calibration is to press the sensor's calibration button continuously (3 seconds).

Note: Since our measurements are relative, the sensor can be calibrated in the classroom. For quantitative measurements, the calibration should be performed outside where there is fresh air.

13. Note that the measured amount of CO_2 appears in the sensor's module box.

14. Close the module setup dialogue box.

Testing and measurements

15. Introduce the CO_2 sensor into the special bottle (the sensor actually covers the bottle).

16. Keep the glass bottle with the leaves wrapped in the aluminum foil at least 10 minutes before starting the measurement.

17. Click the 'Run Experiment' icon to start the measurement.

18. Save the data.

19. To determine the rate of respiration, click the 'Show Cursors' icon , move the two cursors, one to the part of the experiment where the increase starts to be linear and the second to the end of the measurement.

20. Click the 'Show Functions' icon , click the functions tab and select "Linear Fit (between cursors)" from the second drop down menu. Click the 'Calculate Function' icon to perform the calculation; in the box you will see the formula with the best fit line. The slope of the graph is the rate of respiration. Record the result in your table.

21. Remove the aluminum foil from the glass bottle.

22. Remove the sensor from the bottle and let it adjust for 3 minutes. Observe how the CO_2 reading in the sensor's module box changes back to the initial value.

23. Introduce the sensor back into the glass bottle.

24. Fill a glass with water and place it between the lamp and the special bottle with the leaves and the sensor. (The glass with water protects the leaves from the heat of the lamp.)

25. Place the lamp as close to the glass with water as possible but without touching it. Turn on the lamp. It should be on for 5 minutes before you begin the data collection.

26. Click the 'Run Experiment' icon to start the measurement.

27. Save the data at the end of the measurement.

28. To determine the rate of photosynthesis, repeat steps 14-15.

29. Record the slope of the line, m, as the rate of photosynthesis in your table.

30. Remove the leaves from the bottle. Clean and dry the bottle.

Data Table

Leaves	CO_2 rate (ppm/sec)
No light	
With light	

Summary Questions

1. Did you observe any difference between the rate of CO_2 values in the two experiments performed?

2. Which experiment has positive rate values for CO_2? What biological process took place? Explain.

3. Which experiment has negative rate values for CO_2? What biological process took place? Explain.

Challenge

1. What are the factors that could influence the rate of CO_2 level in leaves? Design and perform an experiment to test one of the factors you have listed.

2. Use different types of leaves and compare their rates of photosynthesis and respiration.

Respiration of Germinating Seeds

Objective

- To compare the production of carbon dioxide by germinating seeds and dormant seeds.
- To determine whether germinating seeds and non-germinating seeds respire and what factors can affect them.
- To determine the effect of temperature on seed germination.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- CO2 Sensor: S98242-3ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- A lamp
- A glass
- A plate
- Special glass bottle for the Carbon Dioxide sensor

Materials

- 30 germinating seeds (lentils or any other seeds that are easy to germinate)
- 30 non-germinating seeds (lentils).

Discussion

In some aspects, plants are not very different from people. Although plants can produce sugars from the Sun's energy, when plants need energy they have to metabolize their stored sugars through cellular respiration, just like we do.

A plant's respiration rate is not constant and depends on many factors. After a seed is separated from the plant, it usually goes into a resting period called dormancy. During dormancy, the seed waits until conditions are just right before it begins the germination process.

During this time, seeds cannot produce their own food because they have no leaves. Therefore, in order for a seed to stay alive or grow it needs to use stored energy reserves and undergo cellular respiration. Have you ever wondered why seeds and nuts have so many calories? The seed will use these calories to survive during dormancy and to begin germination.

Cellular respiration occurs in every cell in both plants and animals and is essential for daily living. Cellular respiration is an exergonic reaction, which means it produces energy. It is also a catabolic process - it breaks down polymers into smaller, more manageable pieces. The ultimate goal of cellular respiration is to take carbohydrates and disassemble them into glucose molecules, and then use this glucose to produce energy-rich ATP molecules.

The general equation for cellular respiration is: (the energy released is about 36-38 molecules of ATP).

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$$

Seeds undergo cell respiration during germination. In this activity you will use the CO_2 gas sensor to monitor the carbon dioxide produced by seeds during cell respiration.

You will test both germinating and dormant seeds. In addition, you will test the effect of two different temperatures on cell respiration; other factors such as light and moisture will also be investigated.

Procedure

Experiment setup

1. Put about 30 non-germinating seeds, (lentils) into the special glass bottle.

Sensor setup

2. Connect the USB Module to the USB port on your computer.

3. Connect the Carbon Dioxide sensor to the USB Module using a Data Cable.

4. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon.

5. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar, click the 'Load Configuration' icon.

6. This sets up the experiment parameters as follows:
   Experiment duration to 10 minute
   Sampling rate to 50 per minute

7. If you did not use the Load Configuration function, click the 'On Line Experiment' icon in the main icon bar.

8. Click on the 'Experiment Setup' icon. This opens a dialogue box:
   Set the Experiment Duration to 10 minute
   Set the sampling rate to 50 per minute on the drop down menu.

9. Close the dialogue box.

10. Whether you used the Load Configuration function or not, click the sensor's 'Setup' icon in the sensors module box on the left side of the screen to open a dialogue box and then click the 'Calibration' icon. This will calibrate the sensor to a value of 380 ppm. An alternative way of calibration is to press the sensor's calibration button continuously (3 seconds).

Note: Since our measurements are relative, the sensor can be calibrated in the classroom. For quantitative measurements, the calibration should be performed outside where there is fresh air.

11. Note that the measured amount of CO_2 appears in the sensor's module box. Close the module setup dialogue box.

Testing and measurements

12. Introduce the sensor into the special glass bottle with the seeds.

13. Wait about 3 minutes for the reading to stabilize.

14. Click on the 'Run Experiment' icon to start the measurement.

15. After the measurement, remove the sensor from the glass bottle and let it re-adjust for 3 minutes; observe how the CO_2 reading in the sensor's module box changes back to the initial value.

16. Save the data.

Note: For a better resolution, click the 'Zoom Fit' icon.

17. To determine the rate of respiration, click the 'Show Cursors' icon, move the two cursors, one to the part of the experiment where the increase starts to be linear and the second to the end of the measurement.

18. Click the 'Show Functions' icon, click the functions tab and select "Linear Fit (between cursors)" from the second drop down menu. Click the 'Calculate Function' icon to perform the calculation; in the box you will see the formula with the best fit line. The slope of the graph is the rate of respiration. Record the result in your table.

19. Remove the non-germinating seeds from the bottle.

Test germinating seeds:

20. Obtain 30 germinating seeds and blot them dry between two pieces of paper towel; put them in the special glass bottle.

21. Introduce the sensor back in the glass bottle.

22. Repeat steps 13-19 for the germinating seeds.

Test the effect of light:

23. Introduce the sensor back into the special glass bottle. Fill a glass with water and place it between the lamp and the special bottle with the seeds and the sensor. (The glass with water protects the seeds from the heat of the lamp.)

24. Place the lamp as close to the glass with water as possible but without touching it. Note the time and turn on the lamp. The lamp should be on for 5 minutes before you begin the data collection.

25. Repeat steps 13-19 for the light irradiated germinating seeds.

Test the effect of cold temperature:

26. Introduce the sensor back into the special glass bottle.

27. Fill a deep plate with ice cold water and put the special bottle with the germinating seeds in it so that most of the bottle is in the water.

28. Repeat Steps 13–19 to collect data with the cold germinating seeds.

Data Collection:

Seeds	***CO_2 Rate of respiration (ppm/sec)***
Dormant, room temperature	
Germinating, room temperature	
Germinating, room temperature with light	
Germinating, cool temperature	

Summary Questions

1. Did cell respiration occur in the seeds? Explain.

2. Compare the rate of CO_2 production of germinating and dormant seeds; what is the effect of germination on the rate of cell respiration?

3. How does temperature affect the CO_2 production rate for germinating seeds (room temperature compared to cold germinating)?

4. How does light affect the CO_2 production rate for germinating seeds at room temperature?

Challenge

1. What other conditions beside temperature could affect the rate of respiration?

2. Grow your own seeds (lentils, beans, etc.). Measure the respiration rate at different stages of the germinating process.

Acid Rain

Objective

- To study the acid rain phenomenon.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- pH Sensor: S98242-24ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Acid Rain Kit: S02157

Materials

- Vinegar (CH_3COOH)
- Sodium bicarbonate ($NaHCO_2$)
- Water

Discussion

Acid rain is a phenomenon associated with the development of urban and industrial areas. It consists of the incorporation of chemical compounds such as carbon dioxide, sulfur dioxide and nitrogen oxides to rain water. These compounds are emitted by cars' exhausts, factories and thermoelectric centrals.

When these oxides are in contact with humidity in the atmosphere, they are transformed into secondary polluting agents that form solutions of Carbon, Sulfuric and Nitric acid. Rain carries these compounds to the Earth's surface, deposits them on the soil and in water bodies.

The persistent fall of acid rain damages lakes, rivers and underground waters, causing the death of fish and other organisms in aqueous ecosystems. It acidifies and demineralizes soils, damages forests, national parks and reserves and causes low producing crops. Also, the acidity of the water deteriorates archeological zones, historical monuments, buildings and metallic structures. The dimension of the damage depends on the degree of acidity.

In this experiment, you will produce one of the gases responsible of acid rain - CO_2 - and will quantify the variation in the pH induced in the water when it dissolves.
CO_2 and H_2O (water) create acid H_2CO_3 according to the following formula:

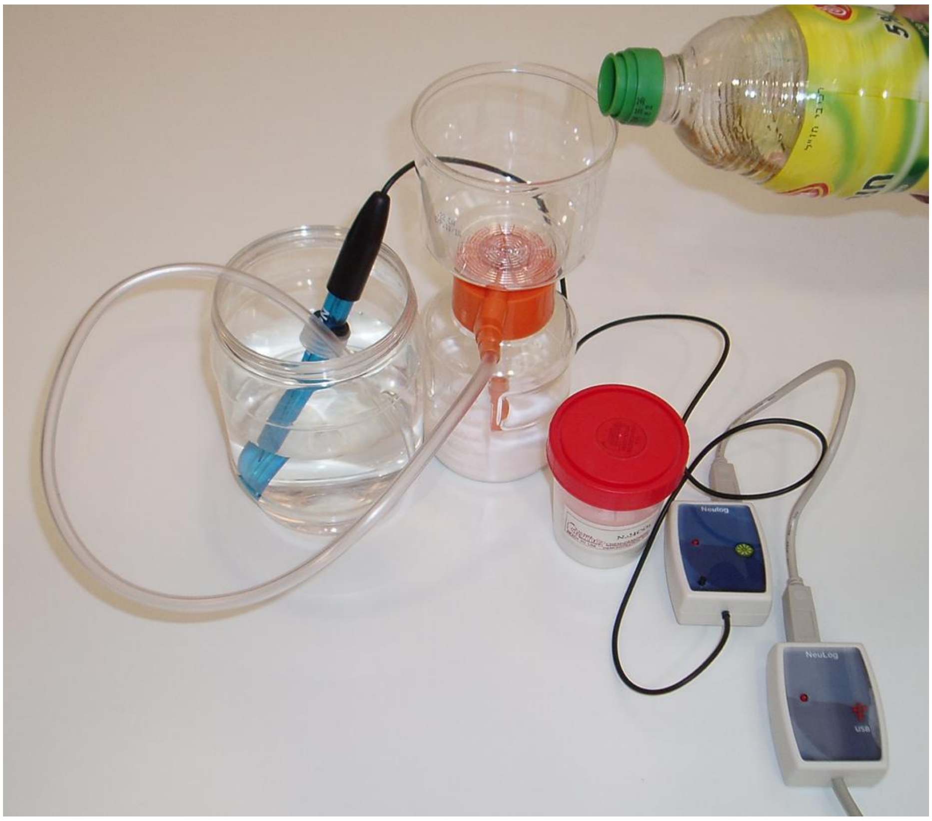
$CO_2 + H_2O \Rightarrow H_2CO_3$

Procedure

Experiment setup

Warning: Please note that the bottom part of the pH sensor consists of a fragile crystal sphere. Even though it has a plastic protection, be careful not to break it.

1. Assemble a system like the one shown below.



2. Put a cup with 100 ml water on the table.

3. Open the gas generator, add two spoonfuls of sodium bicarbonate and close the cap tightly.

4. Insert the hose attached to gas generator into the water.

Sensor setup

5. Connect the USB Module to the USB port on your computer.

6. Connect the pH Sensor to the USB Module using a Data Cable.

7. Unscrew the cap of the storage solution and take out the sensor. Raise the cap to the top of the sensor. Put the solution aside.

8. Introduce the sensor into the water and stir carefully to remove the soaking solution.

9. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon.

10. Observe the sensor's module box on the left side of the screen. Allow the pH value to stabilize.

11. If this experiment was opened through the 'Load Activity' icon located in the 'Tools' sub icon bar, click on the 'Load Configuration' icon.

12. This sets up the experiment parameters as follows:
Experiment duration to 5 minutes
Sampling rate to 10 per second

13. If you did not use the Load Configuration function, click the 'On Line Experiment' icon in the main icon bar.

14. Click on the 'Experiment Setup' icon. This opens a dialogue box:
Set the Experiment Duration to 5 minutes
Set the sampling rate to 10 per second on the drop down menu.

15. Close the dialogue box.

16. Whether you used the Load Configuration function or not, click on the 'Module Setup' icon in the sensor module box to open a dialogue box. Click on the 'Calibration' icon

 to set the value at 7. (For a more accurate calibration, a buffer solution pH = 7 should be used).

17. Close the module setup dialogue box.

Testing and measurements

18. Click on the 'Run Experiment' icon  to start the measurement.

19. Without stopping the measurement, slowly add about 50 ml of vinegar through the funnel. Swirl the gas generator from time to time.

20. You should see gas bubbles in the water.

21. Observe the pH changes in the graph on the computer screen.

Summary Questions

1. We introduced gas into the water. What happens to the water, does it stay the same, becomes acid or basic according to the pH readings?

2. Does the pH level change during the experiment?

Challenge

1. What are the main primary polluting agents that originate acid rain?

2. Develop the equation from the chemical reaction of acetic acid and sodium bicarbonate.

$$NaHCO_3 + HC_2H_3O_2 \Rightarrow$$

3. Develop the chemical reaction of acid rain from Sulfur trioxide plus water.

$$SO_3 + H_2O \Rightarrow$$

4. Develop the chemical reaction of the results of this activity.

5. What was the pH level obtained in the results?

6. Investigate the alterations to the environment produced by acid rain.

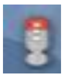
7. Analyze and conclude.

Quality of Water

Objective

- To learn how to evaluate the quality of water.

Modules and Sensors

- Computer with NeuLog™ Software
- 5 Data Cables, 30cm: S98242-49ND
- USB Module: S98242-45ND 
- Temperature sensor: S98242-31ND 
- Oxygen Sensor: S98242-8ND 

- pH Sensor: S98242-24ND 
- Conductivity Sensor: S98242-5ND 
- Turbidity Sensor: S98242-35ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case. All items sensors, software and hardware required for this experiment are included in the **Environmental Starter Pack – S98242CND**.

Equipment and Accessories

- One plastic syringe – 50 mL (for calibration of dissolved oxygen sensor)
- Two Pasteur pipettes (to fill the cuvettes of the turbidity sensor)

Materials

- Sample of distilled water
- Sample of tap water
- Sample of "contaminated" water
- Buffer solution pH = 7 (for calibration of the pH sensor)
- Distilled water (for cleaning the electrodes)
- Nine disposable cups

Discussion

Water quality is the physical, chemical and biological characteristic of water. It is a measure of the condition of the water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to drinking water, safety of human contact and for the health of ecosystems.

In this activity students will receive three unknown samples of water, distilled, tap and "contaminated" water. Through various measurements, such as dissolved oxygen, pH, electrical conductivity and turbidity, they will be able to conclude what contains each unknown sample (and learn to evaluate quality of water).

Procedure

<u>Sensor setup</u>

1. Connect the USB Module  to the USB port on your computer

2. Connect the five sensors, in a chain, to the USB Module using the Data Cables.

> **<u>Note:</u>**
> ***Important:* After connecting the oxygen sensor to USB module wait at least 5 minutes before calibration and measurements**.

3. Run the NeuLog™ software and check that the sensors are identified. If the software is already running, click the 'Search for Sensors' icon .

4. Prepare the dissolved oxygen sensor for measurement:
   a. Carefully remove the rubber protection from the sensor's cap.
   b. Unscrew the cap, fill half of it with the included liquid (DO filling solution) and screw it back.
   c. The calibration of the oxygen sensor in % in liquid assumes the saturation is 100%.
   d. In order to reach this condition, introduce the tip of the oxygen sensor in a container with tap water and inject air with the 50 mL syringe.
   e. Pump about five times.

5. Immediately afterwards, look for the oxygen sensor's module box on the left side of the screen and click on the 'Module Setup' icon  to open a dialogue box. Verify the mode is "% in liquid".

6. Click the ‘Calibration’ icon  which sets the oxygen value to 100% (of oxygen saturation in water). After pumping air, the reading of dissolved oxygen decreases which is normal. The reading shows the real value of dissolved oxygen in the experimental conditions. The oxygen leaves the water and goes to the air.

7. Unscrew the cap of the storage solution of the pH Sensor  and take out the electrode. Raise the cap to the top of the electrode. Put the solution aside.

8. Introduce the pH Sensor into tap water and stir carefully to remove the soaking solution. Then dip the sensor in the buffer solution pH = 7.

9. Click the ‘Search for Sensors’ icon  again and look for the pH sensor's module box on the left side of the screen. Observe the pH value and allow it to stabilize.

10. Click on the pH ‘Module Setup’ icon  in the sensors module box to open a dialogue box. Click on the ‘Calibration’ icon  to set the value at 7.

11. Look at the module box of the Conductivity Sensor. If the units are not mg / L, click the ‘Module Setup’ icon  to open a dialogue box. Select the radio button next to mg/L and then close the dialogue box.

12. If this experiment was opened through the ‘Load Activity’ icon  located in the Tools sub icon bar , click on the ‘Load Configuration’ icon .

13. This sets up the experiment parameters as follows:
Experiment duration to 10 seconds
Sampling rate to 10 per second

14. If you did not use the Load Configuration function, click the 'On Line Experiment" icon in the main icon bar.

15. Click on the 'Experiment Setup' icon. This opens a dialogue box:
Set the experiment Duration to 10 seconds
Set the sampling rate to 10 per second on the drop down menu.
Close the dialogue box.

Experiment setup

16. Assemble a system as in the picture below:

17. Since sensors may interfere with each other, divide the first sample of water into three cups. There should be enough water so that all the sensitive parts of the sensors are immersed.

18. Introduce the dissolved oxygen sensor and the temperature sensor into one cup, the pH sensor into another cup and the conductivity sensor into the third cup.

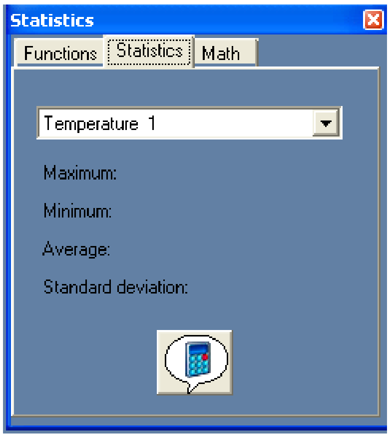
19. Use one pipette to take some of the water sample and fill the cuvette included with the turbidity sensor; introduced the filled cuvette into the sensor.

Testing and measurements

Evaluation of the first sample of water, No. 1.

20. Click the 'On Line Experiment' icon  in the main icon bar. Click on the 'Run Experiment' icon  to start the measurement. You should see five graphs in the monitor. Just two values will be displayed in the Y axis since this is the default.

21. You can use the statistical tools in the NeuLog software to get the average for each measurement. Click on the 'Show Functions; icon  and select the statistics tab in the opened window (see figure).



22. Select the Temperature Sensor from the scroll down menu in the opened window. Click the 'Calculate Statistics' icon  and write down the average value in the following table. Repeat for the other four sensors.

Sample No.	Temperature (°C)	Dissolved Oxygen (%)	pH	Conductivity (mg / L)	Turbidity (NTU)
1	25.9	72.1%	7.1	304	0.00
2					
3					

23. Clean all electrodes and the cuvette of the turbidity sensor with distilled water.

24. Repeat the measurements for the other two samples. Write down your results in the table.

Summary Questions

1. According to the results in the table, determine which sample is distilled water, which is tap water and which is "contaminated" water.

Challenge

1. Get "real" water samples and evaluate them.

Measuring Particles in Air

Objective

- To study air pollution by measuring how much light is transmitted or blocked by particulate matter in the air.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- Light Sensor: S98242-20ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- Table Lamp with 100 W bulb
- Ring stand
- Utility clamp

Materials

- 4 - 10 x 20 cm cardboard cards (not included)
- Clear packing tape
- Scissors

Discussion

There are things floating around in the air. Most of them cannot be seen. These are a kind of air pollution called particles or particulate matter. In fact, particulate matter may be the air pollutant that most commonly affects people's health. Particles can come in almost any shape or size, and can be solid particles or liquid droplets.

Breathing clean air is important for keeping your lungs nice and healthy. Tiny particles of dust and soot in the air can enter your lungs when you breathe, blocking the movement of oxygen.

Harmful particles can come from pollutants in the air such as dust, smog, soot, smoke, pollen and smaller particles coming from vehicle exhausts and other chemicals. Because clean air is important to our health, most cities keep track of air pollution by issuing smog warnings on days when the level is high.

Particulates in the air vary from location to location. In this activity, you will place cards covered with clear packing tape for collecting particles in the air in different locations over the course of a week. Afterwards, you will measure the amount of light that passes through the tape in the test card and compare it to a control card.

Procedure

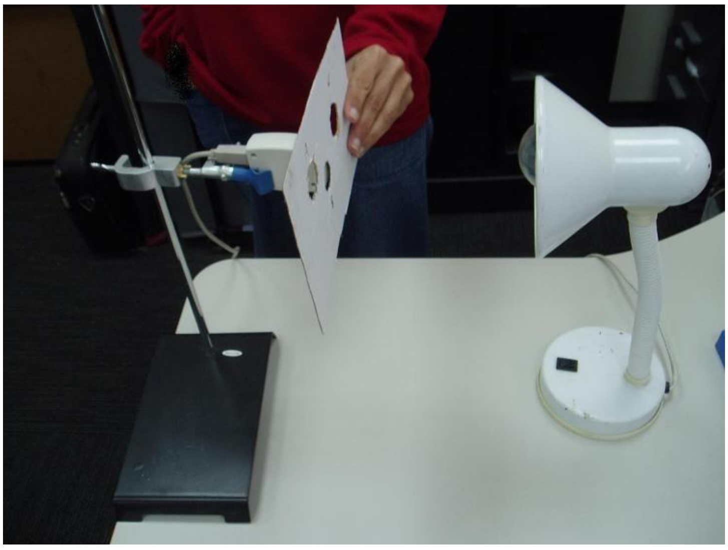
Experiment setup

1. Prepare your test cards.

a) Take one 10x20 cm card for each location to be tested (three different locations) and one control card.
b) Write a title on your test cards: Location 1, Location 2, Location 3 and Control.
c) Draw three circles on each test card of 3 cm diameter and cut them out.
d) Name the circles A, B and C. Each card will test one location. The three samples in each card will allow you to have an average value of the particulates in each location.
e) Take one large piece of clear packing tape and stick it to the back of the card, covering the three holes. The sticky side of the tape should face the side of the cards with the circle's names.

2. Write the experiment day's date on each card and the location where it will be placed. Put the cards in places where they will not be touched by others, with the sticky side (and labels) up. Place the control card in a clean place such as a closed drawer. Leave the cards for a week.

3. After a week, pick up your test cards from their locations. Be careful not to touch the sticky side of the tape.



Sensor setup

1. Connect the USB Module to the USB port on your computer

2. Connect the Light Sensor to the USB Module using the Data Cable.

3. Run the NeuLog™ software and check that the sensors are identified. If the software is already running, click the 'Search for Sensors icon .

4. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar, click on the 'Load Configuration' icon .

5. This sets up a table and the sensor's range to 6,000 Lux.

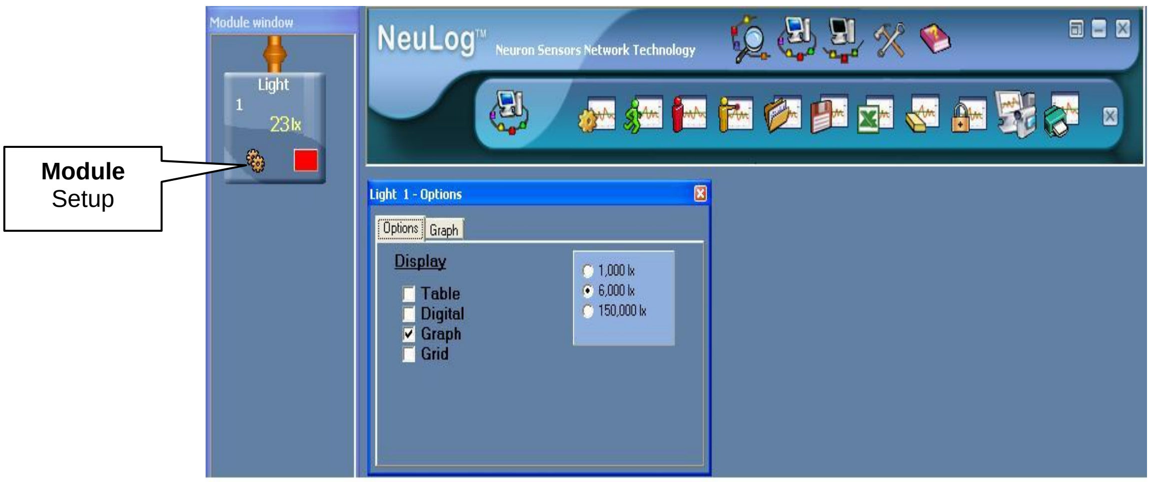
6. If you did not use the 'Load Configuration' function, click the 'On Line Experiment' icon in the main icon bar.

7. Click on the 'Experiment Setup' icon . This opens a dialogue box:
   Click the box next to table.
   Change the "Manual Values" column name to "Location" in your table (clicking on the name of the column will allow you to change its name).

8. Close the dialogue box.

9. Click on the 'Module Setup' icon to open a dialogue window. Set the sensor's range by selecting the radio button next to 6,000 Lux.

10. Your screen should look as the one in the following page:



Note that the measured light intensity reading, in Lux, appears in the sensor's module box.

11. Set up the sensor for collecting data as follows:

a) Attach the light sensor  to the ring stand through a utility clamp.
b) Position the clamp so that the sensor faces the center of the light source and is about 20 cm away from it.
c) Hold the control card in your hand, between the light sensor and the light source.

Testing and measurements

12. Turn on the light source.

13. Move your hand so that circle A of the card is directly in front of the light sensor, as shown in the picture.

14. When the reading has stabilized, click the 'Single Step Mode' icon  and write the value in the table.

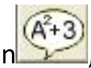
15. Now, move the card so that circle B is in front of the Light Sensor.

16. When the reading has stabilized, click the 'Single Step Mode' icon  and write the value in the table.

17. Move the card so that circle C is in front of the light sensor.

18. When the reading has stabilized, click the 'Single Step Mode' icon  and write the value in the table.

19. Calculate the average of A, B and C for the control card as follows:

Click the 'Show Functions' icon , select the statistics tab and click the 'Calculate Function' icon .

20. Record the average value in the table. Click the 'Clear Experiment Results' icon  to clear the data.

21. Repeat Steps 2-9 with the other location cards, writing the values in the table.

Test Card	Control	Location 1	Location 2	Location 3
Transmitted light A (Lux)				
Transmitted light B (Lux)				
Transmitted light C (Lux)				
Transmitted light average (Lux)				
Percentage of Transmitted light	100%			

Summary Questions

1. Can you observe differences between the light transmitted from the cards that were placed at different locations?

2. The percentage of light transmitted relative to your control sample can be calculated through the following equation:

   Light transmitted = (Transmitted light average/Transmitted light for control) ×100

3. Is there a correlation between the location and the average transmission measured?

4. What could have caused the difference in transmission due to the number of particles in the air, for the chosen locations?

5. Which location had the lowest light transmittance and why?

Challenge

1. Try to think of other contaminated locations and test them. Could you predict which place is more polluted than others?

Study of Slow-Release Food Supplements

Objective

- To monitor how pH values change for two different types of vitamin C tablets dissolved in water over a ten minutes test.
- Study the benefit of slow-release food supplements using slow-release and regular vitamin C tablets dissolved in water.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- pH Sensor: S98242-24ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Materials

- Regular vitamin C tablet
- Slow release vitamin C tablet
- A cup
- Water

Note: If possible, use effervescent vitamin C tablets.

Discussion

When you take a regular vitamin pill, it is rapidly dissolved in the stomach and absorbed into the bloodstream. However, this rapid dissolution of the supplement increases the chances that your body will excrete significant traces of the beneficial vitamins. On the other hand, time-release vitamins use micro-technologies to dissolve much more slowly in the stomach.

The common method for time-release is coating the vitamins, minerals or medicine with a polymer so they are released incrementally into the bloodstream and are absorbed over an extended period of time rather than just a few minutes. This increases the chance that a significant percentage of the vitamins or medicine will be absorbed in the body. In this experiment we will use a pH sensor to follow an example of a slow-release food supplement by dissolving regular and slow release vitamin C tablets in water.

Procedure

Experiment setup

Warning: Please note that the bottom part of the pH sensor consists of a fragile crystal sphere. Even though it has a plastic protection, be careful not to break it.

1. Assemble a system as the one in the picture below.

2. Pour 100 ml of water into a cup.

Sensor setup

3. Connect the USB Module  to the USB port on your computer.

4. Connect the pH sensor  to the USB Module using a Data Cable.

5. Unscrew the cap of the storage solution and take out the sensor. Raise the cap to the top of the sensor. Put the solution aside.

6. Introduce the sensor into the water and stir carefully to remove the soaking solution.

7. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

8. Observe the sensor's module box on the left side of the screen. Allow the pH value to stabilize.

9. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar , click on the 'Load Configuration' icon .

10. This sets up the experiment parameters as follows:
Experiment duration to 10 minutes
Sampling rate to 30 per minute

11. If you did not use the Load Configuration function, click the 'On Line Experiment' icon in the main icon bar.

12. Click on the 'Experiment Setup' icon . This opens a dialogue box:
Set the Experiment Duration to 10 minutes
Set the sampling rate to 30 per minute on the drop down menu.

13. Close the dialogue box.

14. Whether you used the Load Configuration function or not, click the 'Setup' icon on the sensors module box to open a dialogue box.

15. Click on the 'Calibration' icon to set the value at 7. (For a more accurate calibration, a buffer solution pH = 7 should be used).
Set the experiment duration to 10 minutes
Set the sampling rate to 30 per minute.

Your screen should look as the following:

16. Close the module setup dialogue box.

Testing and measurements

17. Click on the 'Run Experiment' icon to start the measurement.

18. Without stopping the measurement, drop the regular vitamin C tablet into the cup. Swirl the cup from time to time.

19. Observe the graph of the measurement.

20. Click the 'Freeze Current Graph' icon .

21. Repeat steps 16 to 18 using the slow release vitamin C tablet.

Summary Questions

1. Compare your graphs.

2. Compare the change in pH (ΔpH).
What could you say about the rate of pH changes?
For which kind of vitamin tablet the pH decreases faster?

Challenge

1. Explain the benefit of slow release supplements to our body.

Fermentation of Yeast

Objective

- To determine the rate of respiration of yeast.

Modules and Sensors

- Computer with NeuLog™ Software
- Data Cable, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- CO2 Sensor: S98242-3ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- A special glass bottle for the Carbon Dioxide sensor

Note: Optimized Fermentation of Yeast kit is available – S02143

Materials

- Table sugar
- Yeast
- Disposable spoon
- Cup with warm water

Discussion

Yeast cells will use oxygen if it is present, and break down sugars all the way to CO_2 and H_2O. In the absence of oxygen, yeast will switch to an alternative pathway that does not require oxygen. The end products of this pathway are CO_2 and ethanol.   The first pathway yields more energy per sugar molecule consumed, and so it is the "preferred" pathway if oxygen is present. in order to determine the respiration rate, in this activity you will use a CO_2 sensor to measure the production of this gas as yeast respire.

Procedure

Experiment setup

1. Prepare a yeast suspension as follows:

2. Add two tablespoons yeast to the special glass bottle.

3. Add one spoon of sugar.

4. Add half a cup of warm water and stir carefully.

5. Allow the yeast to incubate while you prepare the sensor setup.

Sensor setup

6. Connect the USB Module  to the USB port on your computer.

7. Connect the Carbon Dioxide  sensor to the USB Module using the Data Cable.

8. The sensor should be connected to the USB Module for 5 minutes before starting the experiment.

9. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

10. Notice the sensor's module box on the left side of the screen. Observe the CO_2 value and allow it to stabilize.

11. If this experiment was opened through the 'Load Activity' icon located in the Tools sub icon bar , click on the 'Load Configuration' icon .

12. This sets up the experiment parameters as follows:
Experiment duration to 5 minutes
Sampling rate to 10 per second

13. If you did not use the Load Configuration function , click the 'On Line Experiment' icon in the main icon bar.

14. Click on the 'Experiment Setup' icon . This opens a dialogue box:
Set the experiment duration to 5 minutes
Set the sampling rate to 10 per second on the drop down menu.

15. Close the dialogue box.

16. Whether you used the Load Configuration function or not, click on the 'Module Setup' icon in the sensors module box to open a dialogue box. Click on the 'Calibration' icon to calibrate the sensor to a value of 380 ppm.

17. Observe the picture below:

Note: Since thesemeasurements are relative, the sensor can be calibrated in the classroom. For quantitative measurements, the calibration should be performed outside where there is fresh air.

Testing and measurements

18. Introduce the sensor into the special glass bottle.

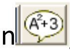
19. Wait about 3 minutes for the reading to stabilize.

20. Click on the ‘Run Experiment’  icon to start the measurement.

21. Observe the graph and wait for the measurement to end.

22. For a better resolution, click the ‘Zoom Fit’ icon .

23. To determine the rate of respiration, click the ‘Show Cursors’ icon , move the two cursors, one to the part of the experiment where the increase starts to be linear and the second to the end of the measurement.

24. Click the ‘Show Functions’ icon , click the functions tab and select "Linear Fit (between cursors)" from the second drop down menu. Click the ‘Calculate Function’ icon .

25. Observe the linear fit in the graph and the formula with the best fit line in the box. The slope of the graph is the rate of respiration.

Summary Questions

1. Was the production of CO_2, as a result of yeast respiration, linear or not?

Challenge

1. Repeat the experiment with other sugar and yeast amounts. Compare the results.

2. Repeat the experiment with different sugars, such as glucose, fructose and/or lactose. Determine if yeast use all types of sugar in the same way.

3. Repeat the experiment with a different type of yeast. Does it affect the results?

Perspiration

Objective

- To study changes in temperature caused by the evaporation of solvents.
- To relate the temperature difference due to evaporation.

Modules and Sensors

- Computer with NeuLog™ Software
- 3 Data Cables, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- 3 Temperature Sensors: S98242-31ND 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Materials

- Two small rubber bands
- Cotton pads
- Alcohol
- Acetone

Discussion

Perspiration is the production of a fluid, consisting primarily of water excreted by sweat glands in the skin of mammals. In humans, sweating is primarily a means of thermoregulation. Evaporation of sweat from the skin surface has a cooling effect.

In this experiment, you will study temperature changes caused by the evaporation of a solvent and link it to perspiration.

Procedure

Experiment setup

1. Wrap the tips of two temperature sensors with a small piece of cotton and secure it with a small rubber band. Wrap the cotton evenly.

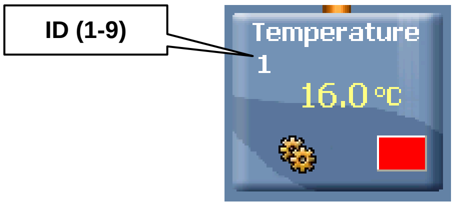
Sensors setup

2. Connect the USB Module  to the USB port in your computer.

3. Connect one Temperature Sensor  to the USB Module using a Data Cable.

4. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

5. Click on the Tools icon  in the main icons bar to reveal the Tools sub icon bar. Bring the cursor to "set sensor ID number" icon . Set the number to 2 and click the icon. A new sensors search will start automatically; your sensor should appear now with ID = 2 (you will see the number 2 in the upper left part of the sensor's module box).



6. Disconnect the sensor from the USB Module and connect another Temperature Sensor. Repeat step 4 with the new sensor assigning the ID number as 3 this time.

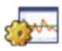
7. Leave this sensor connected to the USB Module and connect the other two sensors forming a chain (any free socket will do).

8. Click the search for sensors icon  again. You should see the three connected sensors, each with a different ID number: 1, 2 and 3.

9. If this experiment was opened through the 'Load Activity' icon  located in the Tools sub icon bar , click on the 'Load Configuration' icon .

10. This sets up the experiment parameters as follows:
Experiment duration to 2 minutes
Sampling rate to 10 per second

11. If you did not use the Load Configuration function , click the On line experiment icon  in the main icon bar.

12. Click on the Experiment set up icon . This opens a dialogue box:
Set the Experiment Duration to 2 minutes
Set the sampling rate to 10 per second on the drop down menu.

13. Close the dialogue box.

Testing and measurements

14. Insert the tip of sensor with ID 1 in the alcohol carefully so that the cup does not tip over.

15. Insert the tip of sensor with ID 2 in the acetone.

16. The third sensor is for control.

17. Leave the sensors in the liquids for about ten seconds.

18. Click on the 'Run Experiment' icon  to start the measurement.

19. Wait about 10 seconds and then remove the sensors simultaneously from the liquids.

20. Put the three sensors on the table with their tips coming out (see picture in previous page).

21. Observe the graph.

Summary Questions

1. What happened to the temperature, did it increase, decrease or stayed stable?

2. Calculate the temperature difference.

3. Compare your graphs.

4. How could we relate the results to perspiration?

Challenge

1. Can you explain the different changes of evaporation temperature for the liquids tested in terms of intermolecular forces of attraction?

Heating the Earth's Surface

Objective

- To study the effect of heating and cooling sand and water in order to compare their heating/cooling rates.

Modules and Sensors

- Computer with NeuLog™ Software
- 3 Data Cables, 10cm: S98242-48ND
- USB Module: S98242-45ND 
- 2 Temperature Sensors: S98242-31ND 
- Battery Module 

NOTE: Individual **NeuLog™** sensors and connection hardware are sold individually or as part of economical Curriculum Starter Packs that include sensors and accessories in a convenient custom case.

Equipment and Accessories

- 2 beakers, 400 mL
- Lamp with 150-W bulb

Materials

- Water, 300 mL
- Sand, 300 mL

Discussion

Heat transfer, also known as heat flow, heat exchange, or transfer of thermal energy is the movement of heat from one place to another. When an object is at a different temperature from its surroundings, heat transfer occurs so that the body and the surroundings reach the same temperature at thermal equilibrium. Such spontaneous heat transfer always occurs from a region of high temperature to another region of lower temperature as required by the second law of thermodynamics.

In engineering, energy transfer by heat between objects is classified as either heat conduction, also called diffusion, of two objects in contact, by fluid convection, which is the mixing of hot and cold fluid regions, and by thermal radiation, the transmission of electromagnetic radiation described by the black body theory. However, engineers also consider the transfer of mass of differing chemical species, either cold or hot, to achieve transfer of heat.

In this experiment we will irradiate two samples (water and sand) to compare the rate of temperature change. We will also study the rate of cooling between these two materials.

Procedure

Experiment setup

1. Fill one beaker with 300 mL dry sand at room temperature.

2. Fill the second beaker with 300 mL tap water at room temperature.

3. Arrange the beakers side by side.

4. Insert a Temperature Sensor in each beaker.

5. Position the lamp so that it is about 20 cm above the sand and the water, but **do not** turn it on yet.

Sensor setup

6. Connect the USB Module to the USB port on your computer.

7. Connect the Temperature Sensor from the water beaker to the USB Module using a Data Cable.

8. Run the NeuLog™ software and check that the sensor is identified. If the software is already running, click the 'Search for Sensors' icon .

9. Check that the sensor's ID number is 1. (See figure of module box below); disconnect the sensor from the USB Module.

10. When two sensors of the same type (i.e. two temperature sensors) are used simultaneously, you must change the ID number of one of them.

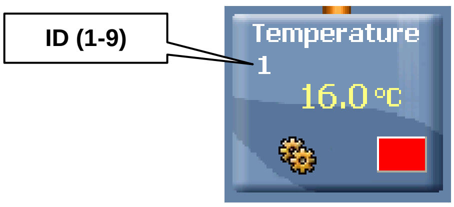
11. Connect the Temperature Sensor from the sand beaker to the USB Module.

12. Click the 'Tools' icon in the NeuLog software main icons bar to reveal the tools-icon bar.

13. Bring the cursor to 'Set Sensor ID Number" icon .

14. Select number to 2 and click the icon. A new sensors search will start automatically.

15. Your sensor should appear now with ID = 2 (you will see the number 2 in the upper left part of the sensor's module box).



16. Connect the Temperature Sensor in the water beaker to the USB Module.

17. Click the 'Search for Sensors' icon . You can now see two temperature sensors module boxes, one with ID 1 and another with ID 2.

Note:

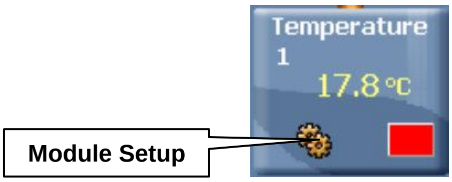
The following instructions set the experiment for an Off Line measurement (disconected from the computer). This allows you to carry out other experiments with your computer and other sensors. This experiment you can also be performed on line (connected to the computer).

18. Click the 'Off Line Experiment' icon in NeuLog's main icon bar.

19. Click the 'Module Setup" icon in the sensors module box to open a dialogue box:

Set the experiment duration to 30 minutes

Set the sampling rate to 10 per second



This procedure downloads the measurement conditions to the sensor and these are stored in its memory.

20. Close the module setup dialogue box.

21. Repeat steps 9 and 10 for the second sensor.

22. Disconnect both sensors from the USB Module.

23. Connect both sensors to the Battery Module.

Testing and measurements

24. Begin measurements by pressing both sensors' start/stop buttons.

Note:

You should see the sensors' red LED On during the measurement. When the LED turns Off, it means the experiment time is over. The measured data is stored in the sensors' memory.

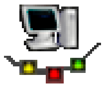
25. Turn on the lamp.

26. After 15 minutes, turn off the lamp.

27. You can observe the development of the measurement through a monitor display unit.

28. If you prefer, you can download the data collected from the sensors to a computer as follows: At the end of the experiment, disconnect the sensors from the battery module.

29. Create a chain with the two sensors and connect them to the USB Module.

30. Click the 'Search for Sensors' icon , then click the 'Off Line Experiment'  icon in NeuLog's main icon bar.

31. Click on the 'Load Data from Sensors' icon  in the sub-icons bar to reveal a box with options:

All (last experiments)
Temperature 1
Temperature 2
Experiments

32. Select **All** (last experiments).

33. This uploads the measurements to your computer.

34. The measurements were saved in the sensors' memory.

35. Observe the graphs and save them.

Summary Questions

1. What was the maximum temperature reached by each sensor?
2. Use the 'Show Cursors' icon  to move the two cursors and record the difference in temperature from initial to maximal measurements; chose the sensor that was in the water (look at the sensor's ID number).
3. Repeat for the sensor immersed in the sand.
4. Repeat procedures in point 1 and 2 but for the cooling part.
5. Put the first sensor in the maximal point and the second at the end. Record the temperature difference.
6. From your results, conclude which material heated faster, water or sand. Explain your results.
7. From your results, conclude which material cooled faster. Explain your results.
8. From your results, try to explain what happens when the sun heats the shore in a beach. Does this generate a temperature difference between the sand close to the sea and the water in the sea?
9. Investigate how this situation affects the weather.

Challenge

1. Use different materials, such as soil, small stones, etc. and compare their rate of heating and cooling.
2. Use different liquids such as alcohol or oil and compare their rates of heating and cooling.