

**STEMkey**  
Module IO4



# **Human anatomy and physiology with smartphones**

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## **Activity 4 – Coagulation of proteins**

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## Module IO4. Human anatomy and physiology with smartphones

### Activity 4: Coagulation of proteins

#### Objectives

Students will use a light sensor from a smartphone as a dynamic colorimeter in an experimental activity on coagulation of proteins.

#### Background

Sensors in a smartphone can be a useful and effective tool for collecting data in different environments. The capabilities of a smartphone depend on the type of phone, but most are equipped with a camera that allows it to be used as an exposure metre with one of the many apps available online. In the activity described, Phyphox was a choice.

Proteins play an important role in the human body and in the bodies of all living things. However, they are unstable and many factors such as heat, acids, bases and many others lead to their denaturation (coagulation). Some of the best known examples are the coagulation of an egg or blood clots.

The task of the exercise is to explore the coagulation of egg white as a model for the processes in the human body, using a smartphone as a measuring instrument.



**Work in pairs**



**60 min**

#### Learning Outcomes

After completing the lesson students will know that / learn about:

- 1) It is possible to use your smartphone as an instrument for collecting data.
- 2) You can turn your smartphone into a dynamic colorimeter.
- 3) Basic optical and technical principles of how to do this.

You will be able to:

- 4) Construct own "dynamic colorimeter".
- 5) Use a light-sensor to quantify changes of light in nature/laboratory.
- 6) Evaluate the suitability of the technology used.
- 7) Make suggestions for improvements and alternatives to the device constructed in a laboratory session.

#### Skills:

- Technological literacy: students develop skills in using the features and functions of their smartphones, including the camera, internet connection, and app installation.
- Camera skills: student will improve their ability to take clear and meaningful pictures and videos while considering lighting, focus and composition.
- Online research skills: students gain skills in conducting online research, evaluating the credibility of sources, and accessing reputable online resources related to human anatomy and physiology.

- Digital organization: students will learn to use note-taking apps and organizational features on their smartphones to create and organize digital notes, bookmarks, and folders for efficient access to resources.

#### Attitude:

- Appreciation for smartphone features: Students will develop an appreciation for the versatility and potential of smartphones as valuable tools for learning and exploration in the area of human anatomy and physiology.
- Openness to Technology Integration: students develop a positive attitude toward integrating technology into the classroom and recognize its benefits for enhancing the learning experience.

### Session description

- pre-lab activities
- work in the laboratory
- homework and assignments
- Summative evaluation

An example of biological laboratory work in the context of adapted teaching and the incorporation of modern working methods is the effect of various substances on protein coagulation. In addition to the acquisition of knowledge and skills, the laboratory exercise can also include motivation, emotions, and fun related to informal experiences (e.g., preparing egg dishes) and the use of smart cell phones. In this way, in addition to acquiring knowledge and manual skills, students can develop information and computer skills and strengthen their digital literacy.

The aim and purpose of the research is to present the use of smart phones as a tool to measure and control measurement data. A lab work on protein coagulation in egg white was chosen as a template for the presentation. The lab work in its original form was developed to be performed in computer-based lab work using stationary computers and the e-ProLab analog-to-digital converter. This adaptation of a laboratory exercise to measure the coagulation rate of protein with a cell phone used an exposure meter built into the phone that was activated by the appropriate application. The laboratory exercise was based on demonstrating the effect of different coagulants (temperature, acid, and alcohol) and the difference between the transparency of an egg white suspension before and after coagulation. Instead of hydrochloric acid, which is found in the digestive system, we used acetic acid, which we all have at home, showing the simulation of gastric juice. The results of the measurements made are explained with real examples, e.g. the effect of temperature on proteins is usefully related to what happens in the human body during sunbathing, the effect of acid to what happens in the stomach, and the effect of alcohol on coagulation to what happens in cell membranes.

In this exercise, participants will use their smartphone as a coagulation sensor.

## Activity 3: Coagulation



### Worksheet

#### LIGHT METER IN MOBILE PHONE

Smartphones with all their functions and meters can be excellent experimental and didactic tools. The light meter is enabled on the smartphone and is used to control the exposure on the LCD screen and can automatically adjust the brightness of the screen.

Luminosity is a physical and photometric quantity with which we measure the total light flux falling on a surface or emitted by a unit of surface in a spatial angle, or the luminance per unit of surface of light traveling in a given direction. Brightness is measured in units called lux - this is the unit of light emitting power, where we calculate the flow of light per unit of surface area. Luminance describes how strong a light source reaches the human eye.

The light meter on the smartphone can be activated and tested using various applications, including the Phyphox application. The written application was developed at RWTH (Rheinisch-Westfälische Technische Hochschule) and is available on Android systems, Google Play. The application can be downloaded for free. In addition to all the other functions of the Phyphox application, we can also measure light intensity. In real time, the application draws a graph showing the relationship between time and light intensity. Phyphox does not support the light sensor on iOS devices. If you need a light sensor, you need to use Android devices or some other light measurement app to test.

Proteins are indispensable biomolecules found in all living organisms. Their diversity in structure and function results from the variety of their monomeric units, the amino acids. They are involved in almost all biological processes important for the life of organisms. The properties of proteins, including coagulation, have been well studied. Egg white contains proteins that are not heat resistant. The temperature that protein molecules can withstand depends on their structure. The addition of energy during heating causes bonds in the protein molecules to break - a phenomenon known as coagulation. Coagulation can also occur in other ways, e.g., with acids and bases, with heavy metal salts, other proteins (e.g., proteins in snake venom, rennet), and with a number of organic compounds (alcohols, alkaloids). Irreversible coagulation is also the coagulation of protein when heated in a pan. In solution coagulation, the protein is separated (precipitated) from the suspension.

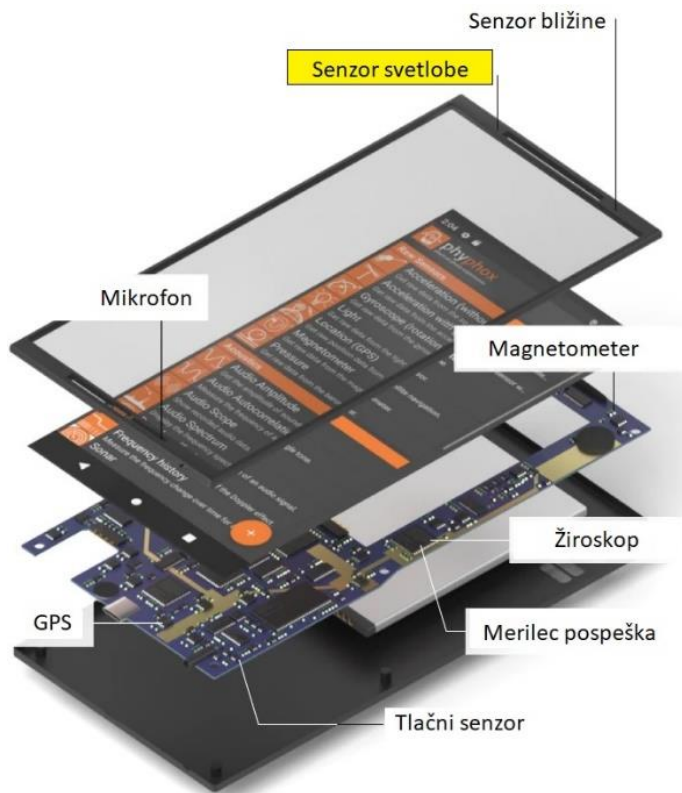


Photo: Meters in a mobile phone that can be used for experimental work (Phyphox)

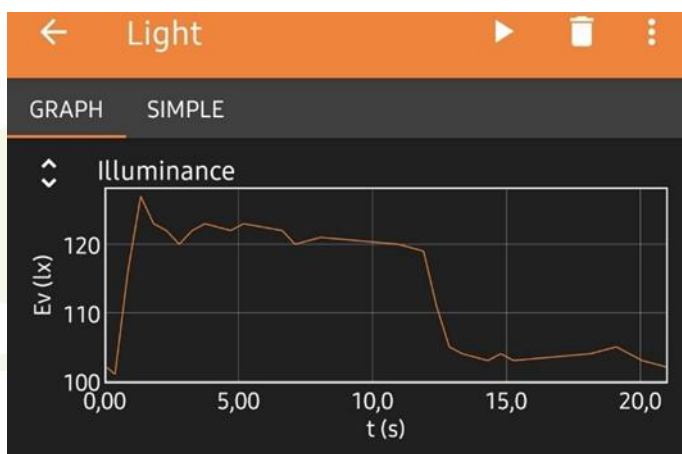


Photo: Example of displaying the results of light measurement in real time (smartphone screen capture, copyright image).

**The chosen Phyphox application has some advantages in presenting concepts, as the measured data can be directly and wirelessly exported to Excel and analyzed. We can also save the data or share it with any other application on the phone.**



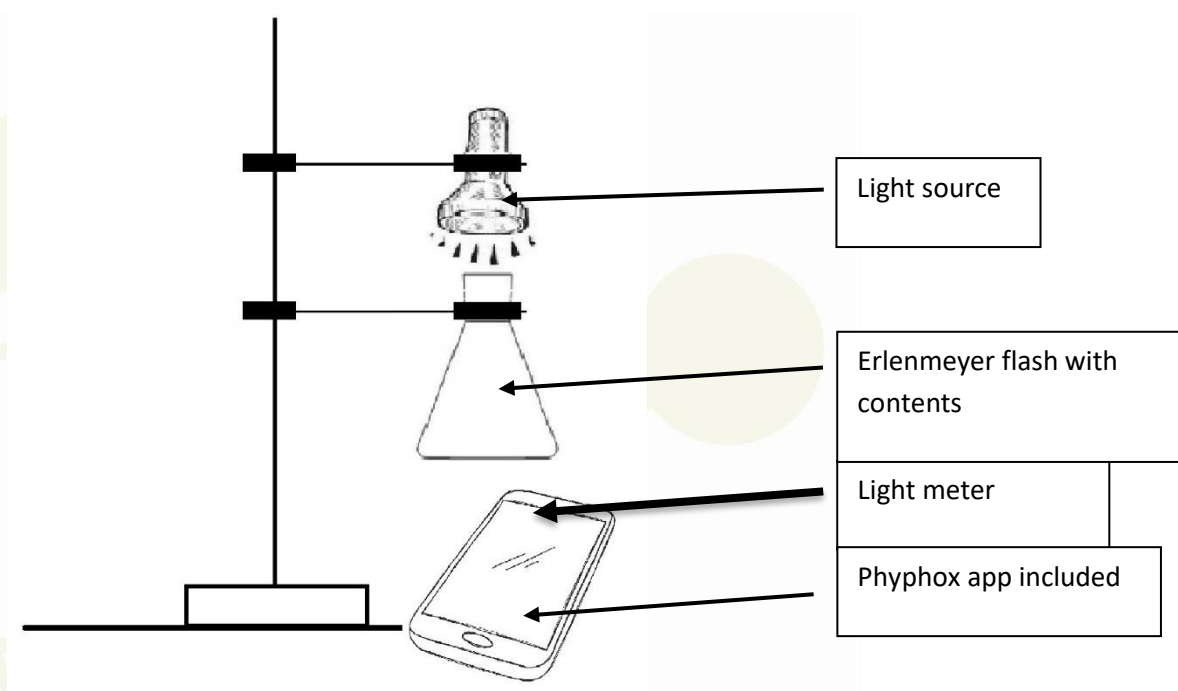


## LET'S GO EXPERIMENTING

### Part 1: Coagulation

For the experimental part, we need inventory and chemicals that can also be found at home, so the experimental part is feasible in the home environment. The material is listed in Table 1. The egg white suspension is made from chicken eggs in a volume ratio of 1:1. Break the eggs by hand, separate the whites from the yolks. Mix the egg whites gently by hand with a glass stick and then make a suspension of egg white and water in a volume ratio of 1:1.

Inventory	Chemicals
<ul style="list-style-type: none"> <li>• stand,</li> <li>• universal clamp,</li> <li>• double muff,</li> <li>• Erlenmeyer flask,</li> <li>• heater,</li> <li>• thermometer,</li> <li>• smartphone (Phyphox application),</li> <li>• a flashlight (or a flashlight on a mobile phone).</li> </ul>	<ul style="list-style-type: none"> <li>• suspension of egg white with water (1:1),</li> <li>• water of different temperatures (25 °C, 65 °C, 80 °C, 100 °C),</li> <li>• acetic acid, <math>\text{CH}_3\text{COOH}(\text{aq})</math> different concentrations (9%, 25%, 50%, 99%),</li> <li>• ethanol <math>\text{C}_2\text{H}_5\text{OH}(\text{aq})</math> different concentrations (70%, 96%)</li> </ul>



Sketch of the assembled apparatus (author's image).

We assemble the apparatus (Fig.) by attaching the clamp to a tripod with a double base, into which we clamp an Erlenmeyer flask. Above the Erlenmeyer flask, we attach another peg on which we place a lamp or a cell phone with a lamp. We place a smartphone under the Erlenmeyer flask, on which we start the Phyphox application and the "Light Sensor" function to measure the illumination. If the experiment is conducted in the home environment, we assemble a similar device from the tools available at home. We must make sure that the phone is always in the same place during the measurement.

Prepare an egg white solution in a 1:1 volume ratio. Put the water in the beaker on the heater and check the temperature of the water we need for the experiment.

- Add 4 mL of the protein suspension to the blank sample in the conical flask. We shine the light through the conical flask and start measuring the light transmission through the sample with the application.
- The experiment continues with the addition of other chemicals by first measuring the transmittance of 4 mL of the protein suspension, stopping the application, adding 5 mL of a chemical, and continuing the measurement.
- We export the data to Excel and analyze them.
- We make sure that we stand in the same place during the measurement and do not create an unnecessary shadow.
- We repeat the measurements three times with each sample.



During the experimental work, we checked the changes in the brightness of protein solutions before and after coagulation. Coagulation was performed at different water temperatures and with different chemicals: Acetic acid at different concentrations, ethanol at different concentrations. The same amount of coagulant was added to all replicates to compare the results. The result of the coagulation of the egg white is an optical change due to the transformation of the internal system and the coagulation of the egg white proteins. The exposure meter detects a decrease in the transparency of the egg white suspension during protein coagulation, and it also detects the speed of coagulation when a certain chemical or agent that triggers coagulation is added.

Results:

#### **- Effect of temperature on proteins**

Students discuss and learn what happens to proteins in the human body when they are exposed to excessive sunlight.

#### **- Effect of Acetic Acid on proteins**



Students learn where and how acids act in the human body.

### **- Effect of alcohols on proteins**

Students learn about the effect of alcohol on cell membranes in the human body.



## EVALUATION OF THE WORKSHOP:

We are interested in your opinion about the use of the tablet in the workshop:

### 1. Because of the use of “smartoscope”, the exercise was:

(Please check only one circle in each row).

	1 – I do not agree at all	2 – I do not agree	3 – I partially disagree	4 – I neither agree nor disagree	5 – I partially agree	6 – I agree	7 – I completely agree
a) fun	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) instructive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) understandable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) unpretentious	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e) successful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

experimenting in science. We examined an example of a laboratory exercise on the topic of protein coagulation using a mobile phone and a light meter. Laboratory exercise is suitable for implementation in primary and secondary school as a study of the influence of various factors on protein coagulation. The results are in line with the expected results for most of the studied factors, however, the method in question would not be suitable for performing more accurate laboratory measurements and scientific study of coagulation. With this exercise, we show students the coagulation of proteins in a simple and understandable way, and at the same time we train them in laboratory work. The laboratory exercise included the use of the freely available Phyphox application and materials that are also available to students in the home environment, especially in cases of school closures, such as during the Covid-19 epidemic, where laboratory work was neglected. From the results of the exercise we conclude that smartphones with built-in meters are a suitable measuring aid in laboratory work, which can be performed in the learning process in the home environment or in distance learning.