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Responsible Research and Innovation (RRI)

Natural nanomaterials

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Universitatea Valahia din Targoviste

Natural nanomaterials

Structure determines the physical properties

An educational module for the chemistry, phisics and biology - lessons for primary and lower secondary school levels, developed by Romanian teachers from Târgovişte.

Developed within the framework of the European project -IRRESISTIBLE – Engaging the Young with Responsible -Research and Innovation – www.irresistible–project.eu

Developers

Proposed by:

- Prof. Adela VĂTAVU (School „Iulian Rusu" Mărceşti)
- Prof. Georgiana Flory ŞTEFAN (School „Ioan Alexandru Brătescu-Voinești")

Revised by:

- Assoc.Prof.PhD. Luminița Mihaela DRĂGHICESCU
- Lect.PhD. Ana Maria Aurelia PETRESCU (Valahia University of Targoviste)
- Romanian Community of Learners (IRRESISTIBLE Project)

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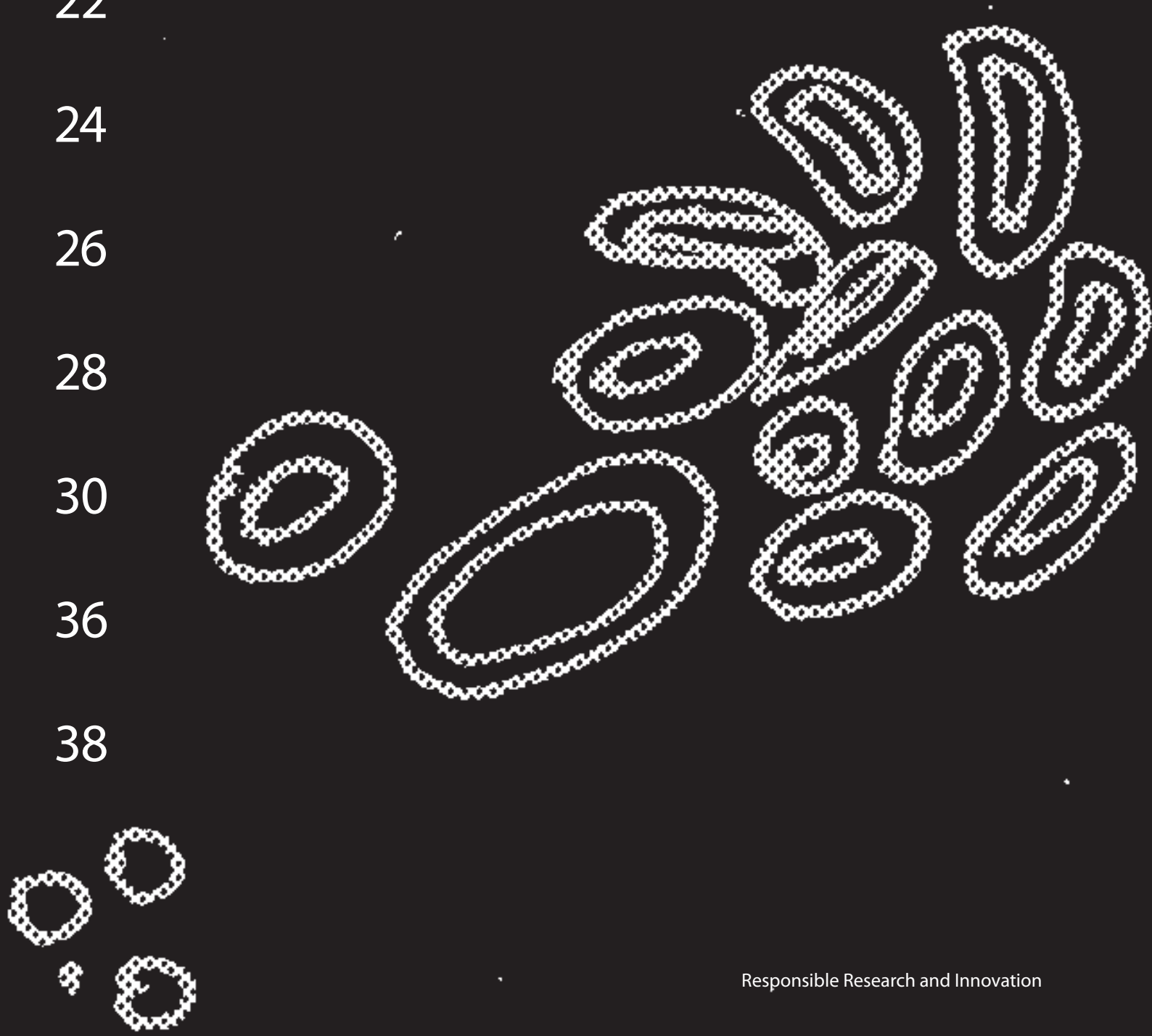


1 Overview

Natural nanomaterials

Natural Nanomaterials teaching activities are designed to increase awareness of students regarding the existence of natural nanomaterials. In this regard experimental approaches will be used to highlight the nanoparticles in natural nanomaterials and to establish structure-function correlations. Through these activities students will express their opinion on nanotechnologies and will develop a responsible attitude towards maintaining health.

What we intend:

1. To demonstrate how structure determines the physical properties (color, smell): natural materials such as milk, are the way they are due to their nanostructure. Milk is white because it contains colloidal nanoparticles (micelles). If you change the structure of these micelles, you change some "macro" properties of milk like color and odor.

2. Explain how the structure of a material imposes function: natural materials have specific functions that are required by the organization of their molecules (nanostructures). If this order changes we get a material with a new function. In cheese production, altering the casein micelles through specific processes (eg. chymosin treatment or lactic acid fermentation bacteria) leads to different products (cheese, yogurt).

So what we try to achieve through educational activities based mainly on scientific research, experiment and demonstration has as a premise the concept of nanotechnology - to invent new materials with new functions by manipulating their molecular structure.

Overview

Grade/Educational level	Primary (p), lower secondary (l.s.)
School subject	Science
Learning unit	The human body functions. The function of digestion. Food and health
Module theme(s)	**Natural Nanomaterials**
Specific competences	1. understanding and explaining the phenomena, processes, materials and procedures encountered in everyday life; 2. investigating the behavior of materials, chemical and biochemical systems in order to establish structure-function correlations; 3. explaining the importance of phenomena, processes and materials for particular areas of activity; 4. theoretical acquisitions capitalization for problem solving situations, to formulate explanations in the investigation and results reporting; 5. evaluating the consequences of the phenomena, processes and materials' actions on his person and the environment.

Derived competences	1.1. highlighting experimentally the nanostructure of milk and gelatine; 1.2. use of laboratory equipment and information technologies for the study of natural nanomaterials; 2.1. analyzing and interpreting the observations / data derived from the investigative work; 2.2. explaining structural changes in molecules; 2.3. argumenting the importance of structure changes in functional determination of nanomaterials; 3.1. exemplify the specific situations of life in which nanomaterials have applicability (processing of milk - yoghurt, cheese); 4.1. communication written and oral of the investigation results using appropriate scientific terminology; 5.1. analysis of the benefits and limits of natural nanomaterials and nanotechnologies use; 5.2. expressing personal opinion associated with a responsible attitude in regard of use on an industrial scale (the food industry) of such products, given the need to promote healthy products in people's lives; 5.3. expressing personal view about the importance of involving social actors in nanosciences' scientific research.
Required preconditions	Knowledge regarding milk composition, pH, micellar structure; Skills for use of laboratory tools, effective communication and teamwork; Attitudes of respect for the truth, valorisation of scientific knowledge, respect for themselves, for others and for the environment; interest for the use of various types of communication.

	Teaching-methods and procedures	Heuristic conversation, observation, experiment, problem solving, case study, explanation, brainstorming, guided discovery, scientific investigation, systematic observation, portfolio
Procedural resources (teaching strategy)	Educational means	L1-E1. transparent containers with milk, gelatin grains, transparent cups for water, wand to mix the solution, bowl with warm water (for heating the water-gelatin solution) (materials required for each group) L1-E2. 1 cup of 150 ml with water, 1 cup of 150 ml with milk at room temperature, 1 glass with 5 ml milk + 145 ml of water and 1 cup with water (about 140 ml) and 10 g of gelatin powder dissolved, pen laser, mixing wand, bowl with warm water (about 1000 C), blank sheet of paper, table (materials required for each group) L1-E3. incomplete pattern sheets, blackboard, chalk L2-E1. two glasses of 400ml, pot with water temp. 1000 C, pH meter or pH indicator paper, 80 ml lemon juice, 2 sticks for stirring, thermometer L2-E2. observation sheets L2-E3. Images with milk's micellar structure L2-E4. containers of yogurt, kefir, buttermilk, cheese various sorts (ripened cheese, fermented cheese, mold cheese), jelly, table L3-E1. documentation sheets, group report L3-E2. flipchart sheets, markers, questionnaires, summary L4 - PPT, PC, posters
	Forms of activity organization	Frontal, in groups, individual
Estimated time		4 lessons / extracurricular activities

For learning activities proposed to be undergone during the natural nanomaterials lesson it is assumed that students know:

- **differences between a fluid and a colloid,**
- **origin of natural nanomaterials,**
- **use of milk and gelatine,**
- **information about health policies.**

Short Theoretical Background

Nature represents the most appropriate way to find resources or inspiration in various fields. Here we find solutions to most complex problems, including those in nanosciences. Many materials that belong to the natural world (animal and mineral) have properties which are the result of inherent nanostructure.

The interaction of light, water and other materials with these nanostructures gives the outstanding properties of natural materials, which can be seen with the naked eye. These nanostructures resulting in supra-molecular organization of the material: tens to hundreds of molecules which are arranged into shapes and structures on the nanoscale. In everyday life we encounter hundreds of useful examples of nanoscience, from geckos that walk on ceiling, seemingly defying the laws of gravity, to butterflies or fireflies which have iridescent colors that shine at night.

In this regard, in the experiments intended to be carried we presented as natural nanomaterials milk and gelatin which are both products with a colloidal structure.

The colloid is a chemical mixture between a liquid and particles suspended in that liquid but not dissolved in it. This occurs because the particles in a colloid are larger than in a solution. A colloid is composed of particles which are between 10-300 nm. They are small enough to be dispersed evenly and maintain the homogenous appearance, but large enough to diffuse light. Particles in a colloid are well dispersed so that they have the appearance of a solution (for example transparent). Thus, a simple way to test a substance to see if it is a colloid is to use a laser beam that will have its light diffused by a colloid.

Gelatin is a protein extracted from animal bones, cartilage and other types of tissue, being produced by the partial hydrolysis of collagen in conjunctive type tissue. During the partial hydrolysis of collagen some of the molecular bonds between collagen particles are broken and their rearrangement is much simpler. By mixing powdered gelatin in water a viscous solution will form, a colloidal gel. The solution will get a liquid-viscous aspect when heated and a gel with pronounced consistency when cooled down.

Milk is an animal product which contains many biomolecules such as proteins and lipids. Proteins are between 2.5-3.5%, and of these, 80% are caseins. Some of these proteins are phosphoproteines precipitated at a pH of 4.6. Another property of caseins is that they are present as micelles of casein (50-300nm) containing calcium, phosphorus and minor amounts of citrate. Micellar casein is considered to have a complex structure composed of hydrophobic and electrostatic interdependence interactions. Maintenance of micelles' integrity represents a balancing act and there are numerous ways which disrupt this balance. These methods are widely used in the dairy industry and in producing cheese and fermented products such as yogurt.

The increase of pH (to about 8) leads to the dissociation of the casein micelles causing the heated milk to become more translucent. This happens because by increasing the pH phosphoseril groups change from units loaded once to units loaded twice which can no longer bind calcium phosphate nanaoclusters. Increased negative charge of the micelles induces electrostatic repulsion, and therefore micelles dissociate.

The decrease in pH to the isoelectric point (4.6) induces dissociation of the casein micelles. This is due to the fact that the calcium micelles exist because of the calcium phosphate; therefore its dissolution causes necessary changes in the stability of micelles. If an acid is added (proton donor) to the milk, phosphoseril and carboxyl groups of proteins are protonated so that they can't interact, in terms of electrostatic energy, with the nanoclusters of calcium phosphate, and they are released from the micelles. It is noted that this does not necessarily lead to dissociation of the casein micelles. At temperatures below 25° C, dissociation occurs at a larger scale, but otherwise the caseins remain in the micelles. This effect will be tested in this experiment by adding lemon juice as a source of acid (citric acid) to cold milk. The cause resides in the fact that the stability of casein micelles is not exclusively linked only to electrostatic interaction, but also hydrophobic interactions.

The last ones are temperature-dependent: hydrophobic interactions are stronger at higher temperatures. For this reason hydrophobic interactions maintain the stability of casein micelles in cold milk even when its pH has been lowered to the isoelectric point. On the other hand, if souring occurs after the milk has been heated (to about 60° C), the micelles are dissociated (calcium phosphate is liberated from the mycelium) and will aggregate due to increased electrostatic forces and hydrophobic interaction. This will be tested by adding lemon juice in hot or cold milk. The attack of chymosine leads to micelle precipitation and formation of a clot. This process is used in cheese production. Chymosine is an enzyme which represents the active ingredient from the clot and the extract from calfs' stomachs which have not yet consumed plants is used for the manufacture of cheese. Chymosine specifically attacks a single bond in k-casein. The presence of k-caseins is fundamental for the overall stability of the casein micelles; for this reason its dislocation causes the loss of stability of the micelle, its aggregation and finally, formation of a clot.

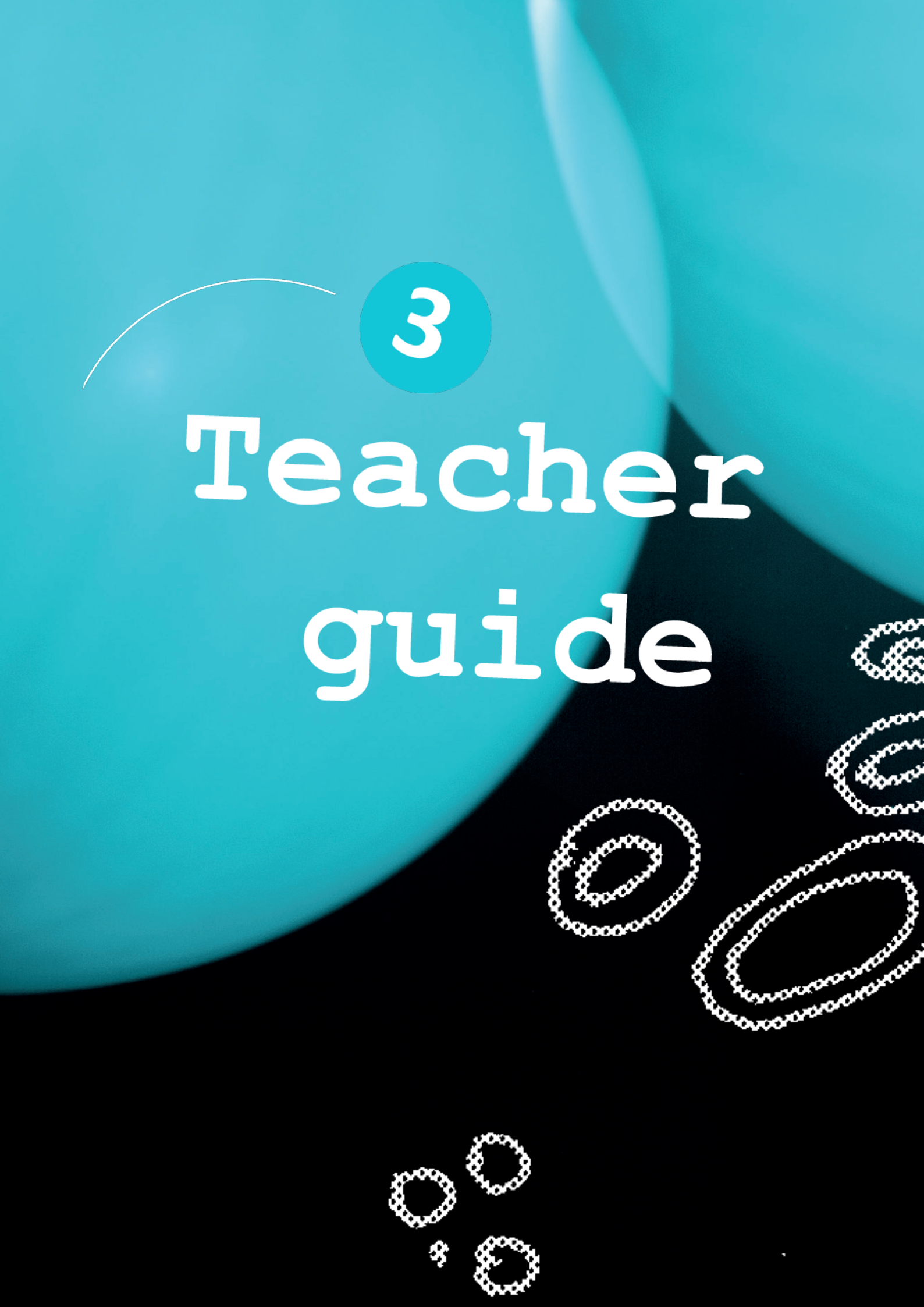
Educational scenario

Steps of teaching approach/time management	Derived competences (codes)	Teacher activity	Learning activities**
1. Engage	4.1, 5.1, 5.2, 5.3	- Plan the learning activities; - Make student groups; - Establish together with students the phases of inquiry-based scientific learning; - Indicates to students links for documentation (bibliography / Webography).	- Students create a mini exhibition of posters or PowerPoint presentations showing the latest news in the field of nanotechnologies on the Natural Nanomaterials subject; -Students present their view about the advantages and limitations of nanotechnologies and create a blog (Choose, eat healthy!) in which they will express their opinion on the advantages and disadvantages of dairy consumption, showing a responsible attitude towards the marketing of certain dairy products.
2. Explore	1.1, 1.2 2.1, 2.2, 2.3	- Present the existing problem in order to be investigated; - Presents specific requirements for the investigative activity; - Inform students about how to register, organize, process and present the information (after each activity a product will be created); - Presents labor protection rules; - Provides students with the materials needed to perform experiments; - Monitors and guides students during the experiments.	- Work with laboratory instruments, make hypotheses, conduct experiments; - Records collected data; - Fill tables, graphs; - Check the solutions which have been found.

Learning activities**	Educational strategy			Evaluation
	Teaching methods and procedures	Means of education	Forms of organisation	
- Activity products (PowerPoint presentations, posters, blog); - Knowledge (and latest news) regarding nanotechnologies; - Technical skills (use of media tools).	heuristic conversation, explanation questioning, brainstorming	PC, projector, bibliography, posters	frontal	oral assessment, systematic observation, evaluation grid - G2
- Knowledge regarding milk composition, its properties and nano-structure; - Activity products (images, photos).	experiment, observation, conversation, guided discovery, scientific inquiry, questioning	E1. transparent containers with milk, gelatin grains, transparent cups, water, rod to mix the solution, bowl with warm water (for heating the water-gelatin solution) (materials required for a group); E2. One 150 ml cup of water, one 150 ml cup of milk at room temperature, 1 glass containing 5 ml milk and 145 ml of water and 1 cup containing water(about 140 ml) and 10 g of gelatin powder dissolved, pen laser, stirring rod, bowl with warm water (about 1000C), blank sheet of paper, table (material required for each group); incomplete pattern sheets, blackboard, chalk; E3 two glasses of 400ml, pot with water temp. 1000 C, pH meter or pH indicator paper, 80 ml lemon juice, 2 stirring rods, thermometer; observation sheets Images with milk's micellar structure, containers of yogurt, kefir, buttermilk, cheese of various sorts (ripened cheese, fermented cheese, mold cheese), jelly, table	frontal, in groups, individually	practical examinations, systematic observation, evaluation grid - G1

3. Explain	2.1, 2.2, 2.3, 3.1	- Provides students with information and images illustrating the latest discoveries in the field of natural nanomaterials; - Provides support to students in structuring the obtained information; - Provides feedback to students; - Helps the restructure / addition / correction of the information obtained assessing its socio-scientific value and capitalizing on the provided feedback.	- Disseminates in groups / class the scientific knowledge identified; - Provides feedback to their peers; - Restructures / adds / corrects knowledge with reference to the feedback and their socio-scientific value.
4. Elaborate	5.1, 5.2, 5.3	- Organizes a learning environment which is motivating, stimulating and likely to place the student in the position of a responsible researcher; - Invites researchers, experts etc. so that students can ask questions in order to deepen their knowledge on the specified topic	- The students who are "experts" in various scientific problems consult scientists in order to inform (prior to producing reports) and restructure / fill / reorganize information.
5. Disseminate / Share / Present / Expose	5.1, 5.2, 5.3	- Manages discussions; - Designs with students an exhibition which will be open for the public in museums and / or libraries. Within the exhibition there will be posters, videos, models and other items made by students; - Coordinates the selection of the most relevant / representative projects made by students	- Experts submit reports, products of their inquiry work, argue their choices, assumptions, and conclusions. - Participates in the selection of the most relevant / representative projects.
6. Evaluate	3.1, 4.1, 5.1, 5.2, 5.3	- Evaluate portfolios, check that students have achieved sustainable acquisition considering the prior established aims; - Ensure a combination of evaluation inter assessment and self-evaluation.	- fill the grids G4, G5, G6

-Tables, questionnaires, completed observation sheets	Explanation, conversation	table layouts, fact sheets, questionnaires	Face to face, in groups	oral assessment, systematic observation, evaluation grid - G4, G5
- Report drafts, web addresses (used in producing reports)	explanation, case study, brainstorming, debate	reports, worksheets, PC, projector	in groups, frontal	oral assessment, systematic observation, evaluation-grid G3, G2
- Experts' reports and their attachments	conversation, explanation, case study	experts' reports	frontal	oral assessment, analysis of the activity products, evaluation grid - G2
- filled evaluation grids: G4, G5, G6	brainstorming, conversation	grid G6	frontal	oral assessment, portfolio, assessment grids - G4, G5, G6.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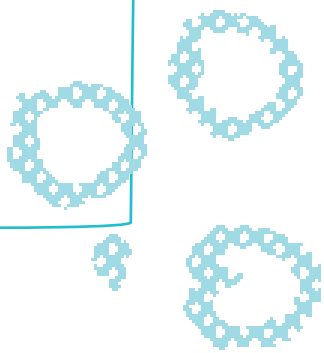
Teacher guide

Teacher guide



This educational activity

facilitates the acquisition / forming of new knowledge, skills, attitudes etc. and covers:

a) colloidal structure of the materials used (in this case of milk and gelatine);

b) how the structure of a material imposes new features and functionalities;

c) advertisement of healthy products for people and the environment;

d) respect for the work involved by responsible scientific research;

e) the civic responsibility of every individual to make appropriate decisions with impact on the environment.

Learning results

At the end of the **first lesson**, the students will be capable to:
- To list the properties of natural materials like milk and gelatine (color, general aspects regarding the material's density, taste, smell);
- To explain what aspect modifications (color, density) resulted from subjecting these materials to a range of treatments (heating - heating);
- To highlight the colloidal structure of analyzed nanomaterials by observing the appearance of a laser beam crossing them (light absorption).

At the end of the **second lesson**, the students will be capable to:
- To highlight structure-property-function correlation according to the type of colloidal material, such as milk;
- To explain (according to their level of development and understanding) how yoghurt and simple cheese are produced.

At the end of the **third lesson**, the students will be capable to:
- To present and reason a personal perspective on the advertisement of healthy food for the population;
- To explain the importance of responsible civic manifestation of an attitude towards health, due to the use of nanotechnology.

At the end of the **fourth lesson**, the students will be capable to:
- To present their work products using a PowerPoint presentation, poster or blog (portfolio) in a mini-exhibition;
- To explain the socially appropriate use of nanotechnology.

Recommended training modalities

The teaching activities within the Natural Nanomaterials theme involve capitalization of basic knowledge from the following subjects: chemistry, physics, biology, civic culture. Their development is achieved through inquiry-based methods such as determination, experiment, interpretation and debate involving a manifestation of civic and appropriate attitudes towards the current problems of society (health, research, civics).

Throughout the promoted teaching strategies, in particular inductive, deductive and heuristic, students will form / develop skills / abilities such as exploration and investigation, communication and effective group work, analysis and synthesis, evaluation and anticipation etc. Students will realize also the need to respect ethical principles and values in making research and innovation.

3.1. Lesson 1

In the first lesson, students get acquainted with a series of concepts regarding properties of natural nanomaterials.

Moments of lesson no. 1

a) Description of the proposed natural nanomaterials (milk and gelatin), in terms of origin, physical characteristics and acquaintance with some concepts that will be used later.
Educational methods: experiment, systematic observation, explanation, guided discovery, brainstorming
Means of education: transparent containers with milk, gelatin grains, transparent cups, water, stirring rod to mix the solution, bowl with warm water (for heating the water-gelatin)
Forms of activity organization: frontal, in groups
Description of the investigative demarche

Experiment procedure (E1)

There will be three groups of students who will receive materials needed to run experiments and determine the origin of the materials which are investigated. They will also identify the visible properties of those nanomaterials.
Questions for guidance throughout the inquiry
-What are milk and gelatin?
-Where do they come from?
-What physical properties of these materials can you identify? (color, smell, taste)
-What happens with the water-gelatin solution when is heated?
-But if we cool it down?
-What can happen to milk if we store it over its shelf life?
-Does it have the same properties as the milk within its validity term?

b) Highlighting the colloidal structure of milk and gelatine
Educational methods: experiment, systematic observation, guided discovery, explanation
Means of education:

- one 150 ml cup with water
- one 150 ml cup with room temperature milk
- one cup containing 5 ml of milk + 145 ml of water
- one cup with 140 ml of water and 10 g of gelatine powder dissolved
- laser pen
- stirring rod
- bowl with hot water (100 0C)

- blank sheet of paper
- table

Forms of activity organization: groups of 4 students

Description of the investigative demarche

Experiment procedure (E2)

Students will be divided into 4 groups. Every group will receive glasses of water, milk, gelatin dissolved in water, milk-water mixture, stirring rod, hot water pot and laser-pen. Gelatin granules will be mixed with 140 ml of water and homogenized.

Subsequently, the glass containing the mixture is inserted carefully into the bowl with hot water and mixing is continued until the solution has a relatively fluent appearance. Remove the glass with gelatin from the bowl with hot water and place it next to the other glasses. Students will be required to point a laser beam at each of these glasses and place a white paper on the opposite side of each glass, recording their comments on an experimental grid of the following type:

Table 1. Experimental data sheet

Sample	It allows the light beam to cross	Light trail (uniform, focus, diffuse)	It is a colloid
Water			
Milk			
Water+milk			
Water-gelatin			

c) Establishing conclusions

Educational methods: systematic observation, heuristic conversation, brainstorming

Means of education: incomplete data sheets, blackboard, chalk

Forms of activity organization: frontal

Description of inquiry approach

Students will receive one sheet to interpret the results of the experiments conducted and establish conclusions. Students will fill the gaps in an incomplete text:

The nanoparticles are suspended in the sample and when the laser light hits them it changes direction. This is seen as a beam in samples..... and.....

The laser forms a spot of scattered light in the sample if the particles are so dense that light can not pass through them, as shown in the sample .....

In the sample..... the light passes without hitting anything and so we can not see the laser light. In conclusion, milk and gelatin are .....

3.2. Lesson 2

The second lesson is more of an experimental type, focused on highlighting the correlation between structure and function of a natural nanomaterial. Meanwhile, in this lesson a number of food products that use properties of these natural nanomaterials will be identified.

Moments of lesson no. 2

a) Highlighting the effect of interaction between milk and citric acid

Educational methods: experiment, explanation, inquiry based learning

Means of education (for each group):

- Two glasses with 400 ml of milk
- Bowl with water at 100^0C
- pHmetre or pH indicating paper
- 80 ml lemon juice
- 2 stirring wands
- Thermometer

Forms of activity organization: in 3 groups

Description of the investigative demarche

Students will be divided into 3 groups and will perform the experiments highlight the interaction between different substances.

Experiment procedure (E3)

pH is measured for each glass of milk with a pH meter or indicator paper. The obtain data is written in a table. One of the glasses with milk is put in the bowl with hot water and hold there until the temperature reaches 60^0C. In this cup (P1) 40 ml of lemon juice are mixed with the aid of the rod and then the pH is determined and noted in a table.

Over the milk from the second glass (P2) 40 ml of lemon juice are added too, mixed with the aid of the rod and the pH is determined.

Table 2. Tabel model

Sample	Initial pH	Temperature	Final pH	Observation
P1				
P2				

b) Establishing changes in the structure, function and properties of milk

Educational methods: systematic observation, heuristic conversation, explanation

Means of education: observation sheets

Forms of activity organization: in groups, frontal

Description of inquiry approach

After students have conducted the experiments they will note what they found during them. They will compare whether the observations are the same or different and will specify the nature of the changes and how they were produced.

Observation sheet

The effect of lemon juice was the same in both samples? If yes, please explain! If not, please explain! What do you think is the explanation of what happened? The sample with simple milk has the same properties as P1? What changed? Do you know an application of this process?

c) Explaining the effect of interaction between milk and citric acid

Educational methods: explanation

Means of education: images with milk's micellar structure

Forms of activity organization: frontal

Description of inquiry approach

The teacher presents images casein micelle structure in milk. Specify using the appropriate level of students' understanding the way milk transforms under the action of citric acid (hydrophobic poles of beta casein polymer).

d) Identifying nanomaterials used in food industry

Educational methods: brainstorming, case study

Means of education: containers of yogurt, kefir, buttermilk, cheese of various sorts (ripened cheese, fermented cheese, blue cheese), jelly, table

Forms of activity organization: frontal

Description of inquiry approach

Through brainstorming students are asked to name foods which use milk or gelatin nanostructure. Students will observe and subsequently analyze differences in appearance, texture and taste. The data will be centralized in a table like the one below.

Table 3

Product	Fluidity / density (for yogurt, kefir, buttermilk)	Creamy or inhomogeneous appearance (cheese)	Odor	Taste
Yogurt				
Buttermilk				
Kefir				
Ripened cheese				
Fermented cheese				
Blue cheese				

3.3. Lesson 3

The third lesson is a debate-like activity; students will be divided into three groups of experts - doctors, businessmen, politicians. Each of the three groups of experts has studied from their own perspective (a doctor, the businessman and the politician) the implications of nanotechnologies (by default uses of natural nanomaterials in the food industry) in the daily life of citizens. They will argue the need to use these materials, their usefulness advantages. The experts will make reports which subsequently will be presented and argue in front of the others.

Moments of lesson No. 3

a) **Launch of the problem - approaching from a certain perspective the use of nanotechnology (with specific applications of milk and gelatin) in order raise civic and moral responsibility of students**

Educational methods and procedures: case study, problem raising, heuristic conversation

Means of education: documentation sheets, group report

Forms of activity organization: in groups of experts

Description of of inquiry approach

The teacher proposes students to study from a certain perspective a problem with the use of nanotechnologies. To achieve this objective students opt for one of the expert groups, gather information and participate to report elaboration.

To prepare the report, the experts, no matter what kind, will consider the following:

- **Doctors** – will provide a brief overview of the importance of milk consumption for human health, depending on age. They will present how they intervene in certain physiological processes of the human body. They will also consider the possible contraindications of drinking milk (lactose intolerance, stimulating bone decalcification etc.), will analyze the impact of positive / negative of dairy consumption in daily life, will make a presentation of how the natural nanomaterials contribute beneficially or not to protection of consumers' health, will raise the issues of respecting the people who have chosen to undergo an exclusively vegetarian regime;
- **Businessmen** – will make a presentation regarding areas of dairy processing, procedures for obtaining various dairy products (modern techniques and traditional), will presented the profitable marketing strategy from the perspective of the manufacturer / supplier of product, will analyze the impact of introducing on the market traditional milk products (sheep cheese, cottage ripened cheese, fresh curd) or licensed ones (like mozzarella, mascarpone, gorgonzola), from a financial perspective;
- **Politicians** – will present the manner in which the promotion of public health policies can produce effects at a social level, will make a plan to promote scientific research in the field of health, will argue the usefulness / importance of this plan, will illustrate the manner in which politicians intervene as decisive factors in public health policies.

b) Comparative Analysis and Conclusions – Discussing reports of expert groups in order to establish the utility, advantages, disadvantages, opportunity, necessity and impact of natural

nanomaterials as healthy products for the population
Educational methods: conversation, explanation, case study
Means of education: flipchart sheets, markers, questionnaires, breviary
Forms of activity organization: frontal
Description of the investigative demarche
After the expert groups' presentations students will clarify a number of issues answering the questions contained in a questionnaire.

Questioner model:
Which are the strongest expert groups' arguments? (list)
- To what extent the use of the right argument (for me personally) manages to convince me? (fit the answer into a category – at all, very little, in small measure, to some extent, largely, total)
- What argument was lacking the one who I consider that didn't convince me? (specify)
- How can any of the experts' arguments influence me? (fit the answer into a category – at all, very little, in small measure, to some extent, largely, total)
- Under what conditions can any of the experts make me change my mind? (specify)
- To what extent can I, as a citizen, influence the decision of one of the experts before? (fit the answer into a category – at all, very little, in small measure, to some extent, largely, total).

Subsequently data will be recorded in a summary (breviary) and diagrams will be made.

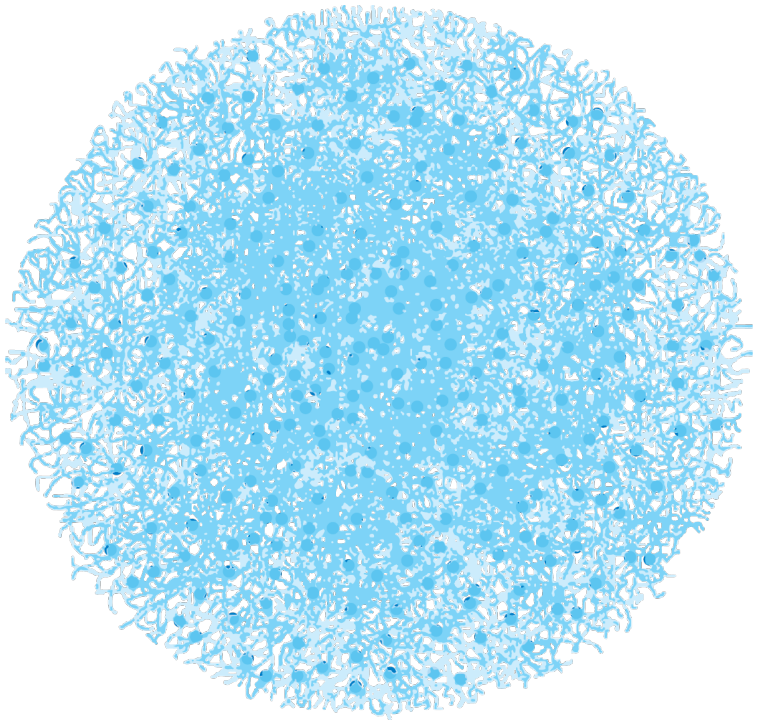


figure 1
The nanocluster model of casein micelles.
Source: Dairy Processing Handbook, Chapter 2, Tetra Pak International SA, http://www.dairyprocessinghandbook.com/chapter/chemistry-milk

3.4. Lesson 4

The fourth lesson is an application type. Students present the latest news in this field, make a mini-exhibition of posters or PowerPoint presentations promoting knowledge in the field of nanotechnology with applications on the subject and a forum: *Choose, eat healthy!*

Moments of lesson No. 4

Educational methods and procedures: explanation, conversation
Means of education: PowerPoint presentations, PC, posters
Forms of activity organization: frontal, in groups
Description of the investigative demarche
Students receive before attending lesson 4 a task which requires them to produce posters or PowerPoint presentations through which to exhibit the latest news in the field of nanotechnology, with applications on the debated theme - Natural Nanomaterials. The teacher will distribute prior to their work a list of references to be consulted. Students will be divided into three groups and will produce and present PowerPoint, posters and forums that will express their views in relation to the news in the field of nanotechnology, with applications on natural nanomaterials; will present the advantages / disadvantages of milk consumption, will express their attitude towards marketing of certain dairy products, taking into account a number of public health policies argued from several perspectives (a person who makes her own decisions in terms of diet, a person who is monitored by health services).

Target competences

Derived competence	Derived competence
1.1. nanostructure experimental evidence of milk and gelatin; 1.2. use laboratory equipment and information technologies for the study of natural nanomaterials;	Comparative experiments highlighting the nanostructure of natural materials
2.1. analyzing and interpreting the observations / data obtained in the course of investigation; 2.2. explaining structural changes in molecules; 2. 3. Reasoning the importance of change in the functional structure of materials;	Experiments highlight the types of milk components Investigations on the structure of colloidal materials Experiments explanations demonstrating the structure-function-properties correlation
3.1. Exemplifying the concrete situations of life in which nanomaterials have applicability (processing of milk - yoghurt, cheese)	Observations on nanotechnology applications in dairy industry
4.1. communicating written and orally the results of the investigation using appropriate scientific terminology;	Explanation of results obtained using specific terminology.
5.1. Analysis of the benefits and limits of natural nanomaterials and nanotechnologies; 5.2. expressing personal opinion, associated with a responsible attitude, with regard to use on an industrial scale (the food industry) of such products, given the need to promote healthy products for people's lives; 5.3. Expressing personal view about the importance of involving social actors in scientific research in nanosciences.	Debates about the benefits and limitations of natural nanomaterials and nanotechnologies use; Explanations on promoting the use of nanotechnologies in the food industry.

3.5. Evaluation

Formative assessment of students aims to:
1. Describe natural nanomaterials;
2. Explain notions like colloid, micelle, casein;
3. Describe the nanostructure of milk and gelatin;
4. Explain structural modifications of molecules;
5. Argue the importance of structural change regarding functional determination of materials;
6. Use laboratory equipment and information technologies for the study of natural nanomaterials;
7. Analyze and interpret the observations / data derived from the investigative activity;
8. Exemplify the concrete situations of life in which nanomaterials have applicability (processing of milk - yoghurt, cheese);
9. Communicate written and orally the results of the investigation using appropriate scientific terminology;
10. Analyze the benefits and limits of natural nanomaterials and nanotechnologies;
11. Express personal opinion, associated with a responsible attitude with regard to use on an industrial scale (the food industry) of such products, given the need to promote healthy products for people's lives
12. Express personal view about the importance of involving social actors in scientific research in nanosciences.

Assessment strategy

1. **Predictive evaluation** will be done in lesson 1, when students' knowledge and skills are targeted; representing prerequisites to acquire new knowledge and the formation of new capabilities. This step will take place during the updating knowledge and skills moment.
2. **Formative evaluation** will be integrated into every lesson and will be achieve through:

- Oral questionnaires;
- Systematic observation of the students' activities (measurements, scoring, handling of instruments, respecting the stages proposed by the protocol etc) by checking the accuracy of data collected and through systematic observations of students' behavior during the proposed activities;
- The project (Power-Point presentation, blog, posters).

3. **Summative assessment** – is present mainly in the 4th lesson, being completed with the help of the portfolio, self-assessment, inter-assessment and oral questioning grids, by filling the SWOT analysis.

Assessment tools

For experiments (E1, E2) from L1, L2 – is assessed the manner of their implementation, the skills to use laboratory tools, the attitude towards the task and the group.

G1 – Grid to assess the experimental phases, the acquisition of the skills to use laboratory instruments, the attitude towards the completion of the task and to the group

Activity sequence	Evaluation criterion	Grades		
		Satisfactory	Good	Very good
Conducting the experiment (E1,E2)	- the arrangement of the materials used	- materials needed to run the experiment are incomplete and randomly arranged	- materials needed to run the experiment are present on the working table, but they are randomly arranged	- all materials are present on the working table and are properly arranged
	- compliance with the labour protocol	- steps of experiment does not follow the order of protocol	- the steps of experiment are undergone hesitantly, in late, but correctly	- experiment steps are followed and manipulation instruments is made without hesitation
	- fill in the tables	- the data from tables contain errors	- the data from tables are correct, but the table is incomplete	- the table contains correct and complete data
	- establish the conclusions (data interpretation)	- no conclusions after the completion of the experiment	- not all the conclusions of the ongoing experiment are present	- clear and complete conclusions
Cooperation within the group	- ability to cooperate and participate in the group	- the student refuses to cooperate	- accepts cooperation in 50% of cases	- constantly participates and cooperates in group actions
	- demonstration of leadership skills - guiding the group through creative thinking and help those who needed assistance	- the student is always withdrawn	- participates, but not as a leader	- get involved, take a leading role, helps his colleagues, when necessary
	- assuming the role / tasks within the group	- the student is reluctant to assume a role in the working group	- accepts his role in the group, but tends to fulfill his colleagues tasks too	- assumes the role within the group, fulfill the tasks.

G2 – Evaluation grid of the PowerPoint presentations, posters, blog (L4)

Activity sequence	Evaluation criterion	Grades		
		Satisfactory	Good	Very good
Elaboration of the Power-Point presentations, posters and blog according to the proposed plan	- ability to comply with the proposed plan	- meets 20% of the plan	- meets 70% of the plan	- fully meets the plan
Development and exploitation of information	- the proper use of data - the selection of relevant data	- errors in data use in 50% of the slides - uses in 50% of the slides data of low relevance	- presents 20% of the slides with redundant data - 20% of the slides contains data not so relevant	-presents conclusive data to over 80% of the slides - the presentation contains data of relevant significance
Interpretation of data obtained	- the use of logical reasoning - argumentation of use of that reasoning - correct interpretation of the data	- data are present, but there is no interpretation - ambiguous presentation of reasoning - inaccurate or misinterpreted data in 40% of cases	- interprets data correctly in 50% of cases - presentation of reasoning, but hesitant argumentation - presentation of reasoning, but hesitant argumentation	- presentation of reasoning, but hesitant argumentation - argumentation of use of a particular reasoning, with evidences in 80% of cases - correct interpretation of the data in requested situations
Establishing conclusions	- the existence of clear conclusions	- conclusions exists, but not shown in the end	- the conclusions are present, but are rendered in an hesitant way	- clear, obvious and logical conclusions

G3 - Assessment tool based on the marks given, by the teacher, to the materials written by students

Activity sequence	Product evaluation criterion	Grades		
		Satisfactory	Good	Very good
Recording of experimental data collected	- elaboration of the table with the measurements made	- the data are written on separate sheets, not in the table	- the data are written on separate sheets, not in the table	The table is correct
Data interpretation and their conclusiveness	- correct interpretation of the data	- the data are present, but inaccurate or incomplete interpretations	- in 20% of cases, data are less conclusive	- conclusive data, interpreted correctly
Scientific reasoning used in interpreting data	- the use of logical reasoning - argumentation of use of a specific reasoning - correct interpretation of the data	- the absence of a particular reasoning or use of a wrong reasoning - the absence of clear argumentation - data interpreted correctly only in 20% of cases	- the use of a partially correct reasoning - partially argumentation of reasoning - data interpreted correctly only in 70% of cases	- the use of correct reasoning - correct argumentation - correct data interpretation
Establishing conclusions	- the existence of clear conclusions	- absent conclusions or partially present	- presentation of clear conclusions, but incomplete in 70% of cases	- conclusions clear, relevant and correctly presented

G4 – Peer evaluation form

Student name and surname: _____

Project title: Natural nanomaterials

What I liked most about activities related to this matter was.....

My suggestions on producing poster / Power-Point presentation (presentation mode, structure etc.) are: .....

I'm not sure what means: .....

I would like to know more about.....

Other ideas or comments:

Note: The students who make the peer evaluation will use the singular form of the first person.

G5 - Auto evaluation grid

Indicator	Grades		
	Never	Sometimes	Always
Involvement in the task			
Presentation of personal opinion			
Argumentation of personal opinion			
Launching a hypothesis			
Supporting hypothesis with arguments			
Collaboration with colleagues			
Contribution with informative materials			
Taking the initiative within the group			
Helping colleagues from group			
The tendency to find culprits for an incorrect handling, an incorrect written information			
Maintaining a relaxed atmosphere in the group			
Constant reflection on personal and group progress			

G6 - SWOT grid analysis of the manner of approaching the subject from IBSE and RRI perspective

	Help the objective fulfilment	Impede objective fulfilment
Internal origin	**S (Strengths)**	**W (Weaknesses)**
Presentation of personal opinion	**O (Opportunities)**	**T (Threats)**

4 Sources

Sources

- Morpho butterfly (pag. 2) - Image credit: William Warby, https://www.flickr.com/photos/wwarby/16595363917
- Milk (pag. 13) - Image credit: Michael Hensmann, https://www.flickr.com/photos/mycael/3710113739
- Healthy food (pag. 21) - Image credit: ACE Diets, http://acediets.com/?page_id=91
- Dairy (pag. 35) - Image source: http://www.glogster.com/letchwk2/dairy-group-2/g-6jjcab2nbpi2vlk5i70hj6u
- http://www.nanopinion.eu
- http://www.imt.ro/NANOPROSPECT
- http://iopscience.iop.org
- http://www.scribd.com/doc/207865564/Alimentealcaline33334.
- http://www.nanowerk.com/spotlight/spotid=23516.php
- http://www.icpe-ca.ro/lib/files/RO_Raport%20Stiintific%202013.pdf
- http://www.ifa-mg.ro/esfro/docs/etape/Etapa4/GT5_nanostiinte.pdf
- http://www.phys.uaic.ro/biofizica-si-fizica-medicala_c2018.html
- http://www.descopera.ro/eticheta/nanotehnologie
- http://www.scientia.ro/tehnologie/123-nanotehnologie.html
- http://www.maibine.eu/ShowMenuArticle.aspx?ID=43

5 Colophon

Colophon

IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation. It is a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1, ACTIVITY 5.2.2 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education. The project IRRESISTIBLE is funded by the EU as FP-7 project number 612367

www.irresistible-project.eu
Coordinator: j.h.apotheker@rug.nl