

# ELABORATION OF SOME MICROBIOLOGICAL CONCEPTS IN HIGH SCHOOL CURRICULA OF BIOLOGY AND THEIR IMPACT IN STUDENT EDUCATION

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## Abstract

Microorganisms are found everywhere in nature, in water, in soil, in the air, in very hot habitats and in very cold ones. To study microorganisms is very important because of their impact in our planet in general and in different aspects of human life. In the framework of students preparation for life, elaboration of microbiological concepts in school must have a special space. For this reason the objective of our study was to compare the way that some important microbiological concepts are elaborated in the previous and actual curricula of biology of high school. Our study was spread in three high schools in Tirana during 2010. After a very careful investigation it is established that according to the previous curricula, students in the first and third grade of high school had the possibility to learn about microorganisms and their impact in human life. The characteristic aspect of the previous curricula is that microbiological concepts are fused with other biological ones. On the other hand, in the actual curricula microbiological concepts are divided in two main lineages: “The study of organism” and “Biotechnology”. This kind of program gives students the possibility to have sustainable knowledge in microbiology and help them to prepare for life, but it would be better if combined with some new methods in teaching and learning.

**Keywords:** *microorganisms, bacteria, viruses, biotechnology, teaching methods*

## ***Introduction***

Dealing with microbiological concepts, takes an important part of the school curricula from both elementary and middle school providing the later a more complete and detailed information. The importance of the basic microbiological concepts relates with the fundamentals itself of microbiology as biological science, which deals with studying of unicellular bodies as well as of viruses which infect them. By studying microbiology at schools, students not only become acquainted with very simple unicellular organisms which can't be observed with a free eye, but they can also understand the influence of such bodies to humans' life; they could finally understand why in the past, when these bodies were not known by the scientists, thousands of people would die from mass epidemics whose causes remained unknown, the food decay used to go out of control or entire families would die due to lack of antibiotics or vaccines to fight infections. Given the great influence that microorganisms have on man's life but also in the frame of preparation of students to life, dealing with microbiological concepts at school represents a fact of an utmost importance.

The main purpose of this modest project has been the comparison between the old and the new curricula of middle school of ways microbiological concepts have been handled as well as their influence at human's life.

Whenever using the term "microorganisms", there is a tendency to relate them to the harm they could cause to humans in cases of diseases, infections or food deterioration. However, it is important to understand, that the majority of microorganisms provide an important contribution to the earth's inhabitants by contributing to the preservation of the balance between live organisms and chemical components of our environment.

Nowadays microbiologists are focused on identifying ways to increase benefits but also limit damages caused by microorganisms and we can well say that microbiology has played an important role vis-à-vis improvement of man's well being and health. A comprehensive study of structural, genetic and biochemical features of microorganisms is of an utmost importance for the medicine, for the examination and curing of many diseases originating from bacteria or viruses.

Microorganisms enable transformation of elements such as carbon, nitrogen, oxygen, sulphur and phosphorous into forms useful to plants and animals. The decomposition of organic waste and not living bodies by microorganisms (mainly bacteria and funguses), it is accompanied with the return of carbon dioxide into the atmosphere.

Microorganisms from sea and sweet waters constitute the basics of the food chain in oceans, lakes and rivers. The great diversity of microorganisms ensures rich genetic resources to solve the issue of environmental cleaning which is one of the most sensitive problems of our times. Humans, by becoming more and more aware of the need for environment protection, feel responsible for recycling waters and also prevent pollution of rivers and oceans.

The whole agricultural system depends in many aspects from microbic activities. Legume plants coexist with specific bacteria which constitute structures named "nodules" at their roots. At these nodules, through the help of bacteria, the atmosphere nitrogen exists in compositions which plants use for their growth, thus reducing the need for the use of chemical fertilizers.

Microorganisms are also useful to the microbial control of harmful insects. In agriculture, microorganisms are fundamental to the digesting process of ruminant animals.

## **Materials and methods**

For the purpose of this research project, texts such “Biology 9“ and “Biology 11“ of the old curricula as well as the programme of the new curricula on Biology as optional subject at 11th class, have been analyzed.

## **Results and discussions**

### ***The approach on microbiological concepts in the old curricula***

In the old curricula the microbiological concepts are dealt with during the first and third school years. (Scientific and natural profiles). In the first year of such curricula some general aspects are covered regarding cells and varieties of its forms as well as classification of uni and multicellular living species. Later, comes the explanation about unicellular living species which are composed of a single cell which performs all functions of a multicellular body, such as: feeding, protection and multiplication. Characteristic unicellular organisms such as amoeba, paramecium and euglena are being mentioned.

Organisms are divided based upon cells into prokaryotes and eukaryotes. This is a good way to treat this issue as it ensures the relation between cells and living species and the learning process is realized pretty well. Further it is explained the construction of prokaryote cell through illustration by pictures of its structure and its composing parts; other forms of these organisms like *Oscillatoria*, *Nostoc* and *Anabaena* are also shown through illustrations. In order to understand the place which microorganisms take in the overall classification of living world, organisms like moneres are explained – as unicellular bodies without a nucleus. They lack many parts of the cells which are well distinguished on the other cells and as “a kingdom” it includes two main types: bacteria and cyan bacteria. Another kingdom which also includes microorganisms, are funguses, where single forms such as moulds and barmes are part of. Today all classification systems are based on the phylogenetic tree built upon three domains (Bacteria, Arce and Eukaryotes) and therefore students must also be explained about this higher level of classification such as domains. Actually this concept is not part of the new curricula.

**Dealing with bacteria** – as one of the most important concepts of microbiology and absolutely necessary to be included in the school curricula as part of students awareness, starts with description of different forms of bacteria such as corks, bacillus, spirils and vibrios, as the most ordinary forms. These concepts are illustrated with the relevant pictures which enable a better imagination from students of the bacteria morphology.

With regard to motion, as one of the most important features of the moving bacteria, there is little mention in terms of existence of “eyebrows”, sometime with flagella and steady on some others. Chapters dealing with structure of bacteria explain about construction of cell walls, capsules, cell membrane, cytoplasm and its content by focusing on the presence of ribosome and genetic material which is not deposited in the nucleus but remains spread over cytoplasm and contain a single round chromosome.

One of the principal features of the living creatures is reproduction. The old curricula deals with this issue by mentioning the two main forms of creatures' reproduction: sexual and the non-sexual forms. At the non-sexual form chapter it is explained the reproduction by means of simple cellular division where a "mother" cell delivers two identical "daughter" cells. This process is accompanied by details provided through specific schemes where division of a prokaryotes bacterial cell throughout all stages from the moment when the round chromosome connects on a point with cellular membrane, up to the creation of two daughter cells from the mother one, are shown.

Another specific characteristic feature of bacteria which is highlighted in the old curricula is the capacity of some bacterial cells to differentiate into well-resistant structures named endospores. Knowledge related to endospores are important for student's formation since they concern directly with human's daily life. The endospores create an array of patogene bacteria and bacteria which cause food poisoning. Although very simple organisms being reproduced by non-sexual ways, the bacteria are capable to exchange genetic information among them. This is done through three main processes: transformation, transduction and conjugation. The conjugation process is shown through illustrated pictures where a cytoplasmic bridge is established between individuals which would enable the passage of plasmid F from F<sup>+</sup> individuals to F<sup>-</sup> ones.

With regard to bacteria, the mutual relations which they establish with plants or animals where they live, is also being studied. These kinds of relation of mutual benefit are named symbiosis. Part of the book is dedicated to the diffusion of bacteria which shows that they could be found in waters, air or soil basically everywhere even in extreme environmental conditions be they extreme hot or extreme cold. Some specific groups of characteristic bacteria such as Eubacteria and Archeobacteria, are also being mentioned. The earlier are described as autotrophe and heterotrophe bacteria while the later include bacteria living in very poor environments. It is also demonstrated the impact to humans' lives of these bacteria, as they may cause many diseases to humans and animals such as gonorrea and syphilis; apart from the pathogen organisms, the useful bacteria to humans are also mentioned.

At middle schools third grade Biology text book, there is a detailed explanation of microbiological concepts, namely the recombinant ADN chapter which deals with the genetic recombination through conjugation as well as the transformation process of bacterial cells. Actually the whole bacteria conjugation process is being provided in a much more detailed manner compared with the first grade book. At the description of the conjugation process, there is also mention of merozygote stage when at the same cell there is one part of giver's chromosome named exogenote as well as the taker's chromosome named endogenote. There are described both the transformation process at bacteria strains *Streptococcus pneumonia* R and S and the related experiment developed with rats.

Another process which is being described is transduction, molecular hybridization and plasmids. The whole life cycle of bacteriophage Lambda is being studied by describing both the lytic and lysogen cycles. Further on are being studied the great DNA and RNA molecules along with the hybridization technique which is based on coupling characteristics of nucleic acids; the studying of this method is important in order to discover the presence of specific sequences of DNA and we may well say that even an RNA could be used to localize at the chromosomal DNA

the location where it was transcribed; the outcomes of this method could be used for several practical purposes.

Specific chapter is devoted to plasmids which are free DNA molecules at the bacterial cell cytoplasm. The plasmids are studied as they are important for the genetic information they contain as well as for the cell division process, the capability to replicate and pass on at daughter cells during the cell division. It is also important to know restriction enzymes and their role on formation of recombinant DNA; they basically would act as “scissors” to cut the DNA molecules and are distinguished from each other since they would cut the DNA molecule at a precise specific sequence. Another chapter is dedicated to the recombinant DNA by which it is explained the combination of two DNA segments with different origins and created during transformation and transduction process. Among the most important restriction enzymes there is EcoRI also known as restriction nuclease; the illustrating schemes and pictures provide a detailed explanation of the way it operates when cutting the DNA chain. The fragments cut by restriction enzymes are being displayed by means of electrophoresis apparatus where the molecules are divided based upon their motion through the pores of a gel which might be agar amidon or polyacrilamyd; depending on the electric power, the molecules would move in accordance to their sizes and their electric charges.

### ***The approach on microbiological concepts in the new curricula***

The Biology programme, as a class-upon –choice of 11th grade, deals with microbiological concepts in a more organized manner, by studying the text based on studies’ guidelines where the microbiological concepts are basically organized in two great lines of study, such as: “Study of organization” and “Biotechnology”.

The first line includes the subline “Applied microbiology”. Through this line, students obtain knowledge, capacities and practical approaches on unicellular or colonial microorganisms, including composition, functioning and practical importance of prokaryote microorganisms as well as of some eukaryote microscopic groups such as: moulds, barm and protists. Knowledge on viruses and their role on our daily life, are also provided.

Teaching and learning processes of applied microbiology would develop at students the critical thinking on practical principal directions of microbiology by raising their interest on daily life applications in fields like: health, industry, agriculture, environment, etc. The aim is that at the end of 11th grade the student should be able to describe the cellular structure along with the main functions like :feeding, reproduction, etc of prokaryote microorganisms, as bacteria or cyan bacteria as well as of procariote microorganisms such as moulds, barm and protists. They should also be able to describe the basic structure of virus, its chemical composition, its reproduction by including the lytic and lysogen cycles of bacteria phagus. They should also be able to discuss on the useful role of microorganisms in industries, namely in productions of yogurt, cheese, bread, wine, etc, in biotechnologies regarding the production of antibiotics, in agriculture for the decomposition of ensilage, etc.

In the new curricula’s programme it is mentioned that its objectives are to enable students:

- To discuss on the composition and role of microorganisms in natural environment as well as on the ecological importance of circulation of nutritive in nature.

- To discuss on the detrimental role of microorganisms to humans' health by studying infective bacterial diseases, food poisoning, influence of HIV virus on immunitary system of organism, on viral hepatitis, means of transmission as well as the role of vaccination for the prevention of these infections.

- To discuss on protection of organism from diseases (role of protecting immunitary system, biological barriers against pathogen microorganisms);

- To observe on microscope bacteria of teeth mucosa, bread mould, observe life in a drop of water (paramecium and euglena). Yet, one of the objectives of the new curricula is to encourage the research and independent activity of students, by allocating specific classes where students can prepare essays with both scientific and historic information on infection of humans from HIV and AIDS in our country. They should also be able to prepare a group-work material regarding the discovery of penicillin and role of Dr. Fleming in this discovery.

The aim of second line "Biotechnology" is that students should gain knowledge and capabilities in order to take their own stands on modern biotechnology concepts; they should also become aware of its different applications in sectors of health, agriculture and environment protection. The main objectives of studying of these subjects related to microbiological concepts are to enable students:

- To be able to describe the genetically modified organisms (GMOs) (prokaryotes, plants, animals).

- To describe recombinant DNA technology including the role of restriction enzymes and ligases which connect DNA.

- To analyse the role of plasmids and genetic vectors for the transport of foreign and human genes in other sheltering genes.

- To understand the techniques used for gene isolation by mentioning isolation of genes which code production of insulin in human pancreas and after, production of human insulin through bacteria.

- To discuss on genetic modification of plants and animals through the use of microorganisms.

- To realize in practice cloning of a plant, i.e. reproduction of hollyhock plant through vegetative replication.

- To prepare a study as team work based on negative and positive aspects of GMOs, about rules of permitting and controlling the genetically modified organisms.

Another line which deals with microbiological concepts related to preparation of students for life is "Biology and issues of public health"; subjects which are discussed in this line aim at enabling students to explain, among others, the influence of infective diseases like hepatitis, HIV/AIDS, tuberculosis, malaria, the sexually transmitted diseases in public health. Yet, they should be able to discuss and obtain knowledge about other social factors such as increase of global population, lack of hygiene, water pollution which could contribute to diffusion of infective diseases. They should recognize the role of vaccination in prevention of infections from diseases caused by microorganisms.

### ***Comparison of two curricula on microbiological concepts approaches***

There are distinctions between the old and new curricula which consist in four main aspects:

- Structure of class organization
- Method of approach at the text
- Organization of school classes
- Illustrations, pictures

*First*, the new curricula of middle school is divided in study lines which are related and continuation of each other regarding information and class subjects which they include. These three main lines which deal with microorganisms concepts are as follows:

- Organization of living organisms with the sub-section of applied microbiology.
- Biotechnology
- Biology and issues of public health.

These three lines summarize the whole information regarding microorganisms, whereas in the old curricula the class programme was organized into chapters and subjects; they started with basic and fundamental issues related to classification of living species, followed by description of different types of microorganisms by their structure, chemical composition and reproduction. The further approach is ensured through the programme of Biology 11 including chapters of recombinant DNA and biotechnology.

*Second*, with regard to the approach method, description in the text of old curricula are more detailed whereas the new curricula contains more general and concise information. This distinction is quite noticeable in the chapter dedicated to bacteria which describes structure and chemical composition by also providing differences and similarities at moulds, barms and protists. This method is expected to help students understand relations and differences between these microorganisms.

*Third*, another distinction of the new curricula is the division of school classes into:

- *Educational classes/hours* where students could discuss about infections from HIV/AIDS or other diseases caused by microorganisms,
- *Practical classes/hours*, experimental ones where knowledge obtained from texts could be applied in practice, i.e. by checking on microscope the microorganisms of mouth, etc.

*Last*, illustrations and pictures which appear throughout most of the pages of new curricula; their careful selection and the good quality contribute to increase the curiosity of students about subjects being discussed; this represent a clear advantage of the new curricula vis-à-vis the old one. The influence of microorganisms on environment, health and any other aspect of our life require that the subjects discussed in the curricula must bear an educational role aiming at preparation of students for life. In order to achieve this objective, specific subjects should be discussed on the positive and negative role of bacteria; in this way students would develop a realistic concept on bacteria.

- Another aspect relates with knowledge and concepts gained by students which should be applied in practice, through concrete illustration examples; consequently the school classes will become much more interesting for the students.

- Beside, more and more educational hours must be devoted to health care, as well as protection from infection by microorganism. This would make the whole both teaching and learning processes will be successful and effective.

## ***Conclusions***

1. In the old curricula the microbiological concepts are discussed in first and third grade of middle school programme (scientific and natural profile).
2. During the first year, these microbiological concepts are dealt with in a more generalist approach, while being much more detailed at the third year. The discussion of microbiological concepts in the frame of other biological concepts represents one of the characteristics of this programme.
3. The new curricula treats microbiological concepts based on two main guidelines: “Study of organization” and “Biotechnology”.
4. The programme of the new curricula enables students to create solid knowledge on microbiology and also helps them to better prepare for life.