UNIT I: Aims and Objectives of Teaching Biological Science

MEANING

Biology is a natural science concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, identification and taxonomy.

Biology literally means "the study of life". Biology is such a broad field, covering the minute workings of chemical machines inside our cells, to broad scale concepts of ecosystems and global climate change. Biologists study intimate details of the human brain, the composition of our genes, and even the functioning of our reproductive system.

Human's exploratory activities have resulted in the accumulation of vast source of knowledge called Biology. In Biology, we study about nature which means the entire universe. The knowledge is now organised in several disciplines for the convenience of study. This knowledge is base inquiry, observations and logical extensions, and is testable by experiment or has logically convincing explanation.

It is this organised knowledge with inquiry, logical reasoning and experimentation as its central themes that we call science. Science may rightly be said to be a domain of inquiry.

AIMS AND OBJECTIVES OF TEACHING BIOLOGICAL SCIENCE IN SCHOOLS

One of the important aims of education is to help students to become responsible democratic citizens of the country. The responsibility of science teachers is not only to teach facts, principles and processes of science, but also to facilitate students to discharge their social responsibilities and preserve democracy as well. They should appreciate how science and technology have developed and are affected by many diverse individuals, cultures and societies. They need to be encouraged to appreciate and participate in the responsible use of science and technology for the benefit of society, to visualize future of our nation and to become sensitive and responsible citizens. It is important to develop critical thinking in them about interconnectivity of science, technology and society in order to maintain a healthy and sustainable society. Students should be encouraged to develop a scientific vision about different issues, about acquiring and processing information, about scientific and technological developments and their relevance to everyday life and long-term implications to society.

Science education aims to make students develop scientific attitude, so that in later life they can help society make rational choices when confronted with various possibilities and challenges.

Humans' inquisitiveness and usefulness of the knowledge of science are the two main factors which have led them to continuously strive to understand the behaviour of nature and use the knowledge of science to make their life more comfortable. In doing so humans systematised knowledge by classifying it into various fields of their activities, built concepts to understand the behaviour of nature and found various ways to exploit it. All these endeavours of the humankinds resulted in a new discipline known as science. Science has

influenced and benefited us so immensely that it has become indispensable. At the same time, the society has also helped science to grow.

Science enhances the quality of our life and it is visible in all walks of life. Since science has been developed by people who are part of a group, society or a country, it is expected that their social, psychological, political, economic perceptions could change the course of development of science.

The science education is aimed for the learner to

- know the facts and principles of science and its applications, consistent with the stage of cognitive development;
- acquire the skills and understand the methods of processes that lead to generation and validation of scientific knowledge;
- develop a historical and developmental perspective of science and to enable her to view science as a continuing social enterprise;
- relate science education to environment (natural environment, artifacts and people), local as well as global and appreciate the issues at the interface of science, technology and society;
- acquire the requisite theoretical knowledge and practical technological skills to enter the world of work;
- nurture the natural curiosity, aesthetic sense and creativity in science and technology;
- imbibe the values of honesty, integrity, cooperation, concern for life and preservation of environment; and
- cultivate scientific temper- objectivity, scepticism, critical thinking and freedom from fear and prejudice.

NEED AND SIGNIFICANCE OF TEACHING BIOLOGICAL SCIENCE

Science has been given due place in our school education programmed by being made as a compulsory subject. Not only is that more and more emphasis now being paid over the scientific and technical education. By doing so infact a right step has been taken to push our country forward and to enable us to compete with other progressive nations. It has necessitated to lay due emphasis on the teaching of science right from the primary stage. Realising such need Kothari Commission has very rightly remarked in their recommendations as follows:

“Science and Mathematics should be taught on a compulsory basis to all pupils as a part of general education during the first ten years of schooling”.

Modern age is science age. We see a network of scientific gadgets based on latest scientific inventions all around us. Science has revolutionised our way of living. Now our lives depend on scientifically invented gadgets so much that we cannot do without them. It is now imperative for everyone not only to understand science but to master it from all angles. According to Herbart Spencer, “The knowledge gained through science is much more useful in guiding our life style than gained through other sources”.

NATURE AND SCOPE

Biology has certain characteristics which distinguish it from other spheres of human endeavour. These characteristics define the nature of biology. Humans have always been curious about the world around them. The inquiring and imaginative human mind has responded to the wonder and awe of nature in different ways. One kind of response from the earliest times has been to observe the physical and biological environment carefully, look for any meaningful patterns and relations, make and use new tools to interact with nature, and build conceptual models to understand the world. This human endeavour is Biology. But Biology is ultimately a social endeavour. Biology is knowledge and knowledge is power. With power can come wisdom and liberation. Or, as sometimes happens unfortunately, power can breed arrogance and domination. Biology has the potential to be beneficial or harmful, emancipative or oppressive. History, particularly of the twentieth century, is full of examples of this dual role of Biology.

In a progressive forward-looking society, Biology can play a truly liberating role, helping people out of the vicious circle of poverty, ignorance and superstition. Biology, tempered with wisdom, is the surest and the only way to human welfare. This conviction provides the basic rationale for Biology education.

Science promotes scepticism; scientists are highly sceptic people. Scientists look at everything with suspicion. Every new observation or a new theory is received with a lot of scepticism. It leads to a lot of debate among scientist. A new observation is accepted only when experimental observations have been checked by independent individuals or groups at various places with identical results. Similarly, a new theory is accepted when theoretical calculations have been repeated by other scientists independently with identical results.

Science, and biology in particular, holds several foundational values that should be conveyed to students as they pursue careers as scientists or science teachers.

Science is based on at least four fundamental values:

- Curiosity is good and should be encouraged.
- Knowledge itself is good—it is good to acquire knowledge.
- It is wrong to falsify or fabricate the data on which knowledge is based.
- It is good to keep an open mind (to be willing to examine and consider new evidence and arguments), tempered by a vigilant level of scepticism**.**

Curiosity is surely the most essential trait a scientist can possess. Curiosity leads to a search for knowledge for its own sake, which is the driving force behind the great majority of scientific discoveries ever made. Acquiring knowledge for curiosity's sake leads naturally to the second value that knowledge is good— not because it may be useful in some pragmatic way, but simply because it increases our store of knowledge about the universe in which we live. Staying open-minded and sceptical is certainly a value and goal for all scientists, provided that one's open-mindedness is reserved for objective evidence, as opposed to subjective opinion.

Curiosity can be a hard sell because, sadly, many of today's students seem to lack curiosity about the world and universe outside their personal spheres of relevance. Even at the college level, many students appear to have no interest in learning about anything as remote as stellar evolution, photosynthesis, Krebs cycle, the Burgess Shale fossils, hydrothermal vent communities, lateral gene transfer, the bacterial origin of mitochondria, and so on. Yet these topics would not seem remote if they were approached in a creative and spirited manner.

Most investigations in science involve some form of scientific method. It shows creativity of humankind in seeking solution to its problems. The approach used by the scientists in the study of astronomy and ecology is observation and prediction. In microbiology they rely on laboratory experiment focused on cause and effect relationship. This is a glimpse of the process by which science works. The essential elements of this process have been collected in what is known as scientific method.

In science, experimentation and theory building complement each other. Sometimes a new experiment throws up observations which force modification in an existing theory or demand the development of an altogether new theory. At other times, theoretical development in a theorypredicts new phenomena which needs to be verified by experiment. This interplay between theory and experiment is a fascinating facet of the scientific process.

Broadly speaking, science is a particular way of looking at nature, which may also be called scientific attitude. One of the most important characteristics of science is that even the most established theories can be modified, or even abandoned, if new experimental results do not fit into the existing theories. This promotes scepticism among scientists. They look at every new observation or theoretical calculation with a healthy dose of scepticism and do not accept it till the result has been reproduced by many scientists at various places. Reproducibility is one of the importantcriteriaforascientificresulttobeacceptable.Itisbelieved that scientists, in their exploration, employ inquiry and scientific method. The use of scientific method and inquiry in daily life promotes scientific temper and rationality. That is why it has been emphasised that all of us should imbibe the spirit of scientific inquiry in our personal lives. So, science can never belong to a country or region. It belongs to the whole mankind.

VALUES OF TEACHING BIOLOGICAL SCIENCE

Teaching science inevitably involves value messages for instance in the management of the curriculum (e.g. science can be presented as physics, chemistry and biology or as rural science, or domestic science or as environmental science each of these involving different value judgements) and the particular selection of knowledge which is included in the curriculum (e.g. breathing and circulation are conventionally taught in a biology programme in such a way as to emphasise anatomy and physiology related to the preparatory needs of future medical students.

In many parts of the world today there is a concern about the role science education may play in establishing a sense of personal and social identity for a student. Implicit in this concern is the recognition of

- The powerful social, economic and cultural impact of contemporary science world-wide;

- The importance of the process, ideas and products of science to individual citizens irrespective of their particular role and status in society; and
- The urgent need to harness science to human welfare.

Baez (1984) in discussion issues of science, environment, education and basic human needs identifies survival needs such as food, shelter, health and safety, development needs such as education and employment, and perceived needs such as wealth, security and growth. He notes that all these are in some form or other dependent upon the physical environment in which we live.

However he goes further in his identification of basic human needs making the point that....'Man does not live by bread alone. His needs go beyond the purely physical and include such things as leisure time and the human qualities of respect, care and affection. Deprived of these a person may languish as surely as if he were deprived of food and water'.

Jennings (1983) in discussing the place of biology in the curriculum and its role in the education of the individual argues that the respectability of school biology as a scientific study was hard earned and the rigour and precision of modern biology make it important for schools to sustain the scientific process dimension to the biology curriculum. However he adds that the key issue is that while retaining this scientific biology curriculum it is necessary to extend it adequately along a human social dimension. He presents an interesting distillation of objectives associated with biology programmes in which he identifies affective as well as cognitive aspects.

According to Kelly (1980), 'It is one of the greatest challenges to biological education to formulate a biosocial synthesis in a way that gives it credibility and a rightful place in the curriculum'.

The affective dimension of biological education has often been more effectively developed in terms of translating affective aims into effective teaching strategies when biological science has been placed in a broader curriculum context such as that of environmental education, health education or personal and social education. The perception of the relevance of biological processes and concepts to the individual has in such programmes been sharpened by the need to look more at the whole education of the person and so individual and social need rather than deriving teaching programmes solely based on the internal logic of the subject. Environmental education programmes for instance often focus upon issues which involve scientific knowledge within a frame work of social values and aesthetic personal life, through their community, culture and environment. In such contexts as these it has been necessary to explore teaching strategies which go beyond the cognitive and give scope for affective development.

Tones (1981) in discussing this aspect of health education suggests that the options open to teachers in Affective Education and Health. It is attempted to be implemented in science programmes that the values context of the cognitive processes starts to be recognised creating problems for the teachers' role in relation to imparting particular sets of values. Teachers may not wish to impose their own values**,** or those of a particular class or culture in the com- munity. A particular approach that has been used by teachers taking this attitude

has been that of value clarification. Simon 1972) has defined value clarification as involving a hierarchy of seven sub-processes:

Prizing:	1. Prizing and cherishing.
	2. Publicly affirming, when appropriate.
	3. Choosing from alternatives.
Choosing	4. Choosing after consideration of concern
	5. Choosing freely.
Acting	6. Acting
	7. Acting with a pattern, consistency and repetition.

The U.K. Association for Science Education in a discussion paper on Planning for Science in the Curriculum (1985) has argued that a broad balanced science curriculum should be seen within the context of a road balanced general education and that each teacher should be aware of the total package that is being prepared for and offered to the students. It is further argued that 'Learning experiences should be constructed so as to take account of student's needs and not only the entry requirements of the profession and higher education or the perceived needs of the nation. Students have to be helped to develop their own identities so that they can become autonomous learners and decision makers and feel a sense of confidence and success in their personal relationships'. This does not necessarily mean that the traditional subjects are not an appropriate way in which to organise teaching, but it does mean that there should be co-ordination across the curriculum. Perhaps in such away we may be able to see means though which science education can contribute not only to man's physical needs but also to those such as leisure and human qualities of respect, care and affection.

Intellectual value

The study of science provide us the opportunity of developing our mental faculties of reasoning, imagination, memory, observation, concentration, analysis, originality and of systematic thinking. Science gives us the insight which enables us to search the truth and the reality of nature around us. Science does not permit us to accept anything which we cannot prove by actual observation, reasoning and experimentation. The queries of all problems and phenomena can be satisfactorily answered only by the wisdom of science.

Disciplinary value

Science develops our personality as a whole. It inculcates spirit of enquiry, seriousness, and systematic thinking. It brings about total transformation of one’s view point and makes thought process more organised. Science makes us think seriously and helps to observe the real nature of the problem. It helps us to judge all the good and bad points, together with the gain and loss likely to be incurred in the plan of action contemplated. Sciene is only the one subject which promotes interest in study, concentration and habit of hard and systematic work. It also inculcates the habit of viewing a problem impartially with an alert mind. This helps to lead one’s daily life successfully in a well organised and systematic way.

Cultural value

From time immemorial man has been trying to maintain and preserve their way of life and standard through the use of science. But somehow our way of life has been changing with the passage of time and progress of science. This change in our life-style is due to the inventions of science. The development of culture is the history of science. We can judge the progress of civilisation and cultureof a nation by its progress in science. Science not only develops our culture but also helps in preserving it.

Moral value

Some people believe that Science is responsible for lack of faith in God, but in reality the situation is reverse. Science does not permit blind faith, it also does not admit faith in idol worship nor follows many useless customs and rituals. The search for truth or reality of nature and search of God are identical aims. Thus pursuit of knowledge of nature or study of science cannot be called contrary to religion and faithlessness. Science and its pursuit not only include all the traits of morality but also develop them. The qualities of honesty of purpose, truth, justice, punctuality, determination, patience, self-control, self-respect, self-confidence and tolerance are automatically developed in man if he follows scientific method in his pursuit of knowledge.in science every conclusion depends upon tests and actual observations and not by cheat and deceit.

Aesthetic value

Science is beauty, art, a source of entertainment and a successful means of attaining physical comforts. Even the study of science is a source of great pleasure, when one gets answers to his questions about the mysteries of nature. Science helps us to utilise our leisure purposefully.

Social value

Science is of great value to society. Science makes a man a useful citizen. Science gives impetus to the progress of society by its new thoughts and inventions. From the very beginning of our civilisation science has played an important role in its development. In fact, the world has become a small social group. Today's society stands on pillars of scientific techniques and knowledge. All our social activities depend upon science. Science is essential for the progress of our society and nation. By studying science we can make our social life happy and comfortable by leading a healthy life and by gaining from public welfare activities based on science.

Vocational value

Science has opened vast vistas of vocations, because scientific principles and inventions have become so universal and pervasive in our daily life. Scientific inventions have now helped widely allthe traditional vocations nowadays like – agriculture, poultry farming and dairy farming. Science has also revolutionized modern vocations like – telephone, radio and television broadcasting etc.

Psychological value

Study of science fulfils the psychological needs of man and helps in evolution of natural curiosity and other instincts like instinct of collection, ego, and self-expression. The instincts of curiosity is responsible for the urge of investigation, experimentation and research. In this way study of science develops all the latent faculties of a child.

Whether we consider from personal or social point of view, the study of science has its special importance. The joy and bliss are obtained from successful investigation of scientific problems but in addition it also gives children self-confidence and insight for solving any life-problem facing them. In brief, the study of science gives us self-confidence and teaches us to lead a successful and meaningful life.

Develops problem-solving skills

With the knowledge of science, you learn to think logically and solve a problem. It is this problem-solving skill, which is learnt in the early years that have enables a person to solve problems. Communications, medicine, transportation, and almost everything you see around you are mainly present because individuals have used their knowledge of science to create real life applications. Knowledge in this subject also enables you to understand many other subjects better.

Awareness about technology

Learning the basics of how certain devices work can help you develop ideas of your own and invent new technology. Even the knowledge of how to use telescopes, microscopes, and other devices in a laboratory can help you in examining objects and determining differences between them. Fixing minor problems in electronic objects in your own home is possible when you have the basic knowledge about technology.

How to conserve natural resources

All aspects of the environment have a deep impact on our lives. As a student, science helps you to learn about how the earth functions, and how to make use of natural resources. It also teaches you how the lack of these resources affects living things, and how you can conserve these resources.

When you learn about wildlife in science, you will learn about the many species that are already extinct, because of shortage or absence of certain resources and environmental changes. Awareness about such aspects can help you contribute towards preserving wildlife. Science also teaches you to recycle and reuse products and promote a greener environment. This knowledge is very essential to help save our planet for the future.

Instils survival skills

Science helps to learn about the various weather conditions, and helps to distinguish between normal weather and dangerous weather. With this knowledge, learner can stay alert

about natural disasters or survive the disaster. Because the learner learn about the characteristics of different objects that they use in day-to-day life, learner will be able to distinguish between things that are safe to eat and those that they should not. Almost everything that a person does requires a basic knowledge of science, and logical reasoning that is based on this subject. So, it is undoubtedly important to learn science from the early days of school.

BLOOMS TAXONOMY OF EDUCATIONAL OBJECTIVES

Taxonomy of educational objectives is intended to provide the classification of goals of our educational systems. The idea of classification of educational objectives was given by Dr.Benjamin S Bloom of Chicago University USA. He classified educational objectives in to three main areas or domains called Cognitive, Affective and Psychomotor. The three domains are interrelated and mutually dependent.

TAXONOMY OF EDUCATIONAL OBJECTIVES

Cognitive Domain	**Affective Domain**	**Psycho – motor Domain**
1. Knowledge	1. Receiving (appreciation)	1.Perception
2. Comprehension	2. Responding	2. Imitation
3. Application	3. Valuing	3. Manipulation
4. Analysis	4. Organising	4. Precision
5. Synthesis	5. Characterizing	5. Articulation
6. Evaluation		6. Naturalization

Cognitive Domain: The recall or recognition of knowledge and the development of intellectual abilities and skills.
Affective Domain: The changes in interests and values and the development of applications
Psychomotor Domain: The development of manipulative or motor skills
The three domains of learning do not occur in isolation but rather work together to make up one whole being.

Cognitive Domain

Cognitive domain includes those objectives which deal with the recall and recognition of knowledge and development of intellectual abilities and skills. **-Blooms et al.**
Benjamthe domain in S Bloom and his coworkers have done the taxonomical classification of this domain in 1956. The domain contains six major objectives arranged in an order on the basis of increasing complexity of tasks. Each of these six is further divided in to specified behavioural objectives.

Categories in the Cognitive Domain

1. Knowledge

This is the first and the lowest level of cognitive domain. It includes recall of information such as specifies, facts, methods, processes, generalizations, patterns etc., Thus, the knowledge objective emphasizes what can be described as memory.

2. Comprehension

This second category includes translation, interpretation and extrapolation. This is also related to the use of ideas. It refers to a type of understanding of the materials or literal message contained in a communication.

3. Application

This third level includes the ability to apply abstract ideas to a concrete situation. The abstraction may in the form of general ideas, rules or procedures or generalized method.

4. Analysis

It means the "breakdown of the materials into the constituent parts and detection of the relationship of the parts and of the way they are organized". Analysis includes analysis of elements, analysis of relationship and analysis of organizational principles.

5. Synthesis

This category is just the opposite of analysis. Synthesis is the "putting together of elements and parts so as to form a whole. This involves the process of working with pieces, parts, elements and arranging and combining them in such a way as to constitute a pattern or structure, not clearly there before".

6. Evaluation

It is the assignment of symbols to phenomenon, in order to characterize the worth or value of a phenomenon, usually with reference to some social, cultural or scientific standards. Evaluation involves judgments in terms of internal evidence as well as external criteria.

To conclude, it may be pointed out that the above six major categories in the cognitive domain do not always appear in isolation from one another.

Affective Domain

This domain involves attitudes, interest, values and appreciation. The affective domain is concerned with 'feeling'. The objectives under affective domain are difficult to define and evaluate. The hierarchy of objectives in affective domain has been developed by Krathwohl, Bloom and Masia in 1964. The order of objectives is in such a way that each category is more abstract and complex than the previous one.

Categories in the Affective Domain

1. Receiving:

This is at the lowest point o the affective domain. Receiving may be defined as "sensitivity to the existence of certain phenomenon and stimuli, that is, the willingness to receive or attend to them".

2. Responding:

Responding refers to a behavior which goes beyond merely attending to the phenomenon; it implies active attending, doing something with or about the phenomenon, and not merely perceiving them.

3. Valuing:
Valuing implies "perceiving them as having worth or value. The three sub-categories of this objective are, acceptance of value, preference for a value and commitment.
4. Organizing:
This involves building up of organized system of values. The individual organizes a set of values such as truth, goodness and helping others, in determining their relationships and deciding their need and priority.
5. Characterizing:
In this category the individual displays the integration of values and it becomes a lifestyle with him. He gets these values organized into some kind of internally consistent system, which has controlled the behavior of the individual for a sufficient time. This category is concerned with one's view of the universe and one's philosophy of life.

Categories in the Psycho-motor Domain
Psychomotor domain concerns with the attainment of neuro-muscular coordination. Here the objectives which deal with manual or motor skills. As the level of coordination goes up, the action becomes more refined, speedy and automatic. Simpson, Kibler were working on this area for systematically classifying educational objectives. R.H. Dave has given the classification of educational objectives under this domain 1969. The order of objectives in such a way that coordination is to be brought about among different parts of a given act or different acts performed with required articulation.
1. Perception
Skill of keen observation, skill of sensing a problem and skill of developing self-motivation are the specific objectives under this category.
2. Imitation
Skill of repeating actions and skill of reflective thinking are the specific objectives under this category.
3. Manipulation
Skill to operate upon with intelligence and manage cleverly are the specific activities that fall in this category.
4. Precision
Skill of experimentation, skill of precise movements and neat execution of skills are the activities which fall under this objective.
5. Articulation
Skill of logical thinking, reflective thinking, skill of mind and body and development of mathematical skill are specific objectives to attain this step.
6. Naturalization
As we practice a skill, in due course it becomes our natural habit. Skill of attaining success and skill of multiple actions are the specific activities under this objective.

CONCLUSION

Biology teaching seen in this way can be developed to contribute to linguistic, mathematical, scientific, personal, aesthetic and physical development, rather than at times actually inhibit or even conflict with some of these development aims an effective science education will be one that is placed in a values context and contributes to the education of the whole individual. Science and in particular biology teaching has affective aims which are

essential contexts for the cognitive aims. Science teaching in a whole curriculum perspective can be effectively organised and lead to a useful rethinking of the purpose of science programmes for individuals especially at the Upper Secondary level where, increasingly, the number of students who will go on to professional or technical level careers in science, technology or related fields is limited (Unesco,1980).