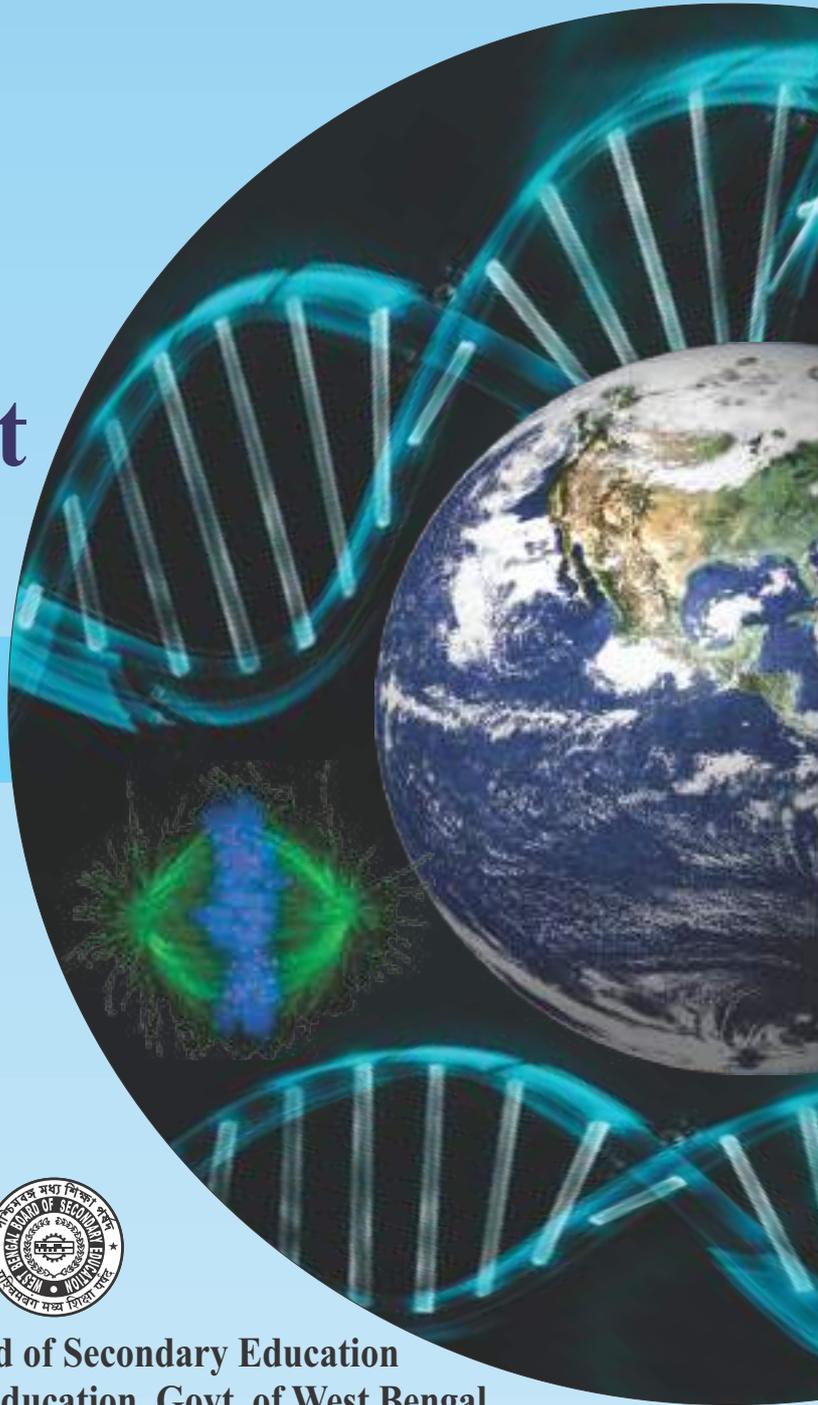


Training Module

Life Science and Environment

Class X



West Bengal Board of Secondary Education
Department of School Education, Govt. of West Bengal
Samagra Shiksha Abhiyan
Planning and Development: Expert Committee,
Department of School Education

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Department of School Education

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July, 2020

The Teachers' Training Programme under SSA will be conducted according to this module that has been developed by the Expert Committee on School Education and approved by the WBBSE.

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FROM THE BOARD

In 2011 the Honourable Chief Minister Smt. Mamata Banerjee constituted the Expert Committee on School Education of West Bengal. The Committee was entrusted upon to develop the curricula, syllabi and textbooks at the school level of West Bengal. The Committee therefore had developed school textbooks from Pre-Primary level, Class I to Class VIII based on the recommendations of National Curriculum Framework (NCF) 2005 and Right to Education (RTE) Act 2009. In 2016 the new curriculum and syllabus of Life Science and Environment for Class X came into effect and textbooks were developed accordingly. However, certain questions evoke in our minds: (i) How will the competencies of the learners be modified, refined or improved in Class X? (ii) How far can the learners establish themselves as citizens with values and responsibilities at the end of Class X? (iii) How far can the learners go beyond the limits of academic disciplines to apply knowledge in their social life? And in trying to find suitable answers to these questions the Expert Committee developed the framework of the Constructivist methodology for knowledge construction.

Following the recommendations of Samagra Shiksha Abhiyan (SSA), the Govt. of West Bengal has arranged an orientation programme of Life Science and Environment for Class X on the method of learning and evaluation. This 'Training Module' has been developed for the said orientation programme.

The Hon'ble Minister in Charge for Education, Dr. Partha Chatterjee, has enriched us with his views and comments. We express our sincerest gratitude to him.

We hope that the orientation programme will be successful and have a lasting effect in the teaching-learning process of the future.

July, 2020
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Kalyanmoy Ganguly

President
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Secondary Education

PREFACE

The Honourable Chief Minister Smt. Mamata Banerjee constituted the Expert Committee on School Education of West Bengal in 2011. The Committee was given the responsibility to review, reconsider and reconstitute all the aspects of the school curricula, syllabi and textbooks. The new curricula, syllabi and textbooks were developed based on the recommendations of the Expert Committee.

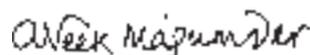
The school textbooks for all classes, from Pre-Primary level to Class VIII, were developed following the guidelines of NCF 2005 and RTE Act 2009. The textbooks for Class X were developed based on the new curriculum and syllabus.

Following the recommendations of Samagra Shiksha Abhiyan (SSA), the Govt. of West Bengal has organized an orientation programme on the method of learning and evaluation of Life Science and Environment for Class X. This 'Training Module' has been developed for the said orientation programme.

The Hon'ble Minister in Charge for Education, Dr. Partha Chatterjee, has enriched us with his views and comments. We express our gratitude to him.

The State level Teachers' orientation programme on the methodology of learning and evaluation has been planned and executed in assistance with School Education Department, Govt. of West Bengal, West Bengal Board of Secondary Education and Samagra Shiksha Abhiyan (SSA). It is hoped that the 'Training Module', developed on behalf of School Education Department, Govt. of West Bengal, West Bengal Board of Secondary Education and Samagra Shiksha Abhiyan (SSA), will help in the effective implementation of the methodology of learning and evaluation.

July, 2020
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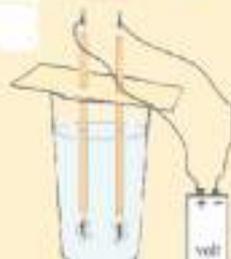
Anindya Sengupta



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Samagra Shiksha Abhiyan (SSA)

Introduction

The Right of Children to Free and Compulsory Education (RTE) Act, 2009, seeks to ensure that children enjoy the benefits of the three aspects of Access, Equity and Quality in school education across the nation. To this effect, the Ministry of Human Resource & Development (MHRD) in line with the proposal of the Union Budget, 2018 -2019 has initiated the scheme of SAMAGRA SHIKSHA ABHIYAN (SSA). The scheme takes a holistic stance in treating school education from Pre-Primary to Class XII as a continuum by merging the erstwhile Sarva Shiksha Abhiyan and Rashtriya Madhyamik Shiksha Abhiyan schemes in one, unified whole.

Scope of SSA

The Samagra Shiksha Abhiyan (SSA) collates the three Schemes of Sarva Shiksha Abhiyan, Rashtriya Madhyamik Shiksha Abhiyan and Teacher Education. The SSA scheme aims at improving school effectiveness measured in terms of equal prospects for schooling and equitable learning outcomes. In harmonizing the different and major effectual factors of school education, the SSA scheme provides for the operational mechanisms and transaction costs at all levels, particularly in using state, district and circle level systems and resources, besides envisioning one comprehensive strategic design for advancement of school education. The shift in the focus is from project objectives to refining systems level performance and schooling outcomes which will be the emphasis of the SSA scheme, alongwith encouraging States towards improving quality of education.

Major Objectives of SSA

The holistic nature of the scheme envisages Universal Access, Equity and Quality, promotion of Vocational Education, refurbishment of the use of Soft or e-Materials in schools and strengthening of Teacher Education.

The major objectives of the scheme are summarized below:

- **Provision of Quality Education and enhancing learning outcomes of students**
- **Bridging Social and Gender Gaps in School Education**
- **Ensuring Equity and Inclusion at all levels of School Education**
- **Ensuring minimum standards in schooling provisions**
- **Support States in implementation of Right of Children to Free and Compulsory Education (RTE) Act, 2009**

Curriculum and Syllabus of ‘Life Science & Environment’ for Class X: A few words

Objectives of Science Education

What should be the objective of science education? To find answer to this question we must try to explore the objective of education. Referring to Mahatma Gandhi it can be said that true education is what inspires the children to manifest their spiritual, cognitive and physical powers. This objective encapsulates the belief that education holds in itself the potential to bring radical change in the individual and the society.

To discuss the objective of teaching science, one must first develop notions about the nature, method, scope and limitations of science education. Man has always observed his surrounding world with awe and admiration. He has tried to seek meaningful relationship between various natural phenomena. He has tried to make different machines to get the benefit of interacting with nature. He has sought the help of various concept models to understand his surrounding nature. This sincere effort of man is called science. Thus, science is a dynamic and expanding resource of knowledge enhanced by ever changing new experiences of mankind. Science is knowledge and knowledge is power. Power engenders wisdom and also leads to freedom. So science is basically an effort that brings changes to the society.

Objectives of ‘Life Science and Environment’

The significance of naming the subject as ‘Life Science and Environment’ lies in knowing about various concepts, principles and methods of Life Science and finding out from the environment the application or cause-effect relationship of those concepts, principles and methods. While designing the curriculum of ‘Life Science and Environment’ care has been taken to manifest how environment is inextricably connected with various aspects of Life Science. Let us now find out the main objectives of learning ‘Life Science & Environment’:

- i) Based on their preliminary idea of the living world, the learners will be able to construct knowledge related to different terminologies used for different biological phenomena, principles and methods.
- ii) This will lead to the development of curiosity, interest, values and awareness among the learners about environment.
- iii) The learners will be able to understand and appreciate the unity regarding the structure, existence and growth of organs of living organisms in the living world rather than their apparent diversity. They will be able to identify the cause-effect relationship of the structure and functions of the living body.
- iv) The learners will be facilitated to develop their clear understanding and values on aspects like environmental conservation, natural resources, role of community, position of man and his influence in the biosphere etc.

- v) The learners will be able to develop a balanced approach to Life Science and Environment so that they have the most modern outlook about the subject.
- vi) The learners will be able to realize the social and economic implications of the topics of 'Life Science & Environment' and relate those to the needs of mankind extensively and apply the same in daily life.
- vii) The learners will be able to develop skills in observation, questioning and experimentation.
- viii) Creativity, innovativeness and intelligence will be developed in the learners.
- ix) The learners will be able to develop a working knowledge of those portions of Physics, Chemistry and Mathematics that are necessary for proper understanding and interpretation of 'Life Science and Environment'.
- x) The learners will demonstrate alertness in evaluating and explaining biological phenomena in daily life.

Curriculum of 'Life Science & Environment': Main characteristics

i) Integrated Curriculum

From the stage of planning and designing the curriculum and syllabus of 'Life Science and Environment' for classes VI, VII, and VIII, environment as a topic has been introduced through the integration of other branches of science (such as Physics or Life Science.) The main policies adopted in this respect are: Learning about the Environment, Learning through the Environment and Learning for the Environment. While presenting various topics in the syllabus for classes VI and VII, mainly Learning about the Environment and Learning through the Environment doctrines have been implemented. However, in the syllabus for class VIII various topics related to Learning for the Environment have been included. This trend has also been followed in the syllabus of 'Life Science and Environment' for class X. The sub-themes, 'Sensitivity and response in plants', 'Locomotion as a type of response in animals' under the theme 'Control and coordination in living organisms' is indeed a true illustration of Learning through the Environment. Similarly the whole theme of 'Environment, its resources and their conservation' is replete with examples of Learning for the Environment, namely, awareness about environmental pollution, treating biodiversity as an environmental resource & the importance of its use in various needs of human society and varied representations of conservation of biodiversity.

ii) Exploratory activity-based curriculum

The curriculum and syllabus of 'Life Science and Environment' have been so designed as to generate in learners an attitude of investigation, exploration and inquiry. While discussing the various themes in the curriculum, it has been suggested that at first an inquiring mindset is developed in the learners through examples from daily happenings and thereby work

the way towards the main topics of the textbook. Further, active participation of the learners wherever necessary will facilitate them in gaining practical experience on the textual topics. This will also help them in developing their skills in the practical field.

iii) Learner-centric approach

Based on the theory of constructivism, the curriculum and syllabus of 'Life Science and Environment' have been so designed that the learners are kept at the centre of the teaching-learning process. Questions that arise in the mind of the learners owing to the multifarious incidents occurring in the surrounding environment has led to the introduction of various topics in the syllabus. Hence various instances of daily life have been presented before the introduction of main topic included in the themes.

iv) Evaluation: an integral part of the curriculum

Learning and evaluation when viewed in the light of Constructivism emphasizes that evaluation is not the final step of teaching; rather it is viewed as a continuous process. In this ongoing process of teaching-learning, the teachers closely observe the learners and record their significant progress or limitations and facilitate them accordingly. Based on this concept, the curriculum for class X has included provision for Internal Formative Evaluation so that evaluation does not get separated from the curriculum. The learners are to be evaluated within the classroom keeping pace with their level of learning. According to the concept of Constructivism, evaluation has an integral relation to learning progress. The appropriate implementation of Internal Formative Evaluation within the classroom will eventually do away with the traditional concept of evaluation with pen & paper at the end of the teaching process. Six tools have been mentioned in this regard. They are: Survey, Nature Study, Case Study, Creative Writing, Model Making and Open Text Book Evaluation. The Internal Formative Evaluation should be conducted within the span of the classroom. There is no need to go beyond the classroom. This enables the teachers to assess the advancement or lacuna of the learners even before the summative evaluation. So there is scope for adopting appropriate measures. Consequently, both the teachers and the learners get ample scope to be familiar with different methodologies and tools used for evaluating the level of learning or skills of the learners.

v) Development of varied skills

During the framing of the curriculum and syllabus of 'Life Science and Environment', the development of various skills of the learners have been taken into consideration. The learners will be able to develop skill in handling microscope by observing permanent slides of different stages of plant and animal cell division, permanent slides showing the reproductive processes of some animals included in the syllabus (e.g. Amoeba, Yeast, Hydra etc.). The psychomotor skills of the learners will be developed by drawing and

labelling pictures related to different topics included in the syllabus (e.g. eye, different stages of cell division, reproductive processes of various organisms etc.). The decision making and problem solving skills in the learners will be developed through discussion on various topics related to the syllabus and solving problems related to it. These skills will not only help the learners to study science in future, but also help them in their daily life.

vi) Use of ICT as a learning aid

Information and Communication Technology (ICT) is an efficacious mode of learning in the present era. It should not be treated as a separate discipline. In fact, there is a wrong notion that only the experts of Information Technology can teach ICT, and not the subject-teachers. This definitely deters effective integration of ICT with different subjects. It also debars the subject-teachers to develop their interest and skills in ICT. Thus, ICT should be viewed as an important tool for the success of the curriculum. In the implementation of ICT as an integral component for the success of education the role of the subject-teachers is irrefutably significant.

To develop a clear conception about various topics included in the syllabus help may be sought from different educational websites. Practical knowledge about different concepts related to the morphology of organisms can be developed by observing the virtual dissections in these websites. There are some comparatively abstract topics in the syllabus (e.g. chromosome, interrelationship among chromosome, DNA & gene, structure of gene, cell division, reproduction, heredity etc.) which are difficult for the learners to visualize easily. For this reason, while discussing such topics if the teacher takes help of related Visual Presentation (e.g. downloaded videos from Youtube or other websites), the learners will be able to see with their own eyes various events that are included in the syllabus. This will help the learners to develop correct understanding about those topics and ward off misconceptions. This is because we know that, 'Seeing is believing'.

Using computer software, e.g. Microsoft Powerpoint, a topic can be explained with ease with the help of slideshow presentations. However, the teacher ought to be careful on two areas — i) information, pictures or Powerpoint presentations downloaded from the websites should be checked for authentication; ii) care should be taken so that copyright laws are not violated for downloading and using information, pictures and Powerpoint Presentations of those websites.

The teachers' active role is desirable for using ICT in the process of learning. Care should be taken so that the teachers and the learners can collectively collaborate in co-creation and exploration for successful implementation of the concept of constructivism by the use of ICT.

Varied areas of Life Skill development in the curriculum of 'Life Science and Environment' for Class X

Some abilities are needed to successfully cope with various demands and challenges of the individual and society. These abilities are nothing but life skills. Life skills enable us to translate knowledge, attitude and values into actual abilities i.e. “what to do and how to do it.” Life skill education is necessary for holistic development of the human beings. Holistic development include development of various physical, mental and social abilities as well as development of cognitive abilities.

The abilities essential for becoming a complete human being can be termed as life skills. Infact, any ability for moving ahead in daily life is actually a life skill. Life skill can be illustrated by citing various examples from daily life – arranging different books at the study place in respect of subjects so that the required book can be found easily whenever necessary, choosing appropriate food for healthy lifestyle, asking suggestions from a stranger about going to a specific place, boarding a particular bus for going to a specific place etc.

The list of essential life skills can vary in accordance with geographical, social and cultural environment. But the most important aspect of it is that when faced with a new challenge she/he is able to apply her/his knowledge for solving the said problem; that is, the urge and skill to learn something new (Learning to learn). Any life skill i.e. ability can be developed through education and practice.

Now the question is how are life skills to be practised and developed? Can these skills be developed through the subjects? Development of various life skills is possible while discussing different key concepts in the classroom included in different themes as mentioned in the syllabus of 'Life Science & Environment' for Class X. It is necessary to try to develop life skills in the classroom through channelling topic-based discussions in specific directions by the timely and appropriate interventions of the teachers.

The areas for discussion and subsequent development of probable life skills given in the following table are samples only. Other life skills except the ones mentioned in the table can also be developed. It is possible to develop the skill of effective communication in almost all the areas for discussion mentioned in the table. For this reason it is not mentioned in the table.

Curricular area	Areas for discussion	Development of probable life skills
1. Control and coordination in living organisms	How does an organism identify change in environment?	Critical thinking
	How do plant hormones help in plant sensitivity ?	Critical thinking, Problem solving
	What can happen if hormones are not secreted at the desired level in an organism?	Critical thinking, Decision making
	How do animals respond to stimuli ?	Critical thinking
	Why do organisms move from one place to another ?	Critical thinking
2. Continuity of life	What kind of relationship exists among chromosome, DNA and gene?	Critical thinking

Curricular area	Areas for discussion	Development of probable life skills
	What is the significance of a cell entering interphase stage after division?	Critical thinking, Decision making
	What can be the effect of uncontrolled cell division?	Critical thinking
	How do new characteristics arise in an organism due to meiosis?	Critical thinking, Problem solving
	What is the necessity of producing new plants artificially?	Critical thinking, Decision making
	What is the significance of reproduction in the existence of a species?	Critical thinking
	How do growth occur in plant and animal cells?	Critical thinking
3. Heredity and common genetic diseases	How do different characteristics get transmitted from parents to their children?	Critical thinking, Problem solving
	Are Mendel's laws of heredity universally applicable?	Problem solving
	What is the necessity of pre-marital genetic counselling?	Critical thinking
4. Evolution and adaptation	How do organisms change over time?	Critical thinking
	How did the origin and gradual development of life occur in the history of earth?	Critical thinking
	How is it possible to understand that evolution has occurred and the process is still going on?	Critical thinking
	Why behaviour of an organism is so important in the process of evolution?	Problem solving, Decision making
	How do behaviour of an organism help in its adaptation in a specific environment?	Critical thinking, Problem solving, Decision making
5. Environment, its resources and their conservation	How do human activities influence nitrogen cycle ?	Critical thinking, Decision making
	How does pollution affect our lives ?	Critical thinking
	How does ever-increasing population affect environmental balance?	Problem solving, Decision making
	How do we benefit from biodiversity in our daily life?	Critical thinking, Problem solving
	What is the necessity of involving common people in conservation efforts?	Critical thinking, Decision making

Sample Pedagogical analysis of ‘Life Science and Environment’ syllabus for Class X

Sl. no.	Theme	Sub-theme	Previous knowledge & class in which acquired		Expected Learning outcomes
			Previous knowledge	Class	
1.	Control and coordination in living organisms	a) Sensitivity and response in plants	(i) Able to differentiate between living and non-living. (ii) Able to list characteristics of living organisms.	IV	Learners will be able to : (i) explain the meaning of the term sensitivity. (ii) explain the response of plants under the influence of a stimulus. (iii) discuss plant sensitivity with the help of appropriate examples. (iv) discuss and appreciate the contribution of Acharya Jagadish Chandra Bose in discovering the sensitivity of plants. (v) identify plant movement as a type of response to stimuli. (vi) describe different types of plant movement with the help of appropriate examples. (vii) compare tactic, tropic and nastic movement.
		b) Response and coordination in plants - Hormones	(i) Able to explain the basic concepts of hormones. (ii) Able to explain the role of hormones in chemical coordination in human body.	VIII	

Sl. no.	Theme	Sub-theme	Previous knowledge & class in which acquired		Expected Learning outcomes
			Previous knowledge	Class	
			(iii) Able to discuss the general characteristics of hormones.	VIII	(iii) describe the source, mode of transport, functioning and fate of different plant hormones (e.g. Auxin, Gibberellin, Cytokinin). (iv) discuss the role of synthetic hormones.
		c) Response and coordination in animals - Hormones	(i) Able to explain the basic concepts of hormones. (ii) Able to explain the role of hormones in chemical coordination in human body. (iii) Able to discuss the general characteristics of hormones. (iv) Able to mention the name of hormones secreted from different endocrine glands of human body and their functions. (v) Able to differentiate between exocrine and endocrine glands. (vi) Able to identify the location of different endocrine glands in humans.	VIII VIII VIII VIII VIII VIII	Learners will be able to : (i) relate different functions in animals and the role of hormones in controlling those functions. (ii) explain the role of hormone as messenger and regulator with suitable examples. (iii) mention the differences between plant and animal hormones. (iv) discuss the names of various endocrine glands in humans, their location, name of hormones secreted from endocrine glands and their role in human body. (v) describe the causes and symptoms of some hormonal disorders in humans.

Sl. no.	Theme	Sub-theme	Previous knowledge & class in which acquired		Expected Learning outcomes
			Previous knowledge	Class	
			(vii) Able to describe the causes and symptoms of various problems and diseases of humans related to inadequate or excessive secretion of hormones.	VIII	(vi) differentiate between endocrine and exocrine glands.
		d) Re-sponse and coordina-tion in animals - Nervous System	(i) Able to mention neural communication in as an example of communication in humans.	VIII	<p>Learners will be able to :</p> <ul style="list-style-type: none"> (i) explain neural control and coordination with the help of experiences from daily life. (ii) identify different components of nervous pathway by using various day-to-day experiences as examples. (iii) mention the differences between mode of action of hormones and nervous system. (iv) mention the structure and function of different parts of a neurone. (v) draw a labelled diagram of a neurone. (vi) discuss different types of neurones, nerves and nervous systems. (vii) explain the functions of ganglia and synapse. (viii) identify the location and functions of different parts of brain.

Sl. no.	Theme	Sub-theme	Previous knowledge & class in which acquired		Expected Learning outcomes
			Previous knowledge	Class	
					<p>(ix) explain reflex action and it's types with the help of appropriate examples.</p> <p>(x) mention the structure and functions of different parts of eye.</p> <p>(xi) draw a labelled diagram of longitudinal section of eye.</p> <p>(xii) mention the differences between monocular and binocular vision.</p> <p>(xiii) explain the process of accommodation for looking at near and distant objects.</p> <p>(xiv) explain different defects of vision (e.g. Myopia, Hyperopia and Presbyopia) and their corrective measures using various lenses.</p> <p>(xv) describe cataract and its corrective measures.</p>
	e) Locomotion as a type of response in animals		(i) Able to describe how locomotory organs (e.g. legs, wings etc.) look like in some familiar animals.	III	<p>Learners will be able to :</p> <p>(i) discuss the motivations behind locomotion with examples.</p> <p>(ii) describe the process of locomotion of some animals (e.g. Amoeba, Paramecium, Euglena, Fish and Bird).</p>

Sl. no.	Theme	Sub-theme	Previous knowledge & class in which acquired		Expected Learning outcomes
			Previous knowledge	Class	
			(ii) Able to discuss changes in organs including locomotory organs in animals to adapt themselves in different environment in which they live.	IV	(iii) mention the role of cerebellum and internal ear in locomotion of humans. (iv) explain then role of movable bone-joints in the movement of associated organs. (v) mention the role of skeletal muscles in movement of organs.

How the learners will learn (Learning indicators) :

- (i) The learners are able to speak about any concept in her/his own language.
- (ii) The learners are able to explain a concept in her/his own language.
- (iii) The learners are able to mention relevant examples about a particular concept.
- (iv) The learners are able to ask relevant questions during a discussion on a concept.
- (v) The learners are able to cite relevant examples from the environment.
- (vi) The learners are able to give appropriate explanation about a concept.
- (vii) The learners are able to apply their knowledge appropriately.

In the same way the other themes included in the curriculum can be analysed pedagogically.

Misconceptions : Samples and Identification

What is misconception

“The cells of animals have plasmalemma but no cell wall; and the cells of plants have a cell wall but no plasmalemma.”

“Respiration occurs in animals and photosynthesis occurs in plants”

“Green plants photosynthesize in sunlight and respire at night.”

“Egestion is excretion.”

(Barrass, 1984)¹

Teachers often come across such concepts as expressed in the above mentioned statements during classroom transactions. Obviously, teachers try to eliminate such misconceptions with care. Misconceptions of the students given at the very outset of the discussion are mere samples. They can be varied. Hence, it is quite relevant to discuss about possible ways of eliminating learners' misconceptions in the purview of science-teaching in India and the world.

Probing children's understanding of science concept has been a focus of research in science education since the 1980s (Wandersee and Mintzes, Sanders 1993, Driver et al. 1994, Garnett et al. 1995). These studies have revealed that children possess numerous ideas that are inconsistent with scientific knowledge even after teaching. These children's ideas have been denoted by various terms such as misconceptions (Fisher, 1983; Lawson and Thompson 1988), alternative conceptions (Gilbert and Swift, 1985) intuitive belief (McKloskey, 1983), alternative frameworks (Driver and Easley, 1978), preconceptions (Anderson & Smith, 1983; Hashweh, 1988), prescientific conceptions (Good, 1991).

(Yip, 1998)²(Cho, Kahle and Nordland, 1985)³

In other words, the ideas that do not conform with the accepted scientific concepts are generally known as misconceptions. Besides, misconceptions of the learners are also regarded with different nomenclatures.

Let us now try to define misconceptions - “*a perception of phenomena occurring in the real world which is not consistent with scientific explanation of the phenomena*” (Modell et al., 2005)⁴.

Importance of identifying misconceptions

Now the question is why in the learning process is it necessary to identify and eliminate misconceptions of the learners?

“.....the relevant concepts held in a student's cognitive structure are the most important factors influencing the learning of new content.” (Ausubel, Novak & Hanesian, 1978)⁵

According to Ausubel's theory of cognitive learning, mentioned above, it is imperative to identify the existing concepts of the learner to make teaching effective. Then based on the learner's existing concept, new concepts are formed. Researches show that often the existing concepts of the learners are key to the success of the learners in the classroom. It is noteworthy that the learners come to the classroom with preconceptions based on their previous experiences. When these preconceptions do not comply with the accepted scientific notions, we call them misconceptions.

Ausubel observed (1963, 1968) that "*Ascertain what the student knows and teach accordingly*". In this case, Ausubel's opinion can be modified to "*Ascertain what the student misunderstands and teach accordingly*" (Fisher & Moody, 2002)⁶. The fact is, often it is seen that some areas of the existing concepts of the learners do not comply with the accepted scientific concepts. And these misconceptions deter them from learning new concepts. These misconceptions are so deep-rooted in the learners that even special teaching-learning strategies adopted for eliminating misconceptions do not encourage the learners to modify their misconceptions and form new concepts.

Research on student learning suggests that student misconceptions serve as barriers to student achievement. These misconceptions are often based on personal experiences and are difficult to bypass en route to meaningful understanding in any context area (Gelman&Gallistel, 1986⁷; Wellman, 1990⁸). Even after instruction designed to address scientific content in an area where misconceptions are held, many students do not reconstruct their thinking. Only those students able to deconstruct their knowledge and reconstruct it using critical thinking and logical reasoning appear to have fewer misconceptions even after high-quality instruction." (Lawson and Thompson, 1988)⁹.

Source and nature of misconceptions

Wandersee, Mintzes and Novak (1994)¹⁰ had studied over 3000 research papers on misconceptions and listed the following main points:

i) Learners generally come to formal science education with a diverse set of alternative conceptions concerning natural objects and events. A majority of science teachers are also unaware of the existence of these misconceptions in the learners'.

ii) Misconceptions of the learners are irrespective of their age, ability, gender and cultural boundaries. All over the world similar misconceptions are common among students and common people.

iii) Many of the interpretations of natural phenomena by the scientists and philosophers of previous generations are rather curiously analogous to misconceptions. The fact that these naive conceptions are widely shared across both space and time is a tribute to their sensibility. In fact, these are mere logical inferences based on limited data. Thus, it is clearly evident that many scientific ideas are counterintuitive. In fact, scientific understanding develops through realization of the workings of the world.

iv) The basis of misconceptions often lies in multifarious personal experiences like observation and perception, peer culture and language, teacher's explanations and instructional materials.

v) Sometimes misconceptions are such that they cannot be eliminated by the formal teaching strategies. Advices like 'this is a wrong concept' or 'this concept is erroneous for this reason' hardly deviate the students from their naive concepts. Strong evidences have to be presented before them for eliminating such conceptual dilemma.

vi) The problem sometimes becomes critical when the teacher herself/himself subscribe to the same misconceptions. The reason is that the common people, and even the scientists also do not always employ scientific method in their everyday effort to make sense of the world. Besides, all persons do not have the means or scope to access the accumulated wisdom of every field. So people try to reach the best solution through their limited knowledge. Hence misconceptions arise.

vii) Unintended learning outcomes develop due to the conflict between the prior knowledge of the learners and the knowledge presented in formal instruction. In fact, often teachers say that "*I told them, they heard me, therefore they know it.*" But the teachers scarcely realize the need to assess the proper development of knowledge of the learners. Thus, the misconceptions grow without the knowledge of the teachers.

viii) For the conceptual change of the learners the instructional approach has to be carefully chosen so that it will help to supplant the deep-rooted misconceptions of the learners with the scientifically accepted concept. Effective strategies for conceptual change are at the heart of inquiry-based science teaching and constructivist learning. *(Fisher & Moody, 2002)⁶*

Types of misconceptions

The misconceptions that develop in formal science education are of three types:

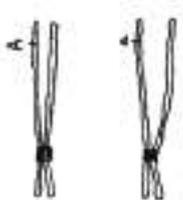
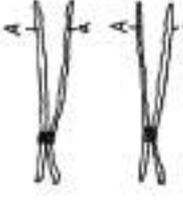
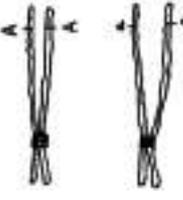
- i) The students come to the class with some informal ideas developed from different experiences of daily life.
- ii) Incomplete or improper views developed by the learners during classroom instruction.
- iii) Erroneous concepts propagated by teachers as well as by textbooks.

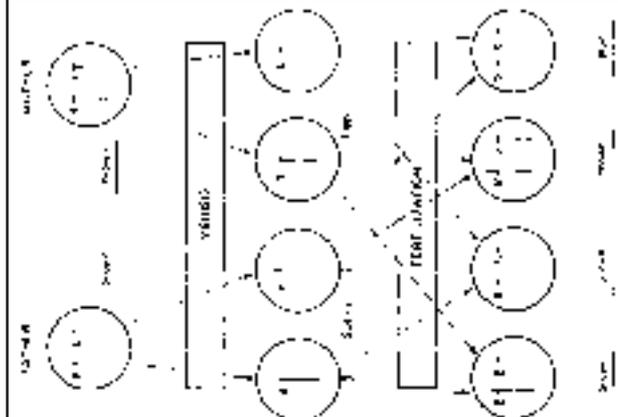
(Yip, Din-Yan, 1998)²

Samples of misconceptions in respect of the curriculum of 'Life Science and Environment' for class X

While going through the different topics of the curriculum of 'Life Science and Environment' for class X, misconceptions may develop among the learners. Samples of such misconceptions are given here. Teachers are perhaps familiar with some of these misconceptions. It is therefore expected that the teachers getting conversant with these type of misconceptions would try to eliminate them from the learners during classroom transaction.

Topic	Misconception/ Myth	Scientific fact
1. Hormone	<p>i) Testosterone hormone can be found only in males and Estrogen hormone only in females. (<i>Nehm & Young, 2008</i>)¹¹</p> <p>ii) Testosterone or Estrogen do not have any physiological role apart from sexual role. (<i>Nehm & Young, 2008</i>)¹¹</p>	<p>In normal condition ovaries in the female secrete Androstenedione, Testosterone and Dehydroepiandrosterone. The amount of Testosterone present in female in their reproductive years is more than FSH, LH, Estrone and Androstenedione. The testes in male also secrete Estrogen in addition to the ovaries in female. Testosterone is secreted from the adrenal glands in both males and females.</p> <p>Testosterone or Estrogen have some non-sexual physiological role apart from sexual role in human body. Some of these are -</p> <ol style="list-style-type: none"> Brain (diurnal rhythm, mood and well-being, memory, cognitive function, etc.) Bone formation and maintenance Immune system Blood cell formation Circulatory system Metabolism
	<p>iii) FSH and LH can be found only in females. FSH and LH do not have any role in males. (<i>Mason, 2011</i>)¹²</p>	<p>FSH and LH control reproductive functions in males. FSH helps in the development of sperms by stimulating Sertoli cells. On the other hand, LH helps in the secretion of Testosterone by stimulating Leydig cells.</p>
2. Nervous System	<p>i) Nerve impulse travels from dendrite to the axons below. (<i>Odom, 1993</i>)¹³</p>	<p>In reality, depolarization can start from different places in the neurones. Once depolarization gets started, from wherever in the neurone it may originate, the action potential spreads throughout the neurone. Also action potentials can travel towards and away from axon and dendrite.</p>

Topic	Misconception/ Myth	Scientific fact
<p>ii) Neurones are segmented. (Odom, 1993)¹³</p> <p>3. Cell Division</p> <p>i) Cell division means only increase in the number of cells. One cell to two cells, two cells to four cells – cells increase in number so on. As a result the organisms grow in size. (Riemeier & Gropengießer, 2008)¹⁴</p> <p>ii) Sister chromatids do not carry same allele. (Brown, 1990)¹⁵</p>	<p>Neurones are not segmented. This misconception possibly came from the concept of the myelin sheath and the saltatory conduction of the action potential in the myelinated neurones.</p> <p>In cell division one cell divides to form two cells. The two daughter cells cannot start dividing instantaneously. Because after the formation of daughter cells from parental cells, the daughter cells are small in size compared to parental cells. So prior to dividing the two daughter cells need to grow. This event occurs in between two cell divisions in the interphase stage. Cell division not only entails division, but both division and enlargement.</p> <p>Most often the learners do not have the following concept that as a result of cell division the daughter cells become small in size and subsequently undergo growth.</p> <p>Actually the sister chromatids carry same allele. The learners face difficulty while solving genetics problems since they have contrary belief. Type 1, Type 2 and Type 3 in the diagram represent the misconceptions related to this concept. (Stewart, 1983)¹⁶</p>	<p>Neurones are not segmented. This misconception possibly came from the concept of the myelin sheath and the saltatory conduction of the action potential in the myelinated neurones.</p> <p>In cell division one cell divides to form two cells. The two daughter cells cannot start dividing instantaneously. Because after the formation of daughter cells from parental cells, the daughter cells are small in size compared to parental cells. So prior to dividing the two daughter cells need to grow. This event occurs in between two cell divisions in the interphase stage. Cell division not only entails division, but both division and enlargement.</p> <p>Most often the learners do not have the following concept that as a result of cell division the daughter cells become small in size and subsequently undergo growth.</p> <p>Actually the sister chromatids carry same allele. The learners face difficulty while solving genetics problems since they have contrary belief. Type 1, Type 2 and Type 3 in the diagram represent the misconceptions related to this concept. (Stewart, 1983)¹⁶</p>
	<p>TYPE 1</p>  <p>showing one, or as here both alleles but labeling a sister chromatid blank</p> <p>TYPE 2</p>  <p>placing different alleles on one pair of sister chromatids</p> <p>TYPE 3</p>  <p>placing different alleles on both pairs of sister chromatids</p> <p>Correct arrangement</p> 	

Topic	Misconception/ Myth	Scientific fact
	<p>iii) As a cell undergoes cell division to produce two daughter cells, the chromosome number decreases in the daughter cells. (Lewis, Leach & Wood-Robinson, 2000)¹⁷</p>	<p>DNA synthesis occurs in the S phase of interphase of mitosis. At that time each chromosome has two chromatids. Two sister chromatids separate from each other and start to travel to the opposite poles of a cell in the Anaphase stage of Mitosis. These separated sister chromatids are then termed as daughter chromosomes. Thus both the daughter cells receive a copy of each chromosome present in the parental cell. As a result, both the daughter cells contain equal number of chromosomes as present in the parental cell.</p>
<p>4. Heredity</p>	<p>i) 'Gene' and 'Allele' - these two words are used interchangeably. (Cho, Kahle, Nordland, 1985)³</p> <p>ii) A gamete contains both the chromosomes present in a pair of homologous chromosomes in a parental cell. (Hacking & Treagust, 1984)¹⁸</p>	<p>An allele is one of the many possible forms of a gene.</p> <p>Only one chromosome of a pair of homologous chromosomes present in the parental cell can be found in a gamete. Monohybrid cross should be taught in such a way that the separation of chromosome (and gene) pairs at meiosis and the reformation of chromosome (and gene) pairs at fertilization get clear for the students. The possibility of generation of misconception is lessened if this process is explained with the help of 'Genes-on-chromosomes' model. In this kind of model, the gametes are represented as separate and distinct haploid cells.</p> <p>A 'Genes-on-chromosomes' model used to illustrate a monohybrid cross involving eye colour (Hacking & Treagust, 1984)¹⁸</p> 

Topic	Misconception/ Myth	Scientific fact
	<p>iii) Dominant genes are more powerful than recessive genes. (<i>Hackling & Treagust, 1984</i>)¹⁸</p> <p>iv) • Mendel's Laws can be found in Mendel's research paper in the form as taught today.</p> <ul style="list-style-type: none"> • Mendel thought that one character was always dominant over another. • Mendel discovered the famous "Mendelian" ratio, 9:3:3:1. (<i>Corcos & Monaghan, 1985</i>)¹⁹ 	<p>iii) Dominant gene gets expressed in phenotype. This has nothing to do with being powerful.</p> <p>a) Law of segregation For Mendel, segregation of characters was not a law. He considered a law to be a statement of relationship between observable things. None of his assumptions about kinds of pollen and egg cells could be verified by any direct observation. In his time, very little was known about chromosomes. Only when the biologists had worked out the process of meiosis and became convinced that the genes were carried on chromosomes, complete understanding of the law of segregation and law of independent assortment was possible.</p> <p>b) Law of dominance Sometimes one gene of a pair masks the expression of a second gene. The word, 'sometimes' is very important. There are various types and degrees of dominance. In complete dominance, the hybrid has a phenotype completely identical to one of the original parents. In incomplete dominance, the phenotype of the hybrid is intermediate between the parental phenotypes. In overdominance, the phenotype of the hybrid is more extreme than that of either parent. In Co-dominance the heterozygote expresses both parental phenotypes.</p> <p>It happened so that the seven pairs of characteristics chosen by Mendel are examples of complete dominance. Mendel himself was well aware that such a phenomenon was not universal. In his own paper he mentioned an eighth trait, flowering time, which shows incomplete dominance.</p> <p>The culprit in elevating the phenomenon of complete dominance to a law by generalizing it seems to have been de Vries (1900). On the other hand, Correns (1900), another discoverer of Mendel's paper, after finding that dominance</p>

Topic	Misconception/ Myth	Scientific fact
	<p>v) The seven pair of characters of pea plant that Mendel worked with were all inherited independently. (Corcos & Monaghan, 1985)¹⁹</p>	<p>did not exist in many traits of peas and other plants, attempted to decrease its importance.</p> <p>c) Law of Independent Assortment</p> <p>Mendel reported four types of seeds from F₂ in dihybrid cross experiment – 315 were round and yellow, 101 were wrinkled and yellow, 108 were round and green and 32 were wrinkled and green. The ratio of these four types of seeds comes approximately to 9:3:3:1. This ratio would be expected if both pairs of characters are independently inherited. Mendel did not mention such a ratio. The idea that he did and concluded from it the concept of independent assortment is a myth perpetuated directly or indirectly in textbooks. (Bernstein & Bernstein, 1982; Jenkins, 1979; Levy, 1982; Neland, 1979; Pai & Marcus-Roberts, 1981; Sherman & Sherman, 1983; Volpe, 1983; Ward & Hertzal, 1980)</p> <p>The truth is that Mendel's dihybrid and trihybrid experiments involved only three of the seven traits - color of the seed albumen, seed shape and the color of the seed coat. Mendel did not report the results of a dihybrid cross involving the other traits, though he said he carried those crosses. Let's see what Mendel himself wrote – <i>In addition, several more experiments were carried out with a smaller number of experimental plants in which the remaining traits were combined by twos or threes in hybrid fashion; all gave approximately the same results. Therefore, there can be no doubt that for all traits included in the experiment this statement the formation of combination series is valid</i> (Mendel, 1865)²⁰</p>

Topic	Misconception/ Myth	Scientific fact
		<p>In this case, the word approximately is important because now we know that for independent assortment of characters to occur the genes that govern these characters need to be located either on non-homologous chromosomes or very far apart on the same chromosome. The seven traits chosen by Mendel are now known not to be on seven different chromosomes. This is at variance to what most of us continue mistakenly to believe, teach, and write in textbooks (<i>Singer 1978; Tortora & Becker 1978; Ward 1980</i>). Lamprecht (1961)²¹ who made an extensive study of linkage in peas reported that three of Mendel's original genes were on one chromosome and two were on another. The other two genes are on two different chromosomes. Now we know that 2 genes are located on chromosome number 1, 3 genes on chromosome number 4 and 2 genes on chromosome number 5. (<i>O'Brien, 1993</i>)²²</p> <p>We do not have Mendel's results on his crosses of a dihybrid involving differences in length of stem and pod shape. These results would have been interesting because it is highly likely that they did not conform to the idea of independent assortment since the genes governing those traits are on the same chromosome only 13 map units apart.</p> <p>Mendel reported the results of a trihybrid cross involving the colour of the seed coat, the colour of the seed albumen, and the form of the seed. The genes for the first two traits are on the same chromosome, chromosome 1, but they are too far apart to show linkage. If those genes had been closer, Mendel undoubtedly would have obtained different results that again would not have confirmed the idea that traits are inherited independently. Luck was definitely on the side of Mendel.</p>
5. Evolution	<p>i) Individuals within a species are all essentially alike. (<i>Fisher & Moody, 2002</i>)⁶</p>	<p>Individuals within a species vary significantly. Because variation can be observed even in individuals of the same species.</p>

Topic	Misconception/ Myth	Scientific fact
	<p>ii) Variations within a population arise due to environmental pressure, e.g. webbed feet of ducks and long necks of giraffes developed due to environmental need. (<i>Fisher & Moody, 2002</i>)⁶</p>	<p>These features came into being from some sudden mutation which proved to be advantageous to the environment at that time.</p>
	<p>iii) Individuals respond to a changed environment by becoming slightly better adapted to that environment with each successive generation. (<i>Fisher & Moody, 2002</i>)⁶</p>	<p>Individuals with an adaptation favoured by the current environment will generally contribute more offspring to the next generation.</p>
	<p>iv) Competition occurs among members of the same or different species. This competition usually takes the form of physical combat and the strongest individuals win. (<i>Fisher & Moody, 2002</i>)⁶</p>	<p>Competition occurs among members of a species for space, food etc. The members who are best suited to that environment ultimately emerge as victors. This has nothing to do with an organism being physically powerful.</p>
	<p>v) Mutations occur in response to needs. (<i>Fisher & Moody, 2002</i>)⁶</p>	<p>Mutations are chance events. Mutations do not arise in response to an organism's need.</p>

Topic	Misconception/ Myth	Scientific fact
	vi) Inherited traits include traits acquired by the parents (such as physical fitness) that are passed on to the offspring. (<i>Fisher & Moody, 2002</i>) ⁶	Inherited traits are those that are specified by the alleles contained in the gametes of the parents.
	vii) Evolution is completely random. (<i>Relethford, 2017</i>) ²³	Some aspects of evolution (e.g. mutation) have a random element. But some other aspects of evolution (e.g. natural selection) are not random. Variations arise in organisms due to mutation. These variations are then filtered by natural selection. As a result, harmful variations decrease and beneficial variations increase in a group of organisms. Whether an organism will be able to survive and reproduce in an environment will depend on the extent to which that organism is able to adjust oneself to that environment. This is not at all a random event.
	viii) Bigger is always better. (<i>Relethford, 2017</i>) ²³	In a popular application of the idea of “survival of the fittest,” it is natural to equate larger size as having the greater chance of evolutionary success. This is because one assumes that biggest is the most fit. Although there are indeed many cases where larger individuals have a greater chance at survival and reproduction, there are also cases where being smaller gives one an evolutionary advantage. It all depends on the nature of the environment where an organism resides.
	ix) Darwin was the first to propound the theory of evolution by natural selection (<i>Rees, 2007</i>) ²⁴	In Scotland, Patrick Matthew, a timber merchant, proposed the principles of natural selection in 1831, almost 30 years before Darwin published his theory. Unfortunately Matthew published his ideas in an appendix to a book on naval timber and arboriculture. (<i>Desmond and Moore, 1991</i>) ²⁵ So, not surprisingly, they were lost to the scientific community.

Topic	Misconception/ Myth	Scientific fact
	<p>x) Accounts of Darwin's theory generally appear under the heading of evolution in textbooks. (Rees, 2007)²⁴</p>	<p>Darwin did not use the word 'evolution' in print until the sixth edition (1872) of his book, <i>On the Origin of Species by means of Natural Selection</i>.</p>
	<p>xi) Darwin created the concept 'survival of the fittest'. (Rees, 2007)²⁴</p>	<p>The expression 'survival of the fittest' was coined by Herbert Spencer in his <i>Principles of Biology</i> in 1864, five years after the publication of the book, <i>On the Origin of Species by means of Natural Selection</i>. Darwin had used this expression for the first time in 1868 in his book, <i>The Variation of Animals and Plants under Domestication</i> (Desmond and Moore, 1991)²⁵. Darwin had used this expression for the first time in the fifth edition (1869) of his book, <i>On the Origin of Species by means of Natural Selection</i>. (Williams, 2000)²⁶; (Boyle and Senior, 2002)²⁷</p>
	<p>xii) Darwin travelled around the world on HMS Beagle and published <i>On the Origin of Species by means of Natural Selection</i> on his return to England. (Rees, 2007)²⁴</p>	<p>Darwin returned to England in 1836. He published his book only in 1859, a long 23 years after he returned to England.</p>
	<p>xiii) Darwin recognised the evolutionary significance of the adaptations shown by the Galapagos finches (Rees, 2007)²⁴</p>	<p>Darwin had great difficulty telling the finches in the Galapagos Islands apart and mixed up the samples of birds collected from different islands. (Desmond and Moore, 1991)²⁵. He could not separate them into species and did not appreciate the significance of the shapes of their bills. Darwin believed that the group contained finches, wrens, 'Gross-beaks' and 'Icteruses'.</p>

Topic	Misconception/ Myth	Scientific fact
		<p>He did not consider these specimens to be particularly important. He had no sense that they were members of a closely related group with bills adapted to the exploitation of particular niches (<i>Desmond and Moore, 1991</i>)²⁵. It was John Gould, Superintendent of stuffed birds at the Zoological Society, who recognized that the specimens represented 12 species of closely related finches (<i>Gould, 1837</i>)²⁸.</p> <p>It was only later that Darwin appreciated the evolutionary significance of the finches. The more detailed work on resource utilisation by Galapagos finches was undertaken much later, principally by <i>David Lack (Lack, 1947)</i>²⁹.</p>
	<p>xiv) Darwin discovered evolution by Natural Selection. (<i>McComas, 1997</i>)³⁰</p>	<p>There is little doubt that Charles Darwin was the dominant force in the discovery of the mechanism of evolution, but he certainly did not do it alone and might not have done it at all except for an interesting convergence of people and events.</p> <p>Darwin returned from his voyage, reviewed the conclusions of the experts analyzing his collections. He also read Malthus' work on population growth and started his own notebooks (<i>Darwin, C.R., 1960-61</i>)³¹ on what he called the "species question." He wrote two manuscripts in 1842 and 1844 detailing his early thoughts about descent with modification. (<i>Darwin, C.R., 1986</i>)³²</p> <p>Ten years later in 1854 Darwin read a paper in the magazine <i>Annals and Magazine of Natural History</i> from a young naturalist working in Southeast Asia named Alfred Russel Wallace. In this paper, Wallace (1855) outlined his view thus, <i>Every species has come into existence coincident both in space and time with a pre-existing closely allied species.</i> (<i>Wallace, 1855</i>)³³</p>

Topic	Misconception/ Myth	Scientific fact
		<p>This was an important clue to the nature of evolution by natural selection since it addressed the issue of divergence. In February of 1858 Wallace wrote his paper <i>On the Tendency of Varieties to Depart Indefinitely from the Original Type</i>³⁴ and sent it to Darwin. Darwin was shocked and dismayed upon reading the research paper. He wrote to Lyell saying - <i>He [Wallace] has today sent me the enclosed and asked me to forward it to you. Your words have come true with a vengeance that I should have forestalled. I never saw a more striking coincidence ... If Wallace had my M.S. [manuscript] sketch written out in 1842 he could not have made a better short abstract! Even his terms now stand as heads of my chapters.</i></p> <p style="text-align: right;">(Darwin, C. R., 1996)³⁵</p> <p>Darwin's 1844 essay were read along with the research paper from Wallace at the Linnean Society meeting in July, an arrangement made by Lyell and Hooker. Finally in 1859 Darwin published his book, <i>On the Origin of Species by means of Natural Selection</i>³⁶.</p>

Identification of misconceptions in the classroom

Misconceptions deter the learning process. Hence, identification of misconceptions in a valid and reliable manner is absolutely important. In this section we will discuss about Diagnostic Tests for identifying misconceptions.

Diagnostic Tests

Hammer (1996)³⁷ used an analogy to relate between a researcher who is involved in the research of knowledge construction of an individual and a physician who diagnoses disease. According to him a doctor, who has knowledge of one or two diseases, will have only one or two avenues open to diagnose a disease, despite having as much technological support as possible. If the diagnosis of the disease is perfect, the treatment will be effective. However, if the diagnosis is erroneous not only will the treatment be ineffective but also harmful. From this analogy it is therefore evident that science education research related to concept development and its method is extremely important in identifying misconceptions in a valid and reliable way.

Now let us try to define diagnostic test - *Diagnostic Tests are assessment tools which are concerned with the persistent or recurring learning difficulties that are left unsolved and are the causes of learning difficulties (Gronlund, 1981)*³⁸. In other words, a diagnostic test reveals the gap between what we want the learners to know and what the learners actually learn.

Types of Diagnostic Test

Diagnostic can be of various types. For example –

- | | |
|----------------------------|-----------------------|
| (i) Interview | (v) Concept map |
| (ii) Open-ended test | (vi) Word association |
| (iii) Multiple-choice test | (vii) Drawing |
| (iv) Multiple-tier test | (viii) Essay |

(Gurel & Eryilmaz, 2015)³⁹

We will discuss about two types of Diagnostic Test – **Multiple-choice Test and Concept Map.**

Multiple-choice Tests

In the Multiple-choice Diagnostic Test there are four options for every question and one of them is a correct answer. In a way these questions are like the common Multiple Choice Questions (MCQ) used in any examination. But there are some basic differences. In both cases, the wrong options are called distractors. However, the distractors of the Multiple-choice Diagnostic Test have certain features:

- The distractors are based on extensive researches.
- The distractors are created such that they are in sync with the learner's own language and choice of vocabulary.
- The distractors are used to diagnose a specific level of conceptual understanding of the learners.
- The distractors help to understand where the learners are finding it difficult to understand.

(D'Avanzo, 2008)⁴⁰

The remark of David Treagust⁴¹ on the importance of the Diagnostic Multiple-choice Tests is worth noting: *The development of multiple-choice tests on students' misconceptions makes a valuable contribution to the body of work in misconceptions research, assists in the process of helping Science teachers more readily use the findings of research in their classrooms.*

Concept Inventory

When identification of the learners' alternative concepts or misconceptions is required, a Concept Inventory is formed with all the related questions of the Diagnostic Test; e.g. Concept Inventory of Natural Selection developed by Anderson et al. (2002)⁴².

Concept inventories are research-based instruments that measure students' conceptual understanding of topics for which students share common alternative conceptions (also called "misconceptions") and faulty reasoning.

(D'Avanzo, 2008)⁴⁰

Diagnostic Multiple-choice Test : Samples

A. Sample of Diagnostic Multiple-choice Test

Bacillus thuringiensis (Bt) bacteria produce a natural insecticide. Widespread use of Bt has led to Bt resistance among insects. Why is this occurring?

- Individual insects that have mutations providing resistance to Bt can survive in the presence of Bt. The survivors pass this Bt resistance on to their offspring.
- Bt-resistant insects increase in the population by chance. There are so many insects that some of them are resistant to each type of insecticide.

- c) In the presence of Bt, individual insects evolve to become Bt resistant.
- d) Natural selection causes insects to generate genes providing resistance to Bt.

Answer [The specific misconception identified by the ‘Distractor’ is also mentioned]

- a) correct
- b) Misconception: Evolutionary theory implies that life evolved (and continues to evolve) randomly, or by chance
- c) Misconception: Individual organisms can evolve during a single lifespan
- d) Misconception: Environmental challenges cause advantageous mutations.

(University of California Museum of Paleontology, Berkeley, 2011)⁴³

B. Sample of two-tier Diagnostic Multiple-choice Test

1. The trait, curly hair, is dominant to straight hair. If we use “C” to represent the dominant allele (gene) for curly hair and “c” for the recessive allele, would a person with genotype Cc have curly hair?

a. Yes b. No c. Don’t know

2. Reason for the above

- a) The person needs to have CC for curly hair.
- b) The dominant allele C is expressed in a Cc condition.
- c) The person may or may not have curly hair.
- d) The recessive allele c is expressed.

Answer : 1. a.

2. b)

(Tsui & Treagust, 2010)⁴⁴

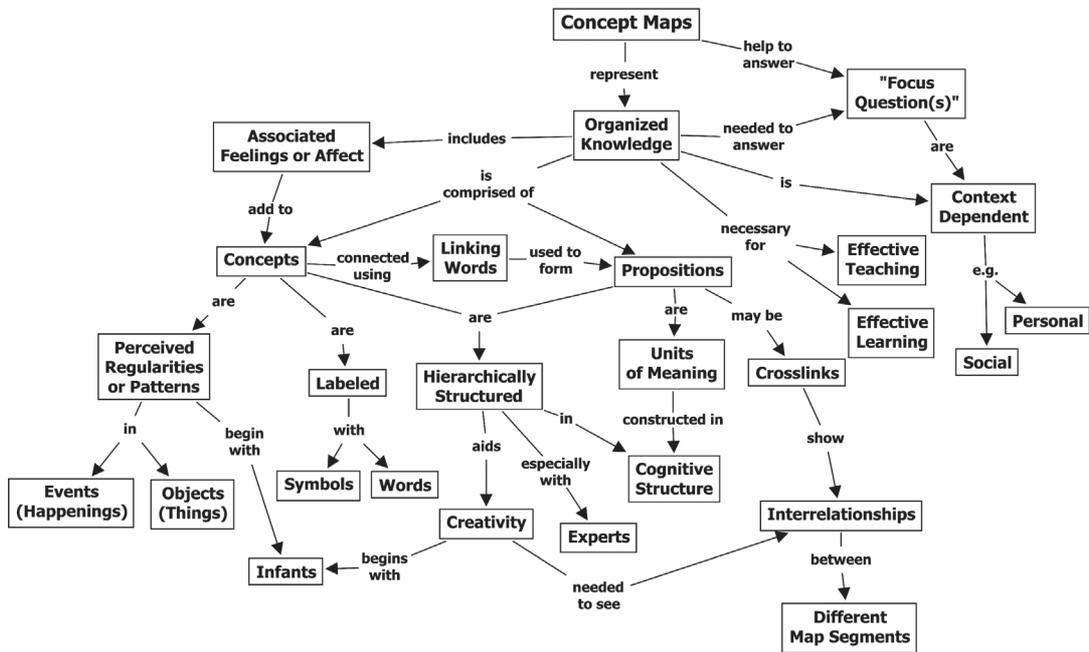
Concept Map

What is a concept map

Let us start with the definition given by Joseph D. Novak, the founder of the Concept map.

Concept maps are visual representation of knowledge and are most often used to depict the connections between different concepts via directional arrows linked to action verbs.

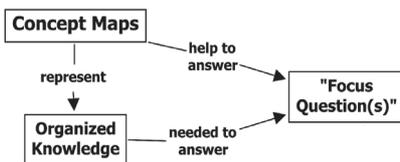
(Novak, 1998)⁴⁵



A concept map showing key features of Concept Map

(Novak & Canas, 2008)⁴⁶

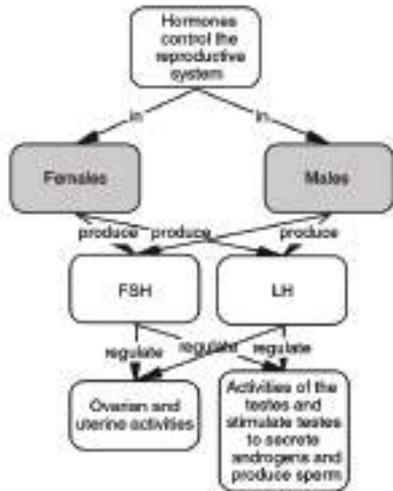
Concept map is basically a visual representation of knowledge. Concept maps are used to interpret the inter-relationship of different concepts. In fact, concept maps express the concepts in an organized manner. In the above diagram Novak has explained the features and components of concept map with the help of a concept map. Now let us identify the components of a concept map.



A small section of the above given concept map is provided here. The components of the concept map can be explained using the adjacent figure.

- (i) 'Concept Maps', 'Organized knowledge' and 'Focus question(s)' are three concepts. These concepts are kept in boxes or circles.
- (ii) The word 'represent' is used to portray the relationship between the two concepts, 'Concept Maps' and 'Organized knowledge'. The word 'represent' is termed as *linking word/linking phrase*. The directional arrows connect the two concepts by the *linking word/linking phrase*.
- (iii) '*Concept Maps represent Organized Knowledge*' — this statement is known as *proposition*. If the two concepts are properly joined with a *linking word/linking phrase*, a meaningful statement can be derived which is known as proposition.

- (iv) In the diagram, the concept ‘Concept Maps’ further joins with other concepts by other *linking word/linking phrase* to form different *propositions*. For example- ‘*Concept Maps help to answer Focus Question(s)*’.
- (v) There is another component in a concept map - *Focus Question*. Concept map has the genesis in *Focus question*. A concept map is formed to find the answer of *Focus questions*. In the concept map of Novak & Canas (2008) given on the previous page the *Focus Question* was ‘**What is the purpose of concept mapping?**’.



(Nehm, R.H. & Young R. 2008)¹¹

(vi) In a concept map a number of directional arrows emerge from a concept to join other concepts. Each of these arrows indicates different relations.

(vii) The concept map has a clear hierarchy - the general concepts or inclusive concepts lie at the top and the concepts subordinate to the general concept are arranged below it.

“.....the concepts are represented in a hierarchical fashion with the most inclusive, most general concepts at the top and the more specific, less general concepts arranged hierarchically below.”

(Novak & Canas, 2008)⁴⁶

Use of Concept Maps

In 1972 Joseph D. Novak formed ‘Concept Map’ as a part of the research project of Cornell University. He used Concept Map mainly to understand how the knowledge of science changes among the children. (Novak & Musonda, 1991)⁴⁷

Students involved in research under Novak gradually realized that concept map is not only useful for observation of knowledge construction in children, but is also helpful for developing children into better learners. Novak realized that using concept map the learners will learn how to learn meaningfully. Consequently, in 1984 the book, *Learning how to learn* was published by Novak & Gowin⁴⁸.

Later on concept map was used for observing not just the child but also to observe meaningful learning of any learner undergoing a learning process. In other words, concept map was started to be used to assess what the student is learning and to what extent. The teachers also use concept map to present the different topics in an organized and integrated manner as part of the instructional design.

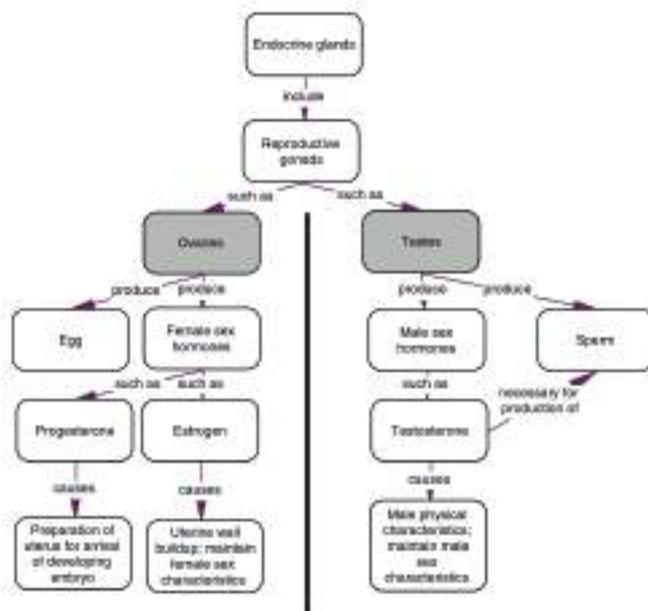
What the student is leaning and to what extent – by trying to know this from concept map the further usage of concept map evolved. What we wanted to teach them and what they had actually learnt – identifying the difference between the two is what the concept map is now

used for. In other words, concept maps are now started to be used to identify the misconceptions/ incomplete concepts. Besides, concept maps are used during and also at the end of the learning process for evaluation purposes. In other words, it is possible to find out how much of a topic the learners have understood by asking the learners to develop a concept map on the topic. Some uses of concept maps are given in the table below, albeit there are other uses of concept maps.

Some of the common educational uses of concept mapping

Use	Description	References
Studies of learning	A tool for the identification of student knowledge and understanding in the course of learning	Novak & Symington, 1982; Novak, 1998
	A method of identifying misconceptions in the course of learning	Kinchin, 2000, 2001
Teaching practice	A method of promoting teacher-student dialogue	Kinchin, 2003
Lesson planning	A means of prescribing content in meaningful ways	Kinchin & Alias, 2005; Martin, 1994
Assessment	Quantifying understanding	Edmondson, 2000

(Hay, D . B, 2007)⁴⁹



(Nehm, R.H. & Young R. 2008)¹¹

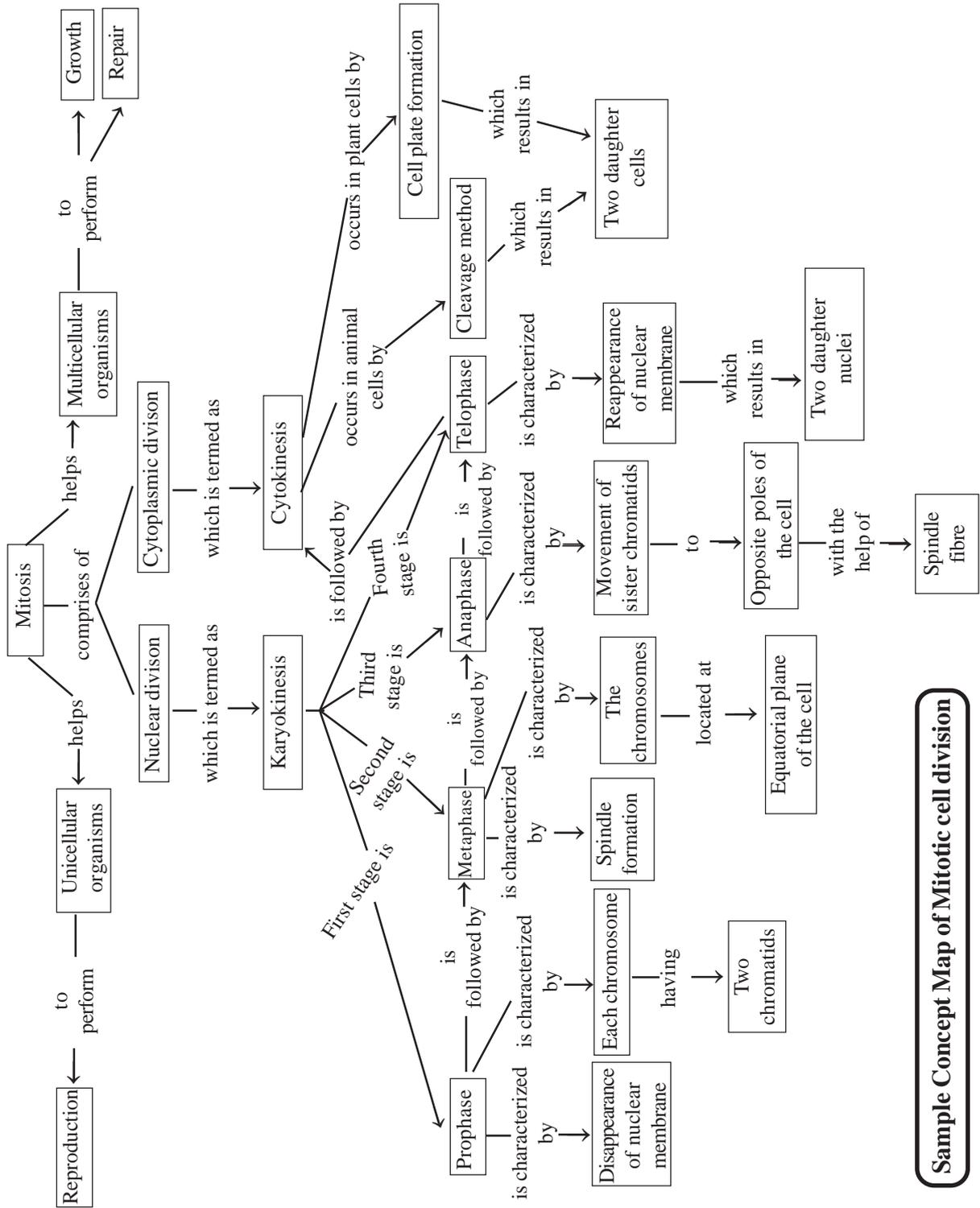
Identification of misconceptions using Concept Maps

Some misconceptions regarding Hormones can be identified with the help of the concept map given here. However the scientifically accepted concepts in this regard are as follows :

i) Testes are not indispensable for the secretion of Testosterone and ovaries are not absolutely necessary for the secretion of Estrogen.

ii) The testes can secrete Estrogen. The ovaries and adrenal glands (in males and females) can also secrete Testosterone.

iii) Besides, reference of sex (male or female) in the discussion on steroid hormones is baffling because Testosterone or Estrogen has non-sexual physiological role both in the males and females.



Sample Concept Map of Mitotic cell division

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Classroom Instructional Design

“The purpose of any design activity is to devise optimal means to achieve desired ends.”

(Charles Reigeluth, 1983)¹

Two important areas are to be noted for making instructional design of a topic – the present level of conceptual understanding of the learners and the expected learning outcomes, i.e. what the students are expected to know at the end of a learning process.

Smith and Ragan (2005) have defined Instructional design as *“the systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources and evaluation”*.

(Smith & Ragan, 2005)²

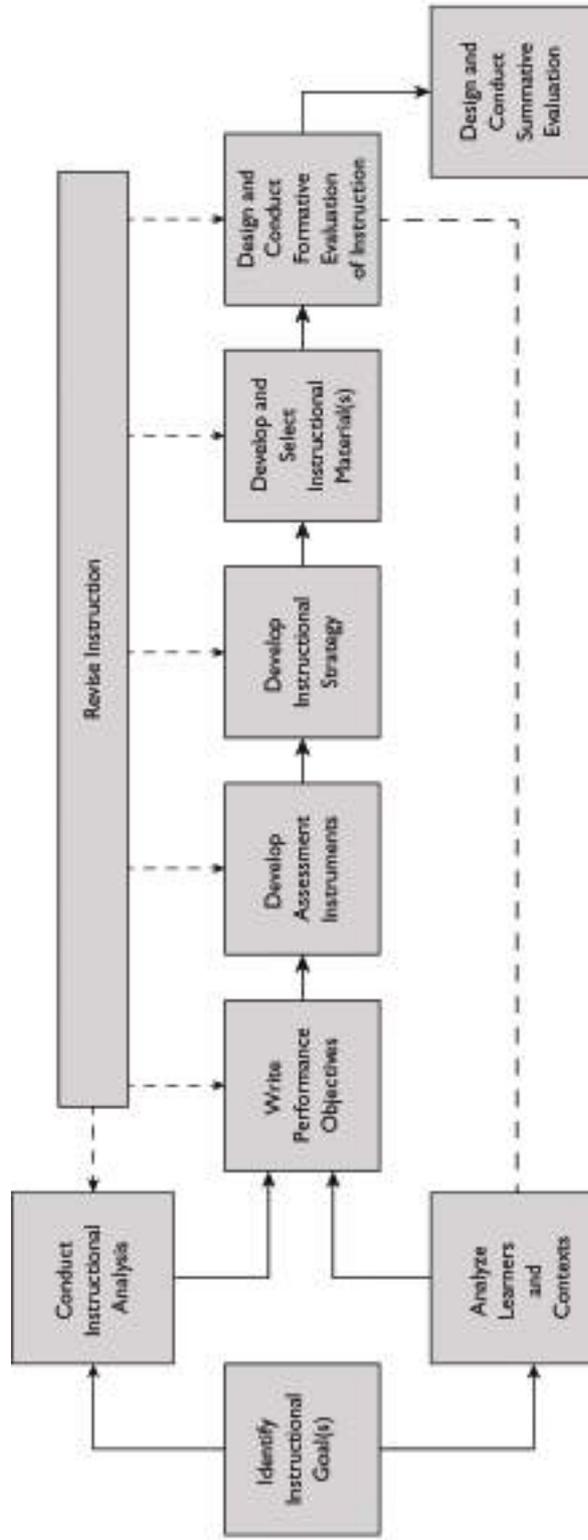
From the above definition of Instructional design it is evident that planning is required for the phases between the present level of conceptual understanding and achievement of the expected learning outcomes. Hence, the main principles of teaching and learning are of paramount importance while planning for these phases. It is also important to identify the information/materials, activities etc. that help in achieving expected learning outcomes of the learners. Here information/material implies text materials facilitating learning, audio-visual materials (pictures, video, animation, multimedia presentation etc.), website, e-learning materials etc.

According to “first principles of instruction” (2002, 2013) of David Merrill the following principles are most important in planning teaching-learning strategies. In his opinion the learning process progresses when the following main principles are implemented in reality –

- learners are engaged in solving real-world problems;
- existing knowledge is activated as foundation for new knowledge;
- new knowledge is demonstrated to the learner;
- new knowledge is applied by the learner;
- new knowledge is integrated into the learner’s world.

(Merril, 2002)³

A model of Instructional Design is provided below. This is actually Systems Approach Model of Dick, Carey & Carey.



(Dick, Carey & Carey, 2009)⁴

Classroom Instructional Design : Sample 1

Unit: Continuity of life

Sub-unit: Cell division and cell cycle (Mitosis)

Expected learning outcomes

The learners will be able to :

- mention the importance of cell division in living organisms.
- discuss the features of different phases of mitosis in animal and plant cells.
- draw diagrams of different phases of mitosis in animal and plant cells.
- mention the difference of mitosis in animal and plant cells.

Key concepts

- (i) Two genetically identical daughter cells are formed from a parent cell in mitosis.
- (ii) As a result of mitosis, organisms grow and also the new daughter cells replace the dead ones in the body where necessary.
- (iii) Mitotic cell division helps unicellular eukaryotes in asexual reproduction and for multicellular eukaryotes it helps in growth.
- (iv) There are four phases of Karyokinesis or nuclear division – Prophase, Metaphase, Anaphase and Telophase.
- (v) In the initial stage of mitosis due to change in the internal arrangement of a cell, spindle is formed, which brings the chromosomes to the equatorial plane of a cell in the metaphase stage.
- (vi) In the Anaphase stage, the two chromatids of each chromosome move to the opposite poles of the cell.
- (vii) In the Telophase stage two daughter nuclei are formed.
- (viii) Then in Cytokinesis or cytoplasmic division stage, the parent cell's cytoplasm and cell organelles are divided in between the two daughter cells.

Background for the teachers

Mitosis is a wonderful process which can be easily observed. In order to understand the process easily we have broken the process into discrete phases. However, it should be remembered that mitosis is a dynamic and continuous process, and not a set of discrete steps.

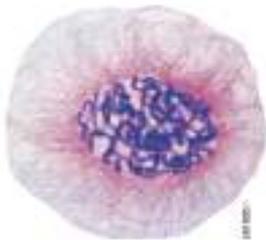
In 1882 German anatomist Walther Flemming invented a kind of dye which helped to observe the behaviour of chromosomes during mitotic process. Flemming then felt that in the intermediate stage between one cell division to another cell division, the cell increases in size only. But now we know the minute details of the important events associated with this stage, i.e. Interphase stage.

Each eukaryotic chromosome is composed of a DNA molecule. In this DNA molecule there are thousands of genes. Besides, there are various protein molecules which are connected with DNA. These proteins help to maintain the chromosome structure and also to control the activities of the gene. This complex structure, known as chromatin, is more or less composed of 40% DNA and 60% protein. That is, chromosome is composed of chromatin which is actually a complex structure of DNA and protein.

As the cell prepares to divide, its chromatin coils up to form distinct chromosomes which can be seen under a compound microscope. Now the question is, why is it necessary for the chromosome to coil up and form a compact structure? This can be explained through an analogy. Suppose we are moving out from one house to another. We bring in all our belongings and arrange them in small boxes. As a result, all the necessary things are arranged in small boxes. Hence, nothing is lost and everything can be easily transported from one place to another. Similarly, before entering the process of cell division, a cell arranges its DNA in a compact manageable package, so that arranging the chromosomes i.e.

DNA in the two daughter cells after the cell division is hassle free.

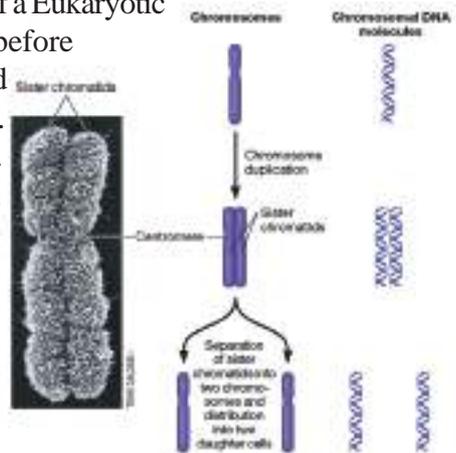
The photomicrograph given here is of a plant cell just before the cell division. In the picture each of the purple thread is actually an individual chromosome consisting of a single DNA molecule tightly wrapped around proteins.



A plant cell from African Blood Lily just before cell division under compound microscope (565X) (Taylor et al.,2018)⁵

The chromosomes of a Eukaryotic cell are duplicated before they condense and the cell divides.

Replication of DNA molecules occur in each chromosome. New protein molecules are synthesized and they attach themselves with DNA. These phenomena occur in the interphase stage of the cell cycle. In this phase each chromosome is composed of two of its own copy. These copies are known as sister chromatids which are joined together along their length by proteins. The sister chromatids are most closely attached to each other in the centromere region.

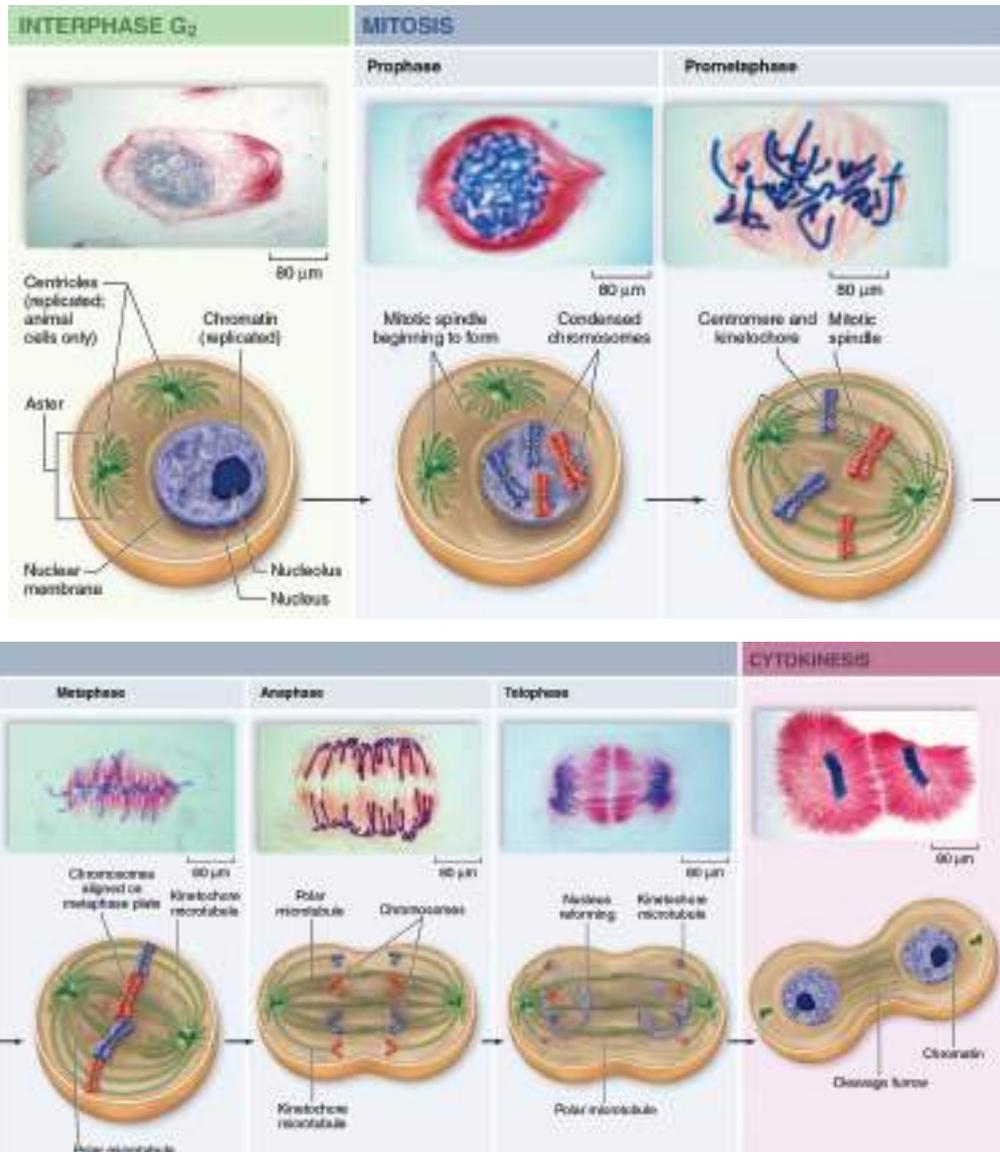


Chromosome duplication (Taylor et al.,2018)⁵

Present level of conceptual understanding of the students

The learners are able to :

- name the cellular organelles participating in cell division and describe their structure.
- discuss the structure of chromosome.
- mention the events occurring in different stages of the cell cycle.



Photomicrograph of different stages of mitotic cell division in African Blood Lily. The chromosomes are stained blue and the microtubules are stained red. Pictures of different stages of mitotic cell division in animal cells are provided below the photomicrographs. (Mason *et al.*,2011)⁶

Process and activity

a) Guiding student inquiry

Teacher's activity	Students' activity
(i) Students may be involved in some activities to incite inquisitiveness or questions in them. For example, how is it possible to get two chalks from one?	(i) Students may break the chalk into two parts.
(ii) A very important conceptual change may be brought in the learners with the help of this activity. As a result of cell division not only the number of cells increase (i.e. from one cell to two), the daughter cells become smaller in size than the parental cell. So only division of cells is not enough. The daughter cells will have to be like the parent cell by growing in size. That is, the students will realize the importance of the Interphase stage. In this case the question can be asked – of the two new pieces of chalk that are formed, are they like the first one? If not, why? Using the analogy of breaking the chalk into two parts, we can explain the necessity of the growth of the daughter cells. The learners can be once more reminded that interphase is not a stage of rest, but in all the three stages of Interphase the cell is quite active and grows. The word 'gap' in the names of G_1, G_2 i.e. Gap_1, Gap_2 stage of interphase, is itself a misnomer.	(ii) The students may say that the two broken pieces of chalk are smaller in size than the original one. Obviously the question may arise in the students that likewise also the daughter cells are smaller than the parental cell. Then how and when do they grow?

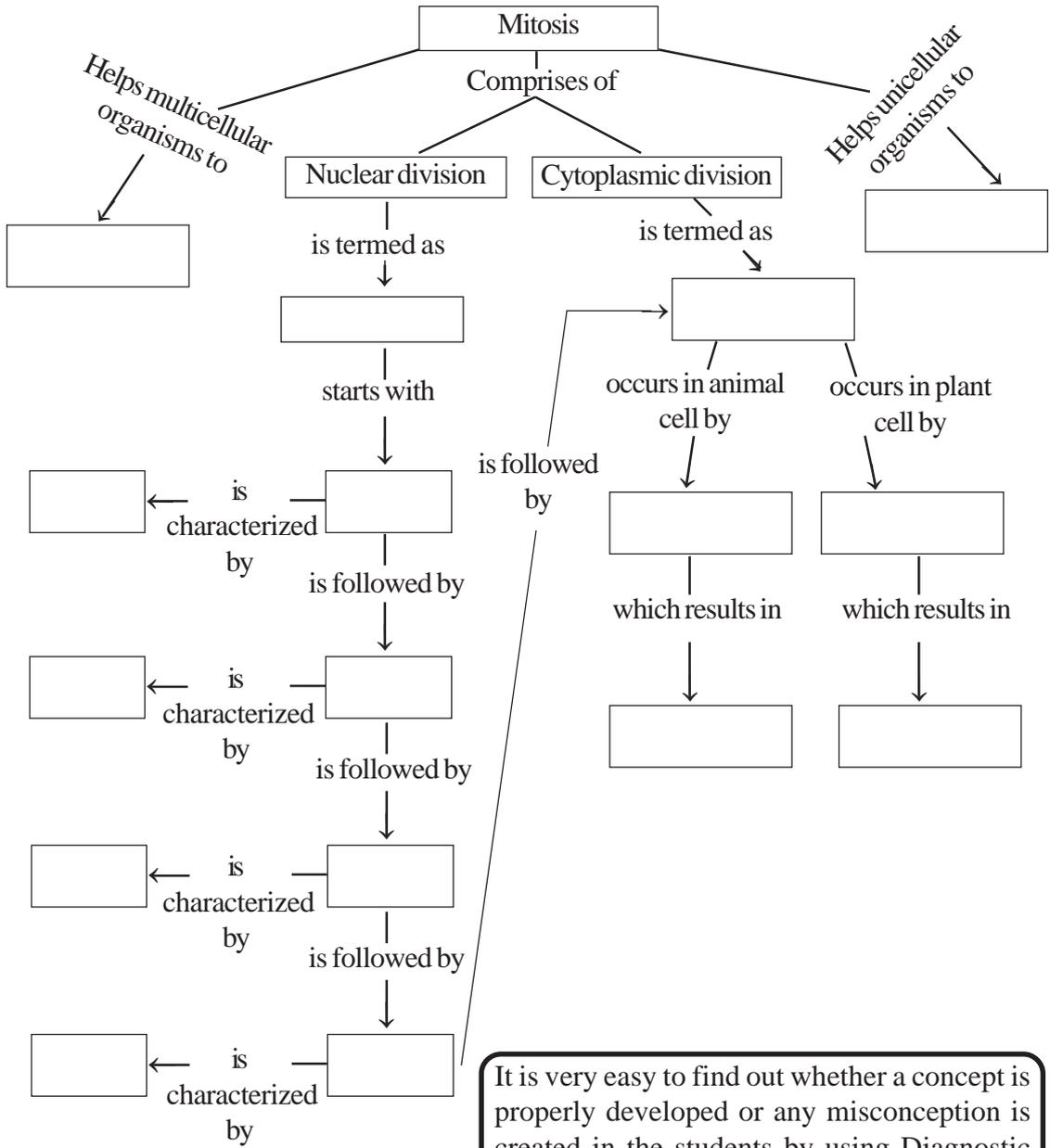
b) Explore, Extend and Integrate

Teacher's activity	Students' activity
(i) The different stages of mitotic cell division is abstract to the students. So it is better to show slides of different stages under a microscope and explain the characteristic features of those stages. If using a microscope is a problem, the photomicrograph of different stages can also be shown. Observing the real pictures of mitosis will help the students to develop their concept easily. Besides, pictures of the different stages of mitotic cell division can also be shown to	(i) Watch the slide/ photomicrograph or picture of different stages of mitotic cell division under a microscope and draw them immediately.

Teacher's activity	Students' activity
<p>them and if necessary some videos can be downloaded from www.youtube.com or other websites. This will help the students to develop the concept of dynamism of cell division. They will also understand that dividing cell division into discrete stages is only for understanding the process easily and that it is actually a dynamic and continuous process going on in all multi-cellular organisms.</p>	
<p>(ii) The students may be told to record the characteristic features of each stage by observing the slides/ photomicrographs/pictures. The teacher will be in the role of a facilitator. If required, the students can be engaged in groups for identification of the characteristic features.</p>	<p>(ii) The students will identify the characteristic features of different stages of mitotic cell division and write them down.</p>
<p>(iii) If the learning process starts by observing the slides/ photomicrographs/ pictures of different stages of mitosis of plant cell, then the students can be told to explain mitotic division of animal cell by observing the slides/ photomicrographs/ pictures of animal cell mitosis. Here, the teacher will surely clarify the differences between the mitotic division in plant and animal cells.</p>	<p>(iii) Watching the slides/ photomicrographs/ pictures of different stages of mitotic cell division of animal cell, the students will be able to explain mitotic cell division in animals to their teacher or peers.</p>
<p>(iv) The teacher may ask them that the heart muscles die due to heart attack or the brain cells die in case of stroke. Hence, there is a permanent damage of those body parts. In living organisms the cell division goes on continuously. Then why can't the brain cells or the heart muscles be repaired?</p>	<p>(iv) The students may take the help of the concept of cell cycle to answer the question. The teacher may help them in this activity. Every second 1 million cell divisions occur to maintain 100 trillion cells in the human body. Some cells divide once a day while other cells do not divide so frequently. Again, some cells like the matured muscle cells or nerve cells do not divide at all. For this reason, a damage in the muscle cells of the heart and nerve cells can never be repaired.</p>

Evaluation

Fill in the blank boxes in the concept map given below .



Classroom Instructional Design : Sample 2

Unit: Evolution and Adaptation

Sub-unit: Theory of Biological Evolution (Darwin's theory)

Expected learning outcomes

The learners will be able to :

- explain the meaning of the word 'evolution'.
- discuss the main features of Darwin's theory with suitable examples.
- explain the importance of variation in the process of evolution.

Key Concepts

(i) Darwin proposed that natural selection is that process through which new species arise from pre-existing species. This theory stands on three observations and two deductions –

Observation 1 : Individuals within a population produce on average more offspring than are needed to replace themselves.

Observation 2 : The number of individuals in a population remain approximately constant.

Deduction 1 : Many individuals fail to survive or reproduce. There is a 'struggle for existence' within a population.

Observation 3 : Variation exists within all populations. That is, all organisms of a species are not identical in regards to their characteristic features. Variations can be observed in them.

Deduction 2 : In the 'struggle for existence' those individuals showing variations best adapted to their environment have a 'reproductive advantage' and produce more offspring than less well-adapted organisms.

Deduction 2 offers a hypothesis called 'Natural Selection' which provides a mechanism accounting for evolution. In Darwin's own words – *As many more individuals of each species are born than can possibly survive, and as, consequently, there is a frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving and thus be naturally selected. From the strong principle of inheritance, any selected variety will tend to propagate its new and modified form.* (Darwin, 1859)⁷

Background for the teachers

Charles Darwin was born in 1809 at Shrewsbury of Western England. His father was an affluent physician. From his childhood he had a deep fascination for nature. He was also a keen student of nature. He had a penchant for collecting different types of insects. At the age of 16, he was sent to Edinburgh University by his father to study medicine, thereby following the footsteps of his father and grandfather. It was the time before the invention of anesthesia. His sensitive mind did not respond to study medical science. Darwin later took admission in the Christ College of Cambridge to study Theology. While studying in Christ College he attended classes on Biology and Geology owing to his deep interest in natural science. During his stay in Cambridge, Darwin became very close to Robert Henslow, a professor of Botany. In the summer of 1831, Darwin attained great experience in Geology while doing field work with Adam Sedgewick. In that year shortly after getting his BA degree, due to the recommendation of Professor Henslow, Darwin was appointed as the 'gentleman companion' of Captain FitzRoy of HMS Beagle, a ship involved in survey. The global voyage (mainly in the southern hemisphere) was originally scheduled for two years but was later extended to five years. In this long voyage Darwin had the scope to observe and collect various types of organisms which were quite different from the ones found in his country England.



HMS Beagle-এর যাত্রাপথ (Phelan, 2013)⁸

In the voyage Darwin had with him Charles Lyell's book, *Principles of Geology*. Lyell was an ardent follower of James Hutton's theory. Hutton viewed that the rocks are formed in earth by erosion and upliftment in a continuous and cyclical way.

Being a follower of this theory, Darwin believed that all the major geological changes of the earth are the effect of a very slow process. So the earth is certainly quite old. In his long voyage along with the observation of different geological specimens, he collected samples of different living organisms and fossils. As for example, in the eastern coast of South America he found a part of a fossil of Glyptodon, an armadillo-like animal whose size was that of a small modern-day car. He also found fossils of Mylodon (giant ground sloth). The length of the smallest one was almost 3 metres. Accepting that the earth is very old, he started to think that the living organisms had sufficient time on earth for *descent with modification*. In that case, the animals of the present era were definitely the descendents of some extinct animals who were to be seen only in fossilized forms. Thus, the species are not constant and fixed, rather they change with time.

Darwin read the book on the prospective effects of human reproductive potential, *An Essay on the Principles of Population* (1798) by Thomas Malthus, a renowned economist. He now applied this theory on other organisms. He was amazed to find that the number of organisms in a population remains more or less the same.

Darwin collected massive data and compared them cautiously. He realized that in an enormous competitive situation, a variation which helps an organism to survive in a specific environment also increases its reproductive ability and raises the possibility of leaving behind fertile offspring. And it is difficult for organisms to leave behind offspring in adverse situation.

In 1836 Darwin returned to England. By 1839 these information helped him to develop his theory of Evolution based on ‘Natural Selection’. But he did not disclose his discovery then. Meanwhile, a naturalist called Alfred Russell Wallace travelled around places like South America, Malay etc. for a very long time and had also read Malthus. Like Darwin, he too came to the conclusion of ‘Natural Selection’.

In 1858, Wallace sent a 20 page article to Darwin. Consequently, in July 1858 at the Linnean Society of London two research papers were read. A year later, in November 1859, Darwin published his book *On the Origin of Species by means of Natural Selection*. All the printed copies (1250) were sold on the day of publication.

Present level of conceptual understanding of the students

The learners are able to :

- explain the meaning of evolution.
- discuss how life originated.
- describe the experiment of Miller and Urey.
- mention the major events of evolution.

(Process and Activity

a) Guiding student inquiry

Teacher’s activity	Students’ activity
(i) The teacher will briefly present the story of Darwin’s voyage with the help of a map. She/he may take the help of a video or animation, if required.	(i) The learners will listen to the voyage of Darwin carefully, ask relevant questions on it and observe the route of the voyage on the map.

Teacher's activity	Students' activity
<p>(ii) The teacher may provide some hints by revealing some information that helped Darwin to develop the Theory of Evolution. In this respect, some examples of biogeography that he observed may be mentioned to the students.</p> <p>While observing the animals in South America, Darwin could not help but compare with his familiar animals. In the grasslands of South America he found Patagonian hare instead of rabbit. Hence, the question arose in him— did the Patagonian hare resemble a rabbit because they both were adapted to similar environment (grasslands)? Since both the animals eat grass, remain hidden behind bushes & shrubs and use their long hind legs to move about. The legs and ears of the Patagonian hare are long but the face resembles a guinea pig which is also an inhabitant of South America. While trying to find out the reason behind this superficial resemblance, Darwin thought that the Patagonian hare and guinea pig might have a common descent.</p> <p>While travelling southward along the eastern coast of South America, Darwin saw Greater Rhea (an ostrich-like bird) in the north. But in the south he saw Lesser Rhea. He came to the conclusion that related species could be modified according to environmental differences (i.e. northern and southern latitudes).</p> <p>Appart from this, the tortoises and finches of different islands of Galapagos archipelago may also be mentioned.</p>	<p>(ii)The learners will become familiar with the thoughts and ideas of Darwin so that they can easily understand Darwin's observation and the inferences related to it. Hence, they can also understand the rationale behind Natural Selection.</p>



Patagonian hare



Rabbit



Greater Rhea



Lesser Rhea

b) Explore, Extend and Integrate

Teacher's activity	Students' activity
(i) The teacher mentions the observations of Darwin along with examples to the students. The students may be asked to explain the decision that they have reached based on those observations.	(i) The learners listen to the observations of Darwin and try to draw conclusions; i.e. try to understand the logic behind Darwin's inferences.
(ii) The teacher cites some new examples that are connected with Darwin's observations. Relevant case study can be presented, if required.	(ii) The learners will see the application of the theory of Natural Selection in real life.
<p>Case Study :</p> <div style="display: flex; align-items: flex-start;">  <div style="flex-grow: 1;"> <p>Some species of clover developed a mutation that caused the poison cyanide to form in the plant's cells. This gave the clover a bitter taste, making it less likely to be eaten. However, when the temperature drops below freezing, some cells rupture, releasing the cyanide into the plant's tissues and killing the plant. In warm climates, natural selection acted in favour of the cyanide-producing clover, but where the winters are cold, non-cyanide clover was favoured. Each kind exists almost exclusively in each climate area.</p> <p style="text-align: right;"><i>(Purves, Sadava, Orians & Heller, 2003)⁹</i></p> </div> </div> <p style="text-align: center; margin-top: 10px;">Clover</p>	
Teacher's activity	Students' activity
(iii) The teacher may present examples of the application of knowledge of different branches of science in the theory of evolution before the students.	(iii) The students will be able to realize the advancement of various branches of science with the passage of time. The integrated form of different branches of science will be clear to them.

Evaluation

Diagnostic questions :

1. A chef sprays antimicrobial cleaner on her counter top. At the first, the bacteria population declines significantly. However, even though she continues to spray in following weeks, the number of bacteria begins to increase again. Why did this happen?
 - (a) Some bacteria had traits that allowed them to survive the initial antimicrobial application. They produced offspring also carrying those traits.
 - (b) After the application of antimicrobial spray, the bacteria needed to adapt by developing antimicrobial spray-resistant traits.
 - (c) The antimicrobial compound caused a mutation for resistance to it. This trait increased in the population over time.
 - (d) The bacteria that tried hardest to become resistant left more offspring, who were also resistant.

Answer: [The specific misconception identified by the ‘Distractor’ is also mentioned]

- (a) correct
 - (b) Misconception: Evolution/natural selection gives organisms/species what they need.
 - (c) Misconception: Environmental challenges cause advantageous mutations.
 - (d) Misconception: Evolution/natural selection involves a will, effort, or intent on the part of the organism/species.
2. A given plant population is pollinated exclusively by a particular bee. A wet spring leads to a disease that wipes out all of the bees in the plant’s habitat. What is the likely outcome for this plant population?
 - (a) A mutation will arise which will allow the plants to be pollinated by other insects.
 - (b) Because they need to change their pollinators, some plant individuals will adapt to be pollinated by other insects.
 - (c) This plant population will die off.
 - (d) Enough variation exists within the plant population to allow it to adapt to any environmental challenge.

Answer: [The specific misconception identified by the ‘Distractor’ is also mentioned]

- (a) Misconception: Environmental challenges cause advantageous mutations.
- (b) Misconception: Evolution/natural selection gives organisms/species what they need. Individual organisms can evolve during a single lifespan.
- (c) correct
- (d) Misconception: Species can evolve the traits necessary for survival and reproduction no matter what.

(University of California Museum of Paleontology, Berkeley, 2011)¹⁰

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Internal Formative Evaluation

Guidelines for Implementation

The WBBSE in consultation with the Expert Committee has issued a circular mentioning the framework for evaluation procedure in respect of the revised curricula and syllabi being followed in all affiliated schools of WBBSE from January 2016. On further recommendation of the Expert Committee, the WBBSE is now issuing the following guidelines for smooth implementation of the Internal Formative Evaluation programme for Class-X in the academic session in 2016:

In case of Internal Formative Evaluation, the following six modalities are to be followed:

1. Survey Report, 2. Nature Study, 3. Case Study, 4. Creative Writing, 5. Model Making, 6. Open Text Book Evaluation.

Out of these six options noted above, any three are to be chosen in an academic year vis-a-vis Internal Formative Evaluation in each of the seven subjects. Therefore, each term will have one modality in relation to a particular subject. Subject teacher(s) are expected to correlate the modalities of Internal Formative Evaluation with the learning competencies of the concerned subjects. Marks obtained in the third Internal Formative Evaluation will be considered as the marks for the Internal Formative Evaluation of Madhyamik Pariksha

1. This programme of Internal Formative Evaluation (IFE) should be considered as an integral part of teaching-learning process for enhancement of learning.
2. The IFE programme should be carried out in the classroom scenario in a stress-free manner before the respective summative evaluations for each term.
3. The assessment techniques should be integrated with the classroom processes and should focus on enhancement of understanding and application of knowledge.
4. During implementation of the IFE, innovative teaching-learning processes are expected to emerge. While planning for such processes, the diverse needs and capacities of students should be taken care of and school should ensure that students are able to participate and derive benefit.
5. The teachers in respective subjects in each school will decide the nature and difficulty level of the activities to be carried out under the banner of Survey, Nature Study, Case Study, Creative Writing, Model Making and Open Textbook Evaluation in a student-

friendly manner according to the needs of the students of the school and accordingly design such IFE programme. However, some exemplar activities for different subjects for IFE are provided herewith.

6. It will be expected that the assessment will be done on the basis of innovative approaches adopted by the students and not necessarily on the accuracy of the end-results.
7. The written records of activities carried out in the classroom for IFE, duly endorsed and assessed by the subject -teacher and signed by the guardian will be preserved by each student until completion of Class-X and will have to be produced at the school for any future requirement.
8. A student will be expected to demonstrate her/his abilities in the following manner during the innovative teaching-learning processes adopted for IFE:
 - Describing a case/event/phenomenon/situation/picture in her/his own language.
 - Exploring further a case/event/phenomenon/situation/picture and producing new examples, alternative explanations, new vocabulary in conformity with the respective discipline.
 - Providing innovative opinions and suggestions in conformity with the discipline.
 - Elaborating the clues, ideas, dialogues, conversations etc.
 - Suggesting innovative approach for presentation of a concept and in problem-solving in conformity with the discipline.
 - Drawing conclusions, making inferences, and taking decisions in respect of a case/event/phenomenon/situation in conformity with the discipline.
 - Creating something new on her/ his own.

Tools for Internal Formative Evaluation : A Brief Note

1. Survey:

The term **survey** is often used to mean collect and interpret information to demonstrate the achievement or otherwise of well-defined goal(s) or specified objective(s). As a part of the Internal Formative Evaluation, the goals or objectives are those expected learning outcomes specified in each subject domain. A survey focuses on factual information and helps surveyors, who are students in the present context, to reinforce their learning under the able monitoring provided by teachers.

2. Case study:

Case studies are stories or contexts. They present realistic, complex, and contextually rich situations and often involve a dilemma, conflict, or problem that students are expected to

analyze/solve by applying their acquired learning skills. It provides an in-depth look into a subject/context of study (the case), as well as its related contextual conditions. A case study involves an intensive study of a learning unit and inspires students to examine as condition, situation, or value of the given context.

3. Nature study:

“Nature study, as a process, is seeing the things that one looks at, and the drawing of proper conclusions from what one sees”. Nature study involves observation of plants, animals, natural phenomena, and human activities as a mode of learning. Nature study attempts to reconcile scientific investigation with spiritual, personal experiences gained from interaction/study with the world/contexts that students live in or are aware of.

4. Model making:

A model connotes a pattern, ideal, reproduction or draft of things (increased, reduced or in actual size). “Apart from real things models can also be mental constructions”. Model making is a logical next step in the thinking process for many ideas. It helps students to concretize abstract and complex concepts/ideas through hands-on experience. A model may be a two-dimensional or three-dimensional representation of concepts/ideas. Model making provides scope for reinforcement of critical and creative thinking skills as well as the problem-solving and decision making skills.

5. Creative writing:

Creative writing involves written expression that draws on creative and critical thinking to convey meaning. Creative writing focuses upon learning competencies in the subject domains, while harnessing the CCT skills. It provides scope or students to apply multiple learning strategies vis-a-vis demonstrating clarity of concepts and their application underlined by aesthetic appreciation of value judgements.

6. Open Text Book Evaluation:

OTBE implies an application of theory to real life situations. It is based upon the principle that the whole objective of learning is not about constant delivery. There must be effective transaction of learning, not just content in the classroom. Therefore, OTBE not only reinforces learning competencies, but also provides scope for transference learning skills. It inspires students to use a range of strategies including accurate decoding to read for meaning, to describe, select or retrieve information, events or ideas from texts and to deduce, infer or interpret information, events or ideas from texts.

Some samples of Internal Formative Evaluation of 'Life Science and Environment'

- **Survey**

Topic : Sound Pollution in daily life : Source and influence

Theme 5 : Environment, its resources and their conservation (Sub-theme : Environmental pollution)

Time required : One period

Expected learning outcomes

The learners will be able to :

- (i) identify the sounds that may cause sound pollution.
- (ii) identify the sources of sound pollution in a locality.
- (iii) explain the influence of sound pollution over humans and other animals.
- (iv) discuss the need to adopt specific measures for preventing sound pollution.
- (v) take active role to create awareness for preventing sound pollution.

Instruction for the students

Conduct a survey on sound pollution in your locality with 5 of your classmates while sitting inside the classroom. The survey should include sources (eg. transport, factory etc.) of high intensity sounds, the effects of sound pollution on human body (eg. ear, heart), the effects of sound pollution on animals, and the necessary steps to reduce sound pollution. Discuss in groups and express your opinion about the necessity for adhering to the legal restrictions imposed on fire-crackers and its effect on human health.

Teacher's role

- (i) To divide students into groups of six and allocate duties.
- (ii) To explain the questions students should ask one another within the survey, as well as cite example questions.
- (iii) To assess the students' work at the end of the class.

Students' activities

Part I (Group Activity)

- Collection of data, exchange of opinions and formation of views regarding sound pollution.

Part II (Individual Activity)

Students should write down in their copies the collected information, opinion and analyses and submit them to the teacher.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● **Nature Study** --- ---

Topic : The impact of air pollution in daily life

Theme 5 : Environment, its resources and their conservation (Sub-theme : Environmental pollution)

Time required : One period

Expected learning outcomes

The learners will be able to :

- (i) identify the impact of air pollution in daily life.
- (ii) identify the possible causes of air pollution.
- (iii) explain the necessity of measures undertaken for preventing air pollution and apply the same in daily life.
- (iv) take active role to create awareness to prevent air pollution.

Instruction for the students

Write about the causes of air pollution in your locality and also the probable impact of such pollution on the health and well-being of people.

Teacher's role

- (i) To explain the work to students and cite certain examples pertaining to the influence of air pollution in daily life.
- (ii) To assess the students' work after class.

Students' activities

Part I (Group Activity)

- To write about the impact of air pollution in the students' locality
- To write about the possible causes of air pollution in the locality.

Part II (Individual Activity)

Opinion , analysis, and inference to be written in a copy and submitted to the teacher.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Case Study

Topic : Thalassemia and Genetic Counselling

Theme 3 : Heredity and common genetic diseases (Sub-theme : Some common genetic diseases)

Time required : Two periods

Expected learning outcomes

The learners will be able to :

- (i) identify thalassemia as a genetic disease.
- (ii) explain how thalassemia can be transmitted from one generation to another.
- (iii) discuss the importance of blood test in thalassemia.
- (iv) explain the importance of genetic counselling in prevention of thalassemia.
- (v) take active role to create awareness for prevention of thalassemia.

Instruction for the students

Read the passage below and solve the problem :

Amulyababu has fixed his son Ajay's marriage . One day during discussion Ratanbabu said to conduct blood test of his son before marriage. Amulyababu inquired the reason, since his son is normal and healthy. Ratanbabu explained that the carrier of thalassemia disease is undetected from outside. If both the nuptial couple have the disease then it includes a chance of infection of the same in their child. Amulyababu took Ajay to a doctor and the doctor inspected him carefully. Then he recommended blood test. Blood test reports divulged that Ajay is a thalassemia carrier. The doctor informed that there was no cause for alarm. Ajay can go through a healthy and normal life. The doctor added that Amulyababu had done a judicious thing by going for medical consultation before the wedlock, for thalassemia is a genetic disease. This means that the child born from parents both carrying this disease has a chance of having the same disease. If Ajay's wife is also a thalassemia carrier then their child will have a 25 % probability of suffering from thalassemia. For this reason, blood tests of Ajay's wife also need to be conducted.

You have read the story. Now answer the questions given below :

- (i) Why is it necessary to conduct blood test for thalassemia before marriage?
- (ii) If two thalassemia carriers marry can their offspring have thalassemia? Write your opinion about the same.
- (iii) What are the symptoms of thalassemia ?

Teacher's role

- (i) To raise various issues related to diseases and society.
- (ii) To bring forth a topic related to the syllabus.
- (iii) To discuss about various examples of genetic diseases.
- (iv) To present a problem related to the selected topic to the students and ask them to solve the problem.
- (v) To divide students into group and explain their work.
- (vi) To assess the students' work.

Students' activities

- (i) To carefully read the presented matter.
- (ii) To discuss the problem with other group members.
- (iii) To reflect upon a solution to the problem through discussion and noting it down in individual copy.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Creative Writing --- ---

Topic : Adaptation of Cactus and Camel in arid and desert region

Theme 4 : Evolution and adaptation (Subtheme : Survival strategies-adaptation)

Time required : One period

Expected learning outcomes

The learners will be able to :

- (i) list some plants and animals living in desert and arid region.
- (ii) identify the problems of the organisms living in arid and desert region. (eg. cactus and camel).
- (iii) explain the inter-relationship between the adaptive characteristics of the organisms living in arid and desert region (eg. cactus and camel).
- (iv) explain how cactus adapts to adverse environmental conditions for a long period of time.
- (v) mention the adaptive characteristics of cactus leaves.

- (vi) explain how a camel adapts to adverse environmental conditions for a long period of time by drinking less or no water.
- (vii) mention the adaptive characteristics of the camel as related to its tolerance of water loss.

Instruction for the students

"The adaptation of camel and cactus in arid and desert region" — express your thoughts on this topic.

Teacher's role

- (i) To inform the students of how much they should write.
- (ii) To discuss with the students regarding the topics to be included in their writing if necessary.
- (iii) To assess the students' work.

Students' activities

- (i) To discuss their writing assignments with the teacher and other students.
- (ii) To make an outline of the topics to be included in their writing before starting to write.
- (iii) To express one's opinion in accordance with the above.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Model Making

Topic : Drawing labelled diagrams of different stages of animal or plant cell mitosis

Theme 2 : Continuity of life (Sub-theme : Cell division and cell cycle)

Time required : Two periods

Expected learning outcomes

The learners will be able to :

- (i) identify the characteristics of various stages of mitosis in plant and animal cells.
- (ii) explain the inter-relationship between different stages of plant and animal cell mitosis.
- (iii) show the characteristics of the stages of plant and animal cell mitosis with the help of a labelled diagram.
- (iv) create models by using readily available materials.

Instruction for the student

Draw a labelled diagram or make a model of an animal or a plant cell mitosis.

Teacher's role

- (i) To explain how to diagrammatically represent the various stages of animal or plant cell mitosis.
- (ii) To acquaint the students with the rules of labelling a diagram.
- (iii) To assess the labelled diagrams in the students' copies.
- (iv) To assess the models constructed by the students.

Students' activities

- (i) To draw diagrams of various stages of animal or plant cell mitosis.
- (ii) To properly label the diagrams of various stages of animal or plant cell mitosis.
- (iii) To make a model on various stages of animal or plant cell mitosis.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Open Textbook Evaluation

Topic : Working for long hours at the computer and eye problems

Theme 1 : Control and coordination in living organisms (Sub-theme : Response and physical coordination in animals — Nervous system)

Time required : Two periods

Expected learning outcomes

The learners will be able to :

- (i) explain the importance of ciliary muscles in accommodation of eye.
- (ii) identify the visual problems that arise from working long hours at the computer.
- (iii) identify physical complications other than eye problems which arise from working long hours at the computer.
- (iv) apply the acquired knowledge related to the process of accommodation of eye.
- (v) discuss how to take care of the eye while working for long hours at the computer and apply the same in real life.

Instruction for the students

Read the passage below and answer the following questions .

Computer is a boon in the twenty-first century. There is no doubt about the overwhelmingly nature of this invention. Nowadays it is hardly possible to complete any work without the help of computer. But the nectar of this boon has also been accompanied by a curse. Due to long hours spent before the computer the normal functionings of the eye are getting hampered.

Along with computers, tablets and smartphones are adding to the complication. If one does not immediately take preventive steps, the eye may give various problems in near future.

Eye specialists are telling us that during the time that is spent before a computer, the ciliary muscles of the eye are exercised the most. As a result, these muscles get exhausted. There are many who take a break from the computer only to read magazines or to glance through the mobiles. Therefore these muscles get no opportunity to relax. As a result, the eyes get extremely stressed. This leads to various problems of the eye. Complications of the eye are accompanied by neck pain, back pain and other symptoms. — From a Newspaper Report

- (i) How do the ciliary muscles help in accommodation of eyes?
- (ii) What eye problems can arise from working at the computer for long hours?
- (iii) What measures can be taken to avoid the eye problems that arise from working long hours at the computer?
- (iv) Why do symptoms such as neck pain, back pain and other symptoms arise after working long hours at the computer? What means can be availed to get relief from these symptoms?

Teacher's role

- (i) To collect a paragraph regarding working at the computer for long hours and eye problems. If necessary to create a paragraph related to this. The teacher should keep in mind that the paragraph selected should bear relevance to the topics included in the syllabus.
- (ii) To design such questions bearing relevance to the syllabus which would influence the students to think on the topic.
- (iii) To assess the answers to the questions as given by the students.

Students' activities

- (i) To study attentively the paragraph regarding working long hours at the computer and eye problems.
- (ii) To be able to identify the relation between the content of the paragraph regarding working for long hours at the computer and eye problems with the relevant portion of the syllabus.
- (iii) To write down the answers to the given questions in their individual copies.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

Marks obtained in the third Internal Formative Evaluation will be considered as the marks obtained in Internal Formative Evaluation in the Madhyamik Examination.
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Internal Formative Evaluation of 'Life Science and Environment': Additional Samples

● Survey

Topic: Observable variations in humans

Theme 3: Heredity and common genetic diseases (Sub-theme: Heredity)

Time required: One period

Expected learning outcomes

The learners will be able to :

- (i) explain the meaning of variation.
- (ii) mention the reasons for variation.
- (iii) identify different observable variation of humans.

Instruction for the students

Discuss with 5-10 of your classmates in the classroom and make a list of different observable variations of humans. You can try to find the following variations –

(i) free and attached earlobe (ii) roller and normal tongue (iii) straight hairline and widow's peak (iv) cleft and non-cleft chin (v) dimpled and non-dimpled cheek (vi) hand clasping / thumb crossing and (vii) hitchhiker's thumb. You can also enlist other observable variations besides the given ones.



attached and free earlobe



roller and normal tongue



straight hairline and widow's peak



cleft and non-cleft chin



dimpled and non-dimpled cheek



hand clasping/thumb crossing



hitchhiker's thumb

Teacher's role:

- (i) To divide the class into groups of 5-10 students and specifying the topic of discussion.
- (ii) To explain different observable variations of humans with the help of demonstration/ pictures.
- (iii) To show the learners how to enlist observable variations.
- (iv) To assess the learners' scripts.

Students' activities

Part-I (Group Activity)

- Collection of data, exchange of opinions and formation of views regarding observable pollution.

Part-II (Individual Activity)

Students should write down in their copies the collected information, opinion and analyses and submit them to the teacher.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Nature Study ---

Topic: Locomotion of plants

Theme 1: Control and coordination in living organisms (Sub-theme: Sensitivity and response in plants)

Time: One period

Expected learning outcomes

The learners will be able to :

- (i) mention from real life experience of the locomotion of plants.
- (ii) identify the locomotion of plants as a manifestation of plant response to a stimulus .
- (iii) classify the different types locomotion of plants.
- (iv) identify plants related with different types of locomotion of plants.

Instruction for the students:

Make a table of different types of plant locomotion that you have seen. Write the name of the plant, very short description of locomotion and type of locomotion.

Teacher's role

- (i) To explain to the students what they have to do, what will be the different columns of the table, what is to be written in those columns and if required to help them in identifying the plants.
- (ii) To assess the learners' scripts.

Students' activities

Part-I (Group Activity)

- (i) To enlist different types of plant locomotion.
- (ii) To give very short description of different types of plant locomotion.

Part-II (Individual Activity)

Students should write down in their copies the collected information, opinion and analyses and submit them to the teacher.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Case Study

Topic: Diabetes (Diabetes mellitus)

Theme 1: Control and Coordination in living organisms (Sub-theme: Response and chemical coordination in animals - Hormones)

Time required: One period

Expected learning outcomes

The learners will be able to :

- (i) explain the importance of hormone as chemical coordinator in human body.
- (ii) relate real life example of diabetes mellitus with the role of insulin hormone in human body.
- (iii) identify the site of secretion insulin hormone human body.
- (iv) explain the role of insulin hormone in human body.

Instruction for the students

Read the following passage and solve the problem:

Alokebabu has been suffering for some time. He needs to relieve himself frequently. He feels thirsty all the time. He doesn't sleep well. Often he wakes up at night to relieve himself. All through the day he feels hungry. Every now and then he can feel the pangs of hunger. Fatigue

has almost got over him. Initially he overlooked this problem. This continued for a month until his wife Kaberidebi took him to a doctor. The doctor listened to his problems patiently. He examined him. He also advised him some blood tests. Looking at his test reports the doctor told Alopebabu that his blood sugar level is higher than the normal. He advised him to do regular exercise and walking. He also advised him to have some restrictions in his food habits.

After reading the story answer the following questions.

- (i) What is Alopebabu suffering from?
- (ii) Which hormone is responsible for his disease?
- (iii) From where does this hormone secrete in human body?
- (iv) What is the role of this hormone in human body?

Teacher's role

- (i) To present to different disease related problems in social life.
- (ii) To present a topic related with the syllabus.
- (iii) To discuss various examples related with excess or less secretion of hormone.
- (iv) To present a problem related to the topic to the students and tell them to solve the problem.
- (v) To divide the students into groups and instruct them about what they have to do.
- (vi) To assess the students' activities.

Students' activities

- (i) To read the topic presented by the teacher.
- (ii) To discuss about the topic with other students of the group.
- (iii) To think about the solution of the problem by discussing in groups and writing it down.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● **Creative Writing** _____

Topic: Importance of Biodiversity in daily life

Theme 5: Environment, its resources and their conservation (Sub-theme: Biodiversity and conservation)

Time required: One period

Expected learning outcomes

The learners will be able to :

- (i) explain the meaning of the word 'biodiversity'.

- (ii) mention various examples of biodiversity.
- (iii) appreciate the importance of conservation of biodiversity.
- (iv) take active role to create awareness regarding conservation of biodiversity.

Instruction for the students

“Importance of biodiversity in daily life” — write your own opinion on this topic.

Teacher’s role

- (i) To instruct the students how much they have to write.
- (ii) To discuss with the students about the main issues of their topic.
- (iii) To assess the students’ activities.

Students’ activities

- (i) To participate in discussion with peers and teacher on the topic.
- (ii) To make a rough draft of the salient points to be written.
- (iii) To write the final draft based on the salient points.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Model making

Topic: Accommodation and modification of the shape of lens of the eye

Theme 1: Control and Coordination in living organisms (Sub-theme: Response and physical coordination in animals - Nervous System)

Time required: One period

Expected learning outcomes

The learners will be able to :

- (i) explain the meaning of the term ‘accommodation’.
- (ii) describe the lens of different shapes required to see near and distant objects.
- (iii) explain the change in shape of the lens for looking at near and distant object with the help of a labelled diagram.

Instruction for the students

With the help of a line diagram and a labelled diagram show how the shape of lens gradually changes due to accommodation while looking at near and distant objects.

Teacher's role

- (i) To explain the meaning of the word 'accommodation' if required.
- (ii) To show how the line diagram of accommodation can be drawn.
- (iii) To acquaint the students with the rules of labelling a diagram.
- (iv) To assess the line diagram prepared by the students.
- (iv) To assess the labelled diagram prepared by the students.

Students' activities

- (i) To draw a line diagram showing the gradual change of shape of the lens due to accommodation.
- (ii) To draw a labelled diagram of the gradual change of shape of the lens to look at near and distant objects.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

● Open Textbook Evaluation --- ---

Topic: Role of PBR in conservation of biodiversity

Chapter 5: Environment, its resources and their conservation (Sub-theme: Biodiversity and conservation)

Time required: One period

Expected learning outcomes

The learners will be able to :

- (i) explain the meaning of the word 'biodiversity'.
- (ii) explain the importance of biodiversity.
- (iii) appreciate the role of PBR in the conservation of biodiversity.
- (iv) take active role to create awareness about PBR in the conservation of biodiversity.

Instruction for the students

Read the passage given and answer the questions that follow:

Not only Rat snakes, Striped Keelbacks, Checkered Keelbacks but also poisonous snakes like Indian Spectacled Cobra, Indian Monocled Cobra, Russell's Viper, Banded Krait are still

found there. Besides sparrows, mynas and crows other birds like Black-hooded orioles, Drongos, Doves, Common tailor birds, Treepies, Coppersmith barbets, Oriental magpie-robins, White-breasted waterhens or Greater coucals still chirp there. One might also find Indian rollers in the 'Banabitan' if s/he tries sincerely. At night one might also find Eurasian eagle-owls, barn-owls and bats. Such a place is not a village far from the hustle and bustle of Kolkata but these animals can be found at the heart of Bidhannagar. This information has been obtained from a survey on biodiversity of Bidhannagar which was carried out by the teachers and students of Bidhannagar Government College.

Once Bidhannagar was a marshy land. In the last few decades the nature and biodiversity of Bidhannagar has been changed due to the effect of planned urbanization. However, even today such animals or trees which are generally not observed in Kolkata but can be found specially in 'Banabitan' and Dattabad areas. Anirban Ray, a scientist of West Bengal Biodiversity Board says, "From the survey it can be seen that trees like Neem, Belleric myrobalan, Indian gooseberry, Kurchi, Arjun, Bakul, Bastard teak (Palash) or Jamun can be found in large numbers along the roads and in the parks. The biodiversity of Central Park is still wonderful. The Indian Spectacled Cobra can be found in the locality of Dattabad, similarly the existence of Common Krait is recorded in 'Banabitan'. A document has been prepared under the leadership of Ramaparasad Bhattacharya. Survey reveals that the birds like Brahminy starlings, Asian pied starlings, Black kites, Eurasian eagle-owls, Barn-owls, Robins, White-breasted waterhens, Bee-eaters, Kingfishers, Woodpeckers can still be seen in Bidhannagar.

However, the Chairman of Biodiversity Board, Ashok Kanti Sanyal said, 'Two organisations have worked on the biodiversity of Bidhannagar. Besides Bidhannagar Government College, a NGO also presented a survey based report. But we cannot consider them as Peoples' Biodiversity Register (PBR). A document is to be considered as PBR as per the Biodiversity Act only if it gets the consent from the Biodiversity Management Committee (BMC) formed at the Block or Municipality level.' He said, although the BMC was formed in Bidhannagar a few years ago yet it is non-functional.

A few years ago under the leadership of former Director of Geological Survey of India, Ashish Ghosh a group of teachers, researchers and students developed a document based on the survey conducted on the biodiversity of Kolkata. But that document was not recognised as the BMC was not formed in Kolkata. Ashok Kanti remarked that some scientists observed that some endeavours for conservation may be taken even on the basis of this report.

According to Board sources, BMC has been formed across the state in 368 blocks and the Municipal areas. Formation of another 100 BMCs are in process. 86 BMCs have formed their PBR which includes Municipalities like Kalyani, Haldia, Madhyamgram, Gobardanga, Joynagar-Majilpur, Medinipur and Darjeeling. Apart from the biodiversity of Banabitan, Saltlake, the satellite-town has wide diversity of animal and plants.

— Daily newspaper

- (i) What is the need for conservation of biodiversity?
- (ii) Mention the role of PBR in the conservation of biodiversity in an area.
- (iii) If you have to form the PBR of your locality, what are the main topics to be included in the document?
- (iv) How will you utilize the PBR of your locality in the conservation of biodiversity?

Teacher's role

- (i) To collect the article on biodiversity and PBR of Bidhannagar. If required, a similar article may be written. But the content of the paragraph should match the syllabus.
- (ii) To set such questions related to the syllabus that make the students think.
- (iii) To assess the answers of the students.

[Source:

- (i) www.wbb.nic.in/pbr.html
- (ii) nbaindia.org/uploaded/pdf/PBR%20Format%2020213.pdf]

Students' activities

- (i) To read carefully the article on the biodiversity and PBR of Bidhannagar.
- (ii) To relate the theme of the article on the biodiversity and PBR of Bidhannagar with that of the topics included in the syllabus.
- (iii) To write the answers in their copies.

Criteria for Evaluation

To assess the extent to which each student has been able to acquire the expected learning outcomes.

Life Science and Environment
Blueprint for Summative Evaluation of Class X
Question Pattern and Distribution of Marks
1st Summative Evaluation

Total Marks: 40

Sl. No	Theme	Group A	Group B	Group C	Group D	Total Marks per Theme	Total Number of Questions
		MCQ One mark per question	VSA One mark per question	SA Two marks per question	LA Five marks per question		
1.	Control and Coordination in living organisms	1×5=5	1×5=5	2×3=6	5×2=10	26	15
2.	Continuity of life – a) Cell division and cell cycle	1×3=3	1×4=4	2×1=2	5×1=5	14	9
	Total	8	9	8	15	40	24

Group A - MCQ : All questions are compulsory. There will be no alternative for MCQ.

Group B - VSA : Out of 11 questions, 9 questions are to be attempted. One (1) extra question is to be set from each theme. VSA questions may be of four types – answer in one word or in one sentence, fill in the blanks, true/false and match column A with column B. In column matching two points are to be kept in mind – i) For each correct matching one (1) mark is allotted. ii) There should be at least one (1) extra option in Column B.

Group C - SA : Out of 6 questions, 4 questions are to be attempted. One (1) extra question is to be set from each theme.

Group D - LA : 3 questions are to be attempted. Alternative question from the same theme is to be set for each question. 5 marks can be given as a whole or can be divided in 3+2 or 2+3.

Life Science and Environment
Blueprint for Summative Evaluation of Class X
Question Pattern and Distribution of Marks

2nd Summative Evaluation

Total Marks: 40

Sl. No	Theme	Group A	Group B	Group C	Group D	Total Marks per Theme	Total Number of Questions
		MCQ One mark per question	VSA One mark per question	SA Two marks per question	LA Five marks per question		
1.	Continuity of life— b) Reproduction c) Sexual reproduction in flowering plants d) Growth and development	1×3=3	1×2=2	2×1=2	5×1=5	12	7
2.	Heredity and some common genetic diseases	1×3=3	1×2=2	2×2=4	5×1=5	14	8
3.	Evolution and adaptation	1×3=3	1×2=2	2×2=4	5×1=5	14	8
	Total	9	6	10	15	40	23

Group A - MCQ : All questions are compulsory. There will be no alternative for MCQ.

Group B - VSA : Out of 9 questions, 6 questions are to be attempted. One (1) extra question is to be set from each theme. VSA questions may be of four types – answer in one word or in one sentence, fill in the blanks, true/false and match column A with column B. In column matching two points are to be kept in mind – i) For each correct matching one (1) mark is allotted. ii) There should be at least one (1) extra option in Column B.

Group C - SA : Out of 8 questions, 5 questions are to be attempted. One (1) extra question is to be set from each theme.

Group D - LA : 3 questions are to be attempted. Alternative question from the same theme is to be set for each question.

5 marks can be given as a whole or can be divided in 3+2 or 2+3.

Life Science and Environment

Blueprint for Summative Evaluation of Class X

Question Pattern and Distribution of Marks

3rd Summative Evaluation/Selection Test

Total Marks: 90

Sl. No	Theme	Group A	Group B	Group C	Group D	Total Marks per Theme	Total Number of Questions
		MCQ One mark per question	VSA One mark per question	SA Two marks per question	LA Five marks per question		
1.	Control and Coordination in living organisms	1×3=3	1×5=5	2×3=6	5×1=5	19	12
2.	Continuity of life	1×3=3	1×5=5	2×2=4	5×1=5	17	11
3.	Heredity and some common genetic diseases	1×3=3	1×3=3	2×2=4	5×1=5	15	9
4.	Evolution and adaptation	1×3=3	1×3=3	2×2=4	5×1=5	15	9
5.	Environment, its resources and their conservation	1×3=3	1×5=5	2×3=6	5×2=10	24	13
	Total	15	21	24	30	90	54

Group A - MCQ : All questions are compulsory. There will be no alternative for MCQ.

Group B - VSA : Out of 26 questions, 21 questions are to be attempted. One (1) extra question is to be set from each theme. VSA questions may be of four types – answer in one word or one sentence, fill in the blanks, true/false and match column A with column B. In column matching two points are to be kept in mind – i) For each correct matching one (1) mark is allotted. ii) There should be at least one (1) extra option in Column B.

Group C - SA : Out of 17 questions, 12 questions are to be attempted. One (1) extra question is to be set from each theme.

Group D - LA : 6 questions are to be attempted. Alternative question from the same theme is to be set for each question. 5 marks can be given as a whole or can be divided in 3+2 or 2+3.

*** This question pattern is indicative of Madhyamik Examination.

Some discussions on type of questions

Necessary things to be noted for framing different type of questions

- **Multiple Choice Question (MCQ)**

There are mainly two parts in an MCQ: the stem and the options. Only one of the options should be absolutely correct while the rest of the options should be incorrect. There should be at least four options. Certain features has to be borne in mind to frame the stem-part of the question:

- (i) The major part of the information has to be included in the stem so that the options are stated with minimum words. It is necessary to state the main theme of the question in the stem portion.
- (ii) The language of the stem should be simple and unambiguous so that the learners have no difficulty in understanding the instruction.
- (iii) Care should be taken in the use of words in the stem. The words used in the stem should be from the known vocabulary of the learners.
- (iv) It is better not to use negative words in the stem.

- ◆ **Things to be noted for framing options:**

- (i) In every MCQ there should be four options. Apart from the correct option, the other three options are called 'Distractors'.
- (ii) There should be only one correct option among the four options.
- (iii) Each of the options should be independent. There should not be any overlapping in the options.
- (iv) The four options i.e. one correct option and three distractors should have similarity in respect of length, complexity and use of language.
- (v) 'All the options given above are correct' or 'None of the above options are correct' — such sentences should not be used as an option.
- (vi) The correct options of various questions should be arranged at random. That is, if in a question (a) is the correct option, then it is desirable that in the subsequent questions the correct option is (b), (c) or (d).

- ◆ **Things to be noted for using distractors:**

- (i) It should be borne in mind that the distractors should be apparently logical.
- (ii) The common errors and misconceptions of the learners may be given as distractors.
- (iii) Sentences that are absolutely wrong should not be given as options.
- (iv) Correct sentence but which is not the correct answer to the question — it is desirable to use such distractors.

- **Very Short Answer type questions (VSA)**

- ◆ **One word answer or answer in a sentence**

Certain things are to be kept in mind for framing these type of questions:

- (i) The use of language in a sentence ought to be as simple and unambiguous as possible so that the learners do not have any difficulty in understanding the question.
- (ii) The questions should be such that the answers would be short and precise.

- ◆ **Fill in the blanks**

Certain things are to be kept in mind for framing these type of questions:

- (i) The use of language in a sentence ought to be as simple and unambiguous as possible so that the learners do not have any difficulty in understanding the question.
- (ii) It should be noted that only one word should fill up each blank.

- ◆ **Identifying correct or incorrect sentence:**

Certain things are to be kept in mind for framing these type of questions:

- (i) The use of language in a sentence ought to be as simple and unambiguous as possible so that the learners do not have any difficulty in understanding the question.
- (ii) Extremely complicated and long sentences should be avoided.
- (iii) It is better not to present more than one idea in a sentence.

- ◆ **Match the columns**

Certain things are to be kept in mind for framing these type of questions:

- (i) An award of 1 mark should be provided for every correct relationship.
- (ii) The number of items included in column B should be at least one in excess of the items in column A.
- (iii) The items included in column A and B should be as brief as possible.
- (iv) Two columns should be in one page.

- **Short Answer type questions (SA)**

Certain things are to be kept in mind for framing these type of questions:

- (i) The use of language in a sentence ought to be as simple and unambiguous as possible so that the learners do not have any difficulty in understanding the question.
- (ii) Questions should be such that the answers should be in two or three sentences.

- **Long Answer type questions (LA)**

Certain things are to be kept in mind for framing these type of questions:

- The use of language in a sentence ought to be as simple and unambiguous as possible so that the learners do not have any difficulty in understanding the question.
- In this type of question the marks can be in 5, 3+2, 2+3. The answer of 2 marks question should be in two/three sentences. The answer of 3 marks question should be in three/five sentences. The answer of 5 marks question should be in seven/ten sentences.

Variety of questions based on the proposed blueprint

- **MCQ and Very Short Answer type questions**

Questions can be set on the following items:

(i) Factors	(viii) Find the odd one out
(ii) Characteristics	(ix) Identifying the correct pair
(iii) Process/method, structural components of body, mention the name of organ/organelle function	(x) Identifying the correct picture sequence
(iv) Occurrence	(xi) Writing the correct logical sequence
(v) Functions	(xii) Various applications of Biology
(vi) Significance	(xiii) Establishing interrelationship (e.g. between event and structure, between structure and function etc.)
(vii) Use of terminologies related to Biology	(xiv) Examples

- **Short Answer type questions and Long Answer type questions**

Questions can be set on the following topics:

(i) Characteristics	(ix) Examples
(ii) Occurrence	(x) Analytical question
(iii) Function	(xi) Drawing diagrams
(iv) Role	(xii) Questions related to diagrams
(v) Significance	(xiii) Diagram analysis
(vi) Difference/comparison	(xiv) Identification
(vii) Determination of cause-effect relationship	(xv) Making line diagram and asking questions on it
(viii) Explanation	

Sample Questions Based on Revised Bloom's Taxonomy

Sl. no.	Cognitive domain	Action verb	Curricular areas (Themes)	Type of questions	Specific questions
1.	Remembering	Match	Control and coordination in living organisms	MCQ	The correct pair is – (a) Adrenal - Thyroxine (b) Pancreas - Glucagon (c) Pituitary - Insulin (d) Testes - ADH
2.	Remembering	Relate	Continuity of life	MCQ	The phase of mitotic division where chromosomal movement is observed is – (a) Metaphase (b) Anaphase (c) Cytokinesis (d) Prophase
3.	Understanding	Extend	Control and coordination in living organisms	SA	How is artificial Auxin used in agriculture?
4.	Understanding	Infer	Heredity and some common genetic diseases	SA	Why is it necessary to go for genetic counselling for preventing thalassemia ?
5.	Applying	Apply	Heredity and some common genetic diseases	MCQ	The probability of having normal son from normal father and colour blind mother is – (a) 0% (b) 25% (c) 50% (d) 100%
6.	Analyzing	Analyze	Evolution and adaptation	LA	Explain the structure of heart of different vertebrates as an evidence of biological evolution.

Sample Question Papers
Life Science and Environment
First Summative Evaluation
Class Ten
Time: 1 hour 30 minutes
Full Marks 40
Group 'A'

1. Write the answer in complete sentence by choosing the correct answer for each question with respective serial number. 1×8=8

- 1.1 The stem of a plant bend towards light - it is termed as stem's —
(a) Hydrotropic movement (b) Phototropic movement
(c) Photonastic movement (d) Seismonastic movement
- 1.2 The hormone which controls the growth and secretion of thyroid gland is —
(a) ACTH (b) TSH
(c) GH (d) ADH
- 1.3 You have observed that in a stage of mitotic cell division the chromosomes are arranged in the equatorial plane at the centre of a cell. The name of the stage is —
(a) Prophase (b) Metaphase
(c) Anaphase (d) Telophase
- 1.4 The portion of the brain that controls the balance of the body is —
(a) Cerebrum (b) Thalamus
(c) Cerebellum (d) Hypothalamus
- 1.5 The cell organelle associated with protein synthesis of a cell is —
(a) Ribosome (b) Centrosome
(c) Mitochondria (d) Microtubule
- 1.6 The name of the 'V'-shaped muscle located on two sides of the vertebral column of fish is —
(a) Pectoralis minor (b) Myotome
(c) Pectoralis major (d) Coracobrachialis
- 1.7 The name of the stage in cell cycle when DNA synthesis occurs is —
(a) G₀ (b) G₁
(c) G₂ (d) S

1.8 The name of a part of eye that functions as a refractive medium is —

- (a) Retina (b) Iris
(c) Cornea (d) Choroid

Group 'B'

2. Answer 9 questions out of 11 given below as instructed. 1×9=9

Fill in the blanks with proper words in the following sentences (any two) : 1×2=2

2.1 The defect of vision associated with the lens of human eye becoming opaque is_____.

2.2 Nucleolus reappears in _____ stage of mitotic cell division.

2.3 Three-layered membrane covering the human brain is termed as _____.

Decide whether the following statements are true or false (any two) : 1×2=2

2.4 Nerve cells cannot divide as the centrosome remain inactive.

2.5 Testes is an exocrine gland.

2.6 Nucleotide is composed of deoxyribose sugar and nitrogenous base.

Match the words in Column-A with those which are most appropriate in Column -B and rewrite the correct pair mentioning the serial no. of both the columns : 1×3=3

Column - A	Column - B
2.7 Chromosomal movement	(a) Auxin
2.8 Node of Ranvier	(b) Telophase
2.9 Controls tropic movement	(c) Axon
	(d) Anaphase

Answer in a single word or in a single sentence : 1×2=2

2.10 Among the following four terms one includes the other three. Find it out and write it:
Prophase, Metaphase, Karyokinesis, Telophase.

2.11 Which plant hormone is responsible for breaking bud and seed dormancy ?

Group 'C'

3. Answer any 4 questions in 2-3 sentences out of 6 questions given below :

2×4=8

3.1 Mention two functions of adrenalin as emergency hormone.

3.2 Write two roles of skeletal muscles in human locomotion.

3.3 Write two differences between tropic and nastic movement.

3.4 Write two roles of auxin in agriculture.

3.5 Distinguish between mitosis and meiosis cell division based on the following features as directed :

- Site of occurrence
- Nature of chromosomal division

3.6 How does cytokinesis occur in mitotic cell division in animals ?

Group 'D'

4. Write the 3 questions or their alternatives given below. The mark allotted for each question is 5 (the division of marks is either 3+2, 2+3 or 5) : $5 \times 3 = 15$

4.1 Draw a neat diagram of an ideal neuron and label the following parts : $3+2=5$

- (a) Dendron (b) Schwann cell
(c) Axon terminal (d) Axolemma

OR

Draw a neat diagram of vertical section of human eye and label the following parts :

$3+2=5$

- (a) Conjunctiva (b) Cornea
(c) Lens (d) Retina

(FOR SIGHTLESS CANDIDATES ONLY)

4.1 (A) Mention two structural characteristics of cell body of Neurone. Mention three structural characteristics of axon. $2+3=5$

OR

Write one function for each of the following parts of human eye : $1 \times 5 = 5$

- (a) Cornea (b) Choroid
(c) Lens (d) Retina
(e) Iris

4.2 What is the importance of accommodation in daily life? How accommodation occurs while looking at distant objects? $2+3=5$

OR

Write about any three motivating factors behind locomotion with examples. Write about the role of feathers in bird flight. $3+2=5$

4.3 Write two significances of cell division. How does amitosis cell division occur ? $2+3=5$

OR

Write three characteristics of the Prophase stage of mitosis. What are the problems faced when the control of cell cycle is destroyed? $3+2=5$

- 1.8 The plant which propagate vegetatively by offset is —
 (a) Water hyacinth (b) Sweet potato
 (c) Ginger (d) Bryophyllum
- 1.9 The phase of human development when secondary sexual characteristics are expressed under the influence of hormones is —
 (a) Childhood (b) Adolescence
 (c) Adulthood (d) Senescence

Group 'B'

2. Answer 6 questions out of 9 given below as instructed. 1×6=6

Fill in the blanks with proper words in the following sentences (any one) : 1×1=1

2.1 The shoot of improved quality that is selected for grafting is termed as _____.

2.2 The gene responsible for colour blindness is present in human _____ chromosome.

Decide whether the following statements are true or false (any one) : 1×1=1

2.3 Lungs are present in all vertebrates in their embryonic stage.

2.4 White flower of pea is an example of dominant trait.

Match the words in Column-A with those which are most appropriate in Column-B and rewrite the correct pair mentioning the serial no. of both the columns (any two) : 1×2=2

<i>Column - A</i>	<i>Column - B</i>
2.5 Amoeba	(a) Lamarck
2.6 Modification of leaves of cactus to thorns	(b) Darwin
2.7 Theory of Natural Selection	(c) Fission
	(d) Prevention of transpiration

Answer in a single word or in a single sentence : 1×2=2

2.8 A pair of related terms is given below. On the basis of the relationship in the first pair write the suitable word in the gap of second pair.

Sexual reproduction : Gamete :: Asexual reproduction : _____ .

2.9 How many autosomes are present in human sperm ?

Group 'C'

3. Answer any 5 questions in 2-3 sentences out of 8 questions given below :

2×5=10

- 3.1 Write one advantage and one disadvantage of self-pollination.
- 3.2 What were the phenotypic and genotypic ratios of Mendel's monohybrid and dihybrid cross?
- 3.3 How a new plant is produced through cutting ?
- 3.4 Mention the adaptive significance of swim bladder of fish.
- 3.5 Show with the help of a checkerboard the percentage of hybrid tall pea plant to be produced from a cross between two hybrid tall pea plant.
- 3.6 Write two examples of observable variations in humans.
- 3.7 Write the differences between convergent and divergent evolution.
- 3.8 What are the main features of Lamarck's law of 'Use and Disuse'?

Group 'D'

4. Write the 3 questions or their alternatives given below. The mark allotted for each question is 5 (the division of marks is either 3+2, 2+3 or 5) :

5×3=15

- 4.1 How sex determination happens in humans? Explain dominant and recessive characteristics with examples. 3+2=5

OR

Show with the help of a checkerboard the type of genotypes to be found in F₂ generation of a cross between a pure black (BB) & rough (RR) haired guinea pig with a pure white (bb) & smooth (rr) haired guinea pig. 5

- 4.2 Explain with the help of a schematic diagram how alternation of generation occurs in fern. 5

OR

How micropropagation ensures rapid propagation of desired varieties of plants? Write the name of a plant which is pollinated by air and another which is pollinated by water. 3+2=5

- 4.3 Explain why 'struggle for existence' occurs. How does inheritance of acquired characters happen according to Lamarck? 3+2=5

OR

How do analogous organs serve as an evidence for the theory of biological evolution? Write the names of two vestigial organs in humans. 3+2=5

- 1.6 The statement which is not true for self pollination is —
- (a) no need of agents
 - (b) new characters do not arise in daughter plant
 - (c) pollination occurs between flowers of two plants of same species
 - (d) flowers are generally dull in colour and odourless
- 1.7 The probability of having a normal son born to normal father and colour blind mother is —
- (a) 0 %
 - (b) 25 %
 - (c) 50 %
 - (d) 100 %
- 1.8 The different type of gametes that can be produced from a pea plant having a genotype of $YyRr$ are —
- (a) Yr, Yy, YR, Rr
 - (b) YR, yR, Yr, yr
 - (c) Yy, Rr, yr, yR
 - (d) YR, Yr, yR, Rr
- 1.9 Autosomal chromosomal disorder is —
- (a) Haemophilia
 - (b) Colour blindness
 - (c) Thalassemia
 - (d) Night blindness
- 1.10 The characteristic feature of homologous organ is —
- (a) different in origin but similar in function
 - (b) similar in origin but different in function
 - (c) different in origin and structure
 - (d) points to convergent evolution
- 1.11 Honeybees perform a set of manoeuvres that resemble a figure 8, when —
- (a) it finds a suitable place to build a shelter
 - (b) it discovers an enemy
 - (c) it finds food
 - (d) it wants to reproduce
- 1.12 The organ of Rohu fish where retia mirabilia is found is —
- (a) Swim bladder
 - (b) Air sac
 - (c) Lungs
 - (d) Gills

- 1.13 The process by which nitrogenous compounds of the soil are broken down, nitrogen is freed and returned to the environment is termed as —
- (a) Nitrification (b) Denitrification
(c) Nitrogen fixation (d) Ammonification
- 1.14 The condition when algal bloom is formed is —
- (a) when greenhouse gases increase
(b) when SPM increases
(c) due to eutrophication
(d) due to an increase of arsenic level of water
- 1.15 The endeavour that first started in the Arabari Forest of West Midnapore district to conserve biodiversity is —
- (a) Cryopreservation (b) JFM
(c) Zoo Garden (d) Botanical Garden

Group 'B'

2. Answer 21 questions out of 26 given below as instructed. $1 \times 21 = 21$

Fill in the blanks with proper words in the following sentences (any five) : $1 \times 5 = 5$

- 2.1 The enzyme having the capacity to destroy germs present in tears is _____.
- 2.2 Movable joints contain _____ fluid.
- 2.3 Separation of _____ chromosomes occurs in Meiosis I.
- 2.4 The specific part of chromosome where a gene is located is termed as _____.
- 2.5 Leaves of cactus are modified to thorns to prevent _____.
- 2.6 _____ is a Biosphere Reserve of West Bengal.

Decide whether the following statements are true or false (any five) : $1 \times 5 = 5$

- 2.7 Cytokinin hormone prevents lateral bud growth in plants.
- 2.8 In meiosis cell division the chromosome number of a daughter cell is half that of the parental cell.
- 2.9 The mother has the main role in determining sex of human child.
- 2.10 Of the four following topics three topics are part of a single topic. Find out that topic and write.
Prophase, Metaphase, Karyokinesis, Telophase.

2.11 Two of the 34 globally identified biodiversity hotspots are located in India.

2.12 Typhoid is a disease caused by water pollution.

Match the words in Column-A with those which are most appropriate in Column-B and rewrite the correct pair mentioning the serial no. of both the columns (any five): $1 \times 5 = 5$

<i>Column - A</i>		<i>Column - B</i>	
2.13	Auxin	(a)	Haploid
2.14	Somatic cell of humans	(b)	Biological magnification
2.15	Microtubule	(c)	Incomplete dominance
2.16	Four O'Clock flower	(d)	Pneumatophore
2.17	Sundri	(e)	Diploid
2.18	DDT	(f)	Spindle
		(g)	Parthenocarpy

Answer in a single word or in a single sentence (any six) :

$1 \times 6 = 6$

2.19 Learning to walk by a child – what type of reflex action is this?

2.20 Mention the role of tail fin in swimming of fish.

2.21 Write the name of one animal cell which does not undergo mitotic cell division.

2.22 In between stock and scion which one is of improved quality?

2.23 Choose the odd one and write it: Tall stem of pea plant, Purple flower of pea plant, Green colour of pea seed, Round shape of pea seed.

2.24 A pair of related terms is given below. On the basis of the relationship in the first pair write the suitable word in the gap of second pair.

Eohippus: Oldest ancestor of horse: _____ : Modern horse

2.25 Write the name one free-living microbe associated with nitrogen fixation.

2.26 What are the effects of sound pollution on humans?

Group 'C'

3. Answer any 12 questions in 2-3 sentences out of 17 questions given below :

$2 \times 12 = 24$

3.1 Mention the role of Auxin hormone in controlling tropic movement.

3.2 Write the reason behind Goitre and one of its symptoms.

3.3 Mention the problem of Hyperopia and the necessary corrective measures.

3.4 Mention the type of bone-joint present in elbow and write the role of that kind of bone-joint in moving the associated organ.

3.5 How does gene relate to chromosome?

- 3.6 Distinguish between mitosis of plant and animal cell based on the following features as directed:
- Formation of spindle fibre
 - Process of cytokinesis
- 3.7 How does a new plant develop from the zygote after fertilization in flowering plants?
- 3.8 Explain hybridization with the help of an example.
- 3.9 State the law of independent assortment related to heredity.
- 3.10 What are the main problems associated with thalassemia?
- 3.11 How does the presence of vestigial organs in different organisms provide evidence for biological evolution?
- 3.12 Mention two adaptive features of camel to withstand extreme water loss.
- 3.13 Write two examples featuring the problem solving ability of chimpanzees.
- 3.14 How does the environment get affected due to various human activities leading to disruption of nitrogen balance in the environment ?
- 3.15 Mention the harmful effects of acid rain on monuments and soil.
- 3.16 Write how do global warming & climate change and introduction of exotic species bring about loss of biodiversity.
- 3.17 Mention the role of environmental pollution in causing diseases like asthma and bronchitis.

Group 'D'

- 4. Write the 3 questions or their alternatives given below. Sightless candidates have to answer question no. 4.1 (A) instead of question no. 4.1. The mark allotted for each question is 5 (the division of marks is either 3+2, 2+3 or 5) : $5 \times 6 = 30$**

- 4.1 Draw a neat diagram of Metaphase stage of mitotic cell division in animal cell and label the following parts : **$3+2=5$**

- | | |
|----------------|-----------------------|
| (a) Chromatid | (b) Polar region |
| (c) Centromere | (d) Chromosomal fibre |

OR

Draw a neat diagram of chromosome and label the following parts : **3+2=5**

- (a) Chromatid (b) Primary constriction
(c) Secondary constriction (d) Telomere

(FOR SIGHTLESS CANDIDATES ONLY)

- 4.1 (A) Write three characteristic features of prophase stage and two characteristic features of metaphase stage of mitotic cell division in animal cells. **3+2=5**

OR

Write the names of five structural parts of an ideal eukaryotic chromosome. **5**

- 4.2 Explain how new characters arise in an organism due to crossing over. Mention one advantage and one disadvantage of cross pollination. **3+2=5**

OR

Number of parents, production of gametes and dependence on mitosis or meiosis - based on these three features distinguish between asexual and sexual reproduction. Mention how an organism grows in the cell enlargement and cell differentiation phases of growth. **3+2=5**

- 4.3 Mention three reasons behind Mendel's success in hybridization experiments. Explain how Mendel performed cross pollination in pea plant. **3+2=5**

OR

Explain with an example how incomplete dominance provides evidence for deviation of Mendel's laws of heredity. Show with an example how a heterozygous organism can be produced. **3+2=5**

- 4.4 Increase in size, reduction of lateral digits and increase in length & thickness of the third digit —based on these three features explain how the fossil history of horse provides support for the theory of biological evolution. **5**

OR

How does a new species arise by natural selection? How will you explain evolution in reference to the presence of tail-like structure in most vertebrate embryos ? **3+2=5**

- 4.5 How does nitrogen fixation occur in the atmosphere? Mention any two environmental problems of the Sundarbans. **3+2=5**

OR

Mention the significance of biodiversity with respect to production of drugs & medicines, maintenance of ecological balance and economic importance. Explain how PBR can create a positive impact in the conservation of biodiversity of a locality. **3+2=5**

- 4.6 Mention how ever-increasing population casts an adverse effect on ecosystem, agricultural land and fresh water. Mention two causes of sound pollution. **3+2=5**

OR

Mention two characteristic features of National Park and name one National Park of West Bengal. Mention the conservation efforts for Red Panda and also mention where in India the conservation efforts are being implemented. **3+2=5**

NOTES

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