National School Curriculum

INSTRUCTIONAL GUIDE FOR BIOLOGY

CLASSES IX & X

Department of Curriculum and Professional Development
Ministry of Education, Royal Government of Bhutan

“Your parents, relatives, and friends would be very proud of what you have achieved. At your age, to have completed your studies is your personal accomplishment. Your knowledge and capabilities are a great asset for the nation. I congratulate you for your achievements. Finally, your capabilities and predisposition towards hard work will invariably shape the future of Bhutan. You must work with integrity, you must keep learning, keep working hard, and you must have the audacity to dream big.”

- His Majesty Jigme Khesar Namgyel Wangchuck

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Foreword

The overriding aspirations of Bhutanese science education is grounded on the philosophical foundations of Gross National Happiness (GNH). In its curricular forefront, Bhutanese science education is informed, in part, by the underlying assumptions of the 21st century educational paradigms. Historically, the Bhutanese science curriculum witnessed several episodes of changes, including the refinement of, and changes to, theories, ideas, and beliefs over time. Therefore, the current Bhutanese science curriculum (NSC) is shaped by several rounds of initiatives undertaken over the past several decades.

In the recent few years, state of affairs around the world witnessed the advent of 21st century real-world issues and challenges. Consequently, as never seen before, the priority to overhaul the art of education itself was echoed at the heart of many education systems around the world. Typically, but not necessarily, there was a unified call to move away from traditional standard-based education systems towards competency-based education systems. The 21st century competency-based education model is, thus, virtually at the centre of many today's education systems. In the face of such global changes, Bhutanese education system cannot afford to sit back and wait for the right time and space. The DCPD at the centre is, therefore, in full pursuit of transforming the art of science teaching from traditional didactic approaches to contemporary approaches of learning.

At the heart of the classes IX to XII biology curriculum is the notion that learners maintain robust understanding when the culture of science practises is enacted either wholly or partially. Such a notion believes that engaging in science practises not only help learners acquire sophisticated understanding but also hone scientific temper and scientific habits of mind. The classes IX to XII biology curriculum, thus, desires to chart a milestone shift from the act of "transmitting science" towards the culture of "doing science". By far, the classes IX to XII biology curriculum also dwells on the philosophical assumptions of the integrated approach of STEM education. As never done before, the classes IX to XII biology curriculum now entails situating both content and instructional practises, oftentimes, in complex phenomena, authentic contexts, or real-world situations. The classroom practises, in contrast to past common practises, are now expected to be either performance tasks or competency-based propelled by scientific inquiry and engineering design process.

I am confident that this instructional guide serves as a springboard in the effective delivery of the classes IX to XII biology curriculum intentions. Overall, I believe that this guide would serve a strong foundation of science education in equipping learners with the ability to think critically, analyse information, and solve complex problems —the skills needed to pursue opportunities within and beyond STEM fields.

Tashi Namgyal
Director

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Introduction

Science education in Bhutan started with a curriculum borrowed from a neighbouring country. In 1986, however, the Royal Government of Bhutan (RGoB) replaced the foreign borrowed curriculum by implementing a localised science curriculum founded on the principles of New Approach to Primary Education (NAPE). Since then, the Bhutanese science curriculum witnessed several episodes of changes, including the refinement of, and changes to, theories, ideas, and beliefs over time. Therefore, the current Bhutanese science curriculum (NSC), including biology is shaped by several rounds of initiatives undertaken over the past several decades.

With the dawn of the 21st century, nations around the world experienced a wide array of unique real-world problems in social, economic, and environmental contexts. In light of such pressing issues, education systems around the world embraced the 21st century educational framework as the new conceptual windows of education. At the centre, this growing call was no exception for Bhutanese education system. The erstwhile Royal Education Council (REC), therefore, initiated science curriculum reform towards the fall of 2020. The science curriculum revision was motivated in part by the growing consensus of competency-based or STEM education.

The goals of science education in Bhutan revolves around the premise of educating youths with a multitude of scientific abilities. At the national level, the classes IX to XII biology curriculum aspires to produce individuals with scientific abilities capable of understanding and evaluating information; have a voice in science funding decisions; evaluating policy matters; and weighing scientific evidence provided in legal proceedings. Further, it purports to produce skilled and motivated future scientists, doctors, biology domain related engineers, and STEM-based workforce or professionals.

At the individual level, the classes IX to XII biology curriculum, however, increasingly seeks to help learners engage in the ethos of scientific practises and scientific habits of mind. It expects that learners become critically aware of the nature of science; possess strong proficiency in designing solutions and conducting scientific inquiry; and possess sharp abilities to participate in the culture of scientific practises and STEM related discourses. It also aspires to provide strong foundations of academic rigour and biological literacy that lends ultimate proficiency to make sense of the phenomena, scientific discoveries, and scientific inventions.

Informed by the new vision of science education, the culture of "doing science" lies at the heart of classes IX to XII biology curriculum. The classes IX to XII biology curriculum, thus, desires to transform science teaching from the culture of "transmission of science" towards "investigating science" or "doing science" in itself. This is certainly, however, not possible if the curriculum itself

believes in providing a large number of isolated facts of equal priority. Therefore, in contrast to earlier curriculum, the present classes IX to XII biology curriculum is now principally centred on disciplinary core ideas to avoid shallow coverage of multiple disconnected facts. The reduction of the sheer sum of details to be mastered is intended to give time for students to engage in scientific investigations and argumentation and to achieve depth of understanding of the core ideas presented. On the same footing, the curriculum also aspires to teach both science contents and practises as one science standard. This is seemingly as opposed to the divorce between science contents and science practises that used to be the common features of the past curriculum.

By far, the classes IX to XII biology curriculum is also motivated, in part, by a growing consensus to augment the spirit of STEM education. It entails transitioning science teaching from a silo-based approach to 21st century integrated or interdisciplinary nature of STEM. As never before, it attempts to raise the standards of engineering and technological design at par with science standards. As its name implies, the engineering, in a very broad sense is, purported to upscale any engagement in a systematic practise of design to achieve solutions to particular human-made problems. Therefore, instructional practises are expected to be delivered in conjunction with other STEM disciplines to make sense of the phenomena and design solutions to address contemporary issues. On the whole, like other science disciplines, the classes IX to XII biology curriculum calls for following paradigm shifts:

1. teaching many isolated facts towards teaching disciplinary core ideas.
2. teaching disciplinary core ideas (science contents) and science processes (science practises) together as one science standard.
3. raising the standards of engineering design process/design challenge at par with the science standards.
4. infusing technological design where appropriate to augment science standards and engineering design.

Purpose of the Instructional Guide

As classes IX to XII biology curriculum put-forth a new vision, the urgency of having this guide appeared more than necessary. This instructional guide (IG) was, thus, developed with the purpose of assisting both teachers and learners in situating robust and heralding classroom practises. The IG in its entirety contains suggestive learning experiences drawn mostly from the classes IX to XII biology curriculum framework. These suggestive learning experiences, at the core, are lesson-like formats developed for each learning objective. They are tied closely with a topic, competencies, and a strand or a theme.

Specifically, each learning experience contains suggestive approaches of delivering curriculum intentions. Each of them contains some generic roles of both teachers and learners. Depending on the nature of the learning objective, each learning experience is driven either by the art of scientific inquiry or the engineering design process. Certain learning experiences, though not often, are centred on some specific inquiry-derived or design-thinking based pedagogical approaches. At the centre, almost all the learning experiences are nested on the pedagogical frameworks of blended learning approaches, such as flip class, virtual enriched, etc. Therefore, almost all the learning experiences contain prolific or sporadic use of digital contents and digital platforms wherever appropriate. Besides, each learning experience is closely followed by suggestive follow-up questions; and suggestive assessment techniques and tools purported to assess learners' learning progression or performance tasks.

Categorically, with such learning experiences in place, it is expected that learners are provided uninterrupted education irrespective of situations or circumstances. With blended learning at the heart of each learning experience, it is expected that teaching is carried out in times of prolonged closure of schools (due to emergencies), holidays, and when subject teachers are on leave or away for official duties.

Class IX

1. Molecules to Organisms: Structures and Processes

Organisms contain structures and processes organised from small to large. This organisation, though not much visible in small organisms, is quite noticeable in higher organisms. How are structures and processes organised in organisms? Every organism, whether small or big, contains cells as the smallest units. Cells, depending on their structures and biological roles, influence almost all structures, processes, and behaviour of the organism. They combine to form structures and functions of tissues, which in turn form organs, organ systems, and organism in itself. It is, therefore, important to understand how interacting systems and subsystems coordinate the behaviour and function of the organism.

Competencies

By the end of class IX, a learner should be to:

a. apply the understanding from the cell to explain that all organisms, either simple or complex, are made up of single or multiple cells.
b. use scientific evidence to support the explanation that an organism contains several interacting systems and subsystems.
c. use scientific concepts from human biological organisation to explain that processes, behaviours, and emotions of an organism are coordinated by several interacting systems and subsystems.

1.1. Cells in Living Organisms

(1.1.1. Scope: Living things are made up of cells. Cells are considered the fundamental units of life.
1.1.2. Scope: Cells occur in various shapes and sizes. The structure of a cell determines the nature of its function.
1.1.3. Scope: Stem cells have unique abilities to differentiate into numerous cells in the body to take up different functions. Therefore, these cells are used for the treatment of certain diseases (e.g., cancer, leukaemia, autoimmune diseases, etc.))

Objective(s):

LO-1. Investigate to provide evidence that living things are made up of cell(s).

Learning Experiences:

The teacher may begin the lesson by informing the learner that every living organism contains cells. Relate cells as bricks that form the walls of the building. The learner may be informed that the cell is the smallest structure of the living things that can live on its own. The teacher may pose the question: Can we observe cells? The lesson may be delivered based on the following order of scientific and engineering practises:

- The learner obtains information on cells from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/nU5B9I5).

- The learner plans and designs an experiment to investigate that living things are made up of cells.
- From the investigation, the learner collects data to show that living things are made up of cells.
- The learner analyses (tabulation, statistics, graphing, etc.) and interprets the data collected from the observation to show that living things are made up of cells.

Questions:
The teacher may ask the following questions to assess the understanding of the learner:

1. Living things are made up of cells. Support the statement with evidence(s).
2. Cells are the smallest units of living things. Explain with reasons.
3. Are there living things without cells? Explain with reasons.

Assessment:
Use rubrics to assess the learner's skills to conduct the experiment, and their ability to observe, analyse and interpret the data to explain that living things are made up of cells. Provide necessary intervention.
For recording and reporting, refer to the science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science curriculum framework
- https://cutt.ly/nU5B9I5

Objective(s):
LO-2. Construct scientific explanation that different cells have specific shapes adapted to carry out specific functions.

Learning Experiences:
The teacher may begin the lesson by asking a question: How does the shape of a cell determine its function? The lesson may be delivered based on the following order of science and engineering practises:

- The learner obtains information on how different cells have specific shapes adapted to carry out specific functions from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/szUqPnF)
- Based on the information gathered, the learner explains how different cells have specific shapes adapted to carry out specific functions.
- The learner makes presentation how different cells have specific shapes adapted to carry out specific functions. The learner critiques each other's explanation and mechanistic reasoning.

Questions:

Teacher may ask the following questions to challenge the thoughts of the learner:

1. Give two examples of cells that relate their shapes with their functions.
2. A cell's function is determined by its shape. Comment.
3. Our biceps pull out forearms up and rotate them outward. Explain this role of the bicep from the structure of muscle cells.
4. What causes the cell to have different structures and functions?
5. How does the structure of a sperm cell help it to function?

Assessment:

Use rubrics to assess the learner's information management skill, ability to construct and explain that different cells have specific shapes to carry out specific functions and communication skills. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science curriculum framework
- https://cutt.ly/szUqPnF

Objective(s):

LO-3. Communicate the scientific information on the application of stem cells in addressing health issues.

Learning Experiences:

The teacher may begin the lesson by informing the learner that stem cells are special human cells that are able to develop into many different cell types. This can range from muscle cells to brain cells. In some cases, they can also fix damaged tissues. Stem cells are of great interest to researchers because of their ability to divide indefinitely and differentiate into many cell types. Stem cells have many existing and even more potential therapeutic applications like treatments for cancer, blood disorders, brain or spinal cord injuries, and blindness. The teacher may ask the learner to gather information on applications of stem cells in the treatment of various health issues by providing relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://youtu.be/8gEl_DVMNLE) a day before the lesson. The lesson may be delivered based on the following order of scientific and engineering practises:

- The learner obtains scientific information on stem cells and their applications in the treatment of various health issues from the relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/7OgX5oN).

- Based on the information gathered, the learner evaluates scientific information on the application of stem cells used in the treatment of various health issues.
- The learner communicates scientific information on the application of stem cells in addressing health issues. They may argue and critique each other's views and claims.

Questions:
The teacher may ask the following questions to assess the understanding of the learner:

1. What are some of the applications of stem cells?
2. Bone marrow and peripheral blood stem cell transplants are ways to treat blood cancers like leukaemia. How do stem cells serve as a repair system in our body?

Assessment:
Use rubrics to assess the learner's information management skill and ability to communicate the applications of stem cells in treating various health issues. Provide necessary feedback and intervention.
For recording and reporting, refer to the science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science curriculum framework
- https://youtu.be/8gEl_DVMNLE
- https://cutt.ly/7OgX5oN

Challenge Your Learners
Teacher may ask the following questions to challenge the thoughts of the learner:

1. 'Cells are considered as structural and functional units of life.' Comment.
2. Will there be life without a cell? Explain.
3. What would be the scenario if cells were similar in structure? Explain.
4. How are the cell structures related to their functions?
5. There are mainly three types of stem cells. How are embryonic cells and adult stem cells different?
6. What is stem cell therapy?

1.2. Photosynthesis: Food for Life

(1.2.1. *Scope: Plants, algae, and some bacteria use light energy to prepare food (glucose) from carbon dioxide and water during photosynthesis. Photosynthesis involves a series of chemical reactions that occur within the structures of the cell. The energy from glucose is later transferred to ATP (adenosine triphosphate), the fundamental fuel of all organisms.*

1.2.2. Scope: Plants that are grown indoors help in maintaining a clean indoor environment and are known to have a wider range of applications in reducing human health issues. However, some plants have the potential of causing allergic reactions in people.)

Objective(s):

LO-1. Develop a model that explains the transformation of energy during photosynthesis.

Learning Experiences:

The teacher may carry out the instructional practises on the transformation of energy during photosynthesis by posing a question: how is energy transformed during photosynthesis? To answer the question, teacher may let the learner gather information on how light energy is converted into chemical energy from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/sIewoZN) one day before the lesson. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on how light energy is converted into chemical energy from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/sIewoZN).
- Based on the information gathered, the learner develops a model (theoretical, conceptual, physical, or simulation) that explains how light energy is converted to chemical energy during photosynthesis.
- The learner displays the model to explain how light energy is converted to chemical energy during photosynthesis and critique each other's work.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Explain how solar energy is transformed during photosynthesis.
2. The food that we eat in the form of rice, cornflake, and bread are the products of photosynthesis. Justify.
3. Is it possible to harvest solar energy trapped by leaves? Suggest some methods with reasons.

Assessment:

Use rubrics to assess learners' information management skills, the ability to use conceptual understanding in designing and developing a model (theoretical, conceptual, physical, or simulation) to explain the transformation of energy during photosynthesis. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC

- Science curriculum framework (NSCFS- 2022).
- https://cutt.ly/sIewoZN

Objective(s):
LO-2. Construct an explanation on the significance of photosynthesis based on scientific reasoning.

Learning experiences:
The teacher may begin the lesson by posing the question: why is the photosynthesis process important to sustain life on Earth? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the significance of photosynthesis using relevant sources (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/UIerzGK)
- The learner constructs an explanation on the significance of photosynthesis giving scientific reasons. The learner communicates the significance of photosynthesis giving scientific reasons.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. Why is photosynthesis important to all living organisms?
2. How would life be on earth without photosynthesis?
3. Photosynthesis can combat global warming. Explain with reasons.

Assessment:
Use rubrics to assess learners' information management skills, ability to explain the significance of photosynthesis. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022).
- https://cutt.ly/UIerzGK

Objective(s):
LO-3. Construct arguments based on scientific reasons that indoor plants reduce human health issues.

Learning Experiences:
The teacher may begin the lesson by informing the learner that indoor plants (houseplants) are plants that can thrive in indoor environments and then pose a question: how would indoor plants

affect human health? The teacher may provide relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/gIeyW0S) a day before the lesson. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the impacts of indoor plants on human health from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/gIeyW0S).
- The learner engages in an argument to support or refute that indoor plants help in reducing human health issues.
- The learner either claims or refutes the scientific reason that indoor plants help in reducing human health issues.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Mention some of the health benefits of growing indoor plants.
2. How do indoor plants reduce health problems?
3. Is growing indoor plants a good practise? Support your answer with reasons.

Assessment:

Use rubrics to assess learners' information management skills, ability to explain the impacts of indoor plants on human health. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022).
- https://cutt.ly/gIeyW0S

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. How chlorophyll in plants absorbs and transforms light energy?
2. Which is the best source of light energy for photosynthesis? Justify.
3. Does the arrangement of leaves in plants affect the rate of photosynthesis? Comment.
4. The rice we eat is a product of photosynthesis. Justify.
5. What would be life on the earth without photosynthesis? Explain.
6. Photosynthesis can combat global warming. Explain with reasons.

1.3. Transpiration: The Perspiration in Plants.

(1.3.1. *Scope: Plants undergo transpiration to lose excess heat and the rate of transpiration varies depending on various internal and external factors. Plants are adapted to conserve water.*

1.3.2: Scope: Green plants are often used to remove contaminants (e.g., toxic substances, trace elements, radioactive substances, etc.) from soil and water (Phytoremediation).)

Objective(s):

LO-1. Construct scientific explanations to demonstrate the relationship between factors and the rate of transpiration.

Learning Experiences:

The teacher may begin the lesson by informing the learner about the concept of transpiration and the factors that influence the rate of transpiration. The teacher may ask a question: how do external factors like light intensity, wind velocity and humidity influence the rate of transpiration? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner predicts how external factors like light intensity, wind velocity and humidity affect the rate of transpiration. The learner identifies variables (dependent, independent and controlled variables).
- The learner designs and conducts experiments to show how external factors such as light intensity, wind velocity and humidity, affect the rate of transpiration.
- The learner analyses (tabulation, statistics, graphing, etc.) and interprets the data collected on how external factors affect the rate of transpiration by referring to relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/8IefOMq).
- The learner draws conclusions based on the experiment. The learner shares their findings with the class.

Questions:

The teacher may ask the following questions to examine the understanding of the learner:

1. Read the statement given below and answer the questions that follow:

   Leaves are of different shapes. One of the factors that affect the rate of transpiration is the shape of a leaf.

   a. Develop a hypothesis for the above statement.
   b. Identify the independent and dependent variables.
   c. Develop a research question based on the above statement.
2. List down the factors affecting the rate of transpiration.
3. How does humidity affect the rate of transpiration in a plant?
4. Design an experiment to show transpiration taking place in a plant.

Assessment:

Use rubrics to assess the learner's ability to identify variables (dependent, independent and controlled variables), design and conduct an experiment, ability to predict the finding, ability to interpret the experiment on environmental factors that influence the rate of transpiration. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022).
- https://cutt.ly/8IefOMq

Objective(s):

LO-2. Design a solution to obtain clean water based on the concept of transpiration.

Learning Experiences:

The teacher may begin the lesson by asking a question: how does the transpiration process help in obtaining clean water? The teacher may provide a situation where a community has an acute shortage of water and ask the learner to purify the contaminated water. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner gathers information on the principle of transpiration that can be used in obtaining clean water from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/rIezEc1)
- The learner plans and designs an experiment to clean the contaminated water based on the principle of transpiration.
- The learner carries out the experiment as designed to test the proposed solution.
- The learner observes, analyses (tabulation, statistics, graphing, etc.) and interprets the data collected.
- The learner shares their findings with the class and critiques each other's work.

Assessment:

Use rubrics to assess the learner's information management skills, ability to design an experiment to explain how the transpiration process can be used to obtain clean water. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/rIezEc1

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. How does transpiration affect the environment?

2. Transpiration is considered as necessary evil'. Comment.
3. How does transpiration help in obtaining clean water?
4. How are plants adapted to survive in the desert?

1.4. Digestion: What's on the plate?

(1.4.1. Scope: 1.4.1. Scope: The digestive system in humans consists of the alimentary canal and accessory organs. During digestion, the food we consume is broken down into simpler forms for absorption by the body and assimilated for growth and development. Food (glucose) is chemically broken down during cellular respiration to release energy that is stored in ATP. During aerobic respiration glucose is converted into carbon dioxide and water releasing the energy.

1.4.2. Scope: The growth and development of our body depend largely on the kinds of food we consume, our dietary practises, and our lifestyles. An imbalance in nutritional requirements can result in certain health issues.)

Objective:
LO-1. Construct a model that provides a scientific explanation on digestive organs and their role in the digestion of food.

Learning Experiences:
The teacher may begin the lesson by informing the learner that the complex food that we take must be broken down into smaller pieces. For this to happen, various digestive organs are involved. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on organs in the digestive system and their roles during digestion from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/MPFZm09)
- Based on the information obtained, the learner develops a model (theoretical, conceptual, physical, or simulation) that depicts the organs involved in digestion and their role in the digestion of food.
- The learner critiques each other's model that explains the role of various organs involved in the digestion of food.

Questions:
The teacher may ask the following questions to examine the understanding of the learner:

1. What happens to the food during digestion?
2. Explain the digestive role(s) of stomach, pancreas, liver, and small intestine.
3. What would happen to digestion if a liver is either damaged or removed from our body?
4. Constipation is one of the most common digestive problems that we often suffer.
   a. What is constipation?
   b. How is constipation caused?

5. Usually when you suffer from diarrhoea, doctors advise you to drink Oral Rehydration Solution (ORS). Why? Support your answer with reason.

Assessment:

Use rubrics to assess the learner's information management skills, ability to develop a model, ability to use the model in explaining the roles of the organs in the process of digestion of food. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/MPFZm09

Objective(s):

LO-2. Communicate scientific information on cellular respiration and its mechanism (*limited to basic concepts of glycolysis, Krebs cycle, and electron transport*).

Learning Experiences:

The teacher may begin the lesson by informing the learner that our bodies are made of cells. The cells need energy to carry out all the essential functions that keep us alive. Cellular respiration provides the energy for the cells to work. The teacher may pose a question: How is energy produced through aerobic respiration? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the production of energy by aerobic respiration from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://bit.ly/3IOkmGm).
- The learner constructs an explanation on the production of energy through aerobic respiration giving scientific reasons.
- The learner communicates the explanation constructed to the class.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. What happens to the food during cellular respiration?
2. Where does glycolysis take place?
3. What happens to pyruvate after entering Krebs cycle?
4. Provide an explanation on how the *bread* that we consume is converted into ATP energy?

Assessment:
Use rubrics to assess the learner's information management skill, ability to construct scientific explanations on production of energy through aerobic respiration, and ability to communicate scientific information. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://bit.ly/3IOkmGm

Objective(s):
LO-3. Develop a model of a diet plan that provides a scientific explanation on healthy eating habits.

Learning Experiences:
The teacher may begin the lesson by informing the learner that we are what we eat. Our body needs a good balanced diet and nutrients for the proper functioning of our body. The teacher may ask the question: How would eating practises affect our health? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the impacts of eating habits on human health from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/RIezvDY, https://cutt.ly/ZIeWXfc).
- The learner constructs a model (theoretical, conceptual, physical, simulation) to explain how good eating habits lead to a healthy lifestyle.
- The learner uses the model to explain how good eating habits lead to a healthy lifestyle.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. What do you mean by a healthy eating habit?
2. Why is diet and nutrition important?
3. "You are what you eat". Comment.
4. Most of the Bhutanese people believe that eating garlic makes one dull. Do you agree? Support your answer with reason(s).
5. What is your view on *Sikam* (phaksha) from a dietary practises point of view? Comment with reasons.

Assessment:
Use rubrics to assess the learner's information management skill, ability to develop a model, ability to use the model to explain eating habits and lifestyle, and ability to answer the questions. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/RIezvDY
- https://cutt.ly/ZIeWXfc

Objective(s):
LO-4. Communicate the scientific information on the effects of eating junk or processed food on the growth and development of our body.

Learning Experiences
The teacher may inform the learner that eating junk food has several health-related and life-style related diseases. To drive the lesson, the teacher may ask a question: How does eating junk food and processed food affect our health? Based on the question, the lesson may be delivered based on the following order of scientific and engineering practises:

- The learner obtains information on the harmful effects of junk food and processed food on human health from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/5IeEjdm).
- Based on the information gathered, the learner analyses the harmful effects of junk food and processed food on our health.
- The learner communicates on harmful effects of junk food and processed food with scientific reasons.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. How does eating junk food or processed food affect growth and development of our body?
2. Is it healthy to eat *pizza* and *hamburgers*? Why?
3. Mention healthy dietary practises with scientific reasons.

Assessment:

Use rubrics to assess the learner's information management skill, ability to analyse, reasoning skill and communication skills. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/5IeEjdm

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. Small intestine is coiled and long compared to the large intestine. Why?
2. Why are food substances digested in unequal proportions in different digestive organs?
3. Usually there is no digestion of food in the oesophagus. Why?
4. How does eating healthy food affect the normal functioning of the body?
5. People love to eat junk food besides its adverse effects on the body. Comment.

1.5. Transport and Exchange in Our Body

(1.5.1. Scope: Circulation of body fluids help in the collection and distribution of substances (i.e., oxygen, nutrients, ions, etc.) and in the removal of waste materials. The circulatory system of humans comprises the heart, blood, and blood vessels.

1.5.2. Scope: Abnormalities in the structure or injuries to the parts (i.e., heart and blood vessels) of the circulatory system result in health complications.

1.5.3. Scope: The inspired air is carried to the lungs by the respiratory tract. The exchange of gases occurs in the lungs and tissues. The circulatory and respiratory systems work together to supply oxygen and remove carbon dioxide from the body.)

Objective(s):

LO-1. Develop a model of the human heart that explains its structure and function.

Learning Experiences:

The teacher may inform the learner about the lesson on human heart one day before the lesson. Teacher may ask the learner to read on the human heart, its structure, and the functions from the relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/1Ieb6VM). The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the human heart, and its structure and function from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g.,https://cutt.ly/XPFZ2mS) .
- The learner develops a model (conceptual, theoretical, physical, or simulation) of a human heart showing its structure and function.
- The learner critiques each other's model and incorporates the feedback and comments.

Questions

The teacher may ask the following questions to check the understanding of the learner:

1. Explain the structure and function of the human heart.
2. How the human heart is structurally adapted to carry out its function?
3. What would happen to our blood circulation if there are no semilunar valves? Comment.

Assessment:

Use rubrics to assess the learner's information management skill, ability to develop a model of a human heart, and ability to critique the model. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/1Ieb6VM
- https://cutt.ly/XPFZ2mS

Objective(s):

LO-2. Design a solution to address issues related to the heart. *(limited to coronary artery disease and heart valve failure).*

Learning Experiences:

The teacher may provide relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/VIeYiOv) on heart-related diseases, one day before the lesson. The teacher may inform the learner that coronary artery disease and failure in the valve are some heart-related diseases. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on coronary artery disease and working of heart valve from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/9IuPmoZ)
- The learner designs a solution to address coronary artery disease and failure in the heart valve.
- The learner shares the designed solution in the class for feedback and comments.

Assessment:
Use rubrics to assess a learner's information management skill, ability to design solutions to address coronary artery disease and failure in a heart valve, and communicating skills. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:
- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/VIeYiOv
- https://cutt.ly/9IuPmoZ

Objective(s):
LO-3. Develop a model that represents how the circulatory and respiratory systems work in coordination for the transportation and exchange of gases in humans.

Learning Experiences:
The teacher may inform the learner that the respiratory system and circulatory system work closely in coordinating the transportation and exchange of gases, such as oxygen and carbon dioxide, in the human body. The teacher may begin the lesson by posing the question: How do the respiratory and circulatory systems work together in exchanging and transporting gases in our body? The teacher may deliver the lesson based on the following order of scientific and engineering practises:
- The learner obtains information on the involvement of respiratory and circulatory systems in the transportation and exchange of gases from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/aIeVZ2H).
- Based on the information obtained, the learner constructs a model (theoretical, physical, conceptual, or simulation) that represents the coordination of respiratory and circulatory systems in the transportation and exchange of gases in our body.
- The learner critiques each other's model and incorporates the feedback and comment.

Questions:
The teacher may ask the following questions to assess the understanding of the learner:
1. How is carbon dioxide produced in cells removed from our body?
2. The oxygen that we inhale finally reaches body cells. Explain.
3. The rice that we consume gets broken down into glucose in the alimentary canal. Glucose then reaches body tissues. How does it reach our body tissues?

Assessment:
Use rubrics to assess learners' information management skills, ability to design a model that represents the coordination of respiratory and circulatory systems in the transportation and exchange of gases in our body, communicating skills, and critiquing skills. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/aIeVZ2H

Challenge Your Students
Teacher may ask the following questions to challenge the thoughts of the learner:

1. How do the respiratory and circulatory systems work together in exchanging and transporting gases in our body?
2. Regular exercise is important for your health. Explain.
3. How does drinking plenty of water improve our blood circulation?

1.6. Response and Coordination

(1.6.1. Scope: The endocrine system through the production of hormones regulates various processes and functions in the body. Endocrine glands (pituitary gland, adrenal gland, gonads, and pancreas) have a significant influence on the body.

1.6.2. Scope: The nervous system consists of the brain, spinal cord, sensory organs, and nerves (bundle of neurons) that connect these organs to different parts of the body. The organs of the nervous system play vital roles in the control and coordination of the body.

1.6.3. Response and coordination in our body are brought by the nervous system and endocrine system. The endocrine system acts as a communication tool within the human body, working together with the nervous system to maintain homeostasis.

1.6.4. *Scope: Plants produce a wide variety of biochemicals (e.g., Auxin, gibberellin, cytokinin, abscisic acid, and ethylene) that regulate their growth and development. These biochemicals are known as phytohormones. The phenomena such as flowering, fruiting, ageing, etc., are regulated by phytohormones.)*

Objective(s):

LO-1. Construct a model that provides a scientific explanation of the human endocrine system. *(limited to the pituitary, thyroid, adrenal, and gonads)*

Learning Experiences:

The teacher may instruct the learner to obtain information on the endocrine system from the relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/PIcPUHy) a day before the lesson. The teacher may begin the lesson by informing the learner that the endocrine system is a network of glands in the body that produce hormones. Hormones are the body's chemical messengers that help in carrying information and instructions from one set of cells to another. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on endocrine systems (pituitary, thyroid, adrenal, and gonads) from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/FIcTRmr).
- The learner develops a model (theoretical, physical, conceptual, or simulation) that represents the major endocrine glands (pituitary, thyroid, adrenal, and gonads), their hormones, and their corresponding roles.
- The learner displays their model that explains the major endocrine glands (pituitary, thyroid, adrenal, and gonads), their hormones, and their corresponding roles.
- The learner critiques each other's model.

Questions:

Teacher may ask the following questions to assess learners understanding of the lesson:

1. Explain the role of pituitary gland, thyroid gland, adrenal gland, and gonads.
2. What would happen to our growth and development if the pituitary gland is damaged or removed? Explain with examples.
3. How is the development of secondary sexual characteristics, such as onset of menstruation, growth of hair, and production of sperm and eggs related to gonads?

Assessment:

Use rubrics to assess learners' information management skills, ability to develop a model to explain the major glands, hormones and their roles, and communicating skills. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/PIcPUHy
- https://cutt.ly/FIcTRmr

Objective(s):

LO-2. Construct a model that explains the structure and functions of the human nervous system.

Learning Experiences:

The teacher may begin the lesson by informing the learner that the nervous system is the major controlling, regulatory, and communicating system in the body. Like other systems in our body, the nervous system is composed of different organs, principally the brain, spinal cord, nerves, and ganglia. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the structures and function of the human nervous system from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/2IcC6TF).
- The learner develops a model (theoretical, physical, conceptual, or simulation) based on the information obtained.
- The learner uses the model to explain the structure and function of the human nervous system.
- The learner critiques and provides feedback to each other.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Describe the function of cerebrum, cerebellum, and medulla oblongata.
2. The response that comes from the spinal cord is involuntary and immediate. Explain.
3. How does the nervous system help in responding to different stimuli? Explain.
4. Withdrawal of your hand after touching a hot pan is an example of the role played by our nervous system. Identify the stimulus, response, motor nerve, sensory nerve and the effector in the example mentioned above.

Assessment:

Use rubrics to assess learners' information management skills, ability to develop a model to explain the structure and role of the human nervous system, and communicating skills. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/2IcC6TF

Objective(s):

LO-3. Construct a scientific explanation on how the human nervous system and endocrine systems work together to bring coordination.

Learning Experiences:

The teacher may begin the lesson by informing the learner that homeostasis is the body's ability to maintain a stable internal environment (regulating hormones, body temperature. water balance, etc.). The teacher may pose a question: How do the nervous and endocrine systems help in coordinating the body functions? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the functioning of the nervous and endocrine systems from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/4Iui2LK, https://cutt.ly/iIuotBA).
- The learner constructs an explanation on how the nervous and endocrine systems work together in bringing the body's coordination in maintaining a constant internal environment.
- The learner shares how nervous and endocrine systems work together to maintain a constant internal environment for scientific reasons.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How do the nervous and endocrine systems help in coordinating the body functions? Explain.
2. Which one, the nervous system or endocrine system, brings more about the response and coordination of our body? Explain with examples.
3. Imagine that you decide to flee after seeing a snake on your way. In this action both your nervous system and endocrine system are involved. Explain the coordination brought by your nervous system and endocrine systems in fleeing from the site.

Assessment:

Use rubrics to assess learner's information management skills, ability to explain how the human nervous system and endocrine system work together to bring the body's coordination in maintaining a constant internal environment. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/4Iui2LK
- https://cutt.ly/iIuotBA

Objective(s):

LO-4. Communicate the scientific information on the roles of phytohormones in the growth and development of plants.

Learning Experiences:

The teacher may begin the lesson by informing the learner that phytohormones are chemical signals (chemical messenger) that control different processes in plants. Plant hormones include ethylene, gibberellins, cytokinins, abscisic acid, and auxins. The teacher may pose a question: How do phytohormones help in the overall growth and development of a plant? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on how different plant hormones carry out specific functions from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/YzwgYyi)
- Based on the information obtained, the learner constructs an explanation on the roles of plant hormones.
- The learner answers the questions posed on the roles of plant hormones.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Mention the role of cytokinin and gibberellin in the growth and development of a plant.
2. Removal of ethylene helps increase the shelf life of fruits and vegetables. Justify.
3. How are fruits and vegetables made available in the off seasons?
4. The growth of a plant in size is regulated by a plant hormone. Comment.
5. Design an experiment to investigate the effect of hormones on growth and development of plants.
6. Sunflowers follow the direction of the sun until they reach the age of maturity. Why?

Assessment:

Use rubrics to assess the learner's information management skills, ability to construct an explanation on how different hormones carry out specific functions to control the growth and development of plants and ability to answer the questions. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/YzwgYyi

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. How does the human nervous system and endocrine systems work together to bring coordination in our body?
2. How do phytohormones regulate the growth and development of a plant?
3. How would auxin affect the growth of a plant?
4. The growth of the plants in height is regulated by hormones. Comment.
5. If you place a ripened fruit cover over an unripe banana, the banana would get ripened. How?
6. Imagine that you decide to flee after seeing a snake on your way. In this action both your nervous system and endocrine system are involved. Explain the coordination brought by your nervous system and endocrine systems in fleeing from the site.

2. Ecosystems: Interactions, Energies and Dynamics

Ecosystems are complex interactive systems that include both living and non-living things. Ecosystems consist of several hierarchical structures, wherein groups of same organism form populations. Individual organisms or populations live, grow, or reproduce within ecosystems. How does this happen? This happens through interdependent relationships with other organisms or populations in their physical environment. These interactions restrain growth; enhance or limit the size of populations; or maintain the balance between resources and those who consume them. Ecosystems are sustained by continuous flow of energy, originating primarily from the sun, and the recycling of matter and nutrients within systems. However, ecosystems experience shifts in population composition and abundance; and changes in the physical environment over time.

Competencies

By the end of class IX, a learner should be able to:

a. apply the understanding of an ecosystem to explain that disturbances to any of the physical or biological components of an ecosystem can lead to a shift in all its population**,** interactions, energy, and dynamics.
b. use the concept of interdependence amongst organisms to understand the intrinsic value of organisms in an ecosystem.

2.1 Interaction in its Environment

(2.1.1. Scope: Organisms interact with each other and with their environment for food, space, reproduction, etc. A variety of relationships, such as predator and prey relationship, competition, and symbiosis exist in an ecosystem.

2.1.2. Scope: Food chains and food webs represent the feeding interactions amongst organisms in an ecosystem. They show the transfer of energy from one organism to another in the process.

2.1.3. Scope: Humans cause changes in the physical environment in various ways (e.g., construction, pollution, deforestation, etc.) that have significant impacts on the health and functioning of an ecosystem.)

Objective(s):

LO-1. Construct a model that explains the interactions amongst the organisms.

Learning Experiences:

The teacher may begin the lesson by posing a question: Why are interactions amongst organisms crucial for their survival in an ecosystem? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on interactions, such as food chains, food web and interactions amongst living organisms from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/PU42BFB)
- The learner constructs a model (e.g., theoretical, conceptual, physical, or simulation) that explains interactions amongst organisms.
- The learner uses the model to explain interactions amongst organisms.
- The learner critiques each other's model in explaining interactions existing amongst organisms.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. What are different types of interactions found in the ecosystem?
2. What do you mean by mutualism? Explain with an example.
3. How is the stability of the ecosystem maintained by interactions amongst organisms?
4. Explain pond ecosystems based on biotic and abiotic components.

Assessment:
Use rubrics to assess learner's information management skill, ability to construct a model that describes the interactions existing amongst the organisms, and critiquing skills. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/PU42BFB

Objective(s):
LO-2. Investigate the impacts of human activities on the stability of the ecosystem.

LO-3. Communicate the scientific information on the ways to minimise the impacts of anthropogenic activities on ecosystems.

Learning Experiences:
The teacher may pose a question: How do anthropogenic activities affect the stability of the ecosystem? and how can we minimise the impacts of anthropogenic activities for a healthy ecosystem? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on anthropogenic activities, and their impact on the stability of the ecosystem from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/DU432Ll)

- The learner collects, analyses and interprets the data on anthropogenic activities, and their impact on the stability of the ecosystem
- The learner draws a conclusion on anthropogenic activities and their impact on the stability of the ecosystem.
- The learner communicates the scientific information on the ways to minimise the impacts of anthropogenic activities on the ecosystem.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Humans are one of the biggest threats to ecosystems. Comment.
2. Suggest various strategies to conserve the population of *White-belleied heron* and *Yartsa goenbub.*
3. Mention three national policies that conserve Bhutan's natural environment.

Assessment:

Use rubrics and checklists to assess learners' observation skills and data management skills to explain the impact of anthropogenic activities on the stability of the ecosystem and their ability to communicate scientific information in minimising the impacts of anthropogenic activities on the stability of the ecosystem. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/DU432Ll

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. Why are interactions amongst organisms crucial for their survival in an ecosystem?
2. How do organisms interact with each other and their environment?
3. How does anthropogenic activities affect the ecosystem?
4. What are some of the strategies to protect our ecosystem?

3. Heredity: Inheritance and Variation of Traits

Have you ever wondered why offspring from same parents are alike but never same? This is influenced by the characters or traits passed from one generation to the next via genes. Genes are short DNA segments that contain information for making specific proteins, which are responsible for the specific traits of an individual. Genes reside in a cell's chromosomes or DNA molecules, each of which contains many genes. At the centre, no two individuals contain the same genes or DNA molecules (see the exception). The resulting effects of the nature of genetic information and interactions with the environment determine how an organism develops and functions. Thus, no two individuals, including identical twins possess the same characters or traits.

Competencies

By the end of class IX, a learner should be able to:

a. apply the understanding of cell division to explain how offspring inherit genes from their parents during reproduction.
b. apply the concept of the influence of genetic (mutation, random mating, random fertilization and recombination) and/or environmental factors (nutrition, light etc.) to explain the occurrence of variation within an individual organism or amongst the individuals of the same species.
c. use the understanding of the relationship of the gene, DNA and chromosomes in terms of size and sequence, to explain the biological role of the gene, chromosome and DNA in determining a character of an organism through molecular and subcellular processes.
d. use the concept of variation of individuals to understand and value the importance of diversity.

3.1. Variation of Traits

(3.1.1. Scope: Differences exist within an individual or amongst individuals of the same species. For instance, leaves borne from the same plant at the same time may not be the same. A person's right hand may not be alike with that of a left hand. Moreover, a person's thumb digit may not be identical to the thumb digit of another person. These differences are called variations. These variations are caused by genetic and environmental factors or combined effects of both genetic and environmental factors.)

Objective(s):

LO-1. Investigate various physical traits to show variation of structures within an organism or amongst the organisms of same species.

LO-2. Construct scientific explanations on why variation occurs within an organism or between organisms of the same species.

Learning Experiences:

The teacher may inform the learner that structures within an organism may vary from one structure to another. The teacher, for instance, may show how the index finger of a left hand varies from the index finger of a right hand in terms of handling ability, texture, etc. The teacher may also inform that such variations also exist within the leaves of a plant. The learner may also be informed that structures, such as the thumb digit, index finger, earlobe, etc., differ from one person to another. The teacher may ask the questions: Why do leaves vary within the plant? Why do leaves of two plants of the same species vary from one to another? The teacher may deliver the lesson based on the following order of scientific and engineering practises.

- The learner gathers information on why structures within an organism or amongst the organism vary from one to another from relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/GIe58W6).
- The learner investigates and notes structural differences existing amongst the leaves born on the same plant or amongst the leaves of the two or more plants of the same species.
- The learner justifies why leaves of a single plant or the leaves of two or more plants of the same species differ one to another.
- The learner constructs scientific explanations on why variations occur amongst the leaves of a single plant or amongst the leaves of the two or more plants of the same species.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. We are alike but not same. Comment.
2. What are the factors that cause variation?
3. Would leave borne from a single plant be alike? Why or why not?
4. Why do offspring from the same parent look alike but not the same? Explain.
5. Are variations beneficial to organisms? Justify your answer.

Assessment:

Use rubrics to assess the learner's information management skills, scientific reasoning skills, analytical skills, and communication skills on why variation occurs amongst the body parts of an organism or between organisms of the same species. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/GIe58W6
- https://cutt.ly/CIe6EkA

Challenge Your Students

Teacher may ask the following questions to challenge the thoughts of the learner:

1. What are the causes of variation?
2. Does variation occur amongst the body parts of an organism? Why?
3. How does random fertilisation add to the genetic variation?
4. What would be the consequence if there is no variation occurring amongst organisms?
5. No two leaves borne on a plant are the same. Comment.

3.2. Chromosome, DNA and Gene

(3.2.1. Scope: DNA (or deoxyribonucleic acid) is the molecule that carries genetic information in all life forms and viruses. Genes are segments of DNA. The activity of a cell depends on its ability to use the information stored in genes. DNA molecule coils and supercoils forming visible structures called chromosomes.

3.2.2. Scope: Proteins are synthesised based on the information in the genes of an organism. The type and structure of proteins determine the characters or traits of an organism.

3.2.3. Scope: A DNA molecule contains two polynucleotide chains formed of nucleotides. A nucleotide consists of phosphoric acid, sugar and nitrogenous bases. Four different types of nitrogenous bases (i.e., adenine, thymine, cytosine, and guanine) are present in a DNA molecule. The arrangement pattern of these bases ultimately determines each organism's unique characteristics.)

Objective(s):
LO-1. Construct a model that explains the relationship amongst chromosomes, DNA, and genes.

Learning Experiences:
The teacher may begin the lesson by informing the learner that genes, DNA, and chromosomes are the genetic entities present in the nucleus of a cell. The activity of a cell depends on its ability to use the information stored in DNA. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on relationships between chromosome, gene and DNA from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/8IrwtOz, https://cutt.ly/hIrrg2X).
- The learner develops a model (theoretical, conceptual, physical, or simulation) that explains the relationship amongst chromosomes, genes and DNA.
- The learner uses the model to explain the relationship amongst chromosomes, genes and DNA.
- The learner shares and critiques each other's work.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. What are genes, DNA, and chromosomes?
2. How are chromosomes, DNA, and genes related? Explain with the help of a diagram.
3. Are genes and DNA same? Comment.

Assessment:
Use rubrics to assess learner's information management skill, ability to develop and use the model to explain the relationship amongst chromosomes, genes and DNA, and ability to critique each other's work. Provide necessary intervention. For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/8IrwtOz,
- https://cutt.ly/hIrrg2X

Objective(s):
LO-2. Develop a model that explains that gene codes for a protein that expresses the character or trait.

Learning Experiences:
The teacher may inform the learner that genes contain instructions for making a protein which in turn determines the trait of the organism. The teacher may inform the learner that every individual has one or more gene(s) that are related to each body character. As an example, the teacher may inform the learner that every individual has one or more gene(s) that specify a protein that determines eye colour. The teacher may pose a question: How does a gene that specify a protein is related to a body character? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner gathers information on the expression of genes in the form of characters or traits through protein mediated mechanisms from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/Nzy77cP).
- The learner develops a model (theoretical, conceptual, physical, or simulation) that explains the expression of genes in the form of characters or traits through protein mediated mechanisms.
- The learner shares the model (theoretical, conceptual, physical, or simulation) that explains the expression of genes in the form of characters or traits through protein mediated mechanisms.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. Explain the biological roles of genes.
2. Provide a detailed account on how the information stored in genes are expressed in the form of characters.
3. Describe how the colour of the eyes is related to the information stored in gene(s).

Assessment:
Use rubrics to assess learner's information management skill, comprehensiveness of the model (theoretical, conceptual, physical, or simulation), and the creativity of the model, ability to relate the model to explain the expression of genes in the form of characters or traits through protein mediated mechanisms. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/Nzy77cP

Objective(s):
LO-3. Construct scientific explanation on why the nature of information encoded in DNA differs from one individual to another.

Learning Experiences:
The teacher may begin the lesson by informing the learner that different individuals have different natures of genetic information encoded in DNA. The teacher may pose a question: Why is the colour of an eye different in different individuals? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on how the genetic information is stored in DNA from relevant materials (e.g., online pieces, books, journals, etc.) or web links (e.g., https://cutt.ly/5IrfxXo).
- The learner constructs an explanation using scientific reasons that the nature of information encoded in DNA differs from one individual to another.
- The learner communicates by providing scientific reasons why the nature of information encoded in DNA differs from one individual to another.

Questions:
The teacher may ask the following questions to assess the understanding of the learner:

1. What determines the nature of genetic information stored in a DNA molecule?

2. Will two individuals have DNA molecules with the same nature of genetic information? Why?
3. What influences variation in observable characters, such as eye colour, hair colour, or the nature of the earlobe amongst individuals? Explain.

Assessment:
Use rubrics to assess the learner's information management skill, the ability to construct why the nature of information encoded in DNA differs from one individual to another and communication skills. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:
- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/5IrfxXo

Challenge Your Students
Teacher may ask the following questions to challenge the thoughts of the learner:
1. Does gene determine your sex? Justify.
2. Genes are instruction manuals in our body. Comment.
3. Is there a chromosome in prokaryotes? If yes, how is it different from chromosomes found in eukaryotes?
4. How are chromosomes, DNA, and genes related? Explain with the help of a diagram.

3.3. Cloning and Genetic Engineering

(3.3.1. Scope: Genetic engineering involves the use of recombinant DNA technology to manipulate the genetic composition of an individual by the insertion of a foreign gene into its genome. Vectors are used to transfer foreign genes into a host. Cloning (nuclear transfer technique and embryo splitting technique) is a technique used to multiply organisms to obtain identical individuals in large numbers.

3.3.2. Scope: There are moral and ethical concerns related to the use of recombinant DNA technology for producing GMOs, clones, and in treating diseases.

3.3.3. Scope: The present Biosafety act of Bhutan provides for the protection, conservation, and safeguarding of biodiversity in Bhutan.)

Objective(s):

LO-1. Construct a model that provides a scientific explanation on cloning and genetic engineering.

Learning Experiences:

The teacher may inform the learner that cloning and recombinant DNA technology are two marvels of gene technologies. Teacher may start a lesson on cloning using Dolly, the first cloned mammal as an example. The teacher may inform the learner that it's possible to clone humans using cells from tears, nasal fluid, or nails, etc. Teacher may introduce the lesson on genetic engineering using one of the GM crops. The teacher may deliver the lesson on cloning and genetic engineering based on the following order of scientific and engineering practises:

- The learner obtains information on how cloning and recombinant DNA technology is carried out from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/GzfxQFO, https://cutt.ly/YIrzw0O).
- Based on the information obtained the learner constructs a model (conceptual or illustrations) on the process of cloning and genetic engineering and cloning. The learner may use relevant software and programming languages or applications such as metaverse.
- The learner shares the developed model (theoretical, conceptual, physical, or simulation) in the class to show how cloning or recombinant DNA technology is carried out.
- The learner answers the questions.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How is cloning and genetic engineering carried out? Explain.
2. Mention advantages and disadvantages of genetically modified organisms.
3. Is it possible to bring back extinct animals using the technique of cloning? Comment.
4. How can recombinant DNA technology save lives of organisms with genetic disorders?
5. How do you see cloning and recombinant DNA technology from a biological, religious, or social values point of view?

Assessment:

Use rubrics to assess learners' information management skills, ability to use the model in explaining the process of genetic engineering and gene cloning, and answering skills. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/GzfxQFO

- https://cutt.ly/YIrzw0O

Objective(s):

LO-2. Construct an argument with scientific reasons on bioethical, societal, and moral issues of cloning and genetic engineering.

Learning Experiences:

The teacher may begin the lesson by informing the learner that cloning and genetic engineering have several issues from biological, religious, and ethical point of view. The teacher may pose the question: What are bioethical, societal, and moral issues of cloning and genetic engineering? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner explores information on bioethical, societal, and moral issues of cloning and genetic engineering from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/iPF2OvZ, https://cutt.ly/BIy1qPR).
- Based on the information explored, the learner constructs scientific arguments to support or refute the claims.
- The learner defends each other's claim by providing scientific reasons and evidence.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. "Cloning is necessary evil". Comment.
2. Are cloning and genetic engineering ethically right? Explain.
3. What are your views on cloning and genetic engineering from a societal and religious point of view?
4. What would be some of the possible results if cloning is allowed in human beings?
5. Are GMOs allowed in Bhutan? Comment.

Assessment:

Use rubrics to assess learner's information management skills, ability to defend the claim, and ability to provide scientific reasons on how cloning and genetic engineering are associated with bioethical, societal, and moral issues. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/iPF2OvZ
- https://cutt.ly/BIy1qPR

Objective(s):

LO-3. Construct scientific explanation on how the adoption of the Biosafety Act of Bhutan contributes towards the conservation of native species.

Learning Experiences:

The teacher may begin the lesson by informing the learner that the Biosafety Act was enacted in 2015 to provide protection, conservation, and safeguarding the biodiversity of Bhutan. The teacher may ask the questions: Have you ever heard that Bhutan does not allow to import foriegn species? How does the Biosafety Act help in conserving native species in Bhutan? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the Biosafety Act of Bhutan from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/2IyLlQ6).
- Based on the information obtained, the learner constructs a scientific explanation on why Bhutan adopted the Biosafety Act and how it helps in conserving the native species.
- The learner communicates how the adoption of the Biosafety Act by Bhutan conserves native species.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Do you think adoption of the Biosafety Act by Bhutan at this juncture is timely? Justify.
2. How would the Biosafety Act adopted by Bhutan support the conservation of natural resources?
3. What are your views on the Biosafety Act by Bhutan? Comment.

Assessment:

Use rubrics to assess learner's information management skills, reasoning skills, and communication skills on how the adoption of the Biosafety act conserves native species in Bhutan. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/2IyLlQ6

Challenge Your Learners

Teacher may challenge the thinking of the learners by asking the following questions:

1. Is it possible to clone and bring back extinct animals, such as woolly mammoths? Comment.
2. Mention three biological benefits of cloning?

3. Recombinant DNA technology used in agriculture has been received well by the farmers. Outline some of the possible drawbacks of it.
4. How can adoption of the Biosafety Act of Bhutan help to conserve Bhutan's rich natural resources?
5. Do you agree that gene technologies, such as cloning and genetic engineering, are associated with biological, social, and ethical issues? Explain.
6. What would be some of the possible results if cloning is allowed in human beings?
7. Are GMOs allowed in Bhutan? Comment.

4. Biological Evolution: Unity and Diversity

Biological evolution is a unifying theory of biology. It provides explanations on the existence of unity and diversity of the species. Biological evolution is supported by extensive scientific evidence. Evidences such as fossil records; anatomical and morphological structures; appearances of embryos provide the credibility of evolution either from common or different ancestral lines. These days, new and different techniques, including DNA and protein sequence analyses, are used to test and further the understanding of evolutionary relationships. How does evolution occur? Evolution, which is continuous and ongoing, occurs when natural selection acts on the genetic variation in a population and changes the distribution of traits in that population gradually over multiple generations.

Competencies

By the end of class IX, a learner should be able to:

a. apply the understanding from fossil records, similarity in morphological structures and embryological structures to explain that all organisms have evolved from common ancestry lines.
b. apply the concept from the theories of evolution to explain how modern organisms have evolved from their ancestral forms.
c. use the concept of the influence of genetic and environmental factors on organisms to explain the process of speciation.

4.1 Evidence of Common Ancestry

(4.1.1. There are various lines of evidence that show the evolution of organisms. One of them is fossil records. Fossil records provide scientific basis for existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.

4.1.2. Scope: The nature of fossils can be related to understand how an environment of a particular area has changed over time. The geographical distribution of living species reflects the pattern of origins of species in a particular geographic location.

4.1.3. Scope: Fossils are used to depict the structural similarities and differences amongst organisms. Fossils represent the vast diversity of life forms that existed on Earth.

4.1.4. Scope: Similarities in the embryonic structure and appearance of the embryonic stages of different organisms show the evolutionary relationship that is not evidently seen in fully developed organisms.)

Objective(s):

LO-1. Construct an explanation on the existence of diversity, evolution and extinction of life forms using data from pictorial fossil records.

Learning Experiences:

The teacher may provide relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/3IutFSD) on fossils and fossil record one day before the class. The teacher may begin the lesson by informing the learner that the fossil record is one of the evidences that depicts the occurrence of evolution. The fossils are the dead remains or traces left by the past living organism in the layers of sedimentary rocks in the form of artefacts, casts, or imprints. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the fossil record from the web link https://cutt.ly/3IutFSD or any other relevant materials (books, online pieces, handouts).
- The learner analyses (e.g., graphing, tabulation, statistic, etc.) and interprets the patterns of evolution from the fossil record in terms of the existence of diversity, extinction, and change of life forms on earth.
- The learner deduces explanations on the patterns of evolution from the fossil record in terms of the existence of diversity, extinction, change of life forms on Earth.
- The learner defends each other's claim.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How do various fossils found in the rock layers explain diversity, evolution, and extinction of organisms?
2. Fossils with complex structures are often found in the rock layers above the fossils that are simpler in structure. Explain such arrangement of fossils in the rock layers in terms of evolution.
3. Support or refute to the claim that fossil records provide evidence for evolution?
4. What could be potential drawbacks of fossils on evolution?

Assessment:

Use rubrics to assess learners' information management skills, ability to explain the pattern of evolution from the fossil records in terms of the existence of diversity, extinction, and change of life forms on the Earth and ability to defend the claim. Provide necessary intervention.
For recording and reporting, refer science curriculum framework

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)

- https://cutt.ly/3IutFSD

Objective(s):

LO-2. Design a model that explains the change in the environmental conditions over time based on fossil records.

Learning Experiences:

The teacher may provide relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/1IuwXRG) a day before the class. The teacher may inform the learner that the change in the environment or climate leads to the change in the physiology, anatomical, or morphological structures of an organism as represented by the fossils. If the change is adverse, it can be mitigated. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the change in the environmental conditions over time-based on the evidence gathered from fossil records from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/MIurYtH).
- The learner designs the model (theoretical, conceptual, physical, or simulation) on how an environment of a particular area has changed over time (climate) using evidence from fossil records.
- The learner uses the model to explain (theoretical, conceptual, physical, or simulation) how an environment of a particular area has changed over time using evidence from fossil records.
- The learner answers the questions.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Can we determine the past environment using fossils? Comment.
2. How do fossils provide evidence of climatic conditions that existed in the past?
3. Imagine that you are trekking up the hillside and you found a fossil of a leaf that has jagged edges. What can you conclude on the climatic condition from the fossil?

Assessment:

Use rubrics to assess the learner's information management skills, communication skills and ability to develop and use the model in explaining how an environment of a particular area has changed over time based on the evidence gathered from the fossil records. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC

- Science Curriculum Framework (2022)
- https://cutt.ly/1IuwXRG
- https://cutt.ly/MIurYtH

Objective(s):

LO-3. Construct scientific explanations on the evolutionary relationships amongst modern organisms either through convergent or divergent evolution.

Learning Experiences:

The teacher may instruct the learner to obtain information on evolutionary relationships amongst of modern organisms either through convergent or divergent evolution from relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/JIy1MZz) one day before the class. The teacher may pose a question: How do similarities and differences amongst organisms determine their evolutionary relationships? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains the information on the similarities and differences in anatomical and morphological structures of plants and animals to support divergent evolutionary relationships or convergent evolutionary relationships from relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/JIy1MZz).
- The learner analyses and interprets the patterns of similarities and differences in anatomical and morphological structures of plants and animals to support divergent evolutionary relationships or convergent evolutionary relationships.
- The learner engages in arguments supported by scientific evidence and reasoning to support or refute the convergent or divergent evolutionary relationships.
- The learner defends the claim.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. What could be the causes of convergent and divergent evolution?
2. How would you explain the evolution of birds based on the shape, size, and function of their beaks?
3. Mountain crow and common crow share similar characteristics? Comment from evolutionary point of view.

Assessment:

Use rubrics to assess learner's information management skill, analysing skills, scientific reasoning skills, ability to argue and defend the claim to support convergent or divergent evolutionary relationships. Provide necessary intervention. For recording and reporting, refer the science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/JIy1MZz

Objective(s):

LO-4. Analyse the structures of embryos to derive evolutionary relationships amongst organisms based on the patterns of similarities.

Learning Experiences:

The teacher may begin the lesson by informing the learner that the evolutionary relationship of the organisms can be built through the study of the embryos of different organisms. The teacher may pose a question: How can patterns of similarities in embryos of different organisms help us understand evolution? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the similarities and differences in the anatomical and morphological structures of the embryo of different organisms to develop linear and non-linear relationships from relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/HIuqwFP).
- The learner analyses the picture of different embryos and constructs an explanation on similarities and differences in the anatomical and morphological structures of the embryo of different organisms to develop linear and non-linear relationships.
- The learner shares the explanation on similarities and differences in the anatomical and morphological structures of the embryos of different organisms.
- The learner evaluates and gives feedback on the explanations.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Vertebrates, such as mammals, reptiles, and birds possess tail-like structure during their embryonic stages. Explain this from an evolutionary point of view.
2. How do embryos provide evidence for evolution of an organism? Support with an example.
3. How reliable is it to explain evolution from the similarities of embryos? Comment.

Assessment:

Use rubrics to assess learner's information management skills, analysing skills, scientific reasoning skills, and communication skills to explain similarities and differences in the anatomical and morphological structures of the embryo of different organisms to develop linear and non-linear relationships. Provide necessary intervention. For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/HIuqwFP

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. How are fossils significant in studying the evolution of organisms?
2. How do the fossils throw light on past life?
3. How can fossils show the change in the environmental conditions over time?
4. Similarity in the early development of animals serves as one of the evidences for evolution. Explain.

4.2 Theories that Explain Evolution

(4.2.1. *Scope: Several theories (e.g. theory of natural selection, theory of inheritance of acquired characters, mutation theory, etc.) explain the mechanism of evolution.*

4.2.2. *Scope: According to Lamarckism, evolution occurs as a result of the inheritance of characteristics that an organism obtains during one's lifetime.*

4.2.3. Scope: Darwinism builds on the idea that an organism is suited to live in an area to survive and reproduce, while others do not. The ratio of individuals that survive, increases in future generations.

4.2.4. Scope: Mutation theory is based on the concept that change in the structure or arrangement of genetic materials results in change of physical traits. The changes caused by mutation could be useful or harmful for an organism and therefore, determines their chances to survive and reproduce.)

Objective(s):

LO-1. Argue with scientific reasons which amongst Lamarckism, Darwinism, or the mutation theory is the most credible theory of evolution.

Learning Experiences:

The teacher may inform the learner to obtain the information on theories of evolution (Lamarckism, Darwinism, and Mutation theories) from relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/aPF8PMT) a day before the lesson. The teacher may begin the lesson by informing the learner that Lamarckism, Darwinism, and

Mutation theory explain the process of evolution. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information from relevant materials (e.g., books, online pieces, articles, etc.) or weblinks (e.g., https://cutt.ly/aPF8PMT) on the theories of evolution (Lamarckism, Darwinism, and Mutation).
- Based on the information gathered, the learner claims and defends with scientific reasoning to support or refute which amongst the theories of evolution (Lamarckism, Darwinism, and mutation theory) is more advanced.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. What would be the present scenario if Lamarckism is true? Support your claim with an example.
2. What are your views on Lamarckism? Comment.
3. How would you explain the evolution of modern giraffes based on Darwinism?
4. Charles Darwin proposed the idea "survival of the Fittest" to support evolution. Comment.
5. Which amongst Lamakism, Darwinism, or mutation theory is the most advanced theory of evolution? Comment.

Assessment:

Use rubrics to assess learners' information management skills, and ability to claim, support or refute which amongst the theories of evolution (Lamarckism, Darwinism, and Mutation theory) best explains evolution. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class IX (2020), REC
- Science Curriculum Framework (2022)
- https://cutt.ly/aPF8PMT

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. Propose your own hypothesis for the existence of simple organisms (e.g., bacteria) which otherwise according to some theory would not be surviving.
2. Which one of the following is correct in terms of 'survival of the fittest'? Those that are fit survived or those that survived were fit.
3. Do you think that only one of the theories was responsible for the evolution of an organism? Support your view.

Class X

1 Molecules to Organisms: Structures and Processes

Organisms contain structures and processes organised from small to large. This organisation, though not much visible in small organisms, is quite noticeable in higher organisms. How are structures and processes organised in organisms? Every organism, whether small or big, contains cells as the smallest units. Cells, depending on their structures and biological roles, influence almost all structures, processes, and behaviour of the organism. In large organisms, cells combine to form structures and functions of tissues, which in turn form organs, organ systems, and organism in itself. It is, therefore, important to understand how interacting systems and subsystems coordinate to form behaviour, function, and emotion of the organisms.

Competencies

By the end of class X, a learner should be able to:

a. apply the understanding of the cell structure to explain the differences between prokaryotic and eukaryotic cells, and processes at the cellular level contribute to the functioning of the organism.
b. argue based on empirical evidence and scientific reasoning to support an explanation for how subsystems of organisms coordinate different biological processes; and regulate the state of emotions.

1.1. Prokaryotic Cells and Eukaryotic Cells

1.1.1. Scope: Prokaryotic cells differ from eukaryotic cells in their structure and functions. Prokaryotic cells have a simple structure with DNA forming a nucleoid and do not have well developed structures (organelles) to carry out specific functions. Eukaryotic cells, on the other hand, contain a nucleus and membrane-bound organelles specialised to carry out specific functions.

1.1.2. Scope: Prokaryotes play important roles in sustaining life and maintaining the quality of the soil. They help in the recycling of nutrients (i.e., carbon, nitrogen and phosphorus) as they are a major part of nutrient cycles. Some bacteria live in the digestive system of other organisms (e.g., humans) and aid in digestion.

Objective(s):

LO-1. Develop a model that compares prokaryotic and eukaryotic cells.

Learning Experiences

The teacher may begin the lesson by informing the learner that cells can be classified based on their structure and function. The teacher may inform that both plant cells and animal cells belong to a group called eukaryotic cells, while bacteria and blue green algae are prokaryotic cells. The teacher may pose the question: How are prokaryotic cells different from eukaryotic cells? The

teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on structures of prokaryotic and eukaryotic cells from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/SIubgOA).
- The learner develops a model (conceptual, theoretical, physical or simulation) to compare and differentiate prokaryotic cells from eukaryotic cells.
- The learner uses the model to differentiate between prokaryotic cells and eukaryotic cells.
- The learner critiques each other's model for necessary comments and feedback.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. In an experiment, an organism was found to be made up of a simple and single cell. Explain the type of cell observed.
2. Cells are often compared with a factory. How is a cell similar to a factory?
3. Both plant cells and animal cells are eukaryotic cells. Comment.

Assessment:

Use rubrics or checklists to assess learners' information management skills, ability to develop a model to differentiate between prokaryotic cell and eukaryotic cell, and ability to critique each other's model. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/SIubgOA

Objective (s):

LO-2. Communicate scientific information on the role of prokaryotes in maintaining the health of the environment.

Learning Experiences

The teacher may begin the lesson by informing the learner that life on Earth came in the form of a prokaryotic cell. The teacher may inform the learner that prokaryotes play a crucial role in maintaining a healthy and clean environment. The teacher may ask the learner to reflect on what would the world be had there been no prokaryotes like bacteria. The teacher, for instance, may claim that the world never gets flooded by dead bodies or dead remains due to prokaryotes. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on how the living cells (e.g., prokaryotes) help in maintaining the health of the environment from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/oIu0UNj).
- The learner communicates the information on how living cells (e.g., prokaryotes) help in maintaining a healthy environment.
- The learner shares the scientific information that the living cells (e.g., prokaryotes) help in maintaining the health of the environment.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How do microorganisms affect the environment?
2. What is bioremediation? How does it help in maintaining a healthy environment?

Assessment:

Use rubrics to assess learners' information management skills, and communication skills on how living cells (e.g., prokaryotes) help in maintaining the health of the environment. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/oIu0UNj

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. Why modern cells are difficult to study compared to primitive cells.
2. Leaves contain several thousand cells. Comment whether leave cells are prokaryotic or eukaryotic cells with reasons.
3. The genetic materials inside the prokaryotic cells are thrown out to the extent of cytoplasm. Why?
4. Everyday living organisms die due to various reasons. Fifteen years from now we expect huge numbers of dead and decayed materials gathered with all the places filled with the remains of living organisms. Much to our surprise, we see our environment clean and clear without the dead remains of plants and animals. Justify.

1.2 In and Out of the Cell

1.2.1. Scope: The movement of substances in and out of the cells occurs by various membrane transport mechanisms (e.g., diffusion, osmosis, active transport system, passive transport

system). The selective nature of the cell membranes helps in regulating all the membrane transport mechanisms.

1.2.2. Scope: The shelf-life of fruits and vegetables depend on the ability of the cell membrane to regulate the movement of substances and therefore, maintaining the concentration of solute inside a cell. The movement of substances across a membrane is regulated based on their relative concentrations inside and outside of the cell.

Objective(s):
LO-1. Design a model that demonstrates the movement of substances in and out of a cell.

Learning Experiences
The teacher may begin the lesson by informing the learner that cells have mechanisms that regulate the entry and exit of substances. The teacher may cite diffusion, facilitated diffusion, osmosis, active transport, etc., as an example of a mechanism that assists in the movement of substances in and out of the cell. The teacher may pose a question: How does a substance move in and out of the cell? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the mechanisms that demonstrates the movement of substances in and out of a cell from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/hU6DBrf).
- The learner develops a model (conceptual, theoretical, physical, or simulation) that demonstrates the movement of substances in and out of a cell.
- The learner uses the model to demonstrate the movement of substances in and out of a cell.
- The learner communicates and critiques each other's model.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. Define diffusion, osmosis, and active transport.
2. How does adding salt in pickles help in its preservation?
3. Design an experiment to show endosmosis and exosmosis.
4. Why do we soak a seed in water before sowing in the soil?

Assessment:
Use rubrics to assess the learner's information management skill, ability to develop and use the model to demonstrate the movement of substances in and out of a cell, and communication skills. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/hU6DBrf

Objective(s):

LO-2. Design a solution to increase the shelf life of fruits and vegetables based on the concept of membrane transport.

Learning Experiences

The teacher may introduce the lesson by sharing the fact that a lot of fruits and vegetables get disposed of due to their short life span. The teacher may inform that this issue incurs economic loss to both the fruits and vegetable growers and the market. The teacher may begin the lesson by posing the question: How can you increase the shelf life of fruits and vegetables based on the concepts of membrane transport? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on membrane transport from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/9Irxlho)
- The learner designs a solution using the concept of membrane transport in increasing the shelf life of fruits and vegetables.
- The learner builds the prototype/solution to increase the shelf life of fruits and vegetables.
- The learner tests the prototype/solution, evaluates and makes changes to the design.

Assessment:

Use rubrics to assess the learner's information management skill, ability to design a prototype/solution in increasing the shelf life of fruits based on membrane transport concept and the ability to evaluate each other's model. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/Gl7WWJk

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. When RBCs are placed in 0.3% NaCl, they burst. Give reason(s).
2. If the cell membrane is permeable, the concentration inside the cell would be the same as the outside. Justify your answer.

3. Explain with scientific reasons how differences in the concentration of substances and temperature affect the shelf life of fruits and vegetables.
4. Nowadays companies develop novel films that help increase the shelf life of fruits and vegetables. Explain how it helps in increasing the shelf life of fruits and vegetables based on membrane transport.

1.3 Photosynthesis: Food for Life.

1.3.1. Scope: Plants synthesise their food by photosynthesis. There are two phases in photosynthesis (i.e., light-dependent and light-independent phases), each of which involve a series of chemical reactions. The light-dependent phase (light reaction) occurs in the thylakoid while the light-independent phase (dark reaction) occurs in the stroma.

1.3.2. Scope: The rate of photosynthesis is affected by various internal and external factors (limited to intensity of light, the concentration of carbon dioxide and temperature). External factors can be controlled to alter the rate of photosynthesis.

1.3.3. Scope: Photosynthesis determines the yield of crops. The ability of plants to absorb sunlight, carbon dioxide, and water is directly related to crop yield.

Objective(s):
LO-1. Develop a model that explains light dependent and light independent phases of photosynthesis.

Learning Experiences:
The teacher may inform the learner that photosynthesis as a biochemical process takes place in two phases. The teacher may introduce these two phases as light dependent phase and light independent phase. The teacher may inform the learner that oxygen, water, and glucose are produced as a result of these two phases of photosynthesis. The teacher may pose the question: What is light dependent and light independent phase of photosynthesis? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on light dependent and light independent phases of photosynthesis from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/mzwFBlj).
- The learner develops the model (conceptual, theoretical, physical, or simulation) that explains light dependent and light independent phases of photosynthesis. The learner may use digital tools and programming languages to design models.
- The learner critiques each other's model and incorporates feedback and comment.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Explain light dependent reaction and light independent reaction.
2. Would there be light independent reactions without sunlight? Comment.
3. Design an experiment to demonstrate the process of photosynthesis.
4. Light dependent reaction and light independent reaction help to maintain the amount of O_2 and CO_2 in the atmosphere. Comment.

Assessment:

Use rubrics to assess the learner's information management skill, ability to develop and use the model to understand light independent and light dependent phase and critiquing skills. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/mzwFBlj

Objective(s)

LO-2. Investigate to show how external factors affect the rate of photosynthesis. (*Limited to carbon dioxide concentration, temperature, and light intensity*).

Learning Experiences:

The teacher may begin the lesson by informing the learner that there are various factors (e.g., carbon dioxide concentration, temperature, light intensity, etc.) that affect the rate of photosynthesis. The teacher may instruct the learner to obtain information on factors affecting the rate of photosynthesis from the relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/cOzqJOV) one day before the lesson. The teacher may ask the question: How do carbon dioxide concentration, temperature, and light intensity affect the rate of photosynthesis? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner plans and carries out an experiment to find out how carbon dioxide concentration, temperature, and light intensity affects the rate of photosynthesis.
- The learner collects, analyses and interprets data to determine how carbon dioxide concentration, temperature, and light intensity affects the rate of photosynthesis.
- The learner draws a conclusion to show how the rate of photosynthesis is affected by carbon dioxide concentration, temperature, and light intensity.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How do carbon dioxide concentration, temperature and light intensity affect the rate of photosynthesis?
2. Read the text given below and answer the questions that follow:

   In an experiment, a Geranium plant receives an adequate supply of sunlight and carbon dioxide. However, the weather being cold the rate of photosynthesis did not increase.

   a. Write down a research question based on the phenomenon.
   b. Write down a hypothesis for the above phenomenon. .
   c. Identify the independent variable and dependent variable.

Assessment:

Use rubrics to assess the learner's investigation skill, ability to analyse and interpret how the rate of photosynthesis is affected by carbon dioxide concentration, temperature, light intensity, and communication skills. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/cOzqJOV
- https://cutt.ly/jl7TQX

Objective(s):

LO-3. Design a solution to improve crop yield using the concept of photosynthesis.

Learning Experiences

The teacher may begin the lesson by informing the learner that photosynthesis is very critical to farmers or food supply of the world. The teacher may claim that the world would run short of food without photosynthesis. The food that we eat in the form of rice or porridge, fruits, vegetables come all the way from photosynthesis. The teacher may ask the question: How can you improve crop yield using the concept of photosynthesis? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information to improve crop yield using the concept of photosynthesis from the relevant materials (e.g., books, online pieces, articles, etc.).
- The learner designs a solution to improve the crop yield by using the concepts of photosynthesis.

- The learner critiques each other's design, incorporates the feedback, and makes changes to his or her design.

Questions

The teacher may ask the following questions to check the understanding of the learner:

1. What are some of the ways to increase crop yield based on the concept of photosynthesis?
2. Design a simple experiment to improve the crop yield of plant based on the concepts of photosynthesis?

Assessment:

Use rubrics to assess the learner's information management skill, ability to design a solution in improving the crop yield by altering the factors affecting photosynthesis, ability to critique each other's work. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. Fruits and foods that we eat are the products of photosynthesis. Explain.
2. Can photosynthesis combat global warming? Explain.
3. How would you explain the national food security of Bhutan based on the concept of photosynthesis?
4. If Mr Dorji is conducting an experiment to determine the rate of photosynthesis in the presence of varying degrees of light intensity, then:
    - identify dependent and independent variables.
    - develop a likely hypothesis of Mr Dorji's experiment.
    - What would be the likely conclusion of Mr Dorji's experiment? Mention it.
5. The factor that is in limited supply for example is similar to the missing one of your favourite menus during a meal. How will you explain the concept of limited supply and what will happen to the rate of photosynthesis, if the factor such as light and CO_2 is in limited supply?

1.4. Transportation of Substances in the Plant

1.4.1. Scope: Distribution of substances (e.g., water, minerals, food, etc) in plants are carried out by vascular tissues (i.e., xylem and phloem). Xylem transports water and mineral salts from the roots up to other parts of the plant, while phloem transports food from source to sink.

Objective(s):

LO-1. Investigate to show the movement of food and water in plants.

Learning Experiences:

The teacher may inform the learner that plants have certain systems to transport materials from one region to another. For instance, the teacher may inform the learner that food prepared by leaves is transported to some distant region, such as root tips. The water absorbed by root hairs climb to a certain height and get exuded out from shot tips. On this aspect, the teacher may pose the question: How are substances, such as food and water transported and distributed in plants? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the movement of food and water in plants from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/6IeLHkt).
- The learner plans and carries out an experiment to show the transportation and distribution of food and water in plants is carried out by vascular bundles. The learner may use relevant software or programming languages to design the experiment to show the distribution of substances in plants.
- The learner collects, analyses and interprets the data to show the transportation and distribution of food and water in plants.
- The learner shares the finding and conclusion to the class.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Name the plant tissues that conduct food and water.
2. Design an experiment to show the translocation of food and water in a plant.
3. How are water and food transported in plants? Explain.

Assessment:

Use rubrics to assess the learner's information management skills, ability to design the experiment and interpret findings to show that transportation and distribution of food and water in plants are carried out by vascular bundles. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/6IeLHkt

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. Suppose you have a potted plant inside your house, and you wanted to observe the translocation of food to other parts of the plant. Design an experiment to demonstrate the translocation of food with aim, materials required, and procedures.
2. What will happen to the plant if its phloem tissues are removed? Explain.
3. Explain how xylem is different from phloem?
4. Pema climbed a tall tree and cut the tree top. Surprisingly, he saw water flowing out from the cut portion. How does this water reach to the top of the tree? Explain.
5. What would happen if a ring of the bark is removed from a tree? Explain.

1.5. Digestion: What's on the plate?

1.5.1. Scope: During digestions, large insoluble food particles are broken down into smaller soluble forms to be absorbed easily by the cells. Digestion occurs in the mouth, stomach and small intestine. Various hydrolytic enzymes (e.g., saliva, lysozyme, gastric enzymes etc.) are an aid in the chemical breakdown of carbohydrates, proteins and fats. The inner walls of the small intestine are adapted for efficient absorption of digested food.

1.5.2. Scope: The health, growth and development of a body depend on our dietary habits. Unhealthy dietary habits such as overeating of fatty food, processed food, lack of balanced diet, etc. can result in several body health issues.

1.5.3. Scope: Anaerobic respiration occurs without the use of oxygen. Due to their ability to undergo anaerobic respiration, microorganisms are used for a variety of applications (e.g., yeast is used in food industries for the improvement of food production).

Objective(s):

LO-1. Develop a model that provides scientific explanation on the chemical digestion of food *(limited to carbohydrates, fats, and proteins).*

Learning Experiences

The teacher may instruct the learner to obtain information on chemical digestion of food (e.g., carbohydrates, fats, and proteins) from the relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/mIufgA9) one day before the lesson. The teacher may begin the lesson by informing the learner that carbohydrates, proteins, and fats are digested both mechanically and chemically. The teacher may pose a question: How is food (e.g., carbohydrates, fats, and proteins) digested chemically in our body? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on chemical digestion of food (e.g., carbohydrates, fats, and proteins) from the relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/mIufgA9).
- The learner constructs a model to explain the chemical digestion of food (e.g., carbohydrates, fats, and proteins).
- The learner uses the model to explain the chemical digestion of food (e.g., carbohydrates, fats, and proteins) in our body.
- The learner answers the questions.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Name three digestive enzymes.
2. Outline the digestion of fish consumed as a dinner.
3. How would the digestion of carbohydrate differ from the digestion of protein?
4. What would happen to digestion if our liver is removed or damaged? Explain.

Assessment:

Use rubrics to assess the learner's ability to develop and use the model to explain chemical digestion of food and answering skills. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/PIeCuEb

Objective(s):

LO-2. Design a solution to enhance the digestion and absorption of food in humans.

Learning Experiences

The teacher may begin the lesson by informing the learner to obtain information on the ways of enhancing food digestion and absorption in our body from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/EIeVauK) a day before the lesson. The teacher may pose the question: How can we enhance the digestion and absorption of food? The teacher may deliver the lesson based on the following order of science and engineering practises:

- The learner obtains information on the ways of enhancing food digestion and absorption from the relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/EIeVauK).

- The learner designs a solution on ways of enhancing food digestion and absorption in the alimentary canal.
- The learner presents the solutions related to enhancing food digestion and absorption in the alimentary canal.
- The learner critiques each other's design and incorporates feedback.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Everyone experiences occasional indigestion symptoms, such as upset stomach, gas, heartburn, nausea, constipation or diarrhoea. How can we prevent ourselves from such indigestions?
2. Why must food be digested before it is absorbed?

Assessment:

Use rubrics to assess learner's information management skill, ability to develop a model to show ways of enhancing food digestion and absorption, and the ability to defend the claim with scientific reason. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/EIeVauK

Objective(s):

LO-3. Communicate the scientific information on unhealthy dietary practises that lead to lifestyle diseases.

Learning Experiences

The teacher may begin the lesson by informing the learner that an unhealthy diet is one of the major risk factors for a range of diseases, including cardiovascular diseases, cancer, diabetes and other conditions linked to obesity. The teacher may, for instance, talk about some of the health implications related to the overconsumption of salt. The teacher may inform the learner that Bhutanese in general consume a lot more than the recommended amount. The learner may be informed of this as one of the growing concerns of Bhutan. The teacher may pose the question: What are unhealthy dietary practises that lead to lifestyle diseases? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains the information on unhealthy dietary practises that lead to lifestyle diseases from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/bIeVnYF).

- The learner constructs an explanation on how unhealthy dietary practises lead to lifestyle diseases.
- The learner communicates scientific information on unhealthy dietary practises that lead to lifestyle diseases.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Mention unhealthy dietary habits that lead to lifestyle diseases.
2. Why is it important to eat the right amount of salt? Explain.
3. Explain how unhealthy dietary practises lead to lifestyle diseases?
4. Mention healthy dietary practises to avoid lifestyle diseases?

Assessment:

Use rubrics to assess the learner's information management skill, ability to construct explanations that unhealthy dietary practises may lead to lifestyle diseases, and communication skills. Provide necessary feedback and intervention to the learner.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/bIeVnYF

Objective (s):

LO-4. Design a solution to improve the human diet based on the concept of anaerobic respiration.

Learning Experiences

The teacher may inform the learner that our diet can be improved through anaerobic respiration. The teacher may inform the learner that one can make use of enzymes or the substances that contain enzymes, such as yeast. The learner may be informed how foods, such as bread, cake, and burnt are made nutritious using enzymes. The teacher may pose a question: How can anaerobic respiration improve the human diet? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the concept of anaerobic respiration in producing improved human diet from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/FzuTCEN).

- The learner designs a solution by applying the concept of anaerobic respiration in producing an improved human diet.
- The learner presents the solution to the class, critiques and incorporates feedback to refine the solutions.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Many of our foods are produced by the action of microorganisms. Explain how it helps in the processing of the food.
2. Design the experiment to describe the action of milk sugar digested into sour taste yoghurt.

Assessment:

Use rubrics to assess learner's information management skill, ability to design a solution for improving human diet using the concept of anaerobic respiration, and critiquing skills. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/FzuTCEN

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. What factors affect digestion efficiency?
2. Doctors and nutritionists recommend always eating unpolished rice. Why?
3. Mention at least three major lifestyle diseases associated with a person's diet?
4. Why is dieting an issue? Explain giving scientific reasons.

1.6 Transport and Exchange in our Body

1.6.1. Scope: Animals contain fluids (i.e. blood, haemolymph, etc) circulating in their bodies. In humans, blood comprises plasma and formed elements (i.e, WBC, RBS and platelets). The blood cells are adapted to carry out specific functions.

1.6.2. Scope: The ABO system of blood grouping is based on the antigens (i.e., A and B) present on the surface of RBCs. The body has antibodies (i.e., a and b) for these antigens. These antigens and antibodies determine the compatibility during a blood transfusion. Blood transfusion is performed for a variety of reasons (e.g., injuries, disease, bleeding disorders and during surgery).

Objective(s):

LO-1. Design a model that provides scientific explanation on the composition of human blood.

Learning Experiences

The teacher may begin the lesson by informing the learner on the importance of blood. The teacher may pose a question: What makes our blood? How are these compositions helpful in functioning of the blood? The teacher may deliver the lesson based on the following order of scientific and engineering practises.

- The learner obtains information on the components of human blood from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/3zwHGHb).
- The learner designs a model (conceptual, theoretical, physical or simulation) to represent the components of human blood. The learner may use relevant digital software and programming languages to design a model.
- The learner uses the model to provide scientific explanation on the composition of human blood.
- The learner critiques each other's work.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Explain the composition of blood in terms of cellular components?
2. Blood is critically important for our survival. Justify with reasons.

Assessment:

Use rubrics and/ checklists to assess the learner's information management skill, ability to design a model to provide scientific explanation on the composition of human blood, and ability to critique each other's design. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/3zwHGHb
- https://cutt.ly/ozwHCEV

Objective(s):

LO-2. Provide scientific explanation on ABO blood typing based on the presence of antigens and antibodies.

Learning Experiences:

The teacher may begin the lesson by informing the learner that there are several human blood grouping systems. ABO blood grouping system may be informed to the learner as one type of common blood grouping system. The learner may be informed that the ABO blood grouping system has blood groups, such as blood group A, B, AB, and O. The teacher may inform that it is important to match the blood group during blood transfusion. The teacher may pose a question: What is blood group A, B, AB, and O in ABO blood typing? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on blood group A, B, AB, and O with corresponding antigens and antibodies from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/FIeVSDK).
- The learner constructs a scientific explanation on ABO blood groups with corresponding antigens and antibodies.
- The learner communicates on the compatibility of blood groups based on the ABO blood typing.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. What is blood group A, B, AB, and O?
2. Why is it important to match blood groups during blood transfusion?
3. What are some of the complications related to mismatch of blood groups during blood transfusion?

Assessment:

Use rubrics to assess the learner's information management skill, ability to construct an explanation on the compatibility of blood groups during transfusion, and communication skills. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

1. DCPD repository
2. Biology Text Book for Class X (2020), REC
3. Science curriculum framework (NSC-2022)
4. https://cutt.ly/FIeVSDK

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. When pathogens enter our body, infections develop disturbing the normal state of our body. Which cellular components of our blood are involved?

2. Blood transfusion is an essential part of the healthcare system in terms of surgical interventions and hematologic malignancies. Explain why the mismatch of blood groups during the blood transfusion leads to serious complications?
3. In a car accident, a woman loses a huge amount of blood and she needs blood for the replacement. However, she is not aware of her blood group. Luckily you have the blood test kit and as you perform the test, you find out that the woman's blood clots with anti-A. Which blood group(s) would you suggest for blood transfusion?

1.7. Response and Coordination

1.7.1. Scope: The endocrine and nervous systems work together to coordinate various processes in the body. Hormones influence human behaviour, growth, reproduction and other bodily processes. Sex hormones cause some pubertal changes such as the development of reproductive organs and emotional changes.

1.7.2 Hormones are used for the treatment of conditions (e.g., infertility, cancer, etc.) by hormone therapy; and also for birth control. The use of some hormones (e.g., steroids) has some physical and psychological implications.

1.7.3. Scope: Synthetic chemicals (e.g., synthetic hormones) are used to manipulate the biological systems of plants and study the influence of phytohormones on plant growth and development. Synthetic hormones are used in commercial farming for improving food production.

1.7.4. Scope: Neurons transmit impulses between the central nervous system and the body parts (i.e., receptors and effectors). A reflex arc is a pathway travelled by an impulse during reflex action. The impulse transmitted by the sensory neurons to the CNS (i.e., Brain and spinal cord) is modulated to make decisions and then transmitted to effectors by motor neurons. The working principle of the human nervous system is applied in the production of devices that are used in daily lives. A bionic device works similar to that of the human nervous system.

Objective(s):
LO-1. Construct scientific explanations on biological, psychological, and social impacts of using steroids.

Learning Experiences
The teacher may begin the lesson by informing the learner that consumption of steroids, such as pills, or drugs are common in many parts of the world. The learner may be informed on some of the biological or short-term benefits of steroids. For instance, the teacher may cite how steroid hormones, such as i-pills, have some reliefs and biological benefits. In contrast to this, the teacher may inform the learner that hormones and drugs produced artificially (e.g., steroids) have

biological, psychological, and social impacts. The teacher may pose the question: What are the biological, psychological, and social impacts of using steroids? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains the information about the biological, psychological, and social impacts of using steroids (e.g., hormone-based pills) from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/IPrUdrO).
- The learner constructs scientific explanations on biological, psychological, and social impacts of using steroids (e.g., hormone-based pills).
- The learner shares and argues biological, psychological, and social impacts of using steroids (e.g., hormone-based pills).

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. The consumption of steroids has psychological and social impacts. Explain.
2. Discovery of synthetic steroid hormones has changed human life. Comment.
3. Steroids, such as synthetic hormones to avoid pregnancy, are largely banned in Bhutan. Comment.

Assessment:

Use rubrics to assess the learner's information management skill, ability to explain why the use of steroids has biological, psychological, and social impacts, and the ability to defend the stand with scientific reasons on why the use of hormones (e.g., steroids) have biological, psychological, and social impacts. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/vIeHlDH

LO-2. Communicate scientific information on the application of synthetic hormones (plant hormones) in enhancing agricultural productivity.

Learning experiences:

The teacher may begin the lesson by informing the learner that hormones are required for normal growth, development, and reproduction in plants. The teacher may inform the learner that their absence would cause improper growth of plants or plant parts. The learner may be informed that one can also apply synthetic plant hormones to speed up or increase the productivity of the plant. The teacher may pose questions: What are the synthetic plant hormones applied to improve agriculture productivity? How the application of phytohormones could improve agricultural

productivity? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on applications of hormones in the improvement of agriculture productivity from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://doi.org/10.1080/09168451.2018.1462693).
- The learner communicates scientific information on the applications of hormones in the improvement of agriculture productivity.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Name three synthetic plant hormones applied in agriculture.
2. Do the usage of synthetic hormones for the modification of plant growth have any environmental implications?
3. How would using hormones to manipulate plant growth disturb the evolution pattern of plants?
4. A farmer grows cucumbers in his field. He wants to increase the number of female flowers in them. Which plant hormone would you suggest him to apply to increase the number of female flowers?
5. How does synthetic hormone help the production of fruits and vegetables in off seasons? Explain with a suitable example.

Assessment:

Use rubrics to assess the learner's information management skill, communication skill and ability to answer questions on how the applications of hormones could improve agriculture productivity. Provide necessary feedback and intervention to the learner.
For recording and reporting, refer science curriculum framework.

Suggested resources:

- DCPD repository
- Srijan Biology, Bhutan edition, class 11, REC (2015)
- Science Curriculum Framework (NSC- 2022)
- https://doi.org/10.1080/09168451.2018.1462693

Objective(s):

LO-3. Construct scientific explanation that sensors in machines work similar to the working of receptors in the human body.

Learning Experiences:

The teacher may begin the lesson by informing the learner that there are sensors in machines that carry out similar functions to that of the working of receptors in the human body. The teacher may

pose the question: How are the working of sensors in machines related to the receptors in the human body? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the working of sensors such as light, touch, sound and speed in the car and the working of the receptors in the human body from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g.,https://cutt.ly/1IeBMg).
- The learner constructs explanations on how sensors in machines work similar to the working of receptors in the human body.
- The learner shares and communicates how sensors in machines work similar to the working of receptors in the human body.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How does the nervous system in your body share certain common features with a computer?
2. Mimicking of the human nervous system may advance Artificial Intelligence (AI). Comment.

Assessment:

Use rubrics to assess learners' information management skills, the ability to relate the workings of sensors in machines to the working of the receptors in humans, and communication skills. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

1. DCPD repository
2. Biology Text Book for Class X (2020), REC
3. Science curriculum framework (NSC-2022)
4. https://cutt.ly/1IeBMgO
5. https://cutt.ly/5PukDnP

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. Explain with scientific reasons that our behaviour and growth is regulated by hormones.
2. Explain the concept of peptide hormone and steroid hormone?
3. The smell of dumplings usually leads to salivation. How does our brain detect the smell?
4. When you stand to give your speech in the morning assembly, your mouth dries up and heart rate increases. Why?
5. There are several plant growth substances. Name the plant growth substances which are responsible for saving the crops from falling?

6. How has the knowledge of plant hormones alleviated the horticulturalist?

1.8 Excretion: Removal of Waste

1.8.1. Scope: Kidneys regulate the concentration of solute in body fluids. Different parts of nephrons function differently, to alter the concentration of urine in order to maintain the required osmotic concentration in the body fluids. The nature of urine does not remain the same.

1.8.2. Scope: Lifestyle practises are linked to the health of the excretory system in various ways. Unhealthy practises such as low physical activity, smoking, alcohol consumption, etc. are associated with kidney dysfunction.

Objective(s):
LO-1. Develop a model that explains how nephrons maintain the osmotic concentration of body fluids.

Learning Experiences
The teacher may begin the lesson by informing the learner that there are many systems that help in maintaining balance in the body. The teacher may inform the learner that the urinary system, a structure composed of kidneys and other structures, is one of the systems that maintains balance in the concentration of our body fluids. The learner may be informed about the structure called nephrons found in our kidneys. The teacher may inform the learner that it is nephrons that form the structure and function of kidneys. The teacher may pose the question: How do nephrons maintain the osmotic concentration of body fluids through urine formation? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on how nephrons in maintain the osmotic concentration of the body fluids from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/gzuFM75) .
- The learner designs a model (conceptual, theoretical, physical or simulation) that explains the role of nephrons in maintaining the osmotic concentration of the body fluids. The learner may use relevant software and programming languages.
- The learner constructs scientific explanations on the role of nephrons in maintaining the osmotic concentration of the body fluids using the model.
- The learner critiques each other's work.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. Draw a structure of nephron and label the part that is responsible for reabsorption of water from filtrate into the blood?
2. How does nephron help in regulating fluid and electrolyte balance?

3. What would happen if the descending limb of the nephron is removed or damaged? Explain.

Assessment:
Use rubrics to assess learner's information management skill, conceptual understanding of the role of nephrons in maintaining the osmotic concentration of the body fluids, ability to translate conceptual understanding into the model, and communication skill. Provide necessary intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:
- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/gzuFM75

Objective(s):
LO-2. Communicate scientific information that kidney failure is linked to unhealthy lifestyle.

Learning Experiences
The teacher may begin the lesson by informing the learners that kidney related diseases are some of the growing concerns in Bhutan and elsewhere in the world. The teacher may inform the learner that the health of the kidneys always depends on the way we lead our lifestyle. The learner may be informed that the most of the kidney failures are linked with or associated with unhealthy lifestyles. The teacher may deliver the lesson based on the following order of scientific and engineering practises:
- The learner obtains information on unhealthy lifestyles that results in kidney failure from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/vIeGyRz).
- The learner constructs scientific explanations on unhealthy lifestyles that result in kidney failure.
- The learner communicates scientific information on unhealthy lifestyles that result in kidney failure.

Questions:
The teacher may ask the following questions to check the understanding of the learner:
1. Mention some of the unhealthy lifestyles related diseases prevailing in your locality?
2. How does unhealthy lifestyles related diseases affect the functioning of the kidney?
3. Design a strategy to advocate how to prevent kidney related diseases in your locality?

Assessment:

Use rubrics to assess the learner's information management skills and communication skills. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/vIeGyRz

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. A person diagnosed with kidney failure is usually characterised by swelling in his/her body parts. How would you relate the swelling of body parts to kidney failure?
2. Generally, we urinate fewer times in summer than in winter and the urine passed is slightly thicker. Justify with scientific reasons?
3. It is said that drinking too much water causes electrolyte imbalance. What could be the scientific reasons?

1.9. Microorganism: Diseases and Drugs

1.9.1. Scope: Microorganisms have many applications in the food industry, waste degradation and management, and in the production of antibiotics, vaccines, insulin etc.

1.9.2. Scope: Microbes (e.g., HIV, coronavirus, Helicobacter Pylori, etc.) cause various types of diseases. Some diseases (e.g., STIs, COVID-19, stomach cancer, etc.) are common these days. Communicable diseases can be prevented through hygienic and safe practises.

Objective(s):

LO-1. Design a solution to treat wastewater/sewage/kitchen waste/municipal waste using the concept of anaerobic digestion.

Learning Experiences

The teacher may inform the learner issues with kitchen wastes, municipal wastes, etc., have become one of the growing concerns in Bhutan. The teacher may inform the learner that such issues need to be resolved at the earliest before they become a serious threat to biodiversity and the nation as a whole. The learner may be informed that issues related to organic waste disposal can be possibly combated using the concept of anaerobic respiration. On this note, the teacher may provide the web link https://cutt.ly/7zdGDbF or other relevant sources (e.g., books, online pieces, articles, etc.) that contain information on microbes and bioremediation

(wastewater/sewage/kitchen waste/municipal waste) a day before the lesson. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on microbes and bioremediation (wastewater/ sewage/kitchen waste/municipal waste) from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/7zdGDbF).
- The learner designs solutions to treat wastewater/ sewage/kitchen waste/municipal waste using the concepts of anaerobic digestion.
- The learner shares the design with the class and critiques each other's design. The learner incorporates the feedback and makes changes to the design.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How does microorganism help in treating wastewater/sewage/kitchen waste/municipal waste in our country?
2. Discuss challenges and opportunities with reference to treating domestic waste using the concept of anaerobic digestion?

Assessment:

Use rubrics to assess learner's information management skill, conceptual understanding of the use of anaerobic digestion in the recycling of waste and the ability to defend the designed solution. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/7zdGDbF

Objective(s):

LO-2. Communicate the scientific information on measures to keep oneself safe from microbial diseases *(limited to HIV, coronavirus, Helicobacter pylori).*

Learning Experiences

The teacher may begin the lesson by informing the learner that diseases related to some microorganisms (e.g., HIV, coronavirus, *Helicobacter pylori*) are spreading at an alarming rate both in Bhutan and world-wide. The teacher may inform the learner on the status of Bhutanese people living with HIV/AIDS or the recent outbreak of diseases caused by *Helicobacter pylori* in some parts of eastern Bhutan. The teacher may pose a question: How can you stay safe from microbial infections caused by HIV, coronavirus, and *Helicobacter pylori*? The teacher may carry out the instructional practises based on the following science and engineering practises:

- The learner obtains information on the causes, symptoms, and transmission of microbial infections caused by HIV, coronavirus, and *Helicobacter pylori* from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/SIeX6f1).
- The learner communicates the measures to stay safe from microbial infections, such as HIV, coronavirus, and *Helicobacter pylori* to class and critiques each other's works.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Explain how *Helicobecter pylori* causes gastric ulcers?
2. With the outbreak of COVID-19 diseases in the world, doctors and scientists have come up with several health protocols to keep ourselves safe from infections. Outline some of the preventive measures of COVID-19?

Assessment:

Use rubrics and checklists to assess learner's information management skills and communication skills. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/SIeX6f1

Objective(s):

LO-3. Communicate scientific information on ways to deal with social stigmas related to STIs and COVID-19.

Learning Experiences

The teacher may begin the lesson by informing the learner that people suffering from HIV/AIDS, STIs, COVID-19 etc., are usually stigmatised and are being discriminated against in society. The teacher may ask the learners to share some of the social stigmas suffered by people living with HIV/AIDS, STIS, etc., based on their experiences and findings. The teacher may inform that people living with such diseases should be provided mental and social support services wherever possible. The teacher may pose the question: How would you support the people suffering from HIV/AIDS and COVID-19? The teacher may carry out the instructional practises based on the following science and engineering practises:

- The learner obtains information on various stigma prevailing in the society for people suffering from HIV/AIDS, STIs, COVID-19, etc.

- The learner develops measures to deal with social stigmas related to STIs and COVID-19, etc.
- The learner communicates information on common social stigmas and measures to deal with the social stigmas suffered by people living with HIV/ AIDS, STIs, and COVID-19.
- The learner argues and critiques each other's work based on scientific evidence, scientific reasons, and logical thinking.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Point out some of the impacts of social stigma related to STIs and COVID-19?
2. Design a poster to address the social stigma related to HIV/AIDS, STIs, and COVID-19 in your community?

Assessment:

Use rubrics to assess the learner's information management skill, ability to engage in an argument on common social stigmas and support required for people living with HIV/ AIDS communication skills. Provide necessary feedback and intervention to the learner.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/qIeCYOE

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. Read the text given below and answer the questions that follow:
   Waste production has become an unavoidable consequence of rapid population growth in cities. It is essential that we manage waste properly to build sustainable and livable cities. Critical issues such as these must be addressed by both the residents of cities as well as the Government.
   - Identify the problem in the above text.
   - Design a solution to solve the problem with the help of microorganisms.
2. The Ministry of Health has started a mass screening for *Helicobecter pylori* to eliminate. Design a plan to advocate on how to prevent the spread of *Helicobecter pylori* in your community?
3. Design solution to prevent the infection from communicable diseases such as HIV and COVID-19?
4. Suppose you are a counsellor in one of the schools in Bhutan. Prepare a presentation on how to deal with the people living with HIV/AIDS or COVID-19 in the school?

2 Ecosystems: Interactions, Energies and Dynamics

Ecosystems are complex interactive systems that include both living and non-living things. Ecosystems consist of several hierarchical structures, wherein groups of same organism form populations. Individual organisms or populations live, grow, or reproduce within ecosystems. How does this happen? This happens through interdependent relationships with other organisms or populations in their physical environment. These interactions restrain growth; enhance or limit the size of populations; or maintain the balance between resources and those who consume them. Ecosystems are sustained by continuous flow of energy, originating primarily from the sun, and the recycling of matter and nutrients within systems. However, ecosystems experience shifts in population composition and abundance; and changes in the physical environment over time.

Competencies

By the end of class X, a learner should be able to:

a. apply the understanding of the ecosystem to explain that organisms grow, reproduce, and perpetuate their species by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.
b. sustainable use of natural resources is essential and any disturbance in the ecosystem can influence the quality and sustainability of natural resources.
c. use the concepts of interdependence amongst organisms to develop solutions to mitigate environmental pollution.

2.1 Organisms in its Environment

2.1.1. Scope: Organisms interact amongst themselves and with their physical environment for their survival. The biotic and abiotic components of an ecosystem are interdependent and interact to maintain the balance in nature.

2.1.2. Scope: The biodiversity of an area is studied at different levels (e.g., genetic diversity, species diversity and ecosystem diversity.). Ecosystem services (e.g., oxygen, water, nutrient cycles, wastewater treatment, etc) are benefits that are obtained either directly or indirectly from the ecosystem.

2.1.3. Scope: Bhutan is rich in biodiversity and is a part of one of the biodiversity hotspots of the world. The presence of diverse forms of habitats in Bhutan is able to support a lot of endangered species of plants and animals.

2.1.4. Scope: Anthropogenic activities pose threat to biodiversity in a variety of ways. For instance, clearing forest for construction and agricultural purposes not only impacts biodiversity but also brings adverse changes to the landscape.

Objective(s):
LO-1. Construct a model that represents biotic and abiotic components of a local ecosystem.

Learning Experience
The teacher may begin the lesson by informing the learner that an ecosystem consists of biotic and abiotic components. All biotic components depend on abiotic components for their growth, reproduction, and survival in an ecosystem. The learner may be informed to reflect on the ponds or rocks ecosystems he or she has seen with its living and non-living parts. The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner explores the local ecosystem (e.g., pond, rock, tree, etc.) and identifies its biotic and abiotic components.
- The learner designs a model (conceptual, theoretical, physical or simulation) of a local ecosystem that represents its biotic and abiotic components. The learner may use relevant software and programming languages to develop a model of a local ecosystem.
- The learner explains the local system based on biotic and abiotic components using the model.
- The learner critiques each other's model that explains the local ecosystem based on its biotic and abiotic components.

Questions:
The teacher may ask the following questions to check the understanding of the learner:

1. Differentiate between the biotic and abiotic components of the ecosystem?
2. Discuss the factors that affect the biotic and abiotic components in the ecosystem?
3. Explain why biotic and abiotic components interact in the ecosystem?

Assessment:
Use rubrics to assess the learner's information management skill, ability to develop a model that represents/explains the relationship between biotic and abiotic components of a local ecosystem, communication skills, and ability to critique. Provide necessary feedback and intervention to the learner. For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/TIYkQcK

Objective(s):

LO-2. Explain with scientific reasons that the health of an ecosystem depends on its biodiversity**.**

Learning Experiences

The teacher may begin the lesson by informing the learner that the existence of different types of species determines the stability and the resilience of an ecosystem. The teacher may pose a question: How does the health of an ecosystem depend on its biodiversity? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on how the health and resilience of an ecosystem depends on its biodiversity from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/OU6cLAl).
- The learner constructs an explanation providing scientific reasons that the health of an ecosystem and resilience depends on its biodiversity.
- The learner provides scientific reasons to support the claim that health of an ecosystem depends on its biodiversity.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Draw the relationship between ecosystem and biodiversity?
2. Explain how species richness is related to ecosystem resilience?
3. We are currently witnessing a steady loss of biodiversity. Discuss the main causes of the loss of biodiversity in the ecosystem.

Assessment:

Use rubrics to assess the learner's information management skill, ability to explain with scientific reasons that the health of an ecosystem depends on its biodiversity, and ability to defend the claim. Provide necessary feedback and intervention to the learner.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/OU6cLAl

Objective(s):

LO-3. Investigate challenges in the management of natural resources in the locality.

LO-4. Design a solution to reduce the impacts of human activities on biodiversity.

Learning Experiences

The teacher may begin the lesson by informing the learner that we face numerous challenges in managing natural resources. The teacher may pose a question: What are some of the challenges faced in managing the natural resources in your community? How are these challenges managed in your community? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner visits the field to examine the challenges faced in management of natural resources in the locality.
- The learner obtains data from the field through observations or by communicating with local people.
- The learner analyses and interprets data (e.g., tabulation, statistics, graphing, etc.) collected from the field on challenges faced in managing the natural resources.
- The learner designs a solution to explain the ways to reduce the challenges faced in the management of natural resources.
- The learner shares the designed solutions with the class and critiques each other's design.
- The learner incorporates the feedback and makes changes to the design.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. The exploration of natural resources by humans can be dated back to the start of the industrial revolution in the 18th century. Identify the natural resources that have existed for centuries in your locality?
2. Based on the answer of above question 1., communicate scientific information on some of the common challenges in managing the identified natural resources in your locality?

Assessment:

Use rubrics to assess the learner's information management skill, ability to analyse and interpret data, ability to design a solution in managing the natural resources and communication skills. Provide necessary feedback and intervention to the learner.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/pU6bEie

Objective(s):

LO-5. Argue with scientific reasons that the introduction of exotic species in an area impacts the native species.

Learning Experiences

The teacher may inform the learner that Bhutan is grappling with issues caused by certain exotic species, such as *Eupatorium* spp., *Lantana camera*, etc. The teacher may inform the learners that invasion by exotic species has several implications. The teacher may provide relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/xU6nOsQ) on exotic species a day before the lesson. The teacher may pose a question: How does introduction of exotic species impact the native species? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on possible impacts of exotic species into native species relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/xU6nOsQ).
- The learner constructs a scientific explanation that the introduction of exotic species often impacts the native species.
- The learner argues on the statement "introduction of exotic species often impacts the native species".

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. How does introduction of exotic species impact the native species?
2. The invasion by some exotic species has a dramatic impact on the nation's economy. Comment.
3. Mention some possible solutions to control the spreading of exotic species?

Assessment:

Use rubrics to assess the learner's information management skill, ability to argue with scientific and logical reasoning on the statement "introduction of exotic species often impacts the native species", and communication skill. Provide necessary feedback and intervention to the learner. For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/xU6nOsQ

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. Ecosystem stability is important to achieve the goals of Gross National Happiness. Justify?
2. List down the human causes of degradation of natural resources in your locality.

3. Explain how the sacred lakes, places and mountains help in preserving the natural resources in Bhutan?
4. Management of water resources in Bhutan has become challenging due to an increase in population. How can you as a local leader address the challenges?

3 Heredity: Inheritance and Variation of Traits

Have you ever wondered why offspring from same parents are alike but never same? This is influenced by the characters or traits passed from one generation to the next via genes. Genes are short DNA segments that contain information for making specific proteins, which are responsible for the specific traits of an individual. Genes reside in a cell's chromosomes. Every cell of any individual organism contains the identical set of chromosomes. In species that reproduce sexually, each cell contains two variants of chromosome, one inherited from each parent. Thus, sexual reproduction gives rise to a new combination of chromosome pairs with variations between parent and offspring. Environmental as well as genetic variation and the relative dominance of each of the genes in a pair play an important role in how traits develop within an individual. Complex relationships between genes and interactions of genes with the environment determine how an organism will develop and function.

Competencies

By the end of class X, a learner should be able to:

a. apply the understanding of cell division to explain growth, development, and repair as the result of a mitotic division of cells.
b. apply the understanding of cell division to explain that reproduction, stability of chromosome number, and continuity of life are maintained by meiotic division of cells.
c. use the understanding of patterns of inheritance to explain that offspring receive half of the chromosome from each parent and genes received from either of the parents is expressed.

3.1 Growth, Development, and Reproduction

3.1.1. Scope: Cell division involves a series of events leading to the division of a mother cell into two or more daughter cells. During these events, the behaviour of chromosomes and centrioles change.

3.1.2. Scope: The growth and development of organisms occur by mitotic division of the body cells and therefore, contain the same genetic composition. A somatic cell contains chromosomes that are arranged in the form of homologous pairs. In humans, a body cell contains 23 pairs of chromosomes. Each pair contains maternal and paternal chromosomes.

3.1.3. Scope: Cell division involves a series of events where a parent cell divides to form two or more daughter cells. During these events, the behaviour of chromosomes and centrioles change.

In animals (e.g. humans), sexual reproduction involves the formation of sex cells (i.e., sperm and ovum) by meiotic division of germ cells. When cells divide by meiosis, crossing over occurs between the maternal and paternal chromosomes which results in the mixing of the genes. The

daughter cells (e.g. sex cells) produced by meiosis differ in genetic composition from each other and also from the mother cell (i.e., germ cells).

Objective(s):

LO-1. Develop a model that explains the production of body cells through mitotic division.

Learning Experiences:

The teacher may begin the lesson by informing the learner that body cells divide repeatedly to produce new daughter cells. The teacher may inform that without such a division of the body cells, the processes such as growth, differentiation, repair, and replacement would not not be possible. The teacher may ask the learner if he or she has noticed how the wounded parts of our body are healed after some time. The teacher may inform this division of body cells as mitotic division. The learner may be informed that during mitotic division, our skin cells divide again and again to produce many new skin cells. Then the teacher may pose questions: How do you think this occurs? Would the new skin cells and the original skin cell contain the same or different genetic information? Why? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the production of new body cells through mitotic division from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/jIYReKx).
- The learner designs a model (conceptual, theoretical, physical or simulation) to show the behaviour of chromosomes, centrioles and nuclear membrane during the phases of mitotic division. The learner may use digital tools and programming languages to design models.
- The learner constructs an explanation on how skin cells are produced through mitotic division using the developed model.
- The learner identifies where, in the body apart from skin cells, this type of cell division takes place; whether or not such cell division also occurs in plants.
- The learner presents and evaluates each other's model.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Where in the body does mitosis take place?
2. During interphase, DNA replication takes place. Why?
3. Explain the behaviour of chromosomes and centrioles during metaphase and anaphase.
4. The nature of genetic information remains the same in mitotic division. Why?
5. Mention the significance of mitotic cell division.

Assessment:

Use rubrics to assess a learner's information management skill, ability to develop a model that explains the production of body cells through mitotic division, ability to explain the process of mitosis, and ability to evaluate. Provide necessary feedback and intervention if needed.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/jIYReKx

Objective(s):

LO-2. Develop a model that explains the production of sex cells through meiotic division.

Learning Experiences:

The teacher may inform the learner that like mitosis, some body cells, such as sperms and eggs also undergo a similar type of cell division. Teacher may inform the leaner that without the division of the sex cells, it would be impossible to maintain the continuity of life, induce variation in the population, or maintain same number of chromosomes generation after generation. The learner may be informed of this division as meiosis or meiotic division. The teacher may inform the learner that the sex cells (sperm in testes and egg in the ovary) divide again and again to produce many new sex cells through meiotic division. The teacher may pose questions: How do you think this occurs? Would the new sex cells and the original sex cell contain the same or different genetic information? Why? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the processes of meiotic division from relevant sources (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/7IeP1hl).
- The learner develops a model (conceptual, theoretical, physical or simulation) to show how sex cells (sperms and eggs) are produced through meiotic division.
- The learner constructs an explanation on how sex cells (sperms and eggs) are produced through meiotic division using the developed model.
- The learner identifies where, in the plant, this type of cell division takes place.
- The learner presents and evaluates each other's model.

Questions:

The teacher may ask the following questions to check the understanding of the learner:

1. Where in the body does meiotic division take place in animals?
2. Would meiotic division take place in a plant? If yes, name the site?
3. What happens to the nature of genetic information during meiotic division? Why?
4. Would daughter cells in meiotic division have the same genetic composition? Why?

5. Mention the significance of meiotic cell division?

Assessment:
Use rubrics to assess a learner's information management skill, ability to develop a model that explains the production of sex cells through meiotic division, ability to explain the process of meiosis, and ability to evaluate or critique each other's' work. Provide necessary feedback and intervention if needed.

Suggested Resources:
- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/7IeP1hl

Objective(s):
LO-3. Construct an argument with scientific reasons to support or refute the concept that body cells have the same genetic composition, while sex cells have different genetic composition.

Learning Experiences:
The teacher may begin the lesson by informing the learner that the body cells have the same genetic composition. The teacher may inform that a cell from the nose would have the same genetic composition of a cell from the liver. The teacher, on the other hand, may inform the learner that sex cells, such as sperms and eggs from same individual would always have different genetic compositions. The teacher may pose a question: Why do you think that the body cells have same genetic composition, while sex cells have different genetic composition? The teacher may deliver the lesson based on the following order of scientific and engineering practises:
- The learner obtains information on why body cells have same genetic composition, while sex cells have different genetic composition from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/FIYAo7A).
- The learner constructs the information on why body cells have same genetic composition, while sex cells have different genetic composition.
- The learner shares and argues to support or refute the idea on why body cells have same genetic composition, while sex cells have different genetic composition.
- The learner answers the questions posed.

Questions:
The teacher may ask the following questions to check the understanding of the learner:
1. If you could take one of your skin cells and one of your nerve cells, would the genetic information in them be the same or different? Support your answer with reason(s).

2. If you could take one of your skin cells and one of Pema's skin cells, would the genetic information in them be the same or different? Support your answer with reason(s).
3. If you could take one of Pema's skin cells and one of Pema's sperm cells, would the genetic information in them be the same or different? Support your answer with reason(s).
4. If you could take two of Pema's sperm cells, would the genetic information in them be the same or different? Support your answer with reason(s).

Assessment:

Use rubrics to assess the learner's information management skill, ability to defend the claim on why body cells have same genetic composition, while sex cells have different genetic composition, and ability to answer the questions. Provide necessary feedback and intervention to the learner.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/FIYAo7A

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of learner:

1. Describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation?
2. Defend a claim with scientific evidence that inheritable genetic variations may result from new genetic combinations through meiosis.
3. Would meiosis of a human be the same as that of a mule? Comment.
4. Are there sex chromosomes in human skin cells? Support your answer with reasons.

3.2. Inheritance and Variation of Traits

3.2.1. Scope: During sexual reproduction, each parent contributes half the number of chromosomes (at random) to the offspring. Each chromosome in a pair contains one copy of a gene (allele) inherited either from the father or mother.

3.2.2. Scope: Each allele in a pair expresses protein and masks the effect of another allele. The structure of a protein determines the traits of an individual. This is the reason why one looks similar either to a father in certain features and a mother in other features.

3.2.3. Scope: Differences occur within an individual or amongst individuals of the same species. These differences are called variations. The variations are caused either due to genetic or environmental factors.

Objective(s):

LO-1. Develop a model that explains the patterns of inheritance of characters of an organism based on Mendel's laws of inheritance.

Learning Experiences

The teacher may begin the lesson by informing the learner that body characters, such as height, tongue rolling, colour of eyes, the shape of ear lobes, etc., are inherited from parents to offspring based on Mendel's laws of inheritance. Teachers may inform that the offspring, oftentimes, do not exhibit the characteristics of a father or mother or both. For instance, a tongue roller father may not have sons or daughters with the same ability to roll their tongue. The teacher may pose a question: How does this happen? How do we inherit characters (e.g., height, tongue rolling, colour of eyes, shape of earlobes, etc.,) from our parents? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the inheritance of characters, such as height, tongue rolling, colour of eyes, the shape of earlobes, etc. from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/8U6RTf).
- The learner develops a model (conceptual, theoretical, physical, or simulation) to explain the patterns of inheritance of characters, such as human height, tongue rolling, colour of eyes, shape of earlobes, etc., based on Mendel's laws of inheritance. The learner may develop the model using Punnett squares and probability statements.
- The learner uses the model to explain the patterns of inheritance of characters, such as human height, colour of eyes, shape of ear lobes, etc.

Questions:

The teacher may ask following questions to assess learners' understanding

1. Are dominant traits always more common than recessive traits? Support your answer with reason.
2. Explain how characters, such as height, tongue rolling, earlobe, and eye colour are inherited based on Mendel's laws of inheritance.
3. Why is it such that a son would be a non-tongue roller even if parents are tongue roller?
4. Suppose, in a pea plant '*S'* allele codes for long stem and '*s'* allele codes for short stem. In the cross Ss X Ss, what percentage of the offspring would you expect to have the same genotype as the parents?
5. In peas, seeds may be round (R) or wrinkled (r). What proportion of the offspring in the following crosses would be expected to be wrinkled?

   a. RR x rr b. Rr x Rr c. Rr x rr

Assessment:
Use rubrics to assess learner's information management skill, ability to use the model to understand the inheritance of characters from parents to offspring based on Mendel's laws of inheritance. Provide necessary feedback and intervention. For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/8U6RTf

Objective(s):
LO-2. Construct scientific explanation the inheritance of sex-linked diseases, such as haemophilia and colour blindness using Punnet squares and probability statements.

Learning Experiences:
The teacher may provide relevant materials (e.g., books, online pieces, articles, etc.) or web links (eg., https://cutt.ly/JIeX1C7) on sex-linked diseases, such as hemophilia and colour blindness a day before the lesson. The teacher may pose a question: How are sex-linked diseases, such as hemophilia and colour blindness inherited from parents to offspring? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on the inheritance of sex-linked diseases, such as haemophilia and colour blindness from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/mzktr6O).
- The learner constructs explanation on the inheritance of sex-linked diseases such as hemophilia or colour blindness using mathematical models, probability statements, and proportional reasoning using Punnett squares.
- The learner presents an explanation of inheritance of sex-linked diseases, such as haemophilia and colour blindness using Punnet square.
- The learner critiques each other's work.

Questions:
The teacher may ask following questions to assess learners' understanding

1. Determine the probability of the offspring in the following cases:
    a) colourblind man marries carrier woman
    b) normal woman marries colourblind man

2. A haemophilic woman marries a normal man. Determine the percentage of carrier females in the offspring using punnett square.

Assessment:

Use rubrics to assess learner's information management skill, ability to construct explanation on inheritance of sex-linked diseases such as colour blindness and haemophilia using Punnet's square, and ability to critique. Provide necessary feedback and intervention.
For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/mzktr6O./ https://cutt.ly/JIeX1C7

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. "If a father has a dimple, son would also have a dimple". Comment.
2. Explain how we inherit characters, such as ability to roll tongue, eye colour, hair colour etc., from our parents.
3. Suppose you sell flower seeds which you can guarantee that seeds will produce all pink-flowered plants. How would you produce these seeds?
4. A normal visioned woman, whose father is colour blind, marries a normal visioned man. What would be the probability of her sons and daughters to be colour blind? Explain with the help of a punnett square.
5. Colour blindness is more common in males than in females. Why?
6. In humans, the gene for normal blood clotting is dominant to the gene for haemophilia. A heterozygous woman for the trait marries a man with haemophilia. What is the probability for couple having,
   a) Carrier daughter b) Normal son c) Haemophilic son
7. A man's maternal grandmother and maternal grandfather are both colour-blind. His father has normal vision. Will this man be colour-blind or normal?

4 Biological Evolution: Unity and Diversity

Biological evolution is a unifying theory of biology. It provides explanations on the existence of unity and diversity of the species. Biological evolution is supported by extensive scientific evidence. Evidences such as fossil records; anatomical and morphological structures; appearances of embryos provide the credibility of evolution either from common or different ancestral lines. These days, new and different techniques, including DNA and protein sequence analyses, are used to test and further the understanding of evolutionary relationships. How does evolution occur? Evolution, which is continuous and ongoing, occurs when natural or artificial selection acts on the genetic variation in a population and changes the distribution of traits in that population gradually over multiple generations.

Competencies

By the end of class X, a learner should be able to:

a. use the understanding of the mutation, genetic drift, and gene flow to explain how the evolution of species occurs.
b. apply the understanding of natural selection to explain how humans have used technology to influence speciation

4.1. Genetic Basis of Natural Selection

4.1.1. Scope: Natural selection supports the organisms with favourable character to survive in an area. This leads to the change in the frequency of certain alleles. Organisms with favoured traits have a higher probability to survive and reproduce.

Objective(s):

LO-1. Construct scientific explain on how natural selection influences the evolution of organisms through changing the frequency of alleles and their corresponding traits.

Learning Experiences:

The teacher may provide relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/WIe7FD) to obtain information on how natural selection influences the frequency of certain alleles and their corresponding traits in a population one day before the lesson. The teacher may inform that new traits arise in a population and natural selection is one of the processes that influence the change or emergence of new traits in a population over time. The teacher may pose the question: How does natural selection influence the frequency of certain alleles and their corresponding traits in a population? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on natural selection that increases or decreases the frequency of certain traits and their corresponding alleles in a population based using Peppered moth, sickle celled RBC, etc., as examples from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/KzkyOX6)
- The learner constructs an explanation on how natural selection increases or decreases the frequency of certain traits and their corresponding alleles in a population using Peppered moth, sickle celled RBC, etc., as examples.
- The learner, taking the example of a Peppered moth, sickle celled RBC, etc., shares the understanding of how natural selection either increases or decreases the frequency of certain traits and their corresponding alleles in a population.
- The learner answers the questions.

Questions:

The teacher may ask following questions to assess learners' understanding

1. How does natural selection change the allele frequencies of the organism in a population?
2. These days, it is common to see in towns in Bhutan that the number of mountain crows are lesser in number than the common crows. Relate this phenomenon in terms of natural selection and corresponding traits of mountain crows and common crows.
3. *Natural selection increases the frequency of advantageous traits allowing it to survive and reproduce.* Explain the statement with a suitable example.
4. An organism with favourable genetic variations will tend to survive and breed successfully
5. Read the text given below and answer the questions that follow:
   Sickle cell anaemia is a disease that causes your body to produce abnormally shaped red blood cells. However, a study of children in Kenya between 16 months and 2 years old showed that those with normal RBC had the lowest chance of surviving malaria while those with sickle shaped RBC had the highest chance of survival.
   a. What is your opinion on sickle cell anaemia?
   b. How natural selection favours sickle cell RBC over normal RBC?
   c.

Assessment:

Use rubrics to assess learners' information management skills, ability to explain how natural selection increases or decreases the frequency of certain traits and their corresponding alleles in a population on genetic basis of natural selection that operates on the genotypes of Peppered moth and sickle celled RBC, and ability to answer the questions. Provide necessary feedback and intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository

- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/KzkyOX6
- https://cutt.ly/WIe7FD3

4.2. Artificial Selection

4.2.1. Scope: Selective breeding is carried out to obtain organisms (i.e., plants and animals) with desired traits. It leads to the alteration of the frequency of alleles associated with certain traits (e.g., the allele frequency of desired traits increases in a population.). Improved varieties of fruits and vegetables have been obtained through artificial selection.

4.2.2. Scope: Artificial selection, hybridization and the use of recombinant DNA technology in agriculture have led to the production of improved varieties of plant and animal species.

Objective(s):
LO-1. Construct scientific explanation on how gene technologies and selective breeding techniques influences the evolution of the organisms.

Learning Experiences:
The teacher may inform the learner that humans are also one of the causes of evolution. The learner may be informed that various human activities in the past and today have led to the evolution of new species. The teacher may cite various subspecies of dogs and fowl found in Bhutan to support the claim. The teacher may pose a question: How do human activities (e.g., artificial selection, gene technologies, hybridization etc.,) lead to evolution? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on human activities, such as gene technologies, hybridisation and artificial selection that lead to evolution through the change in allele and trait frequency from relevant materials (e.g., books, online pieces, articles, etc) or web links (https://cutt.ly/ZIezc4D).
- The learner constructs scientific explanations on how human activities (artificial selection, gene technologies, hybridization etc.,) lead to evolution through the change in allele frequency and trait frequency.
- The learner engages in the argument supported with scientific evidence of human activities, such as artificial selection, gene technologies, and hybridisation leads to evolution through the change in allele and trait frequency.

Questions:
The teacher may ask following questions to assess learners' understanding

1. How does artificial selection lead to evolution of new species?

2. Many subspecies of dogs are quite common in towns and cities of Bhutan. Provide an explanation that accounts for their evolution based on change in allele or trait f
3. Do you think artificial selection affects the process of natural selection? Justify your answer.
4. Discuss some of the advantages and disadvantages of selective breeding.
5. Is the evolution of species through artificial selection always beneficial to humankind? Support your answer with reasons.

Assessment:

Use rubrics to assess the learner's information management skill, ability to argue supported with scientific evidence on anthropogenic activities, such as artificial selection, gene technologies, and hybridisation that leads to evolution through the change in corresponding allele frequency and ability to answer the questions. For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/ZIezc4D

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. How does artificial selection influence the frequency of certain alleles and their corresponding traits in a population?
2. How does artificial selection lead to the evolution of new species?
3. These days, certain subspecies of dogs have become more dominant in cities and towns of Bhutan. Explain this based on artificial selection.
4. Mention some of the latest technologies and methods employed in selective breeding?
5. There are different methods to carry out artificial selection. Select one and briefly explain the most appropriate method which can be used to enhance food security in the future.
6. The susceptibility of tomato plants to a bacterial disease has decreased due to the insertion of a certain transgene by humans. Is this an example of artificial selection? Support your answer with reason(s)
7. Present day dogs and wolves share common ancestors. However, there are a large number of dog breeds as compared to the wolf breeds. Why? Support your answer with reasons.

4.3. Factors Responsible for Speciation

4.3.1. Scope: Evolution is influenced by a variety of evolutionary factors (e.g, genetic drift, genetic variations, mutations, natural selection, etc.). According to the Hardy-Weinberg principle, the gene frequency in a population remains constant when no evolutionary forces are operating on it.

Objective(s):
LO-1. Construct scientific explanation using Hardy-Weinberg's Principle on how organisms evolve through a change in allele frequency of a population over time.

Learning Experiences:
The teacher may inform the learner that Hardy-Weinberg's principle provides a basis to assess if the population is in the stage of evolution or not. The teacher may provide a web link https://cutt.ly/rzkitVH or any other relevant materials (e.g., books, online pieces, articles, etc.) that explains Hardy Weinberg Principle a day before the lesson. The teacher may pose a question: How does Hardy-Weinberg's principle explain the evolution of population? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on how Hardy- Weinberg Principle explains the evolution of population through the change of allele frequencies from relevant materials (e.g., books, online pieces, articles, etc.) or web links (e.g., https://cutt.ly/rzkitVH).
- The learner constructs an explanation using Hardy-Weinberg's principle on the evolution of population through a change in allele frequency over time.The learner may use mathematical models, probability statements, and proportional reasoning to explain the evolution of population through the change in allele frequency over time based on Hardy-Weinberg's principle.
- The learner critiques each other's presentation.

Questions:
The teacher may ask following questions to assess learners' understanding:

1. What is Hardy-Weinberg's principle?
2. How does Hardy-Weinberg's principle determine the evolution of a population?
3. Explain the significance of Hardy-Weinberg equation.

Assessment:
Assess learner's information management skill, conceptual understanding of Hardy-Weinberg's principle in terms of the usage of mathematical models, probability statements, and proportional reasoning in explaining the evolution of population using a rubric. Provide necessary intervention.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC

- Science curriculum framework (NSC-2022)
- https://cutt.ly/rzkitVH

Objective(s):

LO-2. Construct scientific explanation on how evolutionary forces lead to speciation (*limited to mutation, natural selection, isolation, migration, genetic drift theory).*

Learning Experiences:

The teacher may begin the lesson by informing the learner that new species evolve due to evolutionary forces, such as genetic variation, natural selection, genetic drift, isolation, or migration. The teacher may inform that the golden langur and grey langur are believed to have evolved from a common ancestor. The teacher may pose a question: How do evolutionary factors lead to the formation of new species? The teacher may deliver the lesson based on the following order of scientific and engineering practises:

- The learner obtains information on evolutionary factors such as genetic variation, natural selection, genetic drift, migration, gene technology, hybridisation etc., from relevant materials (e.g., books, online pieces, articles, etc) or web links (e.g., https://cutt.ly/HII0TpU).
- Based on the information gathered, the learner constructs scientific explanations on the evolutionary forces (genetic variation, natural selection, genetic drift, isolation, or migration) that bring about speciation.
- The learner provides scientific explanation on the evolutionary factors that lead to speciation.

Questions:

The teacher may ask following questions to assess learners' understanding

1. What are evolutionary factors that lead to the formation of a new species?
2. Speciation is also caused by humans. Explain.
3. Golden langur and grey langur common in Bhutan are believed to have evolved from a common ancestor. Provide an explanation that accounts for their evolution into different species?
4. The domestic fowls are believed to be the closest descendants of the modern-day jungle fowl. Provide an explanation that accounts for the evolution of domestic fowls from jungle fowl.

Assessment:

Use rubrics to assess learner's information management skill, ability to explain how evolutionary forces (genetic variation, natural selection, genetic drift, isolation, or migration) bring about speciation, and communication skills. Provide necessary intervention.

For recording and reporting, refer science curriculum framework.

Suggested Resources:

- DCPD repository
- Biology Text Book for Class X (2020), REC
- Science curriculum framework (NSC-2022)
- https://cutt.ly/HII0TpU

Challenge Your Learners

Teacher may ask the following questions to challenge the thoughts of the learner:

1. How does Hardy-Weinberg's principle explain the evolution of a population?
2. How would you explain the evolution of new varieties of dogs based on Hardy-Weinberg's principle?
3. Do you think Hardy-Weinberg's principle is applicable to the human population? Justify your answer.
4. Explain the significance of speciation in relation to ecological interaction?
5. How do evolutionary forces such as mutation, genetic drift, and gene flow contribute to variations of species?
6. The golden langur and grey langur common in Bhutan are believed to have evolved from a common ancestor. Provide explanations that account their evolution into different species?

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Appendix A

Science and Engineering Practises

The practises described in this chapter are drawn from those that scientists and engineers actually engage in as part of their work or STEM activities. It is important to recognise that the learner cannot reach the level of competence of professional scientists and engineers, any more than a novice violinist is expected to attain the abilities of a virtuoso. Yet learners' opportunities to immerse themselves in these practises and to explore why they are central to science and engineering are critical to appreciating the skill of the expert and the nature of his or her enterprise.

Science practises are major practises (methods) employed by scientists when they observe and investigate the natural and human-made world and build theories and models. The engineering practises, on the other hand are, major practises (methods) used by engineers when they design and build human-made systems. The classes IX to XII biology curriculum, therefore, emphasises following eight science and engineering practises:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence, and
8. Obtaining, evaluating, and communicating information (NRC, 2012).

Each of the above science and engineering element demands learners and teachers to perform wide arrays of practises. The approach to science practises are considerably similar to engineering practises, however, the role of each element in science briefly contrasts with their counterparts in engineering. Each of the practises can be used iteratively or in combination but not in the orderly fashion as presented. The practises are explained in the following sections as:

DISTINGUISHING PRACTISES IN SCIENCE FROM THOSE IN ENGINEERING

1. Asking Questions and Defining Problems

Science begins with a question about a phenomenon, such as "Why is the sky blue?" or "What causes cancer?" and seeks to develop theories that can provide explanatory answers to such questions. A basic practise of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered.

Engineering begins with a problem, need, or desire that suggests an engineering problem that needs to be solved. A societal problem such as reducing the nation's dependence on fossil fuels may engender a variety of engineering problems, such as designing more efficient transportation systems, or alternative power generation devices such as improved solar cells. Engineers ask questions to define the engineering problem, determine criteria for a successful solution, and identify constraints.

2. Developing and Using Models

Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observables and imagine a world not yet seen. Models enable predictions of the form "if . . . then . . . therefore" to be made in order to test hypothetical explanations.

Engineering makes use of models and simulations to analyze existing systems so as to see where flaws might occur or to test possible solutions to a new problem. Engineers also call on models of various sorts to test proposed systems and to recognize the strengths and limitations of their designs.

3. Planning and Carrying Out Investigations

Scientific investigation may be conducted in the field or the laboratory. A major practise of scientists is planning and carrying out a systematic investigation, which requires the identification of what is to be recorded and, if applicable, what are to be treated as the dependent and independent variables (control of variables). Observations and data collected from such work are used to test existing theories and explanations or to revise and develop new ones.

Engineers use investigation both to gain data essential for specifying design criteria or parameters and to test their designs. Like scientists, engineers must identify relevant variables, decide how they will be measured, and collect data for analysis. Their investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions.

4. Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data usually do not speak for themselves, scientists use a range of tools including tabulation, graphical interpretation, visualization, and statistical analysis to identify the significant features and patterns in the data. Sources of error are identified and the degree of certainty calculated. Modern technology makes the collection of large data sets much easier, thus providing many secondary sources for analysis.

Engineers analyze data collected in the tests of their designs and investigations; this allows them to compare different solutions and determine how well each one meets specific design criteria that is, which design best solves the problem within the given constraints. Like scientists, engineers require a range of tools to identify the major patterns and interpret the results.

5. Using Mathematics and Computational Thinking

In science, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks, such as constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable predictions of the behavior of physical systems, along with the testing of such predictions. Moreover, statistical techniques are invaluable for assessing the significance of patterns or correlations.

In engineering, mathematical and computational representations of established relationships and principles are an integral part of design. For example, structural engineers create mathematically based analyses of designs to calculate whether they can stand up to the expected stresses of use and if they can be completed within acceptable budgets. Moreover, simulations of designs provide an effective test bed for the development of designs and their improvement.

6. Constructing Explanations and Designing Solutions

The goal of **science** is the construction of theories that can provide explanatory accounts of features of the world. A theory becomes accepted when it has been shown to be superior to other explanations in the breadth of phenomena it accounts for and in its explanatory coherence and parsimony. Scientific explanations are explicit applications of theory to a specific situation or phenomenon, perhaps with the intermediary of a theory-based model for the system under study. The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence.

Engineering design, a systematic process for solving engineering problems, is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technological feasibility, cost, safety, esthetics, and compliance with legal requirements. There is usually no single best solution but rather a range of solutions. Which one is the optimal choice depending on the criteria used for making evaluations.

7. Engaging in Argument from Evidence

In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated.

In engineering, reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design process, with a critical stage being the selection of the most promising solution among a field of competing ideas. Engineers use systematic methods to compare alternatives, formulate evidence based on test data, make arguments from evidence to defend their conclusions, evaluate critically the ideas of others, and revise their designs in order to achieve the best solution to the problem at hand.

8. Obtaining, Evaluating, and Communicating Information

Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or to learn about the findings of others. A major practise of science is thus the communication of ideas and the results of inquiry—orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers. Science requires the ability to derive meaning from scientific texts (such as papers, the Internet, symposia, and lectures), to evaluate the scientific validity of the information thus acquired, and to integrate that information.

Engineers cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to be able to express their ideas, orally and in writing, with the use of tables, graphs, drawings, or models and by engaging in extended discussions with peers. Moreover, as with scientists, they need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. In engineering and science alike, new technologies are now routinely available that extend the possibilities for collaboration and communication.

Source: Reprinted [or adapted] from National Research Council (2012).

Appendix B

Technology

Technology is one of the elements of the STEM quartet. It is beyond a limited sense often used schools that equates itself with computational and communication devices. Technology results when scientists and engineers apply their understanding of natural and human world to design ways to satisfy human needs and wants (NRC, 2013). As technology in itself is related to the application of science and engineering, it holds significant role in strengthening paths to understand the role of science and engineering. Therefore, technology may be seamlessly amalgamated with science and engineering practises.

The classes IX to XII biology curriculum considers the amalgamation or leverage of technology with science and engineering practises as:

- Any human-made systems and processes.
- Objects - using physical objects, such as gadgets, mobile devices, computers, etc.
- Body of knowledge-using digital resources, digital learning platforms, search engines, etc.
- Activities-using software or programming languages in designing and making in terms of gamification, simulations, animations, robotics, or coding;
- Volition-using technology to promote human and cultural values, socio-economic values, and environmental values.

Appendix C

Specific Science and Engineering Practises

With a growing body of research in science education, numerous specific pedagogies have evolved both in the field of science (scientific methods) and engineering (design process) practises. The specific pedagogical practises of both science and engineering practises are evidence-based and research-proven with adequate theoretical grounding. The specific pedagogies are featured in the following sections as:

A. Specific Science Practises

Specific science practises (scientific inquiry/scientific methods/argument-driven inquiry):

1. Inquiry cycle/science cycle (Question, educated guess, experiment, data analysis, conclusion)
2. Project-based learning
3. Problem-based learning
4. Design-based learning/Biomimcy
5. Nature Inspired Innovation or Natured Inspired Design
6. Case-based learning
7. Game-based learning
8. Story-based learning
9. REI (Research, Evidence, and Inference)
10. RET (Research, Evidence, Task)
11. OMG (observe, measure, and generalise)
12. CER (Claim, Evidence, and Reasoning)
13. Explore-before-Explain (EbE)
14. OEC (Obtain/search, Evaluate, and Communicate)
15. GRE (Gather, Reason, and Explain)
16. IDEAS (Idea, Evidence, and Argument in Science)
17. POE (Predict, Observe, and Explain)
18. PROE (Predict, Reason, Observe and Explain)
19. PEOE (Predict, Explain, Observe, and Explain)
20. POEA (Predict, Explain, Observe, and Apply)
21. TPE (Think, Puzzle, and Explain)
22. Kolbles learning cycle (concrete experience, reflective observation, abstract conceptualization, and active experimentation, etc.)
23. Atkin and Karplus Learning cycle (concept exploration, concept invention, and concept application)
24. Other learning cycles (3E, 4E, 5E, 6E and 7E)
25. 5D inquiry or appreciative inquiry (Define, Discovery, Dream, Design, Deliver)

26. ADDIE model (Analyse, Design, Develop, Implement, and Evaluate)

B. Specific Engineering Practises

Specific engineering practises (engineering design process/ design process/design thinking):

1. DBT (Design, Build, and Test)
2. DDO (Design, Develop, and Optimise the solutions)
3. EDM (Explore, Design, and Make)
4. ADDIE (Analyse, Design, Develop, Implement, and Evaluate)
5. 5D (Definition, Discovery, Dream, Design, Deliver)
6. Comprehensive engineering design process as:

    - Identify the Need & Constraints
    - Research the Problem
    - Imagine: Develop Possible Solutions
    - Create: Build a Prototype
    - Test and Evaluate Prototype
    - Improve: Redesign as Needed

7. Design thinking process:

    - Formulating Problems
    - Seeking Solutions
    - Thriving in Uncertainty
    - Collaborating Constantly
    - Prototyping Ideas
    - Iterating Options
    - Reflecting Frequently

Appendix D

Weighting and Instructional Time for Class IX

Sl No	Core Ideas	Weighting (%)	Instructional Time (min)
1. Molecules to Organism: Structures and Processes			
1.1	Cells in living organisms	5	120
1.2	Photosynthesis: Food for Life	6	180
1.3	Transpiration: The Persperation in Plants	7	300
1.4	Digestion: What's on the Plate?	9	390
1.5	Transport and Exchange in Our Body	9	390
1.6	Response and Coordination	12	450
2. Ecosystems: Interactions, Energies and Dynamics			
2.1	Interaction in its Environment	8	240
3. Heredity: Inheritance and Variation of Traits			
3.1	Variation of Traits	7	200
3.2	Chromosome, DNA and Gene	10	390
3.3	Cloning and Genetic Engineering	7	180
4. Biological Evolution: Unity and Diversity			
4.1	Evidence of Common Ancestry	14	520
4.2	Theories that Explain Evolution	6	240
	Total	**100**	**3, 600**

Appendix E

Weighting and Instructional Time for Class X

Sl No	Core Ideas	Weighting (%)	Instructional Time (min)
1. Molecules to Organism: Structures and Processes			
1.1	Prokaryotic Cells abd Eukaryotic Cells	4	120
1.2	In and Out of the Cell	7	180
1.3	Photosynthesis: Food for Life	10	300
1.4	Transportation of Substances in the Plant	4	180
1.5	Digestion: What's on the Plate?	10	300
1.6	Transport and Exchange in our Body	6	200
1.7	Response and Coordination	7	300
1.8	Excretion: Removal of Waste	5	180
1.9	Microorganisms: Diseases and Drugs	5	240
2. Ecosystems: Interactions, Energies and Dynamics			
2.1	Organisms in its Environment	11	420
3. Heredity: Inheritance and Variation of Traits			
3.1	Growth, Development, and Reproduction	8	280
3.2	Inheritance and Variation of Traits	7	360
4. Biological Evolution: Unity and Diversity			
4.1	Genetic Basis of Natural Selection	5	240
4.2	Artificial Selection	5	120
4.3	Factors Responsible for Speciation	6	180
	Total	**100**	**3, 600**

Note:

The disciplinary core idea-wise weighting and the corresponding instructional hours (both class IX and X) is purported to assist classroom instructional practises and assessment of learner's

performance expectations or competencies (performance or authentic assessments). At times, learning in the context of project-based learning, problem-based learning, or engaging in design challenges may entail learning over an extended period of time. In such a situation, the specific hours of instructional time drawn in the table may neither suffice the need nor appear ideal. Therefore, the scale and proportion of instructional time may change as per the need of the hour so long the learning objectives are achieved as intended. At the same time, if the weighting cleaved against each disciplinary core idea is deemed necessary to tinker as per the need, the same can be changed by small margin or so.

Concurrently, the disciplinary core idea-wise weighting is not entirely based on the length of the instructional time. The weighting is computed considering several parameters, such as length of the instructional hours and the nature of the learning objectives in terms of intricacy, complexity, and relevancy.