BIOLOGY

A Textbook for Grade 11

B11TB

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Monrovia, Republic of Liberia

Star Educational Books Distributors (P) Ltd.
Delhi, India

ISBN : 978-93-95626-24-8

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Printed on 80 gsm Maplitho paper in Bookman 12 pt.
Typeset and Cover designed by Shri Ganpati Enterprises, Delhi - 110 052

Published and Printed at:
Star Educational Books Distributors (P) Ltd., 4736/23, Ansari Road, Darya Ganj, New Delhi - 110002, India for Ministry of Education, Monrovia, Republic of Liberia

Email: info@estar-bk.com, Website: www.estar-bk.com

Foreword

Liberia, having gone through a period of utmost turmoil till 2003, due to the civil wars, is still reeling under its effect and the added trauma of Ebola in 2014 and effects of the COVID-19 outbreak in 2020. The Liberian government, in the past decade, has made valiant efforts to bring order to the lives of its people. In one such effort, the Ministry of Education (MoE) brought changes to the National Curriculum Framework which are relevant to the present generation, and which would prepare them to meet the challenges of the changing trends of the world. The National Curriculum Framework (NCF) 2018 recommends a change in basic assumptions in the teaching learning process from behaviorist to constructivist approach — moving from hardcore print material to the digital world. Keeping in consideration the sociocultural context and varied experiences of learners as laid down in the Framework, our Teaching Learning Materials are expected to be competent to use multiple methods and techniques like e-learning resources, energized textbooks, and readily available reference material to engage the learners.

As a first initiative, the MoE, through its World Bank-funded Improving Results in Secondary Education (IRISE) project, has adapted textbooks for Grades 10 to 12 in five subjects — English Language and Literature, Mathematics, Biology, Physics and Chemistry.

The National Curriculum Framework, 2018, recommends that children's learning at school is a reflection of their life outside the school and shows them the path to become a responsible citizen who makes knowledge-based choices.This principle marks a departure from the legacy of teacher centered learning to student centered learning. The syllabi and textbooks developed on the basis of the NCF indicate a serious attempt to implement the idea of Activity Base Learning (ABL). We hope these

measures will take us ahead in the direction of building a system of education as outlined in the NCF.

Combined with the efforts by the school principals and teachers this will encourage children to reflect on their own learning and to pursue imaginative activities and questions.With this in mind, perhaps for the first time in our country, we are able to provide separate subject specific textbooks accompanied with guides for teachers for 10–12 grades. Not only have these been developed, adapted and modified to the Liberian context, each of the eight Minimum Learning Competencies (MLCs) have been included in each textbook. So as to reach every high school student, for the first time in the country's history we have included the digitized form of the textbook accessible by a Quick Response (QR) code given in each book. Not only does it have the digitized textbook, but it provides additional learning materials for use by students, teachers and interested persons. The links to these e-resources and digitized material is being made available on the MoE's website.

The Textbooks and Teacher Guides have reached the hands of the students after a rigorous quality evaluation by carefully handpicked subject specialists by the MoE, to whom the Ministry expresses gratitude. For the success of this project, I acknowledge the contributions of the IRISE Project Team in the World Bank, and in particular, the Task-Team Leaders; the Project Implementation Team in Liberia headed by its Coordinator Abraham A. Kiazolu II, supported by the Executive Director of the Center of Excellence for Curriculum Development and Textbooks Research, Mrs. Julia K. Sandiman-Gbeyai and her technical working group (TWG), and the International Textbook Consultant and Advisor, Dr Shveta Uppal engaged by the MoE. These notwithstanding would not have been possible without the guidance of the Senior Management Team (SMT) of the Ministry of Education, and in particular, the Deputy Ministers for Instructions, Administration, and Planning, Research and Development, respectively.

Professor Dao Ansu Sonii, Sr.
Minister of Education
Republic of Liberia

Monrovia, Republic of Liberia
January 24, 2023

Acknowledgments

The development of textbooks contributes to the quality of teaching and learning that go on in the classroom.

The Ministry of Education (MoE) has aligned its Curriculum for Grades 10–12 to the National Curriculum Framework (NCF) of 2018. To ensure the provision of Teaching Learning Materials (TLMs) that support the revised curriculum, the Ministry has sought, reviewed and adapted a new set of textbooks and teacher guides along with digitized contents and e-learning resources for the five core subjects taught at the Senior Secondary education level, namely English Language and Literature, Mathematics, Biology, Chemistry and Physics, through an internationally competitive bidding process from the market supported by the World Bank funded Improving Results in Secondary Education (IRISE) Project.

With profound gratitude and honor, we recognize the Senior Management Team of the Ministry, headed by the Coach, Professor D. Ansu Sonii, Sr., for the strategic decision to make teaching learning materials available and accessible to all in the Liberian Senior Secondary School System, and for providing directions through the process of securing these textbooks and other teaching learning materials for our students and teachers. Our special thanks and appreciation to the World Bank for the financial support towards this policy intervention, and its education task-team including Alonso Sanchez, Oni Lusk-Stover and Binta B. Massaquoi for all their technical inputs offered throughout the process to ensure the kind of quality TLMs the Liberian students deserve are made available for improved learning outcomes.

We would like to specifically recognize the invaluable contributions of the 15 subject experts selected by the MoE from across the various education systems and the West African Examinations Council (WAEC) to evaluate, review and sign off on these teaching learning materials. They didn't just deliver according to our expectations, but also ensured the contextual relevance of the materials to the Liberian Secondary

Education Curriculum and its minimum learning competencies (MLCs). These subject experts include Professor Isaac Saye-Lakpoh Zawolo – *Superintendent* of the Monrovia Consolidated School System (MCSS), Mr. Matthew V.Z. Darblo, Sr. – *Mathematics Instructor* at the University of Liberia (UL), Mr. Charles Tieh Bropleh – *Mathematics Specialist* (MoE), Mrs. Linda Y. Dean – *English Specialist*, Mr. Hassan M. Bangura – *English Language and Literature Expert*, Mr. J. Emmanuel Milton – *English Specialist* (MoE), Mr. Moses K.M. Togbah – *Physics Specialist*, Mr. Prince A. Dossen – *Physics Specialist*, Mr. Benjamin Koryah – *Physics Instructor* at the University of Liberia (UL), Mr. Dominic Dugbe Doe – *Chemistry Specialist*, Mr. Patrick A. Anderson, Sr. – *Director of* the Division of Technical and Vocational Education (MoE), Mr. Kandakai Massaquoi – *Chemistry Specialist*, Ms. Patricia N. Doe – *Head* of Biology Department, African Methodist Episcopal University (AMEU), Mr. Job Carpenter – *Biology Specialist* and Mr. Prince Philip K.A. Aderibigbe – *Biology Specialist*.

The MoE is sincerely grateful to Dr Shveta Uppal, the *International Textbook Consultant* engaged by the IRISE Project to provide technical guidance and quality assurance support to the revising of the Textbooks Management Guidelines (TMG) and the procurement process leading to the provision of textbooks, teacher guides, digital contents and e-learning resources for the Senior Secondary School System in Liberia in accordance with the revised TMG. Heartfelt thanks and appreciations also to the *Executive Director* for the Center of Excellence for Curriculum Development and Textbooks Research, Mrs. Julia K. Sandiman-Gbeyai, and members of her Technical Working Group (TWG) for taking up the responsibility to lead the process of making textbooks and other TLMs available to Liberian students and teachers.

Lastly, we acknowledge the IRISE Project Delivery Team led by Mr. Abraham A. Kiazolu, II – *Project Coordinator*, Mr. Fuseini A. Abu – *International Procurement Specialist* and Mr. Lawrence S. Taylor – *Project Control Specialist* who coordinated the entire process.

We remain grateful to you all!

Hon. Alexander N. Duopu, Sr.,
Deputy Minister for Instruction
Ministry of Education, Republic of Liberia
#The Teacher

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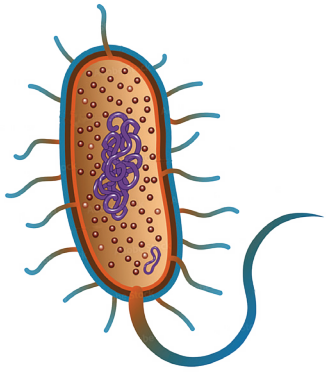

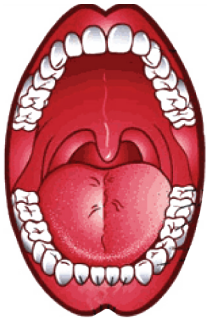

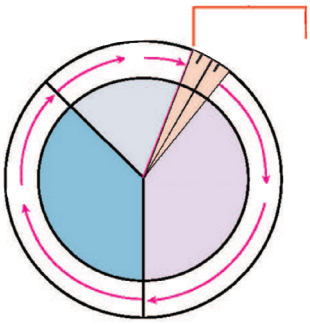

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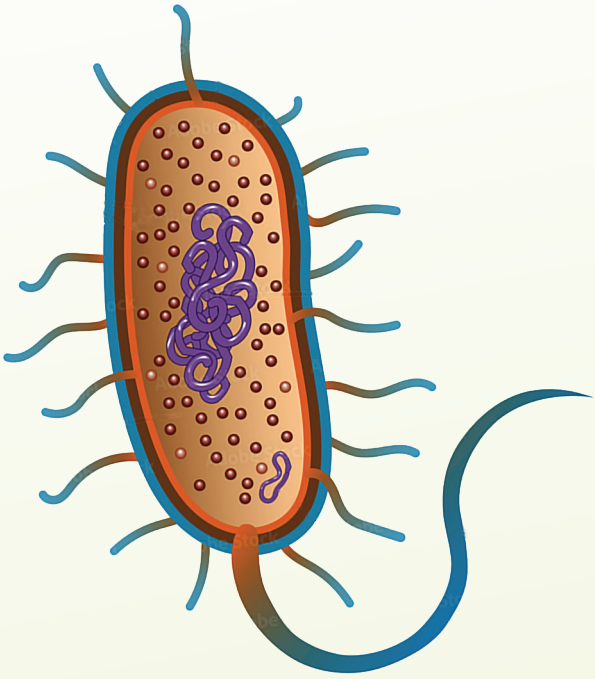
CHAPTER 1

VIRUSES AND BACTERIA



Chapter Contents

Chapter Outcomes

Upon completion of chapter, learners will be able to:

- list the characteristics of Viruses;
- classify Viruses based on Nucleic acid (DNA or RNA);
- explain the life cycle of a Virus;
- list some Viral diseases and organisms they attack, modes of transmission and methods of prevention;
- describe Bacteria of various kinds;
- classify Bacteria;
- list and describe some common Bacterial diseases and their symptoms;
- outline preventive measures of Bacterial diseases;
- distinguish between autotrophic and heterotropic nutrition; and aerobic, anaerobic and facultative and obligate anaerobic respirations;
- explain the economic importance of Bacteria.

Introduction

This chapter deals with Viruses and Bacteria concerning their general characteristics, structures, composition, classification and some of the major diseases caused by them. In addition to these, the lesson gives information about the replication of viruses. Finally, the lesson goes through the mode of transmissions and preventions of sexually transmitted infections caused by Viruses and Bacteria.

1.1 Virus

The word Virus is from the Latin word "Virus"referring to poison and other noxious substances, first used in English in 1392. Virulent, from Latin virulentus (poisonous), dates to 1400. A meaning of "agent that causes infectious disease" is first recorded in 1728, before the discovery of viruses by Dmitry Ivanovsky in 1892. The term virion is also used to refer to a single infective viral particle. The plural is "viruses".

Viruses are microscopic which can be seen only under electron microscope. They do not display, any characteristic of life out side of a living cell.

Virology is the study of viruses: their structure and classification, how they infect and exploit cells to replicate and cause disease, the techniques to isolate and culture them, and their potential uses in research and therapy.

A. General Characteristics of Viruses

Viruses

- are acellular or have no any cellular structures.
- contain a single type of Nucleic acid, either DNA or RNA.
- enclosed within a Protein coat Capsid.
- have few or no enzymes of their own for metabolism.
- are metabolically inert or no respiration, excretion, homeostasis, DNA and Protein synthesis.
- are obligate intracellular parasites or require host cell to reproduce.
- are specific to their hosts.
- can be crystalized.
- cannot be cultured in a nutrient medium.
- can mutate or evolve.

B. Composition of Viral Structure

Viruses display a wide diversity of shapes and sizes, called morphologies. Generally viruses are much smaller than bacteria. Most viruses that have been studied have a diameter between 10 and 300 nanometers. Some filoviruses have a total length of up to 1400 nm; their diameters are only about 80 nm.

A complete virus particle, known as a virion, consists of nucleic acid surrounded by a protective coat of protein called a capsid. These are formed from identical protein subunits called capsomers. Viruses can have a lipid "envelope" derived from the host cell membrane. The capsid is made from proteins encoded by the viral genome and its shape serves as the basis for morphological distinction.

1.2 Classification of Viruses

The International Committee on Taxonomy of Viruses (ICTV) classification system is used in conjunction with the Baltimore classification system in modern virus classification. The Baltimore classification of viruses is based on the mechanism of mRNA production. This classification places viruses into seven groups:

dsDNA viruses (e.g. Adenoviruses, Herpesviruses, Poxviruses)

ssDNA viruses (+)sense DNA (e.g. Parvoviruses)

dsRNA viruses (e.g. Reoviruses)

(+)ssRNA viruses (+)sense RNA (e.g. Picornaviruses, Togaviruses)

(-)ssRNA viruses (-)sense RNA (e.g. Orthomyxoviruses, Rhabdoviruses)

Activity 1

Listing and discussing viruses and bacteria that cause diseases

List down as much as you can viruses and bacteria that cause diseases in humans and other organisms

ssRNA-RT viruses (+)sense RNA with DNA intermediate in life-cycle (e.g. Retroviruses)

Activity 2

Identifying and listening common viral and bacterial diseases

Identify and list the common viral and bacterial diseases of humans, the body part they infect mode of transmission and the prevention methods.

dsDNA-RT viruses (e.g. Hepadnaviruses)

NB: ds = Double strand, ss = Single strand, + = Positive sense, - = Negative sense

1.3 Common Viral Diseases

Table 1 Major viral diseases of humans

Disease	Vector	Attack	Mode of transmission	Prevention method
Common cold	Human	Respiratory tract	Coughing, sneezing hand contaminated	Self/social hygiene
Influenza	Duck/ human	Respiratory tract	Coughing/sneezing	Self/social hygiene
Mumps	Human	Skin	Contact with infected saliva	Vaccination
Chicken box	Human	Skin	Contact with infected person	Vaccination
Rabies	Dog / human	Encephalomyelitis	Bite of infected animal	Vaccination
Polio	Human	CNS		Vaccination
HIV/AIDS	Human	Immune	through blood to blood communication such as through sexual intercourse	Example condom

Viral diseases in plants

Viruses are seldom lethal to plants, but do severely affect the host both in quantity, quality and longevity. Symptoms may often be very characteristic for a specific virus on a specific host. Symptoms along with other criteria are used to identify virus diseases. An advanced array of symptoms can be recognized today as expressions of viral diseases in plants. Some of these would include abnormal leaf color, abnormal vein patterns of leaves, mottling in leaves, spotting patterns in leaves, and abnormal leaf shape. There are also abnormalities of flower color, fruit size, shape and color.

Crop	Disease	Virus	Virus group
Cassava	Mosaic	Indian cassava mosaic virus	Begomovirus
Cotton	Leaf curl	Cotton leaf curl virus	Begomovirus
Groundnut	Bud necrosis	Groundnut bud necrosis virus	Tospovirus
Mungbean Blackgram	Yellow mosaic	Mungbean yellow mosaic virus	Begomovirus
Soybean Pigeonpea	Sterility Mosaic	Pigeonpea sterility mosaic virus	Tenuivirus
Potato	Mosaic	Potato virus Y	Potyvirus
Rice	Rice tungro	Rice tungro badna and rice tungro spherical viruses	Badnavirus and waika virus
Sunflower	Necrosis	Sunflower necrosis virus	Ilarvirus
Tomato	Leaf curl	Tomato leaf curl virus	Begomovirus

1.4 Structure of a Bacteriophage

Bacteriophage is a type of virus that infects and destroys bacteria. It consists of a head, containing the genetic material, and a tail, which attaches to the exterior of a bacterium.

The genetic material of the bacteriophage passes from its head through its tail into the bacterium. The genetic material then directs the bacterium to create new bacteriophages, which eventually burst in to host and, in the process, destroy the host. The released bacteriophages attack nearby bacteria, and the infection process continues. (Figure 1)

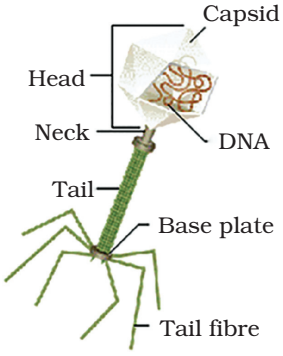


Figure 1. Structure of a typical virus

Review Exercise

1. What do viruses have in common?
   (a) Tail
   (b) Head
   (c) DNA
   (d) Capsid
2. Viruses are better characterized as
   (a) Cellular entities
   (b) Intra- cellular parasites
   (c) metabolically active organism
   (d) self –reproducible organisms
3. Which of the following viral diseases is transmitted by the bite of infected dog?
   (a) Polio
   (b) Ebola
   (c) Mumps
   (d) Rabies
4. Which of the following viruses is equipped with RNA?
   (a) HIV
   (b) Adenovirus
   (c) Herpes virus
   (d) Parovirus

1.5 Life Cycle of a Virus

Viral populations do not grow through cell division, because they are acellular; instead, they use the machinery and metabolism of a host cell to produce multiple copies of themselves, and they assemble in the cell.

The multiplication of viruses in their host cells involves the following steps.

Attachment: binding of the virus to the host cell.

Penetration: entry of the genetic material of the virus into the host cell.

Replication: duplication of the viral genetic material inside the host cell.

Assembly: organizing the genetic material and the capsid of the virus.

Releasing: bursting of the cell membrane of the host by lysis to infect new cells.

The knowledge about viral multiplication has been provided by the work on bacteriophages, especially T_4 phage.

(a) **Lytic cycle:** - The bacteriophage penetrates the host and releases its genetic material or genes and inhibits the host gene replication. By pirating its host's enzymes and protein-building capacities, the virus can replicate itself and repackage, making about 100 new copies before it bursts from and destroys the bacteria. Then, the viral gene codes a lysosome that disrupts the cell wall and bursts (lysis) the bacterial host cell end up with death. (Figure 2)

(b) **Lysogenic cycle:**- In which the injected genetic material of the bacteriophage instead integrates itself into its host genome, passively replicating with it to be inherited by bacterial daughter cells. In about 1 in 100,000 of these lysogenic cells, the viral genome spontaneously activates and starts a new lytic cycle. (Figure 2)

Activity 3

Diagraming the life cycle of bacteriophage.

Draw the lytic and lysogenic life cycle of bacteriophage and show what is happening in each step of the cycles.

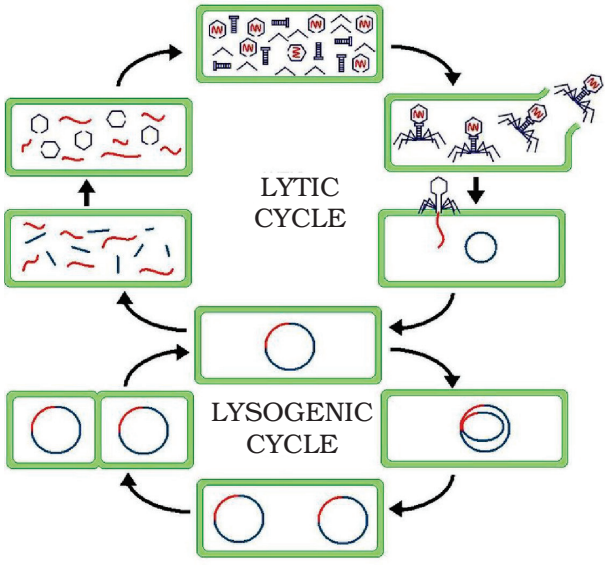


Figure 2. Lytic and lysogenic cycle of bacteriophage T4

1.6 Sexually Transmitted Infections (STI)

Sexually transmitted infections are infections transmitted through sexual intercourse. The opportunities for these infections are unsafe or unprotected sexual intercourse and promiscuity.

STI has replaced the term STD (sexually transmitted disease). In medical science, infection is the term used to indicate bacteria, virus, parasite or other microbe that has entered the body and begun to multiply. The term disease indicates that signs and symptoms of illness are present. There are many people with STIs who have no symptoms; therefore STI is a more accurate term.

Some of the most common STI are

(i) Gonorrhea is caused by bacteria. While most people don't have symptoms, it can cause pus discharge from the penis, vagina or anus, or cause burning pain during urination, pain during sex or in the lower abdomen. Gonorrhea can also infect the throat, anus, pelvic organs and eyes. If not treated, gonorrhea can lead to pelvic inflammatory disease, testicle infections and infertility. Gonorrhea is treated with antibiotics.

(ii) Syphilis is caused by bacteria. Not everyone will have symptoms. If they do, the average time between infection and symptoms is 21 days. Early symptoms may include painless sores in the genitals, mouth and rectum, or a painless rash on the palms of the hands, soles of the feet or the whole body. If not treated early, it can lead to serious health problems like blindness, or problems with the nervous system or the heart. Syphilis is treated with antibiotics.

(iii) Chanchroid:- is a bacterial infection transmitted through sexual intercourse with an infected guy. Its infection can be prevented by having a single partner or wearing condom during sexual intercourse.

(iv) Chlamydia is caused by bacteria. While most people don't have symptoms, it can cause symptoms such as pain when a person urinates (pees), pain during sex or anal discharge. Chlamydia is treated with antibiotics.

(v) Genital herpes is caused by the herpes simplex virus (HSV). It may cause blisters in the genitals, rectum or mouth. Because it's caused by a virus, genital herpes can't be cured easily.

(vi) Genital warts are caused by the human papillomavirus (HPV). It causes skin growths on or around the genitals or anus. The symptoms can vary greatly. Some people have only a few warts while other people have many warts. The warts may also continue to grow and spread or go away on their own. They often come back after treatment. HPV can be prevented by getting immunized.

(vii) Hepatitis B is a viral infection of liver. The virus can be passed on through sexual contact, sharing needles or contact with blood. Some people with hepatitis B have no symptoms, while others may be very tired, have a mild fever or muscle aches. While most people recover, some develop chronic infections. It can lead to serious liver disease, liver cancer and death. Hepatitis B can be prevented by getting immunized.

(viii) Trichomoniasis (also called 'trich') is caused by a *Plasmodium* parasite. Not everyone has symptoms. The symptoms can include pain when urinate, discharge from the penis or vagina, itching in the penis or vagina and pain during sex. Trichomoniasis can't be treated by antibiotics.

(ix) HIV is caused by a virus. HIV can be transmitted through sexual contact, sharing needles or contact with body fluids. HIV attacks the immune system (the body's defense system against illness and infection). Without a strong immune system, the body can't fight infection or disease. If it's not treated, someone with HIV can develop AIDS. While there's no cure, treatments can help people live long and healthy lives.

STIs are infections that are passed on by sexual contact and affect people of all genders. This includes vaginal, anal or oral sex, or intimate skin-to-skin contact without penetration in some instances. Therefore, any type of sexual contact or activity involves some risk. Although most STIs can be cured, some are exceptions i.e., HIV, genital herpes and HPV.

Abstinence—no sexual contact, including intercourse or oral sex—is the only 100% way to prevent an infection. Similarly, practicing safe sex lowers the risk of STI. Using condom every time during sex lowers the risk of STIs. Getting tested is important way to protect ones and others health as it is a sign of right and responsible sexual behavior.

Activity 4

Discussing STIs caused by viruses and bacteria,mode of transmission and prevention. Discussion on the importance of HIV testing and support

Find out some other types of STIs caused by viruses and bacteria, discuss their mode of transmission and prevention methods. Also discuss the importance of HIV testing and support

Review Exercise

1. Which of the following is FALSE about STIs? They are
   (a) Sexually transmitted.
   (b) All curable and treatable.
   (c) Can affect sexually active people of all genders
   (d) The risk of contracting them is lowered by using condom
2. Which of the following STIs is not caused by virues?
   (a) Hepatitis B
   (b) Genital warts
   (c) Trichomoniasis
   (d) Genital Herpes
3. What is the best method in prevention of STIs, especially for young people at your age?
   (a) Abstinence
   (b) Using condom
   (c) Getting tested every time
   (d) Taking shower after having sex.
4. In the Lytic cycle, Viruses:-
   (a) Reproduce outside the host cells
   (b) Allow replication of the host DNA
   (c) Multiply together with the host cells
   (d) Burst and kill the host cells for new cells infection

1.7 Bacteria

A. **Bacteria are a large group of unicellular microorganisms.**

Typically a few micrometers in length, bacteria have a wide range of shapes, ranging from spheres to rods and spirals.

Bacteria display a wide diversity of shapes and sizes, called morphologies. Bacterial cells are typically 0.5–5.0 micrometers in

length. However, a few species are up to half a millimeter long and are visible to the unaided eye.

B. **General characteristics**

- Bacteria do not have a membrane-bound nucleus, and are prokaryotic organisms.
- Their genetic material is typically a single circular chromosome located in the cytoplasm in an irregularly shaped body called the nucleoid.
- The nucleoid contains the chromosome with associated proteins and RNA.
- Like all living organisms, bacteria contain ribosomes for the production of proteins, but the structure of the bacterial ribosome is different from those of Eukaryotes.

C. **Classification and shape**

The Gram stain, developed in 1884 by Hans Christian Gram, characterizes bacteria based on the structural characteristics of their cell walls. The thick layers of peptidoglycan in the "Gram-positive" cell wall stain purple, while the thin "Gram-negative" cell wall stain pink.

There are broadly speaking two different types of cell wall in bacteria, most bacteria have the Gram-negative cell wall and only the Firmicutes and Actinobacteria have the alternative Gram-positive arrangement.

These differences in structure can produce differences in antibiotic susceptibility, for instance vancomycin can kill only Gram-positive bacteria and is ineffective against Gram-negative pathogens, such as *Haemophilus Influenzae* or *Pseudomonas aeruginosa*. By combining morphology and Gram-staining, most bacteria can be classified as belonging to one of four groups

- Gram-positive cocci,
- Gram-positive bacilli,
- Gram-negative cocci and
- Gram-negative bacilli.

Bacterial shapes (Figure 3)

Cocci (sing. coccus, from Greek kókkos, grain, seed) - **Spherical shape**

- Single coccus: One coccus
- Diplococci: two cocci joined together
- Streptococci: chain or string of cocci
- Staphylococci: bunch of cocci, like a grape

Bacilli (sing. bacillus, from Latin baculus, stick) - **rod shaped**

- Bacilli: Simple Rod
- Vibrio: Slightly curved or comma-shaped Rod
- Spirilla: Spiral- shaped Rod
- Spirochaetes: Tightly coiled, Rod

A small number of species have tetrahedral or cuboidal shapes.

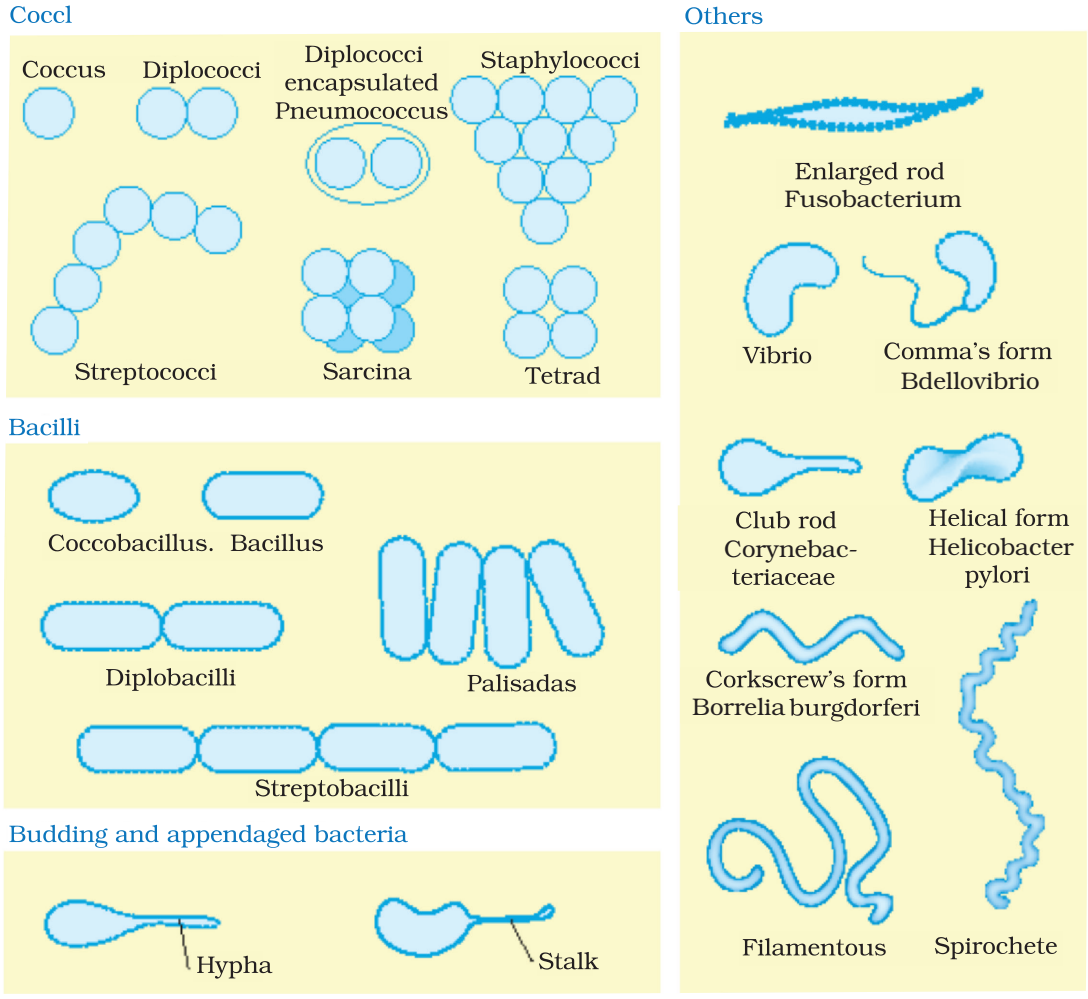


Figure 3. Shapes in bacteria

ACTIVITY 5

Lab activity: Bacteria shapes, composition and structure

Materials

- Microscope
- Slide
- Coverslip
- Yoghurt
- Dropper

Procedure

1. Using a dropper add some drops of yoghurt on a slide and cover it with a coverslip.
2. Using light microscope observe the specimen first through a lower objective then through a higher objective.
3. Draw what you see.

D. Composition

Cellular Structure

Intracellular structures: The bacterial cell is surrounded by a lipid membrane, or cell membrane, which encloses the contents of the cell and acts as a barrier to hold nutrients, proteins and other essential components of the cytoplasm within the cell.

As they are prokaryotes, bacteria do not tend to have membrane-bound organelles in their cytoplasm and thus contain few large intracellular structures. They consequently lack a nucleus, mitochondria, chloroplasts and the other organelles present in Eukaryotic cells, such as the golgi apparatus and endoplasmic reticulum.

Extracellular structures

Around the outside of the cell membrane is the bacterial cell wall. Bacterial cell walls are made of peptidoglycan, which is made from polysaccharide chains cross-linked by unusual peptides containing D-amino acids.

Cell wall is different from the cell walls of plants and fungi, which are made of cellulose and chitin, respectively.

Flagella are rigid protein structures, about 20 nanometers in diameter and up to 20 micrometers in length, which are used for motility. Flagella are driven by the energy released by the transfer of ions down an electrochemical gradient across the cell membrane.

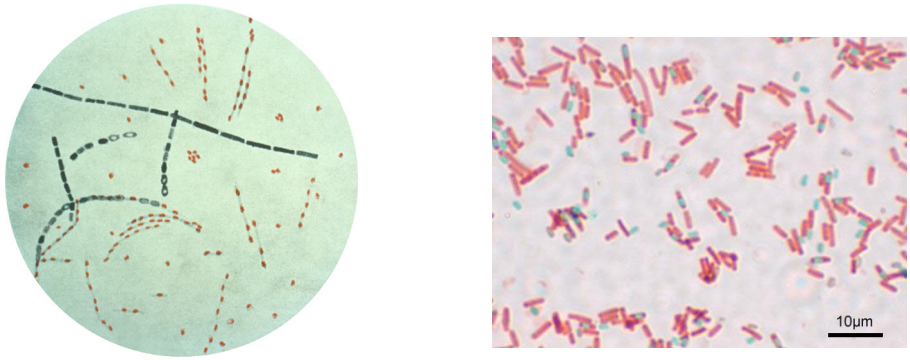
Fimbriae are fine filaments of protein, just 2–10 nanometres in diameter and up to several micrometers in length. They are distributed over the surface of the cell, and resemble fine hairs when seen under the electron microscope. Fimbriae are believed to be involved in attachment to solid surfaces or to other cells and are essential for the virulence of some bacterial pathogens.

Pili (sing. pilus) are cellular appendages, slightly larger than fimbriae, that can transfer genetic material between bacterial cells in a process called conjugation.

Capsules or slime layers are produced by many bacteria to surround their cells, and vary in structural complexity: ranging from a disorganized slime layer of extra-cellular polymer, to a highly structured capsule or glycocalyx.

These structures can protect cells from engulfment by Eukaryotic cells, such as macrophages. They can also act as antigens and be involved in cell recognition, as well as aiding attachment to surfaces and the formation of biofilms.

Endospores are highly resistant, dormant structures formed in Certain genera of Gram-positive bacteria, such as *Bacillus, Clostridium, Sporohalobacter, Anaerobacter and Helicobacterium,*



(a) Bacillus anthracis (b) Endospores

Figure 4. Endospores in bacteria

Bacillus anthracis (stained purple) growing in cerebrospinal fluid In almost all cases, one endospore is formed and this is not a reproductive process (figure 4a) although *Anaerobacter* can make up to seven endospores in a single cell. Endospores have a central core of cytoplasm containing DNA and ribosomes surrounded by

a cortex layer and protected by an impermeable and rigid coat (figure 4b).

Endospores show no detectable metabolism and can survive extreme physical and chemical stresses, such as high levels of UV light, gamma radiation, detergents, disinfectants, heat, pressure and desiccation. In this dormant state, these organisms may remain viable for millions of years, and endospores even allow bacteria to survive exposure to the vacuum and radiation in space.

Endospore-forming bacteria can also cause disease: for example, anthrax can be contracted by the inhalation of *Bacillus anthracis* endospores, and contamination of deep puncture wounds with *Clostridium tetani* endospores causes tetanus.

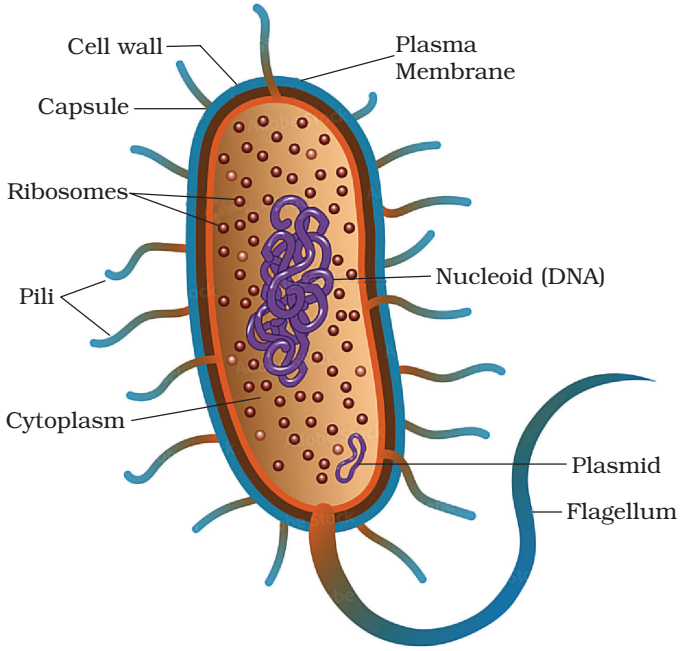


Figure 5. A typical bacterial cell structure

Review Exercise

1. Bacteria are prokaryotic cells because they do **NOT** have:-
   (a) Cell wall
   (b) Ribosomes
   (c) Cell membrane
   (d) Nuclear membrane

2. Which of the following is **FALSE** about bacteria? They are:
   (a) Useless
   (b) Acellular
   (c) Unicellular
   (d) Prokaryotic
3. Which of the following structures is not present in bacterial cells?
   (a) Flagella
   (b) Endospores
   (c) Mitochondria
   (d) Genetic material
4. What type of colony is formed by chains of circular bacteria?
   (a) Spirochetes
   (b) Diplococcus
   (c) Staphylococcus
   (d) Streptococcus

1.8 Common Bacterial Diseases

A. **Tuberculosis (TB):** is a bacterial disease usually affecting the human lungs. It is transmitted by droplets of cough and sneeze.

Symptoms: a prolonged coughing for more than 15 days

- weight loss
- night sweating
- loss of appetite
- fatigue

Prevention: self- hygiene, milk hygiene and ventilation of house and public transport.

B. **Tetanus:** is a bacterial disease affecting skeletal muscles relaxation in humans. It is transmitted through cuts by contaminated materials.

Symptoms: lockjaw and inability to move skeletal bones.

Prevention: self and environmental hygiene

C. Bacterial diarrhea: is a bacterial disease affecting the intestine.

Symptom: frequent watery faeces, weight and appetite loss.

Prevention: personal and food hygiene

1.9 Autotrophic and Heterotrophic Nutrition in Bacteria

A. **Autotrophic nutrition:** It is a type of nutrition, in which organisms manufacture their own food using water and carbon dioxide.

(i) **Photoautotrophs**: these organisms derive energy from sunlight and use CO2 to from organic molecules. e.g. green algae, cyanobacteria & plankton.

(ii) **Chemoautotrophs:** are the organisms that obtain energy from inorganic molecules like hydrogen, iron and nitrogen to make their own food. Sunlight is not required in this process. They use energy from inorgainc molecules like hydrogen, nitrogen and iron to make their own food.

B. **Heterotrophic:** use other organisms or organic compounds to obtain energy e.g. parasitic and decomposer bacteria.

1.10 Aerobic and Anaerobic Respiration in Bacteria

A. **Aerobic respiration:** oxidation of organic compound in the presence of oxygen.

B. **Anaerobic respiration:** oxidation of organic compounds in the absence of oxygen to produce lactic acid.

C. **Facultative respiration:** oxidation of organic compounds in the presence or absence of oxygen.

1.11 Economic Importance of Bacteria

Bacteria are economically important in industries of

- Brewing
- Wine making,

Dairy products

Quite a few genera of bacteria are used in food preparation, directly or indirectly.

Formation of Curd: Milk is converted into curd by bacterial action. The milk's lactose is converted into lactic acid, which gives the characteristic sour taste of the curd. Lactic acid bacteria (LAB) like *Lactobacillus* are added to milk. Indian curd is prepared by inoculating milk with *Lactobacillus acidophilus*.

Yoghurt preparation: It is produced by curdling milk with *Streptococcus thermophilus* and *Lactobacillus bulgaricus*.

Cheese production starts with milk coagulated with lactic acid bacteria and the curd formed is filtered to separate the whey. The solid mass is then ripened with the growth of mould that develops flavour in it. e.g., *Propionibacterium shermanii* is used to make cheese.

In Industry

A large number of products are obtained due to bacterial activity such as

Vinegar or acetic acid produced from fermented beer, wine and cider by ***Acetobacter aceti to flavor and preserve food.***

Citric acid by *Bacillus licheniformis and Corynebacterium species*

Vitamin B12 *by Pseudomonas denitrificans.*

Retting of fibres like jute, etc. *by Clostridium butyricum.*

The curing and ripening of tea and tobacco by *Bacillus megaterium.*

Leather Preparation: Certain species of bacteria are used in removing hair from hides and skins of animals.

In Medicine

Antibiotics production: bacteria have been exploited to produce antibiotics such as Terramycin, Streptomycin, Tetracycline, Aureomycin, Neomycin are obtained from different bacterial species.

Vaccines: several vaccines have been developed from either killed or attenuated (living but multiplying at low rates) bacteria. For example, tuberculosis vaccine, whooping cough vaccine, plague vaccine, DTP (Diphtheria, Tetanus, Pertussis) vaccine, pneumonia vaccine are all prepared with the help of bacteria.

In maintenance of environmental balance and agriculture: Bacteria act as decomposers. They make the nutrient available for plants. Specific genera of bacteria are used as biocontrol agents in agriculture. *Bacillus thuringiensis* (Bt) yields protein-based toxins used to kill some insect pests of crops.

Nitrogen fixation and soil fertility: Certain bacteria are helpful in the fixation of atmospheric nitrogen. *Azotobacter* and *Clostridium* are present in the soil and help in Nitrogen fixation. Species of *Rhizobium* bacteria are present in the root nodules of leguminous plants, and they

increase the soil's Nitrogen content by fixing up atmospheric Nitrogen. The process is known as symbiotic Nitrogen fixation.

Role in nitrogen cycling: Nitrification is one of the most critical steps in the Nitrogen cycle, performed by nitrifying bacteria. Nitrifying bacteria are chemolithotrophic organisms that include the genera *Nitrosomonas, Nitrococcus, Nitrobacter, Nitrobacillus*, etc. These bacteria get their energy by the oxidation of inorganic Nitrogen compounds.

Biogas production: Biogas is a standard domestic and industrial fuel, which contains 50 - 60% Methane, 30 - 40% Carbondioxide, 0 - 3% Sulphur compounds, and traces of other gases like Hydrogen, CO, Nitrogen, etc.

In a biogas digester, (BOD) cattle dung is used to obtain gas (gobar gas) in the following steps:

- **Hydrolysis** is the initial step that needs anaerobic bacteria like *Clostridium, Pseudomonas* etc.
- **Acidogenesis** is the second step, in which the facultatively anaerobic, acidogenic bacteria and obligate anaerobic organisms help convert the simple organic material into acids like formic acid, acetic acid, etc.
- **Methanogenesis** is the last step, in which anaerobic Methanogenic bacteria like *Methanobacterium, Methanococcus*, etc., convert organic acids into Methane.

Sewage treatment: Sewage is agricultural and domestic waste products that pollutes the water. The treatment to remove such waste is partially chemical, biological treatment.

- Secondary treatment is the biological treatment, which reduces the BOD significantly. Aerobic bacteria are used in this process.
- Tertiary treatment is done once there is a reduction of BOD in the settling tank. Mainly Methanogens grow anaerobically and produce biogas.

Review Exercise

1. Which of the following is a product for which bacteria are not used?
   (a) Bread
   (b) Cheese
   (c) Vinegar
   (d) Yoghurt

2. Which of the following products of bacteria are used in medicine?
   (a) Vaccine
   (b) Antibiotics
   (c) Pain killers
   (d) A and B
3. Which of the following is a common bacterial disease transmitted by coughing?
   (a) Leprosy
   (b) Tetanus
   (c) Diarrohea
   (d) Tuberculosis
4. Which of the following nutrition is exhibited by autotrophic bacteria?
   (a) Parasitic
   (b) Saprophytic
   (c) Heterotrophic
   (d) Photosynthetic

Key Terms

- Key terms
- Viruses
- DNA viruses
- RNA viruses
- Retroviruses
- Bacteriophages
- Capsid
- Lytic cycle
- Lysogenic cycle
- Bacteria
- Gram positive
- Gram negative
- Peptidoglycan
- Coccus
- Bacillus
- Spirochete
- *Staphylococcus*/bacillus
- *Streptococcus*/bacillus
- STI

Summary

In this unit you have learnt that

- Viruses are acellular agents that can be seen by electron microscopes
- Viruses are composed of DNA or RNA coated with capsids.
- Viruses are metabolically inactive and have no enzymes for life processes.

- Viruses can infect plants, animals and bacteria
- Bacteriophages infect bacteria only.
- Viruses are mostly specific to their hosts and cause diseases
- Viruses are obligate intra-cellular parasites causing illness and death
- Viruses multiply and reproduce only in their hosts.
- In lytic cycle bacteriophage multiply their gene by stopping their host genome and cause lysis of the host cell.
- In lysogenic cycle bacteriophages multiply their genes along with the host genome and cause lysis when conditions alter in a host cell
- STIs are infections transmitted through sexual intercourse and can be caused by viruses, bacteria and fungi.
- STIs can be treated and cured but if not treated cause serious complications.
- Most STIs can be prevented by wearing condom during intercourse or practicing responsible sexual behavior.
- Bacteria are unicellular microorganisms that can be seen by a compound light microscope.
- Bacteria are prokaryotic cells, devoid of membrane bounded nucleus and other organelles.
- Bacteria have cell wall composed of peptidoglycan used to classify them into gram positive and gram negative.
- Gram positive bacteria stain purple but gram negative bacteria stain red.
- Bacteria like other living organisms are equipped with cell membrane, cytoplasm, ribosomes and genetic material.
- Some bacteria are equipped with highly resistant reproductive structures called endospores.
- Bacteria can exhibit autotrophic nutrition that involve using light or chemicals and some others heterotrophic nutrition involving dependency on other organisms.
- Bacteria can be aerobic or anaerobic or facultative anaerobic in obtaining energy by respiration.
- Bacteria are economically important in making yoghurt, anti-biotics, and vinegar and sewage treatment.

Review Exercises

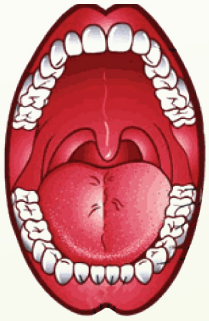
1. Which of the following is **NOT** the feature of viruses?
   (a) Specificity to their hosts
   (b) Ability to mutate and evolve
   (c) Can be crystalized and stored
   (d) Cultured in a nutrient medium
2. Which of the following is exhibited by viruses
   (a) Cellular structures
   (b) Helical or isometric shape
   (c) Metabolic processes involving enzymes
   (d) Asexual reproduction outside their host cells
3. The following viruses are known to infect respiratory tracts; except:
   (a) Adenovirus
   (b) Rhinovirus
   (c) Covid-19
   (d) Filovirus
4. Which of the following viral diseases is common among children?
   (a) Herpes
   (b) Measles
   (c) Yellow fever
   (d) Mononucleosis
5. Which of the following viruses is equipped with DNA?
   (a) HIV
   (b) Covid -19
   (c) Polio virus
   (d) Influenza virus
6. What are bacteriophages?
   (a) Fungi
   (b) Viruses
   (c) Bacteria
   (d) Protozoa
7. Similar to lysogenic cycle, lytic cycle involves:
   (a) Viral multiplication
   (b) Host genome replication
   (c) Viral and host genes replication
   (d) Bursting and killing of the host cells

8. As opposed to gonorrohea and syphilis, HIV/AIDS is:
   (a) Viral infection
   (b) Treatable and curable
   (c) Sexually transmitted
   (d) Prevented by wearing condom
9. Which of the following structures is **NOT** common among bacteria?
   (a) Ribosome
   (b) Mitochondria
   (c) Cytoplasm
   (d) Flagellum
10. In which part of the cell do gram-positive and gram-negative bacteria differ regarding their staining property with Gram's stain?
   (a) Cytoplasm
   (b) Nucleus
   (c) Cell wall
   (d) Cell membrane
11. Contrary to Tuberculosis, Tetanus is:
   (a) A bacterial infection
   (b) An airborne infection
   (c) Prevented by ventilation of houses
   (d) Transmitted through cuts by contaminated rusted materials
12. Which of the following is **NOT** needed for Chemoautotrophic Bacteria?
   (a) Light
   (b) Inorganic ion
   (c) Organic matter
   (d) Dead organisms
13. Which of the following industrial products require Bacteria?
   (a) Leather
   (b) Vitamin B12
   (c) Citric acid
   (d) All of the above
14. Which of the following is **NOT** the economic importance of bacteria?
   (a) Biogas production
   (b) Sewage treatment
   (c) Environmental pollution
   (d) Nitrogen fixation and soil fertility

B11CH02

CHAPTER 2

NUTRITION AND FOOD PRESERVATION



Chapter Contents

Chapter Outcomes

Upon completion of chapter, learners will be able to:

- explain the process of nutrition and state why living things need nutrients;
- outline and classify the types of nutrients found in food;
- classify food into groups;
- demonstrate the presence of various nutrients found in food;
- explain the concept of a balance diet;
- explain the concept of malnutrition;
- determine the dental formula of a mammal (amount and arrangement of teeth);
- explain the importance of dental care in humans;
- name and discuss various methods of preserving and storing food;
- explain methods of preserving food using local resources;
- explain other methods of food preservation in west africa;
- explain the biological basis for preserving and storing food.

Introduction

This chapter deals with the essence of nutrition and its types. Similarly it defines food and nutrients and classifies them along with the technique of testing nutrients in a food. Together with these, the lesson gives focus to balanced diet and malnutrition. In addition, the chapter raises the issues about teeth and dental formula of animals, and the dental care. Finally, it looks into food poisoning and its preservation with the methods and importance of food preservation.

2.1 Nutrition

Nutrition is all the activities by which an organism obtains food and utilizes it to carry out life processes (energy production, body repair, growth, and body regulation).

A. **Autotrophic nutrition:** is a process in which organism synthesize complex organic molecule from simple inorganic molecules to obtain energy. It is the virtue of green plants, algae and some bacteria.

B. **Heterotrophic nutrition:** is a process in which organism break down complex organic molecule into simple molecule to derive energy. It is the feature of animals, fungi, most protists and bacteria.

It can be categorized into

Parasitic nutrition obtaining nutrients form host organisms.

Saprophytic nutrition refers to external digestion of decaying organic matter, absorbing nutrients through the body wall. Some bacteria and fungi are saprophytes.

Holozoic nutrition:- Refers to a method of nutrition that is involved in the ingestion and digestion of solid or liquid organic material and the absorption and assimilation of nutrients by the animal body. These animals can be herbivoures (plant eaters), carnivoures (flesh eater) and omnivoures (flesh and plant eaters).

2.2 Food and Nutrients

Food is anything taken into the body and provide nutrients that

- are needed for body growth and repair.

- release energy when oxidized.
- are needed for the proper functioning of cells.

Nutrients are usable substances contained in foods that are needed for energy, growth and support life processes. These include:

(i) **Carbohydrates:**- are organic compounds made of carbon, hydrogen, and oxygen. The proportion of hydrogen atoms to oxygen atoms is always two to one respectively. The term carbohydrate meaning "hydrate of carbon" stems from the 2:1 ratio of hydrogen to oxygen, same ratio as in water. They are known as carb also.

This is shown in the general chemical formula for carbohydrates, which is (CH_2O) n, where n is the number between three and several thousand. Sugar, starches, and cellulose are typical carbohydrates mainly serve as energy source for living things.

Classification of carbohydrates

A. **Monosaccharides:** are simple sugars. with the words Sugar and starch be classified into:

(i) **Trioses:** are with three carbons and have a general formula $C_3H_6O_3$.
E.g. Glyceraldehyde

(ii) **Pentoses:** are with five carbons and have a general formula $C_5H_{10}O_5$.
E.g. Sugars in DNA and RNA

(iii) **Hexoses:** are with six carbons and have a general formula $C_6H_{12}O_6$.
E.g. Glucose, Fructose and Galactose

B. **Disaccharides:** are sugars composed of two monosaccharides (sugar units). They have a general formula $C_{12}H_{22}O_{11}$. The examples are:

Maltose (malt sugar): in grain; composed of two glucose molecules.

Sucrose (cane sugar): in sugar cane; made of glucose and fructose molecules.

Lactose (milk sugar): in milk; made of glucose and galactose molecules

C. **Polysaccharides:** complex sugars (polymer) composed of repeating units of simple sugars, usually glucose. Have a general formula of Cn (H_2O) n-1 The common examples are:

Starch: stored glucose in the leaves and seeds of green plants.

Glycogen: stored glucose in the liver of animals.

Cellulose: composes the cell wall of plant cells.

Activity 1

Testing for carbohydrates (Reducing and non-reducing sugars) Benedict`s test

You will need

- Benedict's solution
- Glucose solution
- Starch solution
- Test tubes
- Beakers
- Bunsen burner
- Tongs

Method

1. Take a small sample of glucose solution
2. Place equal quantities of benedict's and glucose solution (about 2-3 cm of each) in a one test tube and repeat the same thing for starch solution in another test tube.
3. Put the two test tubes into a beaker of boiling water and record your observation
4. In which test you noticed brick-red precipitate.
5. Repeat the test with carrot and grape juice and record your observation.

Activity 2

Testing fo starch - Iodine test You will need

- Starch solution
- Iodine solution
- Dropper
- Glass

Method

1. Add a few drops of dilute iodine solution to starch solution on glass.
2. Note the colour which appears,
3. Repeat with bread, potato and maize and note colour.

(i) **Lipids:** are organic compounds made of carbon, hydrogen, and oxygen. They comprise a diverse range of water-insoluble or nonpolar compounds of biological origin. Lipids are composed of glycerol and fatty acid units. Include triglyceride, phospholipids and waxes. A triglyceride is composed of a glycerol and three fatty acids. Lipids function as energy reserves, insulators, water proofs and lubricants.

Fats: are animal origin saturated triglycerides and solid at room temperature.

Oils: are plant origin unsaturated triglycerides and liquid at room temperature.

Phospholipid: is with two fatty acids and a phosphate makes cell membrane.

Waxes: are complex lipids with fatty acids and long-chain alcohols.

Activity 3

Testing for lipid - Emulsion test

You need

- Fat or cooking oil
- Ethanol
- water
- Test tubes

Method

1. Add the lipid (food) in to a test tube with about 2-3ml ethanol and shake the mixture
2. Allow it to settle and pour off the ethanol into an equal volume of deionized (pure) water.
3. Note your observation.
4. Repeat it for peanut and castor oil bean and note colour.

(i) **Proteins :** are organic compounds made of carbon, hydrogen, oxygen and nitrogen and rarely sulphur. Proteins are composed of amino acid units. They work as enzymes, transport means, body defence, and structural molecules.

Activity 4

Testing for Protein - Biuret test

You need

- Milk
- Sodium hydroxide

- Copper sulphate
- Test tubes
- Pipette

Method

1. Add 2-3 ml of sodium hydroxide solution to milk and mix it.
2. Add few drops of copper sulphate solution and note the colour.
3. Repeat it for egg albumin and note colour.

Review Exercise

1. Which of the following foods is rich in Carbohydrates?
   (a) Fish
   (b) Bean
   (c) Potato
   (d) Butter
2. Which of the following foods is rich in Proteins?
   (a) Bread
   (b) Red meat
   (c) Orange
   (d) Cabbage
3. What is the nutrient **NOT** contained in Milk?
   (a) Oil
   (b) Fat
   (c) Sugar
   (d) Protein
4. Which of the following foods contains Starch?
   (a) Egg
   (b) Cheese
   (c) Margarine
   (d) Sweet potato

I. Vitamins

Vitamins are complex organic substances included among the essential nutrients. They are required in trace amounts for proper body function. If vitamins are not supplied in sufficient quantities in our diets, our body will face deficiency disease (see Table1). Vitamins cannot be synthesized by mammals and must be obtained from nutrients or mutualistic organisms like bacteria living in our intestine. They are required for proper body function.

Table 1 Vitamins

Vitamin	Major function	Food source	Deficiency diseases	Solubility
A(Retinol)	Visual pigment Green	vegetables, liver, milk	Night blindness, peeling skin	Fat
B1	Coenzyme in CO_2removal during respiration	Meat, grains, legumes	Beriberi, weakening of heart, edema	Water
B2 (Riboflavin)	Part of coenzymes FAD and FMN	Varieties of food	Inflammation and breakdown of skin	Water
B3 (Niacin) Liver, Water	Part of coenzymes NAD+ and NADP+	lean meats, grains	Pellagra inflammation of nerve, mental	water
B5	(Pantothenic acid) Part of coenzyme A, a key connection between carbohydrate and fat metabolism	Varieties of food	Fatigue, loss of coordination	Water
B6 (Pyridoxine)	Coenzyme in synthesis of amino acid metabolism	Cereals, vegetables, meats	Anemia, convulsion, irritability	Water
B12 (Cyanocobalamin)	Coenzyme in the synthesis of nucleic acid	meats, dairy products	Pernicious anemia	Water
Biotin	Coenzyme in fat synthesis and amino acid metabolism	Meat, vegetables	Depression, nausea	Water
Folic acid	Coenzyme in amino acid and nucleic acid metabolism	Green vegetables	Anemia ,diarrhea	Water
C (Ascorbic acid) Scurvy	Formation of collagen, bone, teeth, blood vessels, resistance to infection	Fruit ,green leafy vegetables	breaking of blood vessels	Water
D (Calciferol)	Increases calcium and phosphorus absorption	Fish liver oil, dairy products	Rickets ,bone deformities	Fat

E (Tocopherol)	Protects oxidation of fatty acids and cell membrane	Margarine, seeds, green leafy vegetables		Fat
K	Blood clotting	Green leafy vegetables	Severe bleeding	Fat

The fat soluble vitamins can be stored in fatty tissues in our body for future use. The water soluble vitamins cannot be stored, therefore they shall be included in our daily diet.

II. Minerals

Minerals are inorganic substances required in trace amounts for proper body functions. They are also components of structures in the body. Some minerals act as cofactors and required for proper functioning of enzymes. Minerals are lost in sweat, urine, and other wastes and they have to be replaced by taking them in our diet. Our diet, must supply essential minerals in sufficient quantities. If they are not obtained insufficient quantities our body faces deficiency diseases (see table 2).

Table 2 Minerals

Mineral	Major function	Food source	Deficiency diseases
Calcium	Make up bone and teeth, muscle function, blood clotting, nerve function	Dairy products, fish, green legumes, vegetables	Stunted growth in children- weak bones in adult
Chromium	Helps insulin move glucose from blood into cells	Meat, whole grains, vegetable oils	Abnormal glucose metabolism
Fluorine	Helps make bone and teeth	Fluoride water, sea food	Susceptibility to tooth decay
Iodine	Component of thyroxin hormone	Iodized food, seafood	Goiter
Iron	Component of hemoglobin and carries oxygen	Red meat, fish, poultry	Anemia

Magnesium	Mineralization of bone and teeth, helps enzyme function, muscle contraction and nerve transmission	Nuts, legumes, whole grains, dark leaf green leaf, chocolates	Weakness, muscle jerk, confusion, convulsion, bizarre muscle movements
Phosphorus	Component of bones, teeth, DNA, ATP phospholipids, part of cell metabolism	Meat, fish, poultry, egg, milk	Weak bone
Potassium	Maintain normal body fluid and electrolyte balance, assist nerve impulse transmission and muscle contraction	Fruits, vegetables, grains, meat ,milk	Muscular weakness, vomiting reflex
Selenium	Antioxidant working with vitamin E	Sea foods, meat, grains	Muscle pain, depression
Sodium	Maintain normal body fluid and electrolyte balance, assist nerve impulse transmission and muscle contraction	Table salt, soy sauce, all processed foods	Muscle cramp, loss of appetite, mental apathy
Zinc	Part of insulin, helps many enzyme functions, DNA repair taste perception, functions, wound healing	Protein containing foods, some grains and vegetables	Fever, nausea, vomiting, dizziness

III. **Water**

Water is one of the simplest of the essential nutrients and also the most important substance in life. Water composes most of the body weight of humans and 90 % of the blood plasma. It is a very important solvent and means of transport in a living system. Water also helps in regulating body temperature and removing wastes.

Major groups of foods

Biologists based on the functions of foods, biologists classify them into five groups (Figure1). These groups of food include meat and legumes, milk and cheese, fruits, vegetables, bread and cereals, and fats and sweets. Each group contains the six nutrients in different proportions. So the food that a person consumes in every meal should contain the five groups in a balanced form.

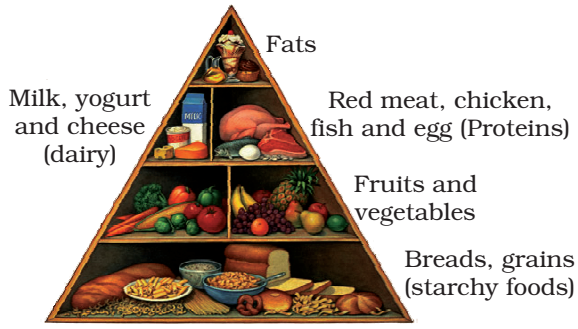


Figure 1. The five major food groups

2.3 Balanced Diet

Balanced diet: - is a diet with the right quantity and quality of nutrients. It is essential to prevent a condition of overweight or underweight.

The health condition of a person at a large extent depends on the correct amount and proportion of each type of food. When these requirements are met, the diet is said to be balanced diet. However, it must be balanced in to different ways.

On one hand, the amount of food taken each day, should not provide -less or more than the amount of energy used during the day.

On the other, a correct balance must be achieved between the proportion of energy-rich foods (carbohydrates and fats), body building foods (proteins), and protective foods (vitamins and minerals) in a diet.

The daily energy requirement of a person varies according to age, sex, body size, occupation and special condition such as pregnancy.

2.4 Malnutrition

Malnutrition: - is a diet problem of taking too little of nutrients such as proteins and carbohydrates.

Kwashiorkor:- caused due, to lack of proteins in the diet especially in children, between 6 months and 3years of age. It is mainly characterized by:

- Enlarged or swollen belly (Figure 2a)
- Poor appetite
- Lethargic or inactive body

- Poor wound healing
- Itchy rash

Marasmus: caused due to lack of carbohydrates or calories in the diet especially in infants under 1 year of age.. It is characterized by:

- loose skin;
- very protruding ribs and bones (Figure 2b);
- decreased subcutaneous fat;
- voracious feeder;
- alert; and
- severe muscle loss.

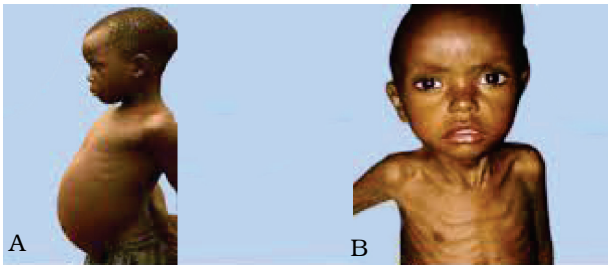


Figure 2. Kwashiorkor and Marasmus

Review Exercise

1. Which vitamin is required for proper vision?
   (a) Vitamin A
   (b) Vitamin B
   (c) Vitamin C
   (d) Vitamin D
2. Which mineral is required for proper function of muscles?
   (a) Iron
   (b) Iodine
   (c) Calcium
   (d) Magnesium
3. Which of the following is true about the importance of balanced diet? It
   (a) Causes obesity
   (b) Effects thinness
   (c) Maintains healthy condition
   (d) Supplies varieties of nutrients

4. What is the cause for marasmus? It is the deficiency of:—
   (a) protein
   (b) vitamin
   (c) mineral
   (d) carbohydrate

2.5 Teeth and Dental Formula

Teeth are hard structures that grow from jaw bones in the mouth. They function to bite, chew, grind and crush food.

A tooth is composed of:

- a **crown** the part above the gum and covered with a hard white layer substance referred to as enamel. Enamel makes teeth appear white.
- a **neck** the part surrounded by gum and covered with a living tissue, dentine.
- a **root** the part inserted in jaw bone and covered with dentine,

Dentine makes the large proportion of a tooth,

A tooth is composed of a central region called pulp cavity that contains nerve and blood vessels (Figure 3).

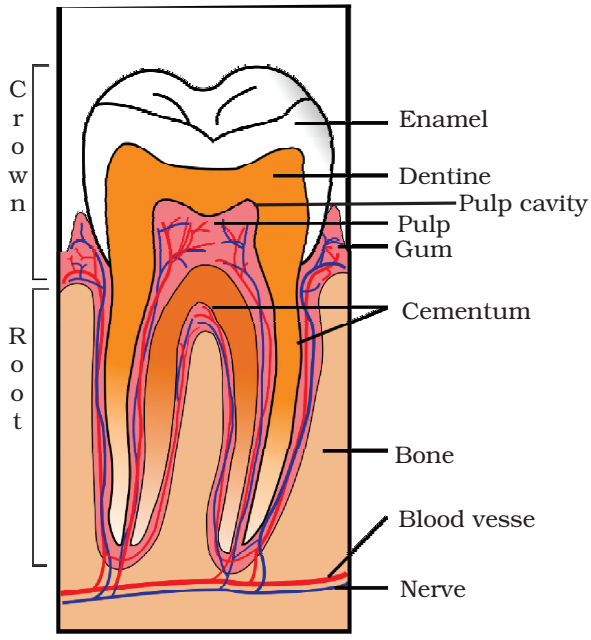


Figure 3. Structures of a tooth

Milk and permanent teeth in humans

There are two sets of teeth that appear in the life time of humans.

Milk teeth: are the first sets of teeth and are replaceable if fallout; such teeth start to loose and fall out when a child is about 6 years old. There are 20 milk teeth in every child,

Permanent teeth: are the second set of teeth and are not replaceable if lost or fall out. There are 28 permanent teeth in humans;

When a person is around 20-25 years of age, develop additional permanent teeth, called wisdom teeth. They are four additional back teeth which make the total number of teeth in adults 32.

Dentition It is the type, number and arrangement of teeth in the mouth and Jaw of animals. Dentition varies among mammals according to their feeding habit.

Types of human teeth

Humans have four types of teeth each which is adapted for its particular function. These are:

Incisors: are chisel shaped front teeth. They are the first to appear in childhood particularly the lower jaw incisors. function for biting, chewing and gnawing food.

Canines: are pointed edge side teeth and function like pincers for piercing and tearing.

Premolars: are flat ridged teeth with depressions far side teeth used for grinding food.

Molars: are wide, strong ridged teeth with depressions. They are the last to appear and function to grind and crush food.

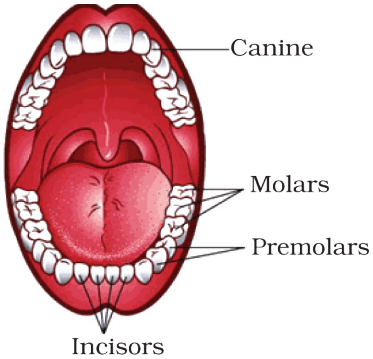


Figure 4. Types of teeth

Dental formula: Is the arrangement that shows the number and type of teeth in one half of the upper and lower jaws. In dental formula each type of teeth is symbolized by the first letter of its name. Moreover, the types of teeth are written according to their order of location in the mouth from the front to the back sides.

The dental formula of adult human is:

I= 2/2, C =1/1, PM =2/2, M =3/3 or alternatively can be shown simple as

The total number of teeth of a mammal is calculated from its dental formula by:

- adding the number of teeth in upper and lower jaws,
- multiplying the sum in each jaw by two.
- finally sum up the product.

For instance, we can calculate the total number of milk teeth in human as follows:

2+1+2 = 5, 5 x 2 = 10 in upper jaws

2+1+2 = 5, 5 x 2 = 10 in lower jaws

Therefore, the total milk teeth are 20

Dental formulae of different mammals are shown below here.

Dog, I = 3/3, C = 1/1, PM = 3/3, M = 2/3 = 42

Cat, I = 3/3, C = 1/1, PM =3/2, M = 1/1 = 30

Sheep, I = 0/4, C = 0/0, PM = 3/3, M = 3/3 = 32

Pig, I = 3/3, C =1/1, PM = 4/4, M = 3/3 = 44

Cattle, I = 0/4, C = 0/0, PM = 3/3, M = 3/3 = 32

2.6 Dental Care

Tooth decay is caused when a sticky film of food, saliva, and bacteria form plaque on teeth after meals. This plaque forms acid and causes loose and fallout of teeth. Teeth can be damaged by snacking, sipping sugary drinks and poor Teeth cleaning.

Dental care is the maintenance of healthy teeth and may be referred to as oral hygiene, the practice of keeping the mouth and teeth clean in order to prevent dental disorders.

Dental care is maintained by brushing teeth regularly using a fluoride tooth paste that avoids plaque formation.

Review Exercise

1. The dental formula for the dog is I 3/3 , C 1/3. Pm 4/4, M 2/3. How many teeth are there in the lower jaw?
   (a) 22
   (b) 20
   (c) 26
   (d) 42
2. The total number of teeth add a mammal with a dental formula of: I=0/2, C =1/1, PM 3/3, M=3/3 is:-
   (a) 16
   (b) 26
   (c) 32
   (d) 34
3. Can make your teeth last a lifetime?
   (a) Washing oral cavity
   (b) Taking excess fluoride
   (c) Taking excess sugary food
   (d) Brushing teeth for plaque removal

2.7 Food Poisoning and Preservation of Food

Food poisoning:- is the spoilage of food mainly by bacteria due to the production of toxins that cause diseases like diarrohea, vomiting, nausea and abdominal cramps; even death. The bacteria *Salmonella* and *Staphylococcus* are medically, the most known in causing food poisoning.

Food preservation is the procedure by which food is treated and handled to stop or slow down food spoilage, loss of quality, edibility, or nutritional value and thus allow for longer food storage.

Preservation usually involves preventing bacteria,some fungi and other microorganisms from developing, as well as retarding the oxidation of rancid-causing fats.

Food preservation, is a term that refers to a variety of techniques for keeping food safe from spoiling after it has been harvested or slaughtered. Food preservation is the procedure by which food is treated and handled to stop or slow down food spoilage, loss of quality, edibility, or nutritional value and thus allow for longer food storage.

2.8 Methods and Importance of Food Preservation

Importance of Food Preservation

- **Stops** the **growth of microorganisms** (such as yeasts) or other microorganisms (although some methods work by presenting benign bacteria or fungi into the food), and slows the oxidation of rancid-**causing fats.**
- **Gives the food more variety.** For example, if fresh peas are unavailable during the hot summer months, canned or dehydrated peas might be substituted.
- **Extends food's shelf-life**. Pineapples, cherries, and other fruits and vegetables can be preserved for lengthy periods of time using various methods.
- **Expands the supply of food**.
- **Cuts down on food waste.** Excess foods that would have been wasted otherwise are processed and preserved, adding to existing supply and reducing food waste.
- **Reduces dietary deficiencies.** Preserved foods help to add variety to the diet. For example, due to arid soil conditions in several Middle Eastern nations, no vegetables are grown. This shortfall is compensated for by importing fresh and preserved fruits and vegetables.

A number of food preservation techniques can be used which can prevent, delay, or otherwise reduce food spoilage altogether. Preservatives can extend the shelf life of food and can last as long as it can be grown, stored, marketed, and kept in the home of the customer for a reasonable period of time.

Preserving or producing nutritional value, texture and flavour is an important aspect of food storage methods, although some methods have drastically altered the character of the preserved foods. These changes have now been seen in many cases as desirable qualities, such as cheese, yogurt, and pickled onions.

Any change that renders food unfit for human consumption is considered food spoilage. Contamination by microbes, insect infestation, or breakdown by endogenous enzymes are all possible causes of these alterations. Food spoilage can also be accelerated by physical and chemical changes, such as the tearing of plant or animal tissues or

the oxidation of certain food constituents. Foods derived from plants or animals deteriorate quickly, once they are harvested or slaughtered. Any mechanical injury, induced during postharvest processing may cause the enzymes stored in the cells of plant and animal tissues to be released. The cellular substance is broken down by these enzymes. Food quality, is degraded as a result of the chemical processes catalysed by enzymes, such as the production of off-flavours, texture deterioration, and nutrient loss.

Drying, refrigeration, and fermentation are some of the oldest methods of preservation. Canning, pasteurisation, freezing, irradiation, and chemical addition are all examples of modern processes. Modern food preservation has benefited greatly from advancements in packaging materials and techniques.

Drying

Drying is one of the most ancient techniques of food preservation which reduces water activity enough to prevent spoilage by some microorganisms or internal biochemical processes.

Refrigeration

Refrigeration preserves food by slowing down microorganism growth and reproduction and the action of enzymes that cause food to rot.

Freezing

It is also one of the most frequently used processes for preserving a wide range of foods, including prepared foods that in their unprepared state would not require freezing.

Salting

The salting or curing process removes moisture from the meat through. Meat is salted or cured with sugar, or a combination of the two. Nitrates and nitrites are also widely used to treat meat, leading to the distinctive pink colour and inhibiting its spoilage.

Crystallization

Sugar is used to maintain fruits, either in fruit syrup such as apples, peaches, apricots, or in a crystallized form where the preserved material

is cooked in sugar to the point of crystallization and the resulting product is then stored in a dry place.

This method is used for citrus (candied peel), angelica, and ginger skins. An alteration of this process creates glacé fruit, such as glacé cherries, in which the fruit is preserved in sugar but then extracted from the syrup and sold, preserving the fruit sugar content and superficial syrup coating.

The use of sugar in brandy or other spirits is often combined with alcohol for preserving luxury products such as fruit. These should not be confused with spirits that are aromatized with fruit such as cherry brandy.

Smoking

Smoking is used to prolong the shelf-life of perishable food. This effect is achieved through the exposure of the food from burning plant materials such as wood to smoke. The meats and fish that have undergone curing are most commonly subjected to this method of food preservation.

Fruits and vegetables are also smoked such as paprika, cheeses, spices, and ingredients for making drinks such as malt and tea leaves, but mostly for cooking or flavouring. It is one of the oldest methods of food preservation which probably emerged, after cooking with fire evolved.

Additives

Additives to the preservative foods can be antimicrobial. These inhibit bacterial or fungal growth, including mould or antioxidants, such as oxygen absorbers, which inhibit the oxidation of food components.

Preservatives

Adding preservatives is the chemical method of food preservation. Conventional antimicrobial preservatives include calcium propionate, sodium nitrite, sodium nitrate, sulphites (sulphur dioxide potassium hydrogen sulfite, sodium bisulfite, etc.), and disodium EDTA (Ethylene diamine tetraacetic acid). BHA (Butylated hydroxyanisole) and BHT (Butylated hydroxytoluene) are antioxidants.

Pickling

Pickling is a food preservation method used in an edible antimicrobial liquid. Pickling can be broadly divided into two categories: chemical pickling and pickling by fermentation.

Canning

Canning includes cooking food, sealing it in sterile canisters or pots, and boiling the containers as a method of sterilization to destroy or weaken any remaining bacteria. Foods have varying degrees of natural spoilage protection and may require the final step in a pressure cooker.

No preservatives are added to high-acid fruits like strawberries and only a short boiling period, while marginal fruits such as tomatoes require longer boiling and the addition of other acidic components. Feeding stuffs with low acidity, such as vegetables and meats, require canning pressure.

Food preserved through canning or bottling is at immediate risk of spoilage after opening the can or bottle.

Pasteurization

It is defined as heat treatment of food material at 72°C for 15 seconds, 63°C for 30 minutes, or 90°C for 0.5 seconds, followed by quick cooling to 7°C. High-temperature-short-time (HTST) treatments are favoured over low-temperature-long-time (LTLT) treatments because they cause less damage to the nutrient composition and sensory properties of meals.

Sterilization

Microbes are completely eliminated during sterilization. Fruits and acidic vegetables, such as tomatoes, can be sterilized at 100°C for 30 minutes; however, non-acidic veggies must be sterilized at 116°C for 30 minutes.

Freezing

Many food products can have their shelf-life extended by storing them at 4°C or below. Fresh fruits and vegetables, eggs, dairy products, and meats are all commonly refrigerated foods. However, some items, such as tropical fruits (bananas, for example), are destroyed by low

temperatures. Freezing is an excellent way to preserve the nutritional value of foods. It's done at a temperature of –18°C to –4°C. The majority of juices are kept by freezing.

Chemicals used

Sulphur dioxide is a bleaching and antioxidant agent. Sulphite, bi-sulphite, and metabisulphite are some of the salts that are employed. The permissible level in fruit juices, including RTS (READY-TO-SERVE) and nectar, is 100 parts per million; however, it is 350 parts per million in squash, crush, and cordial. Sulphur dioxide keeps beverages' original colour for a longer time than benzoic acid.

Benzoic acid, in the form of sodium benzoate, is allowed up to 100 parts per million in RT5 RTS (READT-TO-SERVE) and nectar, and 600 parts per million in squash, crush, and cordial.

Dehydration

Dehydration is the process of removing moisture from food materials in order to preserve them. The temperature of dehydration starts at 43°C and gradually rises to 60–66°C (for vegetables) and 66–71°C (meat and fruits).

For vegetables, the moisture content in dried products should not exceed 6–8 percent, and in fruits, 10–20 percent.

Sweating is a process that is used to equalize the moisture content of preserved materials by storing them in bins or boxes.

Sulphuring is a method of preventing discoloration by fuming food materials (especially potato slices) with sulphur dioxide.

Freeze-drying is accomplished by using high vacuum conditions, that allow for precise temperature and pressure.

Other types of preservation may include **irradiation, jellying, jugging, processing of pulsed electric fields, modified atmosphere, ground burial, bio preservation, and high pressure.**

Roasting:- toast the food at high temperature. It is used for meat, cereals and grains.

Vinegar:- acetic acid used to preserve vegetables.

Ethyl alcohol: - used to preserve wine.

Use of oil:- used to preserve roasted cereals.

Review Exercises

1. Which of the following is the best preservative method for vegetables?
   (a) Salting
   (b) Smoking
   (c) Vinegar
   (d) Frying
2. Which of the following products CANNOT be canned for preservation?
   (a) Juices
   (b) Soft drinks
   (c) Beers
   (d) Biscuits
3. What types of foods are preserved by using oils?
   (a) Milk
   (b) Meat
   (c) Cereals
   (d) Alcohol drinks
4. What type of foods is not preserved by freezing?
   (a) Fruits
   (b) Bread
   (c) Vegetables
   (d) Dairy products

Activity 5

Using preservative methods lemon on food samples (fish) compare with non-preserved foods. Observe the differences in smell and color.

Key Terms

- Nutrition
- Autotrophic
- Heterotrophic
- Holozoic
- Food
- Nutrients
- Carbohydrates
- Monosaccharaides
- Disaccharides
- Polysaccharides
- Lipids
- Fatty acids and glycerol
- Triglycerides (fats and oils)
- Phospholipids
- Proteins
- Amino acids
- Iodine test
- Benedict's test
- Emulsion test
- Biuret test

- Vitamins
- Minerals
- Balanced diet
- Malnutrition
- Dental formula
- Food poisoning
- Food additives
- Food preservatives
- Canning
- Pickling
- Crystallization
- Salting
- Freezing
- Dehydration
- Frying

SUMMARY

- Nutrition is the process of obtaining food for energy, body growth and repair.
- Autotrophic nutrition is a process of synthesizing food by using sunlight or chemicals.
- Heterotrophic nutrition obtaining food by absorbing food from other organisms.
- Food is anything that contains the necessary nutrients providing energy to carry out life processes.
- Carbohydrates are nutrients that provide energy for life processes.
- Fats and oils are nutrients that serve as energy source and insulators, lubricants.
- Proteins are nutrients that function as enzymes, transport means, defence and body builders.
- Vitamins and minerals nutrients are useful for proper body function.
- Water is a nutrient for transport, dissolving substances and body temperature regulation and waste removal.
- Foods are grouped into bread and cereals, fat and oils and sweet, meat and dairy, and fruit and vegetables.
- Balanced diet is a diet that contains the right quantity and quality of nutrients.
- Malnutrition is the lack or absence of the required nutrients in a diet.
- Teeth are hard structures that grow from jaw bones in the mouth used for biting, chewing and grinding food.
- The four types of teeth in humans arranged from front jaws as rows are incisors, canines, premolars and molars.

- Dental formula represents the number of teeth in one half of the upper and lower jaws.
- Mammals differ in their dental formula in accordance with their feeding adaptation.
- Dental care is keeping the hygiene of teeth by regularly brushing teeth with fluoride paste.
- Food poisoning is the contamination of food by microbes specially bacteria that produce toxins causing illness and death.
- Food preservation is protection of food from spoilage.
- Food can be preserve by keeping at very low temperature, dehydration and using chemical preservatives.

Review Exercises

1. Which of the following is not a kind of heterotrophic nutrition?
   (a) Predation
   (b) Parasitism
   (c) Photosynthesis
   (d) Decomposition
2. Which of the following can be considered as food for humans?
   (a) Tea
   (b) Beer
   (c) Coffee
   (d) Banana
3. What types of nutrients provide energy quickly to the body if someone is engaged with labour-intensive work?
   (a) Fats
   (b) Proteins
   (c) Oils
   (d) Carbohydrates
4. What types of nutrients are best to function as appetizers?
   (a) Minerals
   (b) Vitamins
   (c) Lipids
   (d) Proteins
5. What is the type of sugar that is normally added to hot drinks called?
   (a) Glucose
   (b) Maltose
   (c) Sucrose
   (d) Lactose

6. What is the type of carbohydrate stored in animals' liver?
   (a) Starch
   (b) Galactose
   (c) Cellulose
   (d) Glycogen
7. Which of the following solutions of carbohydrates shows brick-red precipitate if benedict's solution is applied?
   (a) Starch
   (b) Fructose
   (c) Glycogen
   (d) Cellulose
8. Which of the following foods shows purple colour when biuret reagent is added to it?
   (a) Milk
   (b) Meat
   (c) Egg yolk
   (d) Palm oil
9. Which of the following vitamins and minerals are essential for strong and proper skeletal system?
   (a) Vitamin A and iron
   (b) Vitamin B and calcium
   (c) Vitamin C and Phosphorous
   (d) Vitamin D and Phosphorous
10. Which of the following vitamins and minerals are essential for blood clotting if someone bleeds?
   (a) Vitamin E and sodium
   (b) Vitamin K and calcium
   (c) Vitamin B and chlorine
   (d) Vitamin C and magnesium
11. Which of the following is **NOT** true about a balanced diet? It is
   (a) Composed of all the five food groups
   (b) Contains the right quantities of the five food groups.
   (c) Essential to prevent overweight or underweight conditions.
   (d) Works only for people with high economic and living standard.
12. Which of the following is **TRUE** about malnutrition? It
   (a) Can be caused by starvation.
   (b) Is a problem of poor nations only.
   (c) Can be solved by eating excessively.
   (d) Is common among poor families only.

13. What conditions are suitable for food poisoning by Bacteria?
    (a) Availability of salt
    (b) Absence of moisture
    (c) Presence of oxygen
    (d) Very low temperature
14. What process comes first to ensure safety of industrial foods?
    (a) Sealing
    (b) Canning
    (c) Sterilization
    (d) Dehydration
15. Which of the following methods of food preservation are **NOT** applicable for meat?
    (a) Frying and boiling
    (b) Drying and smoking
    (c) Stripping and Salting
    (d) Refrigeration and oil

B11CH03

CHAPTER 3

SOIL, ENERGY AND ECOLOGY

Chapter Contents

Chapter Outcomes

Upon completion of chapter, learners will be able to:

- describe about the soil, its formation and composition;
- how Erosion of soil can be prevented;
- soil conservation method;
- weathering of soil;
- liberia food and cash crop production;
- isolation of mechanism of species and Biological succession;
- trophic levels; food chains, food webs;
- discuss various Biogeochemical cycles;
- population its Diversity and growth.

Introduction

This chapter begins with the study of soil formation, composition, types, fertility, erosion, prevention, conservation, maintenance and renewal of soil fertility. In addition, it emphasis on the effects of non-biodegradable substances on soil fertility. Isolation mechanisms of species and types of inter-specific interactions has also been discussed. it continues looking into tropic levels in food chains and food web. Then, it goes through the lesson on conservation of nature including soil, forest, wildlife, oil and minerals. Besides, this chapter focuses on the processes of biological cycles in nature encompassing water, carbon, nitrogen, phosphorous and sulphur cycles. Moreover, this part raises the issues of organisms habitat and niche, population with regard to population density, growth, doubling rate,birth and death rates, density dependent and density independent factors. At the end, the lesson describes ecological successions, both primary and secondary successions.

3.1 Soil

Soil is a medium for plant growth that provides both nutrients and shelter for wide variety of organisms such as bacteria, fungi, worms and insects.

A. Soil formation and composition

Soil is formed from rocks which have been broken up by various physical and chemical processes or weathering.

Physical weathering, can take place as rock freezes, expands and then winded further by the pressure of plant roots.

Chemical weathering, takes place by rain water that removes soluble substance from rock, and reduces them in to smaller fragments.

Activity 1

Explaining of soil formation

Form groups and discuss with members on how soil formation occurs in nature.Then, present your explanations to the class.

Typical soil is composed of:

- Mineral particles of different sizes
- Water

- Air
- Dissolved mineral salts
- Humus
- Microorganisms and other soil dwelling organisms

Soil is composed of a complex mixture of **organic** and **inorganic materials**. Actually, soils vary in their composition.

- Mineral particles of different size
- Water
- Air
- Dissolved mineral salts
- Humus
- Microorganisms and other soil dwelling organisms

B. Types of soil

In general, there are three main types of soil after the word soil add the word notably, sand, clay and silt soil (Figure 1A, B and C).

A

Clay *(Size <.002 mm in diameter)*

B

Silt *(Size between 0.002 and 0.02 mm)*

C

Sand *(Size between 0.02 and 2.0 mm)*

Figure 1. Types of soil

(i) Sandy soil

- contains large soil particles.
- particles packed loosely together.
- particles have greater air spaces and are well-aerated.
- has higher drainage but lower water holding capacity.

(ii) Clay Soil

- contains very small soil particles.
- particles are packed tightly together.
- particles have smaller air space and not well-aerated.
- has lower drainage capacity but higher water holding capacity.

Activity 2a

Collecting, observing and classifying soil types.

In groups of 4-5 students, collect soil samples from school compound and outside. Observe and classify the soil samples in your school lab. Finally, label the identified soil types as clay, sand and silt soil.

(iii) **Silt Soil**

- is smooth unlike clay soil which is sticky.
- drains more water unlike clay soil.
- retains more water unlike sand soil it.

(iv) **Loam soil**

- is a mixture of sand and clay particles
- contains remains of decayed organisms which form humus.

(v) **Humus is**

- composed of the remains of dead organisms and their waste products
- formed at the soil surface
- mixed into the soil the activities of some soil dwelling organisms such as and ploughing.
- Used to improve the texture of soils.

For instance, if humus is added to clay soil, it improves aerations.

Activity 2b

Listing and discusing the composition of soil.

You will need

- sample of soil
- water
- measuring cylinder

Method

1. Add water to the measuring cylinder half-filled
2. Add the sample of soil into the water contained in the measuring cylinder,
3. Allow the soil solution to stand in the measuring cylinder.
4. Observe and record the suspended, floated and settled substances in the measuring cylinder.

C. Soil fertility

Soil fertility is the suitability of a soil for plant growth. It depends on factors such as

(i) **Soil texture**

- smoothness or roughness of soil particles.
- related to water holding, drainage and air holding capacity.
- related to suitability for plant growth.

(ii) **Soil air**

- space between the soil particles.
- dependent on how firmly the soil is compacted.
- In well-aerated, soil at least 20% of its volume is made up of air.

(iii) Soil temperature:

- is the temperature of soil below a depth of about 30cm.
- When the soil temperature is low, organic matters decompose very slowly by decay causing microorganisms.

(iv) Soil water

- Hygroscopic water a thin film of water around each soil particle.
- Capillary water held in the small spaces between the soil particles.
- Gravitational water that drains downwards through the soil.

(v) Soil solution:

- is the liquid phase of soil together with the solutes contained within the liquid.
- increases the fertility of the soil.

(vi) pH:

- is the acidity or alkalinity of soil.

- influences the biological activity in soil and the availability of certain minerals has a greater influence on the growth and development of plants.

Activity 2c

Demonstrating the presence of air in the soil (moisture content).

You will need

- Sample of soil
- Metal stove
- Weight balance

Method

1. Weigh the sample soil and record it.
2. Put the sample soil on the stove and switch on to heat for some seconds.
3. Collect the heated soil and allow it to cool.
4. Weight the cool soil and record it.
5. Note the weight difference and explain your observation.

D. Erosion: causes and prevention

Erosion is the **removal of fertile top** soil by heavy rain and wind. It exposes the sub soil and makes the land **less suitable** for plant growth.

Erosion is also caused by excessive use of inorganic fertilizer, over grazing and deforestation.

(i) **Inorganic fertilizers**

- are chemicals which dissolve immediately in soil water.
- are immediately available to plants (quick action when dissolved).
- can supply one particular mineral, which is deficient and easy to apply.
- if used in excess, precipitate and decrease water retention capacity.
- may upset mineral balance of soil and its structure.

(ii) **Over grazing**

- is removal of vegetation from the land by cattle.
- forms a hard surface layer & will not allow water to soak through it.
- exposes the soil to erosion.
- develops deep channels or gully can be formed.

(iii) **Deforestation**

- is removal of trees by human activities.
- is done to use land for farming, to collect fuel wood, timber and as a result of urbanization.
- exposes the soil to direct heavy rain.
- removes the top soil (erosion).
- leaves ground unstable for growing crop.
- leads to desertification.

E. Soil conservation

Soil conservation is the prevention of soil erosion done by planting trees that keeps the soil covered so that it reduces the run-off and increases the amount of rain water absorbed by the soil.

Soil conservation methods

- **Contour Ploughing** – is ploughing back and forth across the slope of land rather than up and down.
- **Crop – rotation** – Different crops follow one another on a given pieces of ground in successive years in a definite prearranged order.
- **Shelter belting** – Planting trees or shrubs in thick rows to break the wind and reduce its speed.
- **Terraces** – Terraces on hill side to prevent water erosion.
- **Afforestation** – Planting trees and establishment of forest on an area which didn't have forest previously.
- **Dams buildings and reservoir** – To hold run – off water during periods of heavy rainfall to prevent floods
- **Hay and pasture land** – growing grasses and legumes such as clover brings about an increase in nitrogen content of soil because of activity of nitrogen fixing bacteria in root nodules.

F. Maintenance of soil

In Africa, soil fertility depletion and soil degradation present the most serious problems. According to a FAO study (FAO 2001), African soils lose an annual average of 48 Kg/ha of nutrients, the equivalent of 100 Kg/year of fertilizer. To compensate for this loss, they receive an average of only 10 Kg of mineral fertilizer,

compared with a global average of 90 Kg. In addition, African soils are generally poor. Maintaining or increasing soil fertility is one of the most important things farmers have to do to increase output. Farmers have to know the characteristics and constraints of their soils and use sustainable agricultural practices and methods for conserving them and making them more fertile. Soils have to be nourished and cared for, and allowed to rest from time to time.

Soil maintenance includes employing the following methods

- Control of soil erosion which aim at promoting good rain water retention and reducing the surface runoff.
- Crop rotation: Control crop pest and diseases and maximizes the utilization of soil nutrients.
- Control of soil pH: Most soil organisms do well at a certain soil pH.
- Proper drainage: facilitates soil aeration, minimizes the loss of soil nutrient by run-off.
- Weed control: weed compete with crops for nutrients, space sunlight and moisture.
- Intercropping: when different species of crops yields are normally It is the practice of growing multiple crops on the same plot in the same time.
- Minimum tillage: over cultivation destroys the soil structure leading to soil erosion.
- Use of organic fertilizers: manures, compost and crop residues add nutrients to the soil and moderate soil pH.
- Use of inorganic fertilizers: add nutrients to the soil formulated to address the deficiencies of the particular soil of a given region.

G. Renewal of soil fertility is done by

- **Adding compost** Compost is a mixture of decomposed leaves, dried plants, and vegetable waste that can be used as a fertilizer to improve the health of lawn soil. It also feeds worms and other organisms present in the ground and keep it loose to increase aeration. It helps the soil to retain moisture. Using organic compost as a fertilizer is a great way to recycle biodegradable waste.

- **Making compost** is something you can do on your own. Mix one part of wet, green ingredients such as kitchen scraps with three parts of dry ingredients like branches, dried leaves, etc., for best results. Water the compost pile regularly.
- **Prevent hardening** of the soil. A hardened or compressed soil will not allow water to soak and reach the roots of the plants. Soil needs to be loose, so that the grass and plant roots can spread out in search of water. It also helps microorganisms to move freely underneath and turn organic matter into nutrients.
- It's a method in which tiny holes are drilled into the soil so that air, water, and nutrients can easily reach the roots.
- **Get the soil tested:** A high pH level is considered toxic and should be avoided. The test will also indicate the amount of Potassium (K), Calcium (Ca), Sulpher (S), and other nutrients present in the soil and if they are in the right quantity.
- While you can do a soil test yourself, it would be a good idea to get it done by the lawn professionals.
- **Mulch the soil:** Mulching is the process by which layers of manure or compost are applied to the soil surface. It not only helps maintain the soil moisture but also keeps the soil temperature in check. As mulch slowly decomposes, it offers nutrients of the worms and insects underneath and keeps the soil cycle going.
- There are plenty of materials that you can use as mulch for your lawn. Organic residues such as hay, straw, leaves, sawdust, shredded bark, etc., are all great options.
- **Lime treatment:** Soil is treated with lime that restores the pH balance and helps regain its lost fertility. When nutrients such as calcium and magnesium drain out of the soil, it makes the soil acidic. Soil with high acidic content is more likely to get infected with a fungal disease that can destroy the soil structure. This soil acidity is prevented by liming.
- **Grow nutrient-collecting plants:** Some plant species have roots that collect specific nutrients from the soil. They are known as nutrient accumulators and are a great way to increase the fertility of the soil. These nutrient-rich plants can be chopped into pieces and used as mulch all year round.

3.2 Weathering

A. Physical weathering

Physical weathering of rocks is the breakdown of rocks into smaller size particles by pure mechanical processes without changing the chemical composition and mineralogy, except for the removal of some soluble components due to erosion. Many sedimentary rocks are composed of particles that have been weathered, eroded, transported, and terminally deposited in basins. Sandstone is formed from bonded sand-sized particles under water. Its porosity makes it vulnerable to the processes of physical weathering.

Physical weathering reduces the particle size and compactness, and increases the surface area and bulk volume. Physical weathering provides favorable conditions for chemical weathering by loosening the rock mass, decreasing the particle size, and increasing the surface area. Physical weathering is different from erosion or mass wastage, which involves the transport of material.

B. Chemical weathering

Chemical weathering is the decomposition of rocks by a change in the chemical and mineralogical composition, through a combination of several chemical processes. It is a slow but more intense process than physical weathering.

Most of the chemical weathering processes occur in the presence of water. Chemical weathering takes place mainly at the surface of rocks and minerals, leading to disappearance of certain minerals and formation of new products and secondary minerals.

3.3 Liberia Food and Cash Crop Production

Rice

Rice is the staple cereal and an essential food in most of Liberia: people who have not eaten rice will say that they “have not eaten.”

Cassava

Cassava is the preferred carbohydrate staple in some areas such as Sinoe and Grand Kru.

Other major carbohydrate sources are plantain, eddoe, and sweet potato.

Vegetables: hot pepper, okra, eggplant, African eggplant ("bitter ball" or "garden egg"), country tomato, cucumber, and various pumpkins, and palava sauce.

Fruit: pineapple, oranges, banana, coconut, papaya, lime, mango.

Gardens: Maize, hot pepper, okra, eggplant, African eggplant, country tomato, cucumber, and various pumpkins, broad bean, peanut, onion, and palava sauce.

Bush meat and fish

Bush meat and fish are eaten and sold, both fresh and dry. Hunting is more important in the south-eastern counties, and fishing is ubiquitous in the central/northwest.

Cash crops:

Commercial cash crops: rubber, cacao, oil palm, coffee (over-grown farms and low prices are not encouraging the rehabilitation/production of coffee). Secondary cash crops: coconut, sugarcane, kola nut, oranges, pineapple, sugarcane.

3.4 Effects of Non-biodegradable Substances on Soil Fertility

- Non-biodegradable substances are substances that may not be decomposed by biological processes. These include unnecessary utilization of non-biodegradable wastes such as fertilizers and D.D.T like chemical pesticides which make the soil alkaline or acidic, thereby affecting the fertility of the soil. They cause soil destruction and also reduce the crop yield.

Review Exercises

1. Which of the following is NOT useful for soil formation?
   (a) Rocks
   (b) Plant roots
   (c) Soil burning
   (d) Organic matter
2. Which of the following is contained in a given soil?
   (a) Air
   (b) Water
   (c) Humus
   (d) all of the above

3. Which of the following factors is **NOT** the cause for soil erosion?
   (a) Wind
   (b) Runoff water
   (c) Cover vegetation
   (d) Excessive fertilizers
4. Identify the **CORRECT** comparison between soil particles.

Choice	Feature	Clay	Sand	Silt
A	size	Small	Large	Medium
B	Drainage capacity	Low	High	Medium
C	Water retaking capacity	Low	High	Medium
D	Air holding capacity	Low	High	Medium

5. Soil conservation is **NOT** maintained by:
   (a) Soil burning
   (b) Making dams
   (c) Contour ploughing
   (d) Reforestation
6. Soil fertility is maintained by controlling all of the following **EXCEPT**:
   (a) pH
   (b) Weed
   (c) Erosion
   (d) Crop rotation
7. Which of the following is the effect of non-biodegradable substances on soil fertility?
   (a) Soil destruction
   (b) Adjusting soil pH
   (c) Increasing crop yield
   (d) Increasing soil fertility

3.5 Isolation Mechanisms of Species

Isolating mechanisms are intrinsic characteristics of species that reduce or prevent successful reproduction with members of other species.

Geographical Isolation: refers to the separation of members of a population by a physical barrier, such as a mountain or body of water, which disrupts the gene flow between them and allow the process of speciation.

Reproductive Isolation: refers to a set of conditions that can be psychological, ecological, genetic or behavioral, which do not allow animals of closely-related species to unite and mate. In reproductive isolation, there are strong reproductive barriers that keep the related species separate.

Genetic isolation: population of organisms that has little genetic mixing with other organisms within the same species.

3.6 Inter-specific Interactions

Inter-specific interactions are interactions among individuals of different species living in a given area. It is explained in terms of biological associations.

Biological association

Symbiosis

- It is an association of two or more organisms together of different species observed in any ecosystem.

Types of symbiosis

Commensalism is when

- one **species benefits** (the commensal) and the other **neither benefied** nor **harmed** (the host).
- the host species provides a home and/or transportation for the other species.

For example,

- Lichen on a tree.
- Clown fishes live within the waving mass of tentacles of sea anemones;
- The remora, a sucker-fish, lives in close association with sharks or other larger fish.

Mutualism is when

- both **members** of the association **benefit**.(Table 1, Figure 2, 3 and 4)
- one allow organisms to obtain food or to avoid predation.

Table 1 Some examples of mutual relationship

Types of mutual Relationship		Examples
Animal-animal relationship		**Figure 2.** Picture showing Crocodile and bird, The Egyptian Plover bird and the crocodile have a mutual relationship.
Animal-plant relationship		**Figure 3.** Mutual relationship between insects (Bees) and flowers
Plant to plant relationship		**Figure 4.** Growing Lichens (association between algae and fungi on a bark of a tree
Microorganisms and animals or plants		**Figure 5.** e.g. termites and protozoan that inhabits their gut, Nitrogen-fixing bacteria which live in root nodules of leguminous plants.

Parasitism

- a type of association in which one is **benefited (the parasite)** and the other **harmed (host)**.

- When parasite benefits for growth and reproduction to the harm of the other species (host).
- Lice, flea, ticks, etc. are examples of ectoparasites.

Tape-worms, bilharzia and the malaria parasite are examples of endoparasites. (Figure 6).

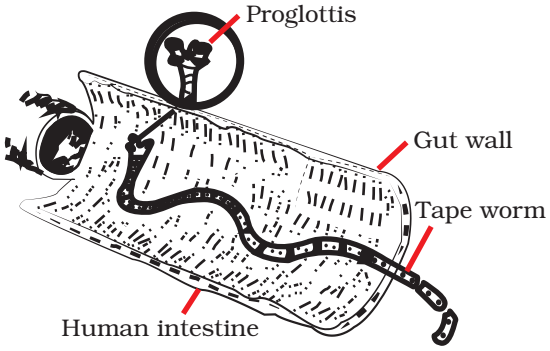


Figure 6. Tape worm attached to intestinal wall

Predation

A type of association in which one is a killer (predator) and the other is a killed (prey) (Figure 7).

Figure 7 . A group of lions (pride) attacking a buffalo

Competition

Interspecific competition occurs when two species attempt to use the same resource (such as light, space, or nutrients) and there is not enough of the resource to satisfy both. Physical interactions over access to resources such as fighting to defend a territory or displacing

an individual from a particular location are referred to as interference competition; consuming the same resources is called exploitative competition.

Review Exercises

1. Which of the following biological association involves the benefit of one but harm the other partner?
   (a) Mutualism
   (b) Parasitism
   (c) Predation
   (d) Commensalism
2. What type of biological association exists between a crocodile and a bird?
   (a) Predation
   (b) Mutualism
   (c) Parasitism
   (d) Commensalism

3.7 Trophic Levels

Trophic level is the feeding position of an organism in a food chain. In a food chain or ecological system, it is occupied by a group of organisms with similar feeding mode.

Trophic levels in a food chain are composed of primary producers, herbivore, primary carnivore, etc.

A. Producers

Producers are green plants or algae that form the first trophic level.

B. Consumers

Consumers are animals and other organisms that are dependent on the producers. These consumers can be:

Herbivores form the second trophic level.

Carnivores form the third and even the fourth trophic levels

Trophic levels can be represented by numbers and graded to a maximum of five levels.

Trophic level is occupied accordingly by the initial producers and various consumers.

1. Producers make their food using sun light.

2. Herbivores or primary consumers directly feed on producers.
3. Carnivores or secondary **consumers** directly feed on the flesh of herbivores.
4. Carnivores or tertiary consumers feed on the flesh of other carnivores.

An additional consumer level is the detritivore trophic level. Detritivores differ from the organisms in the other trophic levels in that they feed on the remains of already-dead organisms; detritus in this case is dead organic matter. A subcategory of detritivores is the decomposers.

C. Decomposers

Decomposers are mostly microbes and other minute organisms that live on and break down dead organic matter. The common examples are bacteria and fungi.

D. Food chain and food web

Ecosystem is the sum of a community and the non-living environment that functions to flow energy and recycle nutrient,

Food chain is a simple model of showing feeding interrelationships among organisms. It is a pathway of energy and nutrient containing food through a community. See Figure 8 and 9. Every food chain begins with a producer organism and consists of consumer organisms that feed on the other. It shows that each organism depends on the other for food.

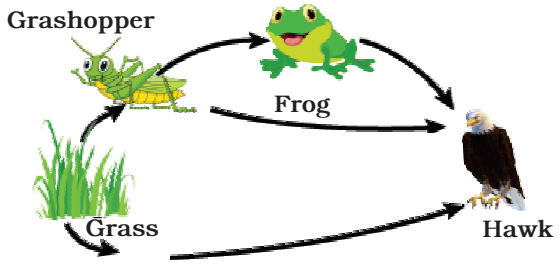


Figure 8. Food web in terrestrial environment

In a food chain:

- plants and algae are **producers.**
- the other organisms are **consumers.**
- **food** is **transferred sequentially** from the producers to consumers
- For example:
- by photosynthesis grass produces food (Producer)
- eaten by a grasshopper (**Primary Consumer**)
- the grasshopper is eaten by a frog (**Secondary Consumer**)
- the frog is eaten by a snake (**Tertiary Consumer**)
- the snake is eaten by a Hawk (bird) (**Quaternary Consumer**)

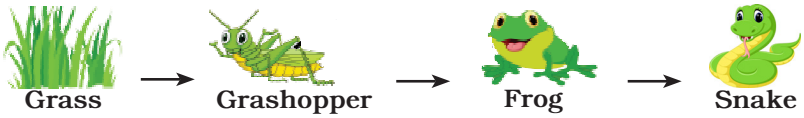


Figure 9. Food chain

In the food chain above,

- Grass is the producer, It provides energy for consumes
- Grasshopper feeds directly on grass therefore it is a Primary Consumer.
- Frog feeds on grasshopper (Primary consumer) and is referred to as Secondary Consumer.
- Snake feeds on from(secondary consumer) and is therefore referred to as Tertiary Consumer.

Food web

Food web is a complex feeding relationship consisting of interlocking or interconnected food chains. See figure 10. It shows the actual food relationships in nature.

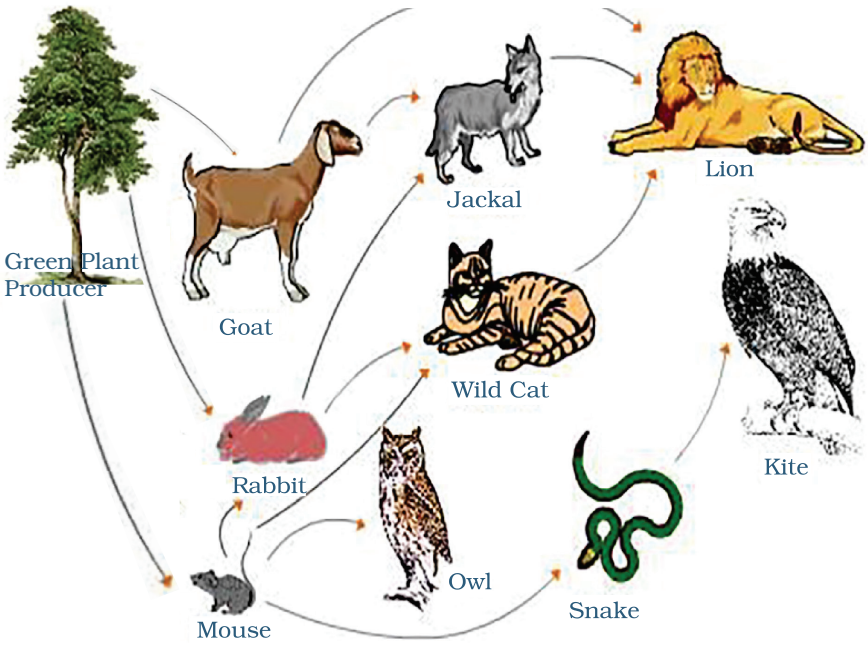


Figure 10. Food web

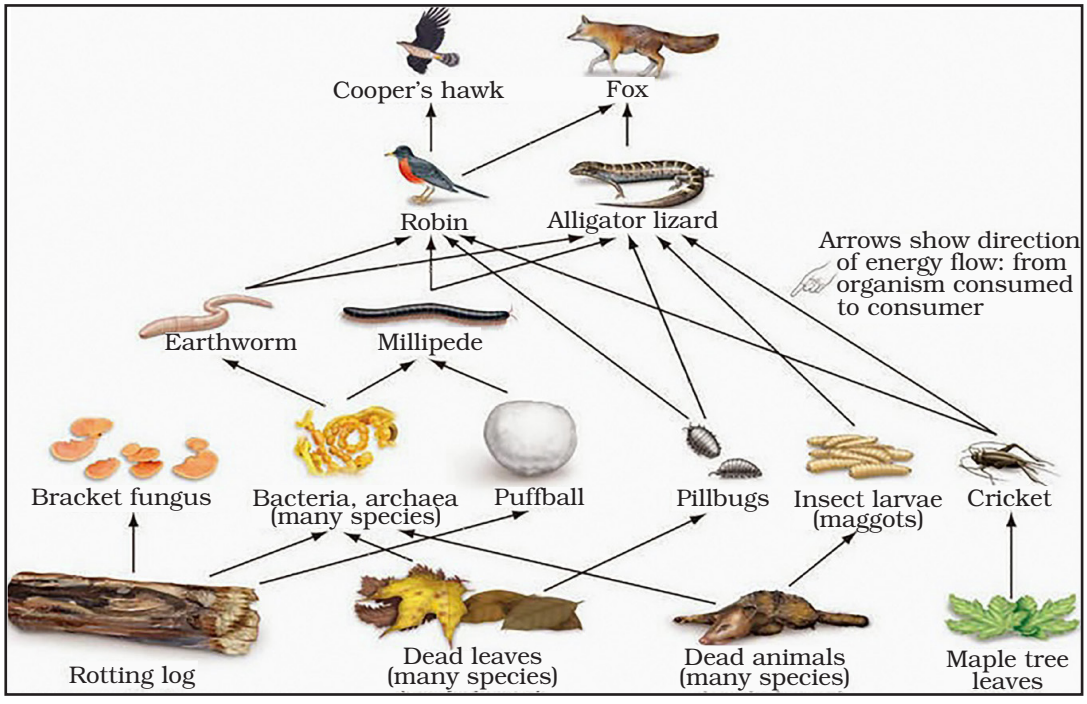


Figure 11. Food Web in a forest

Activity 2d

Drawing Food chain and Food web.

In group of 4 - 5 students draw food chain and food web by considering the organisms in your surroundings and demonstrate to the class what you drew.

Ecological Pyramids

Ecological pyramids are graphical representations of the **number** of organisms, amount of biomass and the **energy** in each trophic level.

Pyramid of numbers

- shows the **number of organisms** involved in each trophic level of a food chain.
- does consider the size of the organisms
- shows the **number** of organisms as it **decreases** from the **lower** (base) to the **upper** (apex) trophic level

Example

Many grass plants → 100 grass hoppers → 10 frogs → 3 snakes

Such a numerical relationship may be represented by what is called a pyramid of numbers (Figure 12).

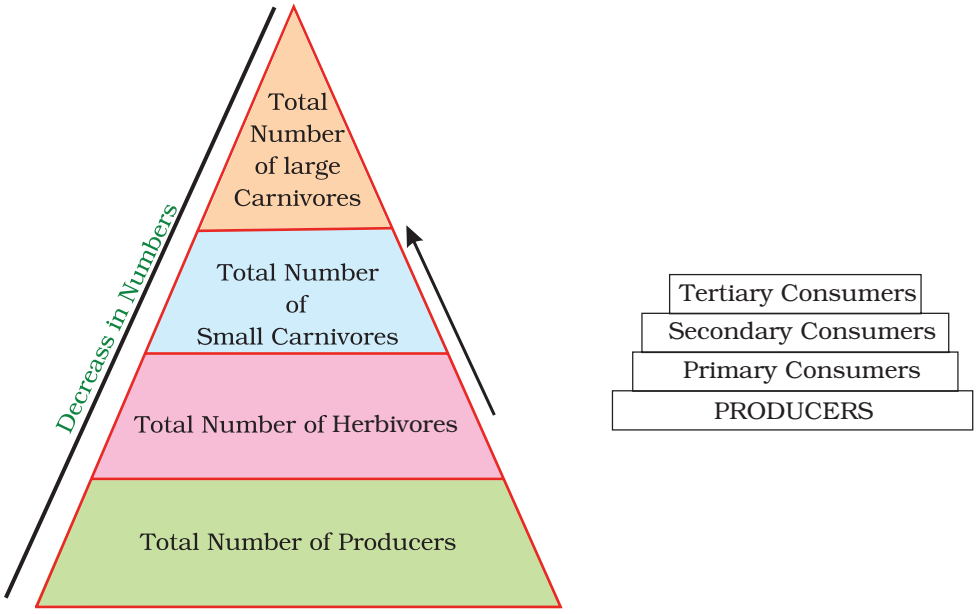


Figure 12. Pyramid of numbers

Pyramid of Biomass

- indicates the total mass of the organisms in each trophic level (Figure 13)
- shows the mass of organisms decreasing from the lower (base) to the upper (apex) trophic level.

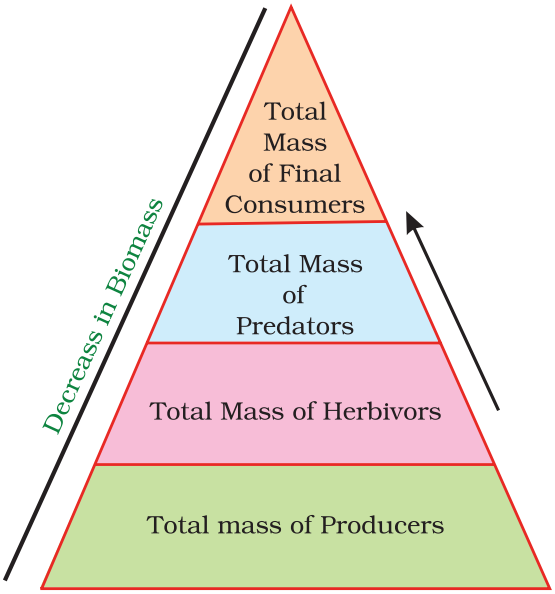


Figure 13. Pyramid of Biomass

Pyramid of Energy

- indicates the total amount of initial energy present in each trophic level (Figure 14).
- also shows the **loss** of the **initial solar energy** as it is transferred through trophic levels
- shows that initial energy is lost for various activities by consumers
- shows the **amount** of energy **decreases** from the **lower** (base) to the **upper** (apex) trophic level
- is more widely used than the other pyramids

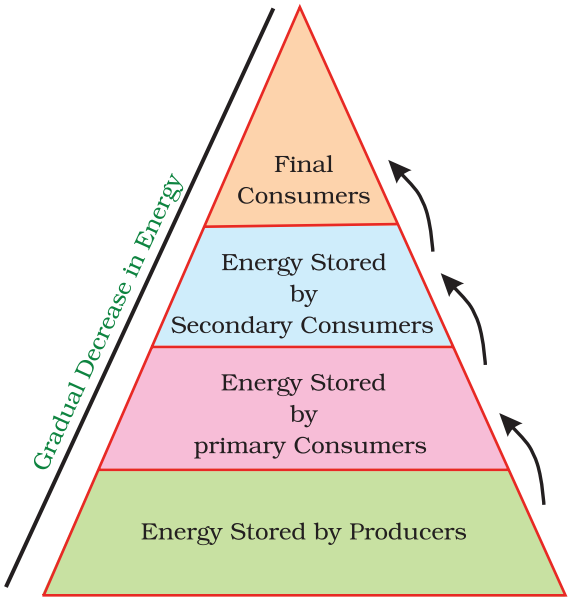


Figure 14. Pyramid of Energy

Productivity of an ecosystem

The **productivity** of a trophic level is the rate at which the organisms in the trophic level collectively synthesize new organic matter (new tissue substance).

Primary productivity is the productivity of the primary producers. An important complexity in analyzing the primary producers is that not only do they synthesize new organic matter by photosynthesis but hey also break down some of the organic matter to release energy by means of aerobic cellular respiration.

Gross primary productivity (GPP) is simply the raw rate at which the primary producers synthesize new organic matter.

Net primary productivity (NPP) is the GPP minus the respiration of the primary producers. The NPP represents the organic matter available for herbivores to use as food.

Secondary productivity is the productivity of a heterotroph trophic level. For instance, the rate at which new organic matter is made by means of individual growth and reproduction in all the herbivores in an ecosystem is the secondary productivity of the herbivore trophic level. Each heterotroph trophic level has its own secondary productivity.

Review Exercises

1. What type of organisms are found in the first trophic level?
   (a) Producers
   (b) Herbivores
   (c) Carnivores
   (d) Decomposers
2. Similar to food chain, food web :-
   (a) Is a linear food relationship
   (b) Is an actual food relationship
   (c) Begins with producers and consumers
   (d) Shows the interdependency of organism for food
3. What happens to the amount of initial energy in the pyramid of energy?
   (a) Increases
   (b) Decreases
   (c) Remains constant
   (d) Difficult to determine
4. What type of productivity represents the organic matter that is available for herbivores use?
   (a) Primary productivity
   (b) Secondary productivity
   (c) Net primary productivity
   (d) Gross primary productivity

3.8 Conservation of Nature

Conservation is the wise utilization of natural resources for the present and the future generation.

A. Soil conservation

The critical goals of soil conservation are proper irrigation, prevention of erosion, and prudent fertilization.

Proper irrigation can turn a desert into a garden as it alleviates some environmental problems. Modern and proper irrigation often uses perforated pipes that drip water slowly into the soil near plant roots. This drip irrigation uses less water, allows the plants to absorb it efficiently, and reduces water loss from evaporation and drainage.

Prevention of erosion can be done by planting trees in rows as windbreaks; terrace hillsides crops, and cultivate crops in a contour

pattern that helps slow the runoff of water and topsoil. Crops such as alfalfa and wheat provide good surface cover and protect the soil better than corn and other crops that are usually planted in more widely spaced rows.

Prudent fertilizers are common fertilizers obtained from manure, fish meal, and compost (decaying plant matter) that contain decomposing organic material. Before the nutrients in these substances can be used by plants, the organic material must be broken down by bacteria and fungi to inorganic nutrients that roots can absorb.

In developed nations today, most farmers use inorganic, commercially produced fertilizers containing minerals that are either mined or prepared by industrial processes. These fertilizers are usually enriched in nitrogen, phosphorus, and potassium, the macronutrients most commonly deficient in farm and garden soils.

Whether from natural sources or a chemical factory, the mineral nutrients a plant extracts from the soil are in the same form. The difference is that naturally derived fertilizers release nutrients gradually, whereas nutrients in inorganic fertilizers are available immediately. However, because the nutrients from inorganic fertilizers are soluble in water, they may not be retained in the soil for long. Problems arise when fields are over fertilized with inorganic products and excess nutrients are not taken up by plants. The excess nutrients are often leached from the soil by rainwater or irrigation. Nutrient runoff into lakes may lead to a sudden increase in the number of algae, which can deplete oxygen, killing off fish and other animals.

B. Forest conservation

The forest is a national resource and a social asset. It yields a great social profit which lies wholly outside the realm of business. But, at present, most of the forests of the world are so over-used that experts predict dire calamities in the not-too-distant future and irreparable damage on a catastrophic scale. If properly used and put on a sustained yield basis, it will be one of man's greatest resources and for this; conservation of forest is the only alternative.

The following steps should be taken for the conservation of forests:

Regulated and Planned Cutting of Trees: by adopting methods like clear cutting selective cutting and Shelter wood cutting.

The clear cutting method is useful for those areas where the same types of trees are available over a large area. In that case, trees of same age group can be cut down in a selected area and then marked for replantation.

In selective cutting only mature trees are selected for cutting. This process is to be followed in rotation. Shelter wood cutting is where first of all useless trees having been cut down followed by medium and best quality timber trees.

The time gap between these cuttings is helpful in re-growth of trees. In regulated cutting only one-tenth of the forest area is selected for use and rotational system is always followed for their protection.

The forest can be managed in such a way that a timber crop may be harvested indefinitely year after year without being depleted. This technique is called the 'Sustained yield' method adopted by many countries of the world.

Control over Forest Fire: Destruction or loss of forest by fire is fairly common; because trees are highly exposed to fire and once started it becomes difficult to control. Sometimes, the fire starts by natural process, i.e., by lightning or by friction between trees during speedy winds, while in most cases it is started by man either intentionally or unintentionally.

Reforestation and Afforestation: The sustained yield concept dictates that whenever timber is removed, either by block cutting or by selective cutting, the denuded area must be reforested. This may be done by natural or artificial methods. Similarly, any forested land which has been destroyed by fire or mining activities should be reforested. In rugged terrain aerial seeding is the method of choice.

Besides all this, fresh afforestation programmes should be started. New plantations will not only increase the forest cover but also help in making up the eco-balance.

Check over Forest Clearance for Agricultural and Flabitation Purposes:

Most of the present-day agricultural land was once forested and then cleared for the use of agriculture. But now it has reached the stage where further clearance will be dangerous for the entire ecosystem.

C. Wildlife conservation

Wildlife refers to animals and plants that live and grow in natural condition.

Methods of conservation.

Controlling hunting allow hunting by developing hunting rules.

Protection of the habitat of wildlife.

Establishing national parks, wildlife reserves and sanctuaries.

D. Oil conservation

Oil and natural gas conservation involves the use of these resources in a better and a well-organized manner with respect to economic social and ambient expenses.

Making **oil conservation** a way of life is in truth a very simple concept. The simplest way to do this is to cut down on your use of cars. Bike, walk, rollerblade, skateboard can be used, or run to your destination. Not only does it conserve **oil,** but also it gives you exercise as well. Another way to make oil conservation a part of life is to choose materials other than plastic which uses crude **oil** for household items.

E. Mineral conservation

Minerals are non–renewable natural resources that are vital for the construction, manufacturing and energy industries. Also, it is important that the natural environment is protected from damage that may be caused by mineral extraction.

Measures to conserve minerals:

- Use of minerals in a planned and sustainable manner.
- Recycling of metals.
- Use of alternative renewable substitutes.
- Technology should be improved to use the low grade ores profitably.

Review Exercises

1. Which of the following is **NOT** important for soil conservation?
   (a) Proper Irrigation
   (b) Prudent fertilizers
   (c) Prevention of erosion
   (d) Excessive fertilizers
2. Which of the following activities harms forest conservation?
   (a) Regulated tree cutting
   (b) Controlling wild-fire

(c) Fresh afforestation
(d) Clearance of forests

3. Which of the following discourages wildlife conservation?
   (a) Poaching.
   (b) Protection of habitat of wildlife.
   (c) Protecting endangered wildlife species.
   (d) Establishing national parks and sanctuaries.
4. Both oil and mineral conservations require:-
   (a) Recycling.
   (b) Excessive use.
   (c) Reducing profitability.
   (d) Use of alternative renewable resources.

3.9 Biogeochemical Cycles in Nature

A biogeochemical cycle or nutrient cycle is a pathway by which a chemical element or molecule moves through both biotic and abiotic compartments of Earth.

Living organism require various kinds of chemical elements such as carbon, hydrogen, nitrogen, oxygen, sulphur, phosphorous, iron, etc. for their biosynthetic and metabolic processes. The absorption and utilization of such elements by an organism is compensated by their recycling (returning back) into the environment.

A. The water cycle

The water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the earth. It involves the following processes:

Evaporation: The transformation of water from liquid to gas phases as it moves from the ground or bodies of water into the overlying atmosphere. The source of energy for evaporation is primarily solar radiation. Evaporation often implicitly includes **transpiration** from plants, though together they are specifically referred to as **evapotranspiration**.

Condensation: The transformation of water vapor to liquid water droplets in the air, producing clouds and fog.

Precipitation: The fall of the condensed water vapor on the earth's surface. Most precipitation occurs as rain, but also includes snow, hail, fog drip, granule, and sleet.

Runoff: The variety of ways by which water moves across the land. This includes both surface runoff and channel runoff. As it flows, the water may infiltrate into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.

Infiltration: The flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater.

Sub surface flow: The flow of water underground, in the vadose zone and aquifers. Subsurface water may return to the surface (eg. as a spring or by being pumped) or eventually seep into the oceans. Water returns to the land surface at lower elevation than where it infiltrated, under the force of gravity or gravity induced pressures. Groundwater tends to move slowly, and is replenished slowly, so it can remain in aquifers for thousands of years. See the Figure 15 below.

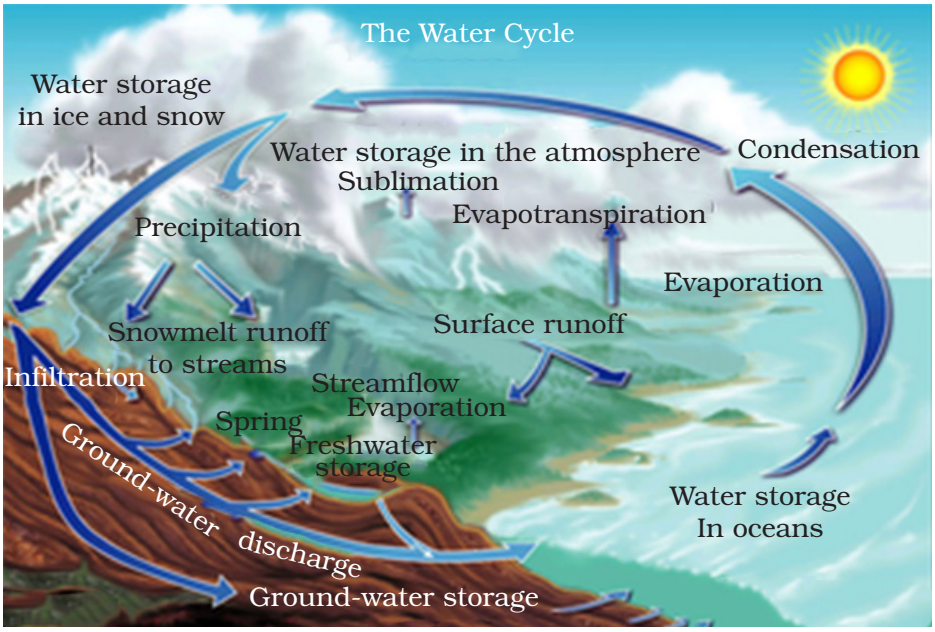


Figure 15. Figure The water cycle

B. The carbon cycle

The carbon cycle exchanges carbon among the biosphere, geosphere, hydrosphere, and atmosphere of the Earth. The carbon cycle is usually thought of as four major reservoirs of carbon interconnected by pathways of exchange.

These reservoirs are:

- the plants.
- the terrestrial biosphere, which is usually defined to include fresh water systems and non-living organic material, such as soil carbon.
- the oceans, including dissolved inorganic carbon, living and non-living marine biota,
- the sediments including fossil fuels.

The carbon exchanges between reservoirs occur because of various chemical, physical, geological, and biological processes. The ocean contains the largest active pool of carbon near the surface of the Earth, but the deep ocean part of this pool does not rapidly exchange with the atmosphere.

Carbon exists in the Earth's atmosphere primarily as the gas carbon dioxide (CO_2). Although it is a small percentage of the atmosphere (approximately 0.04% on a molar basis, and increasing), it plays an important role in supporting life. Carbon is an essential part of life on Earth. It plays an important role in the structure, biochemistry, and nutrition of all living cells.

Carbon cycles as it is released into and removed from the atmosphere by several ways, (Figure 16).

Carbon is released into the atmosphere in several ways

- Through the **respiration** performed by plants and animals.
- Through the **decay of animal and plant matter**.
- **Burning fossil fuels** such as coal, petroleum products, and natural gas releases carbon that has been stored in the geosphere for millions of years.
- **Burning biomass and agrofuels** also releases carbon dioxide.
- **Volcanic eruptions** and **metamorphism** release gases into the atmosphere. Volcanic gases are primarily water vapor, carbon dioxide and sulfur dioxide.

Carbon is removed from the atmosphere

- During **photosynthesis** by autotrophs that produce their own organic compounds using carbon dioxide is absorbed by the

autotrophs from the atmosphere or the water body. The most important autotrophs for the carbon cycle are **trees** in forests on land and **phytoplankton** in the Earth's oceans.

- Carbon is transferred within the biosphere as heterotrophs feed on other organisms or their parts (e.g., fruits). This includes the uptake of dead organic material (detritus) by fungi and bacteria for fermentation or decay.

Carbon is recycled in nature mainly by **photosynthesis** of autotrophs and **respiration** of heterotrophs and autotrophs.

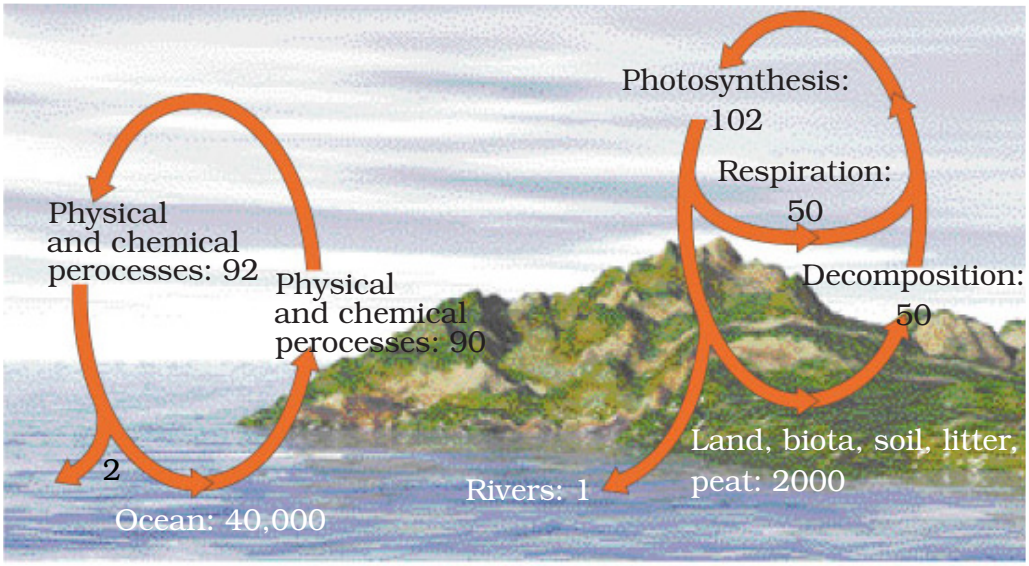


Figure 16. Carbon cycle

C. The Nitrogen cycle

The nitrogen cycle is the biogeochemical cycle that describes the transformations of nitrogen and nitrogen-containing compounds in nature. It involves fixation and denitrification, (Figure 17).

Earth's atmosphere is approximately 78-80% nitrogen, making it the largest pool of nitrogen. Nitrogen is essential for many biological processes; it is crucial for any life here on Earth. It is in all amino acids, is incorporated into proteins, and is present in the bases that make up nucleic acids, the as DNA and RNA.

There are four ways to convert N_2 (atmospheric nitrogen gas) into more chemically reactive forms:

Fixation

Biological fixation: some symbiotic bacteria (most often associated with leguminous plants) and some free-living bacteria are able to fix nitrogen as organic nitrogen. An example of mutualistic nitrogen fixing bacteria is the *Rhizobium* bacteria, which live in legume root nodules. These are diazotrophs. An example of the free-living bacteria is *Azotobacter*.

Industrial N-fixation: Under great pressure, at a temperature of 150-200°C, and with the use of a catalyst, atmospheric nitrogen and hydrogen (usually derived from natural gas or petroleum) can be combined to form ammonia (NH_3). In the Haber-Bosch process, N_2 is converted together with hydrogen gas (H_2) into ammonia (NH_3) which is used to make fertilizer and explosives.

Combustion of fossil fuels : Automobile engines and thermal power plants, which release various nitrogen oxides (NO_2).

Assimilation

Plants can absorb nitrate or ammonium ions from the soil via their root hairs. If nitrate is absorbed, it is first reduced to nitrite ions and then ammonium ions for incorporation into amino acids, intense nucleic acids, and chlorophyll. In the plant with mutualistic relationship with rhizobia, some nitrogen is assimilated in the form of ammonium ions directly from the nodules. Heterotrophic organisms absorb nitrogen as amino acids, nucleotides and other small organic molecules.

Ammonification

When a plant dies, an animal dies, or an animal expels waste, the initial form of nitrogen is organic. Bacteria and fungi, convert the organic nitrogen within the remains back into ammonium (NH4), a process called ammonification or mineralization.

Nitrification

Primarily soil-living bacteria and other nitrifying bacteria perform the conversion of ammonia to nitrates.

Bacteria such as the *Nitrosomonas* species, which converts ammonia to nitrites (NO_2), perform the primary stage of nitrification, the oxidation of ammonia (NH3). Other bacterial species, such as the *Nitrobacter*, are responsible for the oxidation of the nitrites into nitrates (NO_3^-).. It is important for the nitrites to be converted to nitrates because accumulated nitrites are toxic to plant life.

Denitrification

Denitrification is the reduction of nitrates back into the largely inert nitrogen gas (N_2), completing the nitrogen cycle. This process is performed by bacterial species in anaerobic conditions.

The bacteria use the nitrate as an electron acceptor in the place of oxygen during respiration. These facultative anaerobic bacteria can also live in aerobic conditions.

THE GLOBAL NITROGEN CYCLE

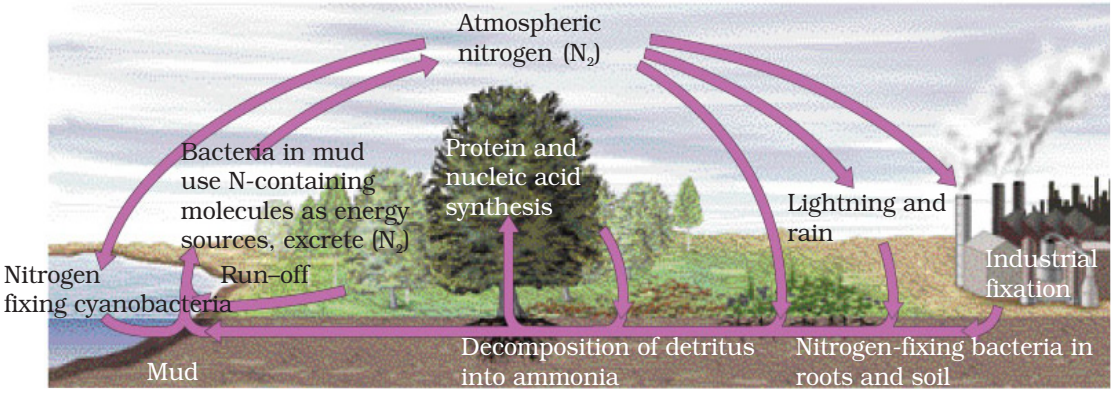


Figure 17. The Nitrogen cycle

D. The Phosphorous cycle

Phosphorous recycles in nature in the form of phosphate compound involving absorption from the ground as phosphate ions by plants and decomposition by microbes, (Figure 18).

Unlike many other biogeochemical cycles, the atmosphere does not play a significant role in the movements of phosphorus, because phosphorus and phosphorus-based compounds are usually solids at the typical ranges of temperature and pressure found on earth.

Phosphorus is an essential nutrient for plants and animals when present in the form of ions PO_4^{3-} and HPO_4^{2-}. It is a part of DNA and RNA-molecules, molecules that store energy (ATP and ADP) and of lipids of cell membranes.

Phosphorus is also a building block of certain parts of the human and animal body, such as the bones and teeth.

Phosphorus normally occurs in nature as part of a phosphate ion, PO_4^{3}. Most phosphates are found as salts in ocean sediments or in rocks.

Human interference in the phosphorus cycle occurs by overuse or careless use of phosphorus fertilizers. This results in increased amounts of phosphorus as pollutants in bodies of water resulting in eutrophication.

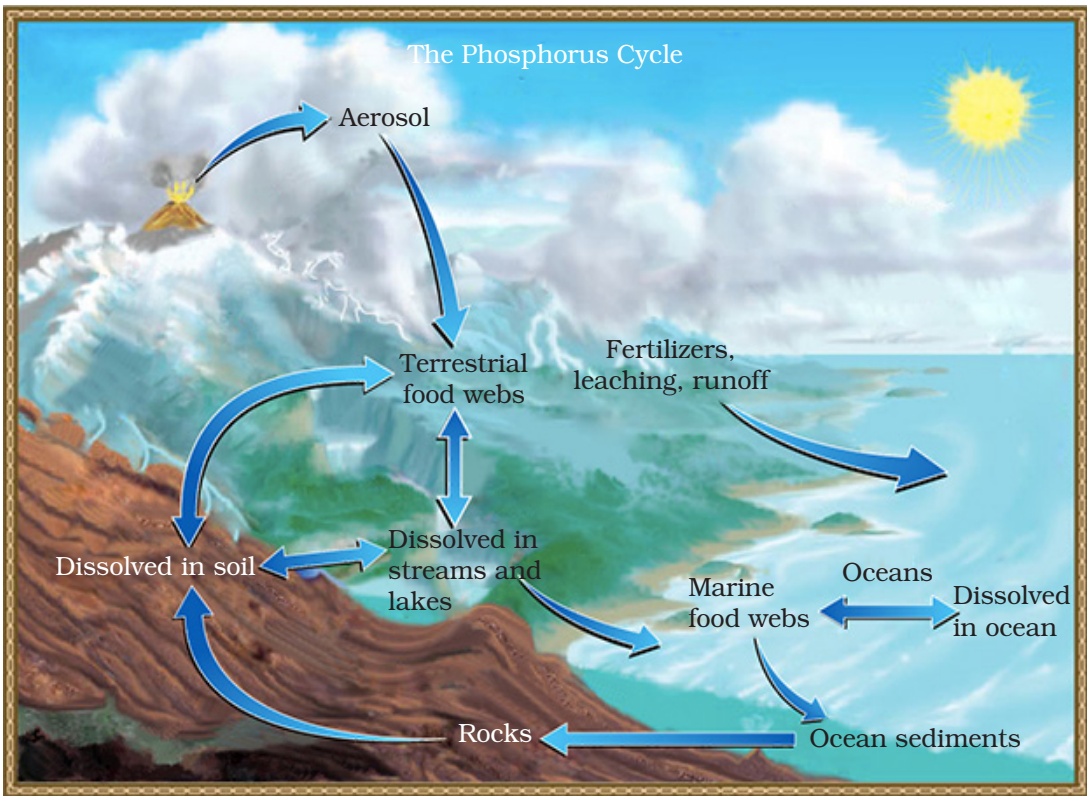


Figure 18. The Phosphorous cycle

E. The Sulfur cycle

Sulphur is one of the constituents of many proteins, vitamins and hormones. It involves the following steps below.

Mineralization of organic sulfur to the inorganic form, hydrogen sulfide: (H_2S).

Oxidation of sulfide and the element sulfur (S) and related compounds to sulfate (SO_4^{2-}).

Reduction of sulfate to sulfide.

Microbial immobilization of the sulfur compounds and subsequent incorporation into the organic form of sulfur.

Human impact on the sulfur cycle is primarily in the production of sulphur dioxide (SO_2) from industry (e.g. burning coal) and the internal combustion engine.

Sulphur dioxide can precipitate onto The surfaces where it can be oxidized to sulphate in the soil (it is also toxic to some plants), reduced to sulphide in the atmosphere, or oxidized to sulfate in the atmosphere as sulphric acid, a principal component of acid rain.

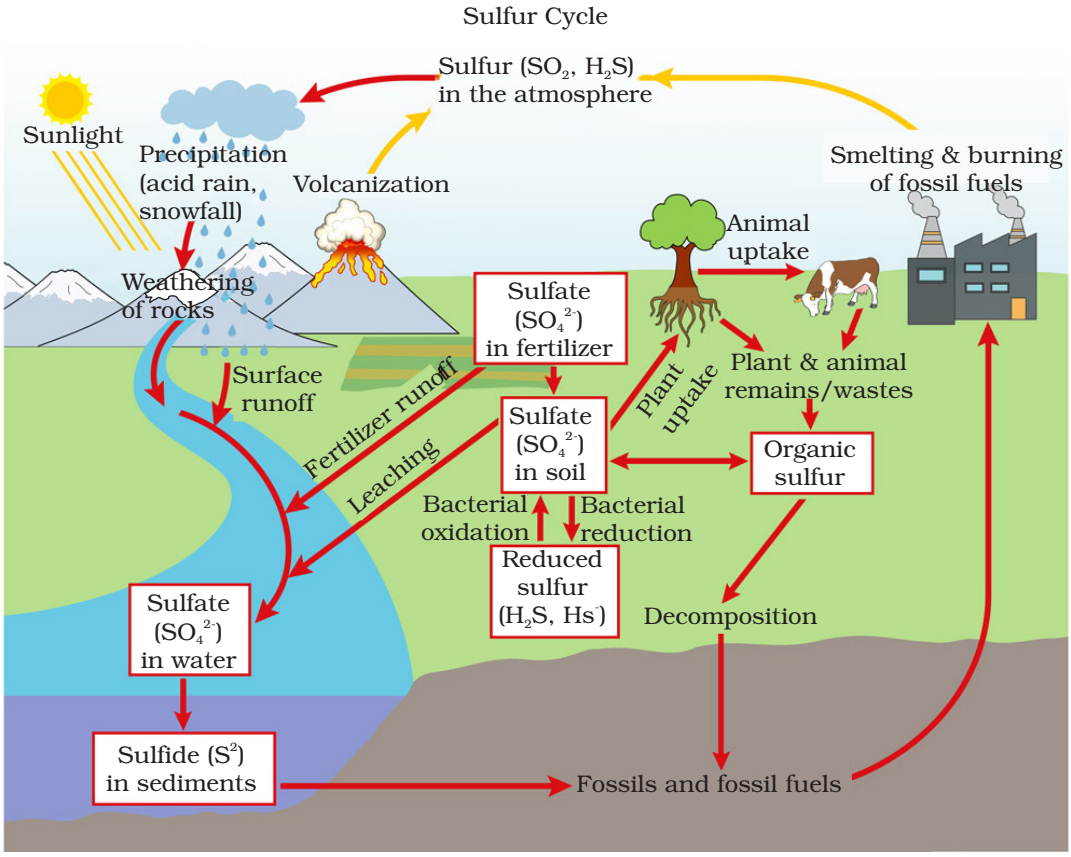


Figure 19. The Sulphur cycle

Activity 3

Diagraming and discussing water, carbon, nitrogen, phosphorous and sulphur cycles.

Make groups of 4-5 students, draw and discuss on the major processes of water, Carbon, Nitrogen, Phosphorous, and Sulphur cycles

Review Exercises

1. What are the most important processes in Water cycle?
   (a) Evaporation and precipitation.
   (b) Photosynthesis and respiration.
   (c) Transpiration and sweating.
   (d) Precipitation and infiltration.
2. What are the most important living organisms in Carbon cycle?
   (a) Fungi
   (b) Animals
   (c) Bacteria
   (d) Green plants
3. What are the most important processes in Nitrogen cycle?
   (a) Industrial Nitrogen fixations.
   (b) Nitrification and denitrification.
   (c) Decomposition and combustion.
   (d) Ammonification and assimilation.
4. Which of the following processes is decisive for the return of phosphorous and sulphur into the atmosphere?
   (a) Absorption
   (b) Assimilation
   (c) Decomposition
   (d) Photosynthesis

3.10 Organisms, Habitat and Niche

Habitat is the place where an organism lives. It is the address of an organism.

Niche is the position or the role of an organism in in the community, including its habitat and its interactions with other organisms. The niche includes the resources an organism uses to meet its energy, nutrient, and survival demands of its environment.

It may be described in terms of space utilization, food consumption, temperature range, appropriate conditions for mating, requirements for moisture, and other factors.

Field trip 3a

(a) Observing and discussing the effects of erosion on soil fertility.

Your school will arrange field trip to farms for the purpose of observing and discussing the effects of erosion on soil fertility. Then, present to the class your observation and discussions.

(b) Digging the school yard dump sites to observe non biodegradable substances (plastic and metallic materials).

Your biology teacher will arrange a visit to your school yards and dig it in searching for non-biodegradable substances. Then, present your findings to the class, class your observation and discussions.

(c) Listing food and cash crops in Liberia by considering the type of soil for cultivation.

Your school administration and biology teacher will arrange a trip to visit and interview the relevant agriculture office about the type of soil suitable for cash crop cultivation of Liberia. After the trip, present your findings to the class.

(d) Discussing the various interspecific interactions.

Your biology teacher will arrange grounds for you to make an investigation in your school compound or residential area in searching for interspecific interactions between species. Finally note your findings and present to the class.

(e) Taking Field trips to visit ecosystems such as ponds and forest regions.

Your school administration and biology teacher will arrange you a field trip to visit aquatic and land ecosystems such as pond and forest for found at your school vicinity. Then, report your observations to the class and present to the class.

3.11 Population

Population refers to groups of individuals of the same species that occur together within a particular area and time.

A. **Population density,** is the number of individuals per unit area. It is the spacing of individuals. For example, if we calculated the density of the human population, we would know how many individuals there are per square mile. It is observed that the population density of urban area is greater than that of rural area.

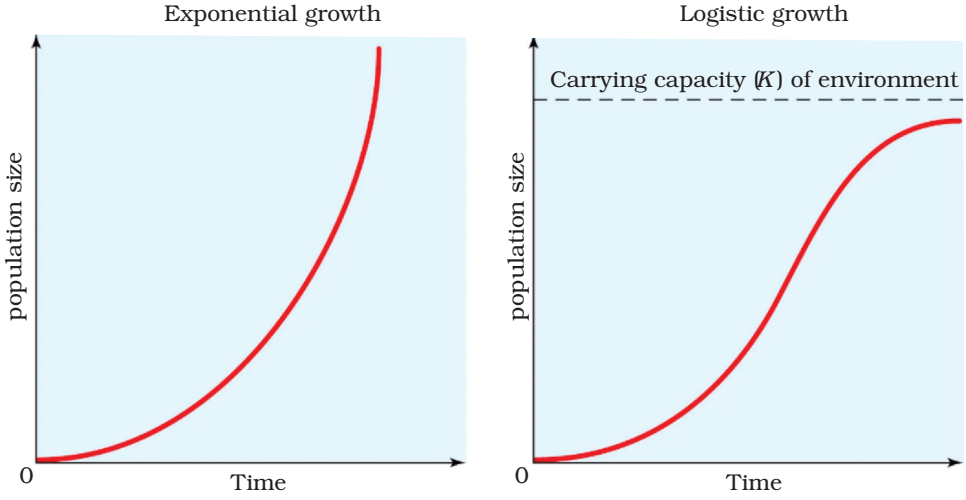
Each population has a particular density and distribution, whether uniform, random, or clumped.

B. **Population growth,** rate is the change in the number of individuals over a specific period of time. Population growth rate can be interpreted over any time period. For example, annual population growth refers to population growth in a year.

This concept can be applied to any type of population. Once calculated, the population growth rate can be applied to estimate future population size.

Exponential pattern of population growth results in a J-shaped curve (Figure 20a). This is because population growth accelerates over time. Such pattern of population growth can be likened to compound interest at the bank: the more your money increases, the more interest you will get. For instance human population exhibits such pattern of growth that growth is still quite rapid.

Logistic growth results in an S-shaped growth curve (Figure. 20b). This because the population size stabilizes when the carrying capacity of the environment has been reached.



A. Exponential growth B. Logistic growth

Figure 20. Patterns of population growth

C. **Doubling time** is the length of time it takes for the population size to double. For human population the doubling time is now estimated to be 53 years.

Such an increase in population size will put extreme demands on our ability to produce and distribute resources. In 53 years, the world will need double the amount of food, jobs, water, energy, and so on just to maintain the present standard of living.

Percent growth rate

Percent Change in the Population

A general formula for calculating population growth rate is as follows:

$$Gr = NtGr = Nt$$

- Gr = growth rate (measured as number of individuals)
- N = change in population
- t = time

To calculate N, which is the population change, you can represent it as follows:

$$N = P2 - P1$$

- P2 = Final population size
- P1 = Initial population size

Putting it all together, the population growth rate in terms of the number of individuals can be calculated using the following formula:

$$Gr = (P2 - P1)\ t$$

Examples

A town's population experiences an increase from 1,000 to 1,125 individuals in ten years. The population change in terms of individuals would be calculated as follows:

$$Gr = (1{,}125 - 1{,}000)\ 10$$

$$Gr = 12 \text{ individuals per year}$$

The population in this example experienced a growth of approximately 12 individuals per year. It is important to note that even though the exact answer is 12.5, the answer must be rounded to the nearest whole number since it is measured in individuals. Also note that a positive answer indicates population growth, whereas a negative answer indicates population decline. If the population change was zero, then the population is considered to be in a state of equilibrium.

Population change can also be calculated in terms of percent change. First, the formula for percent change is:

C= (x2 – x1) x1 – 100 C is the percent change.

- X 1 x 1 is the initial population size. In this example, this equals 1,000 individuals.
- X 2 x 2 is the final population size. In this example, this equals 1,125 individuals.
- Multiply by 100 to get a percent.

Next, enter the given variables into the percent change formula:

C= (1,125 –1,000) /1,000 – 100C =

C = 12.5C = 12.5%

According to the formula, the percent change in the population was 12.5% growth.

Examples

A small town has a net immigration of 3 per 1000, a crude birth rate of 9 per 1000, and a crude death rate of 11 per 1000. What is the growth rate of this town?

$$\text{Growth rate} = \frac{(\text{crude birth rate} + \text{immigration}) - (\text{Crude death rate} + \text{emigration})}{1000} \times 100$$

$$\frac{(9 + 3) - (11 + 0)}{1000} \times 100 = \frac{(12 - 11)}{10} \; 0.1\%$$

Birth and death rates

Birth rate is the number of children born per thousand persons in a year. Along with mortality and migration rates it is used to calculate population growth.

Death rate is the number of persons dying per thousand in a year.

Immigration and emigration

Immigration is the permanent arrival of new individuals into the population,

Emigration is permanent movement of individuals out of a population.

The number of individuals entering (immigration) or leaving (emigration) the population is used to determine how that population size is affected.

Density dependent and density independent factors

Density-independent factors are are abiotic factors such as weather and natural disasters. which affect or limit the population size. The number of organisms present did not influence the effect of the factor. For example, fires don't necessarily kill a larger percentage of individuals as the population increases in size.

Density-dependent factors are abiotic factors that affect or limit the population size. They include factors such as competition, predation, and parasitism.

Review Exercises

1. Which of the following has no effect on the global population growth?
   (a) Natality
   (b) Birth rate
   (c) Death rate
   (d) Immigration
2. Which of the following is a dependent factor?
   (a) Light
   (b) Gravity
   (c) Predation
   (d) Temperature
3. As population of humans increases in a capital city, what happens to the population density?
   (a) Decreases
   (b) Increases
   (c) Remains constant
   (d) Difficult to determine
4. What the population density of an orchid with 20 apple trees in an area of 4 hectares?
   (a) 1 tree/hectar
   (b) 3 trees/hectar
   (c) 5 trees /hectar
   (d) 10 trees/hectar
5. What is the growth rate of a city with a net immigration 10 per t 1000, a crude birth rate 20 per 1000, a crude death rate 10 per 1000 and emigration 4 per 1000?
   (a) 1.3%
   (b) 1.6%

(c) 2.3%
(d) 2.6%

3.12 Ecological Succession

Ecological succession, is the process by which communities tend to change from simple to complex. It involves the replacement or colonization of one community by another in a given ecosystem. It is a change in community composition over time.

A. Primary and secondary successions

Primary succession occurs on bare, lifeless substrate, such as rocks, or in open water, where organisms gradually move into an area and change its nature. Primary succession occurs in lakes and on land exposed after the retreat of glaciers, as well as on volcanic islands that rise from the sea.

Secondary succession occurs in areas where an existing community specially the climax has been destroyed by fire or other natural and human calamities.

B. Pioneer and climax communities

Pioneer community, is the first community to establish. Mostly grass-like plants are pioneers.

Climax community, is the final community to establish. In forests the climax communities are trees. Climax community, cannot be replaced by other species. A climax community of an area may be destroyed due to factors such as climate, or fire, etc and the area will be left open for another series of life forms.

Succession in the Plant Community

- A field devastated by fire or cleared for industrial or agricultural use will recover its vegetation relatively quickly in the absence of erosion.
- In the first years of recovery, bare earth becomes grassland, populated by opportunistic species that can tolerate the bleak environmental conditions.
- Soon, shrubs and other more competitive plants intermingle and dominate.

- Tree seedlings crop up, and by the end of the first century, a coniferous forest occupies what was an overgrazed or blackened stretch of earth.
- The shady forest forms a new environment in which, after another half-century, the seedlings of other kinds of trees may outcompete the initial residents.

Succession that takes place in a cleared area

- The first plants that are likely to appear in this cleared area are many different varieties of weeds. They will appear very soon after the land has been cleared. The weeds are usually 'annual weeds' which means that they last for one year before they seed themselves and then die. These first organisms that invade the area are called colonizers.
- In the second year after the land has been cleared, many permanent herbs will appear. These herbs will continue to grow and establish themselves and will be even more common and evident in the second year. There will still be weeds visible in this area, but the herb plants will be more dominant than the weeds.
- Soon after this, more dominant vegetation in the form of small woody shrubs will become evident. The herbs will continue to grow in the spaces between the shrubs. When the shrubs start producing too much shade for the liking of the herbs, their numbers will gradually reduce. The woody shrubs will be the dominant vegetation, with weeds and herbs still to be found but in reduced numbers.
- Gradually, small trees will become evident, eventually growing into much larger trees. These trees will take away the vital sunlight from the woody shrubs and so their numbers will gradually reduce as well.

Succession that takes place in a pond

- Sometimes it happens that a flow of water becomes trapped and forms a pool of water. If the water does not drain away, but stays, it is called a pond.
- At first it is merely water and nothing else. As the water stands, it will become stagnant and it will attract small organisms

into it. Algae will start growing on the sides and bottom of the pond. When this happens, the algae will trap dust and soil particles that are either blown into the pond or brought there by the small organisms.

- The soil layer will build up and in doing so it will become deep enough for small water-weeds to take root in. The growth of these weeds will attract larger organisms, like frogs, into the pond.
- The larger organisms will bring seeds of larger plants which will germinate and start to grow. These larger plants, like reeds on the side of the pond, will form protective areas for larger animals, like ducks, to nest in.
- Eventually a climax community will be reached. The pond will have a small amount of algae growing in it, but with a good soil layer on the bottom, which anchors the larger water plants and reeds etc. These provide shelter and protection for a wide range of aquatic amphibians and land animals.

Review Exercises

1. As succession progresses, animal species diversity increases due to the fact that :
   (a) Food choice increase.
   (b) Temperature is moderate.
   (c) Less soil is being created.
   (d) Precipitation rates stabilize.
2. A pond that was destructed by drought revived and showed the emergence of new algae and some tadpoles. The form of this succession can be best described as:-
   (a) Early succession
   (b) Late succession
   (c) Primary succession
   (d) Secondary succession
3. A previously bare land was gradually occupied by lichen and mosses, annual herbs, perennial herbs and finally by forests. Which one of the following best describes each stage in the process indicated above?
   (a) Sere
   (b) Succession

(c) Afforestation
(d) Climax community

4. On question '3' above which of the following plant communities are the pioneer communities?
(a) Perennial herbs
(b) Annual herbs
(c) Lichen and mosses
(d) Shrubs and forests

Key Terms

- Soil
- Soil formation
- Clay
- Sand silt
- Humus
- Erosion
- Inorganic fertilizers
- Natural fertilizers
- Deforestation
- Contour ploughing
- Terracing
- Crop rotation
- Compost
- Manure
- Liming
- Mulching
- Symbiosis
- Mutualism
- Commensalism
- Parasitism
- Predation
- Trophic level
- Food chain
- Food web
- Producer
- Consumer

- Decomposer
- Ecological pyramids
- Primary productivity
- Gross productivity
- Net productivity
- Secondary productivity
- Biogeochemical cycle
- Evaporation
- Condensation
- Precipitation
- Photosynthesis
- Respiration
- Nitrogen fixation
- Nitrification
- Denitrification
- Conservation
- Population
- Population density
- Population growth rate
- Doubling rate
- Density dependent factors
- Density independent
- Exponential growth
- Logistic growth
- Ecological succession
- Pioneer community
- Climax community

SUMMARY

- Soil is a medium for plant growth.
- Soil is formed by physical and chemical weathering.
- A typical soil is composed of mineral particles, air, water organic and inorganic substances, and microorganisms.
- Soil is basically classified into clay, sand and silt soil depending on their particle size and other features.

- These soil particles vary in fertility due, to the difference in their water holding capacity, air holding capacity, drainage capacity and humus contents.
- Soil fertility is the suitability of soil for plant growth.
- Soil fertility is affected by its texture, pH, water, temperature, air and solution.
- Erosion is the removal top soil due to wind, runoff water and depletion of nutrients.
- Soil erosion is caused due to deforestation, excessive use of inorganic fertilizers and over grazing.
- Soil erosion is protected by having cover vegetation, wind break and ploughing across a slope.
- Soil conservation is the prevention of soil erosion by planting trees and having cover vegetation to reduce rain water runoff and amount of its absorption.
- Soil conservation methods are contour ploughing, terraces, crop rotation, shelter belting, afforestation, building dams, using fertilizers and hay and pasture land.
- Soil is maintained by controlling erosion, pH, weeds, by practicing crop rotation, fertilizers and proper drainage.
- Soil is restored by composting, mulching, liming, getting soil tested, preventing hardening of soil and growing nutrient-collecting plants.
- Non- biodegradable substances are substances not decomposed by biological resources.
- Non-biodegradable substances alter soil pH and cause soil destruction and reduce crop yield.
- Interspecific interaction occurs between two different species.
- Biological association is the living together two different species.
- Parasitism is an association that benefit parasite but the harm to host.
- Mutualism is an association for common benefit of both partners.
- Commensalism an association for the benefit of commensal, but the host is neither benefitted nor harmed.
- Predation an association in between prey(hunted) and predator (hunter).
- Trophic level is the feeding step where an organism obtains food.
- The first trophic level is occupied by producers or autotrophs or self-feeders using sunlight.
- The second trophic level is occupied by the consumers, herbivoures that directly feed on producers.
- The third trophic and above are occupied by consumers, carnivoures, and scavengers.

- Decomposers are found at different trophic levels and feed on the organic remains of dead plants and organisms.
- Food chain is a model food relationship showing energy and nutrient containing food transfer from producers to the various consumers.
- Food web is the actual or real food relationship in nature showing energy and nutrient containing food from the initial producers to the various consumers.
- Nature is conserved by conserving soil, forest, wildlife, oil and minerals.
- Soil is conserved by proper irrigation, prudent fertilizers and preventing erosion.
- Forest is conserved by regulated and controlled cutting trees, controlling over fire, reforestation and afforestation and checking over forest clearance for agriculture and other activities.
- Wildlife is conserved by controlling hunting, preventing wildlife habitat and establishing botanic gardens, national parks and sanctuaries.
- Oil is conserved by reducing devices that use oils by practicing walk, riding bike or searching for alternative means of transport.
- Minerals are conserved by using them in planned and sustainable manner, using them in recycled manner, and seeking alternative renewable resources.
- Water cycle, mainly involves the processes of evaporation and precipitation.
- Carbon cycle, occurs by the processes of photosynthesis and respiration. Green palnts are the most responsible.
- Nitrogen cycle, requires the processes of nitrification, nitrogen fixation and denitrification carried out by bacteria.
- Phosphorous cycle, involves the processes of absorption, and decomposition.
- Sulphur cycle involves reduction, oxidation and decomposition by bacteria.
- Population is the total individuals of single species that occur in a particular area and time.
- Population density refers to the number of individuals per unit area.
- Population growth rate is the change in the number of individuals over a specific period of time.
- Doubling time is the length of time it takes for the population size to double.

- Percent growth rate is the percent change of population in a given time.
- Birth rate the number children born per thousand persons in a year.
- Death rate the number of dying per thousand in a year.
- Immigration the permanent arrival of new individuals into the population
- Emigration permanent movement of individuals out of a population.
- Density dependent factors are due to biotic factors that depend on the population size.
- Density independent factors are due abiotic factors that do not depend on the population size.
- Ecological succession is the replacement of one community in a given ecosystem by another successively till a stable climax community is established.
- Succession involves pioneer and climax community.
- Primary succession occurs on bare lands or aquatic bodies
- Secondary succession occurs after the destruction of the final community due to natural calamities.
- Primary productivity is the productivity of the primary producers.
- Gross primary productivity (GPP) is the rate at which the primary producers synthesize new organic matter
- Net primary productivity (NPP) is the GPP minus the respiration of the primary producers
- Secondary productivity is the productivity of a heterotroph trophic level.

Review Exercises

1. Which of the following statements is **TRUE** about clay and sandy soil?
   (a) Sandy soil retains moisture than clay soil.
   (b) Clay soil is rich in plant nutrients than sandy soil.
   (c) Sandy soil is rich in plant nutrients than clay soil
   (d) Clay soil has low water retention capacity than sandy soil.
2. What are the components of loam soil?
   (a) Sand, clay and humus
   (b) Clay, silt and fine sand
   (c) Coarse sand and fine sand
   (d) Gravel, water, and humus

3. Which of the following is natural cause soil erosion?
   (a) Rainfall
   (b) Overgrazing
   (c) Deforestation
   (d) Faulty land use
4. All of the following factors is man-made factors for soil erosion?
   (a) High crop intensity
   (b) Faulty farming system
   (c) Mass slide due to gravity
   (d) House construction and mining
5. Which relationship best describes the interaction between Ascaris and humans?
   (a) Parasite- host
   (b) Prey- predator
   (c) Commensal and host
   (d) Producer –consumer
6. One of the following groups of organisms act upon dead organic materials and complete nutrient recycle?
   (a) Parasites
   (b) Carnivoures
   (c) Scavengers
   (d) Decomposers
7. Which of the following is density independent factor?
   (a) Disease
   (b) Predation
   (c) Parasitism
   (d) Temperature
8. Which of the following is the CORRECET sequence of organisms in a food chain?
   (a) Grass ⟶ snake ⟶ rabbit ⟶ hawk
   (b) Grass ⟶ rabbit ⟶ snake ⟶ hawk
   (c) Hawk ⟶ snake ⟶ grass ⟶ rabbit
   (d) Grass ⟶ rabbit ⟶ hawk ⟶ snake
9. In a food chain consisting of: Maize ⟶ Mouse ⟶ Y ⟶ Eagle,what does 'Y' represent?
   (a) First trophic level
   (b) Secondary consumer

(c) Tertiary consumer
(d) Second trophic level

10. To which trophic level herbivoures belong?
    (a) First
    (b) Second
    (c) Third
    (d) Fourth
11. Which of the following pyramids depicts the total mass of dry organic in the community of an quatic environment?
    (a) Pyramid of number
    (b) Pyramid of biomass
    (c) Pyramid of energy
    (d) Pyramid of population
12. The world food problems will be solved if humans depend more on_____ to obtain their food.
    (a) Producers
    (b) Herbivoures
    (c) Carnivores
    (d) Decomposers
13. Which of the following food chain is believed to depict an inverted pyramid of number?
    (a) Algae fish human
    (b) Grass rabbit flea
    (c) Grass goat tiger
    (d) Wheat sheep fox
14. Which of the following is **NOT** observed an ecosystem?
    (a) Energy recycling
    (b) Nutrient recycling
    (c) Abiotic and biotic component
    (d) Interactions among living things
15. The oxidation of NO2- into NO3- involves which of the following bacteria?
    (a) Denitrifying bacteria
    (b) Nitrifying bacteria
    (c) Ammonifying bacteria
    (d) Nitrogen fixing bacteria

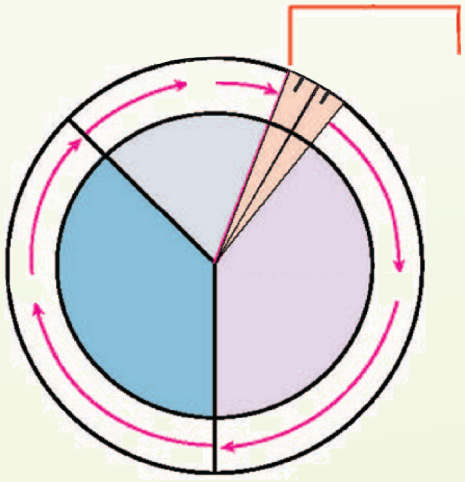
16. Which of the following communities **CANNOT** be pioneer communities in ecological succession?
    (a) Trees
    (b) Mosses
    (c) Lichens
    (d) Grasses
17. How does succession affect the new plant and animals? It makes
    (a) Them easier to kill.
    (b) All of them extinct.
    (c) Them less adapted to the environment.
    (d) Them more adapted to the environment.
18. Which of the following is **NOT** true about a climax community?
    (a) It has a wide diversity of species.
    (b) The life or growth forms indicate the climatic type in an ecosystem.
    (c) Individuals in the climax stage are replaced by other individuals of the same kind.
    (d) The vegetation is intolerant of changing environments.

B11CH04

CHAPTER 4

CELL GROWTH, DIVISIONS AND REPRODUCTION

Chapter Contents



Chapter Outcomes

Upon completion of chapter, learners will be able to:

- describe the stages of the cell cycle;
- list and diagram the phases of mitosis and meiosis;
- distinguish mitosis and meiosis and explain the importance of meiosis in sexual reproduction;
- distinguish between asexual and sexual reproduction;
- list and explain some forms of asexual reproduction in plants nd animals;
- discuss reproduction and parenting in humans (sexuality);
- initiate advocacy on substance abuse and SBV.

Introduction

This chapter starts with cell growth and division that includes the stages of cell cycle, and the cell divisions mitosis and meiosis together with their events. Then, it looks into the process of reproduction and its types (asexual and sexual). More importantly it deals with responsibilities of parenting including the roles of each parent in child rearing and the risk of teenage parenting. On the top of these it views the sexual decisions and impact on the family in relation with reproductive health and rights. Finally, the lesson looks into the advocacy implemented by the youth in playing role to stop substance abuse and school based violence.

4.1 Cell Growth and Division

A. Cell cycle

Cell cycle is an ordered series of events involving cell growth and division. The cell cycle is a four-stage process (Figure 1).

These phases are:-

- **Growth$_1$ or G$_1$phase:** During G$_1$ phase also called the first gap phase the cell grows physically larger, copies organelles, and makes the molecular building blocks it will need in later steps.
- **Syntheses or S phase:** In S phase, the cell synthesizes a complete copy of the DNA in its nucleus.
- **Growth$_2$ or G$_2$ phase:** During the second gap phase, the cell grows more, makes proteins and organelles, and begins to reorganize its contents in preparation for mitosis.
- **Mitosis or M phase:** During the mitotic (M) phase, the cell divides its copied DNA and cytoplasm to make two new cells. M phase involves two distinct division-related processes: mitosis and cytokinesis.

A cell spends most of its time in what is called interphase, and during this time it grows, replicates its chromosomes, and prepares for cell division. The cell then leaves interphase, undergoes mitosis, and completes its division.

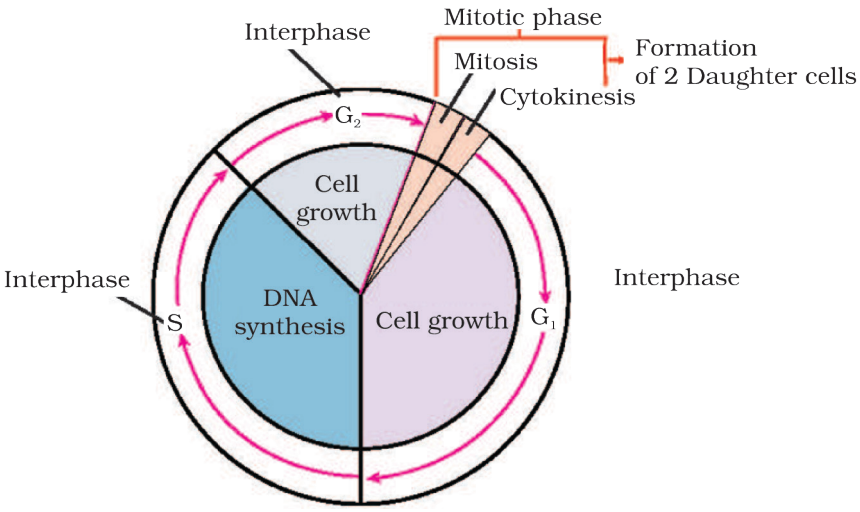


Figure 1. The cell cycle

ACTIVITY 1

Drawing and labeling the stages of cell cycle

Form a group of 4-5 students, draw and label the stages of cell cycle describe the major events of each stage.

Interphase is **composed of G_1 phase (cell growth), followed by S phase (DNA synthesis), and followed by G_2 phase (cell growth)**. At the end of interphase comes the mitotic phase.

B. Phases of Mitosis

Mitosis is a process of cell **duplication, or** reproduction, during which one cell gives rise to two genetically identical daughter cells.

In mitosis, the nuclear DNA of the cell condenses into visible chromosomes and is pulled apart by the mitotic spindle, a specialized structure made out of microtubules. Mitosis takes place in four phases: prophase, metaphase, anaphase, and telophase (Figure 2).

In cytokinesis, the cytoplasm of the cell splits in two, making two new cells. In animal cell division cytokinesis forms cell furrow, but in plant cell, division takes place by plate formation.

Prophase: The chromosomes coil and shorten, and become visible. It becomes apparent that the chromosomes have duplicated. Pairs of identical chromosomes remain attached to each other at the centromere and each chromosome is called a chromatid.

Metaphase: Chromosomes line up along the center of the cell. A pair of structures called centrioles form at the poles of the cell, and produce spindle fibers which attach to the centromeres of each chromosome pair.

Anaphase: The paired chromosomes split at the centromere and the two halves migrate along the spindle fibers to opposite sides of the cell. At the same time, the center of the **cell begins to pinch.**

Telophase: Cell division occurs, and two diploid daughter cells are produced each is identical to the original. Cells return to Interphase and prepare for another round of division. Diploid cells have full complement of homologous chromosomes.

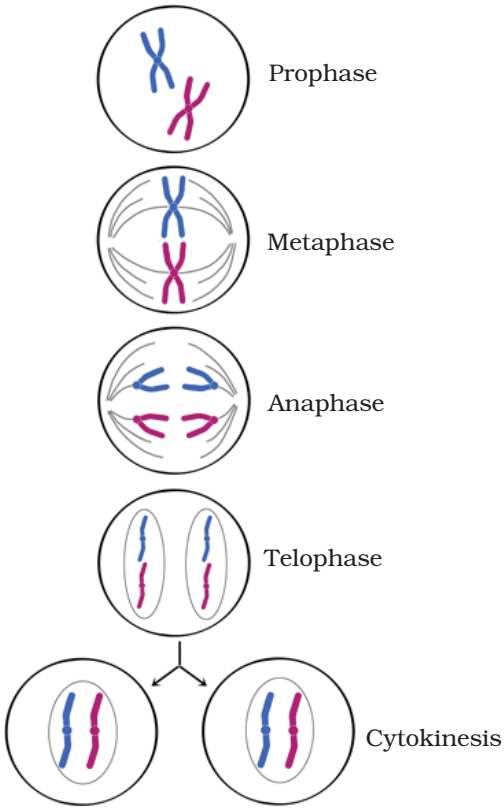


Figure 2. Phases of Mitosis

Diploid cells contain homologous sets of chromosomes and, normally their chromosome number is written as 2n. For instance, each human body cell is diploid and contains 23 pairs of homologous chromosomes, hence the chromosome number is written as 2n=46.

In complex multicellular organisms cells duplicate by mitosis for repairing worn out cells and effecting body growth. However, in unicellular organism it occurs to effect asexual reproduction.

ACTIVITY 2

Drawing and labeling the phase of mitosis.

Form a group of 4-5 students, draw and label the phases of mitois and describe the major events of each phase.

C. Phases of Meiosis

Meiosis:- is a type of cell division in sexually reproducing organisms that reduces the number of chromosomes in producing gametes (the sex cells, or egg and sperm).

Meiosis involves two fissions of the nucleus and giving rise to four gametes, or sex cells, each possessing half the number of chromosomes of the original cell.

Meiosis involves single duplication of homologous chromosomes followed by two successive cell divisions. Moreover, it involves crossing over or exchange of genetic materials and separation of homologous chromosomes to produce four haploid cells.

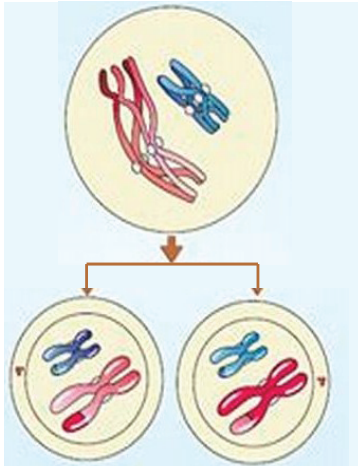


Figure 3. Meiosis I

Stages of Meiosis

Meiosis I: involves single duplication & pairing of homologous chromosomes

- crossing over and separation of homologous chromosomes.
- production of two haploid cells (Figure 3).

Takes place under the process of Leptotene, Zygotene, Pachytene Diplotene and Diakienensis During Prophase I

Meiosis II: involves no duplication of homologous chromosomes.

- separation of sister chromatids.
- production of four haploid cells (Figure 4).

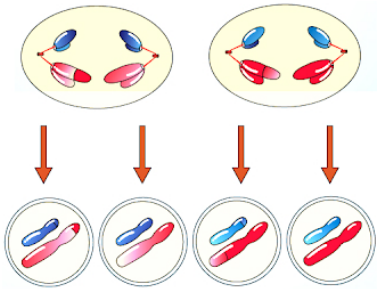


Figure 4. Meiosis II

Phases of Meiosis IInterphase

There are two stages or phases of meiosis: meiosis I and meiosis II. Before a dividing cell enters meiosis, it undergoes a period of growth called interphase.

Prophase I: Chromosomes condense and attach to the nuclear envelope. Synapsis occurs (a pair of homologous chromosomes lines up closely together) and a tetrad is formed.

Metaphase I: Tetrads align at the metaphase plate. Note that the centromeres of homologous chromosomes are oriented toward the opposite cell poles and create opportunity for genetic variation.

Anaphase I: Chromosomes move to the opposite cell poles. Similar to mitosis, microtubules such as the kinetochore fibers interact to pull the chromosomes to the cell poles.

Unlike in mitosis, sister chromatids remain together after the homologous chromosomes move to opposite poles.

Telophase I: Cytokinesis (the division of the cytoplasm) occurs and two **haploid** daughter cells are produced, each with one-half the number of chromosomes of the original parent cell (Figure 5).

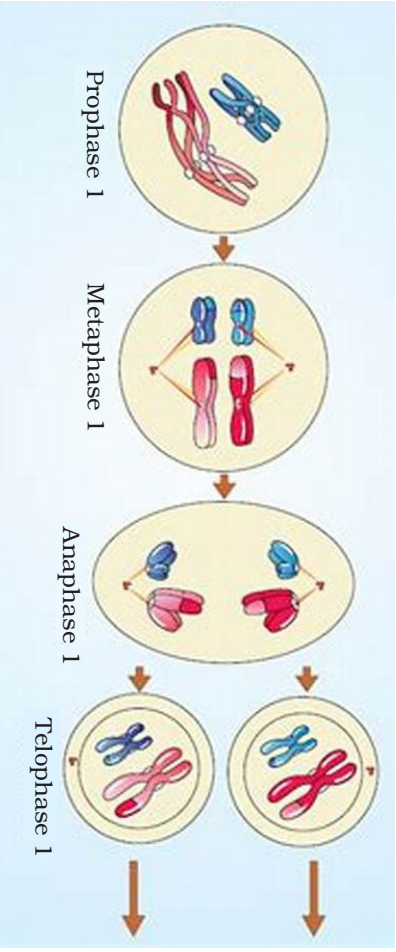


Figure 5. Meiosis I

Phases of Meiosis II

Prophase II: The nuclear membrane and nuclei break up, while the spindle network appears. Chromosomes do not replicate any further in this phase of meiosis.

Metaphase II: Sister chromatids line up at the equatorial plate of the cell attached to the opposite poles by spindle fibers.

Anaphase II: Sister chromatids separate and begin moving to opposite ends (poles) of the cell. Once the paired sister chromatids separate from one another, each is considered a full chromosome.

Telophase II: Distinct nuclei form at the opposite poles and cytokinesis occurs. producing four haploid daughter cells (Figure 6).

Meiosis is a means of gamete production for sexual reproduction of multicellular organisms. The production of gametes occurs in **male gonads**, **testes** and in **female gonads, ovaries.** In human males, it begins during adolescence but in females meiosis I is completed before they are born, while meiosis II begins as the egg matures during the menstrual cycle.

In the case of humans each gamete is haploid and contains 23 single sets of chromosomes. The chromosome number in sperm cell or egg cell is represented as n=23.

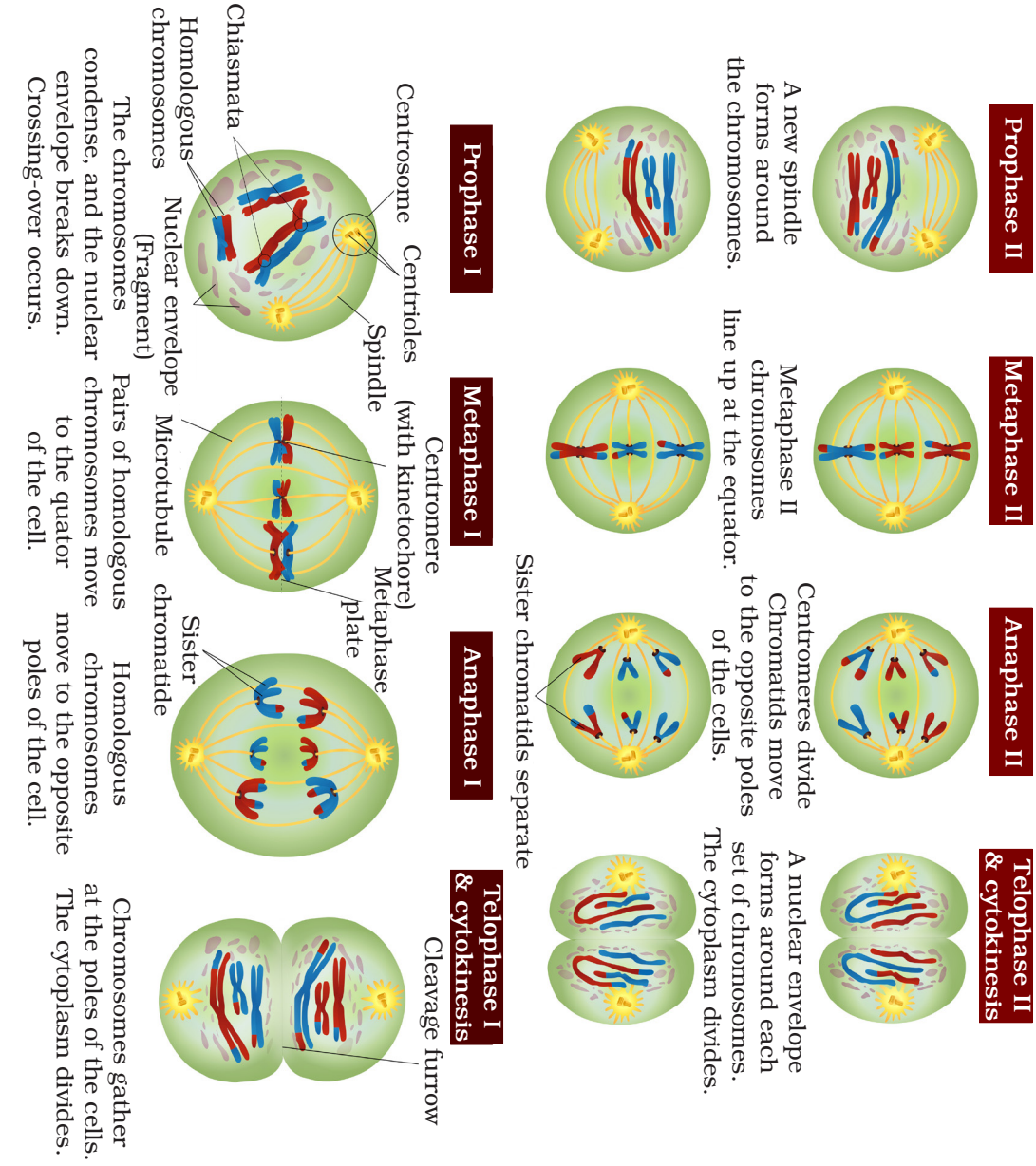


Figure 6. Phases of Meiosis I and II

Activity 3

1. Drawing and labeling the stages and phase of Meiosis.
2. Form a group of 4-5 students; draw and label the stages and phases of Meiosis and describe the major events of each stage and phase.
3. Explaining gametes formation.
4. Form a group of 4-5 students; distinguish between the features and events of Mitosis and Meiosis.
5. Distinguishing Mitosis and Meiois
   Form a group of 4-5 students; Distinguish between the features and events of Mitosis and Meiosis.
6. **Explaining gametes formation**
   Form a group of 4-5 students; Discuss and explain about gamete formation in human male and female
7. **Examining the slices of onions root tip to study the stages of Mitosis under the microscope**
   You will need
   - A light microscope
   - Actively growing root from onion
   - Acidified ethanoic orcein stain
   - Watch glass
   - Hot plate
   - Tweezers
   - Mounted needle
   - Microscope slide and coverslip
   - Blotting paper

   Method

   (a) Cut off the end of a growing root tip above 5mm from the end of the root.
   (b) Pour a little acidified ethanoic orcein stain into the watch glass and add the root tip.
   (c) Place the watch glass, stain and root on arm hot plate for five minutes.
   (d) Remove the watch glass from the hot plate and, using the tweezers, place the root tip on the slide with a drop of ethanoic orcein stain.
   (e) Break up the root tip with the needles to spread out the cells as much as possible
   (f) Place coverslip over the crushed root tip, place the blotting paper over it and press down gently- this will crush the root tip further. The slide is now ready to use
   (g) Look at your slide under the microscope, first using the low-power lens and then moving to igher magnifications.

(h) Make careful observations of the chromosomes and the ways they are arranged in the cells. Make drawings of your observation.

Review Exercises

1. Which of the following stages of the cell cycle involves DNA replication?
   (a) G_1
   (b) S
   (c) G_2
   (d) Mitosis
2. Which of the following cells are the results of Mitotic cell division
   (a) Ova
   (b) Sperm cells
   (c) gametes
   (d) Somatic cells
3. Which one of the following statements is correct about mitosis? It
   (a) Produces two daughter cells.
   (b) Produces haploid daughter cells.
   (c) Is a means of sexual reproduction.
   (d) Reduces chromosome number by half.
4. Which one of the following statements is **NOT** correct about Meiotic cell division? It
   (a) Takes place in germ cells.
   (b) Produces two identical cells.
   (c) Produces four daughter cells.
   (d) Produces genetically varied cells.
5. Similar to Mitosis, meiosis involves:-
   (a) Single nuclear division
   (b) Single cytoplasmic division
   (c) Sister chromatids separation
   (d) Homologous chromosomes separation
6. Where does meiosis undergo in human males?
   (a) Testes
   (b) Ovaries
   (c) Stomach
   (d) Intestine

4.2 Reproduction

Reproduction is the process by which living things produce offspring similar to themselves for their species survival. It begins with cell division.

Types of Reproduction

(i) **Asexual Reproduction:** production offspring by the division of a single parent cell without gamete formation. The offspring produced by asexual reproduction are genetically identical. It is relatively fast mode of reproduction.

Binary Fission: offspring production by the division of a parent cell into two equal offspring cells. It mostly occurs in unicellular organisms such as algae, bacteria and protozoans.

Budding: offspring production from the swelling (bud) of the parent cell. It is commonly exhibited by the unicellular fungi; yeasts (Figure 7).

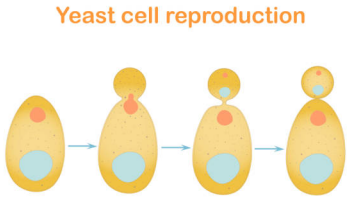


Figure 7. Reproduction by budding in yeast cell

Vegetative propagation: offspring production from the cuts of stems leaves and roots of flowering plants.It can be natural or artificial.

During natural vegetative propagation a vegetative part of a plant like stem develops into a new plant. Vegetative propagation by stem includes both underground stems such as bulbs, tubers, rhizomes, and corms or sub-aerial stem like stolons, runners and suckers.

Bulbs: Plants such as onions and garlic, the bulb is the unit of vegetative propagation that contains underground stem (Figure 8a).

Corms: Thick underground stems with upright position and function. The common example is *crocus* (Figure 8b).

Rhizomes: Horizontal underground stems that can give new shoot. The best example is ginger (Figure 8c).

Runners: Horizontal stems growing from the parent plant those grow above the ground. It is exemplified by wild strawberry (Figure 8d).

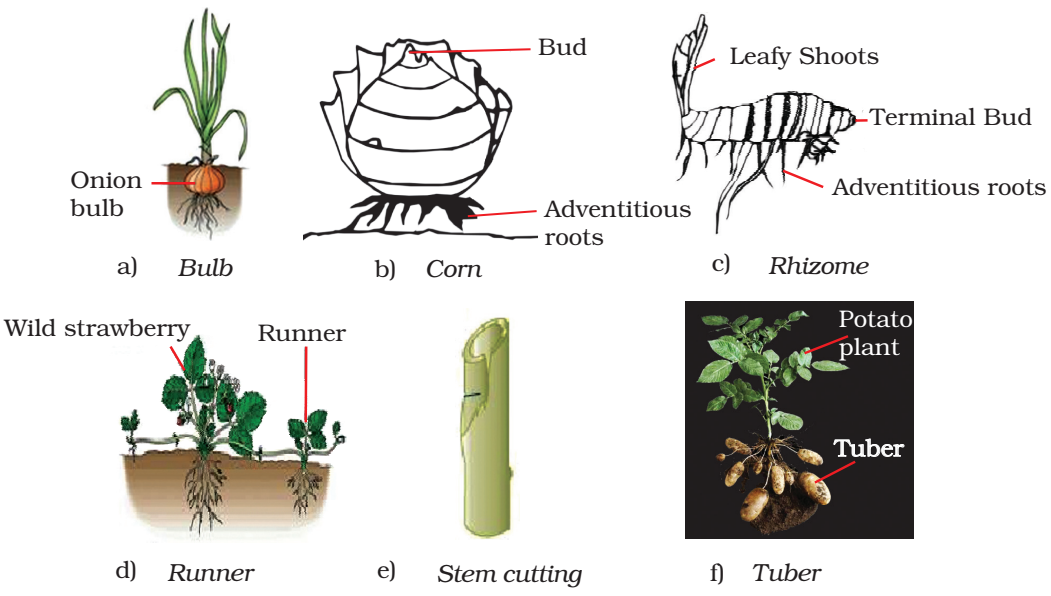


Figure 8. Types of vegetative propagation

Suckers: Form of budding called suckering is the regeneration of a plant by shoots that arise from an existing root system. Banana is the best example.

Tubers: Plant such as potato and sweet potato develop new plant from tube-like underground stem and root respectively (Figure 8f).

Artificial propagation: Production of new plants from vegetative parts by the involvement of humans.

Stem cuttings: Vegetative part from a plant is taken and is rooted in the soil to form new plant. It used to propagate plants such as rose, grapes, and sugarcane. **Grafting:** A technique of transplanting a part of one plant onto another plant so that they grow up as one plant. Both plants are selected for their best qualities. They are genetically related. The supporting (rooted) portion of the plant is called a stock, whereas the transplanted one is known as scion (Figure 9). For instance, orange and lemon plants can be grafted.

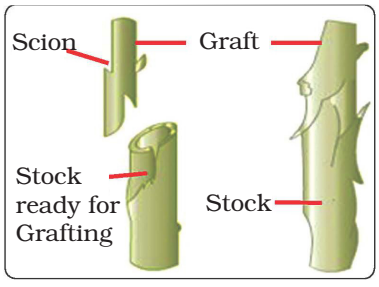


Figure 9. Grafting

Layering: Propagation by bending the lower branch of a plant closer to the ground and covering it with moist soil so that root is induced before the detachment from parent plant.

Cloning: Production of identical copies of an organism naturally or artificially. It is possible to clone plants and animals from a cell or tissue. For instance, plant tissue culture is used in plants like banana and carrot to produce identical plants from their single cells or tissues.

(ii) Sexual reproduction: Production of offspring by the fusion of male and female gametes.

(a) **Conjugation:** Sexual reproduction by the fusion of identical gametes acting as positive and negative gametes. It occurs in organisms such as *Paramecium* and molds. For instance, two strains of *Paramecia* acting as positive and negative gametes fuse to undergo conjugation for rapid binary fission (Figure 10).

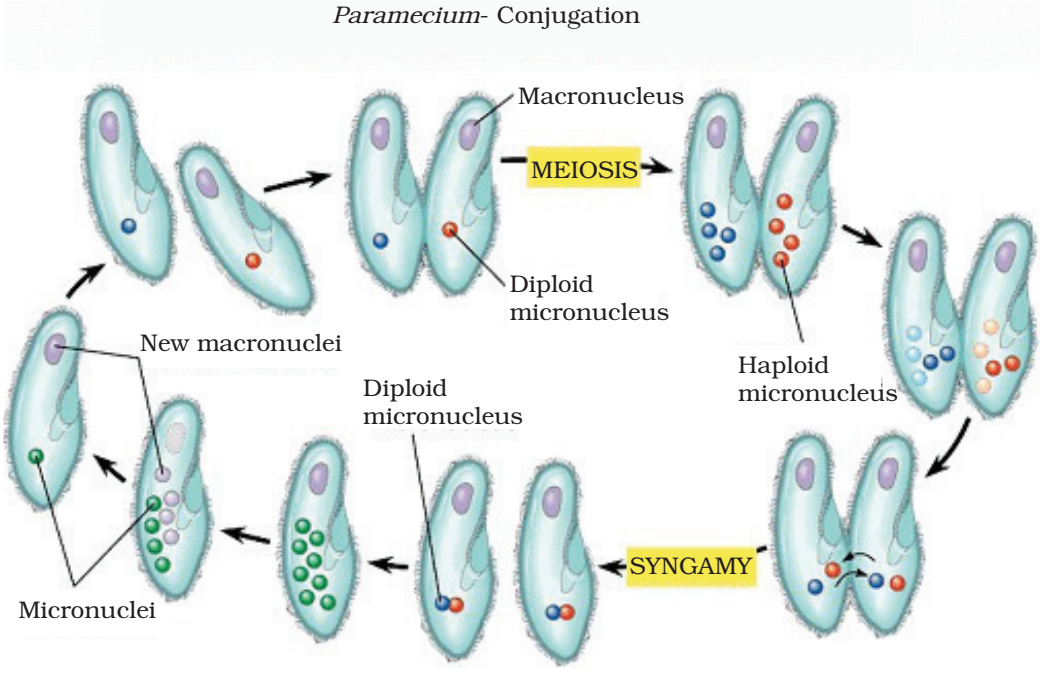


Figure 10. Conjugation in Paramecium

Likewise, two strains of hyphae in moulds acting as positive and negative gametes fuse to undergo fast spore formation for reproduction (Figure 11).

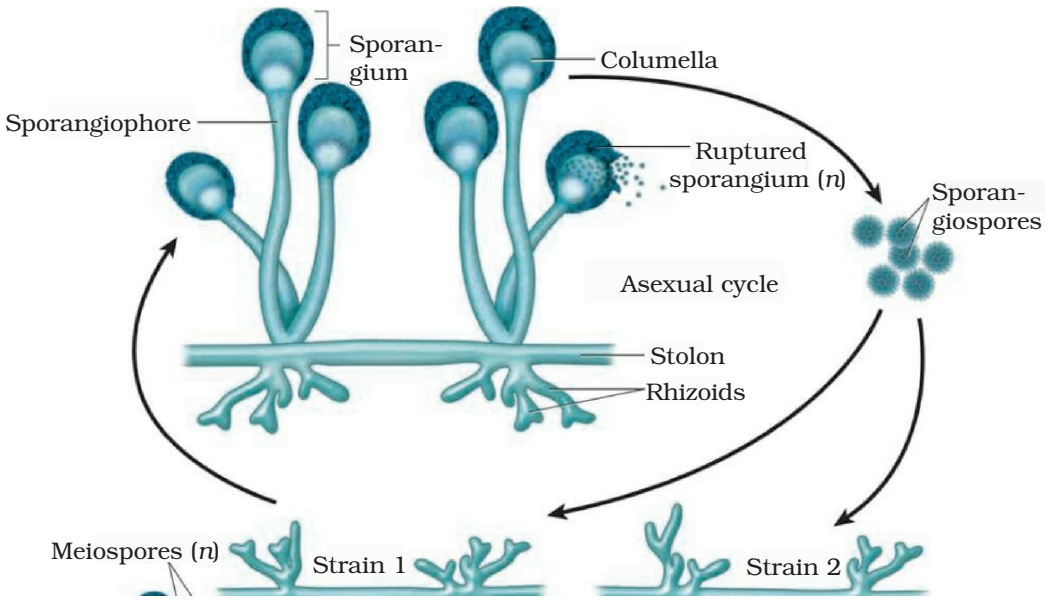


Figure 11. Sexual Reproduction in Rhizopus

(b) **Formation of male and female gametes**

Gametes are sex cells formed in gonads (testes and ovaries) when sexual maturity is attained.

In human, male sex cells or sperm cells are produced inside the testes throughout adult man's life.

In human, female sex cells or egg cells are produced inside the ovaries beginning at adult stage except during pregnancy and menopause.

(c) Meiosis is a means of gamete formation in sexual reproducing organisms,

(d) Fusion of gametes

Structure called zygote. The zygote gradually develops into a many celled structure called an embryo.

As opposed to conjugation, most sexual reproductions in higher animals and plants involve the fusion of distinct male gametes (sperm cells) and female gametes (egg cells).

In some primitive plants and animals fertilization or the fusions of the male and female gametes occur externally, outside the bodies of the organisms. Here the fertilization requires the presence of water.

In other advanced plants and animals fertilization occurs inside their bodies especially in the female parents. Still, in more advanced

organisms, even development of the embryos formed after fertilization occurs inside the female parents.

(e) Fertilization is the union of male and female gametes to form a one celled structure known as zygote.

Review Exercises

1. Reproduction in living things
   (a) Produces exactly identical offspring
   (b) Ensures species survival
   (c) Always involves gametes
   (d) Always requires two parents
2. What type of Asexual Reproduction occurs in Yeast cells?
   (a) Budding
   (b) Binary fission
   (c) Conjugation
   (d) Multiple fission
3. Which of the following organism reproduces Sexually by binary fission and sexually by conjugation?
   (a) Mould
   (b) *Amoeba*
   (c) Bacterium
   (d) *Paramecium*
4. What is the type of vegetative propagation exemplified by ginger?
   (a) Bulb
   (b) Runner
   (c) Rhizome
   (d) Sucker
5. Which of the following plants can be grafted?
   (a) Lettuce and cabbage
   (b) Avocado and mango
   (c) Papaya and pineapple
   (d) Watermelon and peach

4.3 Responsibilities of Parenting

A. What are the roles of each parent in child rearing?

Parenting or child rearing promotes and supports the physical, emotional, social, and intellectual development of a child from infancy

to adulthood. Parenting refers to the details of raising a child and not exclusively for a biological relationship.

Parenting is also a learned task that includes sharing customs and traditions, fostering skills for economic survival, promoting interpersonal and communication skills and **helping children become self-regulatory**, **productive and self-actualized**. It is also a parental functioning in a family, focusing on child caring and socializing. In particular, parenting is the tasks and roles that parents might be expected to perform regarding a child or children.

Parenting is both a biological and social process involving much more than only a mother and father who provides food, safety, and succor for the infant or child. It is the process of parent-child relationships that aim at raising and socializing a child. In particular, parenting can shape a child's attitude, behaviors, and emotional function. It is the process of teaching and training children in which parents engage in order to encourage the child's growth, such as nourishing, protecting, and guiding a child through the course of his or her development. It refers to the process that parents perform toward their children in the everyday life events of the family unit, which depends on parents' cognition, emotions, attributions, attitudes and values. This process aims at providing care, encouraging a child's independent decision-making, fostering skills for economic survival, promoting interpersonal skills and helping children to become self-regulatory, productive and self-actualized in adulthood.

Parenting is a dynamic bi-directional process from parent to child as well as from child to parent. This process is an evolving process that starts from discussions between the couple. It is a thinking process of the couple carried out in order to achieve suitable guidelines for raising the child or children in specific situations of the family that includes the processes of developing and utilizing knowledge and skills appropriately to plan for creating, giving birth, rearing, educating and providing for children.

As this concept analysis, the meaning of parenting could be defined as the process and purposive activity, including interactions regarding to rearing and educating a child that parent or parental figure performs for promoting child's growth, development, including health. In term of critical attributes, parenting yielded three characteristics that involved with both parents and child (process, activity and interaction

or relationship). Explicitly, parenting is a positive, purposive, nurturing activity and interaction process which is specifically aimed at promoting a child's welfare or ensuring the survival and development of children. It is the activity of providing support, care, and love. Thus parenting focuses on three key words: responsibility, guidance, and nurturing of parents.

Roles of the Father in child rearing

Duty to Provide: This is one of the (if not the) most primary duty of the father in the family. The society has placed this role majorly on the father; to secure a home for the family, provide necessaries, sponsor academics, health bills and others.

Decision Making: Another important role of the father is decision making. Culturally and socioeconomically, certain decisions are better made with the accent of the father.

Way Maker: The father has this responsibility of raising the children in conformity with moral and the societal values. It is the father's duty to discipline his children, that they shall have a good foundation which enhances smoother stepping and rising stone for them. The father has a duty to maintain his own reputation and integrity.

Duty to Protect: It is the duty of the father to protect the family. Protection here includes protecting the life of the family by reasonable means against physical, socio-economic threat or harm or otherwise. This extends to protection of the interest of the family which could be manifest through decision making and otherwise.

Model for the male Children: Male kids have this natural tendency of looking up to their fathers.

Duty to train: It is the duty of the father to train the children.

Importance of a father

Impacts the child's success. Chances of educational success increase when fathers are involved in parenting. Children are less likely to get involved in situations like teenage birth, being expelled, or serving a jail sentence.

Contributes to healthy emotional development. Fathers who tend to solve conflict respectfully and nonviolently with their spouse contribute to their children's solid emotional development. Children learn what to expect and how to treat their partners in relationships.

Improves a child's general wellbeing. Present fathers help their children learn how to make better life choices. Fathers highly contribute to their children's cognitive development. Children with developed cognitive function feel more loved which improves behavior.

Provides financial support. Involved fathers might contribute to the larger household bills. Non-involved fathers are also encouraged to provide child support.

Cognitive development. When fathers play with their children, they help them develop a secondary emotional bond with other people. The mother's connection is the primary bond.

Authority figure. Fathers have the responsibility of being authority figures, which helps ensure his child learns how to solve problems.

Remain trustworthy. During teenage years, fathers have the responsibility of establishing and maintaining a reliable figure. Fathers might gain their teen's trust by being patient with them during these years.

Tips on how to be a supportive father

Your biological relationship with the child does not limit fatherhood. Fatherhood is about the quality of relationship you have with your children.

To be a good father, you might try these tips:

Take time. Schedule time to spend with your child, physical presence is equally important to a child.

Listen. To grow close to your child, you might find it better to listen to them more than you lecture their behavior.

Be a positive role model. Remember, children learn through imitation. Your child observes and knows more than you might assume. Always practice positive behaviors.

Respect the child's mother. How children handle their current and future relationships will be influenced by how you treat their mother. Treating her with respect impacts their relationships.

Show affection. To make your child feel secure and safe, practice showing them love whenever you're together.

Be present. Fatherhood never ends. Children notice when you are absent. Try to show up in their important life events, spend quality time together, and play together.

Important Roles and Responsibilities of Mothers

Strongest Emotional Bond with the Child

A mother is the first one to know and connect with her child. Even after birth mother is the first care-giver to her children. The way they interact with child during the early months and years leave a deep impact on child. It will get reflected in the social and emotional setting of child in later years.

Giving Proper Environment for Right Development

Mothers are responsible for the environment that a child gets from the very beginning. Giving apt space for movement, creativity and play offers right environment for child development.

Child's Behavioural Development

A mother knows her child more than anyone else. Therefore, child's behavioural development is closely observed her. Observing child and listening to her voice gives mother an impression of what is going on inside her.

Instills Trust and Security

Mothers can teach children, how to trust and be trustworthy. Once this is understood by child, she will be confident and emotionally secure. Be around your children when they need you and help them become better. Your unconditional love and support will help improve themselves.

Family Bonding

A mother helps her child learn about the importance of family as she is the back bone of the family and holds everyone together. Have family meals together and encourage your child to spend time with family members.

Be kind, loving and caring

If you are kind, loving and caring to your child in daily activities, it will automatically teach her to be the same kind of person when she grows. Your behaviour towards your child has a lasting impact on her development not only when she is a child, but after she grows up as well.

Be Thoughtful and Sensitive

When you understand and respond properly the way your child is thinking, your child will grow up to be a sensitive person. She will be

able to understand other person's perspective also. This will be very helpful in maintaining relationships.

Positive Attitude

Since a mother is soft and handles things in a positive way, it teaches the child that no matter whether life is tough, it can be handled in a better way. You can discuss the problems with your children and explain how you are going to tackle it.

Role of Routine and Discipline in Life

Since a mother helps a child maintain a regular set of pattern in early days, it conveys a message that things can be managed easily and comfortably by following a routine.

Hard Work

A child learns to work hard from her mother. On the other hand your child might see that at the end of the day you get tired but if you explain the pleasure and satisfaction that you get from working hard, the right message will be delivered.

A mother supports and helps her child in improving herself throughout her life. Role of a mother greatly influences child's overall development and well-being.

Mothers tend to be protective of their children while fathers may encourage curiosity and experience.

ACTIVITY 4

Individual writing

Individually write about the kind of family you intend to have for the next ten years. Then, voluntarily share your intention to the class. As a student you are encouraged to wait until you finish education and get married.

ACTIVITY 5

Personal experience sharing

Your biology teacher invites a respected father to talk about the role of father in parenting. Make use of this talk to emphasize the needs for boy's to take responsibility of their babies. Here your biology teacher highlights the challenges babies face when they grow up without their fathers and the long-term effects on them.

B. Risk of teenage parenting

Human sexual behavior is different from the sexual behavior of other animals, in that, it seems to be governed by a variety and interplay of different factors. That is, while "lower" animals or species are driven by a "force" to reproduce and therefore partake in sexual behavior. Humans are not sexually active just for the sake of reproduction; rather, there are a variety of complex factors that lead people to have sex.

An important reason to study human sexuality is that it is a primary source of motivation. Just consider the amount of time spent thinking and planning for sex, let alone the time spent in sexual behavior itself. Sexual motivation does to some extent influence human behavior. Another reason for studying human sexuality is that we may face various personal and social problems involving sexuality, such as, sexually transmitted diseases, unwanted pregnancies, and sexual harassment. This should sound especially timely during the times in which we live.

Human sexuality is the way people experience and express themselves sexually. Sexuality is experienced and expressed in thoughts, fantasies, desires, beliefs, attitudes, values, behaviours, practices, roles and relationships. While sexuality can include all of these dimensions, not all of them are always experienced or expressed. Sexuality is influenced by the interaction of biological, psychological, social, economic, political, cultural, legal, historical, religious and spiritual factors."

Unfortunately the parenthood among teenagers is becoming more and more common. Of course this is a sad reality, because teenagers are too young to become parents themselves. The parenthood requires lots of huge responsibilities which sometimes may be way too much for the teenagers to handle. Just because most of the teenage parenting is unplanned, it means that it can bring lots of changes, disadvantages and troubles as well. Parenting as a teenager can have special challenges, including handling people's judgmental attitudes and finishing education.

Teenage mothers and their offspring are at a high risk group both physically and emotionally. Poverty, malnutrition, complications of pregnancy, and emotional problems such as depression, drug, and alcohol use, are all risks for the mother. Children are also at greater risk of physical, cognitive, and emotional problems.

Activity 6

Role plays: to prevent teenage parenting

1. One boy and one girl students voluntarily play in a classroom by acting as one of them insist the other in having sex but the other effectively refuses to do so. Make discussion on the play.
2. One boy and one girl students voluntarily play in a classroom by acting as one of them discourages the other from joining the group of peers who take alcohol to avoid risky situations against early sex. Make discussion on the play.
3. Any voluntary student act in a classroom to show the correct use of condom by using model penis and real condom.

Review Exercises

1. What does good parenting require?
   (a) Providing a positive role model
   (b) Encouraging productive behavior
   (c) Engaging in adequate supervision
   (d) All of the above
2. Which of the following is NOT the role a Father in a Child Rearing?
   (a) Way maker
   (b) Decision making
   (c) Financial support
   (d) Corporal punishment
3. Which of the following is not the role of a Mother as a parent?
   (a) Affection
   (b) Family bonding
   (c) Positive attitude
   (d) All the above
4. Which of the following is a risk of Teenage parenting?
   (a) Finishing education
   (b) Intended pregnancy
   (c) Emotional pleasure
   (d) Exciting livelihood

4.4 Sexual Decisions and Impact on the Family

A. Making healthy decision on sexual issues

Teens have to make lots of **decisions** about **sex,** including whether to abstain (not have sex), or be **sexually** active. If you are **sexually**

active, you will also need to think about the Kind of relationship you have previously, type of contraception (if you have a male partner) and **sexually** transmitted infection (STI) prevention methods you will use.

If you decide to wait, plan how you are going to say no so you are clearly understood. Stay away from situations that can lead to sex, such as being alone with someone who has been pressuring you or using alcohol or drugs. If your partner doesn't support your decision to wait, he or she may be the wrong person for you.

B. Impacts of Sexual Decision Making on the family

According to the Sexuality Information and Education Council of the United States (SIECUS), a sexually healthy teen will show or have the following qualities within their relationships with themselves, parents and family members, peers and intimate partners.

Relationship with Self

- **Appreciates their own body:**
  - understands changes that happen during puberty, and views them as normal
  - practices health-promoting behaviors, such as abstinence from alcohol and other drugs, and getting regular check-ups
- **Takes responsibility for their own behaviours:**
  - identifies own values and acts on those values
  - understands the consequences of their actions
  - understands that media messages can create unrealistic expectations related to sexuality and intimate relationships
  - is able to tell the difference between personal desires from that of their peer group
  - understands how alcohol and drugs can affect making decisions
- **Knows about sexual health issues:**
  - understands the consequences of sexual behaviors
  - makes decisions about masturbation that fits with personal values
  - makes decisions about sexual behaviors with a partner that fits with personal values
  - understands their own gender identity and sexual orientation
  - understands the effect of gender role stereotypes and makes choices about the best roles for themselves

- understands peer and cultural pressure to become sexually involved
- accepts people with different values and experiences

Relationships with Parents and Family Members

- **Communicates effectively with family members about issues, including sexuality:**
  - has a good balance between family roles and responsibilities and their growing need for independence
  - is able to negotiate with family on boundaries and tries to understand parents point of view
  - respects rights of others and treats adults with respect
  - understands and asks for information about parents' and family values and thinks about them when developing their own values
  - asks parents and other trusted adults, questions about sexual health issues and accepts their guidance

Relationships with Peers

- **Interacts with all people (including those with different sexual orientation and gender identity different from their own) in proper and respectful ways:**
  - communicates well with friends
  - shows empathy in relationships
  - recognizes and stays away from relationships that may not be healthy for themselves or others
  - understands what sexual harassment behaviour is and rejects it
  - respects others' right to privacy and doesn't share personal information that others have shared with them
- **Acts on one's own values and beliefs when they aren't the same as their peers:**
  - understands pressures to be popular and accepted and makes decisions based on their own values

Relationships with Intimate Partners

- **Shows love and intimacy in a way that is appropriate for their age:**
  - believes that everyone has equal rights and responsibilities for love and sexual relationships
  - can say 'no' and accepts when a partner says 'no'

- tries to understand (empathize) how a partner feels

- **Has the skills to decide how ready they are for mature sexual relationships:**
  - talks with a partner about sexual behaviors before they happen
  - is able to communicate and negotiate sexual behaviors
  - if they choose to have sex, protects self and partner from unplanned pregnancy and sexually transmitted infections (STIs) by using birth control, condoms, and other safer sex practices
- People who have sex while using alcohol or drugs are less likely to use condoms.

C. Reproductive health and rights

Reproductive health

Reproductive health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and to its functions and processes.

Reproductive health therefore implies that people are able to have a satisfying and safe sex life and that they have the capability to reproduce and the freedom to decide if, when and how often to do so.

Implicit in this last condition are the right of men and women to be informed and to have access to safe, effective, affordable and acceptable methods of family planning of their choice, as well as other methods of their choice for regulation of fertility which are not against the law, and the right of access to appropriate health-care services that will enable women to go safely through pregnancy and childbirth and provide couples with the best chance of having a healthy infant."

Reproductive rights

Reproductive rights are the right for everyone to make decision about their sexual and reproductive health, including the choice to marry and determine the number, timing and spacing of their children; to sexual and reproductive security free from coercion and violence; to be informed and have access to safe and legal family planning services and to have access to healthcare services enabling women to go safely through pregnancy and childbirth.

D. Infertility cycle of sexuality

The reasons for infertility can be found in women or in men, sometimes even in both. The female reproductive function can be impaired by the innate or acquired circumstances that affect the normal function of reproductive organs, illnesses, or by psychological factors.

For male infertility, the problem can be the production of sperm, transportation of the sperm through the genital tract and disorders that hinder erection and ejaculation.

Infertility brings about many changes in a couple's relationship. It may bond you closer together in unspoken sadness and hope; it may bring out feelings of resentment, of guilt, of mutual support and understanding- a sharing never before experienced. As the initial months of investigations turn into frustrating years it is not surprising that sex quickly loses many of its associations with pleasure and becomes instead an activity with a functional purpose.

The psychological effect of a diagnosis of infertility on sexuality has largely to do with the self-image. It is common for a woman to feel "less of a woman" and a man "less of a man", at least for a time, when faced with infertility.

Infertility and associated treatment may lead to changes in **sexual** self-esteem, **sexual** relations and **sexual** function, which further affected the **infertile** couple›s quality of life, and well-being. For the **infertile** subjects, **infertility** affects self-concept and role perceptions, and is a threat to personal identity.

Activity 7

Sharing experiences

Two girls are allowed voluntarily to share the challenges they have experienced with their family planning and how they have overcome them.

Discuss on the experience they shared.

Activity 8

Role play: to show young people refusing to have sex before completion of high school.

Two students preferably a boy and girl act in a classroom to show in refusing to have sex before completion of high school. Discuss on the play. experience they shared.

Activity 9

Sharing experiences on making sexual decisions,

A boy and girl students voluntarily play in a classroom by acting to show waiting for having sex when they are older with a person they love and have known for a long time. Using contraceptives, condom, absenteeism and delay child bearing.

Activity 10

Skit: On negative and positive decision making about sex.

With a group of 4-5 students, make skit or satire on negative and positive decision making about sex. Present the skits to the class

Activity 11

Role play: Parental influence in decision making (Negative and positive)

Two voluntary students a boy and a girl play in a classroom by acting parental influences in decision making (positive and negative). Discuss on the play.

Activity 12

Role play: The importance of reproductive health rights and how they empower teenagers to make the right decisions about their sexuality.

Two voluntary students a boy and a girl play in a classroom by acting the importance of reproductive health rights and how they empower teenagers to make the right decisions about their sexuality. Discuss on the play.

Review Exercises

1. What is the inability to conceive a baby after unprotected intercourse?
   (a) Fertility
   (b) Sterility
   (c) Infertility
   (d) Reproducibility
2. What is not important for making healthy sexual decision on sexual issues?
   (a) Relationship with self
   (b) Communication with parents
   (c) Interactions with peers
   (d) Ignoring family members

3. Which of the following shows lack of the knowledge of reproductive health?
   (a) Maternity
   (b) Adultery
   (c) Using contraceptives
   (d) Preventium of STI
4. Which of the following is NOT a kind of reproductive right in making healthy sexual decisions?
   (a) Prevention of STI
   (b) Using contraceptives
   (c) Refusing to have sex
   (d) Discouraging marriage

4.5 Consequences of Sexual Decision Making

Decision making about reproductive health and rights

Positive intrapersonal consequences included: feeling

- physically satisfied
- more attractive
- cheered up

Positive interpersonal consequences included: feeling

- closer to one's partner
- one avoided angering or annoying a partner
- one has enhanced his/her

Negative intrapersonal consequences included: worrying

- about pregnancy
- about a sexually transmitted infection
- that parents might find out
- Feeling that one has gone against his/her morals and ethics
- Experiencing pain reputation
- Not enjoying the experience

Negative interpersonal consequences included: *worrying*

- that a partner wants more commitment

- that the relationship is moving too fast
- that another partner may find out
- that one has harmed his or her reputation

4.6 Advocacy

Role of youth in stopping substance abuse

Youth engagement plays an important role in preventing substance abuse among youth. Youth engagement is defined as the sustained and meaningful involvement of youth in an activity focusing outside him or her. A broad range of activities are effective in engaging youth; including but not limited to school or community volunteering, sports, the arts, music and politics. The benefits of engaging youth are significant. Positive outcomes of engagement include a decrease in the rate of substance abuse, a decrease in rate of crime, an increase in academic performance and a more meaningful connection with a youth's community. How do we engage our youth? Communities that play an active role in engaging their youth are increasingly likely to prevent their youth from risky behaviour, such as the use of drugs. Youth that are involved in important decision making that affect their lives, youth that are encouraged and supported to reach their full potential and youth who receive mutual respect from adults, parents, educators and peers are more likely to live a healthy lifestyle. The following provides examples of successful community strategies that prevent substance abuse and other risky behavior:

- Participating in sports-related activities
- Being involved in art projects, such as creating anti-drug messages through video production, newspaper advertisements and painting designs
- Attending career fairs
- Presentations from Colleges and Universities
- Drug awareness projects such as a battle of the bands or an all-night celebration with a "no drugs needed" theme
- Opportunities for leadership, including teaching younger children or other peers about drug use prevention
- Active involvement of parents, which may include forming mutual-support groups, assisting with school curricula,

monitoring youths' activities, and otherwise participating in the lives of young people. Recent research shows that youth who feel emotionally connected with parents and family are less likely to use cigarettes, alcohol, and marijuana.

- School policies and school-based services that serve all youth, including those who may be thinking about trying drugs and those worried about others' use. Recent research suggests that youths' feeling of connectedness with school is a protective factor against risky behavior.
- The engagement of local media by sponsoring and promoting alcohol-free events and creating prevention messages
- Community-wide engagement (businesses, health care providers, and civic organizations) in changing norms regarding substance use, developing youth assets, and providing youth with links to opportunities in careers, further education, and service to the community
- A community website that provides sources of help for youth who have a problem and information on how to be involved in their communit.

Role of the youth in stopping SBV (School based violence)

School violence is violence that occurs in the school setting. It describes violent acts that disrupt learning and have a negative effect on students, schools, and the broader community.

Examples of school violence include:

- bullying and cyberbullying;
- fighting (e.g., punching, slapping, kicking);
- weapon use;
- gang violence; and
- sexual violence.

Places school violence occurs:

- on school property;
- on the way to or from school;
- during a school-sponsored event; and
- on the way to or from a school-sponsored event.

All students have the right to learn in a safe school environment. The good news is school violence can be prevented. Many factors contribute to school violence. Preventing school violence requires addressing the factors that put people at risk for or protect them from violence. Research shows that prevention efforts by teachers, administrators, parents, community members, and even students can reduce violence and improve the school environment.

Youths can play the following roles in stopping school Based violence (SBV)

- Establish club to stimulate advocacy by young people, for young people that provides a platform for children to be trained as advocates so that they may raise awareness about youth issues among policy makers.
- Partnership with local organizations to launch a project.

Clubs create a safe environment for children in schools; members of clubs are trained in child rights, child abuse and violence, and act as advocates to staunch negative behaviours in schools as they unfolded. Further, club members—who are typically older students—raise awareness of the problematic prevalence of violence in schools. The combination of awareness-raising and the presence of older students trained in these matters drove visibility of the need to end violence in school. This help pupils feel safer and make them less tolerant of violence; club members instill a culture of non-violence in schools, as they teach fellow students what, when and how to report. These child-friendly reporting mechanisms make schools safer and increase local children's access to quality basic education. As a result, many schools see a significant increase in enrolment figures. Partnership and campaign with the local and National Governments, as well as development partners initiate them to invest in keeping school safe renovating current facilities and build new facilities. This advocacy effort can result in the Government's allocation of resources to ensure construct safe compound.

Activity 13

Draw posters, write poems, compose songs, prepare speeches, plan a peaceful demonstration, plan radio interview against drug abuse and School Based Violence.

Arrange a kind of event for the school community to conduct the aforementioned activities in the school compound by sharing the duties among groups.

Involve other young people in the school. Fill the school with activities and drawings and writings against drug abuse and School Based Violence.
Organize a hot line, where victims can call for help and advice.
Involve local NGOs.

Review Exercises

1. Who are the most physically abused children in schools?
   (a) Infants
   (b) Toddlers
   (c) Teenagers
   (d) Older children
2. Which of the following is a negative consequence of sexual decision makings?
   (a) Feeling cheer up
   (b) Worrying about pregnancy
   (c) Feeling physical satisfaction
   (d) Feeling closer to one's partner
3. Which of the following is a positive interpersonal consequence of sexual decision makings?
   (a) Experiencing pain
   (b) Worrying about STI
   (c) Feeling one has enhanced his/her reputation
   (d) Worrying that a partner wants more commitment
4. Which of the following role is not much expected from the youth in stopping substance abuse?
   (a) Engagement in drug awareness project
   (b) Participation in sport- related activities
   (c) Involvement in creating anti-drug messages
   (d) Sponsoring and promoting alcohol-free events
5. What kind of role is expected from the youths to stop School based violence?
   (a) Organizing and mobilizing clubs
   (b) Working with the local community
   (c) Working with Government and Government Organizations
   (d) All of the above.

Key Terms

- Cell cycle
- G1 phase
- S phase
- G2 phase
- Interphase
- Mitosis
- Meiosis
- Prophase
- Metaphase
- Anaphase
- Telophase
- Haploid
- Diploid
- Homologous chromosomes
- Sister chromatids
- Asexual reproduction
- Binary fission
- Budding
- Spore formation
- Vegetative propagations
- Conjugation
- Gametes
- Parenting
- Reproductive health
- Reproductive right
- Sexuality
- Infertility

SUMMARY

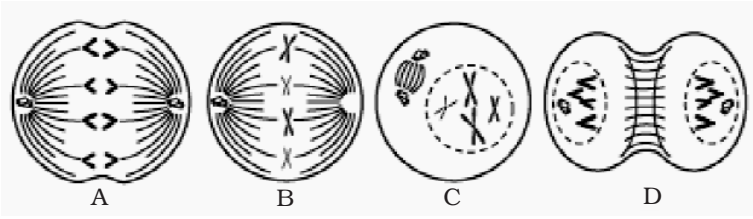
- Cell cycle is an ordered series of events between cell division.
- Cell cycle involves G_1,S and G_2 phases
- Mitosis is a process of cell duplication, or reproduction, during which one cell gives rise to two genetically identical daughter cells.
- Mitosis involves the phases: prophase, metaphase, anaphase and telophase.
- Mitosis produces diploid cells having double set of chromosomes.
- Mitosis is a means of body growth and repair in multicellular organisms , asexual reproduction in unicellular and some multicellular orgnims.
- Meiosis is a type of cell division in sexually reproducing organisms that reduces the number of chromosomes for production of gametes.
- Meiosis involves two stages each with the phases; prophase, metaphase, anaphase and telophase
- Meiosis I involves separation of homologous chromosomes and production of two haploid cells.
- Meiosis II involves separation of sister chromatids and production of four haplod cells.
- Haploid cells are cells having single set of chromosomes.
- Reproduction is the process by which living things produce their likes for species survival.
- Asexual reproduction is offspring production without gamete involvement.
- Binary fission is offspring production by the division of the parent cell into two equal daughter cells.
- Budding is offspring production from bud of a parent cell.
- Vegetative propagation new plant development from the vegetative parts (root, leaf and stem of a plant.
- Natural vegetative propagation includes, bulbs, tubers, runners, rhizomes, corms, suckers.
- Artificial vegetative propagation includes stem cuts, grafting and lyering.
- Sexual reproduction is offspring production by the union of male and female gametes.
- Conjugation is offspring production by the fusion of isogametes acting as positive and negative gametes.
- Fertilization is the fusion of gametes (egg and sperm cells).

- Father and mother have great and significant roles in child rearing.
- Teenage parenting has a high risk of stopping education.
- Making healthy decisions on sexual issues are important in life a they have the impact on family, society and psychology of the individual.
- Reproductive health is a state of complete physical, mental and social well-being, related to reproductive system.
- Reproductive rights are the right for everyone to make decision about their sexual and reproductive health.
- Infertility is the inability to conceive a baby after unprotected intercourse.
- Sexuality is the way people experience and express themselves sexually.
- Sexual decision making impacts reproductive health and right positively and negatively.
- Youths can advocate in stopping substance abuse and SBV by organizing clubs and working with governmental and non- governmental organizations to create awareness and act on these issues by arranging a platform for poems, speech, drams, posters, drawings, demonstration , etc.

Review Exercises

1. In the process of meiotic cell division, the stage at which homologous pairs of chromosomes associated with each other is ;-
   (a) Anaphase II
   (b) Telophase I
   (c) Prophase I
   (d) Metaphase
2. The important event that occurs during an anaphase of mitosis is:-
   (a) Duplication of chromosomes to form its copy
   (b) Pulling the chromatids to opposite poles of the cell.
   (c) The chromatids line up along the equatorial plane of the cells
   (d) The cytoplasm of the cell constricted to form two daughter cells
3. Which of the following is TRUE about meiosis?
   (a) It occurs only in animals.
   (b) It occurs in all cells of your body.
   (c) It results in identical daughters cells.
   (d) It reduces the number of chromosomes in resulting cells.

Use the following illustration to answer question number 4



4. Which of the following indicates the CORRECT order of mitosis in animal cells?
   (a) A-B-C-D
   (b) C-B-A-D
   (c) B-C-A-D
   (d) C-A-D-B
5. If a plant cell having 16 chromosomes undergoes meiotic cell division, how many chromosomes would the resulting daughter cells have?
   (a) 4
   (b) 8
   (c) 16
   (d) 32
6. The 2n chromosome number of horse is 64. The number of horse chromosome in each body cell of a mule is?
   (a) 8
   (b) 16
   (c) 32
   (d) 64
7. Which of the following reagents would you use to stain chromosomes for microscopic observation in a dividing onion root cells?
   (a) Ethanoic orcein
   (b) Iodine solution
   (c) Hydrochloric acid
   (d) Bicarbonate solution
8. Which of the following types of cells are produced by normal Mitosis cell division in human skill cells?
   (a) 2 haploid cells
   (b) 4 haploid cells

(c) 2 diploid cells
(d) 4 diploid cells

9. Both *Moulds* and *Paramecia* undergo conjugation involving:-
   (a) Binary fission
   (b) Spore formation
   (c) Union of isogametes
   (d) Two strains of hyphae

10. During grafting, the transplanted plant is called:
   (a) Bud
   (b) Scion
   (c) Stalk
   (d) Clone

11. Contrary to parenting, parenthood is the:
   (a) Cultivation of children
   (b) Promoting of children's welfare
   (c) Biological relationship with children
   (d) Responsibility of bringing up children

12. Which of the following is the importance of fathers in rearing children?
   (a) Trustworthy
   (b) Financial support
   (c) Authority figure
   (d) All of the above

13. Which of the following is NOT the importance of mothers in rearing children?
   (a) Negative attitude
   (b) Loving and caring
   (c) Thoughtful and sensitive
   (d) Instilling trust and security

14. What are the emotional problems that teenage parents encounter?
   (a) Poverty
   (b) Divorce
   (c) Depression
   (d) Malnutrition

15. Reproductive health encompasses the well-being of an individual:
    (a) Physically
    (b) Mentally
    (c) Socially
    (d) All of the above
16. What does reproductive right ascertain to everyone in making decisions about?
    (a) Choice to marry
    (b) Choice to avoid entertainment
    (c) Determining the sex of children
    (d) Determining number of friends
17. Which of the following is true about infertility in human couples? It is
    (a) Found in women only.
    (b) Innate not acquired
    (c) Affects couple's relationships
    (d) Associated with sin and curse.
18. Sexuality in humans is experienced and expressed in the manner of their sexual:
    (a) Activity
    (b) Practice
    (c) Behaviour
    (d) All of the above
19. What are the Negative Consequences of sexual decision making?
    (a) Feeling satisfied
    (b) Worrying about STI
    (c) Feeling more attractive
    (d) Feeling enhanced reputation
20. What can Youths do to fight against substance abusers?
    (a) Arranging platforms to stop drug and alcohol abuses
    (b) Creating regular awareness about drug and alcohol abuse.
    (c) Working with stakeholders to organize youths against substance abuse.
    (d) All of the above

B11CH05

CHAPTER 5

GENETICS (NUCLEIC ACIDS, PROTEIN SYNTHESIS AND HEREDITY), SEXUALITY AND EVOLUTION

Chapter Contents

Chapter Outcomes

Upon completion of this chapter, learners will:

- explain about Nucleic acid and its types
- discuss the St. of DNA and its types
- discuss the St. of RNA and its function
- explain Transcription and Translation during protein synthesis
- describe the Heredity and Mendel law of heredity.
- discuss Darwin's theory of Evolution and Natural selection.
- list Inherited Diseases.
- explain Sex Determination and discuss it with your friends.
- define variation discuss it sources and causes of variation.
- explain Hardy-Weinberg equation related to population genetics.
- various types of Evolution and evidence of Evolution.

Introduction

This chapter first deals with genetics that studies the transfer, inheritance and expression of heredity. Along with this it deals with molecules of heredity nucleic acids regarding their structures and role in transferring genetic information through the synthesis of proteins for expression of heredity. In addition, it discusses on the Mendel's genetics its principles and laws. Second, it discourses sexuality and its relevance in human reproduction. Finally it deals with the process of evolution which studies about the change and development of populations of species in the course of time.

5.1 Types of Nucleic Acids and their Structures

There are two types of Nucleic acid molecules (DNA and RNA) in the cells of living things. A Nucleic acid molecule is composed of nucleotide units; each nucleotide unit contains pentose sugar, phosphate ion and one of the five nitrogenous bases (Adenine, Guanine, Thymine, Uracil and Cytosine). The bases adenine (A) and guanine (G) are purines with a double ring, and the bases thymine (T) and cytosine (C) are pyrimidines with a single ring (Figure 1).

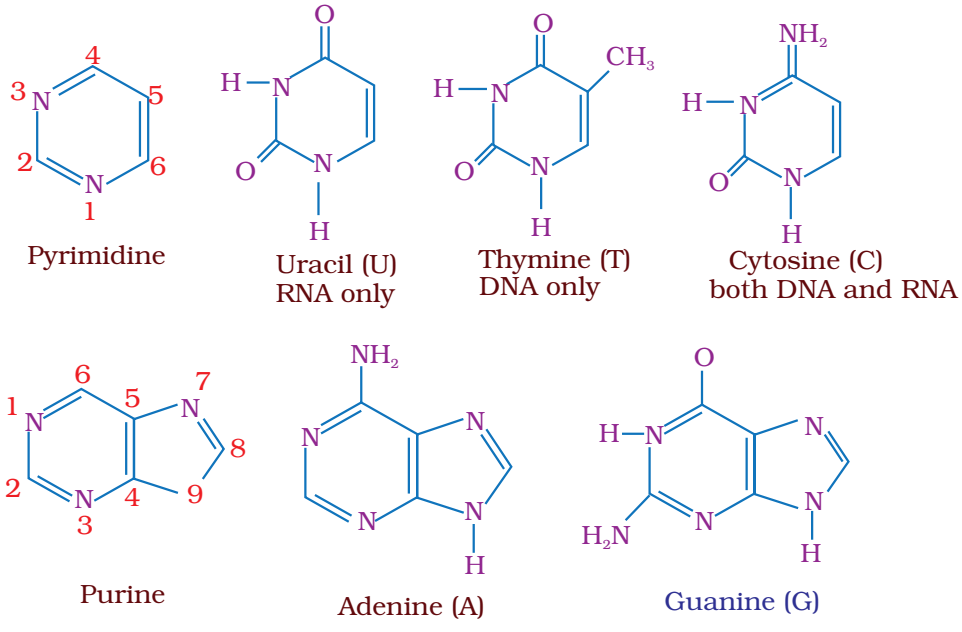


Figure 1. Nitrogenous bases

1. DNA is a nucleic acid molecule composed of the four nitrogenous bases Adenine, Guanine, thymine and cytosine C, each attached with pentose sugar ($C_5H_{10}O_5$), phosphate ion (PO_4^{3-}),
2. **RNA** is a nucleic acid composed of the four nitrogenous bases adenine, guanine, cytosine and uracil, each attached with a pentose sugar ($C_5H_{10}O_4$) and Phosphate ion (PO_4^{3-}). There are three types of RNA molecules in the cell cytoplasm(Figure 2).

5.2 Types of RNA

Messenger RNA (mRNA): - carry genetic instructions in the form of triplet bases or codons from DNA in the cell nucleus to ribosomes for protein synthesis (Figure 2a).

Transfer RNA (tRNA): - a cloverleaf-like shape nucleotide that carries anti-codon at one end and amino acid at the other end. It takes amino acid to the area of ribosomes. There is at least one tRNA molecule for each of the 20 amino acids found in proteins. Each anticodon is complementary to the codon of mRNA (Figure 2b).

Ribosomal RNA (rRNA) : - composes ribosomes for protein synthesis. In Eukaryotic cells, rRNA is produced in a nucleolus within the nucleus. There, it joins with proteins manufactured in the cytoplasm to form two ribosomal subunits, one large and one small. The subunits leave the nucleus and join together in the cytoplasm to form a ribosome just as protein synthesis begins (Figure 2c).

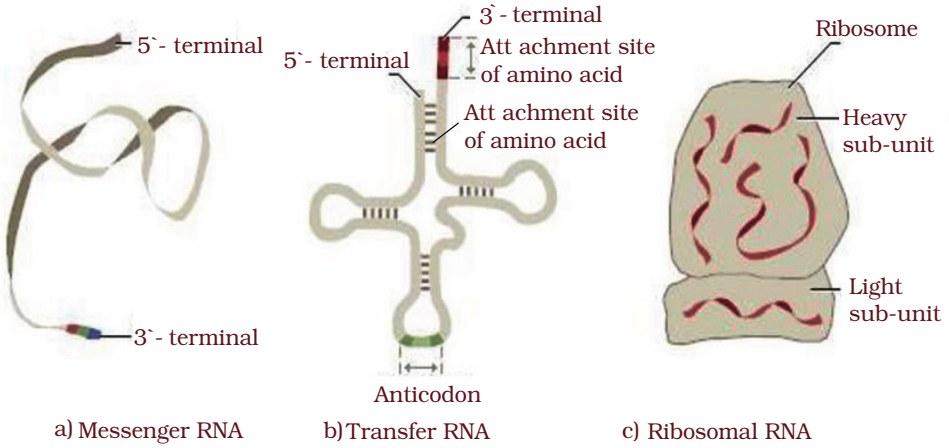


Figure 2. The different types of RNA

5.3 Structures of Nucleotides and Complementary Base Pairing

In Nucleic acids, every nucleotide is composed of a 5C sugar pentose ($C_5H_{10}O_5$), a phosphate (PO_4^{3-}) and one of the five nitrogenous bases. Four of these five types nucleotides molecules join through their sugar and phosphate by phosphodiester bond to form nucleotide chain or strand.

In the case of DNA there are such two complementary strands held through their bases by hydrogen bonds. in which always adenine (A) pairs with thymine (T) and guanine (G) pairs with cytosine(C). Such an arrangement, gives DNA a ladder-like appearance which is twisted or helical (Figure 3).

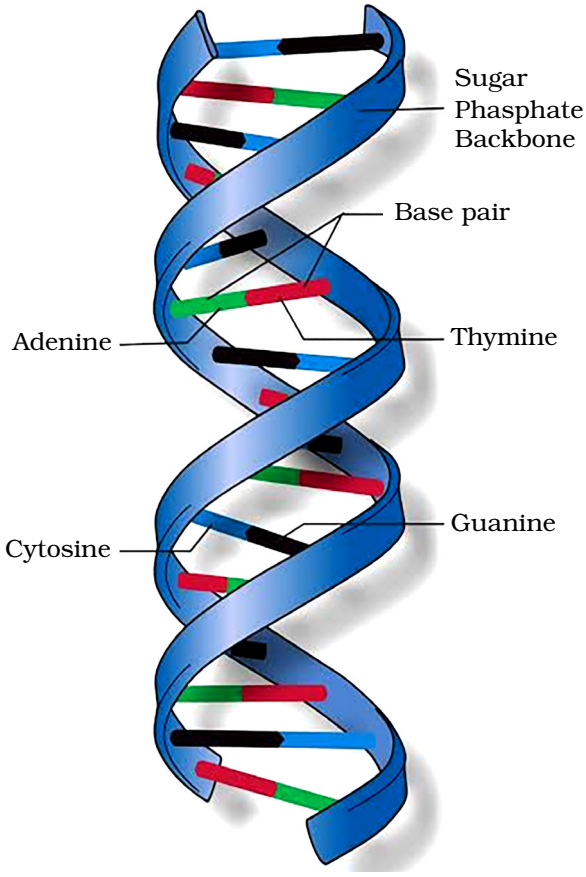


Figure 3. DNA structure

Unlike DNA molecule, there is single nucleotide chain or strand in RNA molecule which contains uracil, adenine, guanine and cytosine bases.

The two strands of DNA are **antiparallel** and run in opposite directions. In the double helix, each strand has a **5`end** where a free **P** appears and a **3` end** where a free **OH** group appears.

With the development of new chemical techniques in the 1940s, Chargaff decided to analyze in detail the base content of DNA in various species. In all the species Chargaff studied, the amount of A always equal to the amount of T, and the amount of G always equal to the amount of C. These relationships are called Chargaff's rules.

Rosalind Franklin was a researcher at King's College in London in the early 1950s. She was studying the structure of DNA using X-ray crystallography. The X-ray diffraction pattern of DNA shows that DNA is a double helix.

In 1951, James Watson and Francis Crick, together, they set out to determine the structure of DNA and to build a model that would explain how DNA varies from species to species, replicates, stores information, and undergoes mutation.

Watson and Crick model of DNA showed that the deoxyribose sugar–phosphate molecules are bonded to one another to build the sides of a twisted ladder. The nitrogenous bases form the rings of the ladder, they project into the middle and hydrogen bond with bases on the other strand. This model of DNA included, complementary base pairing of A with T and G with C as elucidated by the X-ray diffraction.

The double-helix model of DNA permits the base pairs to be in any order, a necessity for genetic variability between species. Also, the model suggests that complementary base pairing may play a role in the replication of DNA.

Review Exercises

1. Which of the following is TRUE about DNA? It is composed of
   (a) Four nucleotide chains
   (b) Two types of nucleotides
   (c) Chromosomes and genes.
   (d) A Molecule of hereditary in all living things.
2. Which of the following is FALSE about RNAs? They are
   (a) Single stranded molecule.
   (b) Composed four types of nucleotides

(c) Contains the nitrogenous base thymine
(d) There are three types of them in living things.

3. If a DNA molecule composed of 200 bases and contains 60 adenine, how many cytosine bases are found in this DNA?
(a) 20
(b) 40
(c) 60
(d) 80

4. Which of the following RNAs is used to make ribosomes for Protein synthesis?
(a) Transfer RNA
(b) Nuclear RNA
(c) Ribosomal RNA
(d) Messenger RNA

5.4 DNA Replication and RNA Transcription

DNA replication is the process of duplication or doubling of DNA in making its own copy DNA replication results the duplication of homologous chromosomes and formation of siser chromatids happening before cell division and reproduction.

DNA replication involves the following processes:

- Separation and **unwinding** the **DNA double helix** catalyzed by the enzyme **helicase**.
- Separated strands or nucleotide chains are used as **templates**.
- Nucleotides complementary to template strands are added to make new complementary strand.
- Addition of **new nucleotides** is catalyzed by the enzyme complex called **DNA polymerase**.
- Synthesis of complementary daughter strand occurs in a 5 –3 direction.
- **Editing wrong** base paring is performed by DNA polymerase.
- Sealing of breaks in the sugar-phosphate backbone is done by the enzyme **DNA ligase**.

Each new DNA is composed one old and one new strand, such a replication of DNA is said to be semi-conservative replication.

During DNA replication, the two DNA strands, serve as a template for a new strand in a daughter molecule. Such a replication of DNA referred to as semi-conservative (Figure 4).

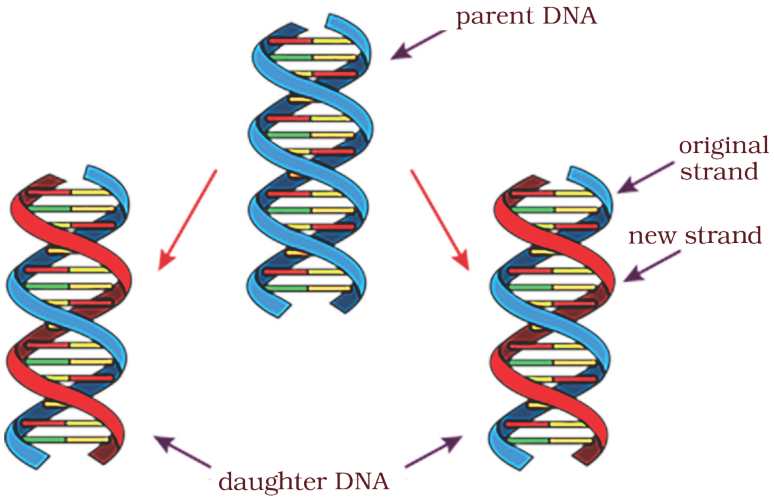


Figure 4. A semi-conservative DNA replication

A daughter DNA double helix has the same sequence of base pairs as the parent DNA double helix had. Complementary base pairing has allowed this sequence to be maintained.

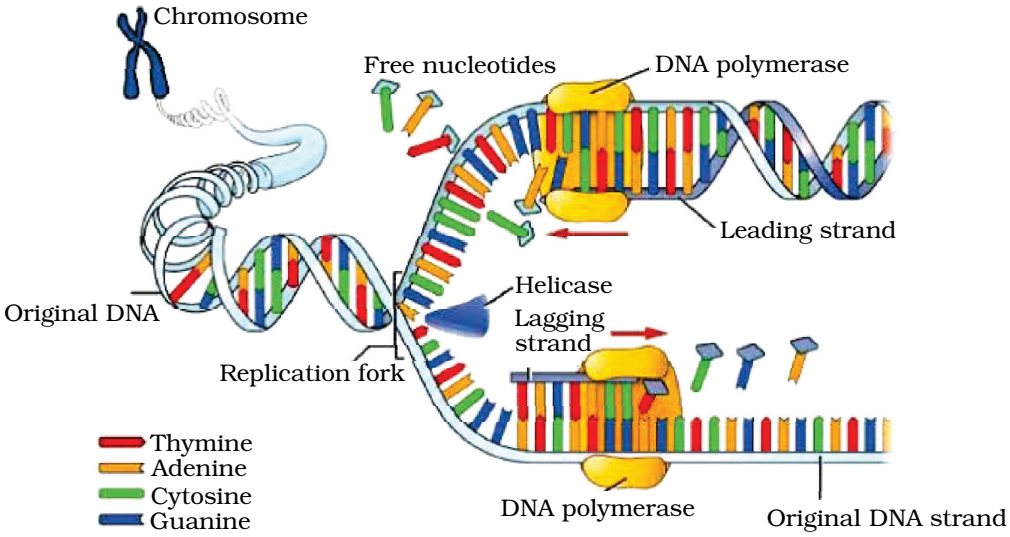


Figure 5. DNA replication in eukaryotes

In Eukaryotes, DNA replication begins at numerous sites, called origins of replication, along the length of the chromosome. At each origin of replication, a replication fork forms, allowing replication to proceed in both directions. Around each replication fork, a "replication bubble" forms. It is within the replication bubble that the process of DNA replication occurs. Replication proceeds along each strand in opposite directions until the entire double helix is copied (Figure 5).

During this replication there are leading and lagging strands depending on the direction of adding nucleotides. In the leading strand new nucleotide addition occurs along the replication fork. However, in the lagging strand nucleotide addition occurs against the replication fork.

ACTIVITY 1

Using DNA model to demonstrate the process of DNA replication

Form groups with 4-5 students use DNA model to demonstrate the process of semi-conservative DNA replication to the class.

RNA transcription

RNA transcription is the synthesis of RNA on DNA Template. It involves one of the two strands of DNA serving as a template to make a stand of mRNA complementary to it. The template DNA strand that transcribes mRNA is called an **anti-sense** stand. Thus, the base sequence on transcribed mRNA strand is similar to the base sequence on non-template strand called sense strand except that T is replaced by U.

Transcription begins when the enzyme **RNA polymerase** binds tightly to a **promoter**, a region of DNA with a special nucleotide sequence that marks the beginning of a gene. RNA polymerase opens up the DNA helix just in front of it, so that complementary base pairing can occur. Then the enzyme adds new RNA nucleotides that are complementary to those in the template DNA strand, and an mRNA molecule results. In Eukaryotes, once transcription is completed, the mRNA is ready to be processed before it leaves the nucleus for the cytoplasm (Figure 6).

Most genes in humans are interrupted by segments of DNA that do not code for protein. These portions are called **introns** because they are intervening segments. The other portions of the gene, called **exons**, contain the protein- coding regions of the gene. In mRNA splicing, the introns are removed and the exons joined together. The result is a mature mRNA molecule consisting of continuous exons.

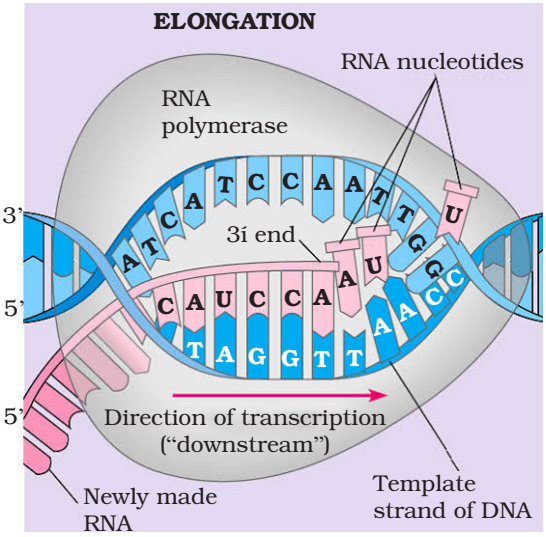


Figure 6. Transcription

ACTIVITY 2

Using charts to explain the process of RNA transcription

In group of 4- 5 students make use of a chart to explain the process of RNA transcription to the class.

5.5 STAGES OF PROTEIN SYNTHESIS

The process of Protein synthesis in the cells of living things is known as translation. It occurs on the cellular organelles, called ribosomes.

The central dogma of molecular biology states that genetic information flows from DNA to RNA to protein. In Eukaryotes, DNA resides in the nucleus but RNA is found both in the nucleus and in the cytoplasm, where protein synthesis occurs.

The information contained in DNA and RNA is written in a chemical language different from that found in the protein specified by the DNA and RNA. The cell needs a way to translate one language into the other. The cell do so using the genetic code.

The genetic code is a triplet base found in one of the two strands of DNA called sense strand. By using a triplet code, the four bases can supply 64 different combinations to code for the 20 different amino acids in protein synthesis. However, three of the codes are stop codes do not code amino acids (Figure 7).

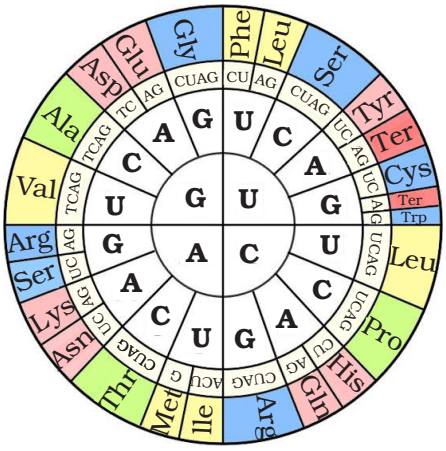


Figure 7. The genetic code.

The genetic code is considered to be almost universal and works for all life forms. It is also degenerate and thereby, an amino acid can be specified by more than one code. However, genetic code is non-overlapping.

A gene product, protein requires two processes, called transcription and translation. In Eukaryotes, transcription takes place in the nucleus, and translation takes place in the cytoplasm.

Translation is by which gene expression leads to protein (polypeptide) synthesis. Translation requires several enzymes, mRNA, and the other two types of RNA: transfer RNA and ribosomal RNA.

A ribosome has a binding site for mRNA as well as binding sites for two tRNA molecules at a time (Figure 8). These binding sites facilitate complementary base pairing between tRNA anticodons and mRNA codons. The P binding site is for a tRNA attached to a peptide, and the A binding site is for a newly arrived tRNA attached to an amino acid. The E site is for tRNA molecules exiting the ribosome.

Translation or polypeptide synthesis has three phases: initiation, an elongation cycle, and termination. Enzymes are required for each of the steps to occur, and energy is needed for the first two steps.

Initiation:- is the step that brings all of the translation components together (Figure 8).

- The small ribosomal subunit attaches to the mRNA in the vicinity of the start codon (AUG).

- The anticodon of the initiator tRNA–methionine complex pairs with this codon.
- The large ribosomal subunit joins to the small subunit.

Elongation: is in which the polypeptide chain increases in length one amino acid at a time (Figure 8):

- The tRNA at the P site contains the growing peptide chain.
- This tRNA passes its peptide to tRNA–amino acid at the A site. The tRNA at the P site enters the E site.
- During translocation, the tRNA-peptide moves to the P site, the empty tRNA in the E site exits the ribosome, and the codon at the A site is ready for the next tRNA–amino acid.

Termination: occurs when a stop codon (Figure 8) appears at the A site. Then, the polypeptide and the assembled components that carried out protein synthesis are separated from one another (Figure 8).

A protein complex called a release factor binds to the stop codon and cleaves the polypeptide from the last tRNA.

The mRNA, ribosomes, and tRNA molecules can then be used for another round of translation.

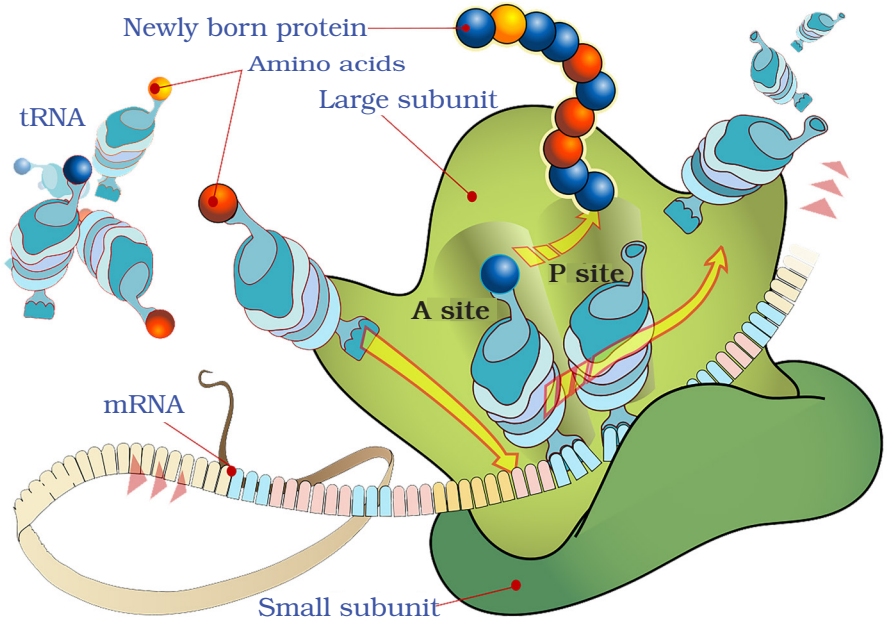


Figure 8. Protein synthesis (Translation)

After translation is complete, a protein contains the sequence of amino acids originally specified by DNA. This is the genetic information that DNA stores and passes on to each cell during the cell cycle, then to the next generation of individuals. DNA's sequence of bases determines the proteins in a cell, and the proteins determine the function of each cell.

5.6 The Importance of Protein Synthesis

The Proteins synthesized are very important in determining the functions of each cell. Depending on the difference in their genes or DNA cells vary in their protein products and biochemistry. The proteins products of translation can be:

Enzymes: biological catalysts that speed up the rate of biochemical reactions in a living system in accordance with their demand for cellular activities.

Structures: compose structures in a living system such as cell, nail, skin, hair and bone etc.

Pigments: coloring materials for biological entities like blood, hair, skin and internal organs

Transport: movement of substances in and out of a cells actively or passively in regulating materials for cellular activities.

Immunity: body defense against foreign bodies by substances such as antibodies in disease prevention.

Messengers: transmit hormonal impulse for coordination of body activities like growth, development and metabolism.

Activity 3

Using chart to demonstrate the process of Protein synthesis

In group of 4-5 students use a chart to demonstrate and explain the process of photosynthesis to the class.

Review Exercises

1. DNA replication does not involve:
   (a) DNA polymerase
   (b) Two template strands

(c) Conservative replication
(d) Complementarity base pairing

2. What the base sequence of a new DNA strand replicated on a template strand of DNA with base sequence of CAGTCG?
   (a) GCTGAC
   (b) GTCAGC
   (c) GATAGG
   (d) TACCGC
3. RNA replication involves :
   (a) Both strands of DNA as template
   (b) Single strand of RNA and DNA polymerase
   (c) Single strand of DNA and RNA polymerse
   (d) Single strand of DNA and DNA polymerase
4. What will be the base sequence of mRNA, if the anti-strand is with base sequence of TAGCAT?
   (a) UAGCAU
   (b) ATCGTA
   (c) ATAATC
   (d) UACGAU
5. Which of the following stage of translation assembles amino acids into proteins?
   (a) Initiation
   (b) Elongation
   (c) Termination
   (d) Distribution
6. Which of the following is not the function Proteins translated in our cells?
   (a) Enzymatic
   (b) Transportive
   (c) Defensive
   (d) Reproductive

5.7 Genetics and Heredity

Genetics is the study of how characteristics of organisms from parents to offspring are transmitted, inherited and expressed through successive generations that bring about similarities or differences among individuals of species.

Heredity is the passing over or transmission of traits from parents to offspring.

1. **The Principles of Genetics**

Biological characteristics are transmitted and inherited during reproduction through the cellular structures of hereditary, called Chromosomes. These chromosomes carry genes to determine the traits of organisms. Moreover, these hereditary structures in Eukaryotic cells are composed of the molecule of heredity called, DNA associated with its protein coat histone.

The chromosomes exist in pair to determine a given trait of organisms and they are not blended during heredity. As a result, these hereditary units are discrete units not mixed during heredity.

2. **Mendel's experiment with garden peas**

Gregor Johann Mendel (1822–1884) carried out experiments with several species of garden plants. Mendel did experiments on garden peas to find out the patterns of the transmission of traits from parents to offspring.

One reason for Mendel's success is that he chose his experimental material wisely. The garden pea, *Pisum sativum*:

- is **easily grown** in experimental gardens or in pots in a greenhouse and hence possible to conduct so many experiments in a short period of time.
- encourage **self-pollination** because of this highly in brede or true breed showing uniformity or little genetic variation that can be cross-pollinated when required
- display many different true-breeding varieties each with contrasting traits

Mendel took advantage of these contrasting traits to determine how the characteristics of pea plants are inherited. His focus on these singular differences between pea strains allowed him to study the inheritance of one trait at a time. For example, plant height.

Mendel focused his attention on contrasting differences between plants that were otherwise the same tall versus short, green seeds versus yellow seeds, and so forth. In addition, he kept careful records of the experiments that he performed.

Firstly, Mendel began his work by obtaining individuals from pure lines or true-breeding lines. A pure line consists of individuals that produce

offspring identical to the parents when they are self-fertilized. Mendel confirmed that individuals that germinated from his tall sized peas produced only tall sized offspring when they were mated to themselves or to another pure- line individual that germinated from a tall sized peas.

Secondly, in this experiment Mendel did the cross-pollination of contrasting characters of a trait. He carefully emasculated or removed the anthers from one variety before its pollen had matured and then applied pollen from the other variety to the stigma, a sticky organ on top of the pistil that leads to the ovary. The seeds that resulted from these cross fertilizations were sown the next year, yielding hybrids of the opposite characters.

For instance, he simply, crossed pure tall and pure dwarf pea plants to investigate how height was inherited. This cross- fertilization, produced hybrids that were uniformly tall. Mendel obtained tall plants regardless of the reciprocal crosses (tall male with dwarf female or dwarf male with tall female). See Figure 9 below.

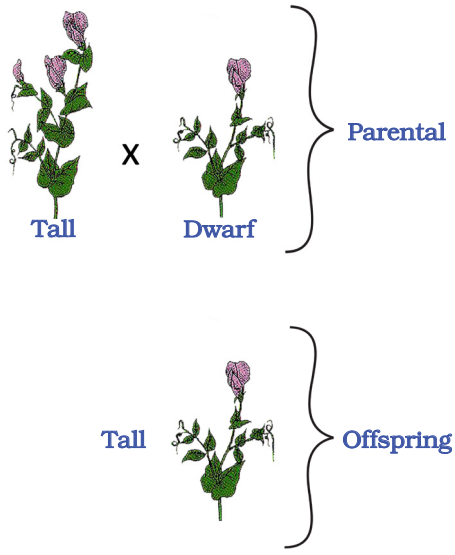


Figure 9. The F1 generation

Even more significantly, however, Mendel noted that the dwarf characteristic seemed to have disappeared in the progeny of the cross, for the entire hybrid plants were tall. To explore the hereditary makeup of these tall hybrids, Mendel allowed them to undergo self-fertilization.

When he examined the progeny, he found that they consisted of both tall and dwarf plants. In fact, among 1064 progeny that Mendel cultivated in his garden, 787 were tall and 277 were dwarf with a ratio of approximately 3:1 (Figure 10).

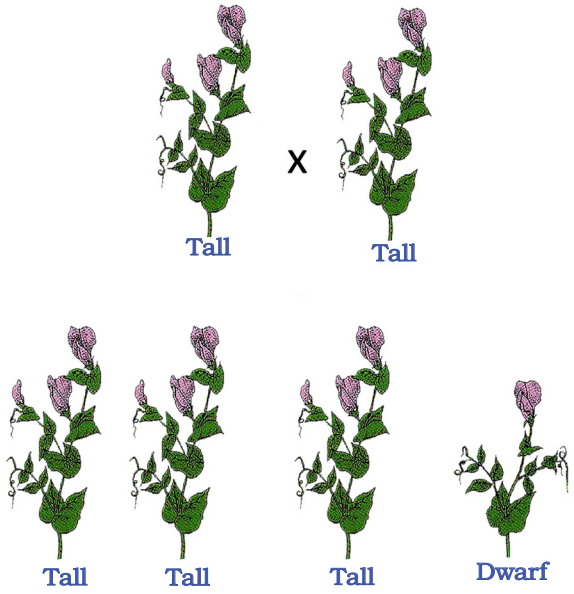


Figure 10. F2 generation

Mendel was struck by the reappearance of the dwarf characteristic. Clearly, the hybrids that he had made by crossing pure tall and pure dwarf varieties had the ability to produce dwarf progeny even though they themselves were tall. Mendel inferred that these hybrids carried a latent genetic factor for dwarfness, one that was masked by the expression of another factor for tallness.

Mendel said that the hidden factor was recessive and that the expressed factor was dominant. He also inferred that these recessive and dominant factors separated from each other when the hybrid plants reproduced. This enabled him to explain the reappearance of the dwarf characteristic in the next generation.

Mendel's results were clearly inconsistent with both the hypothesis of blending inheritance and the hypothesis of acquired characters. To explain the patterns that he observed, Mendel proposed a competing hypothesis called particulate inheritance. He maintained that the hereditary determinants for traits do not blend together or become

modified through use. Instead, hereditary determinants maintain their integrity from generation to generation. Rather than blending together, they act as discrete, unchanging particles.

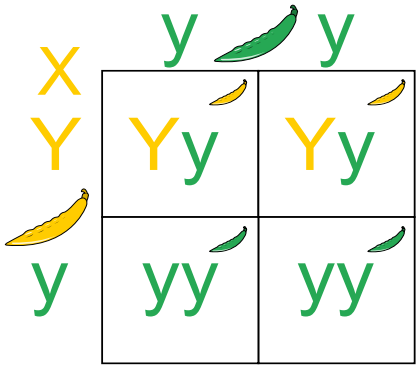
Mendel performed similar experiments to study the inheritance of six other traits: seed texture, seed color, pod shape, pod color, flower color, and flower position (Table 1).

Table 1 Mendel's Monohybrid Crosses

Seed		Flower	Pod		Flower	
Form	Color	Color	Form	Color	Position	Size
						
Round	Yellow	white	Full	Yellow	Axial	Long (6-7ft)
						 Terminal
Wrinkled	Green	Violet	Constricted	Green	Terminal	Short$_{3/4}$-1ft
1	2	3	4	5	6	7

Mendel recognized that the diploid gene number would reduce in gametes; he realized that random fertilizations with a mixed population of gametes—half carrying the dominant allele and half carrying the recessive allele, would produce some zygotes in which both alleles were recessive. Thus, he could explain the reappearance of the recessive characteristic in the progeny of the hybrid plants.

Monohybrid Cross Punnett Square



Test cross

Later, Mendel did test cross to determine the genotype of the dominant by crossing the pure recessive with the dominant and observing the phenotypic ratio of their offspring. For instance, if pure dwarf pea plant is crossed with a dominant tall pea produced the tall and short offspring in equal ratio, the dominant parent would be hybrid tall (Figure 11).

Mendel's analysis of this and other monohybrid crosses by stating two key principles that he discovered:

The Principle of Dominance: In a heterozygote, one allele may conceal the presence of another. This principle is a statement about genetic function. Some alleles evidently control the phenotype even when they are present in a single copy. Thus, Tt, like TT, it is tall.

The Principle of Segregation: states that alleles in a pair segregate from each other during the formation of gametes. In, a heterozygote, the two different alleles segregate and form two possible type of gametes. For instance, a heterozygous tall (Tt), produces T and t gametes.

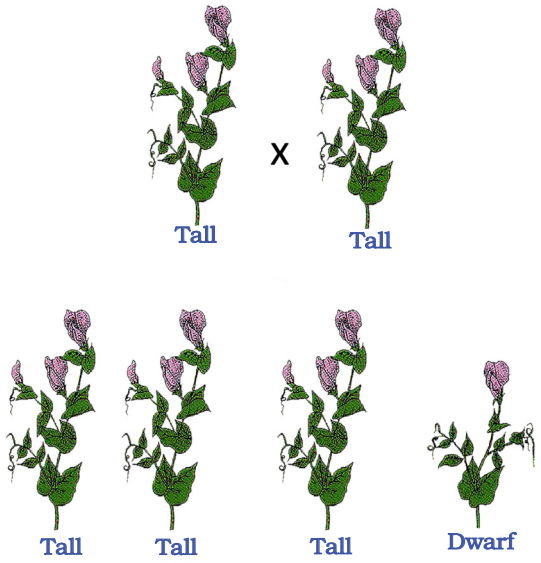


Figure 11. Test cross

ACTIVITY 4

Describing Mendel's contribution to the principles of heredity

In group of 4-5 students describe to the class the contributions of Mendel to the principles of heredity.

Review Exercises

1. If a cross between two purple flower of pea plants produced 39 purple and13 white flowered plants, what would be the expected genotype of the parent pea plants? Both
   (a) Homozygous purple
   (b) Homozygous white
   (c) Heterozygous purple
   (d) Heterozygous white
2. If a cross between smooth and wrinkled seed pea plants produced 24 smooth and 25 wrinkled seed, what would be the expected genotype of the parents?
   (a) Pure smooth and wrinkled seed
   (b) Hybrid smooth and pure wrinkled seed
   (c) Hybrid smooth and hybrid wrinkled seed
   (d) Pure smooth and hybrid wrinkled seed
3. Suppose a cross among two hybrid tall pea plants produced 160 pea plants, what would be the expected phenotypic ratio of these offspring?
   (a) 80 tall: 80 short
   (b) 90 tall: 70 short
   (c) 100 tall : 60 short
   (d) 120 tall : 40 short
4. Suppose a cross among hybrid inflated and pure constricted pods of plants produced 58 pea plants, what would be the expected phenotypic ratio of these offspring?
   (a) 29 inflated : 29 constricted pods
   (b) 43 inflated : 15 constricted pods
   (c) 20 inflated : 38 constricted pods
   (d) 48 inflated : 10 constricted pods

Dihybrid Cross

Mendel also performed experiments with plants that differed in two pairs of contrasting traits. He crossed plants that produced yellow, round seeds with plants that produced green, wrinkled seeds. The purpose of the experiments was to see if the two seed traits, color and texture, were inherited independently. Because the F1 seeds were all yellow and round, the alleles for these two characteristics were dominant. Mendel

grew plants from these seeds and allowed them to self-fertilize. He then classified the F2 seeds and counted them by phenotype.

The four phenotypic classes in the F2 represented all possible combinations of the color and texture traits. Two classes—yellow round seeds and green wrinkled seeds, resembled the parental strains. The other two green round seeds and yellow wrinkled seeds, showed new combinations of traits. The four classes had an approximate ratio of 9 yellow round: 3 green round: 3 yellow wrinkled: 1 green, wrinkled.

To Mendel's insightful mind, these numerical relationships suggested a simple explanation: Each trait was controlled by a different gene segregating two alleles, and the two genes were inherited independently.

Let's analyze the results of this two-factor, or dihybrid cross, according to Mendel. For the seed color gene, the two alleles are Y (for yellow) and y (for green), and for the seed texture gene, they are R (for round) and r (for wrinkled). The parental strains, which were true-breeding, must have been doubly homozygous; the yellow, round plants were YY RR and the green, wrinkled plants were yyrr.

The haploid gametes produced by a diploid plant contain one copy of each gene. Gametes from YY RR plants therefore contain one copy of the seed color gene (the Y allele) and one copy of the seed texture gene (the R allele). Such gametes are symbolized by YR. By similar reasoning, the gametes from yyrr plants are written yr. Cross-fertilization of these two types of gametes produces F1 hybrids that are doubly heterozygous (Figure 12), symbolized by YyRr, and their yellow, round phenotype indicates that the Y and R alleles are dominant.

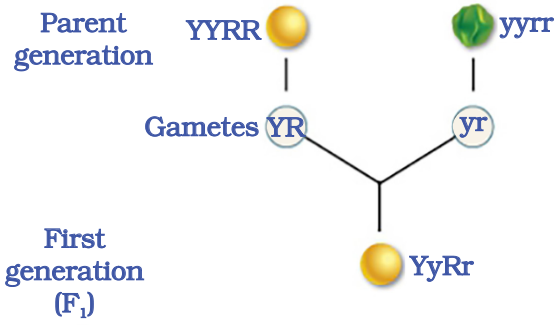


Figure 12. F1 Generation of Dihybrid cross

The Principle of Segregation predicts that the F1 hybrids will produce four different gametes: YR, Yr, yR, and yr. If each gene segregates its alleles independently, these four types will be equally frequent; that is, each will be 25 percent of the total.

On this assumption, self-fertilization in the F1 will produce an array of 16 equally frequent zygotic genotypes. We obtain the zygotic array by systematically combining the gametes (Figure 13).

We then obtain the phenotypes of these F2 genotypes by noting that Y and R are the dominant alleles. Altogether, there are four distinguishable phenotypes, with relative frequencies indicated by the number of positions occupied in the array. For absolute frequencies, we divide each number by the total, 16:

- 9/16 yellow, round
- 3/16 yellow, wrinkled
- 3/16 green, round
- 1/16 green, wrinkled

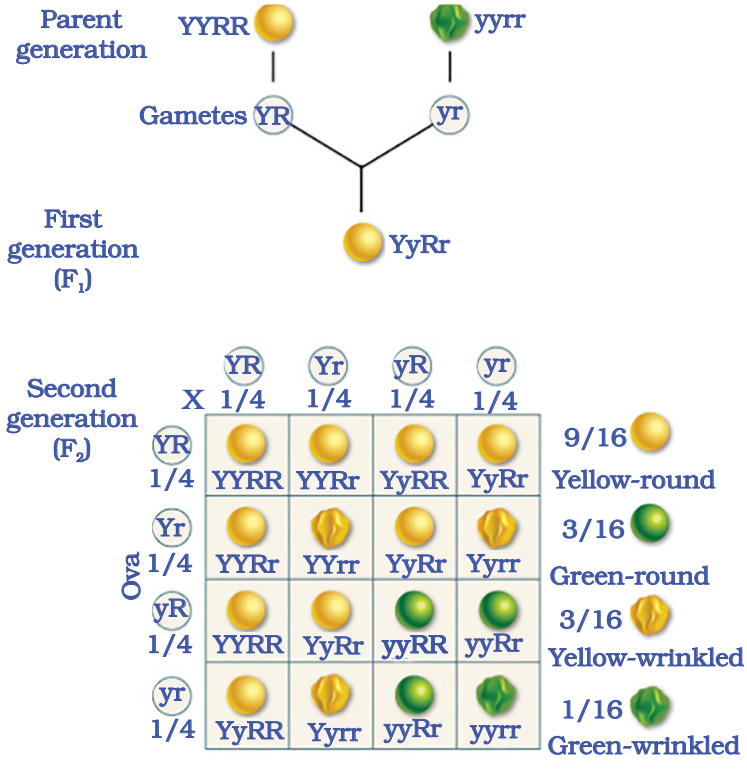


Figure 13. F2 Generations of Dihybrid

Mendel conducted similar experiments with other combinations of traits and in each case observed that the genes segregated independently. The results of these experiments led him to a third key principle:

The **Principle of Independent Assortment:** states that the inheritance of one trait is not affected by the other. For instance, the inheritance of seed color is not affected by the seed shape and conversely.

ACTIVITY 5

Describing Mendel's experiments and results

In group of 4-5 students discuss on Mendel's experiments and results among group members. Then, present your discussion to the class.

ACTIVITY 6

Solving monohybrid and di-hybrid problems using punnett square and stating the importance of the punnett square.

In group of 4-5 students take sample monohybrid and di-hybrid experiments from Table 1 or any biology reference books form library and solve problems using the Punnett square. Then, present your Punnett square and its importance to the class.

3. Genetic terms

In each monohybrid cross experiment Mendel studied the inheritance of one pair of opposite or contrasting characteristics. In his monohybrid experiment Mendel observed that only one of the two contrasting characteristics appeared in the **hybrids**. Mendel called these hybrid generations, the **First filial Generations** or **F1**.

Then, when he self-fertilized these hybrids (F1), they produced consisting of two types of progeny, each resembling the parent plants. He called these generations, the **Second filial Generations** or **F2**.

In this Monohybrid crosses, Mendel understood that if the sperm and egg came from genetically different plants, the **hybrid** zygote would inherit two **different alleles**, one from the mother and one from the father. Such an offspring is said to be **heterozygous**.

Mendel realized that the different alleles that are present in a heterozygote must coexist even though one is dominant and the other recessive, and that each of these alleles would have an equal chance of entering a gamete when the heterozygote (hybrid) reproduces. Furthermore, he found that these F2 progeny consistently appeared in a ratio of **3:1**.

Thus, each trait that Mendel studied seemed to be controlled by a heritable factor that existed in two forms, one dominant, and the other recessive. These factors are now called **genes**, a word coined by the Danish plant breeder Wilhelm Johannsen in 1909; their dominant and recessive forms are called **alleles**—from the Greek word meaning "of one another." Alleles are alternate forms of a gene.

Review Exercises

1. If 800 offspring were produced from the cross of two hybrid tall axial flower pea plants, What would be the expected phenotypic ratio of these offspring?
   (a) 400 tall axial:400 short axial
   (b) 400 tall terminal: 400 short terminal
   (c) 450 tall axial :150 tall terminal: 150 short axial : 50 short terminal
   (d) 200 tall axial: 200 tall terminal: 200 short axial: 200 short terminal
2. If hybrid tall axial flower pea plants crossed with pure short produced 600 pea plants, what would be the phenotypic ratio of these offspring?
   (a) 200 tall axial: 200 tall terminal: 100 short axial : 100 short terminal
   (b) 150 tall axial: 150 tall terminal: 150 short axial : 150 short terminal
   (c) 180 tall axial: 180 tall terminal: 120 short axial : 120 short terminal
   (d) 170 tall axial: 170 tall terminal: 130 short axial : 130 short terminal
3. Suppose a cross among hybrid smooth purple pea plants produced 1600 pea plants, what would be the phenotypic ratio of the offspring?
   (a) 400 smooth purple: 400 smooth white: 400 rough purple: 400 rough white
   (b) 600 smooth purple: 600 smooth white: 200 rough purple: 200 rough white
   (c) 700 smooth purple: 700 smooth white: 100 rough purple: 100 rough white
   (d) 900 smooth purple: 300 smooth white: 300 rough purple: 100 rough white

4. Suppose a hybrid tall smooth seed crossed with short rough seed pea plants Produced 1400 pea plants, what would be the phenotypic ratio of these offspring?
   (a) 350 tall smooth: 350 tall rough: 350 short smooth: 350 short rough
   (b) 400 tall smooth: 400 tall rough: 300 short smooth: 300 short rough
   (c) 450 tall smooth: 450 tall rough: 250 short smooth: 250 short rough
   (d) 500 tall smooth: 500 tall rough: 200 short smooth: 200 short rough

Linkage

Linkage is the existence of different genes on a chromosome. Some of the first evidence for linkage came from experiments performed by W. Bateson and R. C. Punnett .These two fellows crossed varieties of sweet peas that differed in two traits, flower color and pollen length. Plants with red flowers and long pollen grains were crossed to plants with white flowers and short pollen grains. All the F1 plants had red flowers and long pollen grains, indicating that the alleles for these two phenotypes were dominant. When the F1 plants were self-fertilized, Bateson and Punnett observed a peculiar distribution of phenotypes among the offspring. Instead of the 9:3:3:1 ratio expected for two independently assorting genes, they obtained a ratio of 583:26:24:170. Among the 803 F2 plants that were examined, the classes that resembled the original parents (called the parental classes) are significantly overrepresented and the two other (non-parental) classes are significantly underrepresented.

The procedures Bateson and Punnett followed

Red flowers long pollens x White owers short pollens

↓

F1= Hybrid red flowers long pollens

↓ Self-pollinated

F2= 583 Red long: 26 Red short: 24 White long: 170 White short

Recombinant progeny

Bateson and Punnett devised a complicated explanation for their results, but it turned out to be wrong. The correct explanation for the lack of independent assortment in the data is that the genes for flower color and pollen length are located on the same chromosome- that is, they are **linked**.

Bateson and Punnett might have come up with this explanation if they had performed a testcross instead of self-pollination of F1. With a testcross the offspring would directly reveal the types of gametes produced by the doubly heterozygous F1. Doubly heterozygous F1 sweet peas were crossed with plants homozygous for the recessive alleles of both genes produced the following offspring.

Red flower long x white flower short

↓

450 red long: 42 red short: 38 white long: 470 white short

Recombinant progeny

Here in the example, the frequency of the recombinant progeny produced by the cross of two heterozygous F1 plants is therefore, $\frac{42 + 38}{1000}$ = 0.08 i.e 8%

A frequency of recombination less than 50 percent implies that the genes are linked on the same chromosome. For any two genes, the recombination frequency never exceeds 50 percent, the genes are linked and do not assort independently. This upper limit is obtained when genes are on different chromosomes; 50 percent recombination is, in fact, what we mean when we say that the genes assort independently.

Recombinant gametes are produced as a result of crossing over between homologous chromosomes. This process involves a physical exchange between non-sisters homologous chromosomes (Figure 14). The exchange event occurs during the prophase of the first meiotic division, when duplicated chromosomes have paired. Although four homologous chromatids are present, forming what is called a tetrad, only two chromatids cross over at any one point. Each of these chromatids breaks at the site of the crossover, and the resulting pieces reattach to produce the recombinants. The other two chromatids are not recombinant at this site. Each crossover event therefore produces two recombinant chromatids among a total of four.

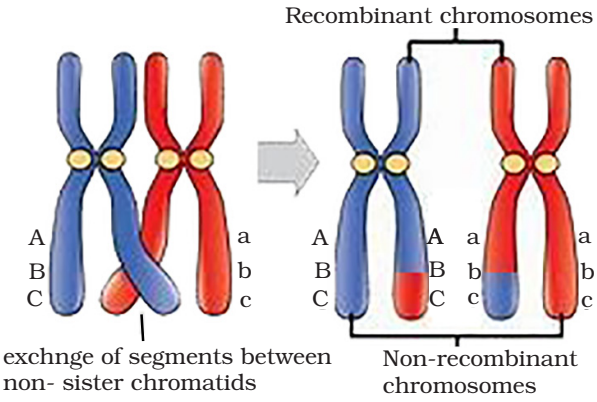


Figure 14

Sex–linked traits

Sex-linked inheritances are traits due to genes found on sex chromosomes. It was first observed by Hunt Morgan when he carried experiment on Fruit flies to study their eye color inheritance.

Morgan's experiments commenced with his discovery of a mutant male fly that had white eyes instead of the red eyes of wild-type flies. When this male was crossed to wild-type females, all the progeny had **red eyes**, indicating that **white** was **recessive** to red.

White eyed male X Red eyed female = All red eyed

When these progeny were intercrossed with each other, Morgan observed a peculiar segregation pattern: all of the daughters, but only half of the sons, had red eyes; the other half of the sons had white eyes.

Red eyed male X Red eyed female = all female red eyed, half males red eyed and half white eyed

This pattern suggested that the inheritance of eye color was linked to the sex chromosomes. Morgan proposed that a gene for eye color was present on the X chromosome, but not on the Y, and that the white and red phenotypes were due to two different alleles, a mutant allele denoted w and a wild-type allele denoted W.

XWY= Red eyed male
XwY= White eyed male
XWXW= Red eyed female
XWXw = red eyed female
XwXw = white eyed female

The wild-type females in the first cross are assumed to be homozygous for the W allele. Their mate is assumed to carry the mutant w allele on its X-chromosome and neither of the alleles on its Y chromosome.

An organism that has only one copy of a gene is called a hemizygote. Among the progeny from the cross, the sons inherit an X-chromosome from their mother and a Y-chromosome from their father; because the maternally inherited X carries the W allele, these sons have red eyes. The daughters, in contrast, inherit an X chromosome from each parent—an X with w from the mother and an X with w from the father. However, because W is dominant over w, these heterozygous F1 females also have red eyes.

$$X^wY \times X^WX^W \downarrow X^WY : X^WX^w$$

When the F1 males and females are intercrossed, four genotypic classes of progeny are produced, each representing a different combination of sex chromosomes. The XX flies, which are female, have red eyes because at least one w allele is present. The XY flies, which are male, have either red or white eyes, depending on which X chromosome is inherited from the heterozygous F1 females. Segregation of the W and w alleles in these females is therefore the reason half the F2 males have white eyes.

$$X^WY \times X^WX^w \downarrow X^WY: X^wY: X^WX^W: X^WX^w$$

Morgan carried out additional experiments to confirm the elements of his hypothesis. In one he crossed F1 females assumed to be heterozygous for the eye color gene to mutant white males. As he expected, half the progeny of each sex had white eyes, and the other half had red eyes.

$$X^wY \times X^WX^w \downarrow X^WY: X^wY: X^WX^w: X^wX^w$$

In another experiment, he crossed white-eyed females to red-eyed males. This time, all the daughters had red eyes, and all the sons had white eyes. When he intercrossed these progeny, Morgan observed the

expected segregation: half the progeny of each sex had white eyes, and the other half had red eyes. Thus, Morgan's showed that the gene for eye color was linked to the X chromosomes.

$$X^WY \times X^wX^w$$
$$\downarrow$$
$$X^wY: X^WX^w$$

Sex linked inheritances due to recessive genes on X sex chromosomes are expressed in both male and female individuals but the prevalence is high in males.

In humans, hemophilia and color blindness are heritable disorders due to recessive genes found on X chromosomes.

5.8 Hereditary Traits

Hereditary traits: - are heritable characters and run through the families of successive generations.

Ear lobe:- is a heritable trait of ear shape which can be attached or free, free ear lobe is dominant.

Haemophilia:- is a heritable disorder of unable to clot blood if there is bleeding. It is due to recessive genes found on X sex chromosomes. It is more prevalent among human males since they have single X sex chromosomes.

Colour blindness:- is a heritable inability to distinguish colours due to recessive genes found on X-sex chromosomes.

Sickle cell anaemia:- is a heritable disorder of RBCs that are sickle-shaped due to base substitution in DNA.

Baldness:- is a heritable loss of head from hair due to genes influenced by the sex of the individual. The gene is dominant in human male but recessive in females. It is more prevalent in human male.

Mental disorder:- heritable disorder of slow or retarded mental growth such as Down's syndrome.

1. Influence of environment on heredity

Environmental factors normally interact with heredity and hence they affect heredity by influencing its full expression or heritability. The expression of a given trait of an organisms explained in terms of phenotype. This to mean that phenotype is the sum of gene and

environment. Similarly, phenotype of an organism changes with the change of the environment. Therefore, traits which are acquired as a result of the the environment are not heritable.

2. Development of trait

The development of certain traits in humans is highly dependent on the environment. Human Traits like body height, body weight, and intelligence are highly influenced by the type of environment where individuals confined to live. When individuals obtain proper nutrition and living condition they show change in their body weight, height and mental capacity, especially younger ones.

Particularly intelligence or mental capacity in young citizens requires the provision of proper environment including food, shelter, medication and technology etc. for its enrichment. The term intelligence refers to an assortment of mental abilities, including verbal and mathematical skills, memory and recall, reasoning and problem solving, discrimination of different objects, and spatial perception.

Activity 7

Discussing some genetic disorders and diseases

In group of 4-5 students read biology reference books from library and discuss on some genetic disorders and diseases. Present the disorders and diseases you find to the class.

Review Exercises

1. Which of the following is TRUE about linked genes? They :
   (a) Assort independently.
   (b) Are governed by Mendel's genetics.
   (c) Are genes found on the different chromosome.
   (d) Form recombinant alleles by crossing over.
2. Which of the following is FALSE about sex linked traits? They
   (a) Can be expressed in both sexes.
   (b) Are inherited due to sex chromosomes.
   (c) Genes are dominant in one sex but recessive in the other.
   (d) Are more prevalent in males if they are due to recessive genes on X sex chromosomes.
3. Which of the following trait in humans is NOT heritable?
   (a) Body scar
   (b) Human sex

(c) Human skin colour
(d) Human finger print

4. Which of the following trait in humans remains unchanged by environmental factors?
(a) Intelligence
(b) Body weight
(c) Body height
(d) Blood group

5.9 ABO Blood Grouping and Rhesus Factor

The genetics of ABO Blood groups

So far, we have discussed inheritance patterns involving only two alleles per gene. But most genes can be found in populations in more than two versions, known as multiple alleles. Although each individual carries, at most, two different alleles for a particular gene, in cases of **multiple alleles, more than two alleles** exist **in the population**.

For instance, the **ABO blood group** phenotype in humans involves **three alleles** of a single gene. Various combinations of **three alleles** called IA, IB, and IO produce four phenotypes: A person's blood type may be A, B, AB, or O.

These letters refer to two carbohydrates, called A and B, that may be found on the surface of red blood cells. A person's red blood cells may be coated with carbohydrate A (in which case they are said to have type A blood), carbohydrate B (type B), both carbohydrates (type AB), or neither carbohydrate (type O).

Matching compatible blood types is critical for safe blood transfusions. If a donor's blood cells have a carbohydrate that is foreign to the recipient, then the recipient's immune system produces proteins called antibodies that bind specifically to the foreign carbohydrates and cause the donor blood cells to clump together, potentially killing the recipient.

Notice that **AB** individuals can receive blood from anyone without fear of clumping, making them "**universal recipients**," while donated type O blood never causes clumping, making those with type **O blood** "**universal donors**."

The four blood groups result from various combinations of the three different alleles:

- I^A (for an enzyme referred to as I, which adds carbohydrate A to red blood cells),

- I^B (which adds carbohydrate B), and
- I^O (which adds neither A nor B carbohydrate).

Each person inherits one of these alleles from each parent. Because there are three alleles, there are six possible genotypes.

- Both the I^A and I^B alleles are dominant to the IO allele.
- Thus, I^AI^A and I^AI^O people have type A blood, with antigen A
- I^BI^B and I^BI^O people have type B blood, With antigen B
- Recessive homozygous, I^OI^O, have type O blood, with no antigen.
- The I^A and I^B alleles are co-dominant: who have type AB blood with antigen A & B.

Examples

I^AI^A x I^OI^O all children with A blood type
I^BI^B x I^OI^O all children with B blood type
I^AI^A x I^BI^B all children with AB blood type
I^AI^O x I^OI^O half of the children with A blood type and half with O blood type
I^BI^O x I^OI^O half of the children with B blood type and half with O blood type
I^AI^B x I^OI^O half of the children with A blood type and half with B blood type

The genetics of Rhesus factor

In addition to ABO blood there are antigens found on human RBC, called Rhesus factor. When there is the Rhesus factor antigen on the RBCs of an individual, the blood type isRh positive. if not, Rh negative. This works for any blood group of humans and hence individuals with Rh negative blood can donate blood to Rh positive ones but not conversely. Thus, Rh negative blood is universal donor but Rh positive is universal recipient.

The genetics of Rhesus factor shows that Rh positive gene is dominant over Rh negative gene. As a result, Rh positive individuals can be homozygous or heterozygous whereas Rh negatives are homozygous.

Pure Rh positive x Pure Rh negative Hybrid Rh positive

The blood of Rh negative individual produces antibodies against the Rh factor antigen. This is manifested when a woman with Rh negative blood conceives an Rh positive child from a a father with Rh positive man. In this case there is Rh antigen and antibody reaction between the bloods of the mother and the conceived child end up with the possible

consequence of its death. This antigen and antibody reaction becomes stronger if Rh positive children are conceived onwards; and results their death soon after birth or at some stage of their development due to the Rh factor antigen and antibody reaction. However, this not a problem in urban society because of the medical treatment offered during pregnancy.

Review Exercises

1. What is the type of blood group in humans that can be donated to any blood group?
   (a) A
   (b) B
   (c) AB
   (d) O
2. What makes AB blood group individuals universal recipient?
   (a) Presence of antigens
   (b) Absence of antigens
   (c) Presence of antibodies
   (d) Absence of antibodies
3. Which of the following blood transfusion in humans does not cause agglutination?
   (a) A+ to O-
   (b) AB+ to O-
   (c) O- to AB-
   (d) B+ to B-
4. If a man having O blood gave birth to children from B blood woman which of the following could be the possible children of this couple?
   (a) A
   (b) B
   (c) AB
   (d) BB

5.10 Evolution and Natural Selection (Darwin's Theory)

Evolution is all the changes that have occurred in living things since the beginning of life. Earth is about 4.5 billion years old but the first life forms or prokaryotes evolved about 3.5 billion years ago. Evolution encompasses common descent and adaptation to the environment. The fact that living things have common descent, they share the same

fundamental characteristics. However, life is so diverse because the various types of living things are adapted to different ways of life.

Natural selection can be an account for the origin of new species and for the great diversity of life. It seems that life has been evolving for a very long time and that variously adapted populations can arise from a common ancestor.

It is important to emphasize three key points about evolution by natural selection.

First, although natural selection occurs through interactions between individual organisms and the environment, **individuals do not evolve**. Rather, it is the **population,** the group of organisms that **evolves** over time as adaptive traits become more common in the group and other traits change or disappear.

Second, natural selection can **amplify** or **diminish** only **heritable traits**. Certainly, an organism may become modified through its own interactions with the environment during its lifetime, and those acquired characteristics may help the organism survive. But unless coded for in the genes of an organism's gametes, such acquired characteristics cannot be passed on to offspring. Thus, a championship female bodybuilder will not give birth to a muscle-bound baby.

Third, evolution is **not goal directed**; it does not lead to perfectly adapted organisms. Whereas artificial selection is a deliberate attempt by humans to produce individuals with specific traits, natural selection is the result of **environmental factors** that vary from place to place and over time. A trait that is favorable in one situation may be useless, or even detrimental, in different circumstances.

5.11 Sexuality: Sex Determination (X and Y Chromosomes)

Sexuality in humans is the way people experience and express themselves sexually. There are many factors that help develop our sexuality, arguably one of the most important, is our actual gender. Whether, we are males or females will likely have a major influence on the development of our individual sexuality. Furthermore, sexuality is an integral part of our personalities whether we are aware of it or not.

The genetics of sex –determination shows that there are specialized chromosomes for determination of maleness and femaleness in humans and other animals. In humans out of the 23 pairs of homologous chromosomes, one pair of homologous chromosome stands for sex determination.

In human males the sex chromosomes are represented as XY, heterozygous whereas in human female XX, homozygous. Consequently, in humans, the sex of a child is determined by the male parent (father) due to the production of sperm cells either with X or Y sex-chromosomes.

5.12 Variation

Variation is inevitable among individuals of a species due to hereditary or environmental factors.

(a) **Continuous variation:** - is a variation with an average or mean value between the extreme ones. Such a variation is highly affected by environment and shows polygenic inheritance. The genes act in additive manner and each gene contributes for the expression of the trait. Polygenic inheritance is determined by more than a pair of genes. when this type of variation is depicted by a graph it assumes a bell-shaped graph. For example human skin colour is determined by two pairs of genes. Here, there is average type of skin colour between black and white.

Pureblack=AABB, AABb/AaBB=Darkbrown, AaBb/AAbb/ aaBB=brown, Aabb/aaBb=light brown, and aabb= pure white.

(b) **Discontinuous variation:** a variation without an average value. This kind of variation is not affected by environment. Human blood type is the best example and shows no average blood type.

5.13 Sources of Variation

(a) Crossing over: is exchange of genetic material between non-sister homologous chromosomes during prophase I of meiosis. It produces recombinant alleles for recombinant gametes or offspring when the genes are linked.

For instance, the hybrid long winged grey body(LlGg) linked genes in Drosophila produces the four types of gametes LG,Lg,lG and lg because of crossing over.

(b) **Independent assortment:** is free inheritance of alleles form different traits due to random arrangement of homologous chromosomes during metaphase I. if you remember Mendel's dihybrid crosses, the inheritance of seed shape is not affected by the seed colour. A smooth seed can inherit yellow or green seed, and a wrinkled seed can inherit yellow or green seed.

(c) **Random fusion of gametes:** - is the random union of gametes or fertilization during sexual reproduction. Siblings show variation because of random fusion of games despite the same father and mother they have.

5.14 Causes of Variation

Since an individual is the sum of genes and environment, any change in these two conditions cause variation.

(a) **Genetic factors:** are due to heritable variation such as mutations and gene recombination.
Mutations are due to sudden changes in structures and amount of genes or chromosomes.
Gene recombination is due to gene reshuffling during meiosis and fertilization.

(b) **Environmental factors:** - are due to changes in the environment such as place, nutrition, climate and exercise etc.

5.15 Consequences of Variation-Natural Selection

Natural selection is the process by which populations become adapted to their environment. In the context of modern evolutionary theory, evolution by natural selection requires:

- **Variation**. The members of a population differ from one another.
- **Inheritance**. Many of these differences are heritable genetic differences.
- **Differential adaptation**. Some of these differences affect how well an organism is adapted to its environment.
- **Differential reproduction**. Individuals that are better adapted to their environment are more likely to reproduce, and their fertile offspring will make up a greater proportion of the next generation.

Natural selection causes a population of organisms, and ultimately a species, to become adapted to the environment. The process is slow, but each subsequent generation includes more individuals that are better adapted to the environment. The individuals that survive best and produce the most offspring is not a random sample of the population.

Altogether, natural selection occurs when individuals with certain heritable traits produce more surviving offspring than do individuals

without those traits. Thus, the frequency of the selected traits increases from one generation to the next. Biologists now know that traits are determined by alleles, particular versions of genes. Thus, the outcome of evolution by natural selection is a change in allele frequencies in a population over time.

Review Exercises

1. Which of the following is FALSE about evolution? It is the change of
   (a) Individuals overtime.
   (b) Species in the course of time.
   (c) Living things from a common ancestor.
   (d) Populations of species through a long period of time.
2. Which of the following is NOT the source of heritable variations?
   (a) Crossing over
   (b) Acquired characteristics
   (c) Independent assortment
   (d) Random fusion of gametes
3. In humans, sex determination is the consequence of:
   (a) Sex chromosomes
   (b) Maternal chromosomes
   (c) Sexual activity of parents
   (d) Paternal chromosomes
4. Continuous variations :
   (a) Are without average values
   (b) Not affected by environment
   (c) Show polygenic inheritance
   (d) Show linear graph when plotted
5. Which of the following is an environmental factor that causes variations among human individuals?
   (a) Climate
   (b) Nutrition
   (c) Living style
   (d) All of the above
6. Which of the following is not useful for the action of natural selection?
   (a) Differential adaptation
   (b) Differential reproduction
   (c) Uniform environment
   (d) Heritable variations.

5.16 Population Genetics

Population genetics is a discipline that studies genes in groups of individuals. It examines allelic variation among individuals, the transmission of allelic variants from parents to offspring generation after generation, and the temporal changes that occur in the genetic makeup of a population because of systematic and random evolutionary forces.

The theory of population genetics is a theory of allele frequencies. Each gene in the genome exists in different allelic states, and, if we focus on a particular gene, a diploid individual is either a homozygote or a heterozygote. Within a population of individuals, we can calculate the frequencies of the different types of homozygotes and heterozygotes of a gene, and from these frequencies we can estimate the frequency of each of the gene's alleles. These calculations are the foundation for population genetics theory.

In 1908 Hardy and Weinberg each published papers describing a mathematical relationship between allele frequencies and genotype frequencies. This relationship, now called the Hardy–Weinberg principle, allows us to predict a population's genotype frequencies from its allele frequencies.

The Hardy–Weinberg principle

The Hardy-Weinberg principle states that equilibrium of allele frequencies in a gene pool will remain in effect in each succeeding generation of a large sexually reproducing population as long as five conditions are met:

- No mutations. Allelic changes do not occur, or changes in one direction are balanced by changes in the opposite direction.
- No genetic drift. The population is very large, and changes in allele frequencies due to chance alone are insignifcant.
- No gene flow. Migration of individuals, and therefore alleles, into or out of the population does not occur.
- Random mating. Individuals pair by chance, not according to their genotypes or phenotypes.
- No selection. No selective force favors one genotype over another.

For example, consider a population of 1000 dogs in which in a population of dog 750 are black and 250 are white. The frequency of the

two phenotypes would be 0.75 or 75% black and 0.25 or 25 % white. Based on these phenotypic frequencies, we can deduce the underlying frequency of genotypes.

If we assume that the white dogs are homozygous recessive for an allele we designate as b, and the black dogs are either homozygous dominant BB or heterozygous Bb, we can calculate the allele frequencies of the two alleles in the population from the proportion of black and white individuals, assuming that the population is in Hardy–Weinberg equilibrium.

Let the letter p designate the frequency of the B allele and the letter q the frequency of the alternative allele. Because there are only two alleles, p plus q must always equal 1.

$$p + q = 1$$

The frequency of the recessive allele = q2= 0.25= q= 0.5

The frequency of the dominant allele = 1- 0.5 = 0.5

The frequency of the heterozygous black dogs = 2pq= 2 x 0.5 x 0.5= 0.5

The frequency of the homozygous black dogs = p2= (0.5)2=0.25

The frequency of homozygous white dogs = q2= (0.5)2=0.25

In real life, these conditions are rarely, if ever, met, and allele frequencies in the gene pool of a population do change from one generation to the next. Therefore, evolution has occurred. The significance of the Hardy-Weinberg principle is that it tells us what factors cause evolution—those that violate the conditions listed. Microevolution can be detected by noting any deviation from Hardy-Weinberg equilibrium of allele frequencies in the gene pool of a population.

Peppered moths can be dark-colored or light-colored, and the percentage of each in the population can vary. If tree trunks are light, light- colored moths make up most of the population, but when the tree trunks are dark due to pollution; dark-colored moths make up most of the population. Predatory birds are the selective agent that causes the makeup of the population to vary. When dark-colored moths rest on light trunks in a non-polluted area, they are seen and eaten by these birds. With the advent of pollution, the trunks of trees darken, so it is the light-colored moths that stand out and are eaten. We know that evolution has occurred in because the population changes from 10% dark-colored phenotype to 80% dark-colored phenotype over time.

The list of conditions for genetic equilibrium stated previously implies that the opposite conditions can cause evolutionary change. These conditions are mutations, genetic drift, gene flow, nonrandom mating, and natural selection.

Mutations

Mutations are spontaneous changes in the amount and structure of genes or chromosomes due to errors during DNA replication or cell divisions (mitosis or meiosis). Mutations occur rarely, randomly and are mostly harmful. Mutations are mostly with recessive alleles. Mutation in Eukaryotes rarely causes a change.

Mutations provide new alleles and therefore are the ultimate sources of variation. Mutations are also the raw materials for evolutionary changes. As an evolutionary process, mutation is slow compared with selection, genetic drift, and gene flow. Evolutionary process due to mutations can be significant in bacteria and archaea because of their short generation times. Mutation in Eukaryotes rarely causes a change.

Mutation is not a significant mechanism of evolutionary change by itself. However, mutation can have a very large effect on evolution when combined with genetic drift, gene flow, and selection.

Genetic Drift

Genetic drift refers to changes in the allele frequencies of a gene pool due to chance. It is a chance driven change that is most marked in small populations. Genetic drift is random with respect to fitness. The changes in allele frequency that it produces are not adaptive. Over time, genetic drift can lead to the random loss of alleles. When random losses of alleles occur as a result of genetic drift, genetic variation in the population declines.

Small populations that occupy nature reserves or zoos are particularly susceptible to genetic drift. When drift leads to a loss of genetic diversity, it worsens the already miserable outlook for some endangered species.

Gene Flow

Gene flow is the movement of alleles between populations that occurs when an individual leaves one population, joins another, and breeds. While organisms can emigrate from a source population or immigrate to a new population, there is movement of their alleles.

The arrival or departure of alleles can increase, decrease, or have no effect on average fitness, depending on the situation. But in every case, movement of alleles between populations tends to reduce their genetic differences.

Gene flow increases genetic diversity in a recipient population if new alleles arrive with immigrating individuals. But gene flow may decrease genetic variation in the source population if alleles leave with emigrating individuals.

Nonrandom Mating

Nonrandom mating occurs when individuals pair up, not by chance, but according to their genotypes or phenotypes. Inbreeding, or mating between relatives to a greater extent than by chance, is an example of nonrandom mating.

Inbreeding decreases the proportion of heterozygotes and increases the proportions of both homozygotes at all gene loci. In a human population, inbreeding increases the frequency of recessive abnormalities.

Natural Selection

Natural selection is the process by which populations become adapted to their environment. As we saw earlier in this topic, evolution by natural selection requires variation, inheritance, differential addictiveness and differential reproduction. In evolution by natural selection, the fitness of an individual is measured by the number of fertile offspring.

Three types of natural selection are known: stabilizing selection, directional selection, and disruptive selection.

Stabilizing or normalizing Selection: occurs when an intermediate phenotype is favored (Figure 15). It can improve adaptation of the population to those aspects of the environment that remains constant. With stabilizing selection, extreme phenotypes are selected against, and individuals near the average are favored. The graph shows a normal distribution curve that is a normal bell-shaped curve.

For instance, the birth weight of human infants ranges from 0.89 to 4.9 kilograms. Babies, whose birth weights are at the extremes of this range, show higher death rate. Babies who have a birth weight between 3.1 kilo- grams and 3.5 kilograms show lowest death rate. Most babies have an **intermediate birth weight,** which gives the best chance of survival.

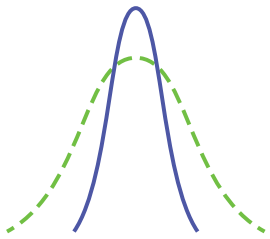


Figure 15. Stabilizing selection

Directional selection: occurs when an extreme phenotype is favored and the distribution curve shifts in that direction (Figure 16). Such a shift can occur when a population is adapting to a changing environment.

The peppered moths are good examples. Peppered moths can be dark-colored or light-colored, and the percentage of each in the population can vary.

If tree trunks are light, light- colored moths make up most of the population, but when the tree trunks are dark due to pollution; dark-colored moths make up most of the population. Predatory birds are the selective agent that causes the makeup of the population to vary.

When dark-colored moths rest on light trunks in a non-polluted area, they are seen and eaten by these birds. With the advent of pollution, the trunks of trees darken, so it is the light-colored moths that stand out and are eaten.

Antibiotic resistant bacteria and pesticide resistant insects exemplify directional selection.

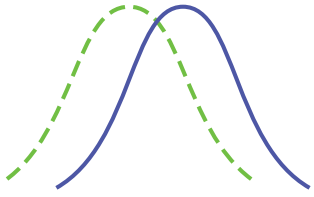


Figure 16. Directional selection

Disruptive Selection: occurs two or more extreme phenotypes are favored over any intermediate phenotype (Figure 17).

For example, British land snails (*Cepaea nemoralis*) have a wide habitat range that includes low- vegetation areas (grass elds and hedgerows) and

forest areas. In **low-vegetation** areas, thrushes feed mainly on snails with **dark shells** that lack light bands. In **forest** areas, thrushes feed mainly on snails with **light-banded** shells. Therefore, the two different habitats have resulted in two different phenotypes in the population.

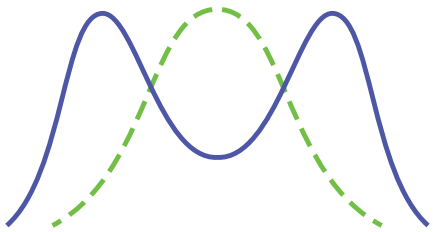


Figure 17. Disruptive selection

Review Exercises

1. According to Hardy-Weinberg principle, which of the following does NOT change allelic frequencies of a population?
   (a) Mutation
   (b) Migration
   (c) Genetic drift
   (d) Rndom mating
2. According to Hardy-Weinberg principle, the allelic frequencies of small population is more liable to change when there is:
   (a) Mutation
   (b) Genetic drift
   (c) Migration
   (d) Non-random mating
3. What type of natural selection favours extreme phenotypes?
   (a) Stabilizing selection
   (b) Directional selection
   (c) Diversifying selection
   (d) Normalizing selection
4. What is the percentage of heterozygous individuals in the population if the frequency of two alleles in a gene pool is 0.19 (A) and 0.81(a). Assume that the population is in Hardy-Weinberg equilibrium.
   (a) 19 %
   (b) 31%

(c) 66%
(d) 97%

5. An allele W, for white wool, is dominant over allele w, for black wool. In a sample of 900 sheep, 891 are white and 9 are black. Assuming that the population is in H-W equilibrium, what is the allelic frequency of the black wool?
   (a) 0.001
   (b) 0.01
   (c) 0.1
   (d) 1
6. In a population that is in Hardy-Weinberg equilibrium, 38 % of the individuals are recessive homozygotes for a certain trait. In a population of 14,500, what is the percentage of and heterozygous individuals?
   (a) 2132
   (b) 5510
   (c) 6859
   (d) 8432

5.17 Convergent and Divergent Evolution

Convergent evolution:- is a form of evolution that occurs in two groups of organisms exposed to similar selective pressures. Then, the two groups become alike. Because selection in these instances has tended to favor changes that made the two groups more alike, their phenotypes have converged.

When species interact with the environment in similar ways, they often are exposed to similar selective pressures, and they therefore frequently develop the same evolutionary adaptations. For instance, fast-moving marine predators such as dolphin, shark and tuna have developed similar streamlining shape to reduce friction.

Divergent Evolution (Adaptive Radiation)

Adaptive radiation is species formation from a common ancestor by occupation of different habitats and niches. Different habitats and niches demand different adaptations due to different selection, consequently a species diverge into different species.

One of the best examples of speciation by adaptive radiation is provided by the finches on the Galápagos Islands, which are often called Darwin's finches.

The Galápagos Islands, located 600 miles west of Ecuador, South America, are volcanic, but they do have forest regions at higher elevations. The 13 species of finches, placed in three genera, are believed to be descended from mainland finches that migrated to one of the islands. Therefore, Darwin's finches are examples of adaptive radiation, or the proliferation of a species by adaptation to different ways of life.

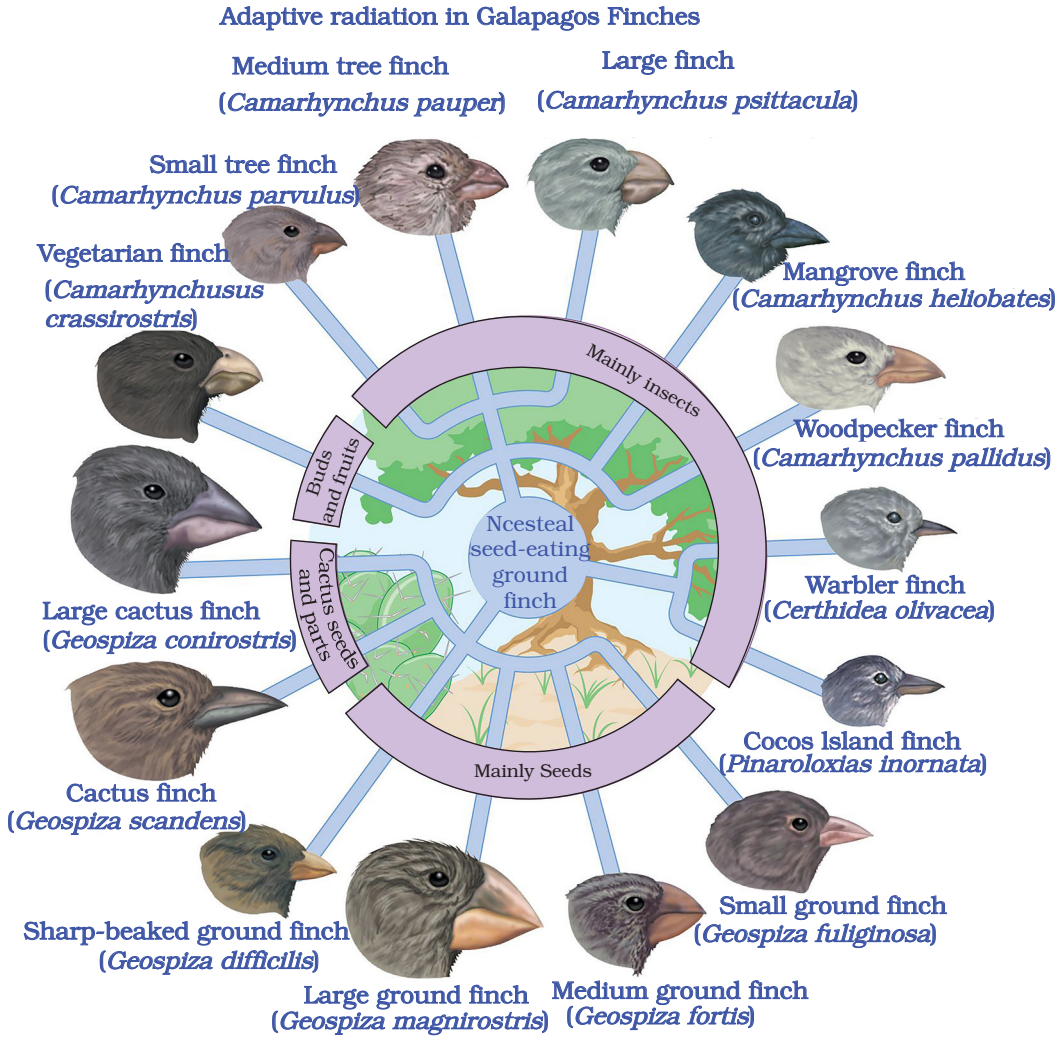


Figure 18. Adaptive radiation in Galapagos Finches

We can imagine that after the original population of a single island increased, some individuals dispersed to other islands. The islands are ecologically different enough to have promoted divergent feeding habits. This is apparent because, although the birds physically resemble each other in many respects, they have different beaks, each adapted to gathering and eating a different type of food Figure 18).

There are seed-eating ground finches, with beaks appropriate to cracking small, medium, or large-sized seeds; cactus-eating ground finches, with beaks appropriate for eating prickly-pear cacti; insect-eating tree finches, also with different-sized beaks; and a warbler-type tree finch, with a beak adapted to eating insects and gathering nectar. Among the tree finches, there is a woodpecker type, which lacks the long tongue of a true woodpecker but makes up for this by using a cactus spine or a twig to search out insects.

5.18 Evidence of Evolution

It is important to examine lines of evidence for Darwin's theory of evolution, to back the idea that living species are descendants of ancestral species that were different from present-day ones.

The Fossil Record

Since the early nineteenth century, biologists have learned about animals and plants that lived long ago by examining preserved traces of those organisms, or fossils.

A fossil can be:

- as large as and complete as an entire perfectly preserved animal or plant
- as small and incomplete as a tiny fragment of a jawbone print
- fossilized footprints, fossil eggs and animal droppings

Fossils have been formed in a variety of ways:

- in cold places when animals sometimes fell into crevasses in ice or become trapped in snow fields.
- insects and other small animals were occasionally trapped in the sticky tree sap that eventually hardened into amber.
- when animals became mired in peat bogs, certain kinds of quicksand, or tar pits.

In all these cases, the material that surrounded the dead animal helped to protect it from decay and acted to preserve it as evidence of past life.

The organic substances of a dead organism usually decay rapidly, but the hard parts of an animal that are rich in minerals, such as the bones and teeth of vertebrates and the shells of clams and snails, may remain as fossils. For example, the fossilized skull of one of our early relatives, *Homo erectus*, who lived some 1.5 million years ago in Africa.

Some fossils are not the actual remnants of organisms. Casts form when a dead organism captured in sediment decomposes and leaves an empty mold that is later filled by minerals dissolved in water. The minerals harden, making a replica of the organism.

Fossils may also be imprints that remain after the organism decays. Footprints, burrows, and fossilized feces (known as coprolites) provide evidence of an ancient organism's behavior.

In rare instances, an entire organism, including its soft parts, is encased in a medium that prevents bacteria and fungi from decomposing the body. Examples include insects trapped in amber (fossilized tree resin) and mammoths, bison, and even prehistoric humans frozen in ice or preserved in bogs.

Many fossils are found in fine-grained **sedimentary rocks** formed from the sand or mud that settles to the bottom of seas, lakes, swamps, and other aquatic habitats. New layers of sediment cover older ones and compress them into layers of rock called strata. The fossils in a particular stratum provide a glimpse of some of the organisms that lived in the area at the time the layer formed. Because younger strata are on top of older ones, the relative ages of fossils can be determined by the layer in which they are found. Thus, the sequence in which fossils appear within layers of sedimentary rocks is a historical record of life on Earth.

Fossils:- are imprints or remains of organisms that lived in the past strata. Strata are layers of rock formed from sedimentary material. The ages of the strata allow scientists to estimate when these species lived, and their characteristics indicate the environment that was found in the region during that time.

The fossils trapped in rock strata are the fossil record that tell us about the history of life. One of the most striking patterns in the fossil record is a succession of life-forms from the simple to the more complex.

Occasionally, this pattern is reversed, showing that evolution is not unidirectional.

Fossil records also serve as **transitional links between groups**. For instance, the Archaeopteryx fossils show that birds have reptilian features, including jaws with teeth and long, jointed tails. Archaeopteryx also had feathers and wings like birds. Archaeopteryx is a transitional link between reptiles and birds..

Of course, the fossil record—the chronicle of evolution over millions of years of geologic time engraved in the order in which fossils appear in rock strata is incomplete. Many of Earth's organisms did not live in areas that favor fossilization. Many fossils that did form were in rocks later distorted or destroyed by geologic processes. Furthermore, not all fossils that have been preserved are accessible to paleontologists. Even with its limitations, however, the fossil record is remarkably detailed.

Anatomical Homology

A second type of evidence for evolution comes from analyzing anatomical similarities among different organisms. Anatomical homology is similarity of structure or organs resulting from common ancestry.

Evolution is a process of descent with modification; characteristics present in an ancestral organism are altered over time by natural selection as its descendants face different environmental conditions. In other words, evolution is a remodeling process. As a result, ancestrally related species can have characteristics that have an underlying similarity yet function differently.

Darwin cited the anatomical similarities among vertebrate forelimbs as evidence of common ancestry. As Figure 19 shows, the same skeletal elements make up the forelimbs of humans, cats, whales, and bats. The functions of these forelimbs differ. A whale's flipper does not do the same job as a bat's wing, so if these structures had been uniquely engineered, then we would expect that their basic designs would be very different.

The logical explanation is that the arms, forelegs, flippers, and wings of these different mammals are variations on an anatomical structure of an ancestral organism that over millions of years has become adapted to different functions. Biologists call such anatomical similarities in different organisms, homologous structures, features that often have

different functions but are structurally similar because of common ancestry.

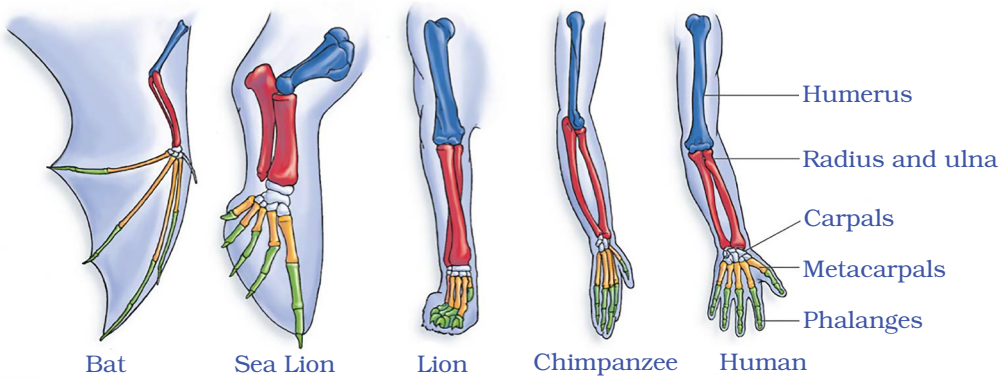


Figure 19. Limbs of vertebrates show homology

Homologous structures show the following features.

- similar embryonic origin and pattern of development,
- similar body plan
- similar or different functions depending on their adaptation.

The more two species have homologous structures the more they are ancestrally related. For instance, apes and humans have more homologous organs and they are more related ancestrally.

In contrast, analogous structures serve the same function but are not constructed similarly, and therefore could not have a common ancestry. The wings of birds and insects are analogous structures.

Embryo

The mechanism of comparing early stages of development in different animal species reveals similarities not visible in adult organisms. At some point in their development, all vertebrate embryos have a **tail** posterior to the anus, as well as structures called **pharyngeal** (throat) pouches. These pouches are homologous structures that ultimately develop to have very different functions, such as gills in fishes and parts of the ears and throat in humans. The most likely explanation for this observation is that new structures (or structures with unique functions) originate by "modifying" the preexisting structures of an organism's ancestors.

Molecular biology

Advances in molecular biology, the study of the molecular basis of genes and gene expression, present-day scientists have a much deeper understanding of homologies than Darwin did. Just as your hereditary background is recorded in the DNA you inherit from your parents, the evolutionary history of each species is documented in the DNA inherited from its ancestral species.

If two species have homologous genes with sequences that match closely, biologists conclude that these sequences must have been inherited from a relatively recent common ancestor. Conversely, the greater the number of sequence differences between species, the more distant is their last common ancestor.

Molecular comparisons between diverse organisms have allowed biologists to develop hypotheses about the evolutionary divergence of major branches on the tree of life.

Now molecular biologists know the sequence of DNA bases in the genomes of many organisms, it has become clear that humans share a large number of genes.

Darwin's boldest hypothesis was that **all life-forms are related**. Molecular biology provides strong evidence for this claim: All living organisms use the same basic biological molecules, including DNA (deoxyribonucleic acid), ATP (adenosine tri- phosphate), and many identical or nearly identical enzymes. Further, organisms utilize the same DNA triplet code and the same 20 amino acids in their proteins.

When the degree of similarity in DNA base sequences of genes or in amino acid sequences of proteins is examined, the data are as expected, assuming common descent.

Vestigial organs

Vestigial structures are anatomical features that are fully developed in one group of organisms but reduced and nonfunctional in other, similar groups.

Most birds, for example, have well-developed wings used for flight. However, some bird species (e.g., ostrich) have greatly reduced wings and do not fly. Similarly, whales and snakes have no use for hind limbs, yet extinct whales and snakes had remnants of hip bones and legs. Humans have a tailbone but no tail.

The presence of vestigial structures can be explained by the common descent hypothesis. Vestigial structures occur because organisms inherit their anatomy from their ancestors; they are traces of an organism's evolutionary history. Vestigial structures are remnants of features that served important functions in the organism's ancestors.

5.19 Theories of Evolution

Evolution is a theory, a collection of carefully reasoned and testable hypotheses about how evolutionary change occurs.

Evolutionary theory is the foundation on which the rest of biological science is built. Nothing in biology makes sense except in the light of evolution. Evolutionary theory is a foundation for much research in genetics, ecology and medicine.

1. Lamarck's theory

In 1809 the biologist Jean-Baptiste de Lamarck proposed the first formal theory of evolution that species are not static but change through time. However, the pattern component of Lamarck's theory was initially based on the scale of nature.

Lamarck hypothesized that evolution occurs and that adaptation to the environment is the cause of diversity. Therefore, after studying the succession of life-forms in strata, Lamarck concluded that more complex organisms are descended from less complex organisms. To explain the process of adaptation to the environment, Lamarck proposed the idea of inheritance of acquired characteristics in which the use or disuse of a structure can bring about inherited change.

Lamarck proposed that evolution occurred by the inheritance of acquired characteristics. That is, changes acquired during an individual's life are passed on to the offspring. For example, he proposed that ancestral giraffes tended to stretch their necks to feed on tree leaves, and this extension of the neck was passed on to subsequent generations, leading to the long- necked giraffe. The idea here is that as an individual develops, its phenotype changes in response to challenges posed by the environment, and it passes on these phenotypic changes to offspring.

If this were the case, then the knowledge you acquire over your lifetime would be passed on to your offspring. Similarly, all circumcized human males would have given birth to circumcized offspring.

2. Charles Darwin's theory

Darwin had spent decades exploring and documenting the diversity of plants and animals, both around the globe and in his native England. So he had a wealth of data on variation within and among species, and he viewed this variation in the context of the ancient and changing Earth as popularized by his geologist friend, Charles Lyell.

Darwin's radical thinking stemmed from his post college life, when he returned to his childhood interests. At the age of 22, Darwin set sail on HMS Beagle, a survey ship preparing for a long expedition to chart poorly known stretches of the South American coast.

During the five-year voyage of the Beagle, Darwin spent most of his time on shore collecting thousands of specimens of fossils and living plants and animals. He also kept detailed journals of his observations. For a naturalist (field biologist) from a small, temperate country, seeing the glorious diversity of unfamiliar life-forms on other continents was a revelation.

He carefully noted the characteristics of plants and animals that made them well suited to such diverse environments as the jungles of Brazil, the grasslands of Argentina, the towering peaks of the Andes, and the desolate and frigid lands at the southern tip of South America.

Many of Darwin's observations indicated that geographic proximity is a better predictor of relationships among organisms than similarity of environment. For example, the plants and animals living in temperate regions of South America more closely resembled species living in tropical regions of that continent than species living in temperate regions of Europe.

Darwin found the South American fossils, though clearly species different from living ones, were distinctly South American in their resemblance to the contemporary plants and animals of that continent. For instance, he collected fossilized armor plates resembling those of living armadillo species.

Darwin was particularly intrigued by the geographic distribution of organisms on the Galápagos Islands. The Galápagos are relatively young volcanic islands about 900 kilometers (540 miles) off the Pacific coast of South America. Most of the animals that inhabit these remote islands are found nowhere else in the world, but they resemble South American species.

For example, Darwin noticed that Galápagos marine iguanas, with a flattened tail that aids in swimming, are similar to, but distinct from, land-dwelling iguanas on the islands and on the South American mainland. Furthermore, each island had its own distinct variety of giant tortoise the strikingly unique inhabitant.

While on his voyage, Darwin was strongly influenced after reading the book of Scottish Geologist, Charles Lyell 'Principles of Geology'. Lyell demonstrated that the earth was very old it had changed slowly and gradually overtime. This was an important idea for Darwin to explain evolution and even to recognize that evolution had occurred. The long periods of time it would have taken for millions of species to have evolved from a common ancestor could be accounted for only if the earth was very old.

By the time Darwin returned to Great Britain, he had begun to seriously doubt that Earth and all its living organisms had been specially created only a few thousand years earlier. As he reflected on his observations, analyzed his collections, and discussed his work with colleagues, he concluded that the evidence was better explained by the hypothesis that present-day species are the descendants of ancient ancestors that they still resemble in some ways. Over time, differences gradually accumulated by a process that Darwin called "descent with modification," his phrase for evolution.

Darwin did not originate the concept of evolution, other scientists had explored the idea that organisms had changed over time. Unlike the others, however, Darwin also proposed a scientific mechanism for how life evolves. In the process he called natural selection, individuals with certain traits are more likely to survive and reproduce than are individuals who do not have those traits. He hypothesized that as the descendants of ancestral populations spread into various habitats over millions and millions of years, they accumulated diverse modifications, or adaptations, that fit them to specific ways of life in their environment.

By the early 1840s, Darwin had composed a long essay describing the major features of his theory of evolution by natural selection. Realizing that his ideas would cause uproar, however, he delayed publication. Even as he delayed, Darwin continued to compile evidence in support of his hypothesis.

In 1858, Alfred Russel Wallace, a British naturalist doing fieldwork in Indonesia, conceived a hypothesis almost identical to Darwin's. Faced with the possibility that Wallace's work would be published first, Darwin finally released his essay to the scientific community.

The following year, Darwin published "The Origin of Species", a book that supported his hypothesis with perfect logic and hundreds of pages of evidence drawn from observations and experiments in Biology, Geology, and Paleontology.

The hypothesis of Evolution set forth in "The Origin of Species" also generated predictions that have been tested and verified by more than 150 years of research. Consequently, scientists regard Darwin's concept of Evolution by means of natural selection as a theory, a widely accepted explanatory idea that is broader in scope than a hypothesis, generates new hypotheses, and is supported by a large body of evidence.

In contrast to Lamarck, Darwin's observations led him to conclude that species are suited to the environment through no will of their own but by natural selection. He saw the process of natural selection as the means by which different species come about.

Darwin's conclusions that organisms are related through common descent and that adaptation to various environments results in diversity were based on several types of data, including his study of Geology, Fossils, and Biogeography.

Darwin's greatest contribution to biology was his explanation of how life evolves. Because he thought that species formed gradually over long periods of time, he knew that he would not be able to study the evolution of new species by direct observation. But he did have a way to gain insight into the process of incremental change, the practices used by plant and animal breeders.

All of this careful work gave Darwin an especially strong foundation in the pattern of evolution. To make sense of the process of evolution, Darwin turned in part to pigeon breeding, a model system that would be easier to study and manipulate than populations in the wild. Pigeon breeding was popular in England at the time, and in Darwin's words, "The diversity of the breeds is something astonishing".

Darwin found inspiration in an essay written by economist Thomas Malthus, who contended that much of human suffering, disease, famine, and war, were the consequence of human populations increasing faster than food supplies and other resources. Malthus's studies of human populations in England and elsewhere led him to a startling conclusion: Since many more individuals are born than can survive, a "struggle for existence" occurs as people compete for food and places to live.

Darwin applied Malthus's idea to populations of plants and animals. He deduced that the production of more individuals than the limited resources can support leads to a struggle for existence, with only some offspring surviving in each generation. Of the many eggs laid, young born, and seeds spread, only a tiny fraction complete development and leave offspring. The rest are eaten, starved, diseased, unmated, or unable to reproduce for other reasons.

Darwin combined his observations of artificial selection with this notion of "struggle for existence" in natural populations, which he knew, from his countless studies, contained variation. From this synthesis arose his concept of natural selection.

The essence of natural selection is this unequal reproduction. Individuals whose traits better enable them to obtain food or escape predators or tolerate physical conditions will survive and reproduce more successfully, passing these adaptive traits to their offspring.

Darwin proposed natural selection as the mechanism of evolutionary change.

According to Darwin, natural selection requires the following steps:

1. The population produces more offspring than the resources of an environment can support. Thus, only some individuals in each generation survive long enough to produce offspring, and among the individuals that produce offspring, some will produce more than others.
2. The individuals of each species struggle to survive because of the presence of limiting factors (food, space, diseases, enemies and climate). In the struggle of nature, certain members are able to solve these limiting factors better than others.
3. The members of a population have heritable variations, meaning that they are passed on to offspring. Individuals every species vary in viability (ability to survive) and fertility (ability to reproduce).
4. The individuals that have favorable traits survive best and reproduce to a greater extent than those that lack these traits. Individuals with certain favorable traits are more likely to survive and reproduce. Since there is a constant struggle for existence and only certain members of a population survive and reproduce each generation.

5. Over time, the proportion of a favorable trait increases in the population, and the population becomes adapted to the environment.

Review Exercises

1. Which of the following is TRUE about convergent evolution? It is consequence of:-
   (a) Different adaptations
   (b) Similar environment
   (c) Diversification of species.
   (d) Similarity of different species.
2. Which of the following TRUE about divergent evolution? It is the formation of:-
   (a) Species from a common ancestor.
   (b) Different species due to similar adaptation.
   (c) Identical species due to a common ancestor.
   (d) Different species due to similar environment.
3. Which of the following molecules serve as evidences for evolutionary relationships of species?
   (a) Lipids and carbohydrates
   (b) Vitamins and minerals
   (c) Proteins and nucleic acids
   (d) Carbohydrates and proteins
4. Which of the following are homologous structures?
   (a) Wings of insects and birds
   (b) Legs of insects and birds
   (c) Exoskeleton of insects and mollusks
   (d) Fore and hind limbs of vertebrates
5. Which of the following is not a fossil?
   (a) The partial body of ancient remains of animals.
   (b) The whole body part remains of primitive plants
   (c) The body of an animal died a year ago
   (d) The prints of body parts in sedimentary rocks.
6. Both Lamarck and Darwin believe in:-
   (a) Natural selection
   (b) Heritable variation
   (c) Acquired characteristics
   (d) Change of living things

Key Terms

- Nucleic acids
- Nucleotide
- Nucleotide strand
- Purines
- Pyrimidines
- Messenger RNA
- Transfer RNA
- Ribosomal RNA
- Complementary strand
- DNA replication
- Template strand
- DNA polymerase
- Semi-conservative
- Transcription
- Anti-sense strand
- Sense strand
- Genetic codes
- Codons
- Anticodons
- RNA polymerase
- Translation
- Heredity
- Genetics
- Monohybrid
- Dihybrid
- F1
- F2
- Phenotype
- Genotype
- Dormant
- Recessive
- Homozygous
- Heterozygous
- Alleles

- Test cross
- Sex-linked traits
- Sex-influenced traits
- ABO blood grouping
- Rhesus factor
- Evolution
- Common Ancestor
- Descendant
- Natural selection
- Sex determination
- Continuous variation
- Discontinuous variation
- Crossing over
- Independent assortment
- Linkage
- Recombinant
- Mutation
- Genetic drift
- Random mating
- Migration
- Gene flow
- Stabilizing selection
- Directional selection
- Diversifying selection
- Speciation
- Hardy Weinberg principles
- Gene frequency
- Gene pool
- Convergent evolution
- Divergent evolution
- Fossils
- Homologous structures
- Analogous structures
- Acquired characteristics
- Fecundity

- Variation
- Struggle
- Differential adaptation

SUMMARY

- The two types of nucleic acids in living things are DNA and RNA.
- Nucleic acids are polymers of nucleotides.
- A nucleotide is composed of a 5Carbon sugar, a phosphate ion and one of the four nitrogenous bases.
- DNA is a nucleic acid composed of deoxyribose sugar ($C_5H_{10}O_4$), a phosphate ion and four nitrogenous bases, adenine, thymine, cytosine and guanine.
- DNA is a double helix molecule composed of two complementary nucleotide chains or strands.
- DNA is a molecule of heredity composing chromosomes that carry genes.
- RNA is a nucleic acid composed of ribose sugar($C_5H_{10}O_4$), a phosphate ion and four nitrogenous bases, adenine, uracil, cytosine, and guanine.
- RNA is single stranded molecule
- RNA is useful for protein synthesis in according with the instruction from DNA.
- There are three types of RNA, messenger RNA, transfer RNA and ribosomal RNA.
- Messenger RNA carry codons for protein synthesis
- Transfer RNA transfer amino acids to the area of ribosomes for protein synthesis
- Ribosomal RNA composes ribosomes for protein synthesis.
- DNA replicates or makes its own copy before cell division and reproduction
- DNA replication involves both of its complementary strands.
- DNA replicates in semi-conservative way by which each new DNA is composed of one old one new strand
- DNA replication is catalyzed by DNA polymerase for addition of nucleotides on 5'to 3' direction of the new strand.
- Transcription is the synthesis of RNA especially on DNA template strand.
- The template DNA strand used for transcription is known as antisense strand
- The bases on transcribed mRNA look-like the bases on non-template or sense strand; except thymine is replaced by uracil.
- Transcription involves RNA polymerase and transcription factor.

- Translation is the synthesis proteins on ribosomes
- Translation involves initiation, elongation and termination.
- Monohybrid experiment is the study of inheritance of a pair of opposite characteristics involving single trait.
- Alleles are versions of a gene.
- Dominant alleles are expressed in homozygous or heterozygous individuals
- Recessive alleles are hidden or masked in heterozygous individuals.
- Homozygous trait is trait with similar alleles.
- Heterozygous trait is trait with dissimilar alleles
- Phenotype is the external appearance of an organism
- Genotype is the internal or the genetic content of an organism.
- The principle of dominance states that one factor is expressed and the other masked in F1.
- The principle of segregation states that factors segregate during gamete formation.
- Dihybrid experiment is the study of inheritance of two pairs of opposite characteristics involving two traits.
- The principle of independent assortment states that the inheritance of one trait is not affected by the inheritance of the other trait.
- Sex linked traits are traits due to genes found in sex chromosomes and expressed in both males and females,
- Haemophilia and colour blindness in humans are sex-linked traits due to recessive genes on X sex chromosomes.
- Sex influenced trais are due to genes dominant in one sex and recessive in the other sex.
- Baldness gene is dominant in human males but recessive in human females.
- Heredity is transmission of characteristics form parents to offspring.
- Heredity can be influenced by environment especially traits like intelligence body weight and height.
- ABO blood group in humans are due to a gene with three alternative alleles (A,B and O) to of these combine to determine blood type of an individual.
- Blood type 'O' is universal donor whereas 'AB' universal recipient.
- Rhesus factor is due to Rhesus antigen. If Rhesus antigen is on RBC of , the blood is Rh positive if not Rh negative. Rh negative is universal donor but Rh positive universal recipient.
- Linkage is the existence of different genes on a chromosome. Such genes do not assort independently and thus the phenotypic and genotypic ratios of crosses deviate from Mendel's expected ratio.

- Linked genes separate and form recombinant gametes due to crossing over, during meiosis and consequently produce recombinant offspring during fertilization.
- Evolution is the process of change in living things over a long period of time.
- Natural selection is the driving force of evolution.
- Natural selection operates when there are heritable differential reproduction and adaptation.
- Sex (Maleness or femaleness) determination in humans and other animals is determined by specialized chromosomes called sex chromosomes.
- Sex chromosomes are heterozygous (XY) in human male but homozygous (XX) in human females.
- Continuous variations are variation with average values and extremes, such variations are highly influenced by environment,
- Discontinuous variation are variations without average values and are not influenced by environment, such genes act in additive manner.
- The sources of variation in sexually reproducing organisms are crossing over, independent assortment and random fusion of gametes that result heritable variations.
- Crossing over is exchange of genetic material between non-sister homologous chromosomes in a tetrad during meiosis, especially during prophase I.
- Independent assortment is the free inheritance of different traits on separate chromosomes
- Random fusion of gametes during fertilization.
- Variations can be caused by genetic factors such as mutations, gene reshuffling, crossing over and independent assortment,
- Variation can be acquired from environment and such variations are not heritable and said to be phenotypic variation.
- Phenotypic variation is the sum of environment and genes.
- Natural selection has consequences in selecting the best adapted and fitted individuals to survive and reproduce more,
- Hardy-Weinberg principle states that equilibrium of allele frequencies in a gene pool will remain in effect in each succeeding generation of a large sexually reproducing population as long as ve conditions (random mating, no mutations, genetic drift and gene flow) are met:
- There are three types of natural selection that lead to the process of evolution.

- Stabilizing selection favours individuals with mean or average phenotypes.
- Directional selection favours individuals with either of the two extremes
- Diversifying selection favours individuals with extreme values.
- Convergent evolution is the evolution of populations of different species become alike due to similar environment that demand similar adaptations,
- Divergent evolution is the development of different species from a common ancestror.
- Fossils or ancient remains of living things are evidences for evolution as they show similarities with the existing related species and different ages.
- Homologous organs are structures which show similarities due to common ancestors.
- Proteins and nucleic acid show similarities in related species.
- Lamarck's theory of evolution states the process of evolution requires the use and disuse of organs and acquired characteristics.
- Darwin's theory of evolution states evolution of living things has occurred by natural selection accompanied by fecundity, variations, struggle among individuals of species.

Review Exercises

1. Which of the following purine bases is common for RNA and DNA?
   (a) Uracil
   (b) Thymine
   (c) Cytosine
   (d) Guanine
2. In DNA molecule, there are:-
   (a) Four nucleotide chains
   (b) Two types of nucleotides
   (c) Two complementary strands
   (d) H bonds between purine bases
3. One of the following components of RNA and DNA are always similar in them.
   (a) Bases
   (b) Sugar
   (c) Phosphates
   (d) Nucleotides

4. If two hybrid purple flowered pea plants produced 300 pea plants, what would be the expected phenotypic ratio of their offspring peas?
   (a) 200 purple: 100 white
   (b) 150 purple: 150 white
   (c) 250 purple: 50 white
   (d) 225 purple:75 white
5. In Mendel's monohybrid experiment on garden peas, how many of the F2 generation expected to resemble their recessive grandparents?
   (a) 25%
   (b) 50%
   (c) 75%
   (d) 100%
6. If two pea plants with heterozygous tall smooth were crossed, how many of their offspring would be heterozygous for one of the features?
   (a) 2/16
   (b) 4 /16
   (c) 6/16
   (d) 8/16
7. If two pea plants RrYy and rryy were crossed, how many of their offspring would be RRYY?
   (a) 0
   (b) 1
   (c) 2
   (d) 4
8. In question '6' above, how many of them would be heterozygous for both features?
   (a) 4
   (b) 3
   (c) 2
   (d) 1
9. Which of the following CAN be the parents of 'AB' child?
   (a) AB xO
   (b) AA xBO
   (c) BB x O
   (d) A x A

10. Which of the following characteristics in humans is determined by more than two alleles in a population?
    (a) Ear lobe
    (b) Widow's peak
    (c) Baldness
    (d) Blood type
11. Which of the following is true about inheritance of Biological characteristics? They are:-
    (a) blended during inheritance
    (b) always dominant or recessive
    (c) lost during inheritance
    (d) inherited via chromosomes
12. According to Mendel's monohybrid experiments on garden peas which one showed the dominant character?
    (a) Short stem size
    (b) Wrinkled seed
    (c) Purple flowers
    (d) Constricted pods
13. Which one of the following trait is NOT sex linked?
    (a) Baldness
    (b) Hairs in ear
    (c) Haemophilia
    (d) color-blindeness
14. Which of the following traits in humans is NOT heritable?
    (a) Kinky hair
    (b) Wide nose
    (c) Thick lip
    (d) Tattoo
15. According to Lamarck ,the earliest ancestors of snakes were legged as opposed to the present, this is because, the descendant snakes:
    (a) Started to be poisonous
    (b) Stopped using legs for walk
    (c) Obtained more food for survival
    (d) Outcompeted the ancestral snakes

16. According to Charles Darwin , the earliest ancestors of giraffe were short naked contrary to the current, this is because, the descendant giraffe:
    (a) better adapted and survived to reproduced more.
    (b) developed long neck as they fed more long trees.
    (c) developed long neck as they tried to feed long trees.
    (d) defeated and killed their predators by their long legs.
17. Which of the following conditions is necessarily required for natural selection to occur?
    (a) Uniform viability
    (b) Uniform fertility
    (c) Uniform environment
    (d) Differential adaptation
18. On which of the following evolutionary ideas do Lamarck and Darwin fully agree?
    (a) Natural selection leads to evolution.
    (b) Acquired characteristics are inherited.
    (c) Life is the result of change and development.
    (d) Evolution occurs by the use and disuse of body parts.
19. Natural selection can be most closely equated with:
    (a) Gene flow
    (b) Genetic drift
    (c) Assortative mating
    (d) Differential reproductive success
20. Which of the following is NOT an observation or deduction on which natural selection is based?
    (a) Poorly adapted individuals never produce offspring.
    (b) Populations have the capacity to increase very quickly.
    (c) There is a struggle for limited resources and only a fraction of offspring survive.
    (d) Individuals whose characteristics fit best with the current environment are more likely to leave more offspring
21. Homologous structures have: dissimilar origin
    (a) And dissimilar functions
    (b) But dissimilar functions
    (c) And dissimilar structures
    (d) Similar origin and similar or dissimilar functions

22. If the DNA of the following animals is hybridized to a human DNA, with which one of the following would human DNA hybridizes more?
    (a) Fish
    (b) Chimp
    (c) Horse
    (d) Mouse
23. Which of the following process of evolution best explains the phenomenon known as industrial melanism?
    (a) Directional selection
    (b) Disruptive selection
    (c) Stabilizing selection
    (d) Adaptive selection
24. Evolution is principally a process of:
    (a) Sudden disruptive change
    (b) Modification and speciation
    (c) Inherited somatic modifications
    (d) Somatic mutation and genetic and genetic recombination
25. Closely related organisms with very different traits have experimented:
    (a) Coevolution
    (b) Divergent evolution
    (c) Parallel evolution
    (d) Convergent evolution
26. The theory of Evolution believes in that living things:-
    (a) Appeared on earth at the time on earth
    (b) Have undergone the same line of evolution
    (c) Are the direct descendants of their ancestors
    (d) Are branching descendants of their common ancestors
27. The struggle for existence refers to the:
    (a) Struggle for animals who cannot breathe
    (b) Hardships between parents of raising offspring
    (c) Hardships newborn offspring face due to predation
    (d) Members of each species compete regularly to obtain food and living space

28. Which of the following is NOT an element in the process of natural selection?
    (a) Individual struggle for survival.
    (b) Genetic variation exists within a species.
    (c) Organisms cause environmental change.
    (d) Fitting with the environment leads to population increase.
29. From which of the following sources did Charles Darwin get the idea that selection can change living organisms? From the:
    (a) Book of Malthus
    (b) Evolution theory of Lamarck
    (c) Work of plant animal breeders
    (d) His observation of the Galapagos birds
30. In a population that is in Hardy-Weinberg equilibrium, the frequency of the recessive homozygote genotype of a certain trait is 0.09. What is the percentage of individuals homozygous for the dominant allele?
    (a) 9%
    (b) 29%
    (c) 39%
    (d) 49%

B11CH06

CHAPTER 6

VERTEBRATES (FISHES, AMPHIBIANS AND REPTILES)

Chapter Contents

Chapter Outcomes

Upon completion of chapter, learners will be able to:

- explain the general characteristics of the phylum Chordata (Vertebrates);
- describe the differences between vertebrates and invertebrates;
- list the general characteristics of the fish and explain the differences among the three groups (jawless, cartilaginous and bony);
- discuss the economic importance of fishes;
- list the general characteristics of amphibians;
- describe the external & internal features of the amphibians using a frog;
- differentiate the structural differences between frog and toad;
- list the general characteristics of reptiles;
- describe the external and internal features of reptiles using a lizard;
- explain the success of reptiles on land as opposed to amphibians.

Introduction

This chapter deals with vertebrate animals or animals with backbones included under the phylum chordate of the animal kingdom. The lesson begins on the general characteristics of chordates with a particular emphasis on sub-phylum vertebrata. However, the chapter treats only the fishes, amphibians and reptiles, regarding the general characteristics, types, external and internal features and life cycle of each.

Phylum Chordata

All chordates have the following general characteristics.

- All are coelomate animals with bilateral symmetry.
- All have a three well-developed germ layers.
- All have a tube-within – a – tube body plan.
- They have a Pharyngeal gill that are paired.
- Most chordates have a post-anal tail, an appendage that projects posterior to the anus.
- Heart is ventral in position.
- Presence of notochord.
- Dorsal hollow nerve cord is present.

Most have a closed circulatory system in which blood flows forward ventrally and backward dorsally.

The above characteristics, however, do not distinguish the chordates from other groups of animals, because the characteristics are also found in other groups of animals.

Hence, it is the following three characteristics that are unique to the chordates and so distinguish them from other groups.

Pharyngeal pouches

(i) All chordates have a notochord during sometime in their life cycle. The notochord is a dorsal longitudinal rod that is firm, yet flexible, and supports the body (See Figure).

(ii) All chordates have a dorsal tubular nerve cord. The nerve cord differs from that of invertebrates not only in position but in being single and hollow rather than double and solid.

All chordates have **pharyngeal gill slits** during sometime in their life cycle.

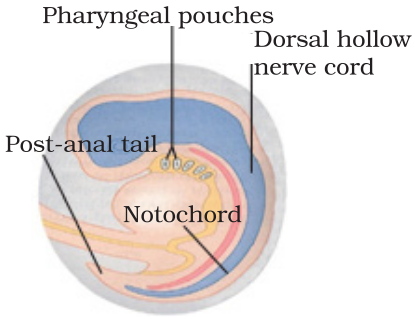


Figure 1. A generalized chordate illustrating important chordate characteristics

Phylum chordata is divided into three subphyla. These are:

(i) ***Sub-Phylum Urochordata*** includes marine animals called tunicates.

(ii) ***Sub-Phylum Cephalochordata*** includes marine animals called lancelets.

(iii) ***Sub-Phylum*** includes animals with backbones.

6.1 Vertebrates

From these subphyla tunicates (urochrdates) and lancelets (cephalo-chordates) are the simplest and the most primitives forms of chordates. The vertebrates, however, are the most advanced and the higher chordates.

One of the divisions of the chordates is the vertebrates. The vertebrates are distinguished from other chordates in having.

- a backbone, or **vertebral column**, that replaces the notochord, the **vertebrae**, these are cartilaginous or bony segments on the vertebral column.
- the **cranium**, or a braincase found anterior to the vertebral column. The cranium enclosed and protects the brain, the enlarged anterior end of the nerve cord.
- a true brain or **cephalization**, i.e. concentration of nerve cells and sense organs in a defined head.

All vertebrates, however, share certain their characteristics with other groups. These characteristics are not necessarily exclusive (unique) to the vertebrates. Hence, the characteristics do not distinguish the vertebrates from other chordates. Among these characteristics some are the following:

- a closed circulatory system with a two, three or four chambered ventral heart.
- paired – kidneys.
- a complete digestive tract and large digestive glands (liver and pancreas).
- muscles attached to the skeleton for movement.
- well-developed organs of special sense (eyes; ears; organs of smell and taste . . .)
- two pairs of appendages; and separate sexes.

A. General characteristics of fishes

- possess vertebral or spinal column and endoskeleton.
- live in freshwater or marine by swimming.
- reproduce by laying eggs that are fertilized by sperm cells outside their body i.e. **external fertilization.**
- **streamlined** body shape covered with **scales.**
- own **fins** in aiding movement.
- breathe by means of **gills.**
- cold –blooded more accurately, **poikilothermic** having body temperature varies with the temperature of the external environment.
- possess nostrils used for detection of food but not for breathing
- equipped with internal ears not visible externally
- **swim bladder** for buoyancy.
- possess eyes for vision.
- have mouth to take in food and also for breathing.
- equipped with lateral **line** or tube with fluid just below skin to detect movement in water.

(i) Jawless fishes

- Do not have Back bone or spinal column.
- They have a round suctorial mouth and rasping tongue,

Figure 2. Lamprey

with which they bore through the skin of its host and sucks its blood and soft tissues. Hence, they are the only parasitic vertebrates.

- They have no paired fins and no scales.
- They possess numerous gills, example Lamprey (See figure 2).

(ii) Cartilaginous fishes

- These are fishes with cartilaginous skeleton.
- All have paired jaws and paired lateral fins.
- Their skin contains placoid scales composed of outer layer and an inner dentine layer (Figure 3).

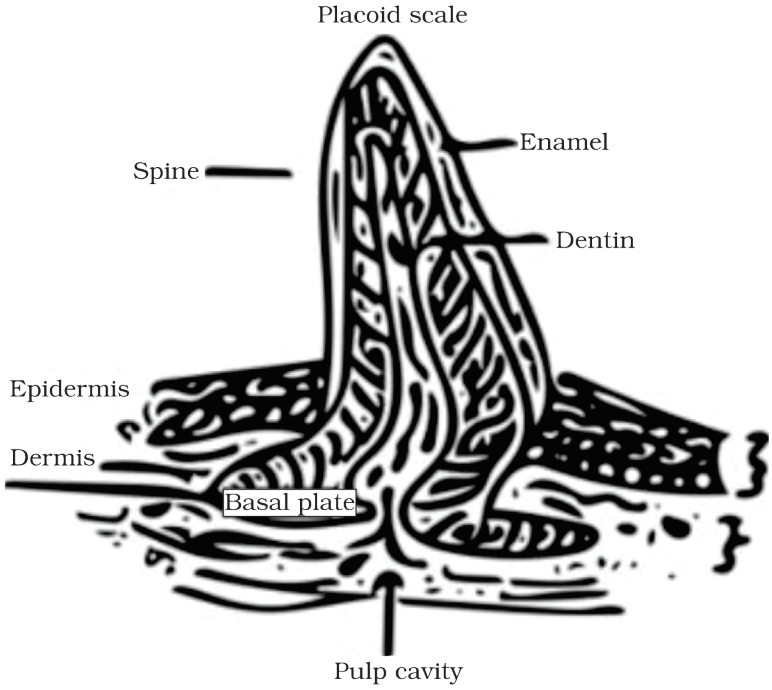


Figure 3. Structure of a placoid scale

- Cartilaginous fishes tend to sink unless they are actively swimming because their bodies are denser than water and they don't have swim bladder.
- Their sexes are separate, and fertilization is internal. Members of this class could be:
  - Oviparous – this means, they lay eggs.
  - Ovoviviparous – the young are born alive after hatching from the eggs incubated within the uterus.

- Viviparous – The embryos develop within the uterus and receive their nourishment from their mother's blood. The offspring are born as juveniles.

- Their respiration is through gills. Examples – sharks, rays and skates (Figure 4).

Figure 4.Chondrichthyes (a) Shark (b) Sting ray (c) torpedo

(iii) Bony fishes

These are modern **bony fishes** with bony endoskeleton.

They have paired jaws and paired lateral fins

Their skin is covered with scales.

They have swim bladders, hydrostatic organs that may also store oxygen (Figure 5). By secreting gases into the bladder or absorbing gases from it, the fish can change the density of the body and so hover at a given depth of water without sinking.

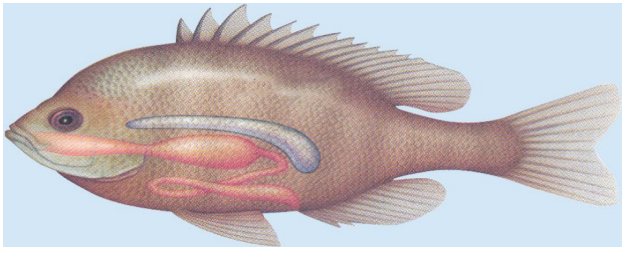


Figure 5. A generalized bony fish showing the swim bladder.

- Unlike the sharks bony fishes generally fertilize their eggs externally and they are oviparous. Examples – Lung fish, eels, perch, tilapia, etc. (See Figure. 6)

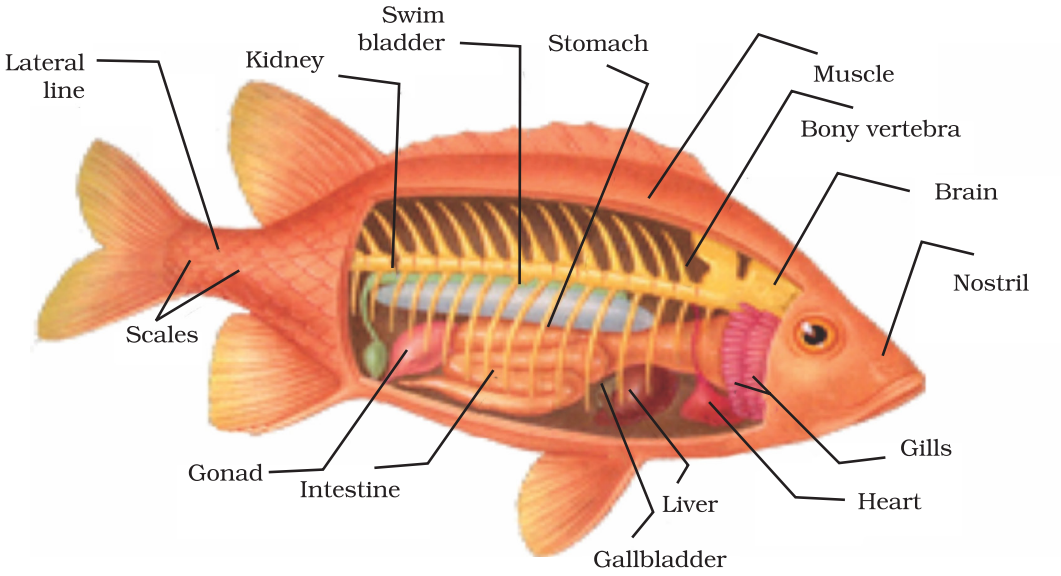


Figure 6. Internal anatomy of a generalized bony fish.

Activity 1 — Laboratory

Identifying and describing the external and internal structures of a fish.

You need

- Sharp dissecting Scissors
- Dissecting board
- A pair of gloves
- A pair of forceps
- Freshly killed bony Fish

Method

Look at the fish provided by your biology teacher. Identify and draw the external features of the fish and label them clearly

Using your scissors carefully cut a hole from the anal side of the lower the body part to the operculum.

Open the abdomen more fully. Find the gonad, intestine, liver, heart and as many other organs from figure 6 as you can.

Draw and label what you can see once you opened the abdomen up fully.

Review Exercises

1. What are the distinguishing features of vertebrate animals?
   (a) Presence of notochord
   (b) Presence of nerve cord
   (c) Presence of spinal column
   (d) All of the above
2. Which of the following features is unique to fishes?
   (a) Internal fertilization
   (b) Presence of endoskeleton
   (c) Egg laying for reproduction
   (d) Presence of gills for breathing
3. What makes jawless fishes different from cartilaginous fishes?
   (a) Two-chambered heart
   (b) Parasitic mode of life
   (c) Presence of notochord
   (d) Variable body temperature
4. What are the unique features of bony fishes?
   (a) Presence of scales
   (b) External fertilization
   (c) Presence of swim bladder
   (d) Presence of uneven-sized tail.

Differences amongst the three group of fishes table.

Table 1 Some of the major differences amongst the three group of fishes

Feature	Jawless	Cartilaginous	Bony
Jaws	Absent	Present	Present
Scales	Absent	Not rounded	Rounded
Skeleton	No bones	Cartilaginous	Bony
Fertilization	External	Internal	External
Swim bladder	Absent	Absent	Present
Feeding habit	Parasitic	Predation/scavenging	Omnivorous
Tail	pointed	Uneven-sized	Even-sized

B. Adaptation, locomotion, respiration and economic importance

Adaptation of fish to life in water

Fish are adapted to live in water, though water is a dense medium. The density of water helps fish to buoyant up but also slows down movement. Fish are streamlined, so reduce the drug on their body and move fast. Besides, the swim bladder is considered an adaptation in saving energy by avoiding the need to keep swimming in order to stay at the same depth. Moreover, the position and shape of fins are well adapted to steering the fish in water.

Fish show many other physiological adaptations to living in water. For instance, the freshwater fishes tend to gain water due to the hypotonic environment but they eliminate the excess water or achieve osmoregulation by their kidneys. On the contrary the marine fish tend to lose water due to the hypertonic environment but they conserve water by swallowing and in some way absorb it through their elementary canal.

Fish also possess powerful eye lenses which need to refract light more strongly than in land animals, the lateral line system which is adapted to detecting vibrations in water.

Locomotion

It must be emphasized that the swimming movements of fish are produced by the whole of the muscular body. The muscles on each side of the spine contract in a series from head to tail and down each side alternately, causing a wave-like movement to pass down the body. The greater weight and limited flexibility of the head leads to a far greater movement at the tail as a result of these waves of contraction.

The sideways and backwards thrust of the tail and body against the water results in the resistance of the water pushing the fish sideways and forwards in a direction opposite to trust. When the corresponding sets of muscles on the other side contracts, the fish experiences a similar force from the water on that direction. The two sideways forces are equal and opposite, unless the fish is making a turn, so they cancel out, leaving the sum of the two forward forces. The tail, in its final lash, may contribute as much as 40 percent of the forward trust.

The main function of the fins is to control the stability and direction of the fish. So, the median fins, that is, the dorsal, anal and ventral fins, control the rolling and yawing movements of the fish by increasing the ventral surface area presented to the water.

The paired fins, pectoral and pelvic girdle, act as hydroplane and control the pitch of the fish, causing it to swim downwards or upwards according to the angle to the water at which they are held by the muscles. The pectoral fins lie in front of the centre of gravity and, being readily mobile are chiefly responsible for sending the fish up or down. The paired fins are also the means by which the fish slow down the stops.

The swim bladder makes fish buoyant so that they do not sink when they stop swimming. When the fish swims to a different depth the pressure needs to be regulated. Some lung fishes which live in poorly oxygenated water in swamps use their swim bladder for breathing air.

Respiration

Gills absorb oxygen dissolved in the water. The movements of the mouth and operculum are coordinated to produce a stream of water, in through the mouth, over the gills and out of the operculum.

There are usually four gills on each side consisting of a curved bony gill bar bearing many filaments. Through the gill-bar run blood vessels which send branches into the gill filaments. The filaments bear smaller filaments down their length which, in turn, divide into smaller branches. So great a number of minute branches provides a very large surface area when the gills are immersed in water. The wall of the gill filaments are very thin, enabling the oxygen to diffuse rapidly into the blood.

The mechanism for pumping water over the gills varies in detail with the type of fish, but in general the pressure in the mouth cavity is reduced by the floor of the mouth being lowered so that water enters through the mouth. The free edge of the operculum is pressed against the body wall by the higher pressure outside, so preventing the entry of water by this route. Next, the volume of the mouth cavity is decreased by raising the floor of the mouth. The escape of water from the mouth is prevented by the closure of in turned folds of skin along the upper and lower jaws.

The pressure thus forces water between the gill filaments, assisted by an outward movement of the operculum which 'sucks' the water from the front to the back of the mouth cavity and over the gills. Finally, as the mouth and operculum close,the fold of skin along the free edge

of the operculum is forced outwards and water escapes between the operculum and body wall.

Economic importance

The bony fishes perch, cod, lungfish, carp, sardines, trout are sources of protein for humans. They are also attractive in their shapes and colours. So people keep some fishes such as gold-fish in aquaria as ornament.

Review Exercises

1. What are the adaptations of fishes to live in water?
   (a) Streamlined shape
   (b) Lateral line system
   (c) Gill filaments
   (d) All of the above
2. What are the main causes for swimming movement of fishes?
   (a) Muscles of their body
   (b) The waving of their fins
   (c) The lateral line
   (d) The swim bladder
3. Which of the following structures play no role in fish respiration?
   (a) Gill
   (b) Lung
   (c) Mouth
   (d) Operculum
4. Which of the following fishes are not good source of protein for humans?
   (a) Carp
   (b) Perch
   (c) Skate
   (d) Tilapia

6.2 Amphibians

General characteristics

- These are partly aquatic and party terrestrial.
- Their thin smooth skin is supplied with numerous blood vessels which permitintake of oxygen to supplement the rather small amount obtained by the lungs.

- Their skin has no scales.
- The adult forms use their lungs for gas exchange and the larval forms use their gills.
- Their heart is three chambered.
- Fertilization is external. The aquatic larvae which is known as tadpole undergoes metamorphosis into terrestrial adult.
- Their body has distinct head and trunk but no neck (Figure 7). Examples Frogs, toads, salamander.

Figure 7. (a) – Toad: and (b)– Frog

A. External and internal features of a frog

External features of frog's body

Skin: loose-fitting smooth and slimy skin with mucous glands. Used for breathing.

Head: bears a wide mouth, a pair of nostrils and protruding eyes.

Ear drum: for sensation of sound waves.

Limbs: hind limbs are webbed and longer than fore limbs for swimming and leap,

Cloaca: an opening at the posterior end to discharge urine, faces and gametes.

Internal features of a frog

Fat bodies are spaghetti shaped structures that have a bright orange or yellow color, look like coral reefs located in the digestive system and function in providing energy during hibernation.

Liver is brown colored organ found behind the heart. It functions to reduce bile and enzymes also breaks down toxic waste.

Esophagus is found behind the glottis. It functions in carrying food from the mouth to the stomach.

Stomach is found below the liver, under the duodenum, curving from underneath the liver. Functions to store food and partially digested here before it enters the small intestine

Rugae found in the digestive system. It allows the stomach and other tissue to expand as needed to assist in the digestion of food.

Small intestine is found next to the stomach, on top of the large intestine the lower part of the digestive system, connecting the stomach to the cloaca. It functions in completing digestion, absorbs nutrients, lined with villi that absorbs nutrients from food.

Duodenum is found on the top of the stomach. It functions as first section of the small intestine

Gall bladder is a green sac under the liver, looks like a green pea found in the digestive system. It functions to hold bile that is produced by the liver for fats.

Bile duct is a tube that goes from the gall bladder to the duodenum in the digestive system. It functions in carrying bile from the gall bladder and digestive juice from the pancreas into the duodenum.

Pancreas is right under the liver near the stomach and functions in making enzymes which help to break down carbohydrates and make insulin.

Mesentery is supportive membrane surrounding the internal organs and attaching to the body wall. it functions in holding small intestine together, it is there so the intestine won't move around in the abdominal cavity

Large intestine is found below the small intestine. It functions to reabsorbs water, prepares waste for elimination

Cloaca is an opening in the back of the frog and functions to allow passage of sperm and eggs and waste products.

Glottis is found in the respiratory system and located past the tongue, before the esophagus. It functions to pass air to the lungs.

Larynx is found in the throat. It functions as voice box, produces croaking sound for mating

Trachea is located behind the esophagus, on top of the branch/ lungs. Functions as part of the windpipe providing a passage way for inhaled air from the mouth and nostrils to the lungs

Bronchi is located below the trachea, in the middle of the lungs and functions to allow air to pass the trachea to the lungs

Lungs are located below the esophagus and function as organs responsible for obtaining oxygen from the air and expelling carbon dioxide

Pericardium is a membrane structure that around the heart and protects the heart

Heart is located below the esophagus and functions in pumping blood to the entire body.

The frog has 3 heart chambers: two atria and a single ventricle. The atrium receives deoxygenated blood from the blood vessels (veins) that drain the various organs of the body. The left atrium receives oxygenated blood from the lungs and skin (which also serves as a gas exchange organ in most amphibians) in the circulatory system.

The right atrium is located on the left side of the heart. and functions to receive deoxygenated blood from the sinus venosus in the circulatory system.

The left atrium is located on the right side of the heart and functions to receive oxygenated blood form the lungs in the circulatory system.

The ventricle is located above the liver and functions in pumping blood out of the heart, to the lungs and other parts of the body in the circulatory system.

Conus arteriosus is located on the right side of the liver and functions as the main artery through which blood exits the heart in the circulatory system.

Sinus venosusis is found on top of the heart and functions the chamber where the blood is stored before entering the right atrium,

Spleen is located under the pancreas and. functions in purifying blood by removing bacteria in the excretory system.

Kidneys are located lie attached to the inside of the back aka deep in the abdomen and wrapped in a thin membrane. They function to filter blood and send urine to the cloaca, removes waste from the blood in the excretory system.

Ureters are located tube off of the bottom of the kidney and attached to the rectum. They function to carry urine from the kidneys to the bladder, tube that drains the kidneys in the excretory system.

Urinary bladder bag like, has an opening in the rectum and on top of the cloaca. It functions to: store urine until elimination, and gets rid of urine.

Cloacal opening is located on the bottom of the organism where the anus should be. It functions as an organ that removes unused sex cells and waste.

Adrenal glands are found attached to the testicle and function as sources of the hormone epinephrine.

Testes are found attached to the kidneys and function as male sex gland that produce sperm.

Seminal Vesicles are enlarged distal sections of the male frog's urinary ducts and functions to collect sperm prior to entry into the cloaca.

Ovaries are found near the oviduct and function in producing eggs.

Oviducts are tubes located on the outer areas function in eggs travel through these, they carry eggs through the cloaca.

Ostium is funnel shaped opening near the cloaca, against the back go the body wall at the anterior end of each tubular oviduct and function where the eggs are collected.

Ovisac is a widened portion of the oviduct and function where the eggs are stored.

Brain is found in the head region and controls all of the nervous system.

Olfactory bulb is located: at the way top, on top of the cerebrum and functions as aka the olfactory lobe, used for the sense of smell.

Cerebrum is located above the optic lobe. It functions to integrate behavior and responsible for learning.

Optic lobes are found above the cerebellum and function in helping with vision

Cerebellum is located above the medulla and function as a center of muscle coordination

Medulla is located under the cerebellum and it is responsible for involuntary activities. (Breathing and heart rate etc.)

Spinal cord is located in between the medulla oblongata and function in conducting signals from the body to the brain and vice versa.

Vertebral column is found around the spinal cord and. functions in protecting the spinal cord.

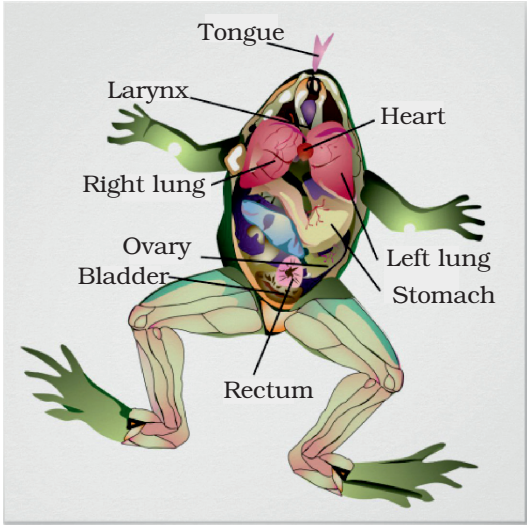


Figure 8. Internal structures of a frog

B. Life cycle

Adult frogs return to water to reproduce, laying their eggs directly in water. Eggs are **fertilized externally** and hatch into swimming larvae forms called **tadpoles**. Tadpoles live in the water, where they feed on minute algae. After considerable growth, their body abruptly changes into that of adult frog. Tail, gills, and lateral line system disappear, and legs grow from the body. The mouth broadens, developing teeth and jaws. A sac-like bladder in the throat divides into sacs that become lungs, the pulmonary vein appears, and the heart develops its internal wall. This process of unexpected change in body form is called **metamorphosis.**

Activity 2 — Laboratory

Collecting and dissecting a frog to study the external and internal structures.

You need

- A live or freshly killed frog
- A pair of forceps
- A pair of gloves

Method

Look at the frog provided by your biology teacher. Identify and draw the external features of the frog and label them clearly.

Using your scissors carefully cut a hole from the anal side of the lower the body part to the trunk.

Open the abdomen more fully. Find the lungs, heart and as many other organs as you can.

Draw and label what you can see once you opened the abdomen up fully

Review Exercises

1. Which of the following features does NOT distinguishes amphibians from fishes?
   (a) Four-chambered heart
   (b) Presence of metamorphosis
   (c) Lungs for breathing on land
   (d) Moistened dry skin for breathing
2. Similar to adult frogs, tadpoles have :-
   (a) Tails
   (b) Mouth parts
   (c) Lateral line system
   (d) Gills for breathing
3. Which of the following animals are not amphibians?
   (a) Frogs
   (b) Toads
   (c) Salamanders
   (d) Chameleons

4. What makes the amphibians survive on land? The presence of:-
   (a) Eyes
   (b) Teeth
   (c) Lungs
   (d) Heart

6.3 Reptiles

A. General characteristics

- These are true terrestrial animals and need not returnto water to reproduce. The female's oviduct secretes aprotective leathery **shell** around the **egg**, which helps to prevent the developing embryo from drying out. Since sperm cannot penetrate this shell fertilization must occur within the body of the female **(internal)** before the shell is added.
- Their body is covered with **hard, dry,** horny **scales** which prevent the animal from desiccation and predators. This dry, scaly skin cannot serve as an organ for gas exchange. Hence, they use their lungs to exchange gases.
- Most have three-chambered heart, but crocodiles have four chambers.
- Their body is divided into head, neck, trunk and tail.
- They are cold-blooded or poikilothermic; have limbs with 5 clawed digits. Example Crocodiles, alligators, turtles, lizards (see figure 9).

Figure 9. A lizard

B. External and internal features of a lizard

External features of a lizard

Dry skin: with scales enables them to survive in dry environment.
Nostril: sense smell
Ear drum: conducts sound wave for hearing
Limbs: with five digits and claws
Tail: wriggles during their motion
Cloaca: to discharge gametes and waste

Internal structures

Tongue: with sticky tip to catch their insect meal.
Teeth: inserted in jaws to seize and capture prey
Kidney: to make and remove urine
Lung: for breathing
Ovaries: for production of shelled egg after fertilization

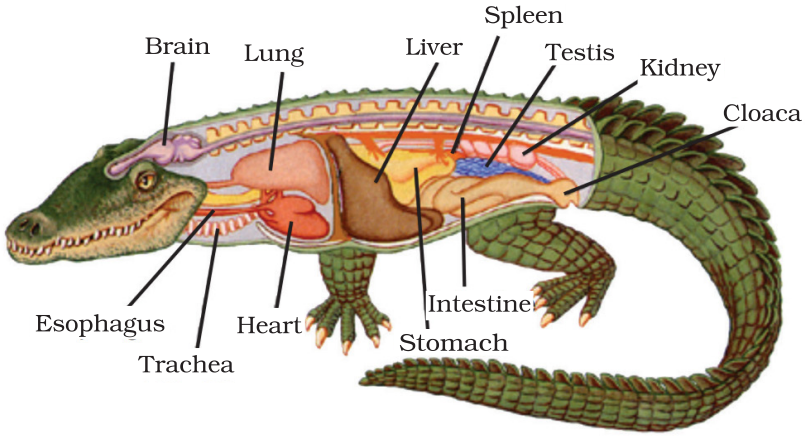


Figure 10. Internal structures of a lizard

C. Internal fertilization and the amniotic egg

The eggs of reptiles are fertilized internally before they are deposited. The male reptiles utilize a tubular organ, the penis, to inject sperm into the female. Most reptiles are oviparous, laying eggs and then abandoning them. These eggs are surrounded by a leathery shell that is deposited as the egg passes through the oviduct. Other species of reptiles are

ovoviviparous or viviparous, forming eggs that develop into embryos within the body of the mother.

The shelled eggs of reptiles and birds constitute one of the most important adaptations of these vertebrates to life on land, since shelled eggs can be laid in dry places. Such eggs are known as **amniotic eggs** because the embryo develops within a fluid-filled cavity surrounded by a membrane called the **amnion**. The amnion is an **extraembryonic membrane**, that is, a membrane formed from embryonic cells but located outside the body of the embryo. Other extraembryonic membranes in amniotic eggs include the **chorion**, which lines the inside of the egg shell, the **yolk sac**, and the **allantois (see** figure 11**)**. In contrast, the eggs of fish and amphibians contain only one embryonic membrane, the yolk sac.

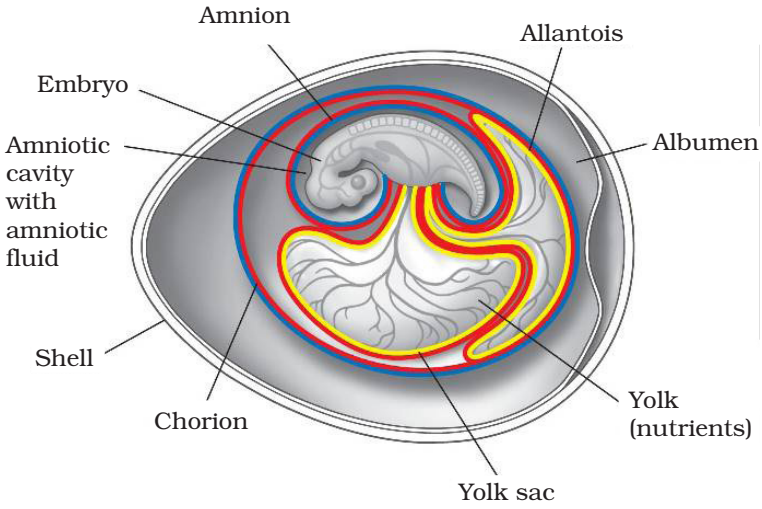


Figure 11. Extraembryonic membrane in reptiles

Activity 3

Drawing and labeling the amniotic egg and highlighting the exraembryonic membrane

Form groups with 4-5 students draw and label the amniotic egg and highlight the extraembryonic membrane to the class.

Review Exercises

1. What features distinguish reptiles from amphibians? Presence of:-
   (a) Lungs
   (b) Internal fertilization

(c) Four chambered heart
(d) Internal development of embryo.

2. Which of the following is TRUE about extraembryonic membrane?
   (a) Protected by leathery shell.
   (b) The feature of reptiles only.
   (c) Shows requirement of water for fertilization.
   (d) Grants external embryonic development.
3. Which of the following reptiles has four chambered heart?
   (a) Snake
   (b) Lizard
   (c) Crocodile
   (d) Tortoise
4. Which of the following structure is absent in reptiles?
   (a) Eyes
   (b) Tongue
   (c) Clawed limbs
   (d) External ear

Key Terms

- Chordates
- Vertebrates
- Vertebral column
- Notochord
- Nerve cord
- Pharyngeal gill slits
- Scales
- Gills
- Operculum
- Streamline
- Swim bladder
- Later lines
- Fins
- Oviparous
- Viviparous
- Ovoviviparous
- Tadpole

- Metamorphosis
- Amniotic egg

SUMMARY

- Vertebrates are animals with vertebra or spinal column
- Vertebrate includes fishes, amphibians, reptiles, birds and mammals.
- Fish are aquatic vertebrate animals adapted to live in water by having gills and streamlined-shape for their fast swimming movement.
- Fish move in water by their muscles and assisted by fins for stability and changing direction.
- They have swim bladder for buoyancy and lateral line to detect movement in water.
- Fish possess two –chambered heart and are poikilothermic.
- Fish reproduce by laying eggs
- Fish can be grouped into jawless, cartilaginous and bony fishes.
- Amphibians are vertebrate animals that partially live in water and partially on land.
- They have moistened skin serving as respiratory organ though they have lungs.
- They are with three-chambered heart and are poikilothermic
- The reproduce by laying eggs in water, fertilized outside their body and hatch into tadpoles.
- Tadpoles undergo series of changes or metamorphosis to develop into young frogs.
- They are four-limbed; the hind limbs are longer than the forelimbs for leaping.
- Reptiles are vertebrate animals with dry skin to survive on land.
- They are mostly with four chambered heart and poikilothermic.
- They reproduce by laying shelled eggs with amniotic fluid and thus show internal fertilization.
- They breathe by the help of their lungs.

Review Exercises

1. Which of the following pairs of animals do NOT belong to the phylum chordata?
   (a) Frogs and toad
   (b) Shark and perch
   (c) Lizard and turtle
   (d) Lobster and crayfish

2. Which of the following pairs of animals do NOT belong to the division vertebrates?
   (a) Crocodile and whale
   (b) Tortoise and lamprey
   (c) Starfish and jellyfish
   (d) Snake and salamander
3. Which of the following is a **FALSE** comparison between bony fish and cartilaginous fish?

Choice	Bony fish	Cartilaginous fish
A	With bony skeleton	With cartilaginous skeleton
B	have round-shaped scales	Have non-round-shaped scales
C	Have uneven shaped tails	Have even-shaped tails
D	Smaller size	Larger in size

4. Which of the following is a **INCORRECT** comparison between a frog and a toad?

Choice	Frog	Toad
A	With smooth skin	With rough skin
B	Has dry skin	Has moist skin
C	Has more webbed-feet	Has less webbed -feet
D	Brightly coloured	Dull coloured

5. Amphibians differ from reptiles in that they have:
   (a) dry skin with scale.
   (b) lungs for breathing.
   (c) four limbs for movement.
   (d) moistened skin for breathing.
6. As opposed to amphibians, fish:
   (a) have dry skin with scale.
   (b) possess gills for breathing.
   (c) show internal fertilization.
   (d) exhibit variable body temperature.
7. Unlike fish and amphibians, reptiles:
   (a) lay shelled eggs.
   (b) have vertebral column.
   (c) are equipped with swim bladder.
   (d) show variable body temperature.

8. Which of the following structure in fish is used to sense movements in water?
   (a) Ear
   (b) Tongue
   (c) Lateral line
   (d) Swim bladder
9. Which of the following is not part of a shelled egg?
   (a) Chorion
   (b) Amnion
   (c) Amniotic fluid
   (d) Umbilical cord
10. Which of the following is not lost during metamorphosis of a tadpole?
   (a) Eye
   (b) Gill
   (c) Mouth
   (d) Tail

Health Related Caution

What are the ways to avoid dengue and malaria fever?

- Time your outings.
- Reduce mosquito habitat.
- Sleep under mosquito-net.
- Put screens on windows and doors.
- Keep your house airy and well-lit.
- Do not let water stagnate anywhere.
- Wear long pants and long sleeves to cover your body.
- Apply mosquito repellent with DEET (diethyltoluamide) to exposed skin.
- Treat clothing, mosquito nets, tents, sleeping bags and other fabrics with an insect repellent called permethrin.

How can a person reduce the risk of getting HIV?

- Get tested for HIV.
- Do not inject drugs.
- Choose less risky sexual behaviors.
- Use condoms every time you have sex.
- Limit your number of sexual partners.
- Get tested and treated for STDs.
- Talk to your health care provider about pre-exposure prophylaxis (PrEP).

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TEXTBOOK MANAGEMENT
Student Textbook Assignment Form

School : _____

District : _____Country: _____

Teacher : _____Subject: _____

Grade : _____

No.	Name of the Student	Name of the Textbook	Barcode Number	Condition of the TB when received	Date Received	Date Returned	Condition of TB when returned	Signature of Student
1								
2								
3								
4								
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