PHARMACOLOGY

Students Learning Outcomes

- Define pharmacology as the detailed study of drugs.
- Define the term 'drug' (the substance or product that is used to modify physiological systems of the body).
- Enlist the various sources of drugs i.e. minerals, animals, plants, synthetics, microorganisms.
- Describe the principle usages of painkillers, antibiotics, vaccines and sedatives.
- State the contributions of Joseph Lister in the discovery of antiseptics and of Alexander Fleming in the discovery of penicillin.
- Categorize and describe the effects of addictive drugs (sedatives, narcotics and hallucinogens).
- Define hallucinogen (drugs that alter ordinary mental and emotional processes) and relate it with Marijuana.
- Define narcotics (drugs that produce semi-consciousness and sleep to get relief from pain) and relate it with Morphine and Heroine (as the most widely used / abused).
- State the associated problems of drug addiction i.e. severe social abandonment and crimes.
- Identify the symptoms of addiction.
- Name different plants, which are common in Pakistan and used for getting hallucinogens and narcotics.
- Categorise sulfonamides, tetracyclines and cephalosporins as the major groups of antibiotics being used.
- Categorise major antibiotics as per their bactericidal and bacteriostatic effects.
- Rationalise the resistance developed in bacteria against the widely used antibiotics.

Introduction

Pharmacology is the science of the properties and effects of drugs on biological systems. The word "pharmacology" comes from the Greek word "pharmakon" which means drug. Pharmacology deals with the designing, developing, and testing of drugs that have the potential to reduce, and in some cases cure diseases. Pharmacology incorporates other biological sciences such as biochemistry, physiology, microbiology and genetics.

Tidbit

Unlike pharmacy, which is the science of the preparation and dispensing of drugs, pharmacology is the science behind how drugs produce their effects on the body, and what the body does to the drugs.

8.1 Medicinal Drugs

Drug means any compound that can modify the biological functions of living organisms. This definition includes not only medicines that have beneficial effects in the treatment of various disorders, but also chemicals such as caffeine, nicotine, alcohol, illegal substances of abuse, and a variety of man-made or natural environmental toxins. Pharmacologists study the actions of all these substances.

Tidbit

When most people think about the word "drug", they usually associate it only with illegal substances, such as cannabis, heroin or cocaine. However in pharmacology, the word "drug" has a much broader meaning.

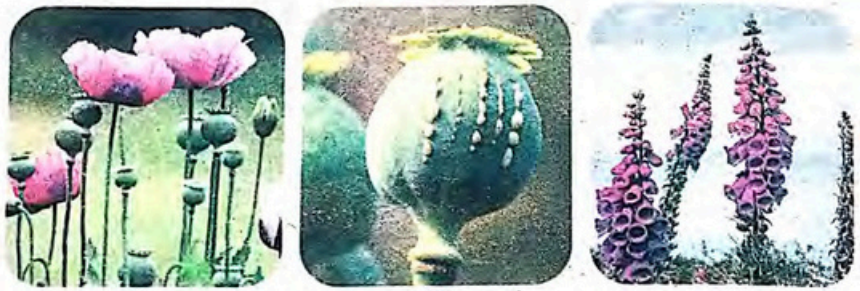
The term medicinal drug is used for any chemical substance, which is used to promote healing, cure disease, control or slow down the progression of disease, prevent disease, decrease complications or reduce excessive harmful activity in the body.

We take drugs through two routes i.e. orally or through injections. Oral drugs are absorbed from our digestive tract into the blood. The blood carries the drug to the liver, where its metabolism occurs. From the liver, the metabolic products of the drug enter the blood again and move to its target tissues. When a drug enters the target tissue it performs its action. The by-products of the action of drugs are carried from the tissues to kidneys, which excrete them out. The second route of drug administration is through injections. Drugs are injected in the muscles (intra-muscular) or directly in veins (intra-venous). Such drugs bypass the route to the liver. In this case, the entire drug is distributed to tissues and its action is faster.

18.1.1 Sources of Medicinal Drugs

Many drugs were discovered long ago. For example, when ancient people looked for food they discovered various roots, leaves, and barks. The people ate these and by trial and error, they learned about the healing effects of these plants. They also learned about toxic effects. However, generally we can see the following as major sources of drugs.

1. Many drugs are obtained from the roots, bark, sap, leaves, flowers, and seeds of **plants**. For example, quinine (antimalarial drug) is extracted from the bark of the Cinchona plant. Similarly, ascorbic acid/vitamin C is taken from lime juice and is used for scurvy and gum bleeding. The drug digitalis, which is used to control heart rate, is extracted from the parts of plant Foxglove. The pain reliever, morphine, is taken from opium (sap of the opium poppy plant).



(a) (b) (c)

Fig.18.1 Plant sources of drugs; (a) Poppy plant, (b) Opium, (c) Foxglove plant

2. Many drugs are also obtained from **animals**, for example, fish liver oil, certain hormones and antitoxins are obtained from animals.
3. Some drugs are taken from **minerals**. For example, tincture of iodine (a liquid to prevent skin infections) is made from mineral iodine.
4. **Microorganisms** and fungi are also sources from which drugs are extracted. For example many antibiotics like streptomycin, neomycin, terramycin are synthesised by using bacteria while antibiotic penicillin is taken from a fungus.
5. Many drugs are **synthesised** in laboratories e.g. aspirin. Pharmacologists use genetically modified organisms for the synthesis of many drugs (antibiotics, vaccines, hormones etc.). Such medicinal drugs may be grouped as synthetic drugs but these are actually taken from natural sources.

18.1.2 important uses of Medicinal Drugs

a. Painkillers

These drugs reduce or relieve pains like headaches, sore muscles, arthritis or any number of other aches and pains. Painkiller drugs are also called analgesics. Different painkillers are used in medicine. All these have advantages and they carry risks too. Some types of pain respond better to certain painkillers than others.

Some painkillers act directly at the site of the affected area to relieve inflammation, others act in the brain to alleviate or stop the sensation of pain. Many painkillers are based on two naturally occurring drugs i.e. aspirin and opiates.

NOT FOR SALE

b. Antibiotics

Antibiotics are among the most frequently prescribed medications in modern medicine for treatment of bacterial infections. Antibiotics cure diseases by killing bacteria or by stopping their growth (division). The first antibiotic penicillin was discovered accidentally from a fungus (Penicillium). Today, over 100 different antibiotics are available to cure minor, as well as life-threatening infections. Your doctor can best determine if an antibiotic needed to be administered for a disease or not.

Tidbit

It is important to realise that antibiotics only treat bacterial infections. Antibiotics are useless against viral infections (for example, the common cold) and fungal infections (such as ringworm).

c. Vaccines

A vaccine is any preparation intended to produce immunity against a disease by stimulating the production of antibodies. Common examples of vaccines are vaccines against small pox, polio, whooping cough and hepatitis B.

d. Sedatives

Sedatives are the drugs that slow down the brain functions. Sedatives block the brain chemicals that conduct communication between brain cells. In this way, sedatives induce sleep and reduce anxiety. Common sedatives are phenobarbital and diazepam.

Tidbit

Sedatives are used with special care because they can cause psychological dependence when taken for longer period of time. If a dependent stops using sedatives, he may suffer restlessness and insomnia (sleeplessness).

18.1.3 Contributions of Joseph Lister and Alexander Fleming

Joseph Lister (1827 – 1912 AD) was a Scottish surgeon. Lister developed an antiseptic spray from carbolic acid (phenol), which was used in operation theatres during surgery to keep the wound clean. He also developed special dressings, containing carbolic acid for keeping the wound clean. Lister's work revolutionised surgery. Although many new antiseptics and disinfectants have been discovered, aseptic surgery is still the basis of saving millions of lives.

Alexander Fleming (1881 – 1955 AD) a Scottish bacteriologist worked in a hospital in London, where he discovered the antibiotic Penicillin. He was working on a culture of bacteria when he noticed a fungus (Penicillium) in one culture. He observed that the fungus released a chemical, which killed the bacteria. The chemical was

For Your Information

Antiseptics are the chemicals used on injured or cut skin. These substances do not allow bacteria to grow and thus reduce the chances of infections. Chemical substances called disinfectants are used to clean objects like tables, floors, utensils etc. They kill microorganisms present on the surface of the objects. Modern antiseptics and disinfectants usually contain alcohols, boric acid or hydrogen peroxide.

extracted and was named as penicillin. It is one of the most important contributions in the history of medicine.

Tidbit

Though the initial intention was to use penicillin for saving the lives of soldiers of World War II, penicillin was eventually made available worldwide for general use.

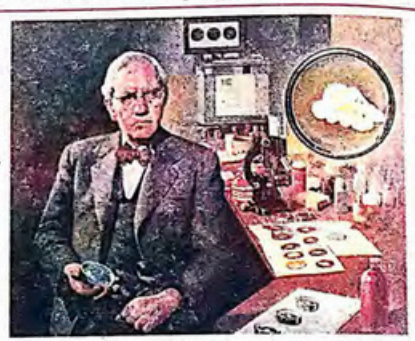



Figure 18.2: Joseph Lister (left); Alexander Fleming (right)

18.2 Addictive Drugs

Drugs are substances that alter the normal functions of the body. There are some drugs, which permanently change the chemistry and neural structures of the brain, if used continuously. As a result, normal functioning without the drug is made nearly impossible. The body craves these drugs if discontinued, often leading to uncontrollable desire for them. This is known as **addiction**. Generally people get drug addicted when they use chemicals which relax them, relieve pain, or heighten their awareness. If it makes them feel good, they want more. Without the drug, they feel tense and tortured. Loss of control and inability to manage without such drugs are the most obvious indicators of drug addiction. Addictive drugs can be categorised as follows:

Tidbit

Sometimes people suffer from emotional trauma and they believe that they need drugs in order to achieve some goals or they use drugs to avoid feelings of depression or anxiety (common symptoms of mental illness).

1. Sedatives

We know that sedatives slow down the brain functions. Use of a sedative is generally initiated to deal with some health problems, for instance to get better sleep or to reduce anxiety. However if a person uses them for a longer period, they are at risk for developing dependence on it and this leads to addiction. An individual taking a sedative may find the prescribed dosage to their satisfaction for a period of time after which they may increase the dosage to achieve the same effect. Some of the effects of taking sedatives in

higher dosage include decreased awareness, confusion and weak respiration, depression and increased stress. A person with sedative addiction may display hostility or aggression, mood swings, poor judgment, and inability to function appropriately in social settings or at the work place.

2. Hallucinogens

Hallucinogens are drugs that cause hallucinations. Hallucinations can be defined as intensive distortions in a person's perceptions of reality. Under the influence of hallucinogens, people see images, hear sounds and feel sensations that seem real but actually do not exist. Hallucinogens cause their effects by disrupting the interaction of nerve cells and the chemical messengers in the brain. Many types of substances are classified as hallucinogens and are generally illegal to use. Some examples of hallucinogens are given below.

Figure 18.3: *Cannabis sativa*

- **Marijuana** is a dry, shredded mixture of flowers, stems, seeds and leaves of the hemp plant *Connabis Sativa*. It is a hallucinogen widely used in Pakistan. Taken through smoke or orally, it produces feelings like excitement, relaxation, laughter, and the perception of slowing down of time etc. Its side effects are anxiety, dizziness, fear, increased heart rate, dry mouth, memory loss, less coordination, poor sense of balance, and slower reaction time.
- **Psilocybin** and **mescaline** are other hallucinogens. These drugs are taken orally. Psilocybin is extracted from a mushroom while mescaline is present in the cactus plant.


Figure 18.4: Psilocybin is taken from a mushroom (left) and mescaline is taken from a cactus (right)

- **Dextromethorphan** is another hallucinogen (also used in cough syrups). It is synthesised in laboratories. The chemical structure of dextromethorphan resembles morphine. Dextromethorphan produces the hallucination of being out of one's body.

3. Narcotics

Narcotics are a small family of drugs obtained from opium (sap of poppy plant). Narcotics relieve pain, induce sleep and cause dullness to the senses. Narcotics work on the central nervous system: the brain and spinal cord. These drugs produce euphoria (sense of well-being) and day dreaming (escape from reality) for some time. The following are the examples of common narcotics.

- Opium contains analgesic drugs such as **morphine** and **heroin,** which are highly addictive. Heroin is the most harmful narcotic, which is synthesised from morphine. It is taken in injections and through smoking. It gives a feeling of wellbeing, relaxation and sedation. Its use leads to respiratory depression and ultimately death.
- **Codeine** is also obtained from opium. It is used in cough syrups. Inside the body, codeine changes into morphine and has the same effects like other narcotics.

18.2.1 Associated Problems of Drug Addiction

Apart from the negative physical effects of drug addiction, there are psychological and emotional effects that are equally disturbing. Some associated problems of drug addiction are given below.

- The self-esteem of drug addicts is damaged. It sinks lower and lower and they develops negative feelings of worthlessness, hopelessness, shame and guilt.
- Drug addicts lose their ability to develop caring and honest relationships. They also destroy their existing relationships.
- They become less assertive and have great difficulty expressing opinions or needs.
- Community members characterise drug addicts as morally weak or as having criminal tendencies. Therefore, they are generally marginalised.
- Drug abuse has led to an increase in the crime rate. Drug abusers commit theft or robbery to steal money to pay for drugs. In desperation they may steal household items and sell them to get money.
- Apart from leading to financial instability, addiction increases the occurrence of conflicts and causes emotional pain for every member of the family.

Tidbit

The best way to help addicts is to guide them to stop. If they promises to stop but fails, you may be saving their lives if you take him to an addiction treatment centre such as of **Anti-Narcotics Force, Pakistan.**

Fig.18.5 Drug addicts: a menace for the society but must be cured and reintegrated

18.2.3 Symptoms of Drug Addiction

Although different drugs have different physical effects, the symptoms of addiction are similar. We can study addiction in terms of physical, behavioural and psychological signs.

a. Physical symptoms

- Bloodshot eyes, pupils larger or smaller than usual
- Changes in appetite or sleep patterns
- Sudden weight loss or weight gain
- Deterioration of physical appearance
- Unusual smells on breath, body or clothing
- Tremors, slurred speech, or impaired coordination

For Your Information

Addiction of drugs occurs very quickly. After just one or two uses, the person may develop a strong desire for the drug. It becomes compulsory for them to use the drug again.

b. Behavioural symptoms

- Drop in attendance and performance at work or school
- Unexplained need for money or financial problems
- Engaging in secret or suspicious behaviour
- Sudden change in friends and hobbies
- Frequently getting into trouble (fights, accidents, illegal activities)

c. Psychological symptoms

- Unexplained change in personality or attitude
- Sudden mood swings, irritability, or angry outbursts
- Lack of motivation
- Fear and anxiousness for no reason

18.3 Antibiotics

An antibiotic is a drug that kills bacteria or stops it from increasing in number. Antibiotics are used to prevent or cure bacterial infections. Antibiotics are categorized as bactericidal and bacteriostatic. Bactericidal antibiotics kill the bacteria while bacteriostatic antibiotics stop or inhibit the growth of bacteria.

In general, the use of bactericidal antibiotics is preferred but many factors may also suit the use of a bacteriostatic antibiotics. When a bacteriostatic antibiotic is used, the duration of therapy must be sufficient to allow the body's immune system to prepare proper defence against the invading bacteria.

For Your Information

A more general term, "anti-infective", describes drugs that do the same to any type of organism that could infect humans including; viruses, parasitic protozoans, bacteria or any other.

18.3.1 Categories of Antibiotics

Antibiotics can be categorised on the basis of chemical structure. Some of the major categories of antibiotics are as follows:

1. Sulfonamides

Sulfonamides are synthetic antibiotics that contain the sulfonamide group. These are bacteriostatic in action. They inhibit the synthesis of folic acid in bacteria. Folic acid is required to make new DNA. So bacteria stop dividing. Sulphonamides are used to treat pneumonia and urinary tract infections.

2. Tetracyclines

Tetracyclines are derived from a species of Streptomyces bacteria. Tetracycline antibiotics are bacteriostatic and inhibit bacterial protein synthesis. Tetracyclines are used in the treatment of infections of the respiratory tract, sinuses, middle ear, urinary tract, skin and intestines.

For Your Information

Tetracyclines are not used in children under the age of 8 and specifically during periods of tooth development.

3. Cephalosporins

Cephalosporins are derived from a species of bacteria *Cephalosporium*. Cephalosporins are bactericidal. These antibiotics interfere with the synthesis of the bacterial cell wall. Cephalosporin is used to treat pneumonia, strep throat, tonsillitis, bronchitis, various types of skin infections, gonorrhea, urinary tract infections etc.

Tidbit

The World Health Organisation describes antibiotic resistant bacteria as "nightmare bacteria". They pose a catastrophic threat to people in every country in the world.

18.3.2 Antibiotics Resistance

Antibiotics play an extremely important role in modern medicine. However, bacteria have a tremendous capability of developing resistance to them. When bacteria are exposed to the same antibiotic over and over, the bacteria can change and are no longer affected by the same antibiotic.

Bacteria have a number of ways to become antibiotic-resistant. For example, they possess an internal mechanism of changing their structure so that any given antibiotic no longer works to inhibit or kill them. They can also develop ways to inactivate or neutralise the antibiotic. Some bacteria can transfer the genes coding for antibiotic resistance to other bacteria to acquire resistance.

Resistance to antibiotics poses a serious and growing problem, because some infectious diseases are becoming more difficult to treat. Resistant bacteria do not respond to the antibiotics and continue to cause infection. Some of these resistant bacteria can be treated with more powerful antibiotics.

18.4 Vaccines

A vaccine is a substance prepared to produce immunity against a disease by stimulating the production of antibodies in the body. Vaccines include, for example, suspensions of killed or weakened (harmless) germs, or components or toxins of germs. The most common method of administering vaccines is through injection, but some are given orally or may be in the form of nasal sprays. Some vaccines provide lifetime immunity, but others have to be repeated to maintain continuous protection.

When a vaccine (inactivated or weakened germs or their components or toxins) enters the blood, the white blood cells recognise it as real disease-causing germs. So they start

NOT FOR SALE

producing antibodies against them. These antibodies remain in the blood. If disease-causing germs enter the blood, the already present antibodies attack and kill them.

For Your Information

During the 1770s, Edward Jenner heard a milkmaid speaking that she would never have the fatal disease smallpox, because she had already suffered from a mild disease cowpox. Taking a clue from it, Jenner took cowpox pus (containing germs) from the hand of a milkmaid and inoculated an 8-year old boy with it. The boy suffered from cowpox. Six weeks later Jenner injected the boy's arm with smallpox germs. The boy did not get smallpox. Jenner claimed that due to cowpox infection, the boy was protected from smallpox.

In 1978, the Government of Pakistan established the Expanded Programme on Immunization (EPI). Its purpose is to vaccinate children aged 0-11 months against nine diseases (Polio, Tetanus, Measles Diphtheria, Whooping cough, Hepatitis B, Pneumonia, meningitis, Tuberculosis,). In 2011, all provinces including Khyber Pakhtunkhwa established their provincial EPI centres. The EPI, Khyber Pakhtunkhwa focuses on polio eradication, increasing immunisation coverage, reducing preventable diseases, increasing immunisation through fixed EPI centres, extending the reach of immunisation services to remote areas, and introducing new vaccines.

Key Points

- Pharmacology is the branch of science, which is concerned with the study of drugs and how they affect living organisms.
- A drug is anything chemical that enters the body and affects the processes in the body.
- Pain relievers are medicines that reduce or relieve pains like headaches, muscular pain, arthritis or any number of other aches and pains.
- The first antibiotic was penicillin, discovered accidentally from a mould culture.
- A vaccine is any preparation intended to produce immunity against a disease by stimulating the production of antibodies.
- Sedatives are drugs that slow down brain functions.
- Drugs if used continuously changes the chemistry and neural structures of the brain. As a result normal functioning without the drug is made nearly impossible. This uncontrollable desire for drugs is known as addiction.
- Hallucinogen is a drug that causes hallucinations, which are intensive distortions in a person's perceptions of reality.
- Narcotics are extracted from Opium (sap of the opium plant). The common narcotics are morphine and codeine.
- An antibiotic is a drug that kills bacteria or stops them from increasing in number.

NOT FOR SALE

Exercise

A. Select the correct answer.

1. Any substance that is used to modify the physiological systems for the benefit of the recipient is:
   a. Medicine b. Vaccine
   c. Narcotic d. Drug
2. Oral drugs are absorbed in the blood and are first taken to;
   a. Kidneys b. Lungs
   c. Liver d. Brain
3. Any preparation intended to produce immunity to a disease by stimulating the production of antibodies is:
   a. Drug b. Antibiotic
   c. Analgesic d. Vaccine
4. Drugs that calm patients down, easing agitation and permitting sleep is termed as;
   a. Painkiller b. Hallucinogen
   c. Sedative d. Narcotic
5. There are two types of narcotic drugs; opiates and synthetic; which one of the following is synthetic;
   a. Morphine b. Codeine c. Methadone d. Heroin
6. The uncontrollable desire for drugs is known as;
   a. Addiction b. Vaccination c. Infection d. Heroin
7. All of the following are classes of antibiotics EXCEPT;
   a. Sulfonamides b. Tetracycline c. Penicillin d. Morphine
8. Which of these is the source of narcotics?
   a. Opium plant b. Cactus plant c. Cannabis plant d. Mushroom
9. Vaccines can be administered through;
   a. Injections b. Mouth c. Nose d. All of these
10. Cephalosporins are derived from;
    a. Fungus b. Bacterium c. Cannabis d. Opium

B. Write short answers to the following questions.

1. What is drug addiction and what are the effects of addiction?

2. Differentiate between antibiotics and vaccines.
3. Enlist the bad effects of nicotine, caffeine and cocaine. Are these addictive?
4. What are the responsibilities of society to deal with drug addicts?
5. How are vaccines prepared?
6. Give two examples of drugs, which are extracted from plants.
7. Define drug addiction. What are the three major categories of drugs, which can cause addiction?
8. Define analgesic, antibiotics, and sedatives.
9. Differentiate between bactericidal and bacteriostatic antibiotics.
10. Define narcotics and give examples.

C. Write detailed answers to the following questions:

1. What roles do drugs play in our life?
2. Differentiate between narcotics and drugs. What are the different symptoms of drug addiction?
3. What are hallucinogens? Give examples with their sources.
4. Describe the mechanisms of action of three groups of antibiotics. Also mention the diseases for which each of these groups is used.
5. What are vaccines? Describe the different ways of producing vaccines.
6. What are the different classes of antibiotics and what is resistance to antibiotics?

Science, Technology and Society

1. Compile a list of various painkillers, antibiotics and sedatives being used in your household.
2. Summarise the antisocial effects of the usage of hallucinogens and narcotics.
3. Analyse the effects of possible over-dosage, under-dosage and drug interactions when using antibiotics without a doctor's consultation.

GLOSSARY

A

Abiotic
Nonliving; specifically, the nonliving components of an ecosystem, such as temperature, humidity, the mineral content of the soil, etc.

Abascisic acid (ABA)
A plant hormone that generally acts to inhibit growth, promote dormancy, and help the plant tolerate stressful conditions.

Absorption
The movement of water and dissolved substances into a cell, tissue, or organism.

Active transport
The movement of a substance across a biological membrane against its concentration or electrochemical gradient, with the help of energy input and specific transport proteins.

Adenosine triphosphate (ATP)
An adenine-containing nucleoside triphosphate that releases free energy when its phosphate bonds are hydrolyzed. This energy is used to drive endergonic reactions in cells.

Alternation of generations
A life cycle in which there is both a multicellular diploid form, the sporophyte, and a multicellular haploid form, the gametophyte; characteristic of plants.

Amino group
A functional group that consists of a nitrogen atom bonded to two hydrogen atoms; can act as a base in solution, accepting a hydrogen ion and acquiring a charge of +1.

Amoeboid
Moving or feeding by means of pseudopodia (temporary cytoplasmic protrusions from the cell body).

Anaerobic
Lacking oxygen; referring to an organism, environment, or cellular process that lacks oxygen and may be poisoned by it.

Antheridium *pl.* antheridia
In plants, the male gametangium, a moist chamber in which gametes develop.

Antibiotic
A chemical that kills bacteria or inhibits their growth.

Antibody
An antigen-binding immunoglobulin, produced by B cells, that functions as the effector in an immune response.

Artery
A vessel that carries blood away from the heart to organs throughout the body.

Asexual reproduction
A type of reproduction involving only one parent that produces genetically identical offspring by budding or by the division of a single cell or the entire organism into two or more parts.

B

Bacteria
One of two prokaryotic domains, the other being the Archaea.

Bbacteriophage
[L. *bacterium* + Gk. *phagein,* to eat]
A virus that parasitizes a bacterial cell.

Bark
All tissues external to the vascular cambium in a plant growing in thickness, consisting of phloem, phelloderm, cork cambium, and cork.

Binary fission
The type of cell division by which prokaryotes reproduce; each dividing daughter cell receives a copy of the single parental chromosome.

Biochemical pathway
An ordered series of chemical reactions in a living cell, in which each step is catalyzed by a specific enzyme; different biochemical pathways serve different functions in the life of the cell.

Biomass
The dry weight of organic matter comprising a group of organisms in a particular habitat.

Biosphere
The entire portion of Earth that is inhabited by life; the sum of all the planet's communities and ecosystems.

Biotechnology
The industrial use of living organisms or their components to improve human health and food production.

Biotic
(by-**ot**-ik) [Gk. *bios,* life]
Pertaining to the living organisms in the environment.

Blood pressure
The hydrostatic force that blood exerts against the wall of a vessel.

C

Carcinogen
A chemical agent that causes cancer.

Catabolic pathway
A metabolic pathway that releases energy by breaking down complex molecules into simpler compounds.

Catalyst
A substance that lowers the activation energy of a chemical reaction by forming a temporary association with the reacting molecules; as a result, the rate of the reaction is accelerated. Enzymes are catalysts.

Centromere
The centralized region joining two sister chromatids.

Centrosome
Material present in the cytoplasm of all eukaryotic cells and important during cell division; also called microtubule-organizing center.

Chromatin
The complex of DNA and proteins that makes up a eukaryotic chromosome. When the cell is not dividing, chromatin exists as a mass of very long, thin fibers that are not visible with a light microscope.

Chromosome
A threadlike, gene-carrying structure found in the nucleus. Each chromosome consists of one very long DNA molecule and associated proteins. *See* chromatin.

Codominance
A phenotypic situation in which both alleles are expressed in the heterozygote.

Cytoplasm
The entire contents of the cell, exclusive of the nucleus, and bounded by the plasma membrane.

D

Daughter cell
A cell that is the offspring of a cell that has undergone mitosis or meiosis. The term "daughter" does not indicate the sex of the cell.

Diaphragm
A sheet of muscle that forms the bottom wall of the thoracic cavity in mammals; active in ventilating the lungs.

Diffusion
The spontaneous tendency of a substance to move down its concentration gradient from a more concentrated to a less concentrated area.

Digestion
The process of breaking down food into molecules small enough for the body to absorb.

DNA
Abbreviation of deoxyribonucleic acid.

DNA ligase
A linking enzyme essential for DNA replication; catalyzes the covalent bonding of the 3' end of a new DNA fragment to the 5' end of a growing chain.

Double fertilization
A mechanism of fertilization in angiosperms, in which two sperm cells unite with two cells in the embryo sac to form the zygote and endosperm.

E

Ecological pyramid
A graphic representation of the quantitative relationships of numbers of organisms, biomass, or energy flow between the trophic levels of an ecosystem. Because large amounts of energy and biomass are dissipated at every trophic level, these diagrams nearly always take the form of pyramids.

Ecology
The study of how organisms interact with their environments.

Ecosystem
A level of ecological study that includes all the organisms in a given area as well as the abiotic factors with which they interact; a community and its physical environment.

Energy
The capacity to do work by moving matter against an opposing force.

Epithelial tissue
Sheets of tightly packed cells that line organs and body cavities.

Evolution
All the changes that have transformed life on Earth from its earliest beginnings to the diversity that characterizes it today.

NOT FOR SALE

Exocrine glands
Glands, such as sweat glands and digestive glands, that secrete their products into ducts that empty onto surfaces, such as the skin, or into cavities, such as the interior of the stomach.

F

Fermentation
A catabolic process that makes a limited amount of ATP from glucose without an electron transport chain and that produces a characteristic end-product, such as ethyl alcohol or lactic acid.

Fertilization
The union of haploid gametes to produce a diploid zygote.

Filtration
The first stage of kidney function; blood plasma is forced, under pressure, out of the glomerular capillaries into Bowman's capsule, through which it enters the renal tubule.

G

Gametophyte
The multicellular haploid form in organisms undergoing alternation of generations, which mitotically produces haploid gametes that unite and grow into the sporophyte generation.

Glucose
A six-carbon sugar ($C_6H_{12}O_6$); the most common monosaccharide in animals.

Glycerol
A three-carbon molecule with three hydroxyl ($\overline{OH}$) groups attached; a glycerol molecule can combine with three fatty acid molecules to form a fat or an oil.

H

Hemoglobin
An iron-containing protein in red blood cells that reversibly binds oxygen.

Hemophilia
A group of hereditary disorders characterized by failure of the blood to clot and consequent excessive bleeding from even minor wounds.

Herbivore
A heterotrophic animal that eats plants.

HIV
Abbreviation of human immunodeficiency virus, the infectious agent that causes AIDS; HIV is an RNA retrovirus.

Hormone
One of many types of circulating chemical signals in all multicellular organisms that are formed in specialized cells, travel in body fluids, and coordinate the various parts of the organism by interacting with target cells.

Hypothalamus
The ventral part of the vertebrate forebrain; functions in maintaining homeostasis, especially in coordinating the endocrine and nervous systems; secretes hormones of the posterior pituitary and releasing factors, which regulate the anterior pituitary.

I

Inflammation

A body strategy initiated by the release of chemicals following injury or infection which brings additional blood with its protective cells to the injured area.

Interstitial cells

Cells in the testes that produce testosterone, the major male sex hormone.

Internal fertization: The union of sperm and egg inside a chamber in the body. This is the mode of reproduction in terrestrial animals.

L

loop of henle: An elongated section of the renal tubule that dips down into the kidney's medulla and then ascends back up to the cortex, separating the proximal and distal convoluted tubules.

M

Meiosis: The division process that produces cells with one-half the number of chromosomes in each somatic cell. Each resulting daughter cell is haploid (In).

Meiosis I: A process of reductional division in which homologous chromosomes pair and then segregate. Homologues are partitioned into separate daughter cells.

Meiosis II: Second meiotic division. A division process resembling mitosis, except that the haploid number of chromosomes is present. After the chromosomes line up at the metaphase plate, the centromeres split and the two sister chromatids separate.

Messenger rna (mRNA): The RNA that carries genetic information from the DNA in the nucleus to the ribosomes in the cytoplasm, where the sequence of bases in the mRNA is translated into a sequence of amino acids.

Migration: Movements of a population into or out of an area.

Mitosis: The process of cell division producing daughter cells with exactly the same number of chromosomes as in the mother cell.

Muscle tissue: Bundles and sheets of contractile cells that shorten when stimulated, providing force for controlled movement.

Mutation: Random heritable changes in DNA that introduce new alleles into the gene pool.

Mutualism: The symbiotic interaction in which both participants benefit.

N

Negative feedback: Any regulatory mechanism in which the increased level of a substance inhibits further production of that substance, thereby preventing harmful accumulation. A type of homeostatic mechanism.

Nerve: Parallel bundles of neurons and their supporting cells.

Neuron: A nerve cell

O

Osmoregulation: The maintenance of a stable fluid environment using hormones to regulate osmotic gradients that adjust fluid concentration, as in the nephrons of the kidneys.

Osmosis: The diffusion of water through a differentially permeable membrane.

Oxytocin: A female hormone released by the posterior pituitary which triggers uterine contractions during childbirth and the release of milk during nursing.

P

Parathyroid glands: Four glands attached to the thyroid gland which secrete parathyroid hormone (PTH). When blood calcium levels are low, PTH is secreted, causing calcium to be released from bone.

Parthenocarpy: The development of fruits without fertilization.

Parthenogenesis: Process by which offspring are produced without egg fertilization.

Pectoral girdle: The two scapulae (shoulder blades) and two clavicles (collarbones) which support and articulate with the bones of the upper arm.

Plasmid: A small circle of DNA in bacteria in addition to its own chromosome.

R

Recessive: An allele whose expression is masked by the dominant allele for the same trait.

Recombinant DNA: DNA formed by the insertion of foreign genes or foreign sections of DNA from one organism into the chromosomes of a host cell.

Replication: Duplication of DNA, usually prior to cell division.

S

Sex chromosomes: The one chromosomal pair that is not identical in the karyotypes of males and females of the same animal species.

Sex hormones: Steroid hormones which influence the production of gametes and the development of male or female sex characteristics.

Skeletal muscles: Separate bundles of parallel, striated muscle fibers anchored to the bone, which they can move in a coordinated fashion. They are under voluntary control.

Skeleton: A rigid form of support found in most animals either surrounding the body with a protective encasement or providing, a living girder system within the animal.

Symbiosis: A close, long-term relationship between two individuals of different species.

T

Thermoregulation: The process of maintaining a constant internal body temperature in spite of fluctuations in external temperatures.

Transcription: The process by which a strand of RNA assembles along one of the DNA strands.

Transfer rna (tRNA): A type of RNA that decodes mRNA's codon message and translates it into amino acids.

Transformation: A genetic transfer mechanism that produces new DNA in bacteria when DNA from a new organism is combined with the DNA of the host cell.

Translation: The cell process that converts a sequence of nucleotides in mRNA into a sequence of amino acids.

U

Urethra: A tube that extends from the urinary bladder through the length of the penis, conveying both sperm and urine, though not simultaneously.

Urine: The excretory fluid consisting of urea, other nitrogenous substances, and salts dissolved in water. It is formed by the kidneys.

INDEX

NOT FOR SALE

مومن تو آپس میں بھائی بھائی ہیں۔
پس اپنے دو بھائیوں میں صلح کرا دیا کرو
اور اللہ سے ڈرتے رہو تا کہ تم پر رحمت کی جائے۔
(سورۃ الحجرات:۱۰)

Authors Profile

1. Zaigham Hasan

Mr. Zaigham is working as Associate Professor in the Zoology Department University of Peshawar. He has been on the Panel of Authors in the Khyber Pakhtunkhwa Textbook Board. In this capacity he was given the Authorship in several textbooks of General Science and Biology. Being an active teacher he has been teaching Biology/Zoology at various levels for the last 20 years.

2. Faiz Nadeem

Mr. Nadeem is working as a Lecturer in Islamabad Model College I-8/3, Islamabad. He has been involved is the writing of Textbooks of General Science and Biology at primary and secondary level.

3. Shafqat Rasool

Mr. Shafqat is a Lecturer in Islamabad Model College F-8/4, Islamabad, He has been involved in the teaching of General Science and Biology for the last 10 years.

4. Dr. Izhar Ahmad

Dr. Izhar Ahmad has received his Ph.D degree in the field of Molecular Plant Physiology from the Univerisity of York, UK. He has been teaching in Islamia College Peshawar for the last 18 years. He is also supervising M.Phil and Ph.D research scholars. He has 30 research publications in peer review journals and has attended various international conferences. He is also the co-author of several textbooks.

Khyber Pakhtunkhwa Textbook Board
Phase – V, Hayatabad Peshawar
Phone: 091-9217714-15 Fax: 091-9217163, Website: www.kptbb.gov.pk

TEXTBOOK FEEDBACK FORM

S#	Statement	Remarks
1.	Overall the book is interesting and user friendly.	
2.	The language and content of the book is age / grade appropriate and the content is free of grammatical and punctuation errors.	
3.	Content is supported with examples from real life / culture.	
4.	Contents / texts are authentic and updated.	
5.	Pictures / diagrams / graphs / illustrations are informative, relevant and clear if not, then identify them.	
6.	Activities, projects and additional work is suggested for reinforcement of concepts.	
7.	Assessment achievements are thought provoking and comprise cognitive, psychomotor and effective skills.	
8.	The textbook is easy to be covered within academic year.	

Page No.	Observation/comments	Suggested amendment along with rationale

General Remarks:

Name & Address:

Contact No. & Email: