Course: Biology-III (6453)
Semester: Autumn, 2021

ASSIGNMENT No. 2

Q.1 Describe role of carbon dioxide in plants with special reference to the Calvin cycle.

In plants, carbon dioxide (CO_2) enters the chloroplast through the stomata and diffuses into the stroma of the chloroplast—the site of the Calvin cycle reactions where sugar is synthesized. The reactions are named after the scientist who discovered them, and reference the fact that the reactions function as a cycle. Others call it the Calvin-Benson cycle to include the name of another scientist involved in its discovery. The Calvin cycle reactions can be organized into three basic stages: fixation, reduction, and regeneration. In the stroma, in addition to CO_2, two other chemicals are present to initiate the Calvin cycle: an enzyme abbreviated RuBisCO, and the molecule ribulose bisphosphate (RuBP). RuBP has five atoms of carbon and a phosphate group on each end. RuBisCO catalyzes a reaction between CO_2 and RuBP, which forms a six-carbon compound that is immediately converted into two three-carbon compounds. This process is called carbon fixation, because CO_2 is "fixed" from its inorganic form into organic molecules. ATP and NADPH use their stored energy to convert the three-carbon compound, 3-PGA, into another three-carbon compound called G3P. This type of reaction is called a reduction reaction, because it involves the gain of electrons. A reduction is the gain of an electron by an atom or molecule. The molecules of ADP and NAD^+, resulting from the reduction reaction, return to the light-dependent reactions to be re-energized. One of the G3P molecules leaves the Calvin cycle to contribute to the formation of the carbohydrate molecule, which is commonly glucose ($C_6H_{12}O_6$). Because the carbohydrate molecule has six carbon atoms, it takes six turns of the Calvin cycle to make one carbohydrate molecule (one for each carbon dioxide molecule fixed). The remaining G3P molecules regenerate RuBP, which enables the system to prepare for the carbon-fixation step. ATP is also used in the regeneration of RuBP.

Photosynthesis

The shared evolutionary history of all photosynthetic organisms is conspicuous, as the basic process has changed little over eras of time. Even between the giant tropical leaves in the rainforest and tiny cyanobacteria, the process and components of photosynthesis that use water as an electron donor remain largely the same. Photosystems function to absorb light and use electron transport chains to convert energy. The Calvin cycle reactions assemble carbohydrate molecules with this energy. However, as with all biochemical pathways, a variety of conditions leads to varied adaptations that affect the basic pattern. Photosynthesis in dry-climate plants has evolved with adaptations that conserve water. In the harsh dry heat, every drop of water and precious energy must be used to survive. Two adaptations have evolved in such plants. In one form, a more efficient use of CO_2 allows plants to photosynthesize even when CO_2 is in short supply, as when the stomata are closed on hot days. The other adaptation performs preliminary reactions of the Calvin cycle at night, because opening the stomata at this time conserves water due to cooler temperatures. In addition, this adaptation has allowed plants to carry out low levels of photosynthesis without opening stomata at all, an extreme mechanism to face extremely dry periods.

Living things access energy by breaking down carbohydrate molecules. However, if plants make carbohydrate molecules, why would they need to break them down? Carbohydrates are storage molecules for energy in all living things. Although energy can be stored in molecules like ATP, carbohydrates are much more stable and efficient reservoirs for chemical energy. Photosynthetic organisms also carry out the reactions of respiration to harvest the energy that they have stored in carbohydrates, for example, plants have mitochondria in addition to chloroplasts.

You may have noticed that the overall reaction for photosynthesis:

$\mathbf{6CO_2+6H_2O \rightarrow C_{612}O_6+6O_26CO_2+6H_2O \rightarrow C_6H_{12}O_6+6O}$

is the reverse of the overall reaction for cellular respiration:

$\mathbf{6O_2+C_6H_{12}O_6 \rightarrow 6CO_2+6H_2O_6O_2+C_6H_{12}O_6 \rightarrow 6CO_2+6H_2O}$

Photosynthesis produces oxygen as a byproduct, and respiration produces carbon dioxide as a byproduct.

CO_2 is no more a form of waste produced by respiration than oxygen is a waste product of photosynthesis. Both are byproducts of reactions that move on to other reactions. Photosynthesis absorbs energy to build carbohydrates in chloroplasts, and aerobic cellular respiration releases energy by using oxygen to break down carbohydrates. Both organelles use electron transport chains to generate the energy necessary to drive other reactions. Photosynthesis and cellular respiration function in a biological cycle, allowing organisms to access life-sustaining energy that originates millions of miles away in a star.

Q.2 How will you differentiate glycolysis from gluconeogenesis?

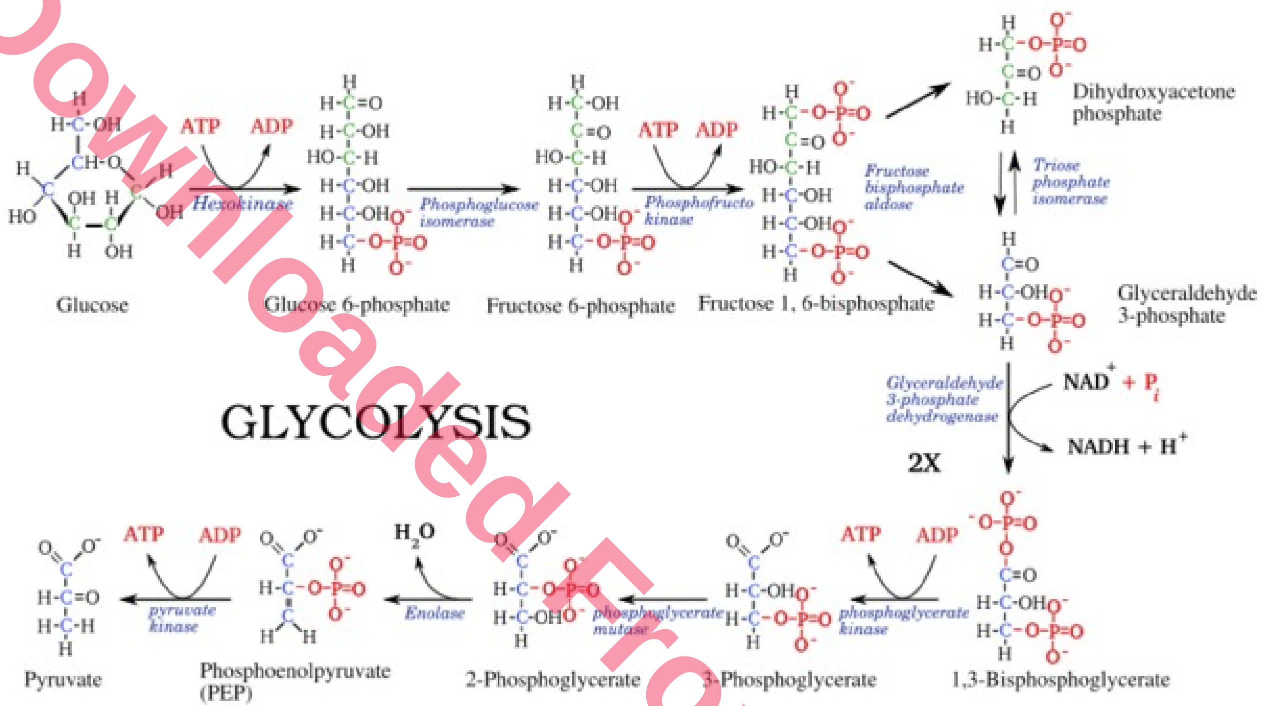
The main difference between glycolysis and gluconeogenesis is in their basic function: one depletes existing glucose, while other replenishes it from both organic (carbon-containing) and inorganic (carbon-free) molecules. This makes glycolysis a catabolic process of metabolism, while gluconeogenesis is anabolic.

Also on the glycolysis vs. gluconeogenesis front, while glycolysis occurs in the cytoplasm of all cells, gluconeogenesis is confined mainly to the liver.

Glycolysis and gluconeogenesis are two metabolic processes found in glucose metabolism of cells. Glycolysis is the first step in glucose breakdown, where two pyruvate molecules are produced. Glycolysis occurs in the cytoplasm of both prokaryotic and eukaryotic cells. Gluconeogenesis is the reverse reaction of glycolysis, where two pyruvate molecule come together to form a glucose molecule. It mainly occurs in the liver, ultimately storing glucose in the form of glycogen. But, gluconeogenesis is not the mirror reaction of glycolysis. The **main difference** between gycolysis and gluconeogenesis is that **glycolysis is involved in the glucose catabolism** whereas **gluconeogenesis is involved in the glucose anabolism.**

The set of reactions that convert glucose into two pyruvate molecules is known as glycolysis. Glycolysis is composed of ten reactions that occur in the cytoplasm. The whole process can be divided into three stages. During the first stage, glucose is converted into fructose 1,6-bisphosphate through phosphorylation, isomerization and second phosphorylation. By converting glucose into fructose 1,6-bisphosphate, two goals are achieved by the cell. The glucose is trapped inside the cell and converted into a compound, which can be readily cleaved into three carbon units. During the second stage, fructose 1,6-bispphosphate is cleaved into three carbon fragments, which are readily interconvertible. During the third stage, three carbon fragments are oxidized into two pyruvate molecules, harvesting ATP. The net reaction of glycolysis is shown below.

Glucose + 2Pi + 2ADP + 2NAD → 2 Pyruvate + 2ATP + 2NADH + 2H$^+$ + 2H$_2$O



Glucose is the main source of energy for almost all the life forms on earth. Glycolysis is the first step of glucose catabolism, which is usually called as cellular respiration, where the cell breaks down glucose through series of reactions in order to produce ATP. ATP powers almost all of the cellular processes. Some cells like brain cells and muscle cells require more energy than normal cells in order to carry out their functions. Therefore, they require more glucose than the other cells.

Gluconeogenesis is the production of glucose from non-carbohydrate sources like glycerol, amino acids, and lactate. The conversion of pyruvate into glucose is roughly the same as the reverse of glycolysis. But, the three reactions which give the essential irreversibility during glycolysis are bypassed by four new reactions. Pyruvate in the mitochondria is carboxylated into oxaloacetate by two of the above mentioned new reactions. Oxaloacetate is decarboxylated and phosphorylated into phosphoenolpyruvate in the cytoplasm by the other two new reactions. The other difference between glycolysis and gluconeogenesis is the hydrolysis of glucose 6-phosphate as well as the fructose 1,6-bisphosphate. Gluconeogenesis occurs in the liver by using lactate and alanine as raw materials. These raw materials are formed by active skeletal muscles by pyruvate. The set of reactions involved in gluconeogenesis is shown in figure 2.

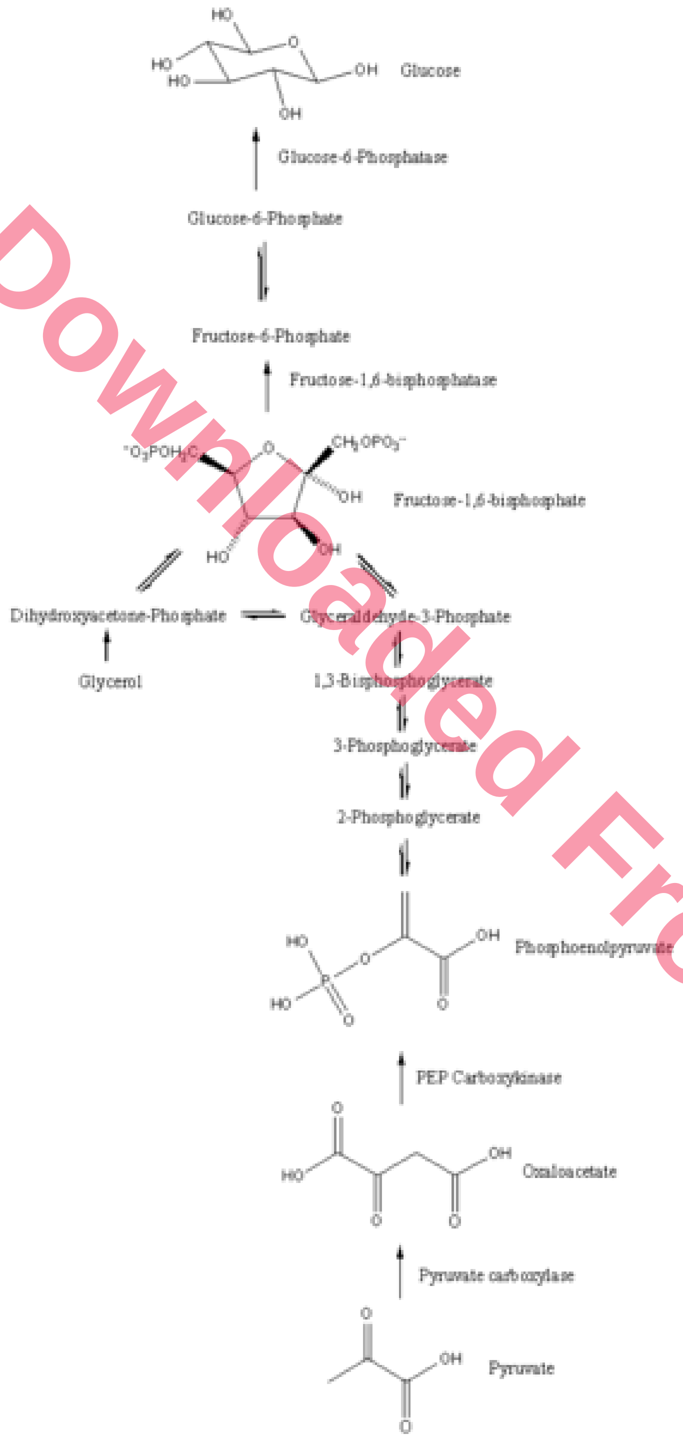


Figure 2: Gluconeogenesis

Gluconeogenesis is reciprocally regulated with glycolysis. When one pathway is highly active the other pathway is inhibited. The key control points are the steps regulated by fructose 1,6-bisphosphatase and phosphofructokinase enzymes. When glucose is abundant, glycolysis is activated by the signal molecule, fructose 2,6-bisphosphate, which is also found in high levels. The two enzymes, pyruvate kinase, and pyruvate carboxylase are also regulated. Allosteric regulation and reversible phosphorylation are involved in the regulation as well.

Difference Between Glycolysis and Gluconeogenesis

Definition

Glycolysis: The set of reactions that convert glucose into two pyruvate molecules is known as glycolysis.

Gluconeogenesis: Gluconeogenesis is the production of glucose form non-carbohydrate sources like glycerol, amino acids, and lactate.

Raw Materials

Glycolysis: The raw material of glycolysis is glucose.

Gluconeogenesis: The raw materials of gluconeogenesis is lactate, amino acids like alanine and glycerol.

Occurrence

Glycolysis: Glycolysis occurs in the cytoplasm of all cells.

Gluconeogenesis: Gluconeogenesis occurs in both mitochondria and cytoplasm.

In Tissues

Glycolysis: Glycolysis occurs in almost all the cells in the body.

Gluconeogenesis: Gluconeogenesis occurs in the liver and kidney.

Metabolism

Glycolysis: Glycolysis is a catabolic process, where the glucose molecules are broken down into two pyruvate molecules.

Gluconeogenesis: Gluconeogenesis is an anabolic process, where the two pyruvate molecules are joined together to form a glucose molecule.

Energy Utilization

Glycolysis: Glycolysis is an exergonic reaction where two ATPs are produced.

Gluconeogenesis: Gluconeogenesis is an endergonic reaction where six ATPs are utilized per one glucose molecule.

Correspondence

Glycolysis: Glycolysis occurs through ten reactions.

Gluconeogenesis: The two essentially irreversible reactions in the glycolytic pathway are bypassed by four new reactions in gluconeogenesis.

Rate Limiting Step

Glycolysis: The enzymes involved in the rate limiting steps are hexokinase, phosphofructokinase and pyruvate kinase.

Gluconeogenesis: The enzymes involved in the rate limiting steps are pyruvate carboxylase, phosphoenolpyruvate carboxykinase, fructose 1,2-bisphosphatase, glucose 6-phosphate phosphatase.

Q.3

a) How pollution is affecting our environment?

There are many causes of pollution including chemical pollution into bodies of water and soil through improper disposal practices and agricultural activities, and noise and light pollution created by cities and urbanization as a result of population growth.

Air and noise pollution can have adverse effects on animals, plants, and humans. Although air and water pollution has been improving over the last few decades, they are still a large topic in the discussion today.

1. Air Pollution

There are two types of air pollutants, primary and secondary. Primary pollutants are emitted directly from their source, while secondary pollutants are formed when primary pollutants react in the atmosphere.

The burning of fossil fuels for transportation and electricity produces both primary and secondary pollutants and is one of the biggest sources of air pollution.

The fumes from car exhausts contain dangerous gases and particulates including hydrocarbons, nitrogen oxides, and carbon monoxide. These gases rise into the atmosphere and react with other atmospheric gases creating even more toxic gases.

2. Water Pollution

Nutrient pollution is caused by wastewater, sewage, and fertilizers. The high levels of nutrients in these sources end up in bodies of water and promote algae and weed growth, which can make the water undrinkable and depleted oxygen causing aquatic organisms to die.

Pesticides and herbicides applied to crops and residential areas concentrate in the soil and are carried to the groundwater by rainwater and runoff. For these reasons anytime someone drills a well for water it must be checked for pollutants.

Industrial waste is one of the main causes of water pollution, by creating primary and secondary pollutants including sulphur, lead and mercury, nitrates and phosphates, and oil spills.

In developing countries around 70% of their solid waste is dumped directly into the ocean or sea. This causes serious problems including the harming and killing of sea creatures, which ultimately affects humans.

3. Land & Soil Pollution

Land pollution is the destruction of land as a result of human's activities and the misuse of land resources. This occurs when humans apply chemicals such as pesticides and herbicides to the soil, dispose of waste improperly, and irresponsibly exploit minerals through mining.

Soil is also polluted through leaking underground septic tanks, sewage systems, the leaching of harmful substances from landfill, and direct discharge of waste water by industrial plants into rivers and oceans.

Rain and flooding can bring pollutants from other already polluted lands to soil at other locations.

Over-farming and over-grazing by agricultural activities causes the soil to lose its nutrient value and structure causing soil degradation, another type of soil pollution.

b) What is eutrophication?

Eutrophication is a big word that describes a big problem in the nation's estuaries. Harmful algal blooms, dead zones, and fish kills are the results of a process called eutrophication — which occurs when the environment becomes enriched with nutrients, increasing the amount of plant and algae growth to estuaries and coastal waters.

Sixty-five percent of the estuaries and coastal waters in the **contiguous U.S.** that have been studied by researchers are moderately to severely degraded by excessive nutrient inputs. Excessive nutrients lead to algal blooms and low-oxygen (hypoxic) waters that can kill fish and seagrass and reduce essential fish habitats. Many of these estuaries also support bivalve mollusk populations (e.g., oysters, clams, scallops), which naturally reduce nutrients through their filter-feeding activities.

Eutrophication sets off a chain reaction in the ecosystem, starting with an overabundance of algae and plants. The excess algae and plant matter eventually decompose, producing large amounts of carbon dioxide. This lowers the pH of seawater, a process known as ocean acidification. Acidification slows the growth of fish and shellfish and can prevent shell formation in bivalve mollusks. This leads to a reduced catch for commercial and recreational fisheries, meaning smaller harvests and more expensive seafood.

In recent years, NOAA's National Centers for Coastal Ocean Science (NCCOS), in collaboration with NOAA's Northeast Fisheries Science Center, has enlisted estuaries' indigenous residents, namely, bivalve mollusks, to help slow and, in some cases, reverse the process of eutrophication, since they efficiently remove nutrients from the water as they feed on phytoplankton and detritus.

A groundbreaking modeling project in Long Island Sound showed that the oyster aquaculture industry in Connecticut provides \$8.5 – \$23 million annually in nutrient reduction benefits. The project also showed that reasonable expansion of oyster aquaculture could provide as much nutrient reduction as the comparable investment of \$470 million in traditional nutrient-reduction measures, such as wastewater treatment improvements and agricultural best management practices.

The NOAA scientists used aquaculture modeling tools to demonstrate that shellfish aquaculture compares favorably to existing nutrient management strategies in terms of efficiency of nutrient removal and implementation cost. Documenting the water quality benefits provided by shellfish aquaculture has increased both communities' and regulators' acceptance of shellfish farming, not only in Connecticut but across the nation. In Chesapeake Bay, for example, nutrient removal policies include the harvesting of oyster tissue as an approved method, and in Mashpee Bay, Massachusetts, cultivation and harvest of oysters and clams are part of the official nutrient management plan.

Q.4 What is sex determination? Give examples from mandolin genetics.

In humans, sex determination is the process that determines the biological sex of an offspring and, as a result, the sexual characteristics that they will develop. Humans typically develop as either male or female, depending on the combination of sex chromosomes that they inherit from their parents. The human sex chromosomes, called X and Y, are structures in human cells made up of tightly bound deoxyribonucleic acid, or DNA, and proteins. Those are molecules that contain the instructions for the development and functioning of all life forms, including the development of physical traits and body parts that correspond with each biological sex. Humans who inherit two X chromosomes typically develop as females, while humans with one X and one Y chromosome typically develop as males. Sex determination is the beginning of the development of many characteristics that influence how a human looks and functions as well as the societal expectations that other humans have for each other.

The process of sex determination begins after fertilization, a process where male and female germ cells fuse to form a zygote, or a single-celled, fertilized egg. Germ cells are those that carry genetic information from parents to offspring during fertilization. Male germ cells are sperm cells and female germ cells are egg cells. When the egg and sperm cells fuse, the zygote divides into multiple cells and later forms an embryo. The embryo includes a combination of part of each parent's genetic information, including one sex chromosome from each parent. The combination of sex chromosomes that an embryo inherits from germ cells determines what biological sex it will later develop as.

A process called meiosis determines the sex chromosome that the parents' germ cells pass on to their offspring. Meiosis occurs inside of the testes and ovaries, the organs in males and females, respectively, that produce germ cells. During meiosis, each cell divides twice, which results in four cells. When the germ cells fuse during fertilization, the resulting embryo will have the normal amount of genetic material, including two sex chromosomes, because it receives one from each parent. Because females tend to only have X chromosomes, the egg cells that they produce typically carry an X chromosome, while the male sperm cell can carry either an X or Y. Therefore, the sex chromosome that a male sperm carries determines whether the offspring will develop into a male or a female.

Typical males and females differ in a variety of physical traits. The main parts of the male reproductive system include the penis, testicles that appear outside the body on the groin, and accessory glands. The penis is the male external sex organ. The testicles produce sperm and a hormone called testosterone, which causes males to develop deeper voices, bigger muscles, and body and facial hair during puberty. Male accessory glands, including the seminal vesicles and the prostate gland, produce fluids. Those glands are near the bladder of the body and connect to the penis and testicles through a tube called the vas deferens.

The main parts of the female reproductive system include the vagina, uterus, ovaries, and fallopian tubes. The vagina is a female organ that connects the internal reproductive organs to the outside of the body. The uterus is an internal reproductive organ in the lower abdominal region and houses an embryo during pregnancy. The female body typically has two ovaries, placed on the right and left sides of the uterus, that produce egg cells and a hormone called estrogen. Estrogen tells the female body to release egg cells during a process called ovulation. There are also two fallopian tubes that connect each ovary to the uterus.

Discussions about why males and females possess different physical characteristics date back to some of the earliest texts. Aristotle, an ancient Greek philosopher who lived from 384 BCE to 322 BCE, suggested that embryos arose from the mixture of male semen and female blood that comes from the uterus. Aristotle also wrote that the amount of heat present during an embryo's development determines its biological sex. Specifically, Aristotle proposed that all embryos are meant to develop into males, but embryos that did not have enough heat would stop development early and grow into females. According to historian Maryanne Horowitz, Aristotle's theories on sex determination lent credibility to the idea that females are a biologically inferior sex because, according to those theories, females were simply underdeveloped males.

Scientists continued to accept Aristotle's ideas about sex determination for centuries after his time. For example, Aristotle's ideas partly influenced Galen, a Greek physician and philosopher who lived between 129 CE to 216 CE. Around 200 CE, Galen documented male and female anatomy in a series of texts and depicted the female reproductive system as an identical but inverted version of the male reproductive system. Following Aristotle's teachings, Galen argues that reproductive organs remain inside of the female body, as the embryo did not develop to the point where it could push those organs outside of the body due to a lack of heat.

It was not until the seventeenth century that scientists began to question Aristotle's teachings. During that time, scientists began to discover germ cells, although the roles of sperm and egg cells during sex determination remained unclear. In 1651, William Harvey, a physician in the United Kingdom, demonstrated that Aristotle and Galen's ideas were not completely accurate, when he observed an empty uterus of an animal that recently mated. That observation implied that the mixture of fluids alone did not always give rise to an embryo. Rather, Harvey wrote that all mammals arise from egg cells, although he did not observe egg cells within the female body. Later, Antonie van Leeuwenhoek, who studied microorganisms in the Netherlands, was one of the first people to observe sperm cells. He described sperm cells in a letter to the Royal Society of London in London, United Kingdom, in 1676 as small eel-like animals, which he referred to as spermatic animalcules, in the semen of men and male dogs. Leeuwenhoek proposed that the spermatic animalcules provide substance vital to forming embryos, while female egg cells provide nutrients to the embryo.

Genetic analysis predates Gregor Mendel, but Mendel's laws form the theoretical basis of our understanding of the genetics of inheritance.

Mendel made two innovations to the science of genetics:

1. developed pure lines
2. counted his results and kept statistical notes

Pure Line - a population that breeds true for a particular trait [this was an important innovation because any non-pure (segregating) generation would and did confuse the results of genetic experiments]

Results from Mendel's Experiments

Parental Cross	F_1 Phenotype	F_2 Phenotypic Ratio	F_2 Ratio
Round x Wrinkled Seed	Round	5474 Round:1850 Wrinkled	2.96:1
Yellow x Green Seeds	Yellow	6022 Yellow:2001 Green	3.01:1
Red x White Flowers	Red	705 Red:224 White	3.15:1
Tall x Dwarf Plants	Tall	1787 Tall:227 Dwarf	2.84:1

Terms and Results Found in the Table

Phenotype - literally means "the form that is shown"; it is the outward, physical appearance of a particular trait Mendel's pea plants exhibited the following phenotypes:

- - round or wrinkled seed phenotype
- - yellow or green seed phenotype
- - red or white flower phenotype
- - tall or dwarf plant phenotype

Seed Color: Green and yellow seeds.

What is seen in the F_1 generation? We always see only one of the two parental phenotypes in this generation. But the F_1 possesses the information needed to produce both parental phenotypes in the following generation. The F_2 generation always produced a 3:1 ratio where the dominant trait is present three times as often as the recessive trait. Mendel coined two terms to describe the relationship of the two phenotypes based on the F_1 and F_2 phenotypes.

Dominant - the allele that expresses itself at the expense of an alternate allele; the phenotype that is expressed in the F_1 generation from the cross of two pure lines

Recessive - an allele whose expression is suppressed in the presence of a dominant allele; the phenotype that disappears in the F_1 generation from the cross of two pure lines and reappears in the F_2 generation

Mendel's Conclusions

1. The hereditary determinants are of a particulate nature. These determinants are called genes.
2. Each parent has a gene pair in each cell for each trait studied. The F_1 from a cross of two pure lines contains one allele for the dominant phenotype and one for the recessive phenotype. These two alleles comprise the gene pair.
3. One member of the gene pair segregates into a gamete, thus each gamete only carries one member of the gene pair.
4. Gametes unite at random and irrespective of the other gene pairs involved.

Mendelian Genetics Definitions

- **Allele** - one alternative form of a given allelic pair; tall and dwarf are the alleles for the height of a pea plant; more than two alleles can exist for any specific gene, but only two of them will be found within any individual
- **Allelic pair** - the combination of two alleles which comprise the gene pair
- **Homozygote** - an individual which contains only one allele at the allelic pair; for example DD is homozygous dominant and dd is homozygous recessive; pure lines are homozygous for the gene of interest
- **Heterozygote** - an individual which contains one of each member of the gene pair; for example the Dd heterozygote
- **Genotype** - the specific allelic combination for a certain gene or set of genes

Q.5 Explain what are ultimate and proximal causes of animal behaviours.

There are three basic methods to study animal behavior; these methods include observational, experimental and comparative. Observational methods include observing the organism of its environment without any manipulation, experimental methods manipulate a variable for examination of how it affects the behavior, and comparative methods use phylogeny to show ancestral relationships. Studying animal behavior can be categorized into proximate and ultimate causes of behavior. The proximate mechanism is immediate behavior, or within a specific amount of time whereas the ultimate mechanism is over a long period of time. To identify if a behavior is proximate or ultimate, Niko Tinbergen developed four questions to identify different behaviors done by an organism. These four questions are: 1) what mechanism caused the behavior? 2) How does behavior develop? 3) What is the function of the behavior? 4) How did the behavior evolve? There are a variety of perspectives to analyze animal behavior. These perspectives are comparative psychology, behaviorism, classical ethology, and other interdisciplinary approaches. When conducting animal behavior research, ethical animal use is required. To decrease the effect on animals, researches are encouraged to follow the three R's, which are replacement, reduction, and refinement.

Scientists utilize three main methods for studying animal behavior; observational, experimental, and comparative. In the observational method, the researcher physically watches the subject in the study without manipulating any variables. In the experimental method, scientists manipulate a specific variable to see how it affects animal behavior. Finally, in the comparative method researchers utilize both the ancestral and derived traits of the subject species to study animal behavior. An extension of the comparative method is comparative psychology, where researchers study animal behavior in order to understand human behavior.

One way to study wild animals is through classical ethology, where the animals are studied in their natural habitat through observation and experimentation. Animal behavior research requires ethical animal use, where animals are treated with handling and care, no malicious intent, and there are benefits for science. Replacement (use of computer technology), reduction (limiting the number of animals), and refinement (improving procedures and techniques) are all necessary factors in ethical animal use.

Early comparative psychology studied animal behavior to understand human minds. The field of behaviorism was derived from comparative psychology, which studies behavior independent of animal consciousness. This ranged from the Classical or Pavlov conditioning, to classical ethology, or, studying wild animals in nature. To quantify and articulate animal behavior, scientists study proximate mechanisms and the ultimate reasons for any behavior. Proximate explanations focus on the immediate cause of the behavior, and answer the questions: what mechanism caused the behavior, and how does the behavior develop? The ultimate explanation focuses on the evolutionary cause, answering the questions: what is the function of the behavior and how did it evolve? Researchers use observational, experimental, and comparative studies to answer these questions. The comparative method uses phylogeny to represent ancestor-descendent relationships. The two most closely related species are considered "sister species." In observational studies, the animal behavior is observed without any influence or manipulation. Experiments involve independent variables, dependent variables, and control groups to test the influence of a specific variable. Importantly, ethical behavior of the researcher needs to be considered for every situation, and there are many sources of ethical standards.

The study of animal behavior on the basis of evolution and the natural environment is called ethology. This approach was used by Konrad Lorenz, Niko Tinbergen, and Karl von Frisch. They were awarded the Nobel Prize in Physiology or Medicine in 1973. Ethologists observe the behavior of different animals in their natural environments. They study the behavior of closely related species. It gives information about the evolution and origin of certain behavior patterns. Ethologists are not interested inlearning. They are interested in animal communication, mating behavior and social behavior.

3. Behavioral ecology: It emphasizes the ecological aspects df animal behavior. The behavioral ecologists studies:

- Predator-prey interactions
- Foraging strategies
- • Reproductive strategies
- Habitat selection
- Intraspecific and interspecific competition
- Social behavior

The study of the evolution of social behavior is called sociobicilogy. It combines many aspects of ethology and behavioral ecology. Sociobiologists emphasize the importance of natural selection.

1. **Proximate causes:** More immediate ecological and physiological causes of behavior are called proximate causes. It includes eating to satisfy hunger
2. **Ultimate causes:** It is another level of causation in behavior. It occurs on the evolutionary time scale. For example, a display attracts a mate. It also increases the chance of passing genetic information to the next generation.

The application of human characteristics to anything not human is called anthropomorphism. The human feelings cannot be assigned to animal behavior. These animals (especially invertebrate) do. not give accurate human behavior. For example an earthworm is placed on a fishhook. It can be explained in two ways:.

(a) Anthropomorphic explanation: We think that the fish . can hurt the

earthworm. Or it can cause pain in it? Hurt and pain are human feelings. These are present in our conscious. Thus application of hurt and pain to earthworm is anthropomorphism. –

(b) Physiological explanation: We can explain this problem in another way. It reduces the anthropomorphic interpretation. We explain it that when the earthworm is placed on the hook, certain receptors are stimulated. These receptors generate nerve impulses. This impulse travel through neuron and causes reflex action. The impulses stimulate muscles. The contraction of muscles allows the worm to escape from the hook. This explanation gives the actual mechanism of reflex. It does not give the feelings of earthworm.