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PRACTICAL HANDBOOK OF ZOOLOGY (B. SC. I)
VOLUME II

AS PER NEP-2020 (2.0) SYLLABUS OF SHIVAJI UNIVERSITY, KOLHAPUR

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PREFACE

We are delighted to present this practical handbook to the B.Sc. students. This book is meticulously aligned with the revised syllabus of the NEP Shivaji University, Kolhapur, implemented from June 2024. In preparing this book, we have consulted various reference books and also gathered information from the internet. To facilitate students' understanding, we have used simple language and included large, accurate, and neatly labeled diagrams.

We extend our heartfelt gratitude to President Prof. K. V. Kurade and Prof. Anil Kurade, Secretary of Karmveer Vittal Ramaji Shinde Shikshan Sanstha, Gadhinglaj, as well as Ashok Anna Charati, President of Janata Education Society, Ajara and our management team for their continuous and supportive encouragement. We also thankful to Hon. Mr. Satej D. Patil (MLA), President, Shri Mouni Vidyapeeth, Gargoti and Management of Shri Mouni Vidyapeeth for their support and encouragement.

We are also deeply thankful to Principal Prof. (Dr.) S. M. Kadam of Shivraj College, Gadhinglaj, and Dr. A. N. Sadale, Principal of Ajara Mahavidyalaya, Ajara, for their essential guidance and support.

We sincerely hope that this book will meet the needs and expectations of B.Sc. first-year Zoology students. We invite readers to point out any mistakes, typographical errors, and to make any suggestions. Corrections and worthy suggestions will be incorporated into the next edition.

- **Mr. K. J. Adate**

Dr. V. V. Ajagekar

Dr. S. A. Vhanalakar

Dr. V. A. Jagtap

B. Sc. Part – I Semester – II

Zoology Practical– II

GENETICS AND ECOLOGY, ETHOLOGY. EVOLUTION AND ENTOMOLOGY

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I. PRACTICAL BASED ON GENETICS

1. Study Mendel's work with the help of different colored beads and other simulations.
2. Examples based on Gene mapping using data of crossing over and linkages.
3. Study of sex-linked inheritance by pedigree study.
4. Study of normal human spread chromosomes and sex determination
5. Identification of genetic syndrome by karyotype analysis
6. Identification of chromosomal aberration by studying karyotype
7. Identification ABO blood group
8. Drosophila culture, Handling, Life cycle and identification of Male and Female Drosophila and Mutants (After induction of mutation)
9. Examples based on Gene interactions and Multiple alleles

II. PRACTICAL BASED ON ECOLOGY, ETHOLOGY, EVOLUTION AND ENTOMOLOGY

ECOLOGY

Preparation of the following about pond and grassland ecosystems.

- Arranging the organisms in the Food chain and food web
- Arranging the organisms in different trophic levels of Ecological Pyramids

ETHOLOGY

- Mimicry in - monarch butterfly and stick insect
- Castes of Honey bee

EVOLUTION

- Types of fossils
- Arrangement of the animals as per the Geological Time Scale

ENTOMOLOGY

- Types of insect Mouthparts (House fly, Honeybee, Mosquito, Butterfly, cockroach)
- Entomophagy - Examples of edible insects according to theory
- Wonders in insects (Based on theory)

STUDY MENDEL'S WORK WITH THE HELP OF DIFFERENT COLOURED BEADS AND OTHER SIMULATIONS

Conducting a practical experiment to simulate Mendel's work using coloured beads is an excellent way to understand the principles of Mendelian genetics, specifically the laws of inheritance: The Law of dominance, The Law of Segregation and the Law of Independent Assortment.Here is a step-by-step guide for conducting the practical simulation based on Mendel's work using colored beads.

Objective

To simulate Mendel's work on the inheritance of traits using colored beads and to demonstrate the basic principles of Mendelian genetics, including dominant and recessive alleles, homozygosity, heterozygosity, and phenotypic and genotypic ratios.

Materials Needed

- Two colors of beads (e.g., Red for dominant allele and Blue for recessive allele)
- Two small bags or cups to represent the gene pool for each parent
- Paper or worksheet to record data

Part 1: Simulating Monohybrid Cross

Step 1: Setup the Parental Generation (P Generation)

- Choose one color of bead to represent the dominant allele (e.g., Red) and another color for the recessive allele (e.g., Blue).
- For the P generation, create two types of parents:
- One homozygous dominant parent (RR) represented by two red beads.
- One homozygous recessive parent (rr) represented by two blue beads.

Step 2: Simulate Gamete Formation

- Place the two red beads in one cup (representing gametes from the homozygous dominant parent) and the two blue beads in another cup (representing gametes from the homozygous recessive parent).
- Randomly pick one bead from each parent cup to represent the combination of alleles in the offspring.

Step 3: Simulate F1 Generation

- Record the results of the first cross between the two parents. For example, the F1 offspring will all be heterozygous (Rr) since they inherit one red bead (dominant) and one blue bead (recessive).

- The phenotype of the F1 generation will all be dominant (since the red bead represents the dominant allele), but the genotype will be heterozygous (Rr).

Step 4: Simulate F1 Cross to Produce F2 Generation

- Now, simulate the cross of two heterozygous F1 individuals.
- To do this, place one red and one blue bead in each of the two cups (representing Rr × Rr).
- Randomly pick one bead from each cup (representing the random fusion of gametes).
- Record the results for each trial, continuing until you have a total of at least 20 offspring.

Step 5: Calculate Phenotypic and Genotypic Ratios

- For each offspring, note whether the combination of beads is:
- Two red beads (RR) – Homozygous dominant
- One red and one blue bead (Rr) – Heterozygous
- Two blue beads (rr) – Homozygous recessive
- Record how many offspring show the dominant phenotype (RR or Rr) versus the recessive phenotype (rr).
- Calculate the phenotypic ratio (dominant to recessive) and the genotypic ratio (RR:Rr).

You should find a 3:1 phenotypic ratio and a 1:2:1 genotypic ratio if Mendelian principles hold.

Part 2: Simulating Dihybrid Cross

- In this part, we simulate Mendel's work with two traits. For simplicity, we will assume two traits, each controlled by two alleles, for example:
- Seed shape: Round (R) is dominant, wrinkled (r) is recessive.
- Seed color: Yellow (Y) is dominant, Green (y) is recessive.

Step 1: Setup the Parental Generation (P Generation)

- Use two more colors of beads (e.g., Yellow and Green) to represent the second trait (seed color).
- For the P generation, create two homozygous parents:
- One parent homozygous for both dominant traits (RRYY) represented by two red and two yellow beads.
- One parent homozygous for both recessive traits (rryy) represented by two blue and two green beads.

Step 2: Simulate Gamete Formation

- Place the red and yellow beads in one cup (representing RRYY) and the blue and green beads in another cup (representing rryy).
- Randomly select one bead from each parent to form a gamete and record the combinations.

Step 3: Simulate F1 Generation

- Cross the two parents to form the F1 generation, which will all be heterozygous (RrYy).
- Record the genotype and phenotype of the F1 offspring.

Step 4: Simulate F1 Cross to Produce F2 Generation

- Now, simulate the cross between two heterozygous F1 individuals (RrYy × RrYy).
- In this case, each parent can produce four types of gametes: RY, Ry, rY, ry. Use four different bead colors to represent these combinations.
- Randomly select one bead from each cup to represent the fusion of gametes, and record the results of each cross.

Step 5: Calculate Phenotypic and Genotypic Ratios

- Record the phenotypes for each offspring, noting which ones are:
- Dominant for both traits (round and yellow: RRYY, RrYy).
- Dominant for one trait but recessive for the other (round and green: R_Yy or wrinkled and yellow: rrY_).
- Recessive for both traits (wrinkled and green: rryy).
- Calculate the phenotypic ratio, which should approach 9:3:3:1 for the four phenotypic combinations.

Analysis:

In monohybrid crosses, the expected phenotypic ratio is 3:1 (dominant to recessive), and the genotypic ratio is 1:2:1 (homozygous dominant: heterozygous: homozygous recessive).

In dihybrid crosses, the expected phenotypic ratio is 9:3:3:1, demonstrating independent assortment of two traits.

Conclusion

This practical helps demonstrate Mendel's laws of inheritance by simulating the random assortment and segregation of alleles, reinforcing the understanding of Mendelian genetics through hands-on activities.

EXAMPLES BASED ON GENE MAPPING USING DATA OF CROSSING OVER AND LINKAGES

Gene mapping is a technique used to determine the relative positions of genes on a chromosome based on the frequency of recombination (crossing over) between them. The concept is based on the observation that the closer two genes are to each other, the less likely they are to be separated by recombination. Genes that are farther apart have a higher probability of crossing over. Here's a practical experiment based on gene mapping using crossing over and linkage data

Objective

To calculate the map distance between genes using recombination frequencies obtained from genetic crosses.

Materials Needed

- Data of recombination frequencies from genetic crosses (provided or hypothetical)
- Calculator or spreadsheet software
- Paper or worksheet to record calculations

Part 1: Understanding Recombination Frequency

The recombination frequency is the percentage of recombinant offspring produced in a genetic cross. It is used to estimate the distance between two genes on a chromosome. One map unit (also called a centiMorgan or cM) is equivalent to a 1% recombination frequency.

Formula: Recombination Frequency (%) = Number of Recombinants ÷ Total Offspring x100

Step 1: Hypothetical Data for Gene Mapping

We will use a hypothetical dataset based on three-point test cross involving three linked genes: A, B and C.

Phenotype	Number of Offspring
Parental ABc	350
Parental abC	340
Recombinant AbC	70
Recombinant aBc	80
Recombinant Abc	50
Recombinant abC	40
Double crossover aBC	10
Double crossover ABC	10
Total	**950**

Step 2: Identify Parental and Recombinant Classes

- Parental classes: The most frequent phenotypes represent parental (non-recombinant) offspring. Here, the parental types are "ABc" and "abC".
- Single recombinant classes: The next most frequent phenotypes represent single crossover events between genes. Here, they are "AbC", "aBc", "Abc" and "abC".
- Double recombinant classes: The least frequent phenotypes represent double crossover events. Here, they are "aBC" and "ABC".

Step 3: Calculate Recombination Frequency

1. **Between genes A and B**

   Count the offspring showing recombination between A and B (single recombinants and double recombinants)

   Single crossovers between A and B: "AbC" and "aBc" = 70 + 80 = 150

   Double crossovers: "aBC" and "ABC" = 10 + 10 = 20

   Total recombinants = 150 + 20 = 170

   Recombination frequency between A and B=170 ÷ 950 x 100 =17.89 %

   Map distance between A and B: 17.89 cM

2. **Between genes B and C**

   Count the offspring showing recombination between B and C

   Single crossovers between B and C: "Abc" and "abC" = 50 + 40 = 90

   Double crossovers: "aBC" and "ABC" = 10 + 10 = 20

   Total recombinants = 90 + 20 = 110

   Recombination frequency between B and C = 110 ÷ 950 × 100 = 11.58 %

   Recombination frequency between B and C= 950 ÷ 110 ×100=11.58%

   Map distance between B and C: 11.58 cM

3. **Between genes A and C**

   Count the offspring showing recombination between A and C (single recombinants and double recombinants):

   Single crossovers between A and C: "Abc" and "abC" = 50 + 40 = 90

   Double crossovers: "aBC" and "ABC" = 10 + 10 = 20

   Total recombinants = 90 + 20 = 110

   Recombination frequency between A and C = 110 ÷ 950 × 100 = 11.58 %

   Recombination frequency between A and C = 950 ÷ 110 ×100=11.58%

   Map distance between A and C: 11.58 cM

Part 2: Constructing the Gene Map

Once you have calculated the map distances, the next step is to determine the gene order and create the map.

Step 1: Determine the gene order

Based on the recombination frequencies, you can deduce that gene A and B are farther apart (17.89 cM), and B and C are closer together (11.58 cM).

The double crossover values also help confirm the order. The rarest classes indicate that the gene in the middle is B.

Step 2: Create the gene map

The gene order is A - B - C, and the distances between them are:

A to B: 17.89 cM

B to C: 11.58 cM

Thus, the gene map can be represented as

A 17.89 cM B 11.58 cM C

Part 3: Interpretation and Analysis

- The map distance between two genes is proportional to the frequency of crossing over between them.
- Double crossover events, though rare, are crucial in determining gene order.
- The total distance between A and C is approximately equal to the sum of the distances between A and B and B and C.

Conclusion

By analyzing recombination frequencies and crossover data, we can create a genetic map that reflects the relative positions of genes on a chromosome. The practical demonstrates Mendel's second law of independent assortment in cases where genes are not linked and also introduces the concept of linkage and crossover events when genes are located on the same chromosome.

STUDY OF SEX-LINKED INHERITANCE BY PEDIGREE STUDY

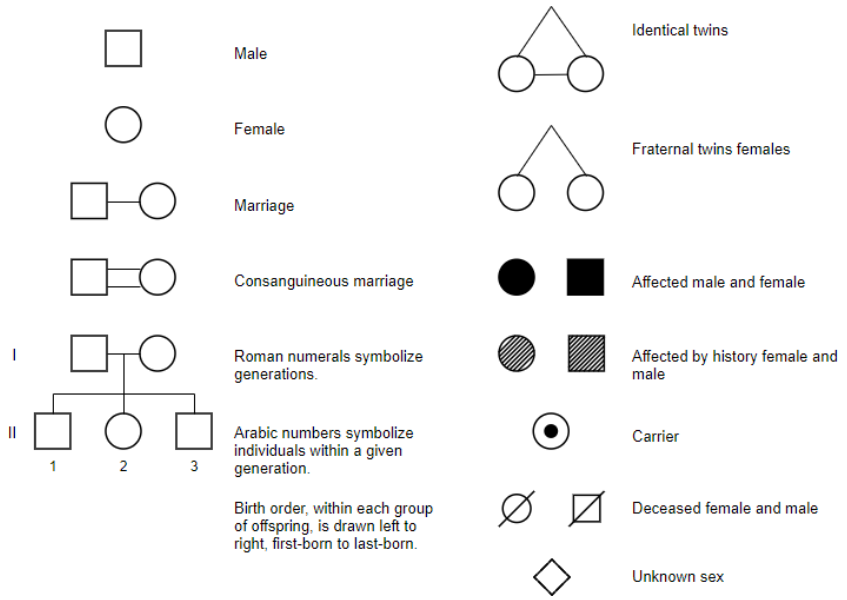
A practical experiment to study sex-linked inheritance using pedigree analysis involves tracing the inheritance pattern of a specific gene or trait over multiple generations. This exercise helps understand the inheritance of sex-linked traits, especially those linked to the X chromosome, like Color Blindness and Hemophilia.

Objective

To study the inheritance pattern of a sex-linked trait through a family pedigree and determine the mode of inheritance (X-linked dominant, X-linked recessive, or Y-linked).

Materials Needed

- Sample pedigree chart (can be hypothetical or based on actual data)
- Paper or worksheet to record observations
- Symbols in pedigree chart



SYMBOLS IN A PEDIGREE CHART

Key Concepts

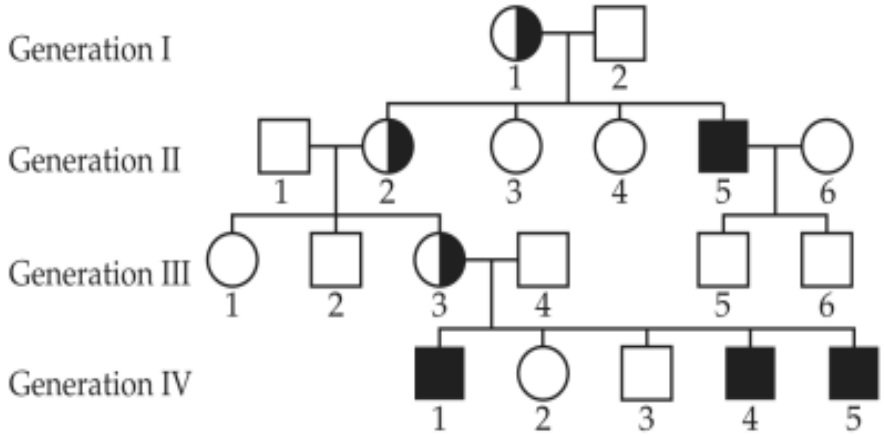
- **Sex-linked inheritance:** Traits controlled by genes located on the sex chromosomes (usually the X chromosome in humans).
- **X-linked recessive inheritance**: More common in males since they have only one X chromosome. Females need two copies of the defective gene to show the trait.
- **X-linked dominant inheritance:** Affected individuals, regardless of gender, will express the trait if they inherit one copy of the gene.
- **Y-linked inheritance:** Only males are affected since females do not inherit Y chromosomes.

Steps for Studying a Sex-Linked Trait in a Pedigree

Step 1: Choose or Create a Pedigree Chart

A pedigree chart is a diagram that shows the occurrence of a genetic trait across several generations. Use a sample pedigree chart for a sex-linked trait like Colour Blindness or Hemophilia or create a hypothetical one.

Here is a sample pedigree for color blindness (X-linked recessive)



PEDIGREE FOR COLOR BLINDNESS

Step 3: Analyze the Pattern of Inheritance

X-Linked Recessive Inheritance

1. **More males affected**: In X-linked recessive inheritance, males are more commonly affected since they have only one X chromosome (XY). If they inherit the defective gene on the X chromosome, they will express the trait. Females must inherit two defective X chromosomes to express the trait.
2. **Carrier females:** Females can be carriers of the trait without being affected. These females have one defective X chromosome and one normal X chromosome.
3. **Trait can skip generations**: If a carrier female passes the defective gene to her sons, the trait may appear in one generation, skip females, and appear again in male offspring.
4. **No male-to-male transmission**: Males pass their Y chromosome to their sons and their X chromosome to their daughters. Therefore, an affected father cannot pass the trait to his sons, but he can pass the defective X chromosome to his daughters, who become carriers.

Step 4: Make Predictions Based on the Pedigree

- Using the pedigree chart and your understanding of X-linked recessive inheritance, make predictions about the inheritance of the trait in future generations.

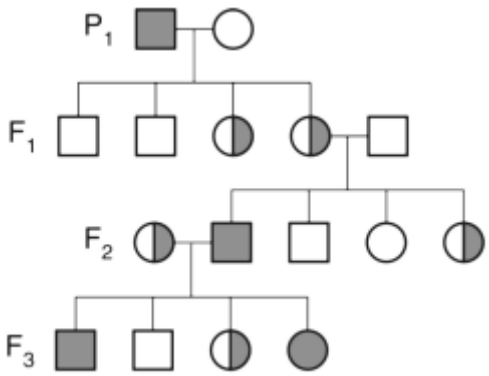
- If a carrier female (X^CX) marries an unaffected male (XY), each child has:
- A 50% chance of inheriting the defective X chromosome.
- Sons who inherit the X^C chromosome will be affected (X^CY). Daughters who inherit the X^Cchromosome will be carriers (X^C X). If a color-blind male (X^C Y) marries an unaffected female (XX), all their sons will be unaffected (since they inherit their father's Y chromosome), but all their daughters will be carriers (since they inherit their father's X^C chromosome).

Step 5: Draw Conclusions

- Based on the analysis of the pedigree and the inheritance patterns, you can conclude:
- The trait follows an X-linked recessive inheritance pattern.
- Males are more likely to express the trait because they only need one copy of the defective allele.
- Carrier females can pass the trait to their sons.
- The trait is not passed from father to son, but affected males pass the allele to all their daughters, making them carriers.

Example Pedigree

Let’s analyze another sample pedigree for hemophilia (another X-linked recessive disorder).



PEDIGREE FOR HEMOPHILIA

Conclusion

This practical exercise using pedigree charts helps identify patterns of sex-linked inheritance and analyze traits that follow X-linked recessive inheritance patterns. It demonstrates the relationship between carrier females and affected males, as well as the lack of male-to-male transmission.

STUDY OF NORMAL HUMAN SPREAD CHROMOSOMES AND SEX DETERMINATION

The study of normal human spread chromosomes and sex determination is a crucial part of understanding human genetics and how chromosomes influence the biological sex of an individual. This practical exercise involves observing human chromosomes, identifying karyotypes and determining the sex of an individual based on their chromosomes.

Objective

To study human chromosomes in a karyotype, identify and count the chromosome pairs, and determine the sex of an individual based on the presence of sex chromosomes (XX or XY).

Materials Needed

- Prepared slides of human chromosome spreads (karyotype preparation)
- Microscope or image of human karyotypes
- Chart of human chromosomes for reference (optional)
- Paper or worksheet to record findings

Human Chromosomes

- Humans have 46 chromosomes arranged in 23 pairs.
- 22 pairs are autosomes (non-sex chromosomes), and 1 pair are the sex chromosomes.
- Chromosomes can be classified based on size, banding pattern and the location of the centromere (middle constriction).

Karyotype

- A karyotype is a picture of an individual's chromosomes arranged in pairs.
- Karyotyping is used to detect chromosomal abnormalities, determine the number of chromosomes and identify the sex chromosomes.

Sex Determination

- The sex of a human is determined by the 23rd pair of chromosomes
- XX for females
- XY for males
- The Y chromosome contains the SRY gene (Sex-determining Region Y), which initiates male sex determination.

Procedure for Studying Normal Human Chromosomes and Sex Determination

Step 1: Prepare and Observe Chromosome Spreads

- Chromosome spreads (also called metaphase spreads) are prepared from dividing cells in the metaphase of mitosis because chromosomes are most condensed and visible during this stage.

- A sample is usually taken from blood, bone marrow or amniotic fluid cells, but for this practical, use prepared slides or karyotype images.

Step 2: Observation under Microscope or with Image

- Place the prepared slide of the human chromosome spread under the microscope.
- Focus on the metaphase spread where chromosomes are clearly visible.
- Observe the chromosomes and try to identify the distinct features of each chromosome, such as size and banding pattern.
- If using an image of a karyotype, you can analyze the chromosomes more easily without a microscope.

Step 3: Identifying Chromosome Pairs

- Begin by identifying the largest chromosomes and the smallest ones. Chromosome pairs are numbered from 1 to 22 based on their size, with 1 being the largest and 22 the smallest.
- Match the chromosomes into pairs based on size, shape, and banding patterns. Chromosomes are typically paired by comparing their lengths and positions of the centromeres.
- For each chromosome pair, note the total number of chromosomes in the spread, which should be 46 in a normal human karyotype.
- Record the presence of 22 pairs of autosomes.

Step 4: Identifying the Sex Chromosomes

- Identify the 23rd pair of chromosomes (the sex chromosomes)
- For females, both sex chromosomes will be large and look identical, indicating the XX karyotype.
- For males, one sex chromosome will be larger (the X chromosome), while the other will be significantly smaller (the Y chromosome), indicating the XY karyotype.

Determine the sex of the individual

- If the 23rd pair consists of two large chromosomes (XX), the individual is female.
- If the 23rd pair consists of one large and one small chromosome (XY), the individual is male.

Step 5: Record Your Observations

- Record the total number of chromosomes (should be 46 in a normal human).
- Record the number of autosomes (should be 22 pairs or 44 autosomes).
- Record the sex chromosomes (XX for female, XY for male).

Part 1: Sample Data Interpretation

Let's interpret an example of a normal human karyotype.

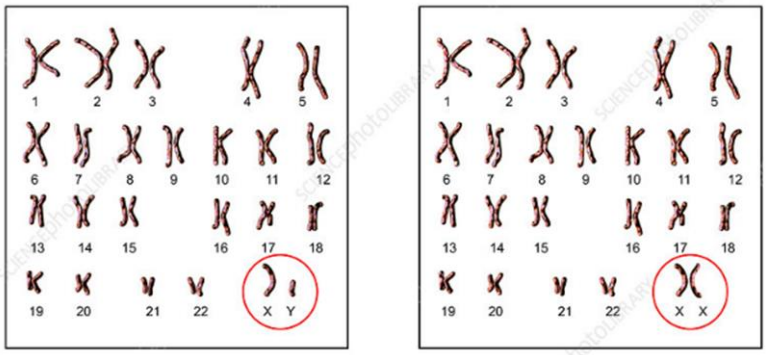
Chromosome Pair	Description
Pairs 1 to 22	Present as identical pairs, large to small
23rd Pair	One large chromosome (X) and one small (Y)
Total Chromosomes	46
Sex Determination	XY – Male

The individual in this karyotype is a male since they have an XY chromosome pair at position 23.

Part 2: Analyzing Different Karyotypes for Sex Determination

Female Karyotype (46, XX)

- Chromosome spread shows 46 chromosomes.
- The 22 pairs of autosomes are normal.
- The 23rd pair consists of two X chromosomes, both relatively large.
- Conclusion The individual is female.



Human Karyotypes (Normal Male and Normal female)

Conclusion

This practical helps studentsto understand how to analyze and identify normal human chromosome spreads, interpret karyotypes, and determine sex based on the presence of XX or XY chromosomes. By analyzing the 23rd pair of chromosomes, sex determination can be accurately carried out, and deviations from normal karyotypes can help identify genetic disorders related to sex chromosome abnormalities.

IDENTIFICATION OF GENETIC SYNDROME BY KARYOTYPE ANALYSIS

Karyotype analysis is a powerful tool used in genetics to identify chromosomal abnormalities, which can lead to genetic syndromes. By studying the number, structure, and arrangement of chromosomes in an individual's cells, specific genetic syndromes such as Down syndrome, Turner syndrome, or Klinefelter syndrome can be identified.

Objective

To study and identify genetic syndromes by analyzing human karyotypes for chromosomal abnormalities.

Materials Needed

- Prepared karyotype images or slides of human chromosomes
- Reference chart of human chromosomes (optional)
- Microscope (if using actual slides)
- Paper or worksheet to record observations

Background Information

A karyotype is an organized profile of an individual's chromosomes. Chromosomes are stained and photographed during metaphase of cell division and then arranged in pairs according to size, banding pattern, and centromere position.

Humans have 23 pairs of chromosomes (46 in total), with 22 pairs of autosomes and 1 pair of sex chromosomes.

Chromosomal Abnormalities

- **Numerical abnormalities:** These involve the gain or loss of entire chromosomes (e.g., trisomy or monosomy).
- **Structural abnormalities:** These involve changes in chromosome structure, such as deletions, duplications, inversions, or translocations.

Genetic Syndromes: Some well-known syndromes caused by chromosomal abnormalities include

- Down Syndrome (Trisomy 21): Extra chromosome 21.
- Turner Syndrome (45, X): Missing one X chromosome.
- Klinefelter Syndrome (47, XXY): Extra X chromosome in males.
- Edward Syndrome (Trisomy 18): Extra chromosome 18.
- Patau Syndrome (Trisomy 13): Extra chromosome 13.

Procedure: Karyotype Analysis and Identification of Genetic Syndromes

Step 1: Preparation and Observation of Karyotypes

- Obtain karyotype images: You can either observe prepared microscope slides of chromosome spreads or use printed or digital karyotype images.
- Examine the chromosomes under the microscope or in the provided image. Look for:
- The total number of chromosomes.
- The pairing of chromosomes (22 pairs of autosomes and 1 pair of sex chromosomes).
- The size, structure, and banding pattern of each chromosome.
- Arrange the chromosomes in pairs from largest to smallest, assigning them numbers from 1 to 22 (autosomes) and the 23rd pair as the sex chromosomes (XX or XY).

Step 2: Count the Number of Chromosomes

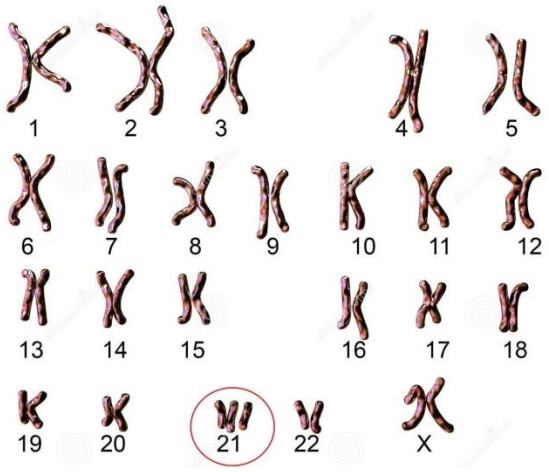
- Count the total number of chromosomes. In a normal individual, there should be 46 chromosomes.
- If there are 47 chromosomes or 45 chromosomes, a numerical chromosomal abnormality is present, which is usually the cause of a genetic syndrome.

Step 3: Identify Chromosomal Abnormalities

Look for abnormalities in the number or structure of the chromosomes. Use the following guidelines for identification of specific syndromes

Example 1: Down Syndrome (Trisomy 21)

- **Description:** Down syndrome is caused by the presence of an extra chromosome 21 (trisomy 21). Individuals have 47 chromosomes in total, with three copies of chromosome 21 instead of two.

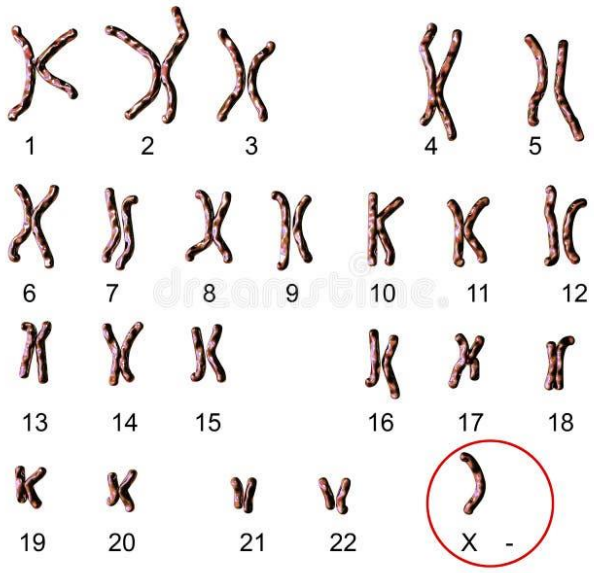


DOWN SYNDROME (TRISOMY 21)

- Steps to Identify
- Count the total number of chromosomes. If there are 47 chromosomes, this indicates an extra chromosome.
- Check chromosome 21. There should be three copies of chromosome 21 instead of the normal two.
- Karyotype: 47, XX, +21 (for a female with Down syndrome) or 47, XY, +21 (for a male with Down syndrome).

Example 2: Turner Syndrome (45, X)

- Description: Turner syndrome is caused by the absence of one X chromosome in females. Individuals with Turner syndrome have only 45 chromosomes instead of the normal 46 and are missing one sex chromosome.

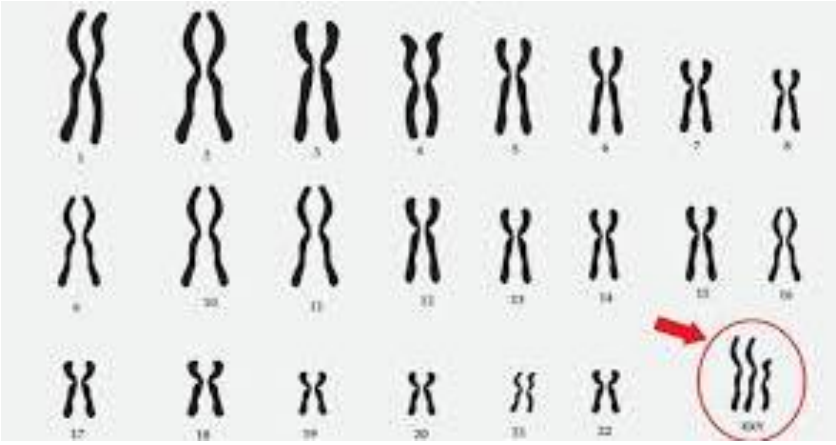


TURNER SYNDROME (45, X)

- Steps to Identify
- Count the total number of chromosomes. If there are 45 chromosomes, this indicates a missing chromosome.
- Check the sex chromosomes. In Turner syndrome, only one X chromosome is present, with no second sex chromosome (no Y chromosome and no second X chromosome).
- Karyotype: 45, X (for a female with Turner syndrome).

Example 3: Klinefelter Syndrome (47, XXY)

- Description: Klinefelter syndrome is caused by the presence of an extra X chromosome in males. Individuals with Klinefelter syndrome have 47 chromosomes in total, including two X chromosomes and one Y chromosome.

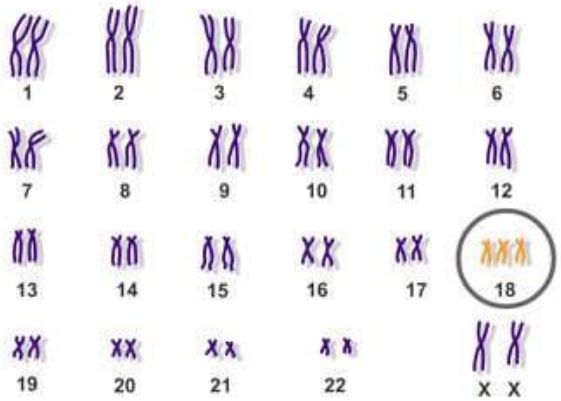


KLINEFELTER SYNDROME (47, XXY)

- Steps to Identify
- Count the total number of chromosomes. If there are 47 chromosomes, this indicates an extra chromosome.
- Check the sex chromosomes. In Klinefelter syndrome, there will be two X chromosomes and one Y chromosome (XXY).
- Karyotype: 47, XXY (for a male with Klinefelter syndrome).

Example 4: Edward Syndrome (Trisomy 18)

- Description: Edward syndrome is caused by the presence of an extra chromosome 18. Individuals with Edward syndrome have 47 chromosomes, including three copies of chromosome 18.

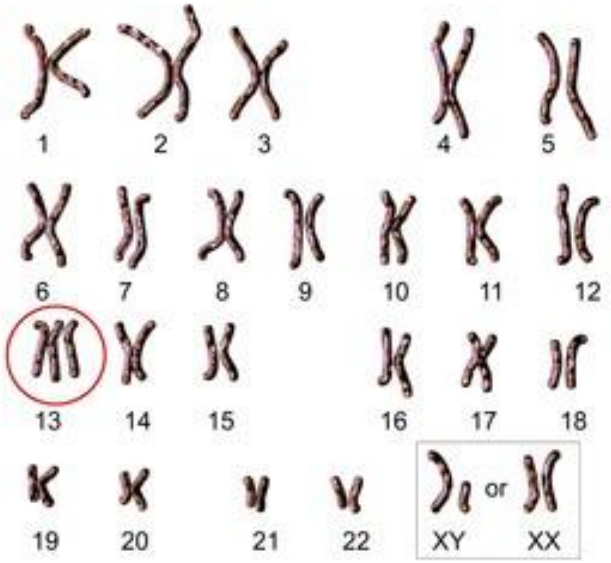


EDWARD SYNDROME (TRISOMY 18)

- Steps to Identify
- Count the total number of chromosomes. If there are 47 chromosomes, this indicates an extra chromosome.
- Check chromosome 18. There should be three copies of chromosome 18 instead of the normal two.
- Karyotype: 47, XX, +18 (for a female with Edward syndrome) or 47, XY, +18 (for a male with Edward syndrome).

Example 5: Patau Syndrome (Trisomy 13)

- Description: Patau syndrome is caused by the presence of an extra chromosome 13. Individuals with Patau syndrome have 47 chromosomes, including three copies of chromosome 13.



PATAU SYNDROME (TRISOMY 13)

- Steps to Identify
- Count the total number of chromosomes. If there are 47 chromosomes, this indicates an extra chromosome.
- Check chromosome 13. There should be three copies of chromosome 13 instead of the normal two.
- Karyotype: 47, XX, +13 (for a female with Patau syndrome) or 47, XY, +13 (for a male with Patau syndrome).

Step 4: Record Your Observations and Conclusions

- Record the total number of chromosomes observed in the karyotype (normal = 46, abnormal = 45, 47, etc.).
- Identify any additional or missing chromosomes, such as an extra chromosome 21 (Trisomy 21) or a missing X chromosome (Turner syndrome).
- Determine the genetic syndrome based on the chromosomal abnormality observed (e.g., Down syndrome, Klinefelter syndrome, etc.).
- Conclude the type of chromosomal abnormality present (numerical or structural) and the associated syndrome.

Conclusion

By analyzing karyotypes, genetic syndromes can be identified based on chromosomal abnormalities. The presence of extra or missing chromosomes often leads to well-known syndromes such as Down syndrome (Trisomy 21), Turner syndrome (45, X) and Klinefelter syndrome (47, XXY). Karyotype analysis is an essential technique in genetic diagnostics for identifying chromosomal disorders and providing important information for medical treatment and counseling.

IDENTIFICATION OF CHROMOSOMAL ABERRATION BY STUDYING KARYOTYPE

The study of chromosomal aberrations through karyotyping is an essential part of cytogenetics, allowing researchers and medical professionals to identify genetic disorders and abnormalities. Here's a step-by-step practical guide based on the identification of chromosomal aberrations by studying Karyotypes.

Objective

To observe and identify chromosomal aberrations in a karyotype and to differentiate between normal and abnormal chromosomal patterns.

Materials Required

- Microscope
- Karyotyping software (if using digital images)
- Prepared slides of metaphase chromosomes (human or other species)
- Karyotype charts (for comparison)
- Staining reagents (Giemsa stain or similar for chromosome visualization)
- Immersion oil (if needed for microscopic examination)
- Ruler and protractor (for measuring chromosome lengths and centromere position)

Karyotyping involves the visualization of chromosomes in metaphase, when they are most condensed and distinguishable. This allows for the identification of structural and numerical chromosomal abnormalities. Chromosomal aberrations can be of two types:

1. **Numerical aberrations** (Aneuploidy): Abnormal number of chromosomes, e.g., Trisomy 21 (Down Syndrome)
2. **Structural aberrations**: Changes in chromosomes structure, e.g., Deletions, Duplications, Inversions and Translocations

Procedure

1. Chromosome Preparation (for lab-based karyotyping)

- **Cell culture and harvest**: Peripheral blood or other tissue samples are cultured to stimulate mitosis.
- **Arrest cells in metaphase**: Cells are treated with colchicine or another mitotic inhibitor to stop cell division at metaphase, where chromosomes are highly condensed.
- **Hypotonic treatment**: The cells are treated with a hypotonic solution to swell them, making chromosomes spread out.

- **Fixation**: Cells are fixed using a fixative like methanol-acetic acid to preserve them for microscopic examination.
- **Slide preparation**: A drop of the cell suspension is placed on a slide and air-dried.
- **Staining**: The slide is stained using Giemsa or other banding techniques to visualize the chromosomes. The most common banding technique is **G-banding** (Giemsa banding).

2. Microscopic Observation

- Place the stained slide under a microscope.
- Use low magnification to locate cells in metaphase.
- Switch to high magnification to examine individual chromosomes.
- Take photographs or use karyotyping software for further analysis.

3. Analysis of Karyotype

- **Arrangement of chromosomes**: Use the software or manual sorting to arrange the chromosomes in a standard format based on size and centromere position (Metacentric, Submetacentric, or Acrocentric).
- Chromosomes are grouped into 7 categories (A-G) based on their size and centromere location.

4. Identification of Chromosomal Aberrations

Numerical Aberrations: Check the number of chromosomes to identify aneuploidies like:

- **Trisomy 21** (47, XX/XY +21): Presence of an extra chromosome 21, indicating Down syndrome.
- **Turner Syndrome** (45, X0): Only one X chromosome and no second sex chromosome.
- **Klinefelter Syndrome** (47, XXY): One extra X chromosome in males.

Structural Aberrations: Look for structural changes like:

- **Deletions**: Missing parts of chromosomes.
- **Duplications**: Extra copies of parts of chromosomes.
- **Translocations**: Parts of chromosomes swapped between non-homologous chromosomes.
- **Inversions**: Reversed segments of chromosomes.
- **Ring chromosomes**: Chromosomes form a ring due to deletion of telomeres and fusion of chromosome ends.

5. Documentation and Interpretation

- Document the karyotype, labelling the chromosomes in pairs.
- Compare the observed karyotype with normal karyotype charts to identify any deviations.
- Report the chromosomal abnormalities along with their clinical implications.

Example of Chromosomal Aberrations

1. **Down Syndrome (Trisomy 21)**
    - **Karyotype**: 47, XX +21 (female) or 47, XY +21 (male)
    - **Observation**: Three copies of chromosome 21.
2. **Turner Syndrome**
    - **Karyotype**: 45, X0 (only one X chromosome)
    - **Observation**: Missing one sex chromosome (no Y chromosome).
3. **Klinefelter Syndrome**
    - **Karyotype**: 47, XXY
    - **Observation**: One extra X chromosome in a male.
4. **Cri du Chat Syndrome**
    - **Karyotype**: 46, XX/XY, 5p-
    - **Observation**: Deletion of part of the short arm of chromosome 5.

Precautions

- Handle all reagents and slides carefully to avoid contamination.
- Ensure proper banding for accurate chromosomal identification.
- Use proper magnification and focusing techniques when analyzing the chromosomes under a microscope.

Conclusion

By studying a karyotype, we can identify chromosomal abnormalities, which can be linked to genetic disorders. Karyotyping is a powerful diagnostic tool in medical genetics, and the detection of chromosomal aberrations helps in understanding the aetiology of various syndromes and conditions.

IDENTIFICATION ABO BLOOD GROUP

The ABO blood group system is one of the most important blood typing systems in transfusion medicine. It is based on the presence or absence of specific antigens (A and B) on the surface of red blood cells and corresponding antibodies in the plasma. This practical will guide you through the process of identifying a person's ABO blood group using a simple agglutination test.

Objective

To determine an individual's ABO blood group by performing an agglutination test using anti-A, anti-B and anti-D (Rh) serums.

Materials Needed

- Blood sample (or synthetic blood samples for demonstration purposes)
- Anti-A serum (contains antibodies against A antigens)
- Anti-B serum (contains antibodies against B antigens)
- Anti-D serum (for Rh factor testing, to determine if the blood is Rh-positive or Rh-negative)
- Glass slides or test tubes (for mixing blood with serums)
- Dropper or pipette
- Sterile lancet (if using fresh blood)
- Cotton swabs and alcohol (for cleaning skin if using fresh blood)
- Marker for labeling slides/test tubes
- Observation sheet to record results

ABO Blood Group System

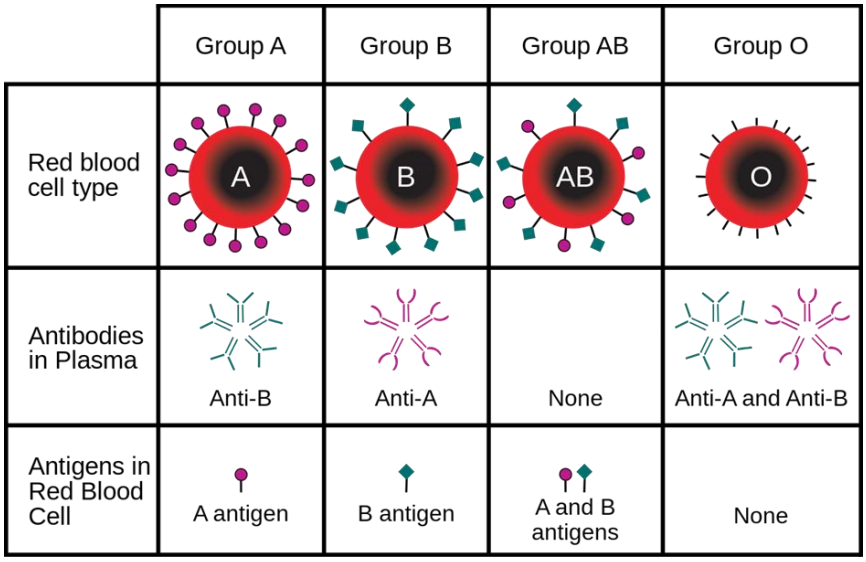
- Type A: Has A antigens on red blood cells and anti-B antibodies in the plasma.
- Type B: Has B antigens on red blood cells and anti-A antibodies in the plasma.
- Type AB: Has both A and B antigens on red blood cells and no ABO antibodies in the plasma.
- Type O: Has no A or B antigens on red blood cells and both anti-A and anti-B antibodies in the plasma.

Rh Factor

The Rh factor is another important antigen. If the D antigen is present, the person is Rh-positive. If absent, they are Rh-negative.

Agglutination Reaction

When anti-A or anti-B serum is mixed with blood containing the corresponding antigen, agglutination (clumping of red blood cells) occurs, indicating the presence of that antigen.



ABO BLOOD GROUP SYSTEM

Procedure

Step 1: Prepare the Work Area

- Clean the workspace and gather all the necessary materials.
- If using fresh blood, clean the skin with alcohol and use a sterile lancet to prick the finger. Collect a small drop of blood on a clean glass slide or test tube.
- Label the slide/test tube into three sections: Anti-A, Anti-B, and Anti-D.

Step 2: Add Anti-Serum to Blood Samples

- Place one drop of Anti-A serum on the part of the slide/test tube labeled "Anti-A."
- Place one drop of Anti-B serum on the part of the slide/test tube labeled "Anti-B."
- Place one drop of Anti-D serum on the part of the slide/test tube labeled "Anti-D" to test for Rh factor.
- Add a small drop of the blood sample to each of the three spots containing the serums.

Step 3: Mix and Observe Agglutination

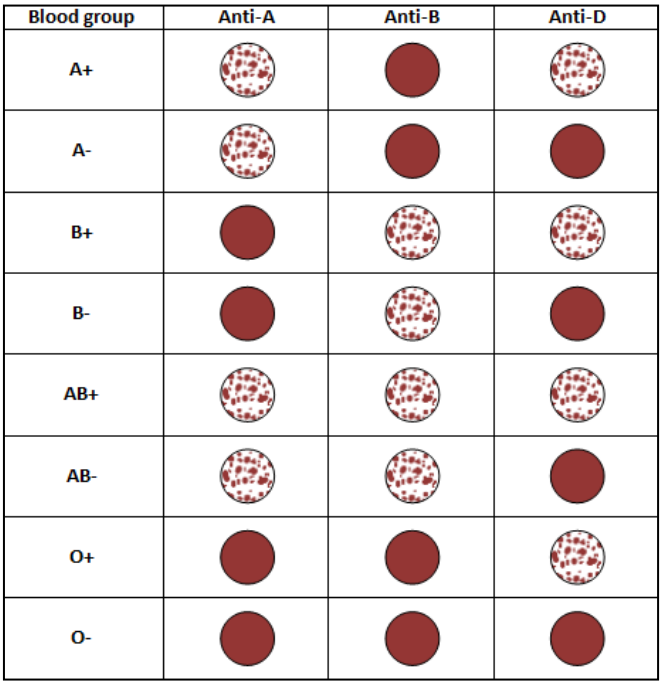
- Use a clean toothpick or stirrer to gently mix each blood-serum combination.
- Observe the slides or test tubes for agglutination (clumping of red blood cells) within 2 to 3 minutes.
- Agglutination indicates a positive reaction: This means that the corresponding antigen is present on the red blood cells.
- No agglutination indicates a negative reaction: This means that the corresponding antigen is absent.

Step 4: Interpret the Results

Based on the presence or absence of agglutination in the reactions, determine the ABO blood type and Rh factor of the sample.

Result Interpretation

Blood Group	Anti-A Reaction	Anti-B Reaction	Anti-D (Rh) Reaction	Conclusion
A+	Agglutination	No agglutination	Agglutination	A positive (A+)
A-	Agglutination	No agglutination	No agglutination	A negative (A-)
B+	No agglutination	Agglutination	Agglutination	B positive (B+)
B-	No agglutination	Agglutination	No agglutination	B negative (B-)
AB+	Agglutination	Agglutination	Agglutination	AB positive (AB+)
AB-	Agglutination	Agglutination	No agglutination	AB negative (AB-)
O+	No agglutination	No agglutination	Agglutination	O positive (O+)
O-	No agglutination	No agglutination	No agglutination	O negative (O-)



Step 5: Record Your Results

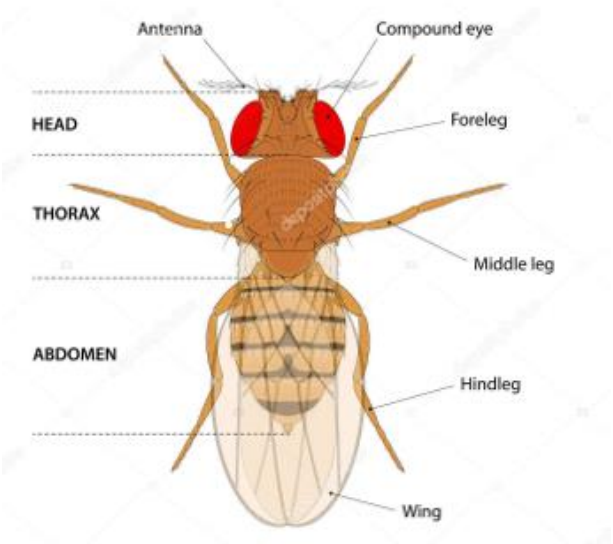
- Record your observations in a table format, noting whether agglutination occurred for each serum.
- Based on the observed agglutination patterns, determine the blood type (ABO and Rh factor) for each sample and write it in the Conclusion column.

Conclusion

This practical experiment demonstrates the process of determining an individual's blood type based on the ABO system and Rh factor. By observing the agglutination reactions with Anti-A, Anti-B, and Anti-D serums, it is possible to accurately identify a person's blood group. This knowledge is critical in medicine, especially for blood transfusions, organ transplants and understanding certain genetic inheritance patterns.

DROSOPHILA CULTURE, HANDLING, LIFE CYCLE AND IDENTIFICATION OF MALE AND FEMALE DROSOPHILA AND MUTANTS (AFTER INDUCTION OF MUTATION)

The Drosophila melanogaster (fruit fly) is a widely used model organism in genetic studies due to its short life cycle, ease of handling, and genetic similarities with humans. In this practical, you'll learn how to handle Drosophila cultures, identify male and female flies, study their life cycle, and recognize different mutants after induction of mutations.



DROSOPHILA MELANOGASTER

Objective

- To culture and handle Drosophila melanogaster.
- To study the life cycle of Drosophila.
- To identify the differences between male and female Drosophila.
- To identify common mutants of Drosophila after mutation induction.

Materials Needed

- Drosophila culture (wild-type and mutant strains, if available)
- Fly food medium (pre-mixed Drosophila food or a mixture of cornmeal, yeast, sugar, and agar)
- Vials or bottles with cotton plugs
- Brushes (for handling flies)
- CO_2 anesthesia or an ice bath (to anesthetize the flies)
- Dissecting microscope or hand lens (for observing small details)
- Petri dishes or small trays

- Fine tweezers
- Fly morgue (container with alcohol or soapy water for discarded flies)

Part 1: Drosophila Culture and Handling

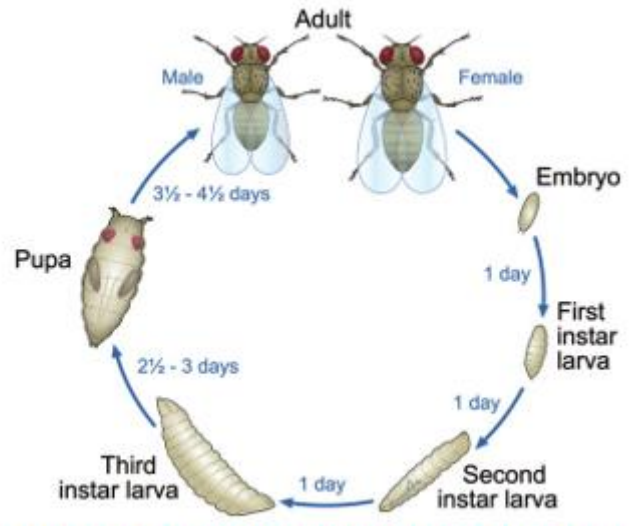
Step 1: Setting Up Drosophila Culture

- Prepare the food medium in culture vials or bottles
- Use commercially available fly food or mix cornmeal, yeast, sugar and agar. Boil and pour into vials. Allow the medium to cool and solidify.
- Ensure the surface is smooth and add a few grains of yeast to the medium.
- Once the food is ready, introduce adult Drosophila flies into the vials
- Place a small group of wild-type flies (5-10) in each vial to allow mating and egg-laying.
- Plug the vials with cotton wool to prevent flies from escaping while still allowing airflow.

Step 2: Handling Drosophila

- To handle Drosophila safely, anesthetize them using CO_2 or an ice bath
- CO_2 anesthesia: Use a small CO_2 pad or chamber to expose flies to carbon dioxide for a short period. This makes them immobile for a few minutes.
- Ice bath: Chill a small petri dish on ice and place the flies in it. They will slow down and stop moving due to the cold.
- Transfer flies carefully using a fine brush or tweezers without damaging their delicate wings or legs.

Part 2: Life Cycle of Drosophila melanogaster



LIFE CYCLE OF DROSOPHILA MELANOGASTER

Step 1: Overview of the Life Cycle

- The life cycle of Drosophila melanogaster is divided into four main stages:
- Egg (1 day after fertilization)
- Larva (3 stages called instars; approximately 4-5 days)
- Pupa (around 4 days)
- Adult (lives for several weeks)
- The entire life cycle from egg to adult typically takes about 10-12 days at room temperature (25°C).

Step 2: Observation of Life Cycle Stages

- Observe the vials after 1-2 days to see eggs laid by the adult flies. Eggs are small, white, and oval-shaped with filaments at one end.
- After 2-3 days, observe larvae emerging from the eggs. Larvae are small, white, and worm-like. They crawl on the food surface, feeding and molting through three instar stages.
- After 4-6 days, larvae crawl to the sides of the vial and form pupae. The pupa is a brownish, elongated structure, marking the transition to adulthood.
- After 10-12 days, adult flies will emerge from the pupae. Observe them and note that males and females are visible shortly after emergence.

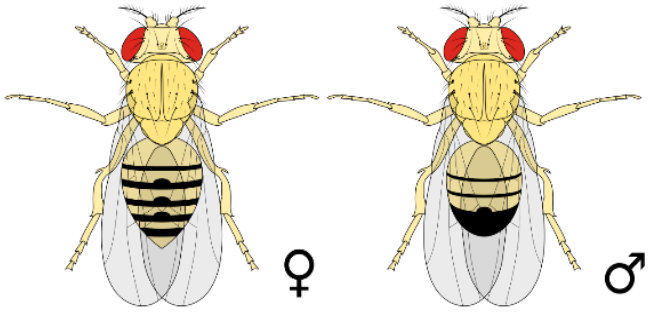
Part 3: Identification of Male and Female Drosophila

Step 1: Anesthetize the Flies

- Anesthetize the adult Drosophila as described in Part 1 to immobilize them for closer observation.

Step 2: Observing Morphological Differences

- Place the anesthetized flies under a dissecting microscope or use a magnifying lens to examine their physical features
- **Size:** Females are generally larger than males.
- **Abdomen Shape:** Females have a more elongated and pointed abdomen. Males have a more rounded and shorter abdomen.
- **Sex Comb:** Males have a characteristic sex comb (a group of bristle-like structures) on the first pair of legs. This is absent in females.
- **Genitalia:** Females have a visible ovipositor at the tip of the abdomen.
- Males have dark, rounded genitalia at the end of the abdomen.
- **Color:** The posterior abdomen of males is typically darker than that of females.



FEMALE AND MALE DROSOPHILA

Step 3: Record Your Observations

- Separate the flies into males and females based on the morphological differences.
- Record the characteristics observed and the ratio of males to females in the vial.

Part 4: Identification of Mutants (After Induction of Mutation)

Step 1: Mutant Strains of Drosophila

Mutations in Drosophila can be induced using chemicals (e.g., EMS), radiation, or they can occur spontaneously. Some common mutant traits include:

- **White eyes:** Mutation causes eyes to be white instead of red.
- **Vestigial wings:** Mutants have small or underdeveloped wings.
- **Curly wings:** Wings appear curled upward.
- **Sepia eyes:** Dark brown or sepia-colored eyes.
- **Ebony body:** Body is much darker (almost black) than the wild-type.

Step 2: Observation of Mutants

Anesthetize both wild-type and mutant flies using the methods described earlier.Place them under a microscope and compare their features with the wild-type flies. Note specific traits such as

- **Eye color:** Compare the eye color (red, white, sepia).
- **Wing shape and size:** Observe any abnormalities in wing development (curly, vestigial).
- **Body color:** Look for differences in pigmentation (e.g., ebony body).
- Record the phenotype (observable traits) of each mutant type and describe how they differ from wild-type flies.

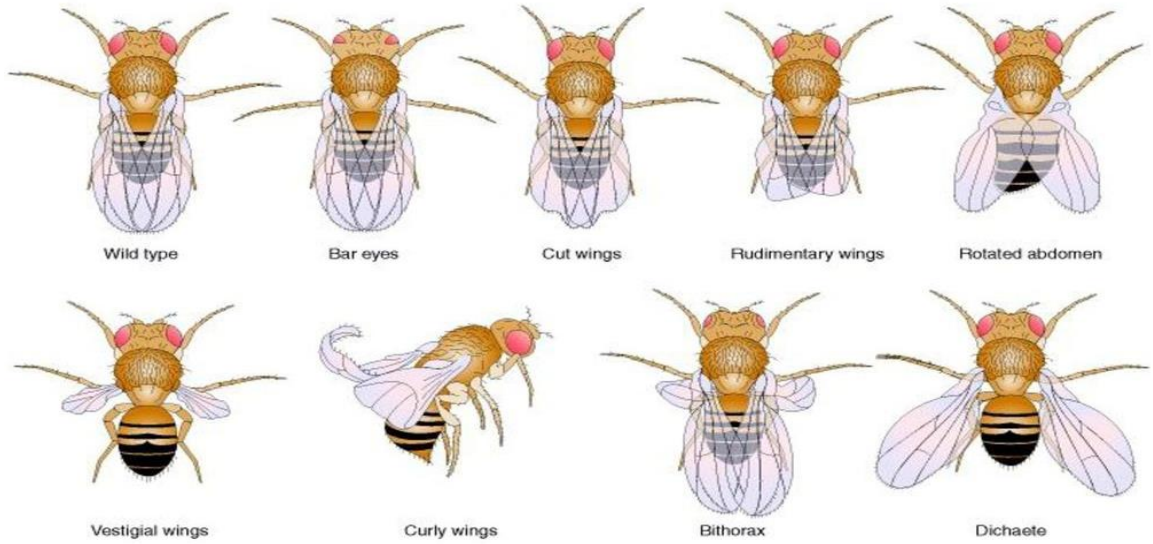
Step 3: Identifying Mutations

- Using the Mendelian principles of inheritance, mutants can often be linked to specific genetic alterations. For example:

- White eyes are linked to mutations in the X chromosome (sex-linked recessive inheritance).
- Vestigial wings follow autosomal recessive inheritance.

Step 5: Record Your Results

- Record observations in a table format, noting the phenotypes of wild-type and mutant flies.
- Include data on:
- Sex (male/female) identification
- Life cycle stage (if relevant)
- Mutant characteristics (eye color, wing shape, body color, etc.)



MUTANT STRAINS OF DROSOPHILA

Conclusion

This practical experiment covers the fundamental aspects of Drosophila handling, life cycle, sex determination, and mutant identification. The short life cycle of Drosophila makes it ideal for observing genetic inheritance and phenotypic variation, providing valuable insights into genetics. The ability to identify common mutations is crucial for understanding how genetic changes affect phenotypes and for studying the principles of inheritance in real-time.

EXAMPLES BASED ON GENE INTERACTIONS AND MULTIPLE ALLELES

EXAMPLES BASED ON GENE INTERACTIONS OF GENES

1. In Rat C represents the gene for the black pigment and A the gene for yellow pigment, combination of two dominant alleles of two different genes one for black and one for yellow results in agouti pattern. While cc genotypes produce cream colour, which appear albino. If a black individual (CCaa) crossed with albino (ccAA) what will be the phenotypes of the F1 and F2 generations? **(ANS: 9:3:4)**
2. In Indian corn let gene C and P interact to produce purple colour grains. The joint action of these two genes can be explained by the selfing of purple varieties, which are heterozygous for the alleles of the genes C and P (genotypes CcPp X CcPp) absence of either of two results into white. Represent the cross by checkerboard**. (ANS: 9:7)**

EXAMPLES BASED ON MULTIPLE ALLELES

1. A man and woman both are having blood group AB. List the possible genotypes and phenotypes of their children and then determine the ratio.
2. In Rabbit full – C, Chinchilla -C^{ch}, Himalayan -C^{h} Albino –c. are genes governing the coat colour. It shows dominance in descending order.
   C> (C^{ch}, C^{h},c) while $C^{ch} = C^{h}$. &C^{ch} = c; and C^{h}> c.

PHENOTYPE	GENOTYPE
Full	C C, C C^{ch} , C C^{h}, Cc
Chinchilla	$C^{ch}C^{ch}$
Himalayan	C^{h} C^{h}, C^{h}c.
Albino	cc

What will be the appearance of offsprings in following crosses?

1. CC X CC^{ch}
2. $C^{ch}C^{h}$ X C^{ch} c
3. $C^{ch}C^{h}$ X C^{h} c
4. C^{h} c X C^{h} c
5. C c X C c
6. CC^{ch} XC^{h} c

PRACTICAL BASED ON ECOLOGY

ARRANGING THE ORGANISMS IN THE FOOD CHAIN AND FOOD WEB

Materials Needed

1. Pictures or Cards of Organisms: These could include plants, animals, insects and other organisms found in pond and grassland ecosystems.
2. String or Arrows: To show the flow of energy between organisms.
3. Paper and Markers: For labeling and creating the food web/chart.
4. Large Chart Paper or Whiteboard: To assemble the food web or food chain.

Procedure

1. Identify the Ecosystem

Decide if you are working with a pond ecosystem or a grassland ecosystem.

2. List of Organisms: For a Pond Ecosystem, include

1. Producers: Phytoplankton, Algae, Aquatic Plants.
2. Primary Consumers: Zooplankton, Small Fish, Tadpoles, Insect Larvae.
3. Secondary Consumers: Larger Fish, Frogs, Small Reptiles.
4. Tertiary Consumers: Birds Like Kingfishers, Herons, Humans.

For a Grassland Ecosystem, include

1. Producers: Grass, shrubs, small plants.
2. Primary Consumers: Grasshoppers, rabbits, deer, antelope.
3. Secondary Consumers: Foxes, birds of prey, snakes.
4. Tertiary Consumers: Wolves, lions, eagles.

3. Arrange the Food Chain

Pond Ecosystem

Example 1: Phytoplankton → Zooplankton → Small Fish → Larger Fish

Example 2: Aquatic Plants → Snails → Fish → Frog → Bird

Grassland Ecosystem

Example 1: Grass → Grasshopper → Frog → Snake → Hawk

Example 2: Grass → Rabbit → Fox → Lion

4. Construct the Food Web

Pond Ecosystem

Draw or arrange multiple food chains, connecting them to show how different organisms interact. For instance, phytoplankton can be eaten by both zooplankton and small fish. Small fish can be eaten by larger fish, frogs and birds. This shows the interconnectedness in a web-like structure.

Grassland Ecosystem

Connect various organisms. Grass can be eaten by grasshoppers, rabbits, and deer. Grasshoppers may be eaten by frogs and birds. Birds might be eaten by larger predators like hawks. This web shows multiple predator-prey relationships.

5. Label the Organisms

Clearly label each organism in your food chain and food web. You can use markers to denote different trophic levels (producers, primary consumers, etc.).

6. Indicate Energy Flow

Use arrows or string to show the direction of energy flow from one organism to another (e.g., from producer to primary consumer).

7. Analysis and Conclusion

Discuss the importance of each organism in maintaining the balance of the ecosystem. Consider the impact of removing one species from the food web (e.g., what happens if all frogs are removed?).

Conclusion

a) Ensure you understand how each organism depends on others within the ecosystem.

b) Observe how energy is transferred through the ecosystem, noting that only about 10% of energy is passed on to the next trophic level, while the rest is lost as heat.

c) This practical exercise will give you a hands-on understanding of how food chains and food webs work in different ecosystems.

PRACTICAL BASED ON ECOLOGY

ARRANGING THE ORGANISMS IN DIFFERENT TROPHIC LEVELS OF ECOLOGICAL PYRAMIDS

Arranging organisms in different trophic levels of ecological pyramids is a critical part of understanding energy flow, biomass distribution and organism numbers within an ecosystem. Here's how you can conduct a practical exercise on this topic.

Materials Needed

1. Pictures or Cards of Organisms: Representing different organisms in an ecosystem.
2. Chart Paper or Whiteboard: To draw the ecological pyramids.
3. Markers or Labels: For identifying trophic levels and organisms.
4. Ruler and Pencil: For drawing accurate pyramids.

Procedure

1. Understand the Types of Ecological Pyramids

- **a)** Pyramid of Numbers: Shows the number of individual organisms at each trophic level.
- **b)** Pyramid of Biomass: Illustrates the total mass of living material at each trophic level.
- **c)** Pyramid of Energy: Represents the amount of energy available at each trophic level, usually measured in Joules or calories.

2. Choose the Ecosystem

Select either a Pond Ecosystem or a Grassland Ecosystem.

3. Identify and Arrange the Organisms in Trophic Levels

Pond Ecosystem

- **a)** Trophic Level 1 (Producers): Phytoplankton, algae, aquatic plants.
- **b)** Trophic Level 2 (Primary Consumers): Zooplankton, small fish, tadpoles, snails.
- **c)** Trophic Level 3 (Secondary Consumers): Larger fish, frogs, small reptiles.
- **d)** Trophic Level 4 (Tertiary Consumers): Birds (kingfishers, herons), large fish.
- **e)** Trophic Level 5 (Quaternary Consumers, if applicable): Top predators like larger birds (e.g., herons), humans.

Grassland Ecosystem

- **a)** Trophic Level 1 (Producers): Grass, shrubs, small plants.
- **b)** Trophic Level 2 (Primary Consumers): Grasshoppers, rabbits, deer, antelope.
- **c)** Trophic Level 3 (Secondary Consumers): Foxes, birds of prey, snakes.
- **d)** Trophic Level 4 (Tertiary Consumers): Larger predators like wolves, lions, eagles.

4. Construct the Ecological Pyramids

Pyramid of Numbers

a) **Pond Ecosystem:** Start with a wide base representing numerous phytoplankton and gradually narrow the pyramid as you move to fewer numbers of top predators like herons.

b) **Grassland Ecosystem:** Start with a broad base of grass and other producers, followed by numerous herbivores like grasshoppers, and fewer numbers of predators like lions at the top.

Pyramid of Biomass

a) **Pond Ecosystem:** Typically, producers (algae, aquatic plants) have the most biomass, followed by decreasing biomass as you move up to larger but fewer predators.

b) **Grassland Ecosystem**: The base will be wide with the biomass of grasses and plants, narrowing as you move to herbivores and further up to carnivores.

Pyramid of Energy

Both Ecosystems: Start with a wide base representing a large amount of energy in producers, with each level above showing only about 10% of the energy from the level below, leading to a sharply narrowing pyramid at the top.

5. Label the Pyramids

a) Clearly label each trophic level with the organisms it contains.

b) Indicate the type of pyramid (numbers, biomass, or energy).

6. Analyze and Discuss

a) Compare the different types of pyramids. Notice that while the shape of the Pyramid of Energy is always a true pyramid, the Pyramid of Numbers and the Pyramid of Biomass can sometimes have an inverted or irregular shape depending on the ecosystem.

b) Discuss the implications of the pyramid shape on the stability and sustainability of the ecosystem.

Example DiagramsPond Ecosystem

Pyramid of Numbers

- Kingfisher (Few)
- Larger Fish (Fewer)
- Small Fish (More)
- Zooplankton (Many)
- Phytoplankton (Most)

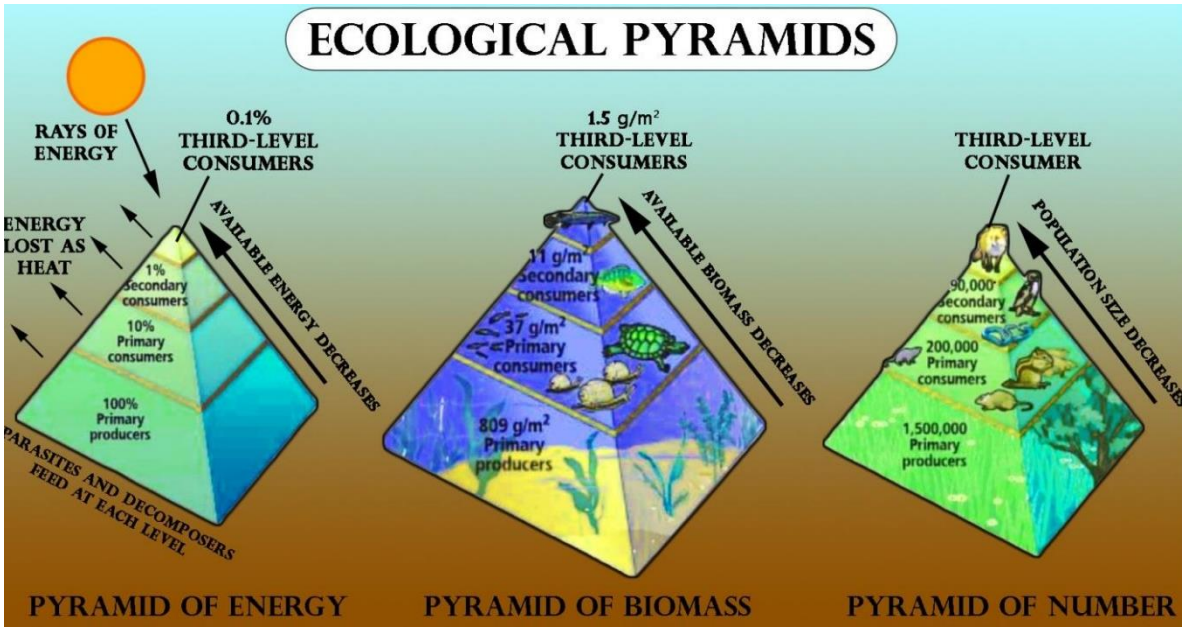
Grassland Ecosystem

Pyramid of Biomass

- Eagle (Least Biomass)
- Fox/Snake (Less Biomass)
- Rabbit/Deer (More Biomass)
- Grass (Most Biomass)

Conclusion

By arranging organisms into different trophic levels within ecological pyramids, you gain insights into how energy flows through an ecosystem, how biomass is distributed, and how population sizes vary at each level. This understanding is crucial for studying ecological balance and the effects of disturbances within ecosystems.



PRACTICAL BASED ON ETHOLOGY

MIMICRY IN MONARCH BUTTERFLY AND STICK INSECT

Ethology is the study of animal behavior, often in natural environments. In this practical, we'll explore mimicry and adaptive behavior in which one organism resembles another to gain some advantage, such as protection from predators.

Objectives

1. To understand the concept of mimicry.
2. To observe and compare mimicry in the monarch butterfly and the stick insect.

Materials Needed

1. Pictures or Models of the Monarch Butterfly, Viceroy Butterfly (for comparison) and stick insects.
2. Magnifying Glass: For observing details in physical models or images.
3. Chart Paper or Notebook: To record observations and make notes.
4. Markers/Pens: For labeling and drawing.

Procedure

1. Monarch Butterfly (*Danausplexippus*)

Objective: To observe and understand Batesian mimicry in monarch butterflies.

Step 1: Introduction to Monarch Butterflies

The monarch butterfly is known for its bright orange and black wings, which are toxic to many predators due to chemicals ingested from milkweed plants during its larval stage.

Step 2: Study Batesian Mimicry

- **Batesian Mimicry:** This is where a harmless species mimics a harmful or unpalatable one to avoid predation.
- **Example:** The viceroy butterfly (*Limenitisarchippus*) mimics the monarch butterfly. Although the viceroy is not toxic, its similar appearance to the toxic monarch discourages predators.

Step 3: Observation

- **Comparison:** Look at pictures or models of both the monarch and viceroy butterflies. Note similarities in color patterns and wing shapes.
- **Discussion:** Discuss how this mimicry benefits the viceroy and contributes to the survival of both species.

2. Stick Insect (Phasmatodea)

Objective: To observe and understand protective mimicry in stick insects.

Step 1: Introduction to Stick Insects

Stick insects are known for their incredible ability to mimic twigs, branches, and leaves. This form of mimicry is primarily a defense mechanism against predators.

Step 2: Study Protective (Cryptic) Mimicry

- **Protective Mimicry**: This is when an organism avoids predation by blending into its surroundings.
- **Example:** The stick insect resembles the twigs and branches of the trees it inhabits, making it difficult for predators to spot.

Step 3: Observation

- **Examine:** Use pictures or real-life specimens of stick insects. Observe how their body shape, color, and posture resemble twigs.
- **Camouflage Test**: Place the stick insect model or image against a backdrop of twigs and leaves. Observe how effectively it blends in.

3. Comparative Analysis

Step 1: Compare Mimicry Strategies

- Monarch Butterfly: Batesian mimicry protects the viceroy by making it appear as an unpalatable species.
- Stick Insect: Protective mimicry allows the insect to avoid detection by predators.

Step 2: Discuss Evolutionary Advantages

- How does mimicry in these species contribute to their survival and reproduction?
- Why is mimicry considered an example of natural selection?

4. Documentation

Step 1: Record Observations

- Draw or describe the monarch and viceroy butterflies, highlighting similarities.
- Draw or describe the stick insect, noting its camouflage features.

Step 2: Conclusion

- Summarize the importance of mimicry in both species.
- Reflect on how these behaviors demonstrate adaptation to the environment and predator-prey dynamics.

Conclusion

By studying the mimicry in the monarch butterfly and stick insect, this practical exercise enhances understanding of how animals use mimicry as a survival strategy. It also underscores the significance of these behaviors in evolutionary biology and ecology

PRACTICAL BASED ON ETHOLOGY

CASTES OF HONEY BEES

Ethology is the study of animal behavior in their natural environment, and in this practical, we'll explore the social structure and behavior of honey bee castes.

Objectives

a) To understand the different castes within a honey bee colony.

b) To observe and compare the roles, physical characteristics, and behaviors of each caste.

Materials Needed

a) Pictures or Models of Honey Bees: Representing the queen, workers, and drones.

b) Magnifying Glass: To observe details in the physical models or images.

c) Chart Paper or Notebook: To record observations and make notes.

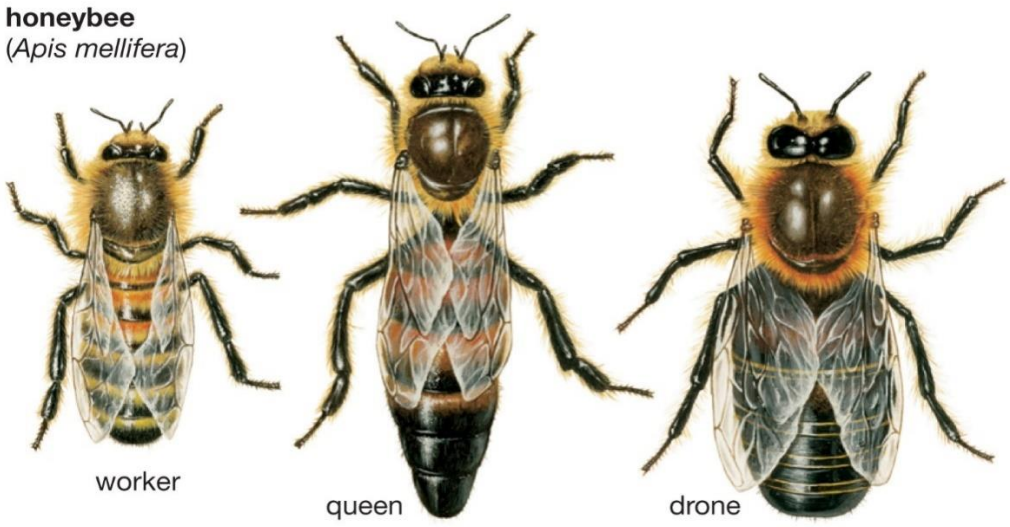
d) Markers/Pens: For labeling and drawing.

e) Video Clips or Documentaries: Showing the activities of honey bee castes (optional but useful).

Procedure

1. Introduction to Honey Bee Castes

Background: Honey bees (*Apis mellifera*) are highly social insects with a well-organized colony structure. Each colony consists of three main castes: the queen, workers, and drones. Each caste has specific roles and responsibilities that contribute to the survival and efficiency of the colony.



2. Identification and Roles of Honey Bee Castes

A. The Queen Bee

Physical Characteristics

- Larger than other bees with a longer abdomen.
- Has a smooth stinger.
- No pollen baskets on the legs.

Role

- The sole reproductive female in the colony.
- Lays eggs—up to 2,000 per day during peak seasons.
- Releases pheromones that maintain the social structure of the hive.

Behavior

- Rarely leaves the hive, except for a single mating flight.
- Communicates with workers through pheromones.

B. Worker Bees

Physical Characteristics

- Smaller in size, with specialized structures like pollen baskets on their hind legs.
- Barbed stinger.

Role

- Perform all tasks needed for the colony's survival: foraging, nursing, cleaning, hive construction, and defense.
- Sterile females

Behavior

- Forage for nectar, pollen, and water.
- Care for the queen, drones, and larvae.
- Regulate hive temperature through wing fanning.

C. Drone Bees

Physical Characteristics

- Larger and stockier than workers but smaller than the queen.
- No stinger.
- Large compound eyes.

Role

- Males whose primary role is to mate with a virgin queen.
- Drones do not gather food or perform any work within the hive.

Behavior

- Congregate in drone congregation areas to mate with queens.
- Ejected from the hive by workers at the end of the mating season or when resources are scarce.

3. Observation and Analysis

Step 1: Examine Physical Differences

- Compare the physical models or pictures of the queen, workers, and drones.
- Use a magnifying glass to observe distinguishing features like size, wing structure and leg adaptations.

Step 2: Role-Playing Exercise

- Discuss or simulate the different roles each caste plays in maintaining the hive's efficiency and survival.
- How do the workers' tasks change based on their age? (e.g., younger workers care for larvae, older workers forage).

Step 3: Behavioral Video Observation (Optional)

- Watch a short video or documentary showing the activities of each caste within a hive.
- Note how each caste interacts with others and their specific tasks.

4. Documentation

Record Observations

- Draw or label diagrams of the three castes, highlighting key physical traits and behaviors.
- Write brief descriptions of each caste’s role within the hive.

Discussion Questions

- Why is it crucial for the colony to have such a well-defined caste system?
- What would happen if one caste (e.g., the queen) were to disappear or fail in its role?

Conclusion

Through this practical exercise, you'll gain a deeper understanding of the complex social structure of honey bee colonies. You'll learn how each caste has evolved distinct physical and behavioral traits that allow them to perform their specialized roles, ensuring the colony's survival and success. This exploration of honey bee ethology demonstrates the efficiency of social insects and the importance of division of labor in nature.

PRACTICAL BASED ON EVOLUTION

TYPES OF FOSSILS

Fossils are the preserved remains or traces of organisms that lived in the past. Studying fossils helps us understand the process of evolution and the history of life on Earth. In this practical, we'll explore different types of fossils and their significance.

Objectives

1. To understand the different types of fossils.
2. To observe and identify examples of each fossil type.
3. To learn how fossils are formed and what they reveal about past environments and organisms.

Materials Needed

1. Fossil Specimens or High-Quality Images: Representing different types of fossils.
2. Magnifying Glass: For detailed observation.
3. Chart Paper or Notebook: To record observations and make notes.
4. Markers/Pens: For labeling and drawing.
5. Textbook or Reference Material: For additional information on fossil types.

Procedure

1. Introduction to Fossils

Fossils are evidence of past life preserved in geological formations. They provide critical information about ancient organisms, their environment, and the evolutionary processes.

2. Types of Fossils

There are several types of fossils, each representing different forms of preservation or evidence of ancient life. Here are the main types you will explore:

A. Body Fossils

Body Fossils

a) **Definition:** Body fossils are the preserved remains of an organism's body parts, such as bones, teeth, shells or leaves.

b) **Examples:** Dinosaur bones, shark teeth and ammonite shells.

c) **Formation:** Typically formed when an organism is buried in sediment soon after death, and the organic materials are gradually replaced by minerals, turning the remains into stone.

B. Trace Fossils (Ichnofossils)

a) **Definition:** Trace fossils are the preserved evidence of an organism's activity, such as footprints, burrows or feces.

b) **Examples**: Dinosaur footprints, worm burrows, and coprolites (fossilized dung).

c) **Formation:** Formed when an organism's activities leave an impression or trace in soft sediment, which then hardens over time.

Trace Fossils (Ichnofossils)

C. Mold Fossils

a) **Definition:** A mold fossil is an impression left in the substrate where an organism once was. The organism itself is not preserved.

b) **Examples:** Impressions of shells or leaves in rock.

c) **Formation:** When an organism is buried in sediment and then decays or dissolves, leaving a cavity in the shape of the organism.

D. Cast Fossils

a) **Definition:** Cast fossils form when a mold is later filled with minerals or sediments, creating a replica of the original organism.

b) **Examples:** Casts of shells, bones or trees.

c) **Formation:** After the formation of a mold, minerals fill the cavity and solidify, creating a cast.

Mold Fossil **Cast Fossils**

E. Permineralized Fossils

a) **Definition:** Permineralization occurs when minerals carried by water are deposited around a hard structure, such as bones or wood.

b) **Examples:** Petrified wood, fossilized bones.

c) **Formation**: The original material is gradually replaced by minerals, but the detailed structure of the organism is retained.

Petrified wood

F. Amber Fossils

a) **Definition:** Amber fossils are organisms trapped in tree resin that hardens and preserves the organisms inside.

b) **Examples:** Insects, small animals or plant material trapped in amber.

c) **Formation:** Organisms are trapped in sticky tree resin, which hardens over millions of years into amber, preserving the organism in exquisite detail.

Insect trapped in amber

G. Frozen or Mummified Fossils

a) **Definition:** These fossils are the actual preserved remains of organisms that have been frozen or mummified.

b) **Examples:** Woolly mammoths found in ice, mummified human bodies.

c) **Formation:** Occurs in environments where the remains are preserved by freezing or desiccation, preventing decay.

Frozen or Mummified Fossils: Woolly mammoth

3. Observation and Identification

Step 1: Examine the Fossils

a) Observe each type of fossil specimen or image. Use a magnifying glass to see detailed features.

b) Note the color, texture and any visible structures in the fossil.

Step 2: Record Observations

a) For each fossil, write down its type, formation process, and what it reveals about the organism or environment.

b) Draw or sketch the fossils to capture their details.

Step 3: Analysis

a) Discuss how each fossil type contributes to our understanding of ancient life.

b) Consider what each fossil tells us about the environment in which the organism lived and the processes that led to its preservation.

4. Comparative Study

Step 1: Compare Fossil Types

a) Compare the preservation quality of body fossils versus trace fossils.

b) Discuss the differences between mold and cast fossils and how they are related.

Step 2: Evolutionary Significance

a) How do different types of fossils help scientists reconstruct evolutionary history?

b) Discuss the importance of Permineralized fossils in studying the detailed anatomy of extinct organisms.

5. Documentation

Step 1: Create a Fossil Chart

a) Draw or print a chart listing each type of fossil with examples and notes on how they are formed.
b) Include sketches of each fossil type based on your observations.

Step 2: Conclusion

a) Summarize your findings on how different fossil types contribute to our understanding of past life and evolution.
b) Reflect on the role of fossils in piecing together the history of life on Earth.

Conclusion

This practical exercise provides a hands-on approach to learning about the different types of fossils and their significance in the study of evolution. By identifying and analyzing various fossil types, you gain insights into the preservation of ancient life and how fossils serve as crucial evidence for understanding evolutionary processes.

PRACTICAL BASED ON EVOLUTION:
ARRANGEMENT OF ANIMALS AS PER THE GEOLOGICAL TIME SCALE

The Geological Time Scale (GTS) is a system that organizes Earth's history into different periods based on significant geological and biological events. This practical exercise focuses on arranging animals according to the periods they first appeared or were dominant in, providing insight into the evolutionary history of life on Earth.

Objectives

a) To understand the Geological Time Scale and its divisions.

b) To arrange various animals in the correct order based on their appearance or dominance during different geological periods.

c) To explore the evolutionary timeline and how different life forms evolved over millions of years.

Materials Needed

a) Pictures or Models of Fossil Animals: Representing different periods of the Geological Time Scale.

b) Geological Time Scale Chart: A reference chart showing the major divisions of geological time.

c) Chart Paper or Whiteboard: For arranging the animals in the correct sequence.

d) Markers or Labels: For identifying the periods and animals.

e) Textbook or Reference Material: For additional information on the evolution of specific animals.

Procedure

1. Introduction to the Geological Time Scale

The geological time scale is a chronological framework that divides Earth's 4.54-billion-year history into hierarchical time intervals. **Eons, Eras, Periods, Epochs**, and **Ages**.

- **Eons** are the largest divisions, spanning hundreds to thousands of millions of years, and include the **Hadean, Archean, Proterozoic and the current Phanerozoic**.
- **Eras** are subdivisions of eons, lasting tens to hundreds of millions of years and include the **Paleozoic, Mesozoic** and **Cenozoic eras** within the Phanerozoic eon.
- **Periods** divide eras into smaller intervals, such as the **Cambrian** and **Jurassic** and can last from tens to over 100 million years.
- **Epochs** further subdivide periods into shorter spans, ranging from several million to tens of millions of years, like the **Eocene** and **Pleistocene.**

- **Ages** are the smallest divisions, lasting millions to tens of millions of years and provide a more detailed chronology within epochs. This structure helps scientists understand Earth's complex history, including its biological and geological changes.

2. Understanding the Major Divisions of the Geological Time Scale

Precambrian (4.6 billion to 541 million years ago)

- Represents the vast majority of Earth's history, during which simple life forms like bacteria and algae first appeared.

Paleozoic Era (541 to 252 million years ago)

- Cambrian Period: Explosion of marine life, appearance of trilobites.
- Ordovician and Silurian Periods: First fish and land plants.
- Devonian Period: "Age of Fishes," first amphibians.
- Carboniferous Period: Extensive forests, first reptiles.
- Permian Period: Dominance of reptiles, major extinction event at the end.

Mesozoic Era (252 to 66 million years ago)

- Triassic Period: First dinosaurs and mammals.
- Jurassic Period: Dominance of dinosaurs, first birds.
- Cretaceous Period: Flowering plants, end of the dinosaurs with a mass extinction event.

Cenozoic Era (66 million years ago to present)

- Paleogene and Neogene Periods: Mammal diversification, first primates.
- Quaternary Period: Evolution of humans, Ice Ages.

3. Arranging Animals on the Geological Time Scale

Step 1: Select Representative Animals

Choose animals that are iconic or representative of different geological periods. Examples include

- **Precambrian:** Cyanobacteria (blue-green algae).
- **Cambrian:** Trilobites.
- **Ordovician:** Early fish (jawless fish).
- **Devonian:** Dunkleosteus (armored fish), early amphibians.
- **Carboniferous:** Giant insects, early reptiles.
- **Permian:** Dimetrodon (early synapsid).
- **Triassic:** Early dinosaurs (e.g., Coelophysis), early mammals.
- **Jurassic:** Stegosaurus, Allosaurus, first birds (Archaeopteryx).

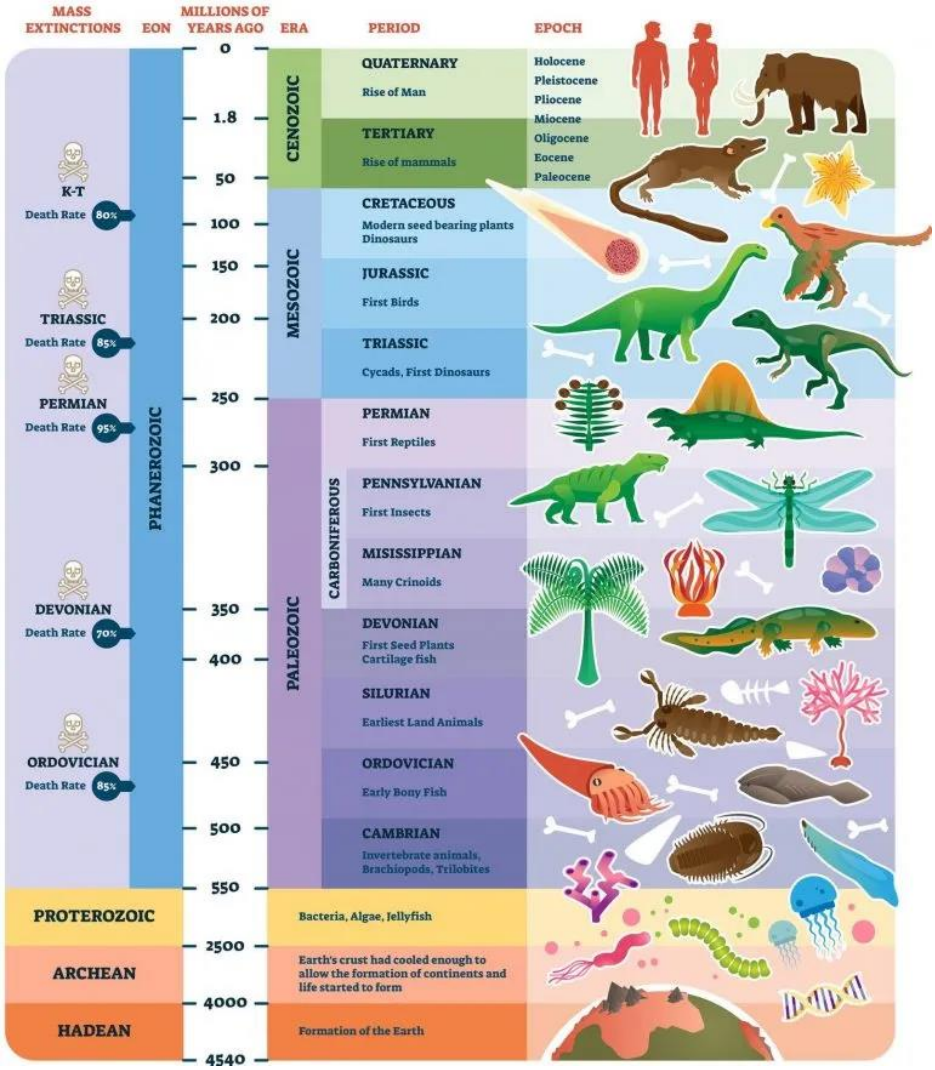
- **Cretaceous:** Tyrannosaurus rex, Triceratops, flowering plants.
- **Paleogene:** Early mammals (e.g., Megatherium), early primates.
- **Neogene: Early hominins (e.g., Australopithecus).**
- **Quaternary:** Woolly mammoth, modern humans (Homo sapiens).

Step 2: Create a Timeline

- Draw a timeline or use a Geological Time Scale chart on a large sheet of paper or whiteboard.
- Mark the major divisions (Precambrian, Paleozoic, Mesozoic, Cenozoic) and their respective periods.

Step 3: Place Animals on the Timeline

- Arrange the selected animals along the timeline according to when they first appeared or were dominant.
- Use pictures, models, or drawings to represent each animal on the timeline.
- Label each animal with its name and the period it represents.



4. Observation and Analysis

Step 1: Discuss the Evolutionary Sequence

- Observe the progression from simple organisms in the Precambrian to more complex life forms in the Paleozoic, Mesozoic and Cenozoic eras.
- Discuss major evolutionary milestones, such as the transition from aquatic to terrestrial life, the rise of dinosaurs, and the diversification of mammals.

Step 2: Identify Mass Extinctions

- Highlight periods where mass extinction events occurred, such as at the end of the Permian and Cretaceous periods.
- Discuss the impact of these events on the evolution of life and the emergence of new dominant species.

5. Documentation

Step 1: Record the Timeline

- Take a photograph or create a detailed drawing of your arranged timeline with the animals placed correctly.
- Write brief notes on each period, highlighting key evolutionary developments and the appearance of the animals you've placed on the timeline.

Step 2: Conclusion

- Summarize the major patterns observed in the evolutionary history of life.
- Reflect on the significance of the Geological Time Scale in understanding the history of life on Earth.

Conclusion

This practical exercise allows you to explore the history of life on Earth through the lens of the Geological Time Scale. By arranging animals according to the periods in which they lived, you gain a deeper understanding of evolutionary processes, the rise and fall of different species and the impact of geological events on the history of life. This exercise also highlights the continuity and change that characterize Earth's biological history, providing a broad perspective on the evolution of life.

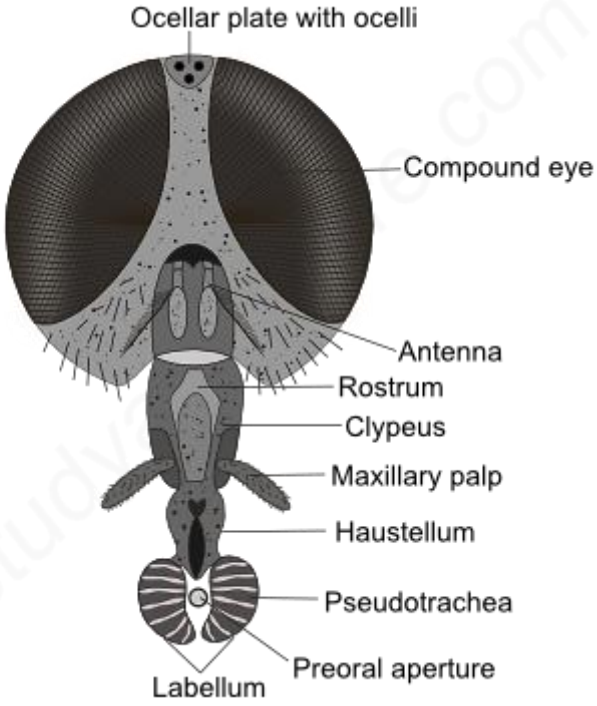
TYPES OF INSECT MOUTHPARTS

HOUSE FLY, HONEYBEE, MOSQUITO, BUTTERFLY, COCKROACH

Mouthparts of insects are modified cephalic appendages. Different insects have adapted themselves to different modes of ingestion of food. The basic structure of mouthparts remains the same.

MOUTHPARTS OF HOUSEFLY

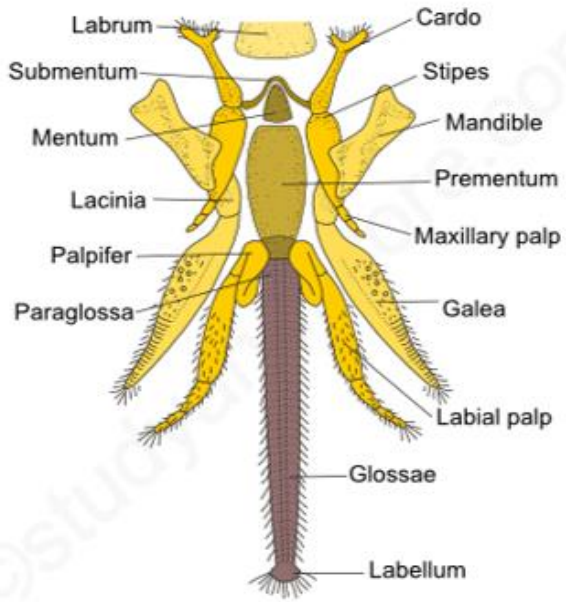
The mouthparts of houseflies are of the sponging type. It consists of Rostrum, Haustellum and Labellum. Haustellum and labellum are modified labium.



- **Rostrum:** It is the basal part of the proboscis and is proximally articulates with the head capsule. It is distally articulated with the haustellum by a hinge joint. The rostrum encloses the pharynx and salivary duct. Pharynx communicated with the food canal. Mandibles are absent. First maxillae are represented by a pair of unjointed palps, which is present on the rostrum
- **Haustellum:** It is the middle part of the proboscis and the proximal part of labium. It bears a median groove on its dorsal side. In this groove, the hypopharynx containing the salivary canal and labrum epipharynx are present. They are closely pressed against each other and form a food canal. Haustellum bears a theca underneath it.
- **Labellum:** This is the terminal part of the proboscis which is formed of two lobes called labella. A preoral opening is present between the two labella. Prestomial teeth are present on the undersurface of the labella. Labellum has sense organs of taste and

smell. The labella bear many grooves supported by semicircular chitinous rings. They appear as tracheae and so they are also known as pseudo tracheae. All pseudo tracheae of both labella converge into the preoral opening.

MOUTHPARTS OF HONEYBEE



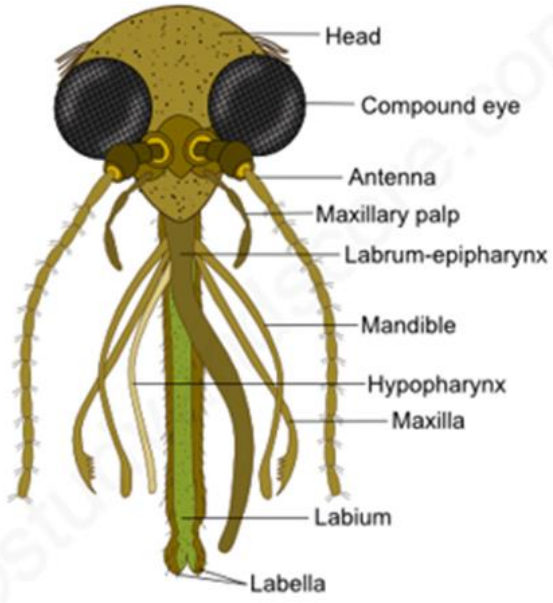
MOUTHPARTS OF HONEYBEE

The mouthparts of honeybee are chewing and lapping type. It shows

- **Mandibles:** The mandibles are a pair of jaws suspended from the head of the bee. The insect uses them to chew wood when redesigning the hive entrance, to chew pollen and to work wax for comb-building. They also permit any activity requiring a pair of grasping instruments. These paired "teeth" that can be opened and closed to get the work done.
- **Proboscis:** The proboscis of the honeybee is not a permanent functional organ, but it is formed temporarily by assembling parts of the maxillae and the labium to produce a unique tube for drawing up liquids such as sweet juices, nectar, water and honey. The insect releases it when needed for use, then withdraws and folds it back beneath the head when it is not needed.
- **Labellum:** The glossae are greatly elongated to form a hairy, flexible tongue. The glossa terminates into a small circular spoon shaped lobe called labellum, which is useful to lick the nectar. Labial palms are elongated and four segmented.

MOUTHPARTS OF MOSQUITO

The mouthparts of mosquitoes are the piercing and sucking type. These types of mouth parts are present in almost all the bloodsucking insects like tse-tse fly, bed bug etc.



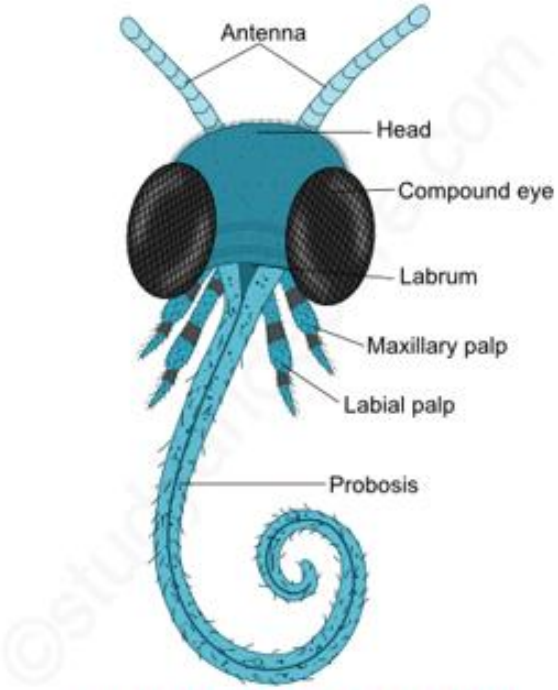
MOUTHPARTS OF MOSQUITO

The mouthparts include labium, labrum-epipharynx, hypopharynx, mandibles and first maxillae.

- **Labium:** It is a long, flesh, flexible and unpaired structure with a groove called labial groove along its mid dorsal side. It is also called proboscis. The labium bears a pair of lobes terminally called labella. The labella are interconnected by a membrane called as Dutton's membrane. Labella represent the reduced labial palps. All the other mouthparts like mandibles, first pair of maxillae and hypopharynx are enclosed in the groove of the labium.
- **Labrum-epipharynx:** This is a compound structure formed by the fusion of labrum and epipharynx. Labrum-epipharynx is a stylet that has a ventral groove, which forms the food canal with the hypopharynx.
- **Hypopharynx:** It is a long flat stylet structure that forms the food canal with the labrum-epipharynx for sucking the blood. It also contains the salivary canal that injects saliva into the blood of the warm-blooded vertebrates.
- **Mandibles:** Two mandibles are present each on either side. These are styles with blade like tips. They are useful to make a wound in the skin of the host. There are two first maxillae, one on each side. These are the styles that bear serrated tips. Each maxilla bears a maxillary palp.

MOUTHPARTS OF BUTTERFLY

The mouthparts of butterflies and moths are siphoning and sucking type. These mouthparts are best suited to draw nectar from the flowers.

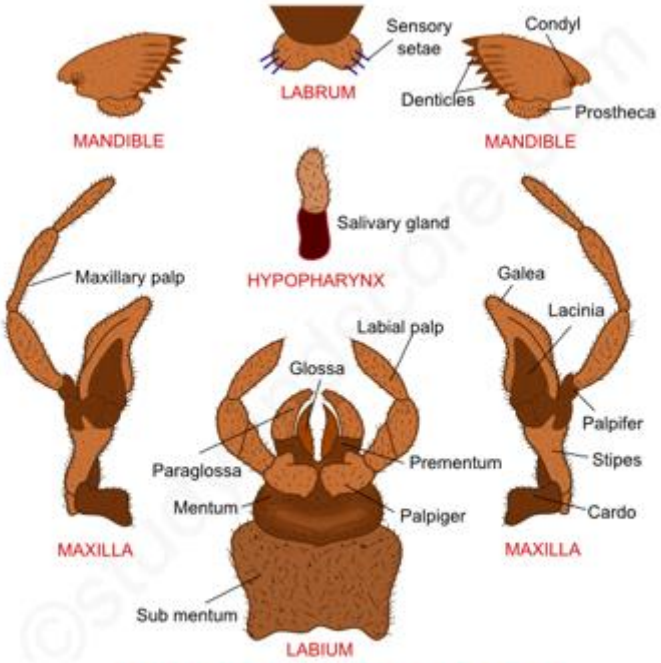


MOUTHPARTS OF BUTTERFLY

- Labium is reduced to a triangular plate bearing labial palps.
- Mandibles and hypopharynx are absent
- Maxillary palps and labial palps are present in a reduced condition.
- The only well-developed structures are galea of the first maxillae. These are greatly elongated semi-tube-like structures. When these two galeae are applied and locked together along the length they form a long tubular proboscis. The locking of galeae is done with the help of pegs and sockets. When not in use the proboscis is coiled like a watch spring.

MOUTHPARTS OF COCKROACH

The mouthparts of cockroaches are biting and chewing types. This biting and chewing type of mouthparts are considered as the most primitive and unspecialized of all the mouthpart types. The other examples include Grasshopper, Dragonfly and Beetle.



MOUTHPARTS OF COCKROACH

The mouthparts of cockroach include Labrum, Mandibles and a pair of first maxillae, labium and hypopharynx.,

- **Labrum:** The mouth is covered by labrum. It is also known as upper lip. This labrum is attached to the clypeus. The labrum bears a gustatory sensilla on its inner surface. Labrum helps in tasting and also handling the food.
- **Mandibles:** These are a pair of triangular, hard, unjointed, stout, chitinised structures. The mandibles are located on either side of the mouth behind the labrum. They are dentate along their inner margins and are masticatory in function. These mandibles are provided with two pairs of muscles namely, adductor and abductor muscles to help the movement of mandibles only in horizontal plane against each other.
- **First pair of maxillae:** A pair of first maxillae is located behind mandibles on either side of the mouth. The first maxilla has two basal segments called cardo and stipes. Cardo is attached to the head capsule and stipes is attached to the cardo. The stipes has five segmented maxillary palp on its outer side. This palp is situated on a small sclerite called palpifer. Inner to the palp two chitinous lobes namely lacinea and galea

are found attached to stipes. Lacinea is pincer like with two terminal denticles whereas galea is the outer soft hood life structure bearing long chitinous bristles. The maxillary palps are used for cleaning the antennae and also the front pair of legs.

- **Labium**: Labium is formed by the fusion of second pair of maxillae. It is also known as lower lip. The basal segment of labium is called post-mentum. Labium includes two segments namely broad rectangular sub-mentum and a triangular mentum. Also pre-mentum is present in front of the mentum. Pre-mentum is formed by the fusion of two stipes and it bears a small sclerite called palpiger. Each palpiger has a 3-segmented labial palp. At the distal end the pre-mentum bears a pair of paraglossae inner to labial palps. A pair of glossae is present between paraglossae. The paraglossae and glossae together constitute ligula.
- **Hypopharynx:** It is chitinous, grooved and a rod-like structure found hanging into the preoral cavity. It is also known as ligula or tongue. Hypopharynx divides the proximal part ofthe preoral cavity into a larger anterior cibarium and a posterior salivarium. The salivary duct opens into salivarium at the base of the hypopharynx.

ENTOMOPHAGY: INTRODUCTION, NUTRITIONAL VALUE, ECONOMIC IMPORTANCE, EXAMPLES

Entomophagy

Entomophagy refers to the practice of eating insects by humans. This practice has been part of human diets for centuries, particularly in Asia, Africa, and Latin America. Insects are consumed for their nutritional value, cultural significance, and as a sustainable food source in various parts of the world. With growing concerns about food security, environmental sustainability, and the need for alternative protein sources, entomophagy is gaining increased attention globally.

Introduction

Entomophagy is the consumption of insects as food. Traditionally, it has been a common practice in many cultures, but it is only recently that the Western world has started to consider it seriously as a potential solution to several global challenges. Insects are an abundant, sustainable, and nutritious food source, which makes them a promising candidate to meet the protein demands of the growing global population.

Nutritional Value

Insects are highly nutritious and can provide a significant source of protein, fats, vitamins, and minerals. The nutritional content of insects varies by species, but in general, they offer:

- **High Protein Content:** Insects such as crickets, grasshoppers, and mealworms contain about 30-80% protein by dry weight. The quality of insect protein is comparable to that of meat and fish, containing all the essential amino acids.
- **Healthy Fats:** Insects are rich in unsaturated fats, including omega-3 and omega-6 fatty acids, which are beneficial for heart health.
- **Vitamins and Minerals**: Insects provide important vitamins like B12, riboflavin, and vitamin A. They are also a good source of minerals such as iron, zinc, magnesium, and calcium.
- **Low Carbohydrates:** Insects generally contain low levels of carbohydrates, making them suitable for low-carb diets.
- **Fiber:** The exoskeleton of insects is made of chitin, a form of fiber that can aid in digestion.

Economic Importance

Entomophagy has significant economic potential

- **Sustainable Livestock Alternative**: Insect farming requires far less land, water, and feed compared to traditional livestock farming. This makes it a more sustainable option, with a lower environmental footprint.
- **Employment and Livelihoods**: Insect farming can create new jobs and support livelihoods, especially in rural areas where traditional farming may be challenging due to environmental conditions.
- **Food Security:** As insects can be reared on organic waste, they can be produced locally and sustainably, contributing to food security, particularly in regions with limited access to conventional protein sources.
- **Feed Industry**: Insects can be used as feed for livestock, poultry, and fish, reducing reliance on traditional feed sources like soy and fishmeal, which are often associated with environmental concerns.
- **Value-Added Products**: Insects can be processed into various value-added products such as protein powders, bars, and snacks, creating opportunities in the food industry.

Examples of Edible Insects

Different cultures around the world consume a variety of insects. Some common examples include

- **Crickets (*Acheta domesticus*):** Widely consumed in Southeast Asia, crickets are known for their high protein content and are often roasted, fried, or ground into cricket flour.
- **Mealworms (*Tenebrio molitor*):** These larvae are popular in Europe and North America for their versatility. They are used in baking, as a topping, or processed into protein-rich products.
- **Grasshoppers (Caelifera):** Commonly eaten in Mexico, where they are known as "chapulines," grasshoppers are typically fried and seasoned with spices. They are rich in protein and minerals.
- **Beetle Larvae (Coleoptera):** Larvae of various beetle species, such as palm weevils, are eaten in Africa and Asia. They are often grilled or boiled and are high in fat and protein.

- **Ants (Formicidae):** Different ant species are consumed across the world, including in South America (e.g., "hormigas culonas" in Colombia) and Asia. They are often eaten roasted and are rich in protein and fiber.
- **Silkworm Pupae (*Bombyx mori*):** Popular in Korea, China, and Japan, silkworm pupae are often boiled or steamed and are a good source of protein, fat, and vitamins.
- **Termites (Isoptera):** In Africa and Asia, termites are commonly eaten raw, fried, or roasted. They are high in fat and protein and are a traditional food source in many cultures.

Conclusion

Entomophagy presents a compelling case for adoption in global diets, particularly as the world faces challenges related to food security, sustainability, and health. Insects offer a nutritious, environmentally friendly, and economically viable alternative to conventional livestock. As the practice of eating insects gains acceptance in more regions, it has the potential to contribute significantly to sustainable food systems and provide a solution to the growing demand for protein.

Crickets

Mealworms

Grasshoppers

Beetle Larvae

Ants

Silkworm Pupae

Termites

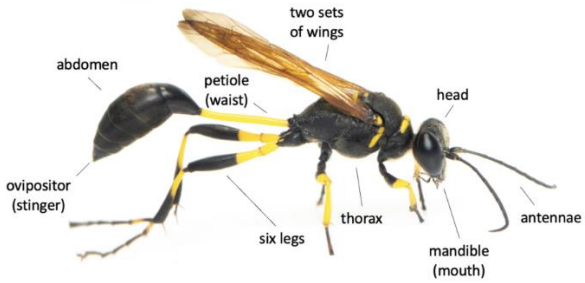
WONDERS IN INSECTS

MUD WASP, PRAYING MANTIS, GIANT COCKROACH, LADYBIRD BEETLE, FIREFLY, PARASITOIDS- APENTELES IN HELICOVERPA

Insects are fascinating creatures and the ones you've listed each have unique characteristics and behaviors that make them stand out. Here's a look at the wonders of each:

I. MUD WASP

- **Nest Building:** Mud wasps, particularly mud daubers, are known for their incredible nest-building skills. They construct their nests from mud, shaping them into intricate tubes or cells. These nests serve as a safe place for their eggs and provide a food source for the larvae.
- **Paralysis of Prey**: Mud wasps paralyze their prey, often spiders, with a sting. The prey remains alive but immobilized, providing fresh food for the developing larvae.



II. PRAYING MANTIS

- **Predatory Skills:** The praying mantis is a master predator. With its front legs adapted into powerful, spiked grasping tools, it can capture and hold onto its prey with remarkable speed and precision.
- **Camouflage:** Many species of mantis have evolved to blend seamlessly into their environment, resembling leaves, flowers, or sticks. This camouflage helps them ambush prey and avoid predators.

PRAYING MANTIS: CAMOUFLAGE

III. GIANT COCKROACH

- **Survival Abilities:** Giant cockroaches, such as those found in rainforests, are resilient survivors. They can live for a month without food and survive in a variety of harsh conditions.
- **Decomposers:** They play a crucial role in the ecosystem as decomposers, breaking down dead plant material and contributing to nutrient cycling in the soil.

GIANT COCKROACH

IV. LADYBIRD BEETLE (LADYBUG)

- **Natural Pest Control:** Ladybirds are voracious predators of aphids and other plant pests. A single ladybird can consume thousands of aphids in its lifetime, making them beneficial for agriculture.
- **Bright Coloration:** Their bright red and black coloration serves as a warning to predators about their unpalatable taste and potential toxicity, a form of defense known as aposematism.

LADYBIRD BEETLE

V. FIREFLY

- **Bioluminescence:** Fireflies are famous for their ability to produce light through a chemical reaction in their abdomen, known as bioluminescence. This light is used for communication, particularly in attracting mates.
- **Variety of Light Patterns**: Different species of fireflies have distinct light patterns, which they use to identify and attract mates. Some species even synchronize their flashing in large groups.

FIREFLY: BIOLUMINESCENCE

VI. PARASITOIDS - APANTELES IN HELICOVERPA

- **Biological Control:** The parasitoid wasp Apanteles lays its eggs inside the larvae of the Helicoverpa species (a type of moth). The wasp larvae then develop inside the host, eventually killing it. This natural process helps control Helicoverpa populations, which are agricultural pests.
- **Host Manipulation:** Some parasitoid wasps can manipulate the behavior or physiology of their hosts to benefit their offspring, ensuring the host survives long enough for the parasitoids to fully develop.

Parasitoids

These insects each play a unique role in their ecosystems and exhibit remarkable behaviors that highlight the diversity and complexity of the insect world.

B. Sc. Part – I Semester – II

ZOOLOGY Practical - II

GENETICS, ECOLOGY, ETHOLOGY, EVOLUTION AND ENTOMOLOGY

Marks-50

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Q. No. 1 Determination of blood group according to ABO blood group system/ Drosophila culture-related experiments	**06**
Q. No. 2 Questions based on karyotype study/ Gene Mapping/ construction of pedigree	**06**
Q. No. 3 Construction of food chain/food web/ Ecological Pyramids.	**05**
Q. No. 4 Experiments based on monohybrid/ dihybrid cross	**06**
Q No. 5 Example in Genetics	**07**
Q. No. 6 Identification (Based on Unit II)	**10**
Q. No. 7 Excursion Report	**05**
Q. No. 8 Certified Journal	**05**

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