Tirumala Tirupati Devasthanams
శ్రీ వేంకటేశ్వర కళాశాల
Sri Venkateswara College
(University of Delhi)
NAAC Grade A+

SRI VENKATESWARA COLLEGE
(UNIVERSITY OF DELHI)

EVENT REPORT

NAME OF THE EVENT : Hands-On Workshop on Research Methodology			
DATE	**DEPARTMENT**	**COMMITTEE/SOCIETY**	**COORDINATORS' NAME**
11-12 February 2025	Department of Botany	Involucre	Dr. Pooja Gokhale Sinha
TIME	**VENUE**	**NUMBER OF PARTICIPANTS**	**NATURE: Outdoor/Indoor;**
9:30 am to 4:30 pm	Botany Hons. Lab, Room 57	30+	Indoor
FINANCIAL SUPPORT/ASSISTANCE (if any):	NA		

	BRIEF INFORMATION ABOUT THE ACTIVITY
TOPIC/SUBJECT	A two-day practical and theoretical workshop to equip students with essential research skills in biological sciences
DESCRIPTION	The Department of Botany organized a Hands-On Workshop on Research Methodology aimed at building students' competencies in laboratory practices, ethical research, biostatistics, plant identification, and field biology. Expert-led sessions were conducted, covering both theoretical concepts and practical applications.
METHODOLOGY	Day 1 Sessions: • Inaugral lecture by Prof. Praveen K. Verma, FNASc., JNU on "Career In Plant Sciences" • Workshop manual release • Laboratory Safety and Ethics by Dr. Sunita Yadav & Dr. Manoj Thakur • Microscopy and Staining Techniques by Dr. Pooja Gokhale Sinha & Dr. Madhu Raina • Intellectual Property Rights by Dr. Aditi Kothari Chhajer & Dr. T. Sarada

	• Instruments: Use and Precautions by Dr. Navneet Kumar, Dr. G. Krishna Kumar & Dr. Amrita Singh
	Day 2 Sessions: • Biostatistics by Dr. Pamil Tayal & Dr. Sachin Kumar • Plant Identification and Herbarium Preparation by Dr. M. Prajna, Dr. Shantanu Mandal & Dr. K. Prasad • Preparation of Solutions by Dr. Sunita Yadav & Dr. Manoj Thakur • Basics of Field Biology by Dr. K. Prasad
INVITED SPEAKERS WITH AFFLIATION DETAILS (IF ANY)	Prof. Praveen K.Verma, FNASc, Professor of Cell & Molecular Biology, School of Life Sciences, JNU
OUTCOMES	The workshop significantly enhanced students' understanding of scientific research by combining theoretical sessions with practical training. Participants gained hands-on experience in lab techniques, data analysis, and fieldwork, equipping them with essential skills for future academic and research pursuits. The event fostered critical thinking, ethical awareness, and confidence in conducting independent research.

PROOFS & DOCUMENTS ATTACHED (Tick mark the proofs attached):

1 Notice & Letters ✓	2 Number of Participants & Name of participants ✓	3 Video clip	4 Photos ✓	5 Feedback Form & analysis
6 News clip with details	7 Sample Copy of the Certificate ✓	8 Posters/ Invites ✓	9 Event report Attested by Event Coordinator & IQAC Coordinator	10 Any other document

Departmental file no: SVC/Department of Botany/2024-25/February 2025/01
IQAC File No: SVC/IQAC/Department of Botany/2024-25/February 2025
Criterion No: IV
NAME OF EVENT-IN-CHARGE & SIGNATURE: Dr. Pooja Gokhale Sinha

Note: Please fill in your own details in places with red font

For Reference

Criterion I	Curricular Aspects (planning & Implementation)		Criterion V	Student Support & Progression
Criterion II	Teaching Learning & Evaluation		Criterion VI	Governance, Leadership & Management
Criterion III	Research, Innovations & Extension		Criterion VII	Institutional Values & Best Practices
Criterion IV	Learning Resources and Infrastructure			

REPORT

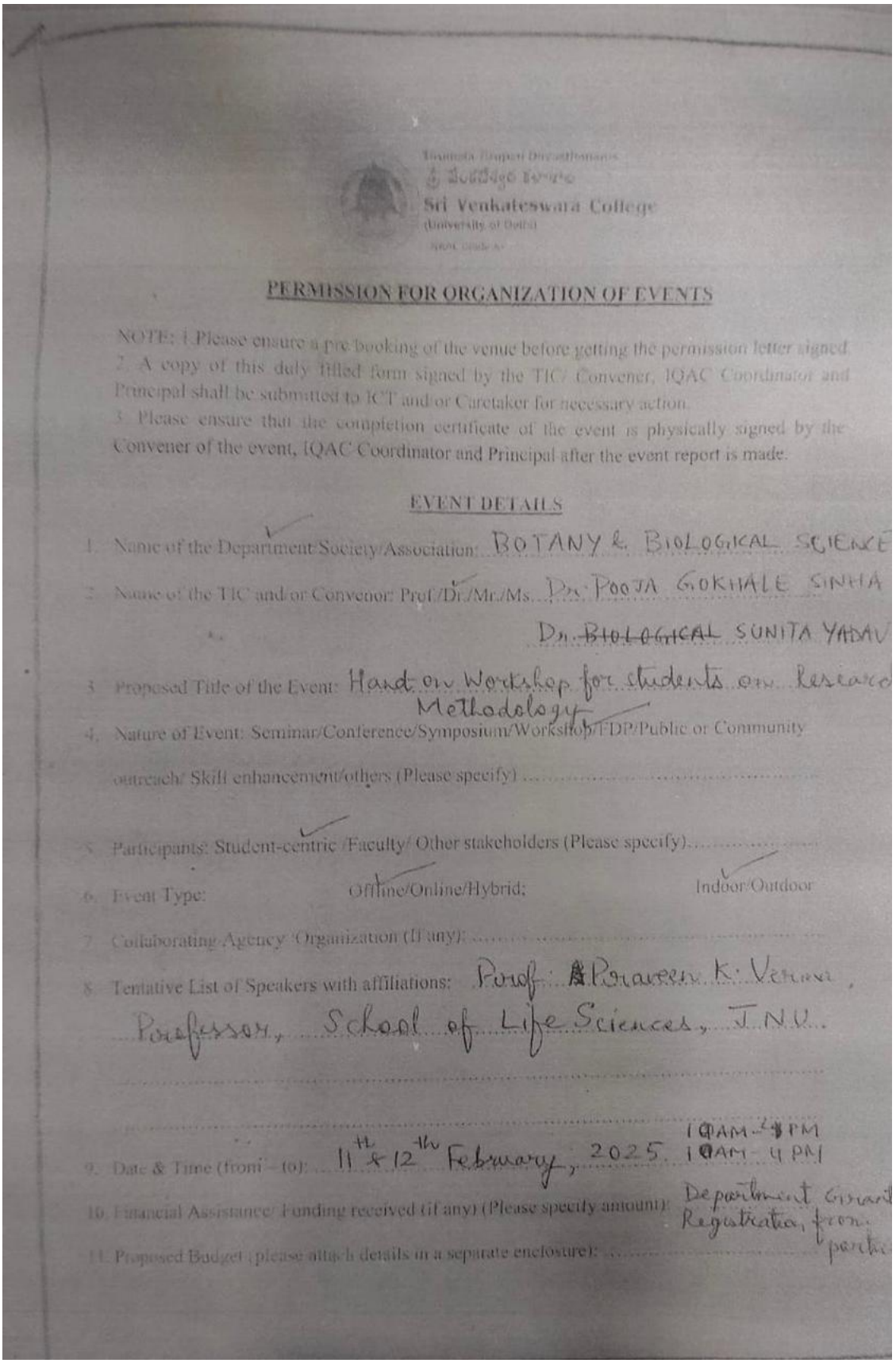
The Department of Botany at Sri Venkateswara College, in line with its commitment to academic excellence, organized a comprehensive two-day Hands-On Workshop on Research Methodology on February 11–12, 2025. The workshop was designed to build a strong research foundation for undergraduate and postgraduate students in the biological sciences by blending classroom theory with practical, real-world applications.

Day 1 began with an inaugural address by Prof. Praveen Varma, emphasizing the role of scientific inquiry in academic and professional growth. Participants then engaged in a series of interactive sessions. These included crucial topics like laboratory safety, research ethics, and intellectual property rights—ensuring students not only understood the importance of responsible research but also legal frameworks protecting innovations. Practical exercises on microscopy, staining, and handling of scientific instruments gave students direct exposure to essential lab techniques.

Day 2 continued this experiential approach. The biostatistics session introduced tools necessary for analyzing experimental data, while the preparation of laboratory solutions focused on accuracy and protocol adherence. A key highlight was the field-based session on plant identification and herbarium preparation—students explored campus biodiversity and created scientifically catalogued plant specimens. The workshop concluded with an engaging lecture on field biology, outlining techniques for field data collection and the importance of ecological documentation.

The workshop was highly successful in fostering analytical thinking, ethical responsibility, and technical competence. Participant feedback praised the balance between hands-on activities and expert-led instruction. This initiative significantly contributed to the participants' readiness for independent research and further academic pursuits.

PERMISSION



Sri Venkateswara College
(University of Delhi)

PERMISSION FOR ORGANIZATION OF EVENTS

NOTE: 1. Please ensure a pre booking of the venue before getting the permission letter signed.
2. A copy of this duly filled form signed by the TIC/ Convener, IQAC Coordinator and Principal shall be submitted to ICT and/or Caretaker for necessary action.
3. Please ensure that the completion certificate of the event is physically signed by the Convener of the event, IQAC Coordinator and Principal after the event report is made.

EVENT DETAILS

1. Name of the Department/Society/Association: BOTANY & BIOLOGICAL SCIENCE
2. Name of the TIC and/or Convenor: Prof./Dr./Mr./Ms. Dr. POOJA GOKHALE SINHA
   Dr. ~~BIOLOGICAL~~ SUNITA YADAV
3. Proposed Title of the Event: Hand on Workshop for students on Research Methodology
4. Nature of Event: Seminar/Conference/Symposium/Workshop/FDP/Public or Community outreach/ Skill enhancement/others (Please specify) .....
5. Participants: Student-centric /Faculty/ Other stakeholders (Please specify).....
6. Event Type: Offline/Online/Hybrid; Indoor/Outdoor
7. Collaborating Agency/ Organization (If any): .....
8. Tentative List of Speakers with affiliations: Prof. Praveen K. Verma, Professor, School of Life Sciences, J.N.U.
9. Date & Time (from – to): 11th & 12th February, 2025. 10AM-2PM 10AM-4PM
10. Financial Assistance/ Funding received (if any) (Please specify amount): Department Grant Registration from participants
11. Proposed Budget (please attach details in a separate enclosure): .....

12. Faculty responsible for Geo Tagged Pictures Dr. Priyanka Deveshwar

13. Faculty responsible for Event Report Dr. Pooja Gokhale + Dr. K. Bras

14. ICT support required, if any (ICT Lab, Laptop, LCD projector)

15. Caretaker support required (tables, chairs, public addressing system, sanitation, manpower assistance)

16. Venue requirement (Seminar hall/ Ground/others) - ~~Seminar Hall~~ for 11th Feb. (10 AM)
- Botany Labs.

Gokhale.
TIC/Convenor (Dr. POOJA GOKHALE)

Date: 27.1.25

For official purpose

Comments (If any)
Criteria 2, 1

For Richa Misra
IQAC Coordinator

Date:

Subject related
Venue – Principal office

Seminar Hall may not be AV
pls look for alternate venue
accordingly take consent of cor
departments

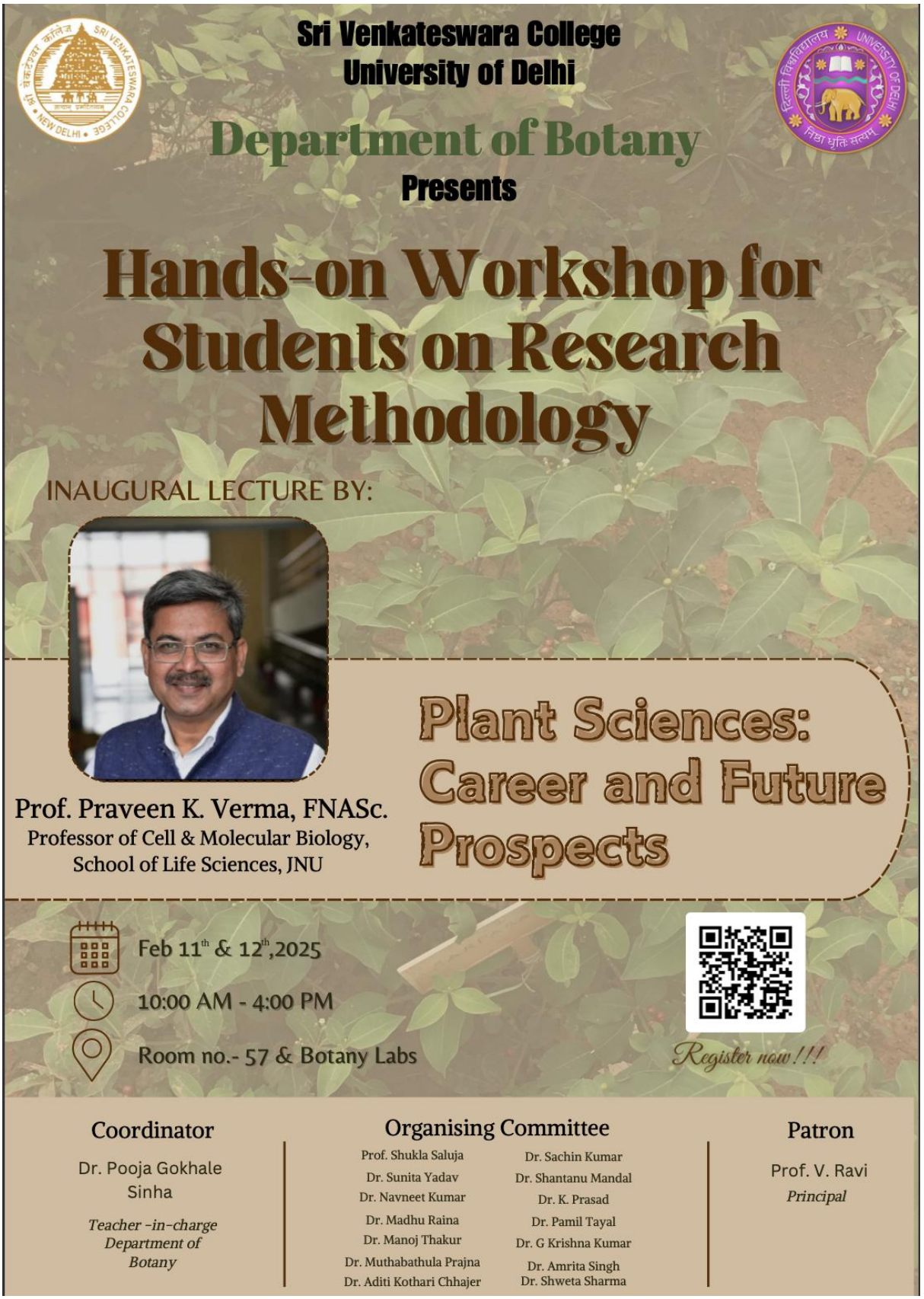
Principal

Date:

Respected Sanjay sir,
Please allot us Room no. 57
for 11th Feb (Tuesday) for 1 & 2
period. Botany General Lab is
the alternate room.

Gokhale.
Prof. Sanjay
pls advise

POSTER


Sri Venkateswara College
University of Delhi
Department of Botany
Presents
Hands-on Workshop for Students on Research Methodology
INAUGURAL LECTURE BY:
Prof. Praveen K. Verma, FNASc.
Professor of Cell & Molecular Biology,
School of Life Sciences, JNU
Plant Sciences: Career and Future Prospects
Feb 11th & 12th,2025
10:00 AM - 4:00 PM
Room no.- 57 & Botany Labs
Register now!!!
Coordinator
Dr. Pooja Gokhale Sinha
Teacher -in-charge
Department of Botany
Organising Committee
Prof. Shukla Saluja
Dr. Sunita Yadav
Dr. Navneet Kumar
Dr. Madhu Raina
Dr. Manoj Thakur
Dr. Muthabathula Prajna
Dr. Aditi Kothari Chhajer
Dr. Sachin Kumar
Dr. Shantanu Mandal
Dr. K. Prasad
Dr. Pamil Tayal
Dr. G Krishna Kumar
Dr. Amrita Singh
Dr. Shweta Sharma
Patron
Prof. V. Ravi
Principal

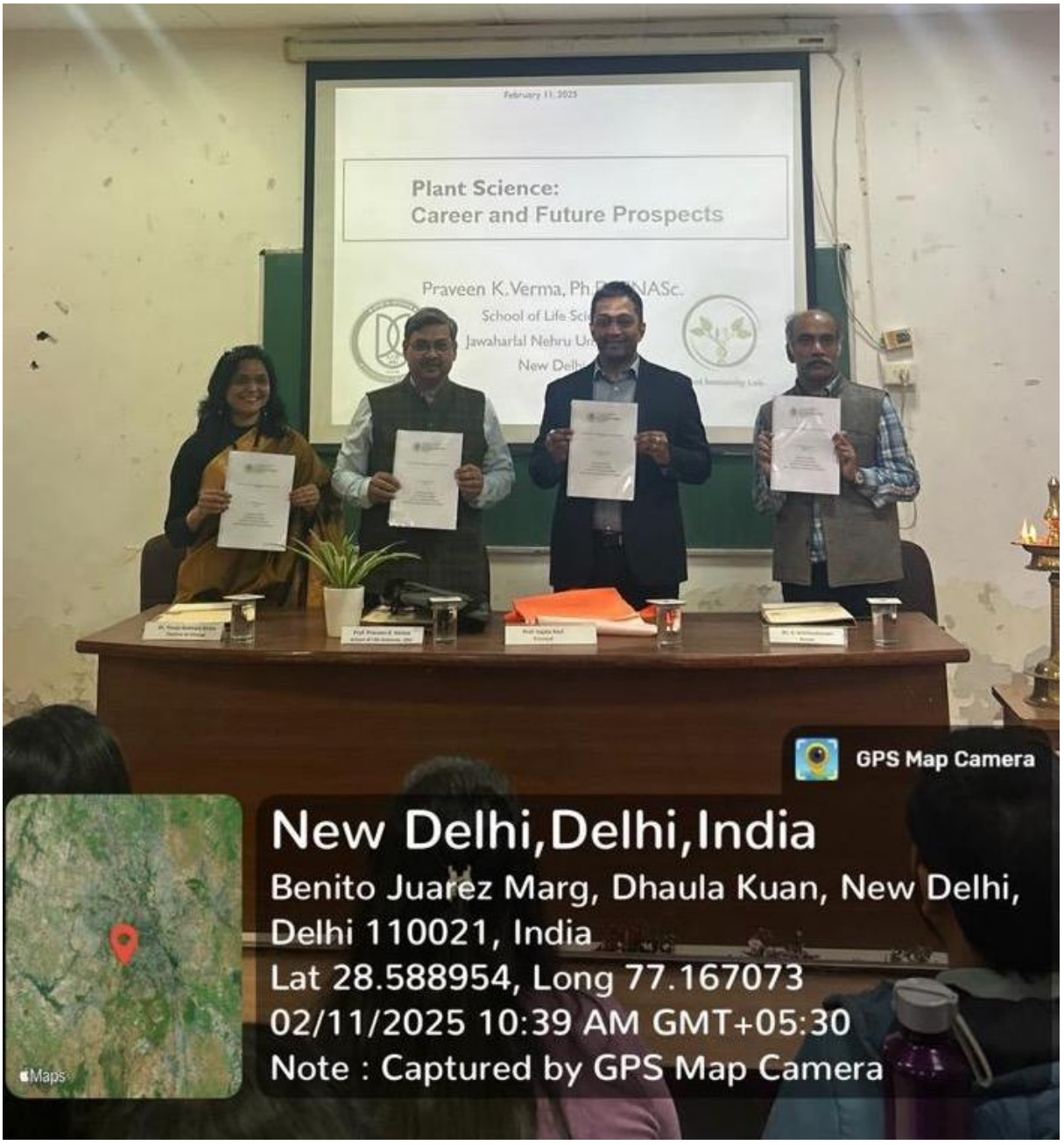
ATTENDANCE

ATTENDANCE (Hands on Workshop on Research Methodology)

Name of Students	Course	Semester	Day 1 (11.02.2025)				Day 2 (12.02.2025)			
			Session 1	Session 2	Session 3	Session 4	Session 1	Session 2	Session 3	Session 4
Alka Rani	Botany Hons.	4th	Alka.	Alka.	Alka.	Alka	Alka	Alka.	Alka.	Alka
Aayushi Nain	Botany Hons.	4th	Aayushi	Aayushi	Aayushi	Aayushi	Aayushi Nain	Aayushi Nain		Aayushi Nain
Suhani Yadav	Botany Hons.	4th	Suhani Yadav	Suhani Yadav	Suhani Yadav	Suhani Yadav	Suhani Yadav	Suhani Yadav	Suhani Yadav	
Deepak Dutt	Botany Hons.	4th	Deepak Dutt	Deepak Dutt	Deepak Dutt	Deepak Dutt	—	—	—	—
Barsha Mandal	Botany Hons.	4th	Barsha	Barsha	Barsha	Barsha	Barsha	Barsha	Barsha	Barsha
Aryan kumar	Botany Hons.	4th	Aryan kr.	Aryan kr.	Aryan kr.	Aryan kr.	Aryan kr.	Aryan kr.	Aryan kr.	Aryan kr.
Gauri Thakur	Botany Hons.	4th	Gauri	Gauri	Gauri	Gauri	Gauri	Gauri	Gauri	Gauri
Sreelekshmi S	Botany Hons.	4th								
Aman Singh	Botany Hons.	4th	Aman	Aman	Aman	Aman	Aman	Aman	Aman	Aman
Vishesh Porwal	Botany Hons.	4th	Vishesh	Vishesh	Vishesh	Vishesh	Vishesh	—	—	—
Atul Kumar Surya	Botany Hons.	4th	Atul	Atul	Atul	Atul	Atul	Atul	Atul.	Atul.
Nivisha V	Botany Hons.	4th	Nivisha V.	Nivisha V.	Nivisha V.	Nivisha V.	Nivisha V.	Nivisha V.	Nivisha V.	Nivisha V.
Neiphretuonuo Kire	Botany Hons.	4th								
ANOUSHKA TIWARI	Botany Hons.	6th					—	—	—	—
Payal Thakur	Bio. Sci.	4th								

Srishti Rathore	Botany Hons.	4th	Srishti	Srishti	Srishti	Srishti	Srishti	Srishti	Srishti	Sric
Tarita Dinesh	Botany Hons.	4th	Tarita	Tarita	Tarita	Tarita	Tarita	Tarita	Tarita	Tari
Shruti Thakur	Botany Hons.	4th	Shruti	Shruti	Shruti	Shruti	Shruti	Shruti	Shruti	shru
Vibhore Ishar	Botany Hons.	4th								—
Aksh Moudgil	Botany Hons.	4th						Ab	Ab	A
Sana Fathima	Bio. Sci.	4th								
Drishti Sethi	Bio. Sci.	4th	Drishti	Drishti	Drishti	Drishti	Drishti	Drishti	Drishti	Dris
Anjali Choudhary	Botany Hons.	4th	—	—	—	—	Anjali	Anjali	Anjali	Anj
Ankita Padiya	Botany Hons.	4th	Ankita	Ankita	Ankita	Ankita	Ankita	Ankita	Ankita	Ank
Kritika Sah	Botany Hons.	4th	Kritika	Kritika	Kritika	Kritika	Kritika	Kritika	Kritika	Kriti
Soniya meena	Botany Hons.	4th	Soniya	Soniya	Soniya	Soniya	Soniya	Soniya	Soniya	Soni
Sweta choudhary	Botany Hons.	4th	Sweta Choudhary	Sweta Choudhary	Sweta Choudhary	Sweta Choudhary	Sweta Choudhary	Sweta Choudhary	Sweta Choudhary	Sweta
SUKRITI DUBEY	Botany Hons.	4th	—	—	—	—	—	—	—	—

PHOTOS


February 11, 2025
Plant Science:
Career and Future Prospects
Praveen K. Verma, Ph
NASc.
School of Life Sci
Jawaharlal Nehru Un
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GPS Map Camera
New Delhi,Delhi,India
Benito Juarez Marg, Dhaula Kuan, New Delhi, Delhi 110021, India
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Maps


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Dhaula Kuan, New Delhi, 110021, Delhi, India
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Hands-on Workshop for Students on Research Methodology
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Dhaula Kuan, New Delhi, 110021, Delhi, India
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Note : Captured by GPS Map Camera


GPS Map Camera
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Lat 28.588731° Long 77.167152°
12/02/25 02:53 PM GMT +05:30
Google


STATISTICAL TERMS
Population
Sample
GPS Map Camera
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Dhaula Kuan, New Delhi, 110021, Delhi, India
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Note : Captured by GPS Map Camera


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Note : Captured by GPS Map Camera


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Dhaula Kuan, New Delhi, 110021, Delhi, India
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Note : Captured by GPS Map Camera


Plant Science:
Career and Future Prospects
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Benito Juarez Marg, Dhaula Kuan, New Delhi, Delhi 110021, India
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Maps

MANUAL RELEASED

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Sri Venkateswara College
(University of Delhi)
NAAC Grade A+

"TWO DAY HANDS-ON WORKSHOP ON RESEARCH METHODOLOGY"
MANUAL

11th& 12th FEBRUARY, 2025

Organized by

Department of Botany

Sri Venkateswara College

University of Delhi (South Campus),

Benito Juarez Road, Dhaula Kuan, New Delhi-21.

Tirumala Tirupati Devasthanams

శ్రీ వేంకటేశ్వర కళాశాల

श्री वेंकटेश्वर महाविद्यालय

SRI VENKATESWARA COLLEGE

(University of Delhi)

NAAC Grade A+

समापन प्रमाण पत्र

COMPLETION CERTIFICATE

यह प्रमाणित किया जाता है कि दो दिवसीय प्रायोगिक कार्यशाला.....(शीर्षक) को (तारीख) को (समय) 11,12 feb.....पूर्वाह्न /अपराह्न से.....पूर्वाह्न/अपराह्न तक वनस्पति शास्त्र (विभाग/समिति) द्वारा (ऑनलाइन/ऑफ़लाइन/हाइब्रिड) माध्यम में सफलतापूर्वक आयोजित किया गया और इस कार्यक्रम की रिपोर्ट अभिलेख के लिए आंतरिक गुणवत्ता आश्वासन प्रकोष्ठ (IQAC) को जमा कर दी गई है।

This is to certify that the 2-day Hands on Workshop on Research Methodology.....(Title) was successfully conducted on 11-12 Feb 2025 (Date) from ..9:30..(Time) am/pm to ..5.....~~am~~/ pm by ....BOTANY.....(Department/Society of) in the (Online/Offline/Hybrid) mode, and its event report has been submitted to IQAC for records.

Departmental file no: SVC_IQAC_BOT_2024-25_feb 2025_offline_04

IQAC File No: SVC_IQAC_BOT_2024-25_ feb.2025_offline_04

Event-in-Charge
Date:

IQAC Coordinator

Principal
17/11/26

Tirumala Tirupati Devasthanams
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Sri Venkateswara College
(University of Delhi)
NAAC Grade A+

"TWO DAY HANDS-ON WORKSHOP ON RESEARCH METHODOLOGY"
MANUAL

11th& 12th FEBRUARY, 2025

Organized by

Department of Botany

Sri Venkateswara College

University of Delhi (South Campus),

Benito Juarez Road, Dhaula Kuan, New Delhi-21.

TWO DAY HANDS-ON WORKSHOP ON RESEARCH METHODOLOGY

MANUAL

Compiled by

Dr. Muthabathula Prajna, Dr. Amrita Singh & Dr. Sarda Thokchom

Inaugural Lecture on – "Plant Sciences: Career and Future Prospects"

by

Prof. Praveen K Verma, FNASc., School of Life Sciences, JNU, New Delhi.

Event Coordinator & Teacher In Charge: Pooja Gokhale Sinha

Organizing Committee:

Prof. Shukla Saluja
Dr. Sunita Yadav
Dr. Navneet Kumar
Dr. Madhu Raina
Dr. Manoj Thakur
Dr. Muthabathula Prajna
Dr. Aditi Kothari Chhajer
Dr. Sachin Kumar
Dr. Shantanu Mandal
Dr. K. Prasad
Dr. Pamil Tayal
Dr. G Krishna Kumar
Dr. Amrita Singh
Dr. Shweta Sharma

Department of Botany

Sri Venkateswara College

University of Delhi.

Table of Contents

1	**Session 1: Microscope use and Slide Preparation**	**4-11**
2	**Session 2: Protecting Creativity and Innovation: An Introduction to Intellectual Property**	**12-13**
3	**Session 3: Preparation of Herbarium and its maintenance**	**14-16**
4	**Session 4: Instrumentation**	**17-27**
5	**Session 5: Preparation of Solutions and Serial Dilution**	**28-32**
6	**Session 6: Biostatistics**	**33-49**
7	**References**	**50**

Session 1: Microscope use and Slide Preparation

By

Dr. Pooja Gokhale Sinha & Dr. Madhu Raina

1. Introduction:

A microscope is the instrument used to magnify and increase the resolution of objects that cannot be seen with naked eyes. Different types of microscopes (Dissecting, Compound, Electron, Fluorescence and Phase contrast etc.) are used in biology laboratories as per the requirement. In laboratories, generally dissecting and compound microscopes are used.

For compound microscopic studies, the object to be observed is placed on a transparent glass slide kept on the stage of the microscope. To improve the visibility and contrast in the microscopic image, colored chemicals known as stains are used. The object may be visualized either by preparing a whole mount or by cutting their sections.

In order to view the object under the microscope, temporary and/or permanent slides are prepared. Temporary mounts are prepared for short term study where the material is discarded soon after the observation. Preparation of a permanent slide allows the material to be kept for a longer duration.

In this handbook, we will study the techniques for microscopic study of tissues, organs, and organisms. It includes different methods of preparation of material, staining, mounting, and visualization.

2. Instruments/Material/Chemicals required for slide preparation:

2.1 Microscopes: For microscopic studies, the different types of microscopes are used:

2.1.1 Dissecting Microscope: It is used to study the morphological features and details of organisms such as flowers, algae, insects, etc. It has lower magnification and resolution than a compound microscope (Fig. 1.1.a).

2.1.2 Compound Microscope: Due to the combination of various lenses (condenser, objective and eyepiece) it has better resolving power and magnification. It can magnify an image up to 1000 times. It is used to study the morphological and anatomical details of the

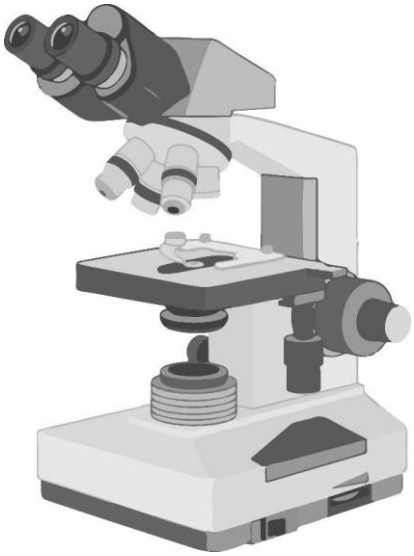
organisms. Depending upon the number of eyepieces, it may be monocular (Fig. 1.1.b) or bilocular (Fig. 1.1.c).



(a)



(b)



(c)

Figure 1.1: (a) Dissecting Microscope, (b) Compound Microscope (Monocular), (c) Compound Microscope (Binocular)

2.2 Other equipment: For the preparation of slide, several small equipment is required.

Equipment and Glassware required in the Biology Laboratory:

(i) Drop bottles
(ii) Staining rack
(iii) Wooden Tray
(iv) Blade
(v) Petri dish
(vi) Watch glass
(vii) Glass marker/Permanent marker/slide labels
(viii) Dissecting needle
(ix) Forceps
(x) Pencil and Erase
(xi) Pair of Scissors
(xii) Coverslips
(xiii) Glass slide
(xiv) Glass Dropper
(xv) Painting hair brush

2.3 Biological material:

The material to be studied under a microscope can be:

- a whole microscopic organism such as *Amoeba*, *Paramecium*
- part of the organism such as pollen grains, cheek cells
- section of the organism such as L.S. of *Hydra*
- section of an organ such as T. S. of stem, root, V.S. of leaf etc.

Depending upon the requirement or availability, we can take fresh biological material or the preserved ones. We will study more about the preservation of the material in the next section.

2.4 Chemicals and Reagents:

Several chemicals are used in Biology laboratory to facilitate microscopic study. These are fixatives, preservatives, stains, dehydrating agents, clearing agents, and mounting media (Table 1.1).

Table 1.1: List of chemicals required for slide preparation.

S. No.	Category	Examples	Use
1.	Fixatives	Acetic acid alcohol (AA), Formaldehyde Acetic Acid alcohol (FAA).	preserve cells, tissues, organs in as near as a life-like condition as possible
2.	Preservative	70% ethanol	For long-term storage and prevents decomposition
3.	Stains	Safranin, Fast green etc.	Increase visibility and contrast
4.	Mounting media	Glycerin, lactophenol	Prevent dehydration

3. Technique of slide preparation:

3.1 Glass slide and its handling:

Glass slide is a colourless, transparent rectangular thin sheet of glass 25mmx75mmX1mm in size.

How to handle a glass slide?

1. Wash your hands with soap to remove oil, dust etc. before slide preparation.
2. Wash the slide with a gentle soap solution and rinse it with water.
3. Drain off the extra water by keeping the slide on a clean surface.
4. Wipe off the extra water with a clean muslin cloth.
5. Always hold the slide from the edges to avoid any finger prints/dust (body oil coming in contact with the slide).

3.2 Methods of Sample preparation:

Some materials are easily available in our neighbourhood or throughout the year (onion peel, pollen grain, cheek cells etc.), and can be used as fresh material. In case fresh material is not available, we may use the preserved ones (grasshopper testes, onion root tips).

3.2.1 Fixation:

Chemicals used to preserve cells, tissues, and organs in as near a lifelike condition as possible are known as fixatives. Example: Acetic acid alcohol (AA), formaldehyde acetic acid alcohol (FAA). Fixation is the process of preserving the samples for further use, and it:

- results in minimum changes like shrinkage or distortion.
- also prevents autolysis and bacterial decay.
- helps in maintaining the cell components in a state suitable for further processing such as sectioning, staining, and mounting.

3.2.2 Preservation:

After fixation for 24-48 hrs., material is transferred to a preservative such as 70% ethanol (70 mL ethanol +30 mL water) for long term storage. Preservatives prevent further decomposition and any chemical change. The preservative should be replaced every six months to maintain its concentration.

3.3 Methods of Slide Preparation:

Biological material may be observed either by mounting or cutting their sections.

3.3.1. **Mounting**: Small objects are mounted directly on the slide. Depending on the requirement and technique of processing of the material, mount may be: whole mount, peel mount, smear preparation, squash preparation, and maceration.

Whole Mount: Small, thin, and transparent objects are mounted as a whole over the slide in order to study their morphology (external form and structure), e.g., *Rhizopus* (bread mold), *Oedogonium* filament, pollen grains, cheek cells, etc.

Peel Mount: To study the epidermal structures (e.g., number, arrangement, distribution, and structure of stomata, trichomes, etc.) of plant leaves, peel mount is done. The leaf is held from the lamina and gently pulled apart. This strips off the epidermis, which comes out as a transparent membranous structure.

The stripped epidermis is stained with a drop of safranin, washed, mounted in glycerin, and observed under microscope.

Smearing: Smearing is a technique used to study various types of bacteria, blood cells, etc. by making a thin film of material on a slide known as a smear. In this process, a drop of material (curd, blood) is taken on a slide and another slide is kept at a 45º angle on the slide,

and it is gently dragged through the material. Slide may be further processed depending upon the requirement.

Squash preparation: It is generally used to study the different stages of cell division. This method consists of spreading the cells in a single layer.

Maceration: It is a technique to observe individual cells of xylem after treating it with Jeffrey's solution. Small pieces of stem are boiled in a mixture of equal volume of 10% nitric acid and 10% chromic acid for 15-20 minutes. It is then teased by a needle and spread over the slide, stained with safranin, and mounted in a drop of glycerin.

3.3.2. Section cutting: In order to study the internal structure of tissues and organs, thin and transparent slices known as sections are cut. Organs, such as stems, roots, leaves, etc., are cut by a blade, razor or equipment such as a microtome. These are called sections, which may be cut in different planes depending upon the type of study.

Planes for Section cutting: The sections may be cut in the following planes of material:

1. **Vertical**: In the case of dorsoventrally flattened structures such as leaves and some bryophytes, the sections are cut perpendicular to the main axis of the material.
2. **Transverse**: When the organ under observation is cylindrical e.g. stem or root, the section cut by passing razor's edge at right angles to the longitudinal axis.
3. **Longitudinal**: When the organ under observation is cylindrical, e.g., stem or root, the section is cut by passing the razor's edge parallel to the longitudinal axis. Two sections are possible in longitudinal plane:
    i. *Radial longitudinal section* (R.L.S.) if it passes along one of the radii.
    ii. *Tangential longitudinal section* (T.L.S.) if section is cut along one of its tangents.

Method of section cutting:

Following steps would be useful for section cutting:

1. Soft, thin, and small materials may be placed in pith (Pieces of carrot and radish roots or potato tubers may be used as pith for embedding and easy handling of the material to be sectioned) by splitting it longitudinally with a blade.
2. A new blade should be used to cut sections, and it must be held properly.

3. The material or the pith with embedded material is held between the thumb and the index finger of the left hand.
4. The material in the left hand and the blade's edge should form a right angle.
5. The blade is now moved quickly over the material, and the stroke is completed in one action only.
6. The sections are carefully lifted by a fine camel hair brush and then transferred to a watch glass containing water.
7. The sections that float on water in the watch glass are considered to be thin.
8. These sections are lifted by a hair brush, placed on a slide in a drop of water, and observed through a microscope.

3.4 Staining: Stains are colored chemical compounds that combine with particular cell or tissue component(s) to impart specific colour (s). These enhance the visibility and contrast in the microscopic image for easy identification.

Stains may be acidic, basic, or neutral. Various types of stains can be used depending upon the chemical composition of the cell for study (Table 1.2).

Table 1.2 Some commonly used stains in Biology laboratory are:

S. No.	Types of stain	Example	Ionic charge	Common Uses
1.	Acidic	Methyl Blue, Aniline Blue	Anion (-)	To stain Cytoplasmic components such as proteins
2.	Basic	Safranin, Crystal Violet	Cation (+)	To stain Nucleus and Nucleic acid
3.	Neutral	Methylene Blue	No Charge	Nuclei and cytoplasm e.g. cheek cells.
4.	Vital stains	Janus Green B	Variable	Mitochondria in living cells

In order to give better clarity and contrast, a double staining method may be used where two stains are used. These stains impart color to different tissue, based upon their cellular character. When a combination of safranin and fast green is used to stain a section of stem or

root, safranin stains the thick-walled xylem, which appears red/pink. Fast green stains the thin-walled phloem cells, giving them a green appearance.

3.5 Mounting: After staining, the material is mounted in a mounting medium to prevent dehydration. It also holds the material in place on the glass slide and protects it from physical harm and degradation. Different types of mounting media are used for preparing temporary and permanent slides/mounts. Water, glycerin, or lactophenol can be used for temporary preparations; whereas Canada balsam or DPX can be used for making permanent slides.

Session 2: Protecting Creativity and Innovation: An Introduction to Intellectual Property

By

Dr. Aditi Kothari Chhajer

We live in an era of rapid innovation, where new inventions emerge at an astonishing pace to meet the ever-growing needs of humanity. Unsurprisingly, brilliant minds seek to safeguard their creations, which they can achieve through patent filings. As a result, there has been a surge in awareness and protection of intellectual property through various methods. Today, intellectual property rights (IPRs) are regarded as assets that often hold greater value than tangible property.

Intellectual Property Rights (IPRs) are legal protections granted to creators and inventors for their innovations, artistic works, and brand identities. These rights allow individuals andbusinesses to control and benefit from their creations, preventing unauthorized use by others.

The main types of IPRs include:

1. **Patents** – A patent is a legally granted exclusive right for an invention. It benefits inventors by offering legal protection for their creations while also serving society by making technical information about these inventions publicly available. This, in turn, fosters innovation and technological progress.
2. **Copyrights** – **Copyright** is a legal right that protects original literary, artistic, musical, and other creative works from unauthorized use. It grants the creator exclusive rights to reproduce, distribute, display, and adapt their work for a specific period. Copyrights subsists in itself, meaning that one does not have to necessarily register for copyright, it is granted automatically. However, copyrights protect the **expression** of ideas, not the ideas themselves. They encourage creativity while balancing public access to knowledge.
3. **Trademarks** – **Trademark** is a legal protection granted to symbols, names, logos, slogans, or other distinctive signs that identify and distinguish goods or services of a business from those of others. It helps build brand identity and prevents unauthorized use by competitors.

4. **Trade Secrets** – A **trade secret** is confidential business information that provides a company with a competitive advantage. Unlike patents or trademarks, trade secrets are not publicly disclosed and are protected as long as they remain secret.
5. **Industrial Designs** – **Industrial design** refers to the aesthetic or ornamental aspects of a product, including its shape, pattern, color, or combination thereof. It protects the visual appeal of a product rather than its function. For example: The unique shape of a smartphone or car, the decorative pattern on fabrics or ceramics or the sleek design of furniture or appliances

Intellectual property (IP) protection offers numerous advantages, fostering innovation and creativity by providing inventors, artists, and businesses with exclusive rights over their creations. These protections prevent unauthorized use, ensuring that creators can benefitfinancially from their work. By granting exclusive rights, IP protection also gives businesses a competitive edge, allowing them to establish strong brand identities through trademarks and copyrights while safeguarding proprietary technologies and processes through patents and trade secrets. Additionally, IP assets can be monetized through licensing, sales, or franchising, generating significant revenue. Legal protection further strengthens businesses by enabling them to take action against infringement, ensuring that their innovations and brand reputation remain intact. Overall, IP protections are essential for economic growth, business success, and continued advancements in technology and creativity.

Session 3: Preparation of Herbarium and its maintenance

By

Dr. Muthabathula Prajna & Dr. Shantanu Mandal

Introduction:

A herbarium (plural herbaria) is a storehouse of dried plant specimens collected from far and wide, mounted on appropriate sheets, arranged according to some known system of classification and kept in pigeonholes of steel or wooden cup-boards and are generally associated with botanic gardens and educational or research organizations.

Objectives:

- To provide facilities for determination of any material including new taxa.
- To enable preparation of new monographs and floras.
- To preserve specimens of historic importance.
- To understand the importance, procedure of herbarium preparation and maintenance of Herbarium.

Methodology:

Herbarium sheet:

The general size of the mounting board or herbarium sheet is 42 x 28 cm. The label with the size of 12 x 8 cm is generally pasted on the bottom right-hand corner of the mountingboard. The specimen is pasted as far as possible in the middle, field number at middle of left margin and accession number and/or barcode at right top of the herbarium sheet.

Collection:

There are three ways of collecting the plant specimens in the field.

1. If the trip is for one day, one can carry the plant press and newspapers or blotters. The specimens are pressed then and there in the field.
2. The second method is to keep the collected specimens in metal can called Vasculum. Wet newspapers must be placed inside the Vasculum to keep the specimens cool. The

plants kept in the Vasculum must be transferred to newspaper that day itself or the Vasculum along with the plants may be kept in a cool place overnight.

3. Now-a-days polythene bags are available and they are of varying sizes. The collected plants are placed inside and the mouth is tied tightly. This is easy to carry and there will be no serious loss of the plant material kept inside. The plants can be pressed after reaching the headquarters.

A very important part of the plant collection work is the recording of field notes. Detailed notes should be entered in the field note-book at the time of collection in the field itself. Generally, the following details should be recorded in the field notebook. a) Date b) Vernacular name c) Locality d) Habitat e) Description f) Collector's name, etc.

Processing of specimens:

The processing of specimens includes**i.** Poisoning,**ii.** Pressing, **iii.** Drying, **iv.** Mounting, **v.** Stitching, **vi.** Labelling, **vii.** Identification/Determination of plants, **viii.** Incorporation, and **ix.** Arrangement.

i. **Poisoning**: The poisoning is generally done by dipping the whole plant in a saturated solution of mercuric chloride in ethyl alcohol.
ii. **Pressing**: It is the process of placing specimens between the absorbents under heavy pressure. All plant parts such as leaves and flowers etc. are spread out neatly. Some leaves are placed facing up and others facing down to show the characters on both surfaces.
iii. **Drying**: Plants should be placed in the press and be tightened. The faster the drying, greater will be the quality of the dried specimen.
iv. **Mounting**: After the specimen is pressed, dried and poisoned, it is affixed along with a label on a mounting sheet. The mounting sheets are made from heavy long-lasting white card sheet in uniform size of 28 x 42 cm. The common technique now in use in our country is pasting specimens to sheet with glue.
v. **Stitching**: The stitching should be small and independent and thread should not be carried from one stitch to another on the lower side of the mounting sheet. A knot is put at the back and thread is cut after each knot.
vi. **Labelling**: Herbarium label is fixed on the bottom right-hand corner about 1 cm away from edges of the mounting sheet. The size and design of herbarium labels slightly

vary according to need. Size is about 8 x 12 cm. In general, the label should contain the following data. 1. Name of the family, 2. Name of the genus and species, 3. Locality of collection, 4. Date of collection, 5. Habitat, 6. Collector‟s name and field number and 7. Vernacular name and local uses.

vii. **Identification**: For the purpose of identification, the scientific method is to first study the characters of the plant, check them with the flora of the region, work through the family, genus and species keys and compare with full description and illustration**.**

viii. **Incorporation**: The mounted, identified and accessioned herbarium sheets are sorted out family, genus and species wise. All the sheets of the same species are filed in lighter covers called the "species cover or folders"; and all the species (with species covers or folders) belonging to one genus are placed in one more folder of heavy paper called the genus cover.

Herbarium Maintenance:

Contact insecticides used in herbaria are Cyanide gas, Paradichloro benzene (PDB), Carbon dioxide or DDT. Digestive poisons are the salts of Mercury and Arsenic. Mercuric chloride is the insecticide.

Handling of specimens should be done with care without damaging the specimen as it has to be stored for longer periods for the use by students, scholars, scientists etc.

Outcomes:

After going through the session one can understand the importance of Herbarium, its preparation and maintenance. This helps in handling the herbarium specimen in future.

Session 4: Instrumentation

Agarose Gel Electrophoresis & pH meter

By

Dr. Guduru Krishna Kumar

I. Principle, procedure, and applications of Agarose Gel Electrophoresis

Objective: To demonstrate the Agarose Gel Electrophoresis for separation of the nucleic acids

Procedure:

i. Take the agarose in concentrations of 0.7%-2% depending on the size of bands needed to be separated. (e.g., 2 g of agarose will make a 2% gel).

ii. Mix agarose powder with 100 mL 1xTAE in a microwavable flask (TBE can be used instead of TAE).

iii. Microwave for 1 to 3 minutes until the agarose is completely dissolved.

iv. Let agarose solution cool down to about 50 °C for 5 minutes (about when you can comfortably keep your hand on the flask).

v. Add ethidium bromide (EtBr) to a final concentration of approximately 0.2-0.5 μg/mL (usually about 2-3 μL of stock solution per 100 mL gel).

vi. Pour the agarose gel slowly into a gel tray with the well comb in place.

vii. Place the poured gel at room temperature for 20 to 30 minutes or until it has completely solidified.

viii. Meanwhile, take the gel box (electrophoresis unit) and fill with 1xTAE (or TBE) until the gel is covered.

ix. Once solidified, place the agarose gel into the gel box

x. Carefully load a molecular weight ladder into the first lane of the gel

xi. Add a loading buffer to each of the samples and carefully load into the additional wells of the gel.

xii. Run the gel at 80-150 V until the dye line is approximately 75-80% of the way down the gel. A typical run time is about 60 to 90 minutes depending on the gel concentration and voltage.

xiii. Afterwards, turn OFF power, disconnect the electrodes from the power source, and then carefully remove the gel from the gel box to observe under UV light to visualize the DNA fragments.

Applications: Agarose gel electrophoresis is a routinely used method for separating proteins, DNA or RNA.

i. Estimation of the size of DNA molecules
ii. Analysis of PCR products for molecular genetic diagnosis or genetic fingerprinting
iii. Separation of restricted genomic DNA prior to Southern analysis, or of RNA prior to Northern analysis.
iv. The agarose gel electrophoresis is widely employed to estimate the size of DNA fragments after digesting with restriction enzymes, e.g. in restriction mapping of cloned DNA.
v. Agarose gel electrophoresis is commonly used to resolve circular DNA with different supercoiling topology, and to resolve fragments that differ due to DNA synthesis.
vi. In addition to providing an excellent medium for fragment size analyses, agarose gels allow purification of DNA fragments.

II. Principle, procedure, and applications of pH meter

Objective: To demonstrate the pH meter for analysing various test solutions

Procedure:

i. Turn on the pH meter and wait for an adequate time for it to initialize (check your pH meter operating manual for the exact time).
ii. Calibrate with suitable standard buffer solution pH range (0-7 for acidic or 7-14 for basic solutions).
iii. Remove the electrode from the standard buffer solution and clean it with deionized water.
iv. After rinsing, blot the dry electrode with non-abrasive Kimwipes or Shurwipes to remove excess water.
v. Maintain the temperature of the sample at 25°C for appropriate reading.
vi. Place the electrode in a test solution, stir the test solution and also press the measure button to measure the pH value.

vii. Then, wait until the reading gets stabilized for 1 to 2 minutes.

viii. Once the reading gets stabilized press the measure button and record the pH value and also the temperature.

ix. When done, remove the electrode, rinse it with deionized water, and blot dry with a Kimwipes.

x. Lastly, immerse the probe in a 3M potassium chloride storage solution.

Applications:

i. **Assessing soil pH in agriculture**: Major crops require an alkaline climate, and pH meters help monitor soil acidity.

ii. **Water treatment and purification**: pH meters are used in water treatment facilities and RO water purifiers to ensure water quality.

iii. **Chemical industries**: pH meters are used to neutralize wastewater from steel, pulp, paper, pharmaceutical, biotech, and petrochemical industries.

iv. **Laboratory research**: pH meters are essential tools in biology, environmental science and chemistry laboratories.

Colorimeter, Centrifuge and Water Bath

By

Dr. Amrita Singh

III. Colorimeter

A colorimeter is a device that measures the absorbance of particular wavelengths of light by a specific solution. The process is known as colorimetry. A colorimeter compares the amount of light passing through a solution with the amount that can pass through a pure solvent sample. It contains a photocell to detect the amount of light that passes through the solution under investigation. It is a light-sensitive instrument that measures the absorbing capacity of an object or substance. Colorimetry is referred to if the measured light is in the visible range of the electromagnetic radiation. In this method, a beam of light from a light source is allowed to pass via sample holder containing the analyte in the solution, the intensity of light transmitted will be less than the light passing through sample in the cuvette. The absorbed light is

in proportion to the concentration of the analyte. The color of the sample is an intrinsic characteristic of the solution or it can be evolved by the addition of suitable reagents. The absorption of the sample is compared to that of standards from which the concentration of the test sample can be calculated. The colorimeter measures that change so users can analyzethe concentration of a particular substance in that medium. The working principle of this device is based on Beer–Lambert's law, which states that the absorption of light transmitted through a medium is directly proportional to the concentration of the medium.



Figure 4.1: Colorimeter

Parts of a colorimeter: The parts of a colorimetry are as follows:

1. **Light Source/Radiation source:** Mostly an electric lamp is used as a radiation source. Commonly used lamp is tungsten filament lamp (for wavelength 320-700 nm). Any lamp source which gives adequate intensity of radiation over the entire wavelength region can be used. The source of light for colorimetry should provide continuous radiation from 320 to 700 nm with adequate intensity which should be stable and fluctuations free. As the tungsten filament lamp fulfils the above criteria, this lamp makes its place in the most colorimeters.
2. **Slit:** In a colorimeter, the slit is used to control the beam of light passing through the sample by allowing only a narrow, focused beam to enter, minimizing unwanted stray light and ensuring that only the desired wavelength reaches the detector; essentially

acting as a light source that produces a monochromatic beam by filtering out extraneous wavelengths from the white light source.

3. **Condenser:** In a colorimeter, a condenser lens is used to focus the light beam from the light source into a parallel beam of light, ensuring that the light is evenly distributed across the sample solution within the cuvette, allowing for accurate absorbancemeasurements based on Beer-Lambert Law; essentially, it concentrates the light to create a uniform illumination on the sample.
4. **Filter:** A filter is a colored optical component that selects a specific wavelength of light, allowing only the desired color to pass through and interact with the sample, ensuring that the measurement is made using the light that is most effectively absorbed by the substance being analyzed; essentially, it isolates the specific wavelength of light that the analyte in the solution absorbs most strongly, maximizing the accuracy of the colorimetric analysis.
5. **Cuvette:** A cuvette is used in a colorimeter to hold the liquid sample that is being analyzed for its color intensity by measuring the amount of light it absorbs at a specific wavelength; essentially, it acts as the container where the light passes through the sample solution to be detected by the colorimeter. Cuvettes are typically small, transparent containers with clear sides to allow light to pass through, and often have a standardized path length for accurate measurements.
6. **Photocell:** In a colorimeter, a photocell is used as the light detector, measuring the intensity of light that passes through a colored solution, which allows for the determination of the concentration of the substance in the solution based on the principle that more concentrated solutions absorb more light, resulting in a weaker electrical signal from the photocell; essentially, the photocell converts the amount of transmitted light into an electrical signal that can be read and interpreted as concentration. By comparing the electrical signal produced by the photocell when light passes through a sample solution to a reference solution, the concentration of the analyte in the sample can be calculated.
7. **Read out device:** In a colorimeter, the "read out device" is used to convert the electrical signal generated by the light detector (photocell) into a readable format, typically displaying the absorbance or transmittance of a sample as a numerical value

on a digital display, allowing the user to see the measured color intensity of a solution; essentially, it is the part that shows you the results of the colorimetric analysis.

WORKING PRINCIPLE OF A COLORIMETER

The principle behind this is based on Beer-Lambert's Law, which states that the absorbance of light by a solution is directly proportional to the concentration of the absorbing species. The colorimeter operates based on two fundamental laws of photometry, which are:

i. **Beer's Law:** When monochromatic light passes through a colored solution, amount of light transmitted decreases exponentially with increase in concentration of colored substance. i.e. the amount of light absorbed by a colored solution is directly proportional to the concentration (c)of substance in the colored solution, Aαc

ii. **Lambert's law:** The amount of the light transmitted decreases, exponentially with increase in pathlength (l) of the cuvette or thickness of colored solution through which light passes. i.e. the amount of the light absorbed by a colored solution depends on pathlength (l) of cuvette or thickness or depth of colored solution, Aαl

iii. **Combined Beer– Lambert's Law:** It is denoted as, amount of light transmitted through a colored solution decreases exponentially with increase in concentration of colored solution & increase in the pathlength of cuvette or thickness of the colored solution i.e., A= εcl, where, ε = molar absorptivity/ molar absorption coefficient/molar extinction coefficient (Lmol -1 cm-1)

The value for molar absorptivity ε is constant for a given compound at a given wavelength under prescribed conditions of solvent, temperature, pH, etc. It is a measurement of how strongly a chemical substance absorbs light at a given wavelength.

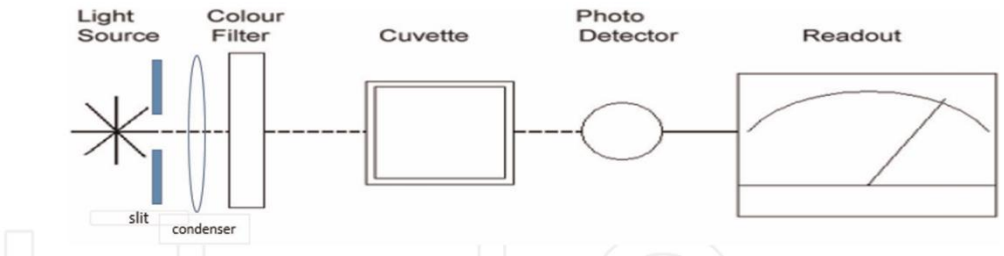


Figure 4.2: Instrumentation of a colorimeter

CALIBRATION CURVE:

A plot of absorbance values against known concentrations of a substance is known as a standard graph or a calibration curve and the standard curve should always be linear. The linearity of the curve represents that it follows Beer-Lambert's law. A calibration curve is prepared by plotting known concentrations of a given substance against absorbance at a particular wavelength (usually the λmax). The relationship between absorbance and concentration is linear if the Beer's law is obeyed. Unknown concentration of a substance is measured by comparing the absorbance of unknown to the absorbance of knownconcentrations of the same substance measured under exactly identical conditions (same pathlength l usually 1 cm, same wavelength or the same band of wavelength, same temperature, same solvent, and same instrument etc.).

APPLICATIONS OF COLORIMETER

Colorimeters are used in many industries to measure the concentration of a substance in a solution, or to assess the quality of a product.

1. **Medical**
   i. **Blood analysis:** Colorimeters measure the concentration of haemoglobin in blood samples to assess the health of a patient
   ii. **Biochemical analysis:** Colorimeters analyse samples like urine, plasma, and serum to estimate biochemical compounds like glucose and proteins
2. **Food and beverage**
   i. **Quality control:** Colorimeters measure the color of ingredients and final products to ensure quality and consumer satisfaction
   ii. **Monitoring**: Colorimeters monitor the growth of bacteria and yeast cultures in food and beverage manufacturing
3. **Water quality**
   i. **Pollutant measurement:** Colorimeters measure pollutants like chlorine, fluoride, cyanide, and dissolved oxygen in water bodies to assess water quality
4. **Manufacturing**
   i. Textile manufacturing: Colorimeters ensure the consistency and quality of colors in fabrics and dyes
   ii. Paint manufacturing: Colorimeters ensure the consistency and quality of colors in paints

iii. **Pulp and paper manufacturing:** Colorimeters manage the color of pulp and control printing colours

5. **Other applications**

i. **Screen quality:** Colorimeters assess the color contrast and brightness of computer, mobile, and television screens

ii. **Drug identification:** Colorimeters help identify counterfeit and substandard drugs.

IV. Centrifuge

A centrifuge machine is basically a rotating platform that can hold some tube-like glassware (or plasticware) and spin them in a high velocity so that the liquid inside them presses down hard on the bottom of the tubes. It is a mechanical or electromechanical device used to separate various components of a liquid. It achieves that by simulating a very high gravity environment inside the tubes by producing centrifugal forces by spinning very fast. Centrifugation uses gravity and centrifugal force to separate particles heavier than the liquid medium. It is a highly accelerated form of sedimentation.



Figure 4.3: Centrifuge

WORKING PRINCIPLE OF A CENTRIFUGE:

A centrifuge works with the principle of sedimentation due to gravitational force. When a tube is spun with the bottom side outward to the spin, the centrifugal force created by the spin acts like high gravity on the tube's sample. This pulls down the heavier (denser) components of a mixture faster than the lighter components – and they neatly lay down at the bottom of the tubes in layers. The rate of centrifugation is expressed as revolutions per minute (RPM).

COMPONENTS IN A CENTRIFUGE:

Centrifuge has three basic components: a rotor, a drive shaft, and a motor.

The rotor holds the tube or bottles containing the liquids to be centrifuged. Different rotor types and sizes can be mounted on the drive shaft. The drive shaft is connected to the motor which provides the power to turn the rotor and thus the tube can be spun at definitive speed. Rotation of the rotor about the central axis generates a centrifugal force on the particles in the suspension.

APPLICATIONS IN BIOLOGICAL SCIENCE

1. Remove cellular debris from blood to prepare cell free plasma or serum.
2. Concentrate cellular elements and other components for microscopic analysis or chemical analysis
3. Separate lipid components like chylomicrons from other components of plasma.
4. Separation of subcellular organelles, RNA, DNA. In order to study the macromolecules and metabolic processes within the cells, it is helpful to isolate one type ofsubcellular organelle from the rest of the cell contents by subcellular fractionation. Centrifugation is one of the techniques used for subcellular fractionation.

V. WATER BATH

A water bath is a laboratory equipment that is used to incubate samples at a constant temperature over a long period of time. Water bath is also used to enable certain chemical reactions to occur at high temperatures. Water bath is a preferred heat source for heating flammable chemicals instead of an open flame to prevent ignition. The other areas of its utilizations include warming of reagents, melting of substrates, or incubation of cell cultures.

The water bath is a robust and reliable equipment with an easy to clean stainless steel tank and sturdy metal outer case. The heating element is located inside the tank to facilitate rapid warm-up and responsive heating.

All water baths have a digital or an analogue interface to allow users to set a desired temperature. Different types of water baths are used depending on application. The water baths are mostly used up to 99.9°C. When temperature is above 100°C, alternative methods

such as oil bath, silicone bath, or sand bath are preferred. Some water baths have an additional shaking or stirring mechanism that can be set at varying speeds.



Figure 4.4: Typical water bath with digital display of temperature

TYPES OF WATER BATHS

1. Circulating Water Baths: Circulating water baths are ideal for applications when temperature uniformity and consistency are critical, such as enzymatic and serologic experiments. Water is thoroughly circulated throughout the bath resulting in a more uniform temperature.

2. Non-circulating Water Baths: This type of water bath relies primarily on convection instead of water being uniformly heated. Therefore, it is less accurate in terms of temperature control. In addition, there are add-ons that provide stirring to non- circulating water baths to create more uniform heat transfer.

3. Shaking Water Baths: This type of water bath has extra control for shaking, which moves liquids around. Shaking feature can be turned on or off. In microbiological practices, constant shaking allows liquid-grown cell cultures to constantly mix with the air.

APPLICATIONS OF WATER BATH

- Water bath thermostatic system finds usage in regular bacteriological and laboratory applications requiring incubation as well as general test procedures.

- Other than this, these are used in applications involving tissue culture, growth observation studies, enzyme reaction studies, fermentation analysis, and other specialized applications.

Session 5: Preparation of Solution(s) and Serial Dilution

By

Dr. Sunita Yadav & Dr. Manoj Thakur

A **solution** is a homogeneous mixture composed of two or more substances. In a solution, one substance (called the **solute**) is dissolved in another substance (called the **solvent**). The solute and solvent are evenly distributed at the molecular or ionic level, meaning that the solution appears uniform throughout.

What is Solution Concentration?

Solution concentration refers to the quantity of solute present in a given quantity of solution or solvent. It provides insight into the strength or potency of a solution. The concentration of a solution is a fundamental concept in sciences that describes the amount of solute dissolved in a solvent. It plays a crucial role in various chemical processes and applications, from industrial manufacturing to laboratory experiments. This part of the manual provides a detailed explanation of different aspects of solution concentration, including types, significance, and methods of measuring concentration. Understanding the different types of concentration helps in accurately describing and manipulating solutions for various applications, whether in laboratory experiments, industrial processes, or everyday tasks. These types include percentage concentration, molarity, normality, molality, and units like parts per million (PPM) and parts per billion (PPB). Each type offers a unique way of expressing concentration, tailored to specific needs and contexts, providing insights into the solution's composition and behavior.

Percentage

Percentage concentration is one of the simplest ways to express concentration. It indicates the amount of solute present in 100 parts of the solution. This can be expressed as mass percent, volume percent, or weight/volume percent:

- **Mass Percent**: This represents the mass of the solute divided by the total mass of the solution, multiplied by 100. For example, if a solution contains 10 grams of solute in 90 grams of solvent, the mass percent is
  $10/100 \times 100 = 10\%$
- **Volume Percent**: This refers to the volume of solute divided by the total volume of the solution, multiplied by 100. It is commonly used when both solute and solvent are

liquids. For instance, if 30 milliliters of alcohol is added to 70 milliliters of water, the volume percent of alcohol is 30/100×100=30%.

- **Weight/Volume Percent**: This is used when the solute is in a solid form and the solvent is a liquid. It is the mass of solute divided by the volume of solution, multiplied by 100. For example, a solution with 5 grams of salt in 500 milliliters of water has a weight/volume percent of 5/500×100=1%.

Molarity

Molarity (M) is a measure of the number of moles of solute per liter of solution. It is widely used in laboratory settings because it directly relates to the number of molecules of solute in a solution. Molarity provides a precise measure of concentration and is essential for preparing solutions with accurate amounts of solute. For instance, a 1 M solution contains 1 mole of solute in every liter of solution.

Normality

Normality (N) is a measure of concentration equivalent to the number of equivalents of solute per liter of solution. It is particularly useful in acid-base reactions and redox reactions. Normality considers the reactive capacity of the solute, which can vary depending on the type of reaction. For example, in a reaction where 1 mole of an acid reacts with 1 mole of base, the normality of the acid solution is equal to its molarity.

Molality

Molality (m) refers to the number of moles of solute per kilogram of solvent. Unlike molarity, which is based on the total volume of the solution, molality is based on the mass of the solvent. This measure is particularly useful in situations where temperature changes can affect the volume of the solution. Molality provides a consistent measure of concentration regardless of temperature fluctuations.

Parts per million (ppm) and parts per billion (ppb)

ppm and ppb are units used to describe very dilute concentrations. ppm indicates the number of parts of solute per million parts of solution, while ppb indicates the number of parts per billion. These units are often used in environmental chemistry and quality control to measure trace amounts of substances.

Importance of Solution Concentration

Solution concentration plays a crucial role in a wide array of scientific and industrial applications, making it fundamental to chemistry and related fields. Accurately knowing the

concentration of a solution is essential for understanding its properties, such as reactivity, solubility, and the rate of chemical reactions. It influences the formulation of products, from pharmaceuticals to industrial chemicals, ensuring efficacy and safety. In analytical chemistry, precise concentration measurements are vital for accurate results and reproducibility. Moreover, in environmental science, concentration data helps monitor pollutants and ensure regulatory compliance. Thus, grasping the concept of solution concentration is key to optimizing processes, ensuring quality, and solving practical problems in numerous disciplines.

I. Preparation of 0.5 M EDTA Solution (500 mL)

Objective: To prepare a 0.5 M solution of ethylenediaminetetraacetic acid (EDTA) for use in biological experiments, particularly in molecular biology and biochemistry.

Procedure:

1. Weighing and Initial Dissolution:

- **93.05 g of $Na_2EDTA \cdot 2H_2O$** (EDTA disodium salt dihydrate) is required to prepare 500 mL of a 0.5 M solution.
- The weighed EDTA is transferred into a **1L glass beaker** containing approximately **400 mL of distilled water** and stirred using a magnetic stirrer.
- Initially, the EDTA will not dissolve completely due to its poor solubility at neutral pH.

2. pH Adjustment for Complete Dissolution:

- To facilitate dissolution, **1N NaOH (or concentrated NaOH dropwise)** is added while stirring continuously.
- As the pH increases, EDTA gradually dissolves, becoming fully soluble between **pH 8.0–8.5**.
- The pH is monitored using a **calibrated pH meter**, and NaOH addition is stopped once the solution clears.

3. Final Volume Adjustment:

- The solution is transferred to a **500 mL volumetric flask**, and distilled water is added to bring the final volume to **500 mL**.
- The flask is inverted multiple times to ensure uniform mixing.

4. Storage and Stability:

- The prepared solution is stored in a labelled **glass or plastic bottle** at **room temperature or 4°C**, depending on usage frequency.
- The solution remains stable over time, provided it is protected from contamination.

Expected Outcomes and Applications in Biological Experiments:

- The **0.5 M EDTA solution** functions as a **chelating agent**, sequestering divalent cations (e.g., Mg^{2+}, Ca^{2+}), which are crucial cofactors for enzymatic reactions.
- It is widely used in **DNA and RNA extractions**, **prevention of nuclease activity**, and **buffer preparation** in molecular biology.
- In **cell culture and protein biochemistry**, EDTA is employed to disrupt **cell adhesion** and inhibit **metalloproteases**.
- The solution enhances the efficiency of **electrophoresis buffers** by maintaining ionic stability.

II. Serial Dilution for Fungal Isolation from Soil Samples

Objective: To perform serial dilutions of soil samples for isolating and quantifying fungal colonies on agar plates, ensuring accurate enumeration and identification of fungal species.

Procedure:

1. Soil Suspension Preparation:

- Weigh **1 g of soil** and transfer it into a **sterile 50 mL conical tube** containing **9 mL of sterile distilled water or 0.85% saline**.
- Vortex or shake vigorously for **2–3 minutes** to ensure uniform suspension.

2. Serial Dilution Steps:

- Transfer **1 mL** of the soil suspension into a new **sterile tube** containing **9 mL of sterile diluent** (1:10 dilution; $\mathbf{10^{-1}}$ dilution).
- Repeat the process by transferring **1 mL** from the $\mathbf{10^{-1}}$ dilution into another **9 mL of diluent**, creating a $\mathbf{10^{-2}}$ dilution.
- Continue serial dilutions up to $\mathbf{10^{-6}}$, depending on expected fungal load.
- Change pipette tips between dilutions to prevent cross-contamination.

3. Plating the Dilutions:

- Using a **sterile pipette**, transfer **100 µL** from each dilution (10^{-2} to 10^{-6}) onto **Potato Dextrose Agar (PDA) or Sabouraud Dextrose Agar (SDA)** plates.
- Spread the inoculum evenly using a **sterile glass spreader** or **L-shaped spreader**.
- Allow plates to absorb the liquid before incubation.

4. Incubation:

- Incubate plates at **25–28°C** for **3–7 days** under **dark or ambient light conditions**, monitoring fungal growth.

Expected Outcomes:

- **Dilution-based fungal enumeration**: Colonies will appear as **distinct fungal growth** on plates, with fewer colonies observed at higher dilutions.
- **Morphological differentiation**: Different fungal species may exhibit **diverse colony textures, colours, and sporulation patterns**, aiding in preliminary identification.
- **Isolation of pure fungal cultures**: Single colonies can be subcultured onto fresh plates for **further taxonomic and molecular identification**.
- **Avoidance of overgrowth**: Serial dilution ensures **isolated colony formation**, preventing excessive fungal overgrowth and facilitating accurate colony counting.

This method provides a **quantitative and qualitative** approach to studying fungal diversity in soil samples.

Session 6: Biostatistics

By

Dr. Pamil Tayal

INTRODUCTION TO BIOSTATISTICS:

Biostatistics is the study of statistics as applied to biological areas such as biological laboratory experiments, medical research (including clinical research), and health services research utilizes the statistical methods for the analysis of the data. Thus, "Biostatistics is defined as the science of collection, analysis and interpretation of facts and numbers connected with biology. Biostatistics is also called biometrics. Biometrics refers to biological measurements". The purpose of statistics is not only to collect numerical data but also to provide a methodology for handling, analysing and drawing valid inferences from the data.

History of Statistics:

1. **Adolphe Quetelet** (1796-1874) – use the statistical methods for the first time in his work and applied them to the problems of biology, medicine and sociology.
2. **Francis Galton (1822-1911) – Father of Biostatistics and Eugenetics.** His notable contributions are in the field of heredity, eugenetics, psycology and statistics. The understanding of correlation, measurement of agreement between two variables was proposed by him.
3. **Karl Pearson – (1857 – 1936) –** applied statistical methods in the demonstration of natural selection and laid the foundation for descriptive and correlation statistics.

Statistical methods:

The five basic methods are mean, standard deviation, regression, hypothesis testing, and sample size determination.

I. **Mean:** It is one of the simplest and most popular analysis methods easy to apply to data. The mean is the average value of data used in research. In statistics, the term "mean" is commonly used to indicate average. It is calculated by adding the data

values and dividing them by the total number of data points. Though it is a common method, it is advised to have other methods supporting it for effective decision-making.

II. **Standard Deviation:**Standard Deviation is a common statistical analysis tool to determine the deviation of a set of values from the mean value. The standard deviation value will be low if the deviation from the mean is small and vice versa.

III. **Regression:**The regression method helps comprehend the relationship between two or more variables used in the analysis. It shows how one variable is dependent on the other and their inter effect on each other. There is simple linear regression using a single independent variable to interpret the dependent variable and multiple linear regressions using multiple independent variables to interpret the outcome.

IV. **Hypothesis Testing:**The method tests the validity and authenticity of a hypothesis, outcome, or argument. It is an assumption set at the beginning of the research; after the test is over and a result is obtained based on it, the belief can be either true or false. In addition, it can check whether the null hypothesis or alternative hypothesis is true.

V. **Sample Size Determination:**The technique derives a sample from the entire population, representing the total population. When there is a large data set, and the analysis gets challenging, a small sample is taken for study and research.

Statistical terms:

Biostatistics is the science which deals with development and application of the most appropriate methods for the: (i) Collection of data, (ii) Presentation of the collected data, (iii) Analysis and interpretation of the results and (iv) Making decisions on the basis of such analysis. For instance - the estimation of oxygen in a collected water sample. The water samples which were collected from the source form a population. The estimation of O2 in each water sample is the collection of data. The amount of oxygen in the water is the data. Arranging values in columns is called tabulation. In one water sample, the amount of oxygen will be higher and in another is lower. It is interpretation.

I. **Population** - Population is a group of individuals or study elements or observations. In the estimation of oxygen, all the water samples form a population. The value of each sample is a variable. The population containing limited number of individuals is called a finite population. Eg: Number of students in a class; Number of coconut trees

in a grove. The population containing unlimited number of individuals is called an infinite population. Eg: Stars in the Sky; Fishes in the sea.

II. **Data**- The values recorded in an experiment or observations are called data. There are two types – (I) Primary data- The data collected by investigator. It is the first-handinformation. The person collecting the data is called investigator. (II) Secondary data- The data collected from another source. Eg: Data collected from Newspaper, Journals, etc.

III. **Samples** - A small representative fraction of a population is called a sample. Getting a sample from a population is called sampling. Eg: Only a few rice is examined from a boiling pot to arrive at a conclusion.

IV. **Qualitative variable** - It is a variable or characteristic which cannot be measured in quantitative form but can only be identified by name or categories, for instance place of birth, ethnic group, type of drug, stages of breast cancer (I, II, III, or IV), degree of pain (minimal, moderate, severe or unbearable).

V. **Quantitative variable** - A quantitative variable is one that can be measured and expressed numerically and it can be either discrete or continuous. The values of a discrete variable are usually whole numbers, such as the number of episodes in a series or number of children in a family. A continuous variable is a measurement on a continuous scale. Examples include weight, height, blood pressure, age, etc.

Although the types of variables could be broadly divided into categorical (qualitative) and numerical (quantitative), it has been a common practice to see four basic types of data (scales of measurement).

I. Nominal data represent categories or names. There is no implied order to the categories of nominal data. In these types of data, individuals are simply placed in the proper category or group, and the number in each category is counted. Each item must fit into exactly one category.

II. Ordinal Data have order among the response classifications (categories). The spaces or intervals between the categories are not necessarily equal. For example: strongly agree, agree, no opinion, disagree, strongly disagree. In this situation, we only know that the data are ordered.

III. Interval Data: In interval data the intervals between values are the same. For example, in the Fahrenheit temperature scale, the difference between 70 degrees and 71 degrees is the same as the difference between 32 and 33 degrees. But the scale is not a RATIO Scale. 40 degrees Fahrenheit is not twice as much as 20 degrees Fahrenheit.

IV. Ratio Data: The data values in ratio data do have meaningful ratios, for example, age is a ratio data, and someone is 40 is twice as old as someone is 20.

Both interval and ratio data involve measurement. Most data analysis techniques that apply to ratio data also apply to interval data. Therefore, in most practical aspects, these types ofdata (interval and ratio) are grouped under metric data. In some other instances, these types of data are also known as numerical discrete and numerical continuous.

Aims of biostatistics:

- Quantify Health Data – Provides numerical insights into health and disease patterns.
- Improve Decision-Making – Assists policymakers and healthcare providers in making data-driven decisions.
- Enhance Medical Research – Ensures the validity and reliability of medical studies.
- Monitor and Control Diseases – Helps in tracking and managing the spread of diseases.
- Evaluate Treatments & Interventions – Assesses the effectiveness of medical treatments and healthcare programs.
- Develop Predictive Models – Uses statistical tools to forecast health risks and outcomes.
- Optimize Healthcare Resources – Supports efficient allocation of medical resources based on data analysis.
- Ensure Data Accuracy & Interpretation – Ensures the correct application and interpretation of health-related data.

Limitations of biostatistics:

- Statistics is not concerned with individual observation.
- Statistics do not analyse qualitative phenomenon.
- Statistical generalisations are true only on average.
- Improper use of statistics.

Collection of data:

In Statistics, data collection is a process of gathering information from all the relevant sources to find a solution to the research problem. It helps to evaluate the outcome of the problem. The data collection methods allow a person to conclude an answer to the relevant question. Most of the organizations use data collection methods to make assumptions about future probabilities and trends. Once the data is collected, it is necessary to undergo the data organization process.

The main sources of the data collections methods are classified into two types, namely primary data and secondary data. The primary importance of data collection in any research or business process is that it helps to determine many important things about the company, particularly the performance. So, the data collection process plays an important role in all the streams.

1. ***Primary Data Collection Methods*:** Primary data or raw data is a type of information that is obtained directly from the first-hand source through experiments, surveys or observations. The primary data collection method is further classified into two types. They are *Quantitative Data Collection Methods* - It is based on mathematical calculations using various formats like close-ended questions, correlation and regression methods, mean, median or mode measures. This method is cheaper than qualitative data collection methods and it can be applied in a short duration of time. *Qualitative Data Collection Methods* - It does not involve any mathematical calculations. This method is closely associated with elements that are not quantifiable. This qualitative data collection method includes interviews, questionnaires, observations, case studies, etc. There are several methods to collect this type of data.

   Observation method is used when the study relates to behavioural science. This method is planned systematically. It is subject to many controls and checks. Interview method of collecting data in terms of verbal responses. It is achieved either by personal interview (an interviewer is required to ask questions face to face to the other person) or telephonic interview (an interviewer obtains information by contacting people on the telephone to ask the questions or views, verbally).

   Questionnaire Method - the set of questions are mailed to the respondent. They should read, reply and subsequently return the questionnaire. The questions are printed in the definite order on the form.

2. ***Secondary Data Collection Methods:***Secondary data is data collected by someone other than the actual user. It means that the information is already available, and someone analyses it. The secondary data includes magazines, newspapers, books, journals, etc. It may be either published data or unpublished data. Published data are available in various resources including Government publications, public records, historical and statistical documents, business documents, technical and trade journals, unpublished data includes diaries, letters, biographies, etc.

Sampling:

In biostatistics, a **sample** refers to a subset of individuals or data points selected from a larger population for analysis. Since studying an entire population is often impractical due to time, cost, and logistical constraints, researchers use samples to draw conclusions about the population with a certain level of confidence. Thus, sample should be a true representative of the whole population.

Essentials of a good sample:

- Samples selected from the population should be homogenous and be true representatives of the population.
- Sampe should have characteristics similar to the population from which they are collected.
- The number of observations in a sample should be more to make the results more reliable.
- The individual items composing the sample should be independent of each other.

Sampling is used extensively for many reasons:

- In several situations, samples provide more accurate information about the population than that provided by census, as census often turns out to be incomplete. For example, animals keep moving. It will be impossible to count all the organisms of a population in a given area or a given culture for a particular attribute.
- Studying a sample and collecting data from it is cheaper and faster than studying the whole population.
- A sample can be studied more carefully and accurately than studying large number of individuals of a large population.

- In case of random sampling, each and every attribute of the population has equal opportunity to be represented in the sample.

The **sample size** is the number of observations or individuals included in the sample, and it plays a crucial role in the reliability and accuracy of statistical results. A sample that is too small may lead to biased or inconclusive results, while an excessively large sample may require unnecessary resources. Determining an appropriate sample size depends on factors such as study objectives, variability within the population, and the desired level of statistical power.

There are several **types of sampling methods** in biostatistics, broadly classified into **probability sampling** (where each member has a known chance of being selected) and **non-probability sampling** (where selection is based on non-random criteria). Common probability sampling methods include **simple random sampling** (where every individual has an equal chance of being chosen), **systematic sampling** (selecting every nth individual from a list), **stratified sampling** (dividing the population into subgroups and sampling proportionally), and **cluster sampling** (selecting entire groups or clusters instead of individuals). In contrast, non-probability sampling methods include **convenience sampling** (selecting readily available subjects), **quota sampling** (ensuring certain characteristics are represented), and **purposive sampling** (selecting individuals based on specific criteria). Choosing the appropriate sampling method is essential for minimizing bias and ensuring the generalizability of research findings.

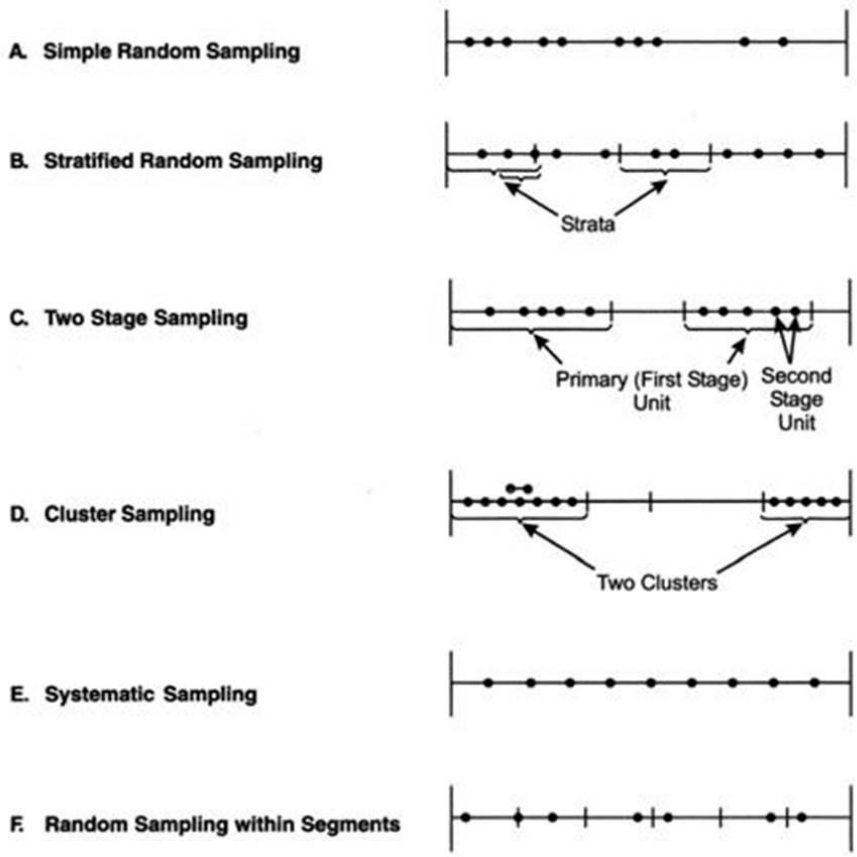


Figure 6.1: Types of sampling methods

Advantages of Sampling:

The advantages of sampling are:

- Sampling is comparatively more economical as it consumes less energy, less time and less expenditure.
- It is the most scientific method of data collection.
- It is most suited in case of large population.
- It requires a smaller number of investigators.
- It is most suited to those places and situations where census method cannot be applied, e.g., to estimate forest productivity not all the trees but only a suitable number is counted, or to estimate the number of RBCs in blood of a person per cc. only small samples of blood are drawn.

Classification of data:

The collected data, also known as raw data or ungrouped data are always in a unorganised form and need to be organised and presented in meaningful and readily comprehensible form in order to facilitate further statistical analysis. It is, therefore, essential for an investigator to condense a mass of data into more and more comprehensible and assimilable form. The process of grouping into different classes or sub classes according to some characteristics is known as classification, tabulation is concerned with the systematic arrangement and presentation of classified data. Thus classification is the first step in tabulation. For Example, letters in the post office are classified according to their destinations viz., Delhi, Madurai, Bangalore, Mumbai etc.

Objectives of Classification of Data: The following are main objectives of classifying the data:

- To simplify the complexities of raw data and make the data easily accessible and easily understandable.
- To make data attractive so as to leave a lasting impression.
- To facilitate quick comparison and easy study.
- To present the data in the condensed form by the summation of the items.
- To ensure detection of errors and omissions in data.
- To ensure proper use of collected data.
- To simplify the complexities of raw data and to draw statistical inferences.
- To help drafting the final report.
- It facilitates comparison and highlights the significant aspect of data.
- It helps in the statistical treatment of the information collected.

Presentation of data:

The most frequently used methods of data presentation are – tabular, graphic, and diagrammatic forms.

Tabulation: Tabulation is the process of summarizing classified or grouped data in the form of a table so that it is easily understood and an investigator is quickly able to locate the desired information. A table is a systematic arrangement of classified data in columns and rows. Thus, a statistical table makes it possible for the investigator to present a huge mass of data in a detailed and orderly form. It facilitates comparison and often reveals certain patterns

in data which are otherwise not obvious. Classification and 'Tabulation', as a matter of fact, are not two distinct processes. Actually, they go together. Before tabulation data are classified and then displayed under different columns and rows of table.

Major Objectives of Tabulation are:

- To simplify the complex data in a systematic form
- To facilitate easy comparison
- To facilitate the analysis of data through central tendency and measures of dispersion
- To draw valid inference / conclusions
- To detect errors if any in the data

Table Number

Title of the Table

Stub heading	Caption (Column headings)	Total
Stub (Row entries)	Body	
Total		

Foot note (if any)

Source of Data (if any)

Figure 6.2: Representation of A Table – the above parts should be mentioned while presenting a table

Graphic presentation of data:

Graphical Representation is a way of analysing numerical data. It exhibits the relation between data, ideas, information, and concepts in a diagram. It is easy to understand and it is one of the most important learning strategies. It always depends on the type of information in a particular domain. There are different types of graphical representation. Some of them are as follows:

- **Line Graphs** – Line graph or the linear graph is used to display the continuous data and it is useful for predicting future events over time.

- **Bar Graphs** – Bar Graph is used to display the category of data and it compares the data using solid bars to represent the quantities.
- **Histograms** – The graph that uses bars to represent the frequency of numerical data that are organised into intervals. Since all the intervals are equal and continuous, all the bars have the same width.
- **Line Plot –** It shows the frequency of data on a given number line. ‘ x ‘ is placed above a number line each time when that data occurs again.
- **Frequency Table** – The table shows the number of pieces of data that falls within the given interval.
- **Circle Graph** – Also known as the pie chart that shows the relationships of the parts of the whole. The circle is considered with 100% and the categories occupied is represented with that specific percentage like 15%, 56%, etc.
- **Stem and Leaf Plot –** In the stem and leaf plot, the data are organised from least value to the greatest value. The digits of the least place values from the leaves and the next place value digit forms the stems.
- **Box and Whisker Plot** – The plot diagram summarises the data by dividing into four parts. Box and whisker show the range (spread) and the middle (median) of the data.

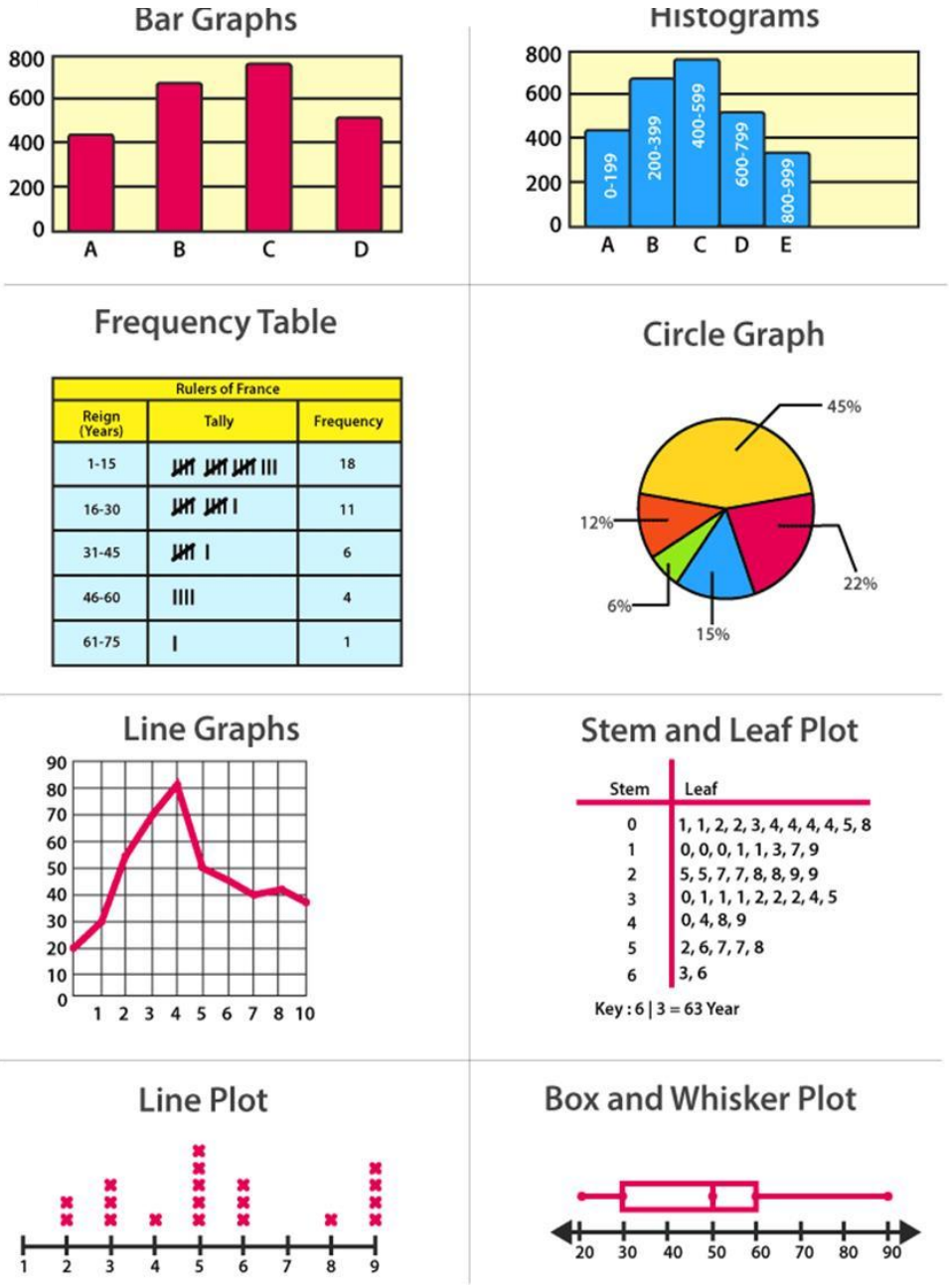


Figure 6.3: Types of graphical representation of data

Merits of Using Graphs: Some of the merits of using graphs are as follows:

- The graph is easily understood by everyone without any prior knowledge.
- It saves time.
- It allows us to relate and compare the data for different time periods.
- It is used in statistics to determine the mean, median and mode for different data, as well as in the interpolation and the extrapolation of data.

Simple Bar Diagram:

Bar diagram comprises a group of equi spaced and equi width rectangular bars for each class or category of data. Height or length of the bar reads the magnitude of data. The lower end of the bar touches the base line such that the height of a bar starts from the zero unit. Bars of a bar diagram can be visually compared by their relative height and accordingly data are comprehended quickly. Data for this can be of frequency or non-frequency type. In nonfrequency type data a particular characteristic, say production, yield, population, etc. at various points of time or of different states are noted and corresponding bars are made of the respective heights according to the values of the characteristic to construct the diagram. The values of the characteristics (measured or counted) retain the identity of each value.

Different types of data may require different modes of diagrammatical representation. Bar diagrams are suitable both for frequency type and nonfrequency type variables and attributes. Discrete variables like family size, spots on a dice, grades in an examination, etc. and attributes such as gender, religion, caste, country, etc. can be represented by bar diagrams. Bar diagrams are more convenient for non-frequency data such as income expenditure profile, export/imports over the years, etc.

Pie Diagram:

A pie diagram is also a component diagram, but unlike a bar diagram, here it is a circle whose area is proportionally divided among the components it represents. It is also called a pie chart. The circle is divided into as many parts as there are components by drawing straight lines from the centre to the circumference. Pie charts usually are not drawn with absolute values of a category. The values of each category are first expressed as percentage of the total value of all the categories. A circle in a pie chart, irrespective of its value of radius, is thought of having 100 equal parts of 3.6° (360°/100) each. To find out the angle, the component shall subtend at the centre of the circle, each percentage figure of every component is multiplied by 3.6°.

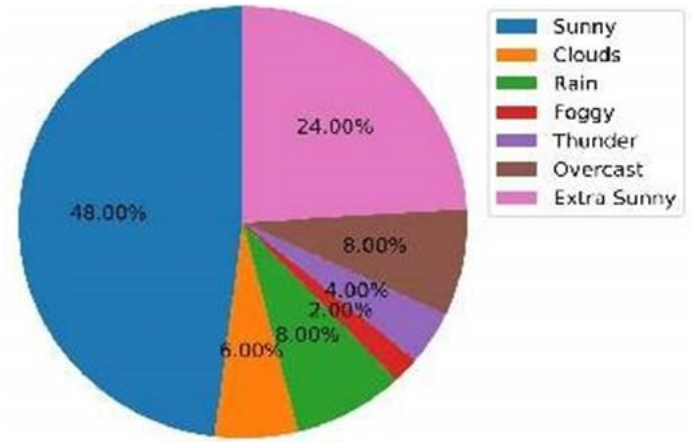


Figure 6.4: Representation of a pie chart

Frequency Curve:

The frequency curve is obtained by drawing a smooth freehand curve passing through the points of the frequency polygon as closely as possible. It may not necessarily pass through all the points of the frequency polygon but it passes through them as closely as possible.

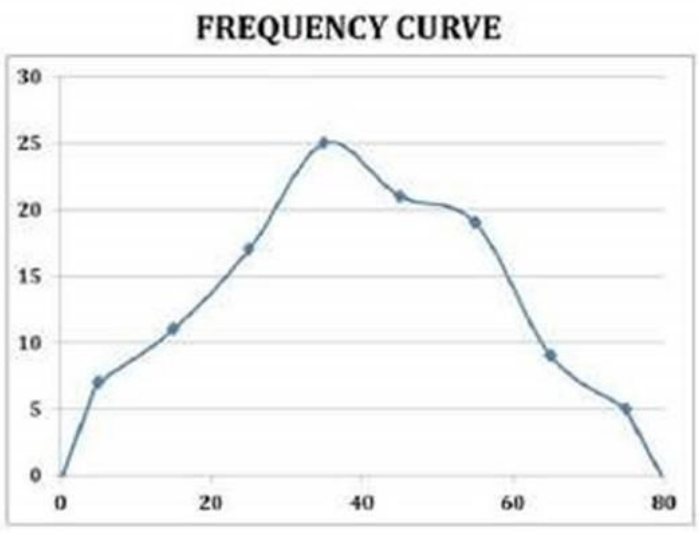


Figure 6.5: Representation of a frequency curve

Measures of central tendency:

In statistics, the central tendency is the descriptive summary of a data set. Through the single value from the dataset, it reflects the centre of the data distribution. Moreover, it does not provide information regarding individual data from the dataset, where it gives a summary of the dataset. Generally, the central tendency of a dataset can be defined using some of the measures in statistics.

The central tendency is stated as the statistical measure that represents the single value of the entire distribution or a dataset. It aims to provide an accurate description of the entire data in the distribution.

The central tendency of the dataset can be found out using the three important measures namely Mean, Median and Mode

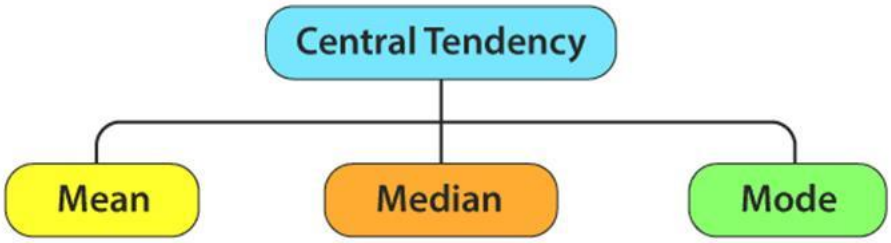


Figure 6.6: The three measures of central tendency

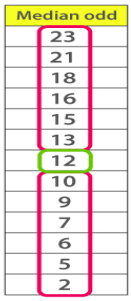
Mean: The mean represents the average value of the dataset. It can be calculated as the sum of all the values in the dataset divided by the number of values. In general, it is considered as the arithmetic mean. Some other measures of mean used to find the central tendency are as follows:

- Geometric Mean
- Harmonic Mean
- Weighted Mean

It is observed that if all the values in the dataset are the same, then all geometric, arithmetic and harmonic mean values are the same. If there is variability in the data, then the mean value differs. Calculating the mean value is completely easy. The formula to calculate the mean value is given by:Mean $=X_1 + X_2 + X_3 \ldots\ldots\ldots\ldots X_n/N$

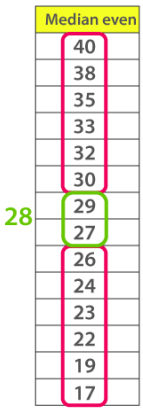
Median: Median is the middle value of the dataset in which the dataset is arranged in the ascending order or in descending order. When the dataset contains an even number of values, then the median value of the dataset can be found by taking the mean of the middle two values.

Consider the given dataset with the odd number of observations arranged in descending order – 23, 21, 18, 16, 15, 13, 12, 10, 9, 7, 6, 5, and 2.



Here 12 is the middle or median number that has 6 values above it and 6 values below it.

Now, consider another example with an even number of observations that are arranged in descending order – 40, 38, 35, 33, 32, 30, 29, 27, 26, 24, 23, 22, 19, and 17



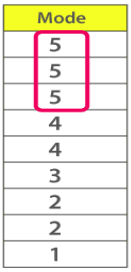
When you look at the given dataset, the two middle values obtained are 27 and 29.Now, find out the mean value for these two numbers.

i.e.,(27+29)/2 =28

Therefore, the median for the given data distribution is 28.

Mode: The mode represents the frequently occurring value in the dataset. Sometimes the dataset may contain multiple modes and, in some cases, it does not contain any mode at all.

Consider the given dataset 5, 4, 2, 3, 2, 1, 5, 4, 5



Since the mode represents the most common value. Hence, the most frequently repeated value in the given dataset is 5.

Based on the properties of the data, the measures of central tendency are selected.

- If you have a symmetrical distribution of continuous data, all the three measures of central tendency hold good. But most of the times, the analyst uses the mean because it involves all the values in the distribution or dataset.
- If you have skewed distribution, the best measure of finding the central tendency is the median.
- If you have the original data, then both the median and mode are the best choice of measuring the central tendency.
- If you have categorical data, the mode is the best choice to find the central tendency.

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