Seminar Report

On

[Cryo-Electron Microscopy]

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(M.Sc. 1st year, Sem 1)

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CERTIFICATE

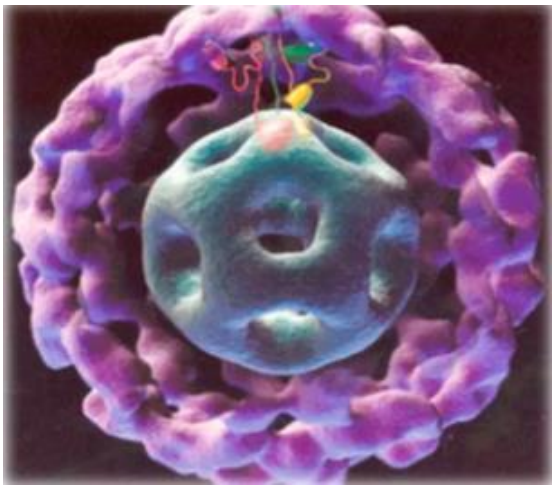
This is to certify that the seminar report entitled *[Cryo-Electron Microscopy]* submitted is a bonafide record of a seminar presented by *[*Meena Ramesh Badole*]* (M.Sc. I semester I), 2024-2025.

Place: Nagpur

Date: _____ Dr. P. M. Tumane

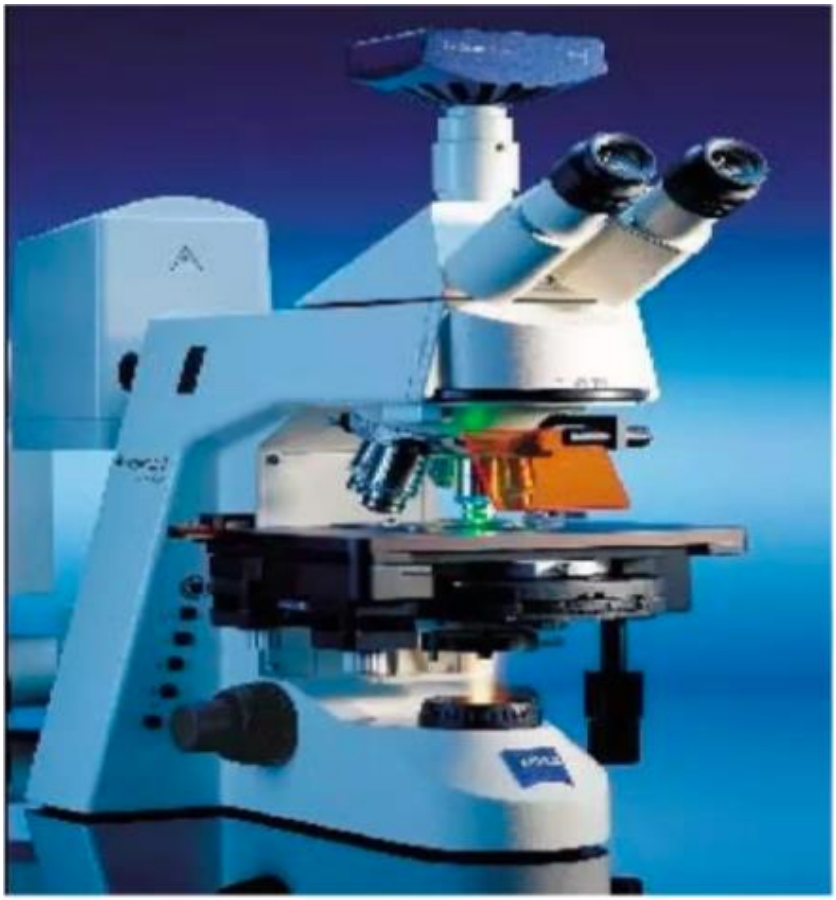
Cryo-Electron Microscopy

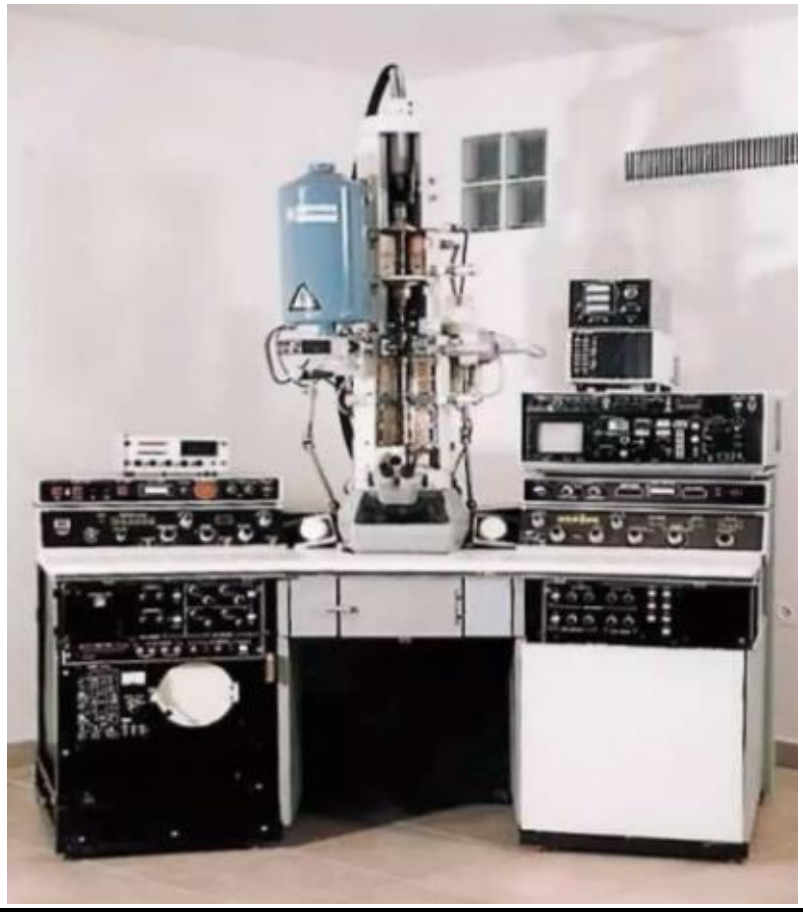
Cryo-Electron Microscopy (Cryo-EM) is a powerful imaging technique that allows scientists to observe the structure of biological specimens at cryogenic temperatures. By freezing samples rapidly, Cryo-EM preserves the natural structure of biological materials, providing high-resolution images of macromolecular complexes, viruses, and even cells.



Principle of Cryo-Electron Microscopy

Cryo-EM relies on the principle of imaging biological samples at very low temperatures (cryogenic conditions). In this technique, samples are rapidly frozen to preserve their natural state without the need for chemical fixation or staining. The frozen samples are then exposed to an electron beam, and the scattered electrons are used to form high-resolution images. Unlike traditional electron microscopy, Cryo-EM minimizes damage to the samples, allowing for detailed 3D reconstructions.



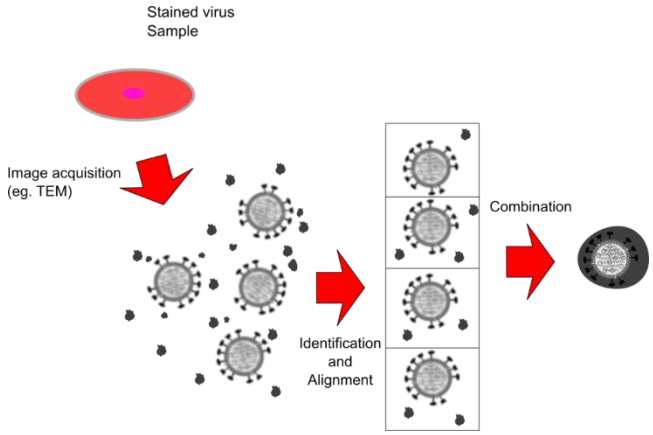


Parts of a Cryo-Electron Microscope

- **Electron Source:** Generates the high-energy electron beam that passes through the specimen.
- **Cryo-Stage:** Holds the specimen at cryogenic temperatures (typically below -180°C) to preserve its structure.
- **Sample Grid:** A thin grid where the biological specimen is placed and rapidly frozen in liquid ethane or propane.
- **Objective Lens:** Focuses the electrons passing through the sample to form an image.
- **Detectors:** Capture the scattered electrons to produce high-resolution images of the specimen.
- **Image Processing Software:** Used to reconstruct the 3D structure of the sample from 2D images taken at different angles.

Types of Cryo-Electron Microscopy

- **Single Particle Analysis (SPA):** Used for studying isolated macromolecules like proteins in solution, offering near-atomic resolution.



- **Cryo-Electron Tomography (Cryo-ET):** Produces 3D images by tilting the sample and acquiring images at different angles.
- **Electron Crystallography:** Involves analyzing two-dimensional crystals of biological samples to determine their atomic structures.

Applications of Cryo-Electron Microscopy

- **Structural Biology:** Helps in determining the structure of large protein complexes, viruses, and ribosomes at near-atomic resolution.
- **Virology:** Used to visualize viruses like HIV and influenza, aiding in drug design and vaccine development.
- **Cell Biology:** Enables 3D imaging of cellular organelles and macromolecular assemblies in their native environment.
- **Drug Discovery:** Cryo-EM assists in understanding the interaction between drug molecules and their target proteins.

Advantages of Cryo-Electron Microscopy

- **High Resolution:** Provides near-atomic resolution without the need for crystallization of the sample.
- **Native-State Imaging:** Samples are preserved in their natural state, without requiring chemical fixation or staining.
- **3D Reconstruction:** Allows for detailed 3D models of macromolecules and organelles.
- **Minimal Damage:** The use of cryogenic temperatures reduces radiation damage, allowing for longer imaging sessions.

Disadvantages of Cryo-Electron Microscopy

- **High Cost:** Cryo-EM instruments and the associated cryogenic infrastructure are expensive.
- **Complex Sample Preparation:** Preparing samples for Cryo-EM, including rapid freezing and grid preparation, is technically challenging.
- **Limited Throughput:** Imaging and data processing can be time-consuming, limiting the number of samples that can be analyzed in a given time.

Examples of Cryo-Electron Microscopy Instruments

- **Thermo Fisher Scientific Titan Krios:** One of the most advanced Cryo-EM instruments, capable of atomic-resolution imaging of biological macromolecules.
- **JEOL CRYO ARM 300:** A high-performance Cryo-EM system used for high-resolution 3D imaging of biological specimens.
- **FEI Talos Arctica:** Designed for rapid screening and high-quality imaging of cryo-EM samples, often used for structural biology research.

Conclusion

Cryo-Electron Microscopy has revolutionized structural biology by providing detailed images of biological macromolecules in their native state. Its ability to reveal atomic-level details without the need for crystallization has made it a vital tool for researchers studying proteins, viruses, and cellular structures. While it faces challenges like high costs and technical complexity, Cryo-EM continues to be a cornerstone technology in the field of molecular biology.