Cryo Electron Microscopy: Notes for UPSC Science and Technology

Current topics in science and technology especially in space science are important for the IAS exam. IAS aspirants must go through these topics as part of their UPSC preparation as it can help them score valuable marks in prelims and mains exam.

Early development of the Cryo Electron Microscope

In the 1960s, the use of Transmission Electron Microscopy for proper analyzing work was limited because of the radiation damage due to the presence of high energy electron beams. Scientists hypothesized that examining specimens at low temperatures would reduce beam-induced radiation damage. Both liquid helium and liquid nitrogen were considered as cryogens. The result of the experiment was inconclusive.

In 1981, Alasdair McDowall and Jacques Dubochet, scientists at the European Molecular Biology Laboratory, reported the first successful implementation of cryoEM. McDowall and Dubochet vitrified pure water in a thin film by spraying it onto a hydrophilic carbon film that was rapidly plunged into cryogen (liquid propane or liquid ethane cooled to 100 K). The thin layer of amorphous ice was less than 1 μm thick and an electron diffraction pattern confirmed the presence of amorphous/vitreous ice

Richard Henderson, Jacques Dubochet and Joachim Frank are selected for the Nobel Prize in Chemistry – 2017 by the Royal Swedish Academy of Sciences. They were selected for developing cryo-electron microscopy for the high-resolution structure determination of bio-molecules in solution. In 1990, Richard Henderson was successful in making use of the electron microscope for generating the 3 dimensional (3D) image of a protein at atomic resolution. This technology was made widely applicable by Joachim Frank. Jacques Dubochet contributed to Cryo – electron microscopy by vitrification of water which ensured that the biological sample did not vary in terms of its shape even when frozen or when in vacuum.

How does Cryo Electron Microscopy Work?

Cryo-electron microscopy is a specific type of electron microscopy that is based on the principle of forming a 3D image by collection and combination of thousands of projections of bio-molecules. With the help of this, the researchers can now visualize the processes never seen before by freezing the mid-movement of the bio-molecules. Cryo-electron microscopy makes it possible to freeze the bio-molecules at the cryogenic temperature i.e., at -150°C, preserving their natural shape. By this, the structure of molecules is revealed in exquisite detail.

It is significant for better understanding of basic Chemistry and for the development of pharmaceuticals as it simplifies and improves the imaging of bio-molecules.

It facilitates the study of fine viruses, protein complexes and cellular structures at a molecular resolution as it gives the scientists an opportunity to have a look at the machinery of life in a 3D form. The earlier forms of electron microscopes made it impossible to study the bio-molecules in 3D form as the powerful beams often destroyed the biological matter. The resolution now has improved from shapeless blobs to imaging the proteins at atomic resolution. The Cryo-Electron Microscopy has broken several limitations, moving biochemistry into a new Era.

Questions relevant to Cryo Electron Microscopy

What is cryo electron microscopy used for?

Essentially, Cryo-electron microscopy (Cryo-EM) is a type of transmission electron microscopy that allows for the specimen of interest to be viewed at cryogenic temperatures.

How does cryo electron microscopy work?

Electron microscopes work by generating a beam of electrons. Electromagnetic lenses are used to focus the beam, which is then fired at a sample. But with cryo-EM, samples don't require this sort of preparation – they can simply be frozen and then studied in their normal state.

When was cryo electron microscopy invented?

Henderson, a professor at the Molecular Research Council (MRC) Laboratory of Molecular Biology in the U.K., produced the first high-resolution model of a protein, bacteriorhodopsin, using electron cryo-microscopy (cryo-EM) in 1990.