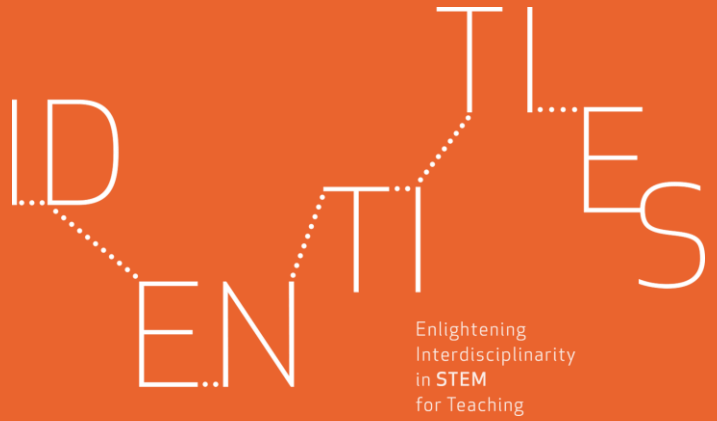

NanoScience-NanoTechnology module

ID analyst: Activity 3a – Worksheet 1

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~1021 AD – Book of Optics

Muslim scholar Ibn al-Haytham writes his *Book of Optics*.

It eventually transforms how light and vision are understood.

He described the laws of rectilinear propagation of light and of reflection and refraction.

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1590 – Two-lenses microscope

Johannes & Zacharias Jansen produced a microscope based on two lenses held within a tube. It could magnify an object up to 20 or 30 times its normal size.

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1609 – Compound microscope

Galileo Galilei develops a compound microscope with a convex and a concave lens.

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1660 – Anatomy advancement

Marcello Malphigi discovered capillaries, taste buds and their associated nerves.

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1665 – First use of term ‘cells’

English physicist Robert Hooke published *Micrographia*, in which he coins the term ‘cells’ when describing tissue. The book included drawings of hairs on a nettle and the honeycomb structure of cork. He used a simple, single-lens microscope illuminated by a candle.

The drawings of these microscopic observations helped promote rising public interest in microscopy.

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1675 – Living cells first seen

Antonie van Leeuwenhoek builds a simple microscope with one lens to examine blood, yeast and insects. He invents new methods for making lenses that allow for magnifications of up to 270 times.

Leeuwenhoek observed and reported on bacteria, spermatozoa, red blood cells, simple plants, the optic nerve and striated muscle.

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1690 – Huygens' publication of Traité de la Lumière

Huyhens' construction was used to trace geometrical wavefronts

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1813 – Improvements in chromatic aberration problems

In 1813, the Italian botanist Giovanni Battista Amici solved the problem of chromatic aberrations (colour separation) by inventing a horizontal achromatic reflecting microscope based on mirrors.

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1820’s – Advancements in spectroscopy

During the early 1820s, Joseph von Fraunhofer made experimental advances with dispersive spectrometers that enabled spectroscopy to become a more precise and quantitative scientific technique.

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1830 – Improvements in spherical aberration problems

In 1830 Joseph Jackson Lister minimized the problem of spherical aberrations (image blurring) by using one lens with a small spherical aberration and then added a series of lenses to form a high magnification from the entire set resulting in increased resolution.

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1830's – Cell theory

Schleiden (1838) & Schwann (1839) published their works on cell theory and proposed that cells were the building blocks for plant and animal life.

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1850 – Microscopes & public health

In 1850 Arthur Hill Hassall published his second book, '*A microscopical examination of the water supplied to the inhabitants of London and the suburban districts*' which became an influential work in promoting the cause of water reform.

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1852 – Study of the fluorescence phenomenon

In 1852 Stokes observed that the fluorescence typically is observed at longer wavelengths than the excitation light and that the absorption and emission of light from a fluorescent molecule is related to its structure.

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1857 – Pasteur's discoveries

In 1857 Pasteur discovered the lactic acid bacterium with an optical microscope. Another milestone was his experiments that refuted the theory of spontaneous generation

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1874 – Abbe equation

Based on the theory of diffraction Ernst Abbe writes a mathematical formula that correlates resolving power to the wavelength of light. Abbe's formula makes it possible to calculate the theoretical maximum optical resolution of a microscope.

$$\delta = \frac{0.61\lambda}{\sin\theta_{max}}$$

By 1895 the optical microscope achieved an Abbe resolution of about 0.2 μm.

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1878 – Development of oil-immersion microscopes

The use of oil-immersion objectives provided the maximum theoretical resolution with visible light.

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1880’s – Discoveries of pathogenic protozoa

Robert Koch used the microscope with the new immersion objectives to discover the pathogenic protozoa and bacteria that caused tuberculosis and cholera and the achromatic microscope permitted him to describe the life cycle of the anthrax bacillus.

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1892– Vaccination for cholera

In 1892, Waldemar Haffkine developed an effective vaccine with less severe side effects, later testing it on more than 40,000 people in the Calcutta area from 1893 to 1896.

His vaccine was accepted by the medical community, and is credited as the first effective human cholera vaccine.

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1921 – Vaccination for tuberculosis

Immunotherapy as a defence against TB was first proposed in 1890 by Robert Koch.

Today, the only effective tuberculosis vaccine in common use is bacilli Calmette-Guérin (BCG), first used on humans in 1921.

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1929 – First fluorescence microscope

In 1929, Carl Zeiss produced an intravital microscope that was used for studies of living kidney function, liver function and the detection of vitamins and bacteria in living tissues

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1931 – Transmission electron microscope

Ernst Ruska and Max Knoll design and build the first transmission electron microscope (TEM), based on an idea of Leo Szilard. The electron microscope depends on electrons, not light, to view an object.

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1932 – Invention of phase contrast microscope

In 1932 Fritz Zernike invented a phase contrast microscope which converts small differences in the phase of the light interacting with a specimen into corresponding differences in intensity that the human eye can detect.

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1939 – First observed virus

In 1939 Kausch & Ruska in Germany made the first photomicrographs of the tobacco mosaic virus

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1939 – Scanning electron microscope

Manfred von Ardenne builds the first scanning electron microscope (SEM), which used a focused electron probe to study the surface of a specimen.

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1940's – Characterization of cell organelles

With the fluorescence microscope it became possible to characterize the fine structure of viruses, the cell and its organelles, the nucleus, cell membranes, & neuronal synapses

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1940’s-1950’s – Advancements in materials science

Studies of small particles, such as the carbon black that gave strength to automobile tires, and the pigments that were used to color paints and cosmetics. Their small size made it possible to analyze their outlines in the transmission electron microscope (TEM), and determine their size, shape, and number, but not reveal internal structure.

In the 1950s, the microscopic analysis of thin foils dominated the research. Studies of crystal defects such as stacking faults and dislocations in these thin films were popular.

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1970’s – High Voltage Electron Microscopes

They allowed for the first time to study the ultrastructure of whole dehydrated cells (whole mounts), which could not be penetrated by the lower voltage electron beams of conventional electron microscopes (50-100 kV).

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1980's – Transistors' advancement

Transistors' technical innovation led to the personal computer, so that we could control microscopes automatically.

It also led to semiconductor cameras that could detect light very efficiently in digital images, and these could be processed and analyzed by computers.

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1981 – Video camera microscopes

In 1981 two laboratories published about remarkable and unexpected improvements in light microscopy by the use of a video camera and a real-time image processor.

The new method of video microscopy allowed for the first time a direct observation of a wealth of very small previously unseen and highly dynamic cellular constituents including microtubules and vesicles down to a size of 50 nm (up to x15000 magnification).

This almost immediately shifted the biologists view of cell away from the static electron microscopy-dominated view to the new dynamic one.

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1981 - Scanning tunnelling microscope (STM)

Gerd Binnig and Heinrich Rohrer invent the scanning tunnelling microscope (STM). The STM ‘sees’ by measuring interactions between atoms, rather than by using light or electrons. It can visualise individual atoms within materials.

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1990's - Nanotechnology Research & Technology

STM-based technology has enabled us to control the position and motion of arbitrarily small objects down to a sub-Angstrom unit scale.

STM & AFM instruments allow fabrication of nanometer-scale structures down to the atomic level by using a variety of different methods. It has even proven feasible to build up well-defined nanometer structures by appropriately arranging individual atoms.

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2000’s - Nanotechnology Research & Technology

Initial trials to realize nanometer-scale devices based on STM technology have began.

The close interaction between scanning probe methods and silicon-based microfabrication allowed the development of smaller scale integrated circuits.

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2010 – Atoms of a virus seen

Researchers at UCLA used a cryoelectron microscope to see the atoms of a virus (Chemistry Nobel prize 2017).

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2020 – Covid-19 3D mapping

The first 3D atomic-scale map of the coronavirus has been created by researchers at the University of Texas at Austin and the National Institutes of Health.

This is a significant and vital step towards developing vaccines, therapeutic antibodies and other medical counter-measures.

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