Phase contrast is a microscopy technique that High Resolution Electron Microscopy (HREM) and Cryo-EM have borrowed from the Zernike's optics method proposed in 1935. It essentially consists in a conversion of a spatial phase modulation into a spatial intensity modulation. We will mainly show how this technique is used in materials science applications but doing so we will also introduce and discuss the relative importance of some concepts and quantities of general interest like kinematical and dynamical theory of the electron diffraction, contrast, dose rate, resolution, aberrations, contrast transfer function, coherence.

At first, some basic concept of the scalar diffraction theory will be recalled and then trying to pass these ideas to transmission electron microscopy we will introduce the phase-object and a general image formation theory for a linear and space invariant system. This theory is at the basis of both the coherent and incoherent (STEM imaging) atomic resolution techniques that will be compared showing their respective pros and cons. Examples of HREM applications to C-related materials and defects in semiconductors with their image simulations will be used to illustrate the main milestones of the way that has led to the improvement of the transmission electron microscope resolution. This will also allow us to show how the interpretability of the first experimental HREM micrographs has changed eventually reaching the direct interpretability of the projected atomic structure.