Nano2Fun and the Nobel Prize in Chemistry 2014

We are able *to see* the word thanks to light that illuminates the objects, interacts with them and finally transports relevant information towards our eyes. Human eyes are very sophisticated light-detectors, but they are designed to see *big* objects, the ones we manipulate in our daily life. But, with the progress of science, we started to interact with *small* objects, like for example bacteria. Scientists then invented microscopes that magnify images allowing us to see small objects, down to a few hundreds of microns. This is already a great achievement, but scientists want more: sometimes it is necessary to see *very small* objects, like viruses, or the protein aggregates that form in the brain of Alzheimer patients. For these *very small* objects, optical microscopes are not suitable due to the intrinsic nature of light. In fact, light travels as a wave, and the wavelength, which defines the distance over which the wave shape repeats, roughly represents the minimum distance between two objects to be distinguished. The so-called diffraction limit applies to all optical instruments (microscopes, telescopes, etc.), and for visible light set the limit of the size of objects to be examined to 2 microns (approx). Attempting to *see* viruses using light in an optical microscope is like trying to measure the thickness of a hair with a ruler!

The diffraction limit was considered unbreakable until a couple of decades ago, when Eric Betzig, Stefan Hell e W. E. Moerner proposed different methods to overcome it, opening the way to the visualization of *very small* objects in fluorescence optical microscopes. The three scientists indeed obtained the Nobel Prize in Chemistry 2014 for the development super-resolution fluorescence microscopy, and its implications in bio-imaging.

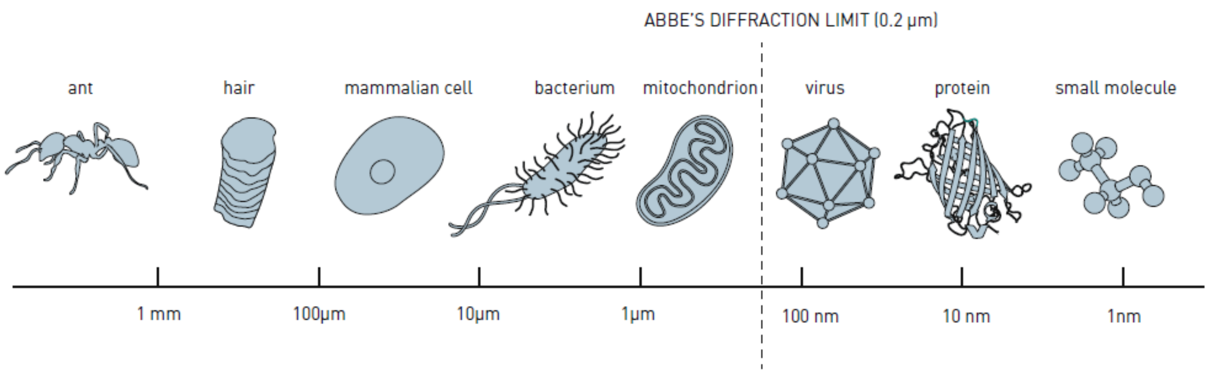

Figure 1. The diffraction limit (From www.nobelprize.org)

Fluorescence microscopy exploits molecular probes that emit light after excitation (fluorescence). Fluorescence microscopy is a very sensitive technique: even a weak light is easily detected in the dark. But, as with all optical imaging techniques, fluorescence microscopes suffer of the diffraction limit. Betzig and Morner introduced just a few fluorescent molecules in the sample, as to ensure that their mutual distance is larger than the light wavelength. In this way the microscope will be able to distinguish the signal from different molecules. The overlap of several scans will produce at the end a super-resolved image. Hell proposed a different approach, called Stimulated Emission Depletion (STED) that makes use of two laser beams, one to excite the fluorescent molecules, and another one to deactivate a part of them by stimulated emission. In this way fluorescence is detected from a sample region smaller than the diffraction distance.

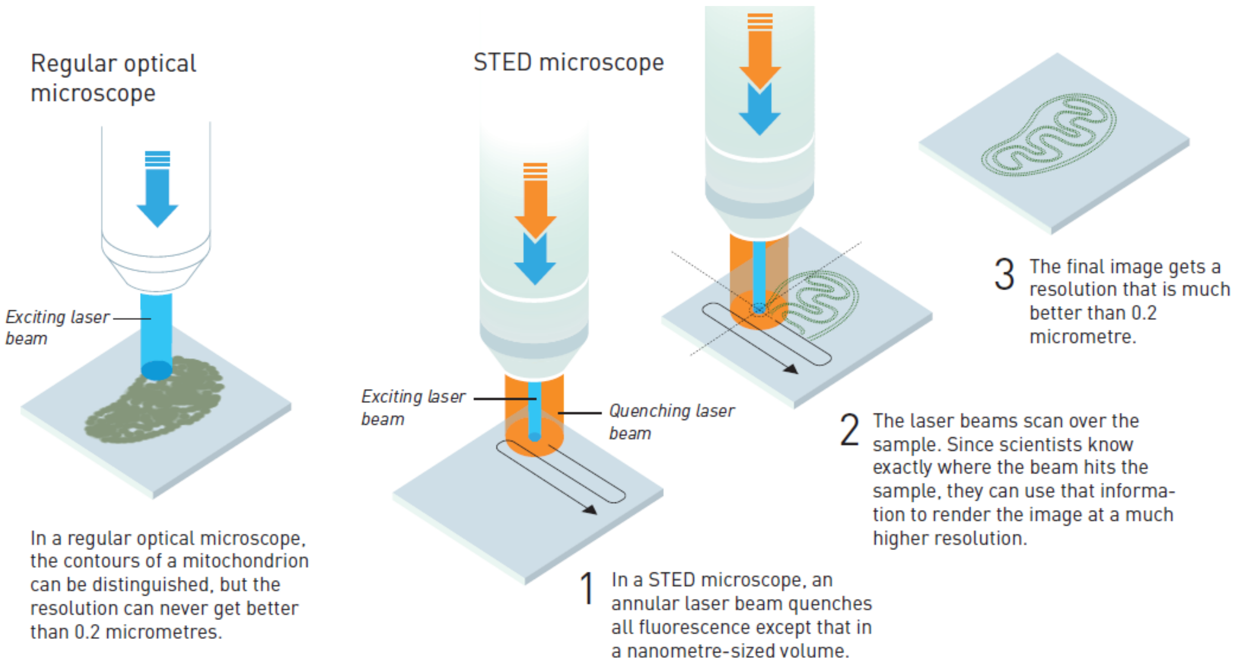

Figure 2. The principle of STED microscopy (from www.nobelprize.org)

Nano2Fun researchers celebrated enthusiastically the Nobel Prize for Chemistry 2014. Nano2Fun is an ITN-MC project funded by the EU Commission under FP7. It is focused on the development of super-resolved techniques for nanofabrication and imaging, based on two-photon absorption process. These techniques allow to fabricate (photo-polymerization) and to image (microscopy) small objects in three dimensions. Both techniques use light, and are therefore diffraction-limited. To overcome the diffraction limit, Nano2Fun aims at implementing STED in two-photon polymerization and two-photon microscopy. Nano2Fun researchers met in Antwerp (Belgium) on September 18-19, 2014. The meeting offered a fruitful opportunity to discuss first results obtained by the early stage researchers that were hired and started their activity since a few months. During the round-table on the Project status after its first year, the scientific discussion touched upon STED feasibility and advantages in either microscopy or nanofabrication… and this happened just two weeks before the assignment of the Nobel Prize for STED! Nobel Prize for Chemistry 2014 represents a reward also for Nano2Fun, since the importance of one of the main topics of its research program is now recognized worldwide.

Figure 3. The social dinner of the Nano2Fun meeting in Antwerp.