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Trends in nano-optics and their biomedical applications

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The development of the field of nano-optics during recent years, and the knowledge acquired meanwhile about the interaction of light with nano-structures opens up new ways for remote sensing even inside live cells. The Photonic Force Microscope (PFM) able to manipulate and track nano-particles with nano-meter precision can provide the instrumental framework. Depending on size and shape, metal nano-structures have plasmon resonances at distinct frequencies. With a tunable laser adjusted to their resonance the light scattering cross-section increases significantly allowing tracking small particles down to a size of about 5 nm. Furthermore, metal particles can be used as "nano-lenses" concentrating the electromagnetic field of light at their surface. In this way, only fluorophores in close vicinity will be excited. For fluorescence measurements inside a cell this provides the same advantage of very low background fluorescence, as total internal reflection fluorescence (TIRF) excitation provides close to a surface allowing single molecule fluorescence measurements with nano-meter resolution everywhere inside cells. An even more exciting possibility lays in the identification of single molecules without labeling by measuring a Raman "fingerprint". Certain geometric features of metal nano-particles can enhance the Raman signal of a molecule by a million times when in contact and so nano-meter sized particles become chemical sensors with single molecule sensitivity. In this way metal nano-particles within a PFM provide a new analytical tool with single molecule sensitivity and nano-meter position resolution with huge potential for cell-biological studies on regulation and transport processes within living cells.

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