Single Imaging Development and Its Impact on the Life Sciences

In 1995, using fluorescent probes, Prof. Yanagida and his group were able to successfully observe single molecules in an aqueous environment (Nature, 374,555-1995), which soon thereafter led to the observation of movement (Nature,380,451-,1996) and enzymatic reaction (Nature, 374,555-1995) by single biological molecules. From there, Prof. Yanagida's group was the first to apply this technology to observe signal transduction within a cell in real time (Nature Cell Biol,2,168-,2000; Science,286,1722-, 2001). This development has opened new fields in the life sciences.

1) Life Science System Dynamics

Using fluorescently labeled and Q-dot labeled proteins, these same imaging techniques have the potential to see in real time signal transduction within a cell, which offers tremendous potential on understanding the dynamics of various intra-cellular systems like a cell's metabolism. This is the result of advances in microscopy techniques that achieve better and better diffraction limits both in vitro and in vivo for improved nanometric scale imaging.

2) Using living systems as models for energy efficient machines

Having achieved unprecedented accuracy to observe the movement of single biological molecules, we will be able to understand how they move. Single molecule motility is the result of a process called "yuragi". Yuragi describes how molecules flutter or vibrate while moving towards their final destination rather than moving along a strict, constrained path. This is because biological molecules use noise from their environment, which causes a great deal of error. Therefore, a bias exists to assure the molecules travel correctly. Perhaps counter-intuitively, the yuragi mechanism requires less energy than had the molecule travelled deterministically by eliminating noise. The yuragi mechanism is used at all levels in an organism, from cells to the brain, and offers a new paradigm to cut energy demands. Therefore it has large implications in robotic design and information networks and is becoming a focal point of interest in the life sciences.

3) Impact on Genomic Science

The ability to image single molecule enzymatic reactions and the rapid advances in imaging technology means that in the near future we should be able to image DNA sequences at the single molecule level such that in the next five years it is expected we will be able to read the 30 billion bases in human DNA in 20 minutes (Pac.Bio.,Co.). Such speed will enable researchers to continuously observe gene expression in a cell over time, which will open the doors to understanding how cells develop and specialize to fulfill their assigned function.