

# Lasers and biology

Hideo Tashiro

Photodynamics Research Center

The purpose and recent topics of the photobiology group are introduced. A laser manipulator capable of trapping a single living cell, making a direct binary contact from a desired direction and judging the formation of cell-to-cell adhesion is produced by using optical trapping technique. The specificity of cell adhesive capability is tested with isolated hydra cells, demonstrating a clear difference in adhesive property between ectodermal and endodermal epithelial cells.

Light and life are deeply related. Light does not only act on living organisms, but it provides us an effective means of observing organisms. Particularly, with recent progress in optical techniques, the importance of light has further increased in acquiring information on living organisms without invasive contact. Light is also attracting attention as a means of controlling a micron-scale environment inside cells. Thus, laser beams, well-controlled light in time, space, and wavelength, can work as a monitor or activator of biological events.

The basis of the research activities of our laboratory is not the research into specific photo-biological phenomena, but the development and application of new observational techniques using laser light. The following is one example of our current research conducted with laser techniques.

A laser beam focused with a microscopic objective lens can trap small particles near its focus and then manipulate them.<sup>1)</sup> This effect called optical trapping is now becoming an effective tool for biological studies as non-invasive optical tweezers under microscope. As a matter of course, our recently developed device<sup>2)</sup> for the measurement of cell-to-cell contact forces utilizes this effect to manipulate isolated cells, making a direct binary contact from a desired direction.

Figure 1 shows a schematic diagram of our 3-dimensional laser micromanipulator. The system consists of a cw-Nd: YAG laser, a microscope and a sample chamber. Two laser beams

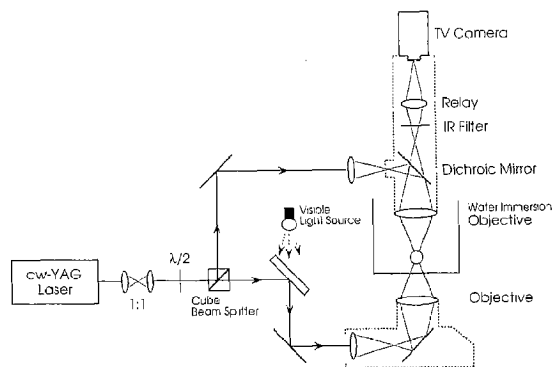


Fig. 1. Schematic diagram of the three-dimensional laser micromanipulator.

are introduced to the microscope through a telescope, so that the focused laser spots are superposed on the imaging plane of the microscope. In principle, the upward beam gives the

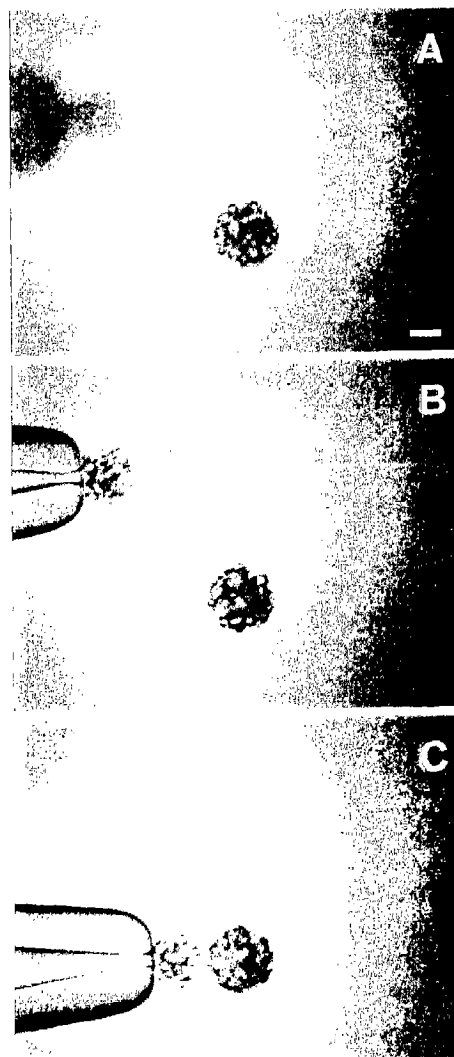


Fig. 2. Laser manipulation procedure of hydra cells to the top of a micropipet.

buoyant force and the downward produces the transverse trapping force. The sample chamber is fixed to a 3-dimensional transitional stage. A cell trapped by laser is moved relatively to the chamber by translating the stage.

Figure 2 indicates how to manage a trapped cell to the top of the micropipet. First, by lowering the microscope stage with the chamber on it, the cell captured in focused beams is lifted to the height of the micropipet until the pipet is imaged clearly. Then, the stage is horizontally moved so that the trapped cell comes closer to contact with the target cell which has already been captured at the top of the pipet. The counter-propagating beam technique proved to be effective for stable manipulation of cells as large as  $40\ \mu\text{m}$ . Using this

system, the specificity in one-to-one cell adhesion between ectodermal and endodermal epithelial cells as clearly elucidated for the first time.

Biological dynamics shown in dynamic instability of microtubule assembly and disassembly, or in the growth of and the axonal transport in nerve cells, are also currently studied with the aid of laser techniques. So, laser and its related techniques become now indispensable at the frontier of biological studies.

#### References

- 1) A. Ashkin: *Science* **210**, 1081 (1980).
- 2) H. Tashiro, M. Uchida, and M. Sato-Maeda: *Opt. Eng.* in press.