Lasers can now place energy on command almost as our imagination wishes. We are at the dawn of a new age, the Light Age.

Laser light is produced by stimulated emission, a process first explained by Einstein. Lasers generate light ranging in wavelengths from the deep infrared to the deep ultraviolet. Additionally, lasers can make light with an enormous span of other characteristics: pulse durations, pulse energies, peak and average powers, spectral bandwidths, coherence lengths, polarizations, and spatial beam properties.

Key to harnessing light’s capability for medicine is an understanding of the way it interacts with the various tissues via photothermal, photomechanical, and photothermal processes. It can do so selectively, interacting strongly with certain tissue (or foreign matter) while hardly affecting adjacent tissue. The principal property governing light’s selective interaction is its wavelength (color). All tissues absorb light differentially according to wavelength. Even small wavelength changes can result in enormous changes in absorption. If the wavelength is sufficiently short, the light energy absorbed can break chemical bonds. The result can be cell death, DNA alteration, or more mild changes in tissue properties. If the absorption is abrupt, photomechanical change (eg, shock waves or tissue ablation) may result. Whether accompanied by other processes or not, photothermal processes generally occur. These may be as innocuous as mild tissue heating or as pronounced as localized superheating, yielding temperature rises of thousands of degrees in billions of a second at the cellular level.

All of these photo-processes are used today to cause selective change within various structures of the eye. For example, in LASIK surgery, deep ultraviolet light from argon fluoride excimer lasers is used to ablate corneal tissue, locally altering corneal shape and changing its refractive power. The shock wave from a focused Nd:YAG laser is used to destroy opacified posterior capsules. Heat from the absorption of visible or near infrared light (eg, from argon ion or diode lasers) is used to photocoagulate the retina to seal tears.

Exciting new laser methodologies are emerging in laser selectivity. These techniques focus not just on the selective targeting, but also on the intentional “selective anti-targeting” of the tissues surrounding or adjacent to the targets of interest. This new concept of selective anti-targeting attempts to substantially reduce side effects by imparting the least photochemical, photomechanical, and photothermal stress to the surrounding tissue structures, while maintaining a high degree of therapeutic effect on the target.

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