LASER TISSUE INTERACTION
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Tissue effects
The energy in the laser beam is available as radiation, heat, and a photo-acoustic or mechanical form. But it is the thermal effect that is commonly used for surgical procedures. If we consider a single exposure of a short duration, the following events, in varying degrees of combination, would be possible.

![Tissue interaction diagram](image)

**Reflection**
Some of the energy will be reflected back from the surface of the tissue. Normally, such reflections are minimal due to high absorption of the energy by the tissue. However, polished metal instruments are used in the surgical field and should the beam strike surface of one of these instruments, significant reflection will occur. The intensity of the reflected beam will depend upon whether the reflective surface is concave or convex. The reflected beam will only cause damage if it remains in focus over a distance. For practical purposes, the whole theatre is considered to be the hazard zone from the reflected beam, and is known as the 'nominal hazard zone'. All personnel working in the hazard zone are required to wear protective eyeglasses, specific to the laser being used.
Absorption
For any type of tissue effect, all or some of its components must absorb the laser energy. Apart from bone, all tissues are predominantly made up of water. The CO₂ wavelength is strongly absorbed by water and, therefore, it is not surprising that the CO₂ laser has been widely used for soft tissue work in a number of specialties.

Photothermal effects
Following tissue absorption, the energy is converted into heat, the effects of which are known as photothermal effects. As the temperature rises beyond a certain level (approximately 55°C), the tissue will be irreversibly damaged with denaturation of protein and coagulation, invoking an inflammatory response. However, if the exposure continues, the tissue will suffer immediate thermal necrosis with consequent blistering. The necrotic tissue will slough off (or peel off from the blisters). During exposure, as the temperature continues to raise even further, both intra- and extracellular water boils at 100°C, and water vapors is formed. Then the cells explode and the cellular debris flies out with force. With sustained exposure, the temperature of the tissue continues to rise rapidly, resulting in charring at about 350°C. This is blackened carbon, which is often seen lining the crater. It should also be noted that, when solid particles cross the path of the beam, their temperature rises even further and they may glow. This incandescence may also be observed when the beam strikes blackened tissue.
Conduction

Absorbed energy heats up the tissue. The heat starts to spread in all directions due to conduction. The conducted energy results in the thermal necrosis and coagulation seen in the bed of the ulcer crater. The conducted energy may also cause inadvertent damage to important underlying structures or to those in close proximity. Therefore, it is necessary to ensure that the depth of the thermal damage is minimized. This can be achieved in several ways. Use of superpulse at a low power setting is extremely effective for minimizing the depth of thermal damage. Thus, any surgery on the free edge of the vocal cord is best undertaken using the superpulse mode, with intermittent exposure to allow a period of cooling.

Scatter

Some of the energy undergoes multiple internal reflections within the tissue, and scatters randomly, heating the tissues. The phenomenon of scatter can easily be demonstrated by pressing the laser pointer onto the tip of the finger in dark: the whole tip glows due to the extensive scatter of the red laser beam.

Coagulation

In contrast to the conventional mechanical energy of the scalpel, the laser causes a zone of coagulation in the ulcer crater. In this respect, it resembles diathermy, the important difference being that the energy in diathermy lacks fine control. Coagulation occurs as a result of denaturation of the protein in the tissue. If the main aim of surgery is to remove tissue as cleanly as possible, coagulation is an undesirable side-effect. The extent of the coagulation zone is dependent upon: Wavelength, Thermal relaxation property of the tissue, Exposure time, High power density, Fluency, Ablation, Charring, and Fluence.