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physiological responses or secondary processes, such as decreased pain and inflammation and improved tissue repair [11, 12].

Oxygen (O_2), the stable superoxide anion, and hydrogen peroxide (H_2O_2), its consequence (with the addition of two protons), have both been shown in a few studies to be generated by light's interaction with mitochondria in cells via cytochrome C oxidase [5]. Burdon and Davies independently demonstrated that a relatively low concentration of H_2O_2, between 0.1 and 0.5 mol/10^7 cells, elicited bio-stimulatory effects. It was recently revealed that the metabolic activities of human glioblastoma might be suppressed by low-average-intensity radiation pulsed at picosecond durations and near-infrared (1,552 nm) wavelengths. MTS is a metabolic test that was used to assess cellular metabolic activities across a range of fluence exposures.

Laser-induced metabolic inhibition can be mitigated to some extent by pre-treating the growth medium with the enzyme catalase before exposing the cells to the laser [13, 14].

Without catalase therapy, cellular metabolic activity reverts to its control/sham-exposed levels after initially increasing. However, the loss in cellular metabolic activity is greatly attenuated when catalase is present (the catalase acts by removing hydrogen peroxide that has traveled outside of the cells) [12, 15], indicating a functional role of H_2O_2 (Figure 1.6).

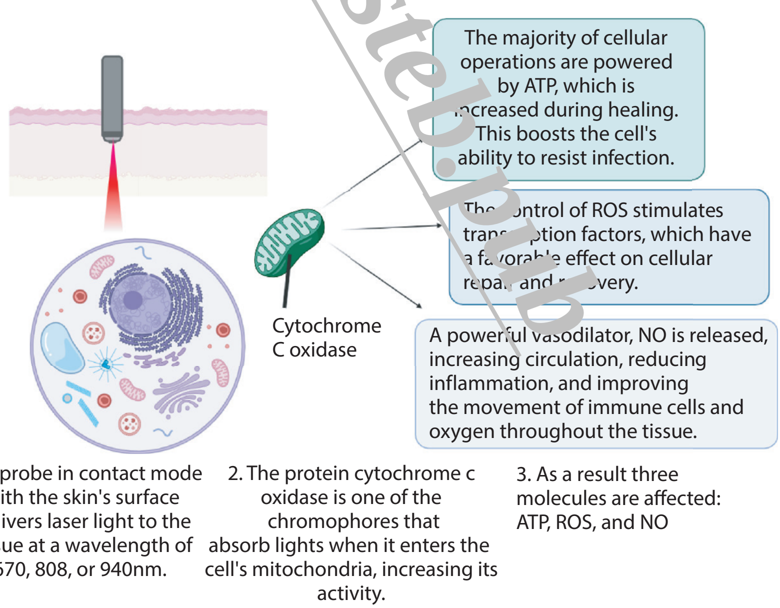

Figure 1.6 Mechanism of laser therapy in tissue.

1.5 Implications of Lasers on Tissues

1.5.1 Photothermal Impacts

Tissue chromophores (pigments) convert laser energy into heat through an interaction with the laser's wavelength. Pigment, hemoglobin, and xanthophyll are some of the chromophores found in ocular tissue that absorb lasers at visible light wavelengths; proteins absorb at UV wavelengths; and water absorbs infrared radiation. Tissue reaction depends on both the absolute temperature and the length of exposure. Vaporization, coagulation, and necrosis are all possible outcomes [16].

1.5.2 Photochemical Effects

Photoreceptors undergo chemical changes when exposed to light; isomerization of 11-cis retinal to all-trans retinal is one example. A photosensitive dye is infused intravenously during photodynamic therapy, and a particular laser wavelength is used to stimulate the dye's molecules. Cell structures in regions where the dye concentrates, such as the walls of vascular tissue, are irreversibly oxidized when the excited photosensitizer passes its energy to tissue oxygen, creating radicals [17, 18].

1.5.3 Photomechanical Effects

Photo disruption results from a sudden increase in tissue temperature over the vaporization threshold brought on by laser absorption. High laser energy delivered in the microsecond-to-nanosecond range could ionize plasma status and vaporize transparent ocular tissues without pigment absorption, leading to temperatures above 100°C and explosive vapor bubbles that could rupture nearby tissue or eject fragments of tissue from surfaces. The excimer laser used in corneal operations works on this principle [19, 20].

1.6 Spectroscopy Using a Laser-Induced Breakdown Mechanism: Its Use in Medicine and Other Fields

In optical emission spectroscopy (also known as laser-induced breakdown spectroscopy, or LIBS) [21–23], high-energy laser beams interact with matter, creating plasma, whose light can then be used in many applications (solids, liquids, or gases). If the plasma's distinctive parameters have a large enough effect on the emitted light, then the atomic spectroscopic study of the light can reveal a wealth of information on the underlying physical processes and elemental structure of plasmas [24].

Over the past two decades, LIBS has attracted more and more attention due to its usefulness in a variety of fields, including manufacturing, ecology, medicine, and the forensic arts [25–27]. It is a useful and sensitive new tool for elemental analysis. With the added benefit of requiring little to no sample preparation, it is a highly adaptable method for determining the elemental makeup of samples in a short amount of time.

Recently, LIBS has been widely used in the investigation of human tissue samples and other biological and medical systems.

Generally speaking, there are two basic types of medical uses for LIBS [28]:

(1) Clinical specimens from humans (such as teeth, bones, urinary bladder and gallstones, liver tissues, or other tissue samples)
(2) Examining and analyzing microorganisms (such as bacteria, molds, yeasts, and viruses)

About the first type of use, Patlak used the LIBS method to investigate the contribution of individual factors to gallstone production (under emphysema and mucosal gall bladder conditions) [29]. The samples were collected in the Purvanchal area of Uttar Pradesh, India. The goal of the study was to determine whether or not gallstones developed in different environments (with different diets, for example) have significantly different elemental compositions. According to the results, gallstones are more common in female patients than in male patients. Patients who regularly used tobacco, chewed tobacco or smoked cigarettes, or imbibed alcoholic beverages were shown to be at increased risk. The researcher also pushed the LIBS method's boundaries by using it to examine human fingernails and baby teeth in real-time. The roots of caries can be revealed through elemental analysis of tooth samples, a major problem in oral health. Cairo University's Lasers and Emerging Materials (LLNM) Laboratory used LIBS for yet another medicinal application. It was used for the detection and staging of liver cancer [30]. The plasma on the liver's surface was started using radiation from a 532 nm neodynium-doped (ND): YAG laser at a power density of 5.7 108 W/ cm^2.

The emitted light was examined, and its analysis revealed the presence of cancerous tissue's trace constituents. The radiation emitted from the materials was captured using an Echelle-type spectrograph, and a 25 µm multimode quartz optical cable was used to transmit the signal. By linking an intensified charge coupled device (ICCD) camera to the spectrograph, the gathered light may be scanned over the spectrum (Figure 1.7). The Kestrel-Spec software directed the machine to take pictures from the available camera. A single-shot detection within the system extended from 200 to 1,200 nm in wavelength.

A spam 16 software spectrum analyzer was utilized to determine the various components. A low-pressure Hg- lamp was utilized to calibrate the emission spectrum's wavelengths, while all the relative intensities (sensitivity) in the emission Deuterium halogen lamp lights were used to calibrate the spectra. The researcher measured the levels of Mg, K, Ca, Na, Fe, Mn, and Cu in the liver tissues. To decide on cancer classification, an artificial neural network (ANN) was given the results from the LIBS approach. The neural network developed at LLNM is optimal for classifying a benign tissue from a cancerous tissue. There was a dramatic increase in the amounts of several trace elements in malignant tissues compared to normal tissues, and this increase occurred throughout all stages and grades of the disease. This used the LIBS approach which allowed the researchers to draw the following conclusions:

The capacity to diagnose malignant cells and tissues, the method's ease of use, and the reduction in the chances of contamination and misdiagnosis all speak in favor of it.

Since reliable results can be obtained from a relatively small sample size, the procedure is non-invasive, and it provides real-time quantification of all

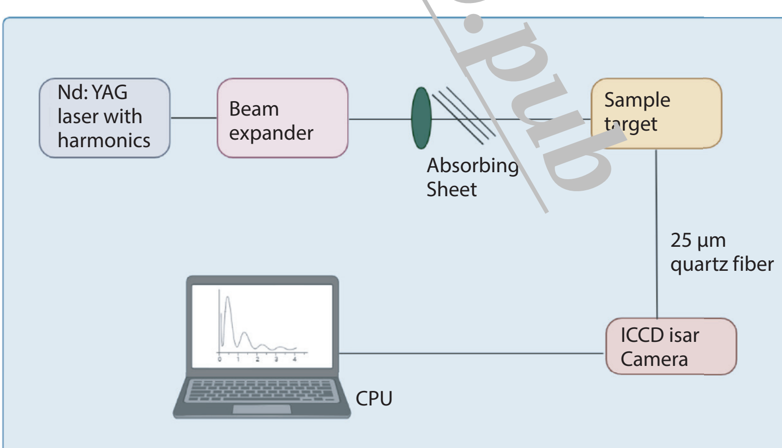

Figure 1.7 Experimental preparation for laser-induced breakdown spectroscopy.