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Review Article

# Bio-photonics in dentistry: A review

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ABSTRACT

Biophotonics is the new extended branch of photonics, which is the combination of photonics and biology. It is also known as biomedical optics as it has become an important tool for biomedical diagnosis, therapy, monitoring, imaging, and surgery. This branch deals with action of light on biological matter mainly tissue. Three types of laser-tissue interactions are known based on interaction time and active power density. Photochemical, photothermal, photomechanical and photoionization effects.



## 1. Introduction

Photonics is one of the cutting-edge technologies of the new era. It is an optical technology which implements in health care system by different wavelength of light and its interaction with various patterns of photon-tissue. This technique has several advantages including: Rapid, sensitive, specific, inexpensive and non-invasive procedure.

Oral diseases are accompanied by change in oral tissue structures. For example: Caries, non-caries lesions, gingival inflammation, periodontal diseases, precancerous lesions and cancer/tumor of oral tissue. Dentistry has always relied on modern science and technology to improve diagnostic tools and advance treatment options.[1]

National Center for Optics and Photonics Education (NCOPE), defines Photonics as the technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. Lasers and other light beams are the “preferred carriers” of energy and information for many applications. Photonics involves cutting-edge uses of lasers, optics, fiber-optics, and electro-optical devices in numerous and diverse fields of technology- alternate energy, manufacturing, health care, telecommunication, environmental monitoring, homeland security, aerospace, solid state lighting, and many others.[2]

Photonics transmits, processes, and stores information using photons rather than electrons, resulting in a massive increase in capacity and speed in information technology.On the other hand, Photonics and biology are combined in biophotonics. Biophotonics is the study of how light interacts with biological materials.[3]

## 2. Spectrum of Radiation

The smallest units of energy are photons which may be transferred as elementary particles or waves, and are generally referred to as light. This strength can be visible as mild electromagnetic spectrum; however, electromagnetic radiation includes an extensive variety of wavelengths and frequencies. Gamma rays have the smallest wavelengths and its photons include the best quantity of strength. Most gamma-rays measure 10 picometers. Between 400 to 700 nm is the visible light. Low frequency radio waves, which can be up to 100 kilometers long, are on the other end of the spectrum. The longest recognized radiation has a

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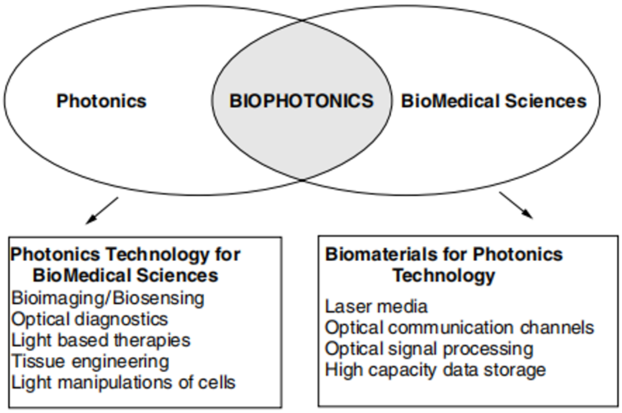


**Fig. 1:** Amalgamation of photonics and biological sciences

wavelength ranging from 10,000 km to 100,000 km. The only electromagnetic spectrum radiation that can travel through water is visible light.[4]

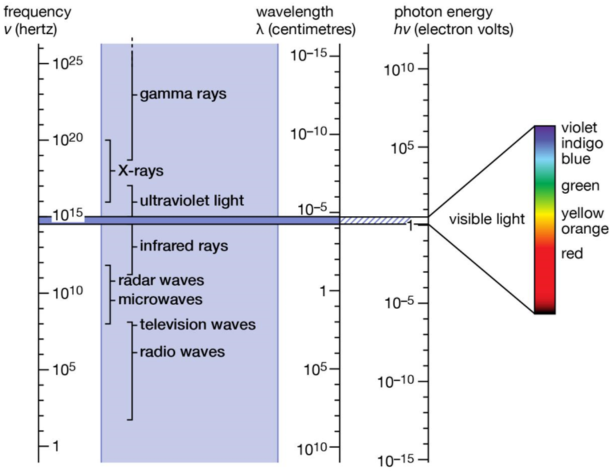


**Fig. 2:** Electromagnetic spectrum of radiation

## 3. Scope of Biophotonics for Health Care

Nowadays, laser is the most commonly used device for treatment of different diseases. Several light-based technologies such as optical probes are already being used in clinical practices both in medical as well as dental setup. Photodynamic therapy is nowadays being used to treat cancer also. Laser-tissue interactions are extensively being used in dentistry such as for removing caries, crown cutting and preparing teeth for fillings. All of this is done by precisely focusing lasers at specific points in enamel without damaging the surrounding tissues. Other uses of lasers in dentistry are periodontal surgeries, sterilization of root canals, oral ulcers treatment, and teeth whitening.[5]

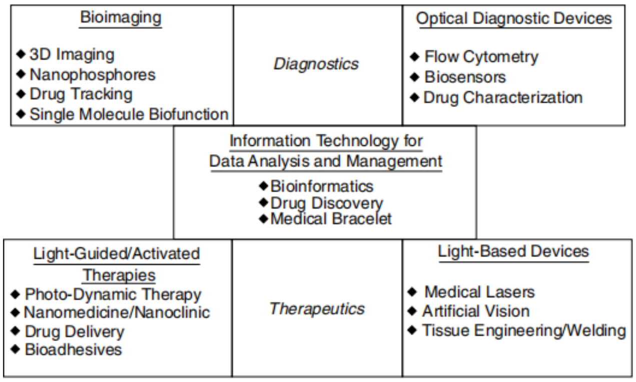


**Fig. 3:** The broad versatile scope of biophotonics for health care

## 4. Classification

Biophotonics is an important tool in detecting early dental disease, in providing more effective minimally-invasive treatments and in restoring both the functionality and aesthetics of the damaged tissue.

In Dentistry, it can be categorized on the basis of its application:[6]

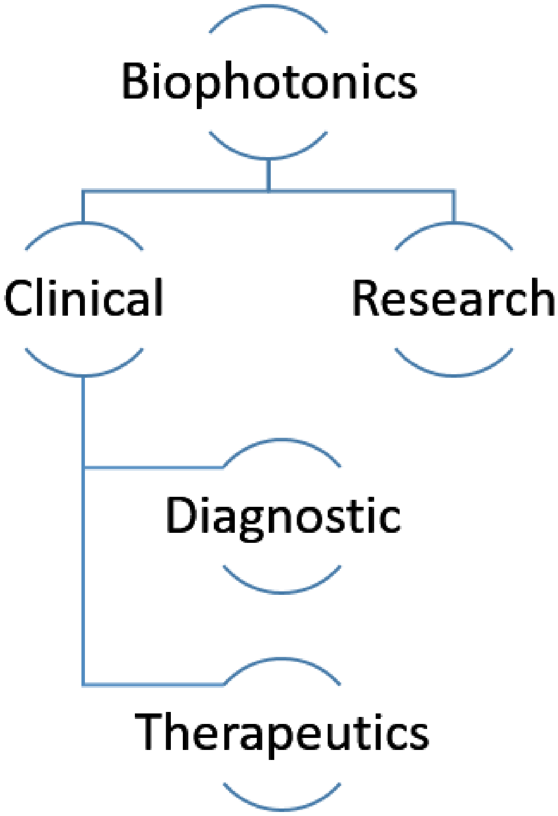


**Fig. 4:** Classification of Biophotonics

## 5. Diagnostic

The interaction of low-energy light with the tissue generates luminescence, that provides information about different clinical variables such as pH, flow and oxygen saturation of blood. It also provides information on the physiological and pathological cause of biochemical changes.[7]

## 6. Therapeutic

Thermal interaction: By heating up the tissue with a laser, the tissues break down. This leads to solidification, evaporation, carbonization, and melting. This heat can also be used for welding of the tissue. Incisions can also be made with these high energy lasers.[8]

Laser Tissue Interaction: When laser interacts with tissue, a complex process takes place.Studies have shown various cell level responses as an increase in number of mast cells, degranulation, production of procollagen in cultures of human skin fibroblast and the increase action of fibroblast and the response of macrophageas a response of different lasers.[9,10]

### 6.1. *Thermal properties of tissues*

According to Boulinois,[11] laser effects have been divided into 4 types, on the basis of their biological interactions:

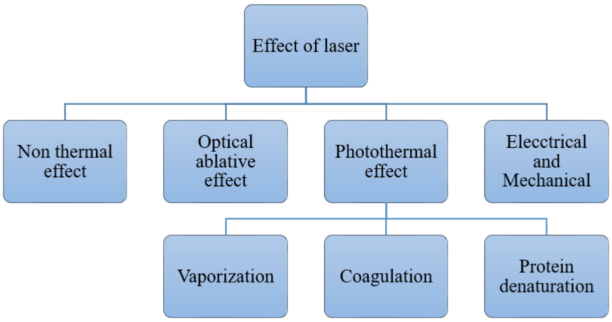


**Fig. 5:** Effect of laser

### 6.2. *Photodynamic therapy*

In this therapy, for therapeutic effect, light is being used to accelerate chemical reactions in the body. Photodynamic effect is achieved by photosensitizing agent. This is also known as photoradiation therapy or photochemotherapy.[12]

Photo-biostimulation: Photochemical effect on tissues is induced by extremely low-power light. This does not damage tissue because of less heat production; it also induces healing of the tissue by deep penetration into it thus, photochemical effect is initiated. The application of photo-biostimulation in cases of post extraction swelling, sensitivity and any oral lesions have shown effective results.[6]

Bioimaging: X-ray and optical imaging has affected dental practice dramatically. 2-D and 3-D image reconstruction has provided us with better visualization of the underlying pathology, allowing the change in measurement of the disease severity over time, thus helping in planning the treatment and patient care. It also has variety of uses, including the analysis of gene expression, assessment of wound healing, pharmacokinetics, pharmacodynamics and toxicity of infectious diseases.[13]

## 7. Research & Future Trends

### 7.1. *Photomechanics*

Photomechanical experiments are based on optics that are used to study the stress-strain distribution in the periodontium and allows us to identify the property gradients of the biological materials. These experiments are highly sensitive and are used to calculate clinical material variables within dental structure and biological interfaces. Dental biomechanics most commonly uses photoelasticity and moire interferometry in addition to speckle pattern interferometry. It used to be considered laborious and time-consuming to analyze optical fringes for clinical experimental data.

### 7.2. *Spectroscopy*

A spectrum may be considered as electromagnetic radiation that is absorbed or released by a sample as a representation of electromagnetic energy. The quality of an absorption spectrometer is determined by the fact that a certain species does not absorb light in all sections of the spectrum, but only to a given degree, which varies from species to species. It acts as a fingerprint for identification for a molecular species. An ultraviolet-visible spectrometer measures changes in molecules electronic states, while an infrared spectrometer determines changes in their vibrational states. Through these methods, it is possible to measure the chemical properties of biochemical substances noninvasively.

Raman scattering is based on measurements of high-energy photons that interact with the material of interest (or crystal lattice).

### 7.3. *Fiber-optic sensors*

With optical fibers, health care has made significant progress, but more needs to be done. In the future, fiber optics will offer flexibility of beam manipulation. Recent research has developed a variety of fiber optic sensors with the goal of providing a rapid, noninvasive and safe method for testing physiological variables. Fibre optic-based sensors feature numerous advantages including electrical isolation, physical flexibility, and the lack of need for having an electrical power supply to operate the unit. Additionally, they can be used to customize probes for specific functions. By combining fiber optics with spectroscopic techniques, these probes offer many advantages.[14]

Dentists had struggled with a variety of issues related to the diagnosis and treatment planning for periodontal tissues. But, soon after the introduction of new technology i.e., Biophotonics, great impact has been seen on health care. Many advances have been made in the instruments being used in health care using essential technologies such as

1. CCD detectors,
2. Small lasers,
3. Easy-to-use computing platforms combined with fiber-optic connected instrumentation, and
4. Volume holographic elements

The most notable advantages of photonics-based approaches are rapid detection and noninvasive tissue modification. These techniques enable for early illness detection and the deployment of preventative or less invasive therapy regimens that avoid tissue damage. Biophotonics is entering a new era of clinical testing and assessment to understand the underlying principles and possible risks of the technology. Although traditional clinical procedures may be replaced by optical spectroscopy, it is critical to integrate the benefits of photonics with lessons gained from the past by physicians. With the help of this method more clinically effective technology can be developed. Biophotonics has a bright future in terms of therapeutic applications and fundamental research. It is expected to play a significant role in development of new technologies with considerable health care advantages and enormous commercial possibilities for various biomedical businesses in the future. Some of the future opportunities in the field of biophotonics are development and testing of nano-probes, in vivo optical biopsy, optical biosensors for early detection of cancer, tissue adhesion, contouring, regeneration and real time monitoring of drug delivery. Long-term clinical evaluations should be used to back up all of these technological tools.[15]

## 8. Conclusion

All health practitioners who intend to operate lasers must understand the principles of laser light, the optical characteristics of matter, and interaction between light and tissue. Biophotonics is a strenuous topic due to the intricacy of optical properties of light and biological tissues along with their interaction. When using this biotechnology, however, a basic understanding is required. The optical qualities of the tissue receiving specific light will determine which treatment protocols and laser parameters are appropriate for the inter linkage to provide best result in every way possible. The recent findings in the field of photonics have sparked an increment in interest in biophotonics science. These driving forces for biotechnology investigation are continually allowing new applications and providing enormous hope for fresh, previously unimagined future possibilities.

## 9. Source of Funding

None.

## 10. Conflict of Interest

None.

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