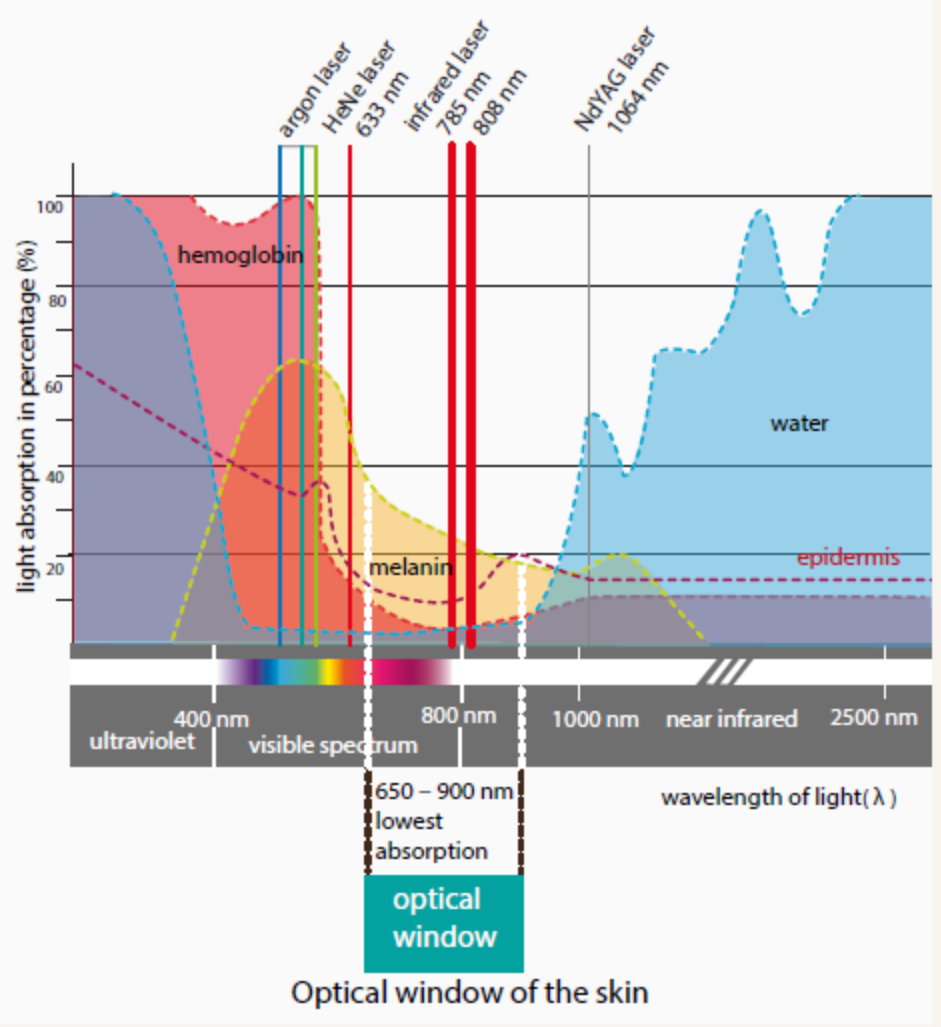
A Brief Overview of Laser Wavelengths by Geoff Sharp

The Optical or Therapeutic Window

The following graph is republished from the book Laser Field Therapy by Anja Fuchtenbush, Volmar Kriesel and Peter Rosen.

This graph shows the absorption of light into different component of the human body. It shows a low valley in the centre of the range where the light can travel the greatest distance. This is the optical window and it ranges from 650nm to 900nm and the high-end extends up to about 940nm. There is a lot of literature emphasizing the optical window and how it is used to predict the best wavelength for therapy lasers. Recent developments show that each wavelength has advantages but 650nm to 900nm is the best wavelength because it has the best combination of depth of penetration (low absorption), cellular interaction and energy transfer efficiency.



Optical window of the skin

Red (600 to 660nm)

Much of red wavelength interacts with melanin (near the surface) and with the haemoglobin in the blood. There is also some reaction with mitochondria (secondary peak of the Cytochrome C Oxidase curve). This energy is absorbed close to the surface making it the best option for superficial scar tissue, burns, cosmetic issues and other non-structural issues. Because some of the energy in this wavelength is transferred in the blood stream (but not haemoglobin), this wavelength can also be used to treat more complex problem where the exact treatment location might be unknown. The energy can flow through the body and interact with damaged cells in many parts of the body operating more like a vitamin that goes where it needs to go. This wavelength is also best for treating the lymph system and acupuncture points.

Near Infrared Lasers (800 to 860mn)

The most important wavelength is in the range of 800 to 860mn with the peak around 810mn. This is one of the best wavelengths to get a combination of deeper penetration and cellular interaction. Lasers in this range are optimised to interact with the mitochondria and they trigger an increase in cytochrome C oxidase and adenosine triphosphate, two key chemicals required in the PBMT. Several studies have shown extremely positive results in experiments with rats in the regeneration of damaged tissue.

EFFECT OF LOW LEVEL LASER THERAPY (830 NM) WITH DIFFERENT THERAPY REGIMES ON THE PROCESS OF TISSUE REPAIR IN PARTIAL LESION CALCANEOUS TENDON. Oliveira FS1, Pinfildi CE, Parizoto NA, Liebano RE, Bossini PS, Garcia EB, Ferreira LM. - Lasers Surg Med. 2009 Apr;41(4):271-6. doi: 10.1002/lsm.20760. (*Publication*)

LASER-INDUCED REGENERATION OF CARTILAGE. Emil N. Sobol, Olga I. Baum, Anatoliy B. Shekhter, Anna Guller, Andrey V. Baskov - J. of Biomedical Optics, 16(8), 080902 (2011) (*Publication*)

905nm Super Pulsed Lasers

All 905nm lasers are super pulsed. Laser diodes that operate in this range must be pulsed to keep the diode from overheating. This wavelength is also very popular because super pulsing the laser eliminate the risk of eye damage. This wavelength is unique because it interacts primarily with the iron in haemoglobin. When a 905nm laser interaction with the iron in haemoglobin, it oxygenates the area. Oxygen is another key chemical in the healing process so that some conditions might get the best result with a super-pulsed laser.

980nm Lasers

At 980nm, it is outside of the optical window and approaching the peak interaction of light with H^2O in the body. As the wavelength increases, it approaches 100% absorption by water. Although some of the energy is also interacting with the tissue and performing the same function as an 800 to 850nm laser, the bulk of the energy goes to creating thermal gradients in the H_2O that increase circulation and blood flow. The increase in circulation may help with tissue relaxation. This is also the most popular wavelength for high-end pain control lasers and many doctors feel that 980nm system provide the highest level of pain control. This is great for laser surgery but less than ideal for therapy. The big issue here is that any energy that is converted into heat cannot be converted into chemical energy (which is the main goal of PBM).

Multiple Wavelengths at the Same Time

Another debate is the idea of using multiple wavelengths at the same time. Is it better to treat with one wavelength at a time or multiple bands at the same time? According to some manufacturers, like Multiradiance (TerraQuant), TheraLase, Lumix, Chattanooga and K-laser, the answer is multiple wavelengths create a synergy. One the other hand manufacturers, such as Thor, Avant, Apollo, Nexus and Laserex, support one wavelength at a time.
Both concept have a niche:

- Point and Shoot- If you would not go to the trouble to try and control the dosage for each wavelength, it may be better with a multi wavelength shot-gun approach to treatment. It may be the case that only 1% of the dosage wanted at a specific wavelength enters the tissues but it is better than nothing.

- Precision - If dosage is a concern and the best results wanted the therapist needs to control each wavelength independently so that the appropriate dosage for each wavelength is achieved.

In theory, it is better to treat each area with the optimum dosage (wavelength and total energy). In the real world, combining the wavelengths simplifies the protocol, reduces the therapy complexity, reduces the treatment time and give patients at least some energy in the wavelength that might have the biggest impact.

400nm (UV) Light is Not Good for Therapy Lasers

Some manufacturers are starting to integrate UV (blue) light into their lasers because of its antibacterial properties. UVB is the primary wavelength of light that causes disease. It kills bacteria by destroying the DNA. It could be argued that it might be a good addition to a battlefield medical laser because in the field, there is no time for proper sanitation and

maybe killing or mutating every living thing in the area will cut down on infections but this is a rare and unproven case.

UV light is indiscriminate meaning that it kills both the bad bacteria and the good. Humans cannot survive without the good bacteria so using a UV light when it is not necessary is only hurting the ecosystem and the patients. Humans have already observed that overuse of antibiotics has helped bacteria evolve into “super bugs” that are getting unstoppable. In general, the wide spread use of UV light helps kill off the weak bacteria making room for strong, eventually the bacteria will evolve and become stronger to the point that clinicians don’t have any weapons to stop them. With a few exceptions, there is not a good reason to use UV light to treat the majority of conditions and the overuse of UV light could have some very negative outcomes for everyone.

Diseases caused by light

The 3 main wavelengths that can cause damage to tissue are:

- UVC: 200-290nm - Mostly absorbed by the ozone laser so there is less evidence of diseases caused by UVC.
- UVB: 290-320nm - Causes DNA damage. The major cellular chromophores that absorb in the UVB range are nucleic acids (DNA and RNA) and some proteins. Even though UVB can cause DNA damage, it is used to treat Psoriasis and other inflammatory skin disorders.
- UVA: 320-400nm - The energy from the sun in the UVA range is about 1000 times less than UVB so there is less evidence to the potential for tissue damage.