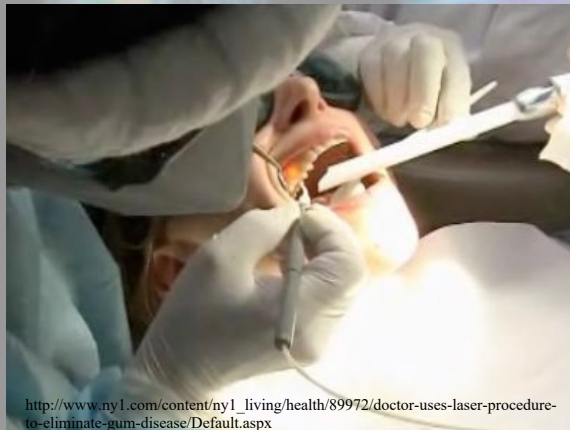
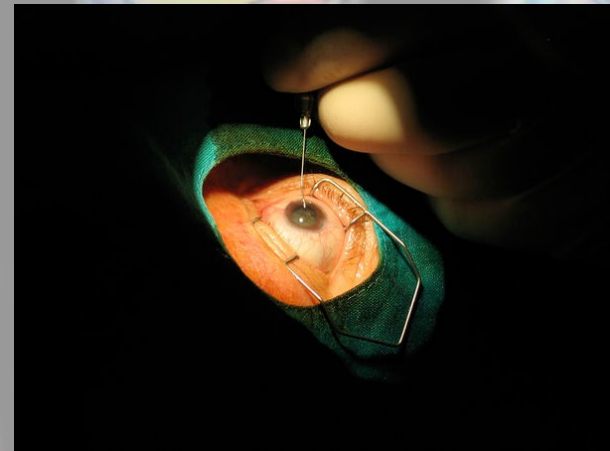


# *Applications in Dermatology, Dentistry and LASIK Eye Surgery using LASERs*



# Lasers in Dermatology

## - *Types of Tattoos*

### *Decorative Amateur & Cultural*

These tattoos are usually tribal or gang related in nature and consist of primarily black India Ink. Tattoos are placed superficially and unevenly in the dermis and respond well to laser treatment with only a few treatments.

### *Professional*

In the past usually seen in military and biker tattoos, but now many people have tattoos – less of a taboo. Placed deeply in the dermis and consist of greater pigment density – vibrant and diverse shades of color. No regulation of tattoos and the artist may mix or overlay inks which makes laser treatments difficult.



<http://www.crimelibrary.com/photogallery/prison-tattoo-field-guide.html>

One of the most common criminal tattoos is the teardrop underneath the eye. The most widely accepted meaning of the teardrop is the wearer has killed someone. The teardrop can also mean that the wearer has served a long prison sentence, or is mourning the loss of a family member. A clear teardrop, like the one pictured, can mean that the wearer has committed an attempted murder, or alternatively, that a close friend was killed and the wearer is seeking revenge.



<http://loudmeyell.com/30-patriotic-military-tattoo-designs.html>

# Lasers in Dermatology

## - *Types of Tattoos*

### *Cosmetic*

Applied to disguise scars, broadening lips, eye and lip liners, or providing rosy cheeks. Colors are usually off-white, reddish-brown, red, dull orange, or flesh tones. Many colors are made from iron pigments. Iron has two oxidation states: ferrous oxide which is black and ferric oxide which is red-brown in color.

### *Medical*

These tattoos are placed to designate a radiation port for cancer therapy or radiation treatments. Mostly in black India Ink and are easily removed.

### *Traumatic*

Natural tattoos related to injuries of the skin such as power burns from gunshots, or from gunshots themselves or from scraping the skin as in a motorcycle accident.



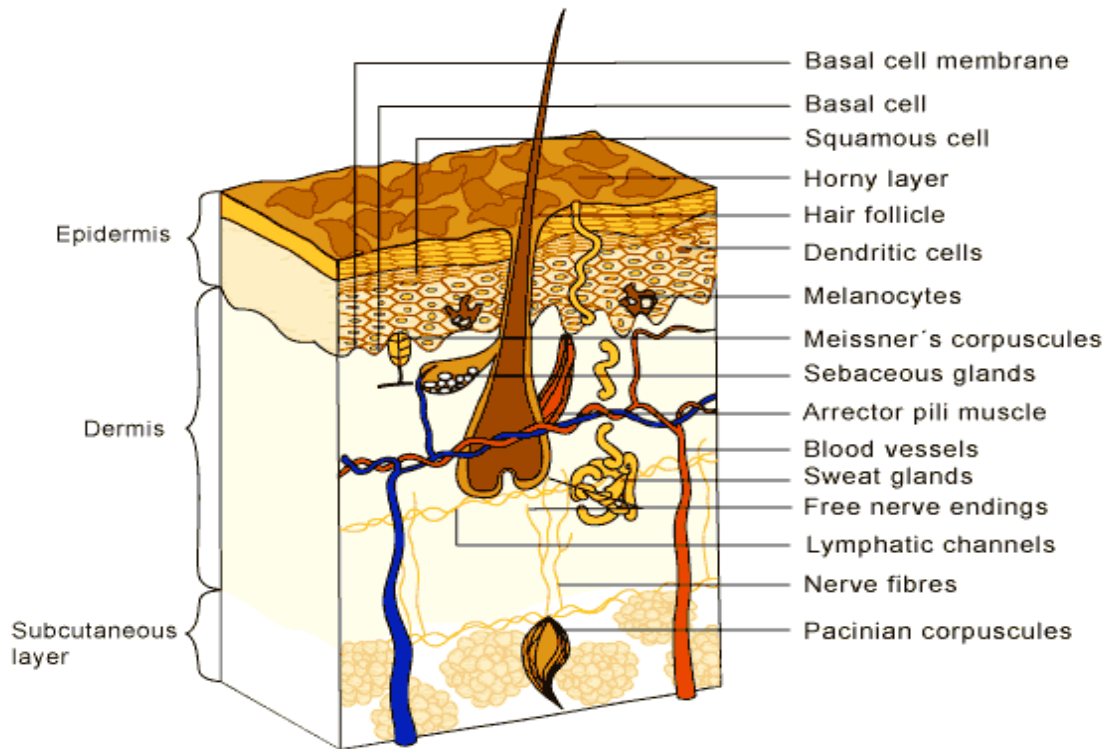
<http://www.cosmetictattoos.com/>



[www.gopixpic.com/640/motorcycle-road-rash-pictures-warehouse/](http://www.gopixpic.com/640/motorcycle-road-rash-pictures-warehouse/)

# Lasers in Dermatology

## - *Skin structure*



[http://skincancer.dermis.net/content/e01geninfo/e7/index\\_eng.html](http://skincancer.dermis.net/content/e01geninfo/e7/index_eng.html)

- Skin is the largest organ in the human body.
- Structure of the skin
  - Epidermis
  - Dermis
  - Subcutaneous Layer

# Lasers in Dermatology

## - *Skin structure*

*Epidermis* – or the uppermost layer of skin is made up of cells called keratinocytes, which are stacked on top of each other, forming different sub-layers. The keratinocytes develop at the bottom and rise to the top, where they are shed from the surface as dead skin cells. The epidermal layer is constantly renewing itself, the live cells changing into dead, hard, flattened cells. Melanocytes and Langerhans cells are other important cells found in the epidermis which have some specialized functions.

- *Melanocytes*

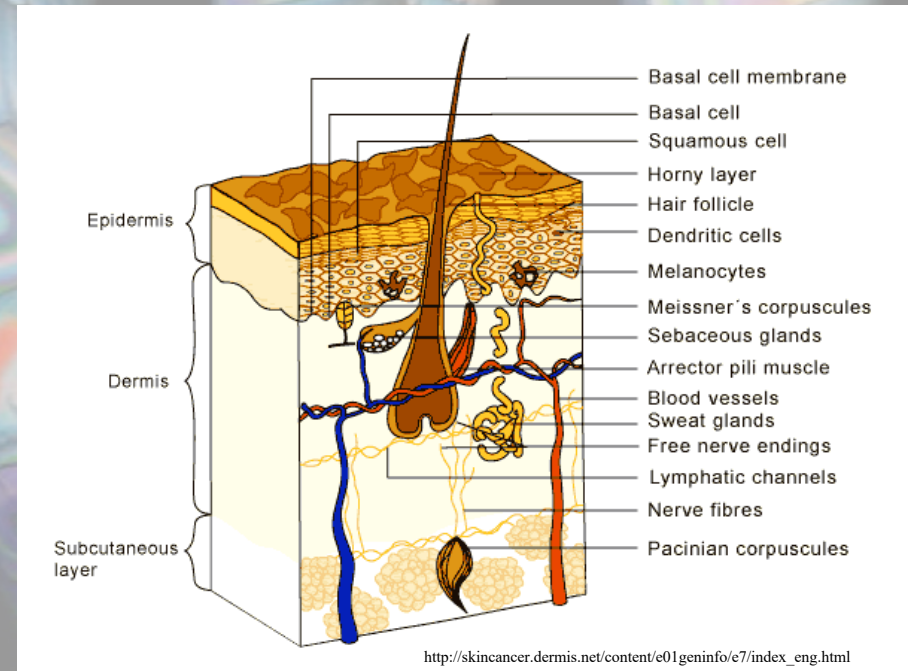
These cells produce a dark pigment called melanin which contributes to skin color and provides UV protection. They are located at the bottom of the epidermis.

- *Dendritic (Langerhans) cells*

These cells are involved in the epidermal immune system by engulfing foreign material that invades the epidermis and these migrate out of the skin to stimulate an immune response.

- *Basal cells*

Small cells found at the bottom of the epidermis.



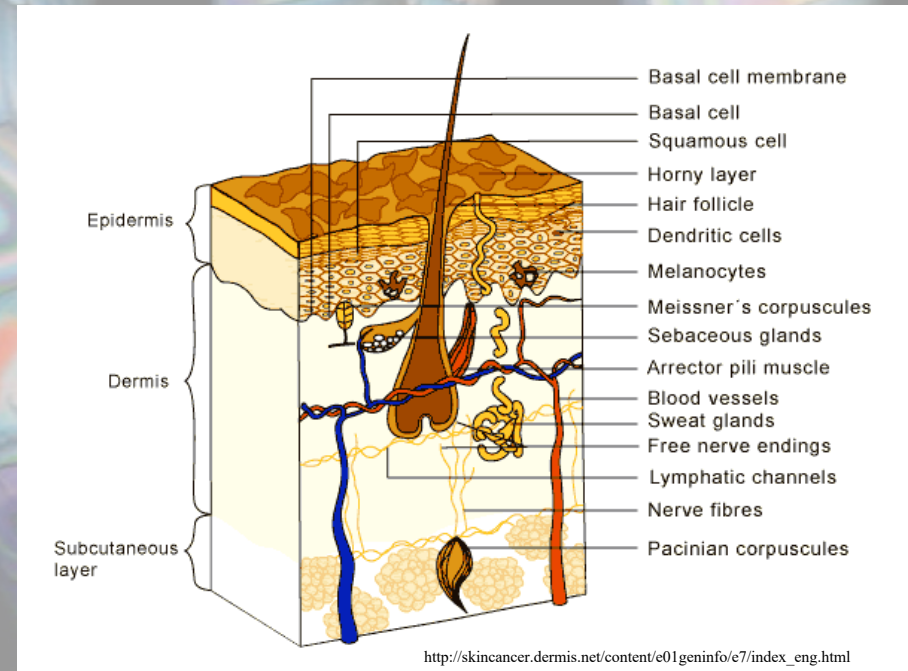
# Lasers in Dermatology

## - *Skin structure*

*Dermis* - consists mostly of connective tissue and is much thicker than the epidermis. It is responsible for the skin's pliability and mechanical resistance and is also involved in the regulation of the body temperature. The dermis supplies the avascular epidermis with nutrients by means of its vascular network. It contains sense organs for touch, pressure, pain and temperature (Meissner's corpuscles, Pacinian corpuscles, free nerve endings), as well as blood vessels, nerve fibers, sebaceous and sweat glands and hair follicles.

The *subcutaneous layer* below the dermis consists of loose connective tissue and fat. It acts as a protective cushion and helps to insulate the body by monitoring heat gain and heat loss through radiative transmission.

- The epidermal layer of skin is ~ 0.05mm – 1.5mm thick while the dermis is 0.3mm (eyelids) to 3mm (back) thick.
- Tattoos are placed in the dermal layer of skin so that they are permanent.



# Lasers in Dermatology

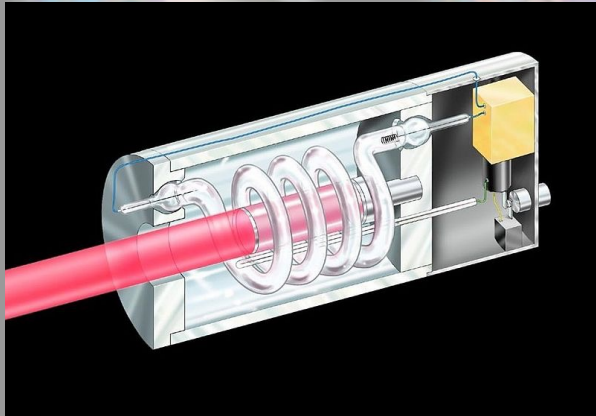
## - *Types of Lasers*

*Q-switched Ruby* – An aluminum oxide crystal ( $Al_2O_3$ ) with chromium ( $Cr^{+3}$ ) impurities replacing some of the aluminum. These laser at  $694nm$  (red) and is pulsed at about  $40ns$  with an intensity of  $10^8 W/cm^2$  with a treatment dose of about  $6 - 8 J/cm^2$ . These are used in the removal of blue, black and green pigments. Spot size is roughly  $6mm$  and repeat rate of  $10 Hz$ .

*Q-switched Nd:YAG* – A solid state device that contains a crystal rod of yttrium-aluminum-garnet ( $Y_3Al_5O_{12}$ ) doped with neodymium ( $Nd$ ) that lases at two wavelengths,  $532nm$  (green) &  $1064nm$  (IR). These are pulsed at  $10ns$ . Spot size varies from  $0.8 - 8mm$  and treatments of  $1 - 12 J/cm^2$  for red pigments and  $5 - 6 J/cm^2$  for blues/greens are common. These are used in the removal of red ( $532nm$ ) and black and blue pigments ( $1064nm$ ).

# Lasers in Dermatology

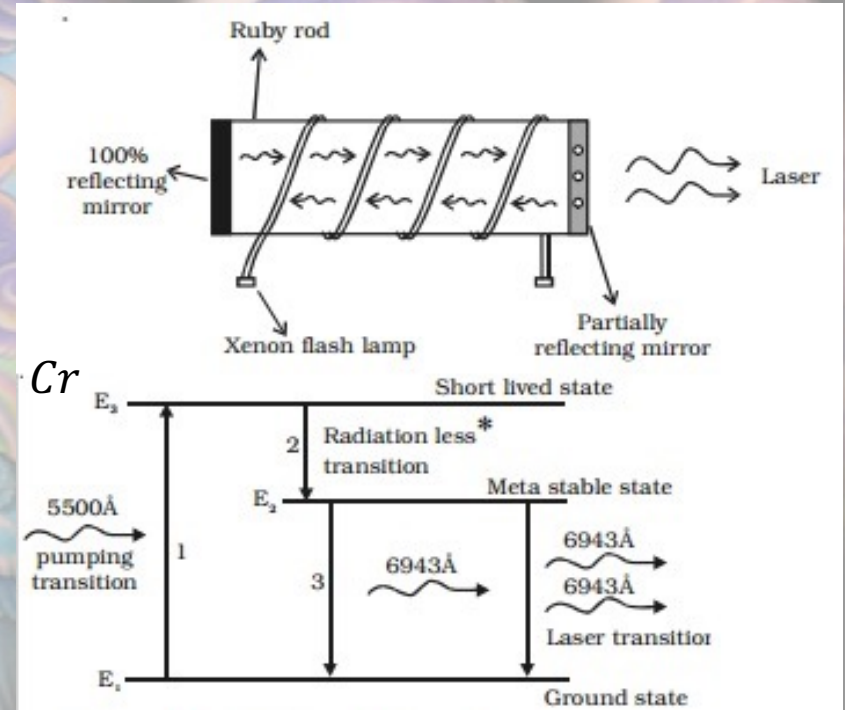
## - Types of Lasers



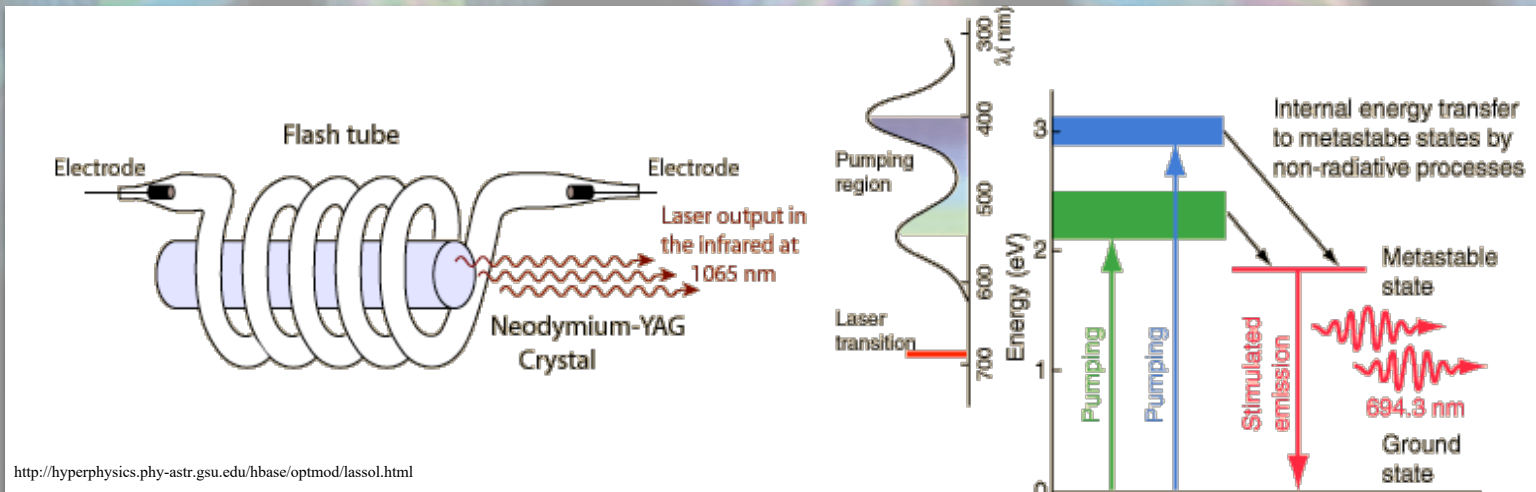
[https://chem.libretexts.org/Bookshelves/Physical\\_and\\_Theoretical\\_Chemistry\\_Textbook\\_Maps/Physical\\_Chemistry\\_\(LibreTexts\)/15%3A\\_Lasers\\_Laser\\_Spectroscopy\\_and\\_Photochemistry/15.05%3A\\_What\\_is\\_Inside\\_a\\_Laser](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Physical_Chemistry_(LibreTexts)/15%3A_Lasers_Laser_Spectroscopy_and_Photochemistry/15.05%3A_What_is_Inside_a_Laser)



<http://trade.indiamart.com/details.mp?offer=1951584455>



[https://www.brainkart.com/article/Ruby-laser---Generation-Process-and-Energy-Level\\_2939/](https://www.brainkart.com/article/Ruby-laser---Generation-Process-and-Energy-Level_2939/)



<http://hyperphysics.phy-astr.gsu.edu/hbase/optmod/lassol.html>



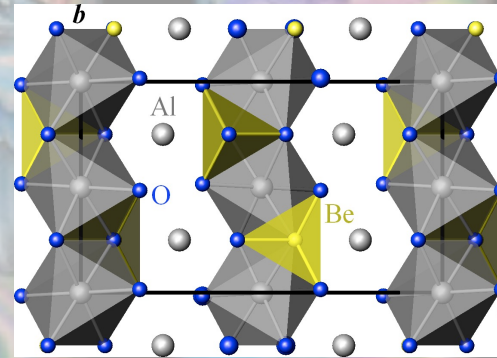
# Lasers in Dermatology

## - *Types of Lasers*

*Q-switched Alexandrite* – an orthorhombic crystal which lases at 755nm (red/IR) with a pulse duration of 75ns. It has a typical spot size of 3mm, and treatment doses are about 4 – 8 J/cm<sup>2</sup>. Useful in the removal of black, blue and green pigments.



<http://www.marinmineral.com/gemxl.html?cur=cand>



<http://kokoba42.blogspot.com/2014/06/birthstones-alexandrite-june.html>

*Q-switched* – a sophisticated electromagnetic switch placed in the laser medium to keep the medium from lasing (by blocking light) until very high population inversion occurs – produces very high energy pulses for the laser.

# Lasers in Dermatology

## - *Getting a Tattoo*



- Tattoos machines are a set of needles that make holes in the dermal layer of the skin.
- The ink flows down the needles into the holes and by capillary action gets deposited into the dermis.

# Lasers in Dermatology

## - *Tattoo Inks*

- Tattoo inks are not regulated by any authority.
- The inks can be bought from many sellers (China) and there's no guarantee as to what's in the inks.
- The primary concern in tattoo inks are the presence of heavy metals.
- Permanent tattoo inks may contain mercury, which at high levels can harm the brain, heart, kidneys, lungs, and immune system of people of all ages.



# Lasers in Dermatology

## - *Tattoo Inks*

- Red ink may contain heavy metals like cadmium or iron oxide. Cadmium intoxication can lead to kidney, bone, and pulmonary damage. The majority of cadmium is transported bound to proteins and the first organ reached after uptake into the bloodstream is the liver.
- Blue ink may contain cobalt. Cobalt poisoning that occurs from constant contact with your skin will likely cause irritation and rashes that will go away slowly. Absorbing a large amount of cobalt over longer periods of time can lead to serious health problems such as: cardiomyopathy (a problem where your heart becomes big and floppy and has problems pumping blood), nerve problems, thickening of your blood
- Other colors are derived from heavy metals (including lead, antimony, beryllium, chromium, nickel and arsenic) all of which have toxic effects in the body.
- White blood cells attack the tattoo as soon as it is placed. Over time more of the inks get removed (and filtered to the liver) from the dermis and the tattoo fades.

# Lasers in Dermatology

## - *Tattoo removal surgery*



- An artist will give you the tattoo but a physician (generally a dermatologist or plastic surgeon) has to remove the tattoo.
- A tiger tattoo before treatment on the left and after one treatment on the right.
- The image on the right most likely needs several more treatments to completely remove the tattoo.
- The treatment was most likely done with a *Nd:YAG* laser or a *Q-switched Alexandrite*.

# Lasers in Dermatology

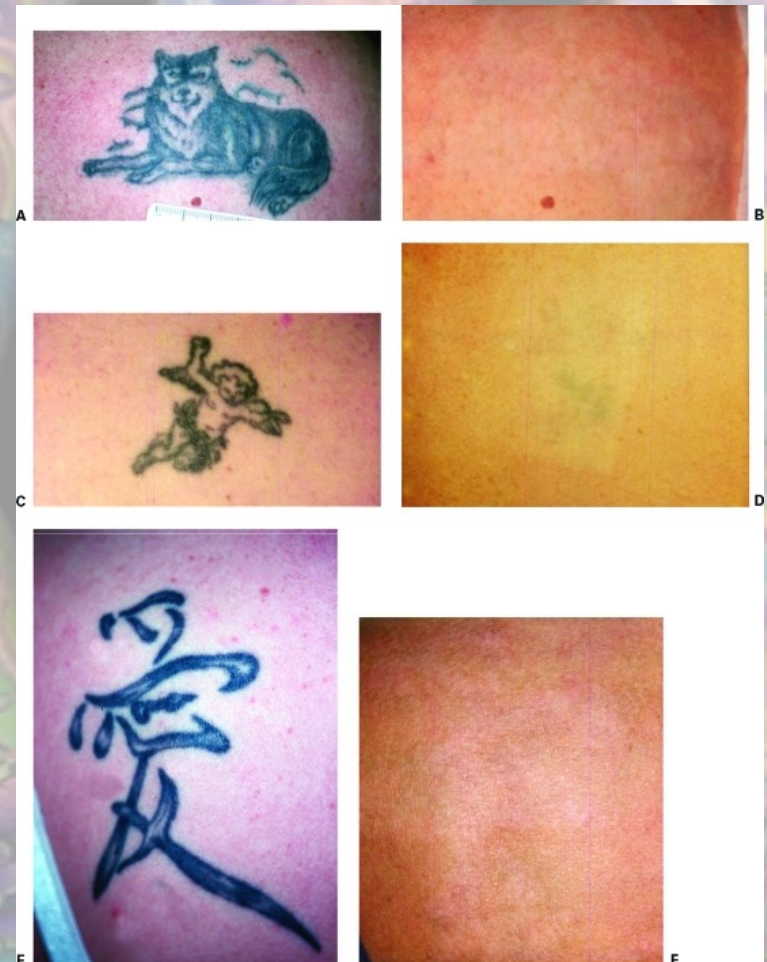
## - *Tattoo removal surgery*

Tattoo removal of black inks using a Q-switched Ruby Laser.



<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2884836/>

The Ruby laser will lase at 694nm.  
What do you notice immediately after treatment with this laser?



<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2884836/>

# Lasers in Dermatology

## - *Tattoo removal surgery*

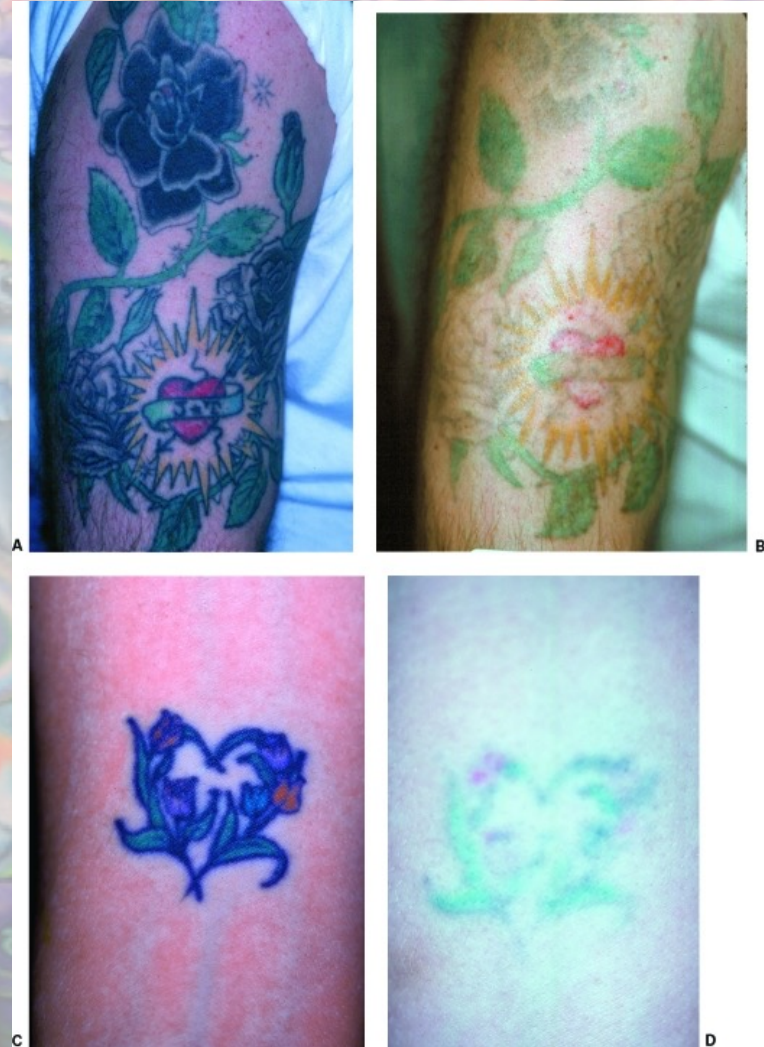
Tattoo removal with a Q-switched Nd:YAG and Alexandrite lasers.

The ND:YAG lases in two wavelengths,  $532nm$  (green) &  $1064nm$  (IR).

The Alexandrite lases at  $755nm$  .

What do you notice?

What can you conclude?



# Lasers in Dermatology

## - *Tattoo removal surgery*



Costs: \$100 – \$300 per hour to get a tattoo. This depends on the level of skill of the artist.

Depending on the size and complexity of the tattoo the cost a few hundred to several thousand dollars.

Costs: \$200 – \$500 per session to remove the tattoo. Depending on the number of sessions, which depends on the size, complexity and colors in the tattoo could cost a lot. Most insurances do not cover tattoo removal as it usually is not medically necessary.



# Lasers in Dermatology

## *Adverse Effects:*

- Painful
- Multiple treatments
- Scarring with continuous beam lasers
- *Hypopigmentation* – a lightening of the skin's pigmentation in the treatment area.

## *Benefits:*

- Minimal risk of scarring with Q-switched lasers
- Permanent or mostly permanent pigment removal
- Relatively safe

## References:

1. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1578573/>
2. <http://www.nlm.nih.gov/medlineplus/ency/article/002495.htm>
3. <http://www.scientificamerican.com/article/tattoo-ink-mercury-and-other-toxins/>