THE SCIENCE OF TATTOOS

(1) Though tattoos seem to have become recently popular, they have actually been around for thousands of years. Some of the oldest tattoos date back to over 3200 BC and were found on mummies that were preserved in the glacial ice of the Alps. Tattoos have been used by many cultures to mark rites of passage from childhood to adulthood, to signify status, to symbolize fertility and to identify someone as a part of a group or tribe. These days many people also get tattoos as a form of self-expression and body adornment.

(2) The process of tattooing involves using a tattoo machine which is fitted with a single use, multi-pointed disposable needle. The needle is dipped into a small pot of ink (similar to the way a paint brush is used) and when the machine is turned on, the needle extends and retracts (like a sewing machine) at a rate of up to 50 times/second. The sharp tips of the needle puncture the epidermis (the outermost layer of the skin) and carry the ink further down into the dermis (the layer just below the epidermis). Despite what most people think, the ink is not "injected" into the skin. Unlike medical needles, which are hollow, tattoo needle tips are solid and are merely used to create small punctures. The ink coating the outside of the tips is pushed into the wounds by the tips and the tissues of the dermis will "suck up" the ink using capillary action.

(3) Reaching the dermal layer is critical for creating a permanent tattoo. If the ink only reaches the epidermis, the tattoo will fade quickly as cells of the epidermis are easily shed. Epidermal cells shed at a rate of 30 000 to 40 000 an hour, so you lose about 1 million epidermal cells a day. In a months time, your entire epidermis will have replaced itself. The dermal layer is permanent and is the perfect area to place the ink. If the needle goes too deep, then the ink is put in the sub-cutaneous fat, under the dermal layer, which can cause the ink to migrate and make the tattoo blurry.

(4) Tattooing causes an inflammation reaction for two reasons: first, because tissue has been physically damaged by the puncture wounds and second, because the tattoo ink is treated like an invading pathogen (much like a bacteria or virus) by your immune system. The macrophages (a type of white blood cell) of your immune system flood into the inked area and try to engulf the ink particles and carry them away through the blood stream toward the liver for disposal. However, the macrophages can only engulf the smaller ink particles. The majority of the ink particles are much bigger than any one macrophage. It would be like a rabbit trying to engulf a 3 foot carrot in one bite.

(5) Ink particles that aren't disposed of by macrophages stay in the dermis causing the tattoo to become permanent. They can be suspended in the gel-like matrix of the dermal layer and they can also be permanently taken inside of dermal cells called fibroblasts. Ironically, they are also found inside of any macrophages that end up trapped in the dermal layer. However, macrophages are persistent and will try to break apart, engulf and carry away the ink as long as the ink is there. As this happens, the crispness of any new tattoo begins to get fuzzy over time and look increasingly faded as the macrophages nibble away at the ink.

(6) Tattoo laser removal technology depends on the action of the macrophages. This technique uses a laser that produces short bursts of intense light that fractures the large ink particles into smaller fragments that are easily engulfed by macrophages. Different lasers must be used for different ink colors because different colors respond to different wavelengths of light. Since black absorbs all wavelengths of light, it is the easiest ink color to remove, while other colors, like green, are

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difficult to break apart as they absorb only specific and limited frequencies of light.

(7) The removal process is expensive, takes a long time, and comes with its own side effects. Laser removal can take more than 12 laser sessions depending on the tattoo and how a person's body responds to the treatments. Each session requires a recovery phase of 4-6 weeks, for the skin to respond and heal, before the next session can begin. Thus, the total time required to remove some tattoos can take over a year. Even then there still might be a ghost image left. For people with darker skin, they also risk hypopigmentation (loss of natural skin pigment) in the area that's treated with lasers. This is because the lasers can accidentally target some of the dark natural pigments in the skin (e.g. melanin) and destroy them. Tattoos further away from the heart are also harder to remove because circulation is poorer.

(8) There is some controversy over the tattoo inks used as their safety is not tightly regulated. Many of the colored inks use toxic heavy metals to increase their stability. For example, mercury is found in red inks and lead is found in yellow, green and white inks. These heavy metals can cause issues if a person needs an MRI (magnetic resonance imaging) to locate tumors or other diseases in the body. Since MRIs use very strong magnets, sometimes heavy metals in tattoos can respond by heating up and causing burns in the tattooed area.

Article Questions

1) Why is the epidermis a bad location to place the tattoo ink?

2) Why don't macrophages get rid of all of the tattoo ink?

3) Why does a tattoo begin to lose its sharp lines as time goes by?

4) How do lasers help remove tattoos?

5) In paragraph 7, the last sentence states, "Tattoos further away from the heart are also harder to remove because circulation is poorer." Why do you think this makes tattoos harder to remove using laser removal techniques?

6) How might the heavy metals used in inks become a health concern when trying to remove tattoos using laser?