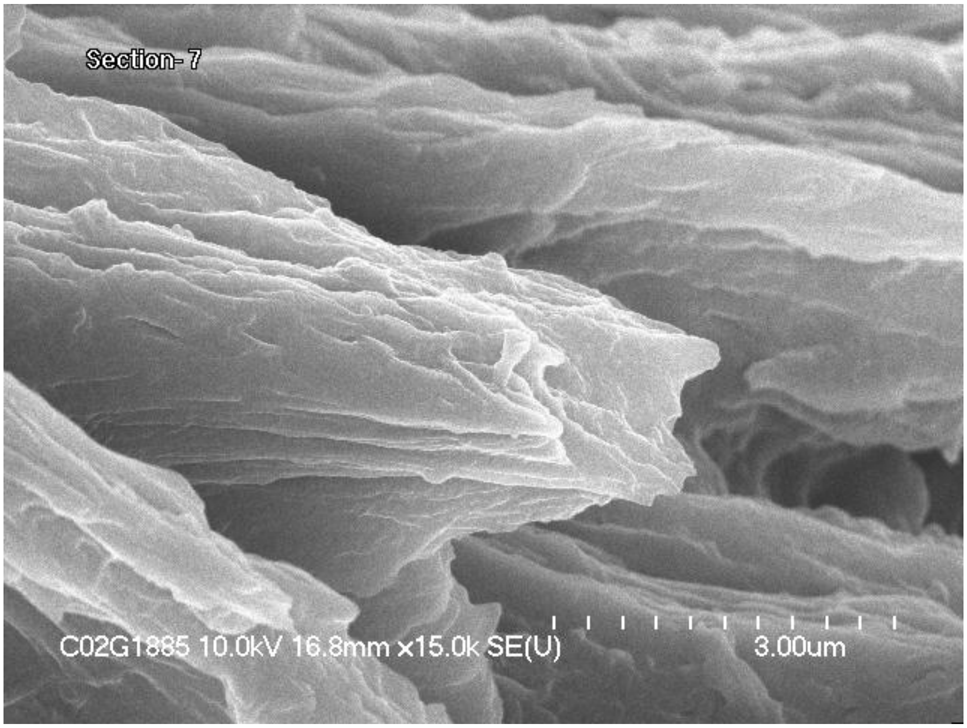
Now Entering a Nail Plate Construction Zone!

By Doug Schoon

Ever wonder what's inside the nail plate and what makes it so amazingly strong and durable? Well, put on your hard hat, because we're going into the natural nail to learn about its many hidden secrets. You may recall that the nail plate is made up millions of tiny cells (see Figure 1) and each nail cell contains specialized proteins called *keratin*. There are basically two types of keratin: "*crystalline*" and "*non-crystalline.*" Substances that are crystalline have orderly chemical structures that are almost perfectly arranged, i.e. quartz, diamond, sapphire and topaz. Non-crystalline substances have a less organized structure and have very different properties. For example, the crystalline gemstones have "transparency", as do many other types of crystalline substances, including *crystalline keratins*. The *non-crystalline keratins* are less transparent and contribute to the cloudy appearance of the nail plate. But what great tricks do these two types of keratins perform to carry out such impressing feats of amazing strength and durability?



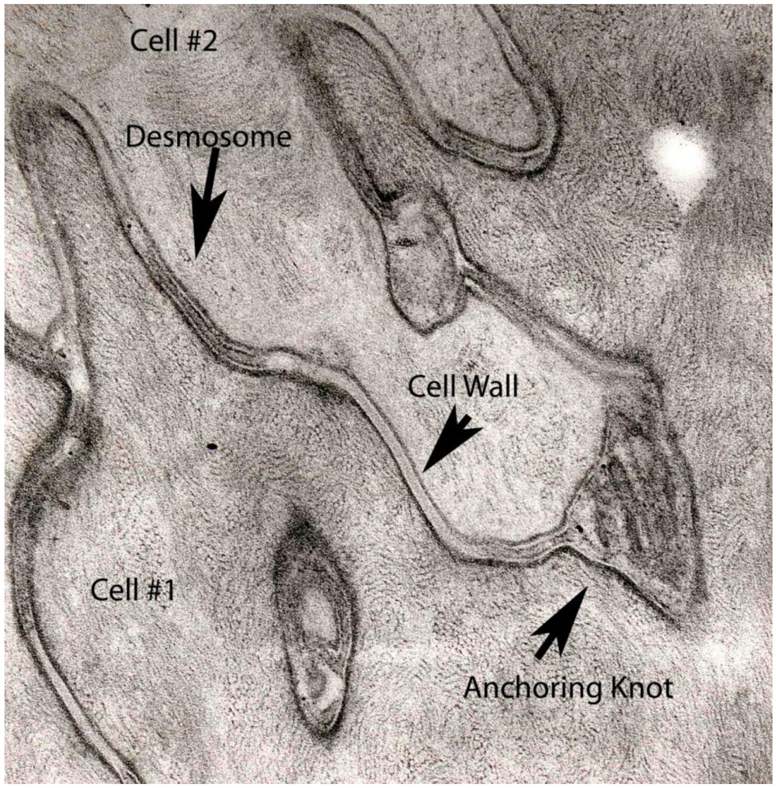
A single nail cell sandwiched between other cells, magnified by 10,000 times. Many millions of nail cells combine to create a nail plate.

Figure 1

Image courtesy "Nail Structure and Product Chemistry, 2nd Ed., Doug Schoon

Scientists have uncovered many of the natural nail's secrets and have learned that crystalline keratin forms microscopic-sized fibers and this happens inside every one of the millions of nail cells that make up the nail plate. These tiny crystalline fibers are spiraled like springs or corkscrews, allowing them to pack tightly together, side-by-side, into compact bundles. These bundles are two-thousand times narrower than a human hair, so they can only be seen under very powerful microscopes. Each tiny bundle is enmeshed in a "sea" of gel-like substance made from non-crystalline keratin. The gel-like keratin helps to suspend, support and protect each crystalline bundle. This sea of keratin gel has a secondary purpose: it helps regulate the flow of water and oils as they pass through the nail plate.

There's a whole lot going on inside the nail cell, but what holds all the nail cells together to make a nail plate? Each nail cell is connected to its neighboring cells by an inter-locking connection as part of a gigantic network of nail cells that fit together much like a miniature jig-saw puzzle. Each nail cell is attached to its neighboring cell by a connecting doorway called a *desmosome* (see figure 2). Each nail cell has several desmosomes connecting it to several different nail cells. Each desmosome not only links the cells together, it is also an open door into the adjacent cell. This means the nail plate is one continuous, interconnected mass of keratin fibers packed into millions of adjoining compartments. Figure 2 shows the walls between two cells (thick lines) are not straight and smooth, but instead, interlock and form contorted anchoring knots to help hold nail cells together like a jig-saw puzzle. Each of these nail cells are also embedded in a blend of natural body oils which fill the narrow spaces between each cell.



A desmosome and an anchoring knot joining two nail cells together, magnified by 13,000 times.

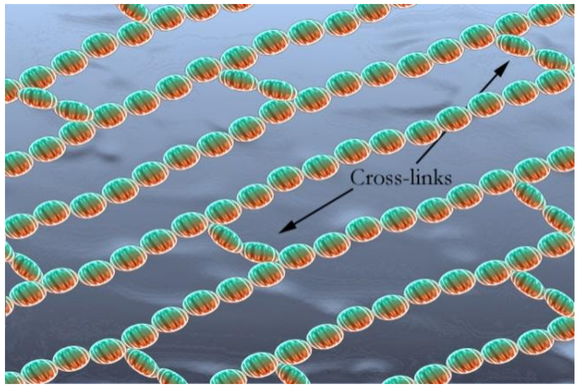
Figure 2

Image courtesy "Nail Structure and Product Chemistry, D. Schoon, 2nd Ed.

Not that we've examined the nail cell, inside and out, and found that it's mostly made of crystalline and non-crystalline keratin, let's go one more step deeper into the nail and see what is holding the keratin together!

Keratin is made of proteins and all proteins are made from amino acids bonded together into strong chains. Protein chains usually contain between 5,000-100,000 amino acids, much like pearls on a necklace. When equal thickness is compared, keratin proteins are actually stronger than steel! Amino acids are held together in chains by *covalent bonds* - the strongest type of chemical bonding in the world. In fact, without them, there would be no life on Earth; they're that important!

Covalent bonds occur in many materials, not just keratin, i.e. muscle, hair, skin, lungs and every other part of the body, which is why they are so important to all living things. It is safe to say that without covalent bonds, humans, plants and animals would not exist. Covalent bonds not only hold each of us together, they account for things we see in everyday life, such as the fantastic strength of spider webs or the extreme hardness of diamonds. Keratin is further strengthened by *sulfur cross-links,* which are covalent bonds created between two separate protein chains (see Figure 3). These cross-links join the chains together like rungs on a ladder. Cross-links can turn individual protein chains in the nail plate into an ultra-tough, net-like structure. Cross-links also make the surface of the nail plate highly resistant to stains and the damaging effect of solvents, cleaners, etc. The high level of cross-linking in nail and hair keratin is a primary source of their strength and durability. Nail plates contain many more cross-links than hair, which explains why they are so much tougher.



Artist rendition of cross-links joining protein chains together to create a tough, net-like structure. The oval beads represent amino acids that are linked together by covalent bonds to create long polymer chains.

Figure 3

Image courtesy "Nail Structure and Product Chemistry, D. Schoon, 2nd Ed.

You may recall that polymers are defined as long chains of individual molecules called monomers. These monomers are linked together by covalent bonds. Therefore, the covalent bonds that hold amino acids together also create long polymer chains. We normally don't think of keratin as a "polymer", but of course it is. Keratin is a polymer made from the amino acids that serve as monomers.

It is clear that our nail plates are an engineering masterpiece and we should marvel at their amazing ability to resist breaking and cracking. Considering what we put them though each day, it's a wonder they can grow any length at all. Next time you bang your nail really hard and the plate doesn't break, you'll know that the billions of amino acids are cooperating in unison, both crystalline and non-crystalline keratins. These are but a few of the natural nail's best kept secrets of success. You can learn more about the wonders of the natural nail from my DVD, Doug Schoon's Brain in 3D. To learn more about this DVD and find lots of free articles, pictures and more about the natural nail on my website DougSchoon.com.

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