Nature's Legos

By Sam Shames

When I was a kid I loved to play with Legos. My friends and I used to sit around for hours making everything from cites to airplanes to dragons. Even though we were working with a limited set of pieces, we felt the possibilities were endless. We found that by combining bricks of different length and shape, we could create almost anything we could imagine, even though we only started with about 30 or 40 different types of pieces. In that sense, our Lego creations were a lot the range of biomaterials that have been created through millions of years of evolution.

Just like my friend and I, biology creates materials from a very limited toolkit, 20 different Amino Acids, small molecules which can be linked together into larger chains. But by combining these 20 different pieces into specially sequenced long chains, Mother Nature has been able to create some of the most amazing materials the world has ever seen. This is like the equivalent of being able to produce any food on earth—frittata, filet mignon, or fudge—all using different combinations of five basic ingredients.

When a sequence of amino acids is strung together into a long chain, the result macromolecule is called a protein. Proteins are by far the most interesting of all biomaterials because they are the materials that biology uses to get stuff done. One example is a protein called hemoglobin. Hemoglobin is responsible for carrying oxygen through your blood and is made up of 574 amino acids linked together into four chains. Another essential protein is collagen, which serves as connective tissue and holds muscle together. Like hemoglobin, collagen is made from the very same 20 amino acids, but arranged it a difference sequence, resulting a completely different material.

In addition to using proteins to create materials for use inside of organisms, many animals also create materials that help them to survive in their environment. The abalone shell made by the Abalone, a small snail, is made up of 99% calcium carbonate, the same material as blackboard chalk. However, the abalone shell is also made using protein, and the one percent protein that the organism uses results in a material that is 3000 times harder than its geological counterpart[1]. Another incredible biomaterial is spider silk. Stronger than steel, spider silk is a fiber made from a combination of two different chains of amino acids—two different proteins.

Looking at biology through the lens of its materials renews by sense of awe at Mother Nature. Thinking about all the different types of materials—from the enzymes that digest the food I eat and make replicate my DNA to the antibodies that keep me safe— that evolution has created from 20 simple building blocks gives me the same sense of amazement I used to get a kid when I take a piece of Lego rocket ship and turn it into a football stadium. Back then I use to think I was pretty resourceful designer for constantly recreating new things out of the same pieces. Today though, I recognize that Mother Nature is top dog.

[1] 2012 Organic and Biomaterials Chemistry, MIT