Patrick Rice, born in Sydney, Australia, is a junior majoring in Neuroscience. He enjoys sci-fi, chilling on summer nights, and the occasional act of defiance. Things that amuse him include casual rhyming and random events that occur with precise timing. Aspiring to acquire knowledge after he completes college, he plans to one day research neurological features ranging from long-term potentiation to seizures. He plays rugby, finds good books lovely, and you can usually find him goofing off with his buddies.

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A Brief Explanation of Bonding Patterns in Carbon

The sixth element, carbon, is the basis for life as we know it. Carbon's extraordinary ability to form up to four bonds with as many different partners allows it to create a staggering amount of molecules with the help of a relatively small amount of elements, namely hydrogen, oxygen, nitrogen, and phosphorus. If those five sound familiar together, it's because they are the atoms necessary to build DNA, the major components of which are carbon-based sugars. DNA codes for proteins, which are made up of a series of amino acids — also carbon structures. Proteins are the tools of the cell, allowing it to perform many actions, chief among them being the manipulation of carbon sugars to provide the energy necessary for the action of life.

In most carbon-based molecules, there are two ways the bonded elements can be arranged around a central carbon atom, known as sp2 and sp3. In sp2 (also known as "trigonal planar"), the central carbon is bonded to three elements, which are arranged around the carbon in a single plane. Because atoms repel one another, the three constituents spread into an approximately equilateral triangle, forming 120° angles with respect to the central carbon. A well-known example of carbon in this form is graphite, commonly known as the lead in pencils. Graphite is comprised of millions of sp2 carbon atoms bonded together in a single-plane sheet, forming a hexagonal pattern. The bonds between these carbons are very strong, and it is tough to tear a single sheet (a single sheet of these carbons is known as graphene). However, in graphite, these sheets stack on top of each other, barely connected to each other through interactions collectively known as the Van der Waals force. When graphite is rubbed against something, these weakly interacting sheets slide off each other, and stick to the surface onto which they are being rubbed.

In sp3-bonded carbons, the central carbon is now bonded to four separate atoms or molecules, also known as a "tetrahedral" configuration. Once again, the constituents bonded to carbon want to be as far apart from each other as possible, but with four members this cannot be accomplished in a single plane, unlike in the trigonal planar arrangement. To solve this, the bonding partners utilize 3D space, forming a three-sided pyramid around the central carbon. This results in bond angles of approximately 109.5°. A great example of carbon bonding in this manner is the common diamond. A pure diamond is actually comprised of only carbon atoms, all bonded together in the tetrahedral configuration. This pattern lends the strength of a single sheet of graphene to 3D space, which is the source of the "hardness" of diamonds, otherwise known as it's resistance to scratching. It is a common misconception that diamond is the "strongest" natural material known to man. Because of the tetrahedral structure, diamond has cleavage planes where it is relatively easy to split, compared to iron or steel.

Recently, carbon structures have become the focus of much research, due to the development of carbon nanotubes (CTNs). At its most basic level, a carbon nanotube is a sheet of graphene "rolled" together so the edges meet and bond, forming a tube. Researchers are interested in nanotubes due to the remarkable variety of properties they display. CTNs are the strongest and stiffest materials in terms of tensile strength and elasticity, respectively. CTNs also have promising electrical properties, as they can act as either metals or semiconductors, and conduct heat very well. In fact, it is a combination of these last two properties that is being applied to produce fabrics that can generate electricity from heat, including that which is generated by your own body (from its processing of carbon-based sugars). It was recently demonstrated that a multilayed thermoelectric fabric containing CTN layers with an area of approximately 10 cm2 could produce enough energy to power a wristwatch (Hewitt et al.). When the fabric is subject to a large temperature difference, charge carriers within the CTNs (usually electrons) diffuse towards the cold end, where they are less dense. This property, called the Seebeck effect, creates a movement of charge, resulting in a current and readable voltage. Further applications of this kind of material include applying it to the lining of winterjackets to power handheld devices, recapturing some of a vehicle's wasted heat energy, or using it in roofing materials in order to mitigate a building's energy costs.

The structural potential of carbon has yet to be fully realized due to the vast possibility of bonding patterns, just as the potential in the incredible complexity of life may never be fully realized. The beauty of carbon lies in its ability to construct so many different tools out of so few building blocks. Two molecules may be identical in terms of their atomic constituents, but may be completely unique on a physical level.

This same intricate beauty, arising from common roots, is found in everyday life — from humanities' wild variety of cultures, belief systems, and personalities to something as simple as one's desire to be more connected to another. It is this elegance that motivates Donna McDermott's piece "Carbon Chains."