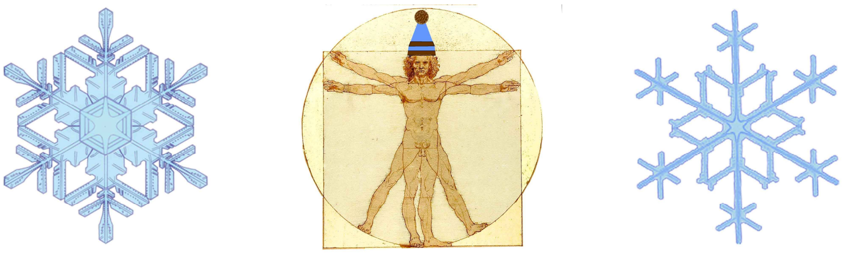
Seeing ourselves in a flake of snow

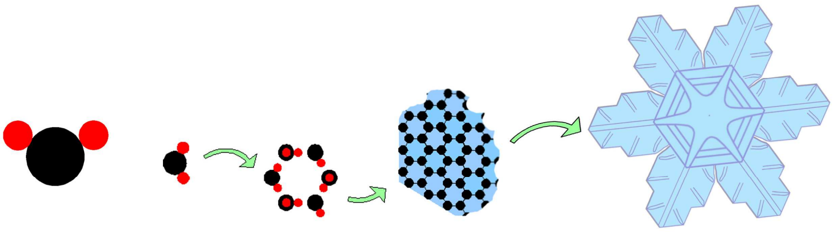
The silently falling snow crystal can vanish in one's breath, yet can build up into glaciers that carve mountains. Individually weak yet collectively strong; people are like that too. And if we look deeper into the little flake's tumble from the clouds, we may see even more parallels to ourselves.



Consider its birth. A snow-crystal's origin lies with some fleck of mineral or organic matter kicked up from the ground. Though most never get far, the occasional bit of dust floats high enough to be caught in a series of updrafts. Upward it floats, cooling all the while, until dew nucleates on its surface. The dust, like the irritant in an oyster that starts the pearl, becomes a miniscule speck, engulfed in a tiny yet growing ball of water – a droplet. This droplet may be as near to a perfect sphere as we are likely to find anywhere. But spherical perfection doesn't last.

When the droplet cools below freezing, it enters a supercooled state in which it may crystallize into ice. But it cannot freeze right away. Think of the supercooled droplet as an unfertilized egg, needing a tiny ice 'seed' to transform into ice. These seeds, properly called 'ice nuclei', do more than just catalyze ice; acting a little like sperm, they also can influence the crystal's development. Most drops never acquire such a seed, but the lucky one that does will freeze after being supercooled below 32 °F to a temperature determined by the seed. The result is the start of a snow crystal – a featureless bit of ice, still shaped like a pearl, but with the power to bloom into a uniquely elaborate design. Sometimes, the seed gives rise to a polycrystal, meaning that the ice consists of several crystals stuck together. When the crystalline lattices of the joined crystals have a particularly close relationship, crystallographers appropriately call them twins. Regardless, at the moment of birth, each crystal, like a newborn baby, can't do much except grow.

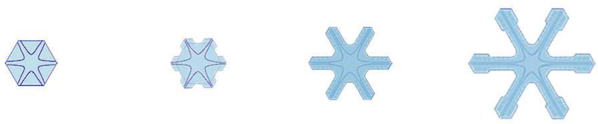
The secrets for a snow crystal's growth lie in the water molecule. Though it is only an oxygen atom with two hydrogens sticking out like Mickey Mouse ears, the water molecule nevertheless acts like the genetic code for snow. And like a genetic code, the H_2O does not determine how each crystal ends up; rather, serving more like a code of conduct, the water molecule controls how the crystal reacts to each new environment. The rest is up to the whims of the ever-changing air currents – the changing air temperature and humidity that pass by our falling crystal. And when the crystal is large enough to descend through the uprising air, it passes near, and sometimes collides with, droplets and other crystals that are still going up. Such close encounters with other cloud inhabitants also affect the crystal. Each crystal tumbles through a different sequence of such environments, gaining distinct features along the way, just as we stumble through life, learning and adjusting at each new turn.



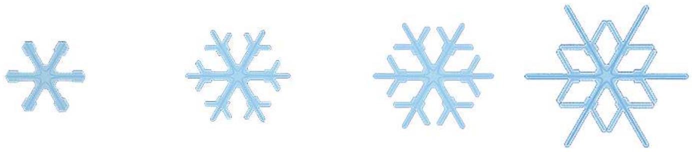
Ever since the 1930s, when the Japanese physicist Ukichiro Nakaya first grew a snow crystal in his laboratory, scientists have mainly studied how snow crystals grow under nearly constant conditions. For example, Nakaya showed that a crystal's primary 'habit', which can be either tabular or columnar, usually depends only on the air temperature. Though we still have much to learn along that line, I recently started to wonder about the ever-adjusting crystal tumbling from one cloudy environment to another. How much diversity does that give to a crystal, and can we quantify it? As far as I can tell, the answers to such questions have no practical value whatsoever, and for this reason, they have received almost no attention from scientists. To me though, science at its root is only about how nature works, and I wondered how this diversity thing worked.

In trying to grasp snow crystal diversity, I was lucky in that other researchers had only just measured how cloud temperature and humidity changes across a fraction of an inch –about as large as the largest crystal. Armed with their results and some recent laboratory data, I could track an imaginary falling crystal and estimate how often it would grow some new distinguishing feature. Typically, this would happen less than a thousand times during a crystal's journey. With a few other considerations, this leads us to the "snow variety number", the number of possible distinguishable snow crystals in a typical storm cloud. To get an idea of its approximate size, imagine writing the number on a sheet of paper by writing a "1" and then adding a "0" each second. After 6 seconds you would have 1,000,000 or a million. After 30 you'd have a number about equal to the total number of snow crystals that have *ever* fallen on Earth, and at about a minute, you'd have the number of atoms in the known universe. But you would have to keep writing zeros for another seven and a half minutes before you got the snow variety number. On paper, it would fill most of this paragraph. Clearly, with a number that big, no photographer need worry about running out of new crystal designs to reveal to us.

But the more interesting findings were qualitative. Most of the crystal diversity comes from the fall through the cloud, and not from any variations in the ice seed and droplet that gave birth to the crystal. In other words, the 'nurture' of a snow crystal by the cloud contributes more to a crystal's appearance than the 'nature' it was born with. Moreover, cloud regions where crystals are most sensitive to the temperature produce not only the most diversity, but also the largest crystals. Being sensitive is not such a bad thing for a snow crystal - it's a lesson we might apply to ourselves.



We find it hard to break old habits, and the snow crystal is no different. In the Magono-Lee habit classification used by cloud physicists, a given crystal falls into one of 80 habits. But most of these are variations on the two primary habits, the tabular and the columnar. One or the other of these habits is impressed upon the crystal early in its life-journey, the same primary habit as other crystals born in the same region of the cloud. But regardless of where the crystal goes and what it encounters along its way, the crystal likely won't change its primary habit. And all the crystals that started together, though they may end up taking very different journeys and may differ greatly in other ways, will share the same primary habit. They are a little like us in that regard.

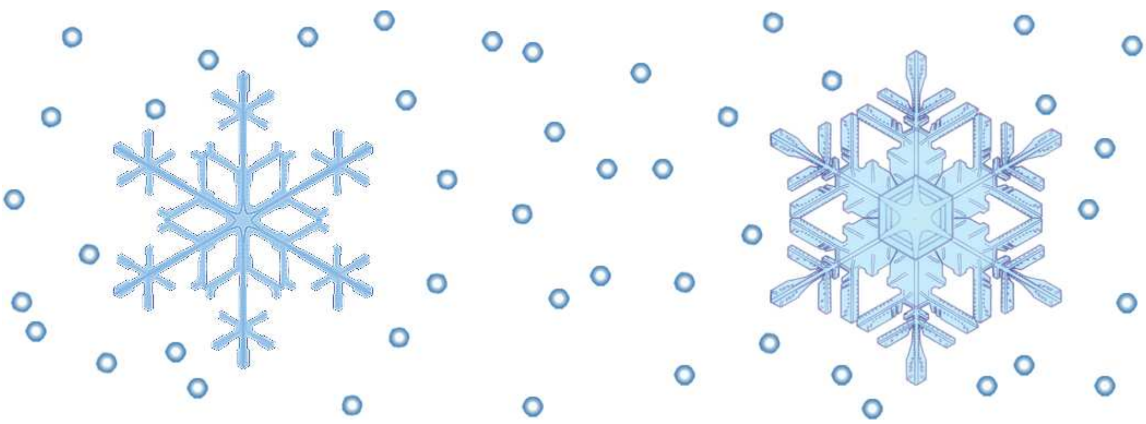


Though one often gets the impression from the literature that the six-branched snow crystal has perfect symmetry, flaws in the symmetry are common. This was noted long ago by Robert Hooke, a contemporary of Sir Isaac Newton. Hooke greatly enjoyed viewing the "curiously figur'd snow" as they appeared to him on a black cloth. At first he imagined that all six branches of a given crystal were exactly alike. But as the microscope opened up new vistas at smaller scales, he changed his mind:

> *Observing some of these figur'd flakes with a Microscope, I found them not to appear so curious and exactly figur'd as one would have imagin'd, but like Artificial Figures, the bigger they were magnify'd, the more irregularites appear'd in them...*

Although some irregularities may arise from crystalline defects in the freshly frozen droplet, most flaws probably arise during growth when the crystal approaches or collides with other inhabitants of the cloud. The crystal gets its flaws as it gets its diversity, and the crystalline defects matter little to snow. Many other materials require defects for growth to occur, but snow is an unusual crystal. Under most cloud environments, a snow crystal readily grows the same with or without crystalline defects. Indeed, some scientists think that this capacity to grow so readily allows snow crystals to become diverse, highly intricate, yet nearly symmetrical. This makes me think. Would any of us have ever wondered about the diversity of snow, and would we have ever noticed its flaws, if some crystals were not so nearly perfect in the first place? I doubt it. For this reason, we should appreciate the flaws. And it probably wouldn't hurt if we viewed people the same way.

The way a snowfall transforms city and country is magical. The outdoors, once grey and dreary, becomes white and fresh, while the indoors, once confining and cold, becomes cozy and warm. But snow does much more than transform winter. In all seasons, while we busily go about our daily routines, snow and its icy cloud kin are always busy working their magic in other ways: melting into raindrops, electrifying a thunderstorm to create a fiery light show, and quietly moderating our climate. It’s a lot of work for a delicate crystal. And for a cold, lifeless little flake, a snow crystal takes a journey with surprising parallels to our own. But what about the journey’s end? Perhaps Wilson Bentley, the Vermont farmer who first photomicrographed snow, said it best when he wrote that the snow crystals teach us that all earthly beauty is transient and must soon fade away. But though the beauty of the snow is evanescent, it fades but to come again.



- Jon Nelson