IUPAC Large or Small? Some Fractal Character?

by Richard Hartshorn

Some of you will have come across delightful pictures of those weird beasts called fractals, whether they be mathematically generated, or those that abound in nature (such as ferns). If you haven't, then I think you should spend a little time hunting some down on the web. Apart from the almost magical self-similarity at different scales (which means that even if you zoom in you get a picture that looks very similar to that you started with), the other notable feature of fractals is that they have non-integer dimensions. A piece of paper is two-dimensional when laid out flat; a ball is a three-dimensional. A crumpled up piece of paper, an object with some two-dimensional character due to its origin (and the fact that it is still really only a surface) and some three-dimensional character (as it does fill space in some way), is somewhere in the middle. A coastline is more than one-dimensional but less than two dimensional—it too is a fractal. One of the interesting features of fractals, like a coastline, is that the length that you measure depends on the size of ruler you use.

So what does this have to do with IUPAC? As I was contemplating possible topics for this column, I was considering the question of whether IUPAC might be considered a large organisation or a small one. I am not sure whether I have an answer, but I certainly think that it matters which size of ruler you choose to use!

For example: with only five paid employees, the Secretariat staff, it would be hard to argue that IUPAC was large. On the other hand, IUPAC currently has around 2000 scientists actively involved in its Divisions, Committees, Commissions, and Project Task Groups. Suddenly we don't seem so small, and this contrast also serves to illustrate a challenge for the Secretariat. The 400:1 ratio seems pretty overwhelming to me, and underlines just how well our staff do. Of course there are many more than 2000 scientists who have been involved with us at some stage, and they come from all over the world.

We currently have 55 countries represented by our member National Adhering Organisations (53 full members and 2 provisional members), and two more Associate National Adhering Organisations. Perhaps this does not seem so large when compared with the United Nations membership of 193 states or that of the Organisation for the Prohibition of Chemical Weapons (192 states), but many of those other countries cannot join IUPAC because they do not have the chemical society or academy of science which, by statute, must be our member body. That does not stop scientists volunteering to contribute to our work though, which means that there are actually over 90 nations represented in our member directory. So are we large or small geographically? I am not sure.

Financially, our annual income can be as high as USD 1.5 million if our investment returns are good, but on the organisational large vs small scale, I think that would rate on the small side. Of course such measures again completely ignore the value of the "in kind" contribution from our volunteers, and this also explains why a large fraction of our expenses relate to bringing these volunteers together (travel and accommodation). Once again, it is not clear whether we should be considered large or small.

Finally, as we consider the question "IUPAC: large or small?," perhaps we should think about impact. IUPAC was established because of the need for standardisation in Chemistry, and through our first century we have made a huge difference to the academic and industrial worlds by providing nomenclature, critical evaluation of data and parameters, setting standards for methods and techniques, and many other tools for the modern chemist. As curators of the Periodic Table and the data presented in it, we provide something that even non-scientists know and can recognise, and a foundation for a great deal of science. I think that based on impact we are clearly a large organisation, and certainly large within our discipline. Perhaps our

Table of Contents (cont.)

challenge is to ensure that our successors can say the same at the end of our second century.

In terms of impact, 2019 represents a huge opportunity for us to enhance our impact (or perhaps awareness of our impact) within and outside our discipline. 2019 is the IUPAC centenary year, and perhaps more significantly, the International Year of the Periodic Table. This represents a huge chance to promote what we do and to bring people and their organisations into the IUPAC fold.

We welcome companies though our Company Associates program, volunteers through our project system, and individual members through our Affiliate Membership Program. We welcome opportunities to recruit keen scientists and new member countries from all over the world. Doing so will add financial and intellectual vitality to our organisation—new members always will!

Richard Hartshorn <richard.hartshorn@canterbury.ac.nz> has been involved in IUPAC since the late 1990s, initially with the Inorganic Chemistry Division and then with the Chemical Nomenclature and Structure Representation Division (as President in 2010-13). He serves as Secretary General since January 2016.

Stamps International

See also www.iupac.org/publications/ci/indexes/stamps.html

Nitrogen Fixation before Haber

Much has been written about the German chemist Fritz Haber (1868-1934), who embodies at once the best and the worst that chemistry has offered to humankind. He received the Nobel Prize in Chemistry a century ago (1918) "for the synthesis of ammonia from its elements," an industrial process that led to the pervasive use of nitrogen-based fertilizers in agriculture and enabled the unprecedented population growth experienced in the world ever since. On the other hand, Haber is often considered the "father of chemical warfare" for his role in the development and deployment of chlorine and other poisonous gases during World War I. This note, however, is not about Haber's legacy but pays tribute instead to two resourceful Norwegians who preceded him in the quest for converting atmospheric nitrogen into more reactive, bioavailable forms of the element.

In 1903, Kristian Birkeland (1867-1917), a professor of physics at the University of Christiania (Oslo), and Samuel Eyde (1866-1940), an engineer and industrialist, jointly developed an electric arc process for the commercial production of nitrogen oxides and nitric acid starting from air. The pair of stamps shown here was issued in Norway on 29 October 1966, the exact date marking the latter's birth centennial, to commemorate their early contributions to what is now commonly referred to as nitrogen fixation.

The chemistry involved in the Birkeland-Eyde process wasn't entirely new: Henry Cavendish, William Crookes, Lord Rayleigh, and others had already investigated the effect of electric discharges on mixtures of nitrogen and oxygen. Although the Birkeland-Eyde process was very inefficient in terms of energy consumption, it was commercially viable for a few years only because of the inexpensive (hydro)electricity available in Norway at the time. Within a couple of decades, the Haber-Bosch synthesis of ammonia, and the Ostwald process for its conversion to nitric acid, became the dominant industrial processes for the large-scale production of nitrogen-based fertilizers and explosives.

Interestingly, Birkeland was unsuccessfully nominated four times for the Nobel Prize in Chemistry (three of them together with Eyde), and thrice for the Nobel Prize in Physics. However, he is also recognized today for his important contributions to our current understanding of geomagnetism, solar wind, and the nature of polar auroras. As for Eyde, he had a successful career in business and politics: Norsk Hydro, the company he co-founded with Birkeland in 1905, is today one of the world's largest manufacturers of aluminum, and he was a member of the Norwegian Parliament (1918-1920) and served as Ambassador to Poland from 1920 to 1923.

Written by Daniel Rabinovich <drabinov@uncc.edu>.