THE DA VINCI PROFILE – BREADTH AND DEPTH

Susan L. S. Stipp

Leonardo da Vinci was *the* Renaissance man. He is known as an artist, a musician, a scientist, an engineer and an inventor. His sketches and writings demonstrate that he was able to draw on a vast and profound understanding of nature. His knowledge base was both broad and deep.

As the Renaissance gave way to the Age of Enlightenment, centres of learning that had been associated with the church became universities. Learning divided into branches, such as natural science, philosophy, medicine, theology and law, and became entrenched. In the last two centuries, branches became further divided and study across even related disciplines, such as engineering, physics, chemistry, geology, biology and medicine, became much less common. Nowadays, our universities are so portioned out that a student in a typical geology department might rarely interact with a chemist or an engineer, and a researcher in biology might struggle to find a colleague who could explain the Miller indices used to describe a biomineral. Some geology departments subdivide even further, with "hard," "soft" and "wet" groups not speaking to each other, squabbling over the next recruitment, square metres of space and students.

Today's scientist is the product of more than a century of specialisation. The situation is like the fingers on a hand. The hand was science in da Vinci's time. The thumb became biology; the fingers became geology, chemistry, physics and engineering. Students have learned their discipline and researchers have pushed the limits of knowledge, so the fingers have become longer and longer, but not wider. The fingers on a hand diverge, just as the sciences have diverged from each other, leaving a lot of space between the fingers.

In most universities today, departments are homogeneous. Perhaps it is "like likes like"; people feel more comfortable with others who share their interests. Perhaps it is distrust of the unknown, or some myth that only a person educated in a topic is able to learn it and teach it at an undergraduate level. Whatever the cause, the aversion to heterogeneity is strong. I have attended faculty board meetings and sat on selection committees and even on PhD examining boards, and have heard a seemingly perfect candidate declared by colleagues as not good enough because s/he was "too much of a physicist" and "not really a chemist" and "did not have a bachelor's degree in geology." One could have looked upon the candidate's interdisciplinary background as a huge plus for the scientific breadth of the team or for the new doctorate's chances in the job market, but that was not the general sentiment.

The sad part is that, in general, the attitude toward hiring staff in academia and industry, and for designing study programs, makes the disciplinary fingers grow even longer. But the interesting part is that society's big challenges in today's world can only be solved by an interdisciplinary approach: climate change and ocean acidification, dwindling resources, mounting waste-disposal problems, ensuring safe drinking water and minimising the risk of disease for exploding populations, and developing sustainable energy. These problems demand a concerted effort by physicists, chemists, biologists, geologists and engineers, as well as by our long-diverged cousins in medicine, the social sciences, economics, policy, sociology and so on. To solve them successfully, people must understand at least a little of each other's field, or communication will be impossible. People will not even be able to understand what each other knows, let alone define the questions and find the answers.

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Instead of growing longer fingers, we must fill the gaps between them. The important breakthroughs in science and in innovation (defined as invention, designing practical applications with technical solutions to problems) are going to come from researchers who have a solid background in two or more disciplines.

Our theme for this *Elements* issue clearly demonstrates the richness offered by interdisciplinary study. Each article in the following pages relies on at least two natural science disciplines. Many of the previous and planned *Elements* themes also cross disciplinary boundaries, showing that timely and exciting research is very rarely monodisciplinary. Exciting science challenges known limits of knowledge, often in the space between the fingers.

So, should our department staff in academia, government and industry not reflect such diversity? And should our educational programmes not encourage study outside the field of specialisation? In some countries, universities and even secondary education cover only one or two subjects. Graduates are very young, deeply specialised and often immature. In other countries, tertiary education is at liberal arts colleges, where course topics range over a whole spectrum but where substance is lacking and postgraduate specialisation is only available to a fraction of the graduates. Some institutions aim at a middle path. The secondary school and universities I was fortunate to attend offered students a palette of courses and insisted on a "non-science" option every semester to provide breadth, while the main courses of specialisation demanded a solid depth of understanding. I have never regretted the base

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THIS ISSUE

Imagine a not-too-distant future when routine analyses of urine samples might detect people at risk for osteoporosis. This is one of the potential applications of metal stable isotopes in the medical field. As guest editors Tom Bullen and Anton Eisenhauer point out, after having concentrated their efforts on detection and measurement, isotope researchers have now moved to the next step: developing applications for these tiny isotope differences. So read on and consider how you might contribute to this fast-expanding field.

FIVE YEARS OLD!

Elements closes its fifth year of publication with this issue. In 2009, we published 39 thematic articles, contributed by 80 authors from 11 countries. Triple Point and Parting Shots, written by two of the founding principal editors, both reflect on the accomplishments and challenges of these first five years. We have now covered 29 topics in the Earth sciences; our lineup is complete till the middle of 2011, and we have many proposals on hand. Please check the preview on the next two pages to get a taste of the exciting topics we are going to cover in 2010. We hope there will be something for everyone in this mix of review and leading-edge coverage of science.

This milestone calls for some celebration. Past principal editors Mike Hochella and Bruce Watson are organizing a special session entitled "Geochemistry Far from Equilibrium" at the next Goldschmidt Conference. IMA 2010 will present a series of *Elements* plenary lectures each day of the conference. Principal editor David Vaughan and past principal editor Ian Parsons are busy working out the program. More on these events will be provided in the next issue of *Elements*.

GOLD ISSUE REVIEWED IN SEG NEWSLETTER

Elements "Gold Issue" was reviewed by Scott Wood in the Society of Economic Geologists Newsletter. You can read the review and sample this very interesting newsletter, as we have arranged with SEG for a free link until the end of January for *Elements* readers:

www.segweb.org/publications/SEG_October_2009_Newsletter_Elements.pdf.

ELEMENTS IN THE NEWS

We are pleased to report that our managing editor, Pierrette Tremblay, received the Association of Earth Science Editors Award for Outstanding Editorial Contributions "for her outstanding editorial and organizational skills in creating and managing *Elements*, a highly successful bimonthly mineralogical/geochemical journal supported by 15 societies and read by society members in about 100 countries." She received the award in November, 2009, at the AESE annual meeting in Houston, Texas, where she gave a talk entitled "Extreme Copublishing: *Elements* Five Years Later."

THANKS

We are indebted to the guest editors (names in bold) and the 80 authors of Volume 5 who have worked hard to bring their science to the nonspecialist audience of *Elements*. Many will attest that it was a lot of work, but that the final product made it all worthwhile.

Ariel D. Anbar, **Derek C. Bain**, Bridget A. Bergquist, Joel D. Blum, Florian Böhm, Abdelmalek Bouazza, Robert J. Bowell, Laurie L. Brown, Richard K. Brown, **Thomas D. Bullen**, **Charles R.M. Butt**, Kathleen A. Carrado, George E. Christidis, G. Jock Churchman, James S. Cleverley, Claire M. Cobley, David R. Cooke, **John W. Delano**, Bertrand Devouard, John H. Dilles, Rafal E. Dunin-Borkowski, **Anton Eisenhauer**, Don D. Eisenhour, Karl Fabian, Lintern Fairbrother, **Joshua M. Feinberg**, Ray E. Ferrell Jr., Jörg Fischer-Bühner, **Emmanuel Fritsch**, Carmen Gaina, Will P. Gates, Jérôme Gattacceca, Jean-Pierre Gauthier, Lee A. Groat, Timothy L. Grove, Monika Guelke, Necip Güven, **Richard J. Harrison**, Shelley E. Haydel, Pamela S. Hill, **Robert M. Hough**, Warren D. Huff, Robert E. Kane, Stefanos Karampelas, Başak Kısakürek, Peter Komadel, Michael J. Krawczynski, Brendan M. Laurs, Maggy F. Lengke, Paul G. Lucey, Barbara A. Maher, Shane F. McClure, Suzanne A. McEnroe, Merlin Méheut, Artashes A. Migdisov, Marc D. Norman, Franck Notari, Mihály Pósfai, Frank Reith, Peter Robinson, Pierre Rochette, **Benjamin Rondeau**, George R. Rossman, Edwin A. Schauble, Silke Severmann, James E. Shigley, Gordon Southam, John A. Tarduno, G. Jeffrey Taylor, Richard M. Tosdal, Friedhelm von Blanckenburg, Nicolaus von Wirén, Thomas Walczyk, John L. Walshe, Benjamin P. Weiss, Dominik J. Weiss, Mark A. Wieczorek, Lynda B. Williams, Anthony E. Williams-Jones, Younan Xia.

We also acknowledge reviewers, copy editors, and proofreaders who toil in the background. Their contribution is essential to ensure *Elements*' high editorial standards.

Finally, and not least, we thank our advertisers who stayed the course in spite of an uncertain economic landscape: Activation Laboratories, Advanced Mineral Technologies, Amcol International, Arizona State University, Australian Scientific Instruments, Bartington Instuments, Cambridge University Press, CrystalMaker, Elsevier, Excalibur, GAAJ-ZENHOKYO Laboratory, GemNantes, International Center for Diffraction Data, ioGlobal, RockWare, Nu Instruments, Savillex, Smart Elements, Spectromat, Springer, Thermo Scientific. A special mention goes to RockWare, Savillex, and Excalibur, who advertised in each issue of 2009 and have committed to do the same in 2010.

Susan Stipp, David Vaughan, and **Hap McSween**

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I got from my old-fashioned education, from those really tough courses in differential equations, computer programming, quantum mechanics, optics and hydrological engineering, or from the eye-opening courses in sociology, non-verbal communication, Latin and psychology!

Today's young people need a broad set of skills and knowledge to keep as many doors open as possible for future employment and for solving society's problems. Our universities, industry and governments need a broad set of expertises among their department team members to be able to compete in the forefront of research, education, innovation and policy. Perhaps we ought to plan our group strategies, study programmes and recruitment announcements with the da Vinci profile in mind.

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* Susan Stipp was the principal editor in charge of this issue.