International History, Philosophy and Science Teaching Group

NEWSLETTER

April 2007

www.ihpst.org

CONTENTS

1. 2007 IHPST Conference, Calgary, (April 15 submission deadline), www.ucalgary.ca/ihpst07

(a) *Organisation and Paper Submission*

The International History, Philosophy and Science Teaching Group will hold its *Ninth* Conference, at the University of Calgary, June 24 (evening) – 28 (noon), 2007

Conference Chair: Professor Ian Winchester (winchest@ucalgary.ca)
Conference Secretary: Linda Lentz (lentz@ucalgary.ca)
Programme Chair: HsingChi von Bergmann (ihpst07@ucalgary.ca)

*Contact Email***:** ihpst07@ucalgary.ca or hsingchi@ucalgary.ca

The Conference Theme is: *Contextual Approaches to Science and Mathematics Teaching*

Calgary is about a two-hour drive from the Rocky Mountains and the delightful towns of Banff and Lake Louise. More details, including registration, travel, accommodation, and tourism options will shortly be available at the conference web site: **www.ucalgary.ca/ihpst07.**

Proposals (max.1,000 words) and Abstract (max. 150 words) need to be submitted as attachments to programme chair by **15th April 2007**. The files should be named: SURNAME_proposal.doc and SURNAME_abstract.doc.

Two files need to be sent with each submission: a Proposal for evaluation by programme committee, and an Abstract for printing in programme if submission is accepted.

Notification of acceptance will be provided to participants no later than *May 5th, 2007*.

Participants who have not submitted registration payment by *May 22nd, 2007* will NOT be included in the printed program.

(b) ***Springer Distinguished Lecture***

The Springer Distinguished Lecture will be given by Professor Garland Allen, School of Biology, Washington University, St Louis. He has published on topics in the history and philosophy of biology, and on the history of eugenics. The lecture will be concerned with how the history and philosophy of biology can assist pedagogical efforts to cultivate process skills in science and to illuminate science as a way of knowing.

(c) Conference Registration

Registration for the Ninth IHPST Conference is now open as of January 2, 2007. Delegates may register on-line by going to the following link:

http://www.peopleware.net/1540

Please note that in order to register on-line delegates will be required to provide either a VISA or Mastercard for payment purposes.

For those who do not wish to register on-line, you may also complete the PDF IHPST Registration Form (please download it from the website) and fax or mail it back to the Conference & Special Events office as per the information provided on the form.

On-line registration will close on June 19, 2007.

Advanced registration for the conference is encouraged. Please note: meals cannot be guaranteed for those who register after Monday, June 11, 2007 due to catering cutoff requirements. As such, delegates who register after this time period cannot be guaranteed access to the Conference Dinner on June 26.

Refund Policy: A $50.00 administration fee will be withheld for cancellations received in writing prior or on April 30, 2007. NO REFUNDS will be issued after this date.

(d) ***Anticipated Contributors***

It is expected that about 200-250 educators, historians, philosophers, teachers, scientists and cognitive scientists from about 30 countries will engage with theoretical, curricular and pedagogical issues in contemporary science education.

Prospective participants are encouraged to contact colleagues and put together panels or symposia on these issues.

Among those that have indicated that they are preparing submissions for the conference are:

Jonathan Osborne, King's College London
Ian Winchester, University of Calgary
William McComas, University of Arkansas
Igal Galili, The Hebrew University of Jerusalem
Samson Nashon, University of British Columbia
Steven Norris, University of Alberta
Jesús Vázaquez-Abad, Universté de Montréal
David Rudge, Western Michigan University
Zoubeida Dagher, University of Delaware
Andreas Quale, University of Oslo
Ismo T. Koponen, University of Helsinki
Mansoor Niaz, Universidad de Oriente
Michael Ford, University of Pittsburgh
Colin Gauld, University of New South Wales
Norman Lederman, Illinois Institute of Technology
Judith Lederman, Illinois Institute of Technology
Michael Clough, Iowa State University
Michael Matthews, Uni. of New South Wales
Joanne Olson, Iowa State University
Dana Zeidler, University of South Florida
Arthur Stinner, University of Manitoba
Don Metz, University of Winnipeg
Stephen Klassen, University of Winnipeg
Peter Heering, University of Oldenburg
Fabio Bevilacqua, University of Pavia
Steve Alsop, York University
Kevin de Berg, Avondale College
Eric Howe, Assumption College
Michael Ackeroyd, Bradford College
Steve Alsop, York University
Susan Barker, University of Alberta
Larry Bencze, University of Toronto
Michael Bowen, University of New Brunswick
Karen Goodnough, Memorial University
Samia Khan, University of British Columbia
Jolie Mayer-Smith, University of British Columbia
Barbara McMillan, University of Manitoba
Olive Chapman, University of Calgary
Bonnie Shapiro, University of Calgary
HsingChi von Bergmann, University of Calgary
Ronald G. Good, Louisiana State University
Mick Nott, Kings College London
Bharath Sriraman, University of Montana
Clark Chinn, Rutgers University
Don Howard, University of Notre Dame
Robert Carson, Montana State University
Calvin Kalman, Concordia College
Stuart Rowlands, University of Plymouth
Eric Scerri, University of California – Los Angeles
Andoni Garritz, Uni. Nacional Autónoma de México
Mariana Hagberg, Karlstad University
Niklas Gericke, Karlstad University
Patrice Potvin, Université du Québec à Montréal
Kostas Skordoulis, University of Athens
Wendy Sherman, Iowa State University
Panos Kokkatos, University of Athens
James Carifio, University of Massachusetts

(e) Conference Accommodation

Blocks of rooms have been booked for delegates both on and off campus. Delegates are encouraged to book early even if you have to cancel or change your reservation at a later date.

NOTE: Please be sure when booking accommodations at either location to reference the IHPST Conference so that you receive the special conference rates that have been negotiated.

<u>*On-Campus Housing*</u>

University of Calgary, Summer Conference Housing
3456- 24th Avenue NW Calgary

Guest may either complete the PDF Conference Housing Form (can be found on the website) and fax it back to the Conference Housing office directly, or they may contact the Conference Housing office via telephone.

Contact Information:
Fax: (403) 220-6760
Phone: (403) 220-3203
Toll Free: 1-877-498-3203
Web site: http://www.ucalgary.ca/residence/guestaccommodation/

There are two types of accommodation reserved for the IHPST Conference: traditional residence and apartment-style residence (refer to website for floor plans and more detailed descriptions)

On campus per person rates range from approximately $33.00 for a shared dorm room to $75.00 for single private suite style accommodations, plus applicable taxes, per night.

Please note that the rooms are based on availability and all unused rooms will be released on May 1, 2007 (delegates may still call after this date to inquire about availability). As such, delegates are encouraged to book on campus accommodations on or before April 30, 2007 in order to avoid disappointment.

Off-Campus Housing

Best Western Village Park Inn
1804 Crowchild Trail NW Calgary (approximately 15-20 minute walk to campus)

Guests wishing to reserve accommodations for the Best Western Village Park Inn may do so by contacting the hotel by phone or by going to the following link and completing the requested information:

http://www.villageparkinn.com/reserve.html

Please note that if you are using the on-line option, please be sure to reference the IHPST Conference in the comments section of the form.

Contact Information:
Phone: (403) 289-0241
Toll Free: 1-888-774-7716
Fax: (403) 289-4645
Web site: http://www.villageparkinn.com/

There are two types of accommodation reserved for the IHPST Conference: standard rooms (2 beds per room) and business plus rooms. The business plus rooms include a full buffet breakfast and upgraded bathroom amenities.

Room rates range from $114.00 for a standard single room to $144.00 for a business plus double occupancy room, plus applicable taxes, per night. All prices are in Canadian Dollars.

Please note that rooms are based on availability and all unused rooms will be released on June 2, 2007 (delegates may still call after this date to inquire about availability). As such, delegates are encouraged to book off campus accommodations on or before June 1, 2007 in order to avoid disappointment.

(f) Transportation

The Calgary International Airport is well served by many international and domestic airlines with non-stop flights from Canada, the U.S. and overseas. It is also possible to reach Calgary by car or bus. Calgary has excellent east-west access along the Trans Canada Highway (Highway #1) and north-south access via Highway #2.

A taxi to the University from the Airport will cost approximately $35.00 one way. If checking into conference housing, direct the driver to take you to Cascade Hall. You will not need a car during the conference, but if you are renting a car, a few companies located at the Airport or downtown include:
Budget 1-800-268-8900
www.budgetcanada.com

Avis 1-800-879-2847
www.avis.com

Hertz 1-800-263-0600
www.hertz.com

Thrifty 1-800-367-2277
www.thrifty.com

Parking is available for a fee on campus for conference housing guests and in designated pay lots for other delegates. Parking is available free of charge for guests staying at the Best Western Village Park Inn in their designated lots.

(g) *Scholarship Support*

The IHPST Group and the journal *Science & Education* have some small amount of money available to support the conference attendance of scholars from depressed economies. It is anticipated that this will be a maximum of USD1,500 from which the recipient will need to fund all their own travel, registration and lodging expenses.

Applicants are required to send one file as Word attachments to the IHPST secretary (m.matthews@unsw.edu.au) by April 15, 2007. It should be labelled SURNAME_scholarship.doc.

This document should contain the following information:

NAME
INSTITUTIONAL ADDRESS (in full, for mail purposes)
EMAIL ADDRESS
BRIEF VITAE (list educational qualifications, teaching experience, publications or conference presentations, prior engagement with IHPST conferences)
CURRENT POSITION
SCHOLARSHIP IMPACT (give an account of how participation in the IHPST Calgary conference might be beneficial for the applicants own work and what flow-on effects it might have on their colleagues or local teachers.)

CALGARY CONFERENCE PROPOSAL (please insert, beginning on new page, the proposal that is being submitted to the Calgary Conference

This scholarship application is to be submitted in parallel with the conference submission, it does not replace the need to submit to the conference by the closing date of April 15)

Please note that scholarship support will only be available for scholars who have had proposals submitted and accepted for the Calgary conference.

2. *Science & Education* Report

(a) Volume 16 Number 6

Volume 16 Number Six of *Science & Education* has been printed and will be mailed to subscribers by Springer Publishing.

Science Learning and Entertainment: From the 18th to the 20th Century Jürgen Teichmann, Arthur Stinner & Falk Riess (editors)

Its Contents are:

The papers are available on the web for those whose institutions subscribe to the appropriate Springer journal package.

(b) Journal on the Web

The journal *Science & Education* is now available on the web at: http://www.springerlink.com/ (then PUBLICATIONS, then S, then ‘Science & Education’), or more directly at:

The above articles, and all published articles since Volume One, 1992, and all articles that are currently accepted and ‘in print’, are available on the web via Springer’s journal site: www.springer.com/journal/11191

Or the articles can be accessed directly at:
http://springerlink.metapress.com/content/1573-1901/

All articles can be downloaded as pdf files for free if the individual's institution subscribes to the relevant Springer journal package; otherwise they can be downloaded for a fee.

Alternatively subscription renewals for printed journals and new subscriptions (USD95 pa, with discount for students, retired faculty and scholars from depressed economies), can be effected at the IHPST web site: **www.ihpst.org**

The Springer site is now linked to Google, and articles can be searched in Google by typing in author name and first words of title. This goes direct to the Springer site and the pdf file of the article.

Approximately 3,000 institutions around the world have subscribed to the on-line version of the journal, while many institutions have subscriptions to both print and on-line versions.

The on-line version is heavily used. In 2006 there were 23,584 article-downloads, an increase of one thousand over 2005 downloads. These figures make *Science & Education* one of the most down-loaded of all Springer education journals.

The web site provides many services to researchers:

- # The 'On Line First' section allows access to all accepted, forthcoming articles in the journal. As soon as an article is accepted for publication, a typeset pdf version of it is posted on the web and can be accessed by individual journal subscribers or by individuals whose institutions subscribe to a Springer package that includes *'Science & Education'*.
- # The Contents of each issue of the journal, back to Volume 1 Number 1 in 1992, are available. These can be downloaded by subscribers and individuals whose institutions subscribe to the journal. They are also available, at a cost, to non-subscribers.
- # Full details of the Editorial Board and Submission process are posted.

(c) Manuscript Submissions

Scholars can submit manuscripts in file form direct to the journal at:

www.editorialmanager.com/sced/

Thereafter they can check on its progress through the review process. Most submissions are reviewed by three senior scholars, usually involving a spread of educator, historian, philosopher or cognitive scientist. The submission site also has a guide to the journal's format and style conventions.

3. Vale, David Gruender (1928-2007)

Sadly, David Gruender a founding member of the IHPST Group, died Sunday March 25, aged 79 years. David was a driving force behind the First Conference of the International History, Philosophy and Science Teaching Group which was held at Florida State University in 1989. Apart from contributing to the scholarly programme, he successfully sought university support for the conference, and found local and national funds. He co-edited, with Kenneth Tobin, one of the journal special issues associated with the conference – *Science Education* **75**(1). He was planning to contribute to the Group's coming Calgary conference.

David was Emeritus Professor of Philosophy at Florida State University, where he taught from 1967 to 1999. He was a native of Cleveland, Ohio. He stood 6-foot-6; was musically accomplished on the piano and bass; and worked in a medical laboratory, in a children's home and as a police reporter for the *Cleveland Plain Dealer* before moving into academia. He took his BA degree from Antioch College, his MA degree from the University of Chicago, and his PhD in philosophy from the University of Wisconsin. He taught philosophy at Kansas State and Case Western Reserve universities before moving to FSU.

His special interest was the history, philosophy, metaphysics and ethics of science. He explained in a 2006 interview that he was concerned with: "How we test things, how we develop theories and how we get to the bottom of the way the world works". Galilean topics were of particular interest to him. He recent papers have been on ethics in the philosophy of science, Hume on causation, constructivism and learning, and Aristotle and Hempel on explanation.

David was a long-time member of the Tallahassee Scientific Society, which promotes science education, and he spoke frequently at schools and seminars. In 1995, he was an instructor in a National Science Foundation-funded FSU program that helped middle-school teachers earn specialized degrees in science instruction. He often re-enacted scenes from the history of science to inspire his students.

Michael Ruse, professor of philosophy at FSU, and a participant in the first IHPST conference, said: "Of all the things I'll remember about David, it was his feeling that science education in America is in a poor state and those of us with an understanding had an obligation to contribute. …David wasn't interested in his own career; he was much more interested in what he could do to help other human beings."

David is survived by Betty, his wife of 32 years; three daughters; three stepchildren; and seven grandchildren.

Two of his IHPST publications are:

Gruender, C.D.:1989, 'Some Philosophical Reflections on Constructivism'. In D.E. Herget (ed.) *The History and Philosophy of Science in Science Teaching*, Proceedings of the First IHPST Conference, Florida State University, pp.170-176.

Gruender, C.D.: 2001, 'A New Principle of Demarcation: A Modest Proposal for Science and Science Education', *Science & Education* **10**(1-2), 85-95.

4. NARST Conference: History, Philosophy & Sociology Strand

The National Association for Research in Science Teaching (NARST, www.narst.org/) is holding its annual conference in New Orleans, April 15-17 2007. The programme is divided into different research strands, with Strand 13 being devoted to 'Historical, Philosophical and Sociological Studies'.

The following sessions are being held.

Effects of Launching of Sputnik on Science Education in the United States

i. Effects of the Launching of Sputnik on Science Education in the United States: Preparing for the Golden Anniversary of Sputnik I Launch

iv. Views on Evolution and Creationism: The Cases of Theology and Science Undergraduates in Korea
Seung-Urn Choe, Yumin Ahn, Miae Lee, Na-Hae Sung

v. Investigating Undergraduate Atmospheric Science Studentsí "Ideas" about the Nature of Science
Loran E. Carleton, Gerald H. Krockover

Role of Cultural Practices on Teachers' Views on the Nature of Science

i. Investigating Toxic Risk and Sharing Results Online: What Do Preservice Science Teachers Know about Science, Inquiry, and Literate Practices?
Julie A. Bianchini, Emily Kang, Gregory J. Kelly

ii. Science Teachers' Inspiration for Teaching SSI: A Gap With Reform Efforts
Hyunju Lee, Klaus Witz

iii. The Relationship of Cultural Values, Intellectual Levels and Preservice Teachers’ Views of Nature of Science
Valarie L. Akerson, Cary A. Buzzelli, Lisa A. Donnelly

Students' Conceptions of the Nature of Science

i. Turkish College Biology Students' Acceptance of Evolution
Deniz Peker

ii. Students' Beliefs in Pseudo-Science
Mats Lundstr–m

iii. Improving Reflective Judgment in High School Students Through Socioscientific Issues
Dana L. Zeidler, Brendan E. Callahan, Karey Burek, Troy D. Sadler, Scott Applebaum

iv. A Change in Perspective: Science Education Graduate Students' Reflections on Learning About NOS
George V. Akom, Renee S. Schwartz, Brandy Skjold, HangHwa Hong
Fang Huang, Robert E. Kagumba

Teachers' Conceptions of the Nature of Science

i. Explicit/Reflective Approach to Enhance Pre-Service Science Teachersí Understanding of the Nature of Science Concepts
Behiye Bezir Akcay, Hakan Akcay

ii. A Study on Prospective Teachers' Beliefs About the Nature of Science and Self-Efficacy
Bilge Can, Esin Perkmez

iii. Scientific Modeling for Inquiring Teachers Network (SMIT-N): The Relationship Between Elementary Teachers' Views of Scientific Modeling and Nature of Science
Orvil L. White, Valarie L. Akerson, Huseyin Colak, Khemmedwadee Pongsanon

Views of the Nature of Science from Biology, Philosophy /Theology, Pre-service Instruction, International Perspectives, Scientists, and a (Kansas) Classroom Teacher

i. Views of the Nature of Science from Biology, Philosophy /Theology, Pre-Service Instruction, International Perspectives, Scientists, and a (Kansas) Classroom Teacher
Lawrence Scharmann, Mike U. Smith, Jonathan Osborne, George Griffith

Symposium on Inquiry and the Learning of Science Theories and Practices

i. Inquiry and the Learning of Science Theories and Practices
Richard Duschl, Nancy Brickhouse, Fouad Abd-El-Khalick, Philip Bell
Daniel C. Edelson , Richard Grandy

5. Current Research

Apart from contributions to *Science & Education* the following are some papers published in recent years that bear upon the research concerns of the IHPST Group. Suggestions for up-dating this list should be sent to the Editor at m.matthews@unsw.edu.au

Niaz, M.: 2006, ‘Facilitating Chemistry Teachers’ Understanding of Alternative Interpretations of Conceptual Change’, *Interchange* **37**, 129-150.

Niaz, M.: 2006, ‘Can the Study of Thermochemistry Facilitate Students’ Differentiation between Heat Energy and Temperature’, *Journal of Science Education and Technology* **15**, 269-276.

Mamlok-Naaman, R., Ben-Zvi, R. & Hofstein, A., Menis, J., & Erduran, S.: 2005, ‘Influencing Students' Attitudes towards Science by exposing them to a Historical Approach’, *International Journal of Science and Mathematics Education* **3**(3)

Niaz, M.: 2005, ‘The Quantitative Imperative vs the Imperative of Presuppositions’, *Theory & Psychology* **15** (2), 247-256.

Niaz, M.: 2005, ‘Do General Chemistry Textbooks Facilitate Conceptual Understanding?’, *Química Nova* **28**(2), 335-336.

Niaz, M.: 2005, ‘An appraisal of the controversial nature of the oil drop experiment: Is closure possible?’, *British Journal for the Philosophy of Science*, **56**(4), 681-702.

Brito, A., Rodríguez, M.A. & Niaz, M.: 2005, ‘A Reconstruction of Development of the Periodic Table Based on History and Philosophy of Science and its Implications for General Chemistry Textbooks’, *Journal of Research in Science Teaching* **42**(1), 84-111.

Abd-El-Khalick, F. 2005, ‘Developing Deeper Understanding of Nature of Science: The Impact of a Philosophy of Science Course on Preservice Science Teachers’ Views and Instructional Planning’, *International Journal of Science Education* **27**(1), 15-42.

Lawson, A.E.: 2005, 'William Harvey, Predicting Capillaries, and the Nature of Science: One More Time', *The American Biology Teacher* **67**(4), 202-203.

Lawson, A.E.: 2005, 'Conducting High Quality Research', *International Journal of Science and Mathematics Education*, **3**(1), 1-5.

Lawson, A.E.: 2005, 'What is the Role of Induction and Deduction in Reasoning and Scientific Inquiry?' *Journal of Research in Science Teaching* **42**(6), 716-740.

Dagher, Z., & BouJaoude, S.: 2005, 'Students’ Perceptions of the Nature of Evolutionary Theory', *Science Education* **89**(3), 378-391.

Nola, R. & Irzik, G.: 2005, *Philosophy, Science, Education and Culture*, Springer, Dordrecht.

Ben-Ari, M.: 2006, ‘Whose Final Hour? The Problem of Naive Egocentric Catastrophism in Doomsayers and Catastrophists’, *Skeptic* **12**(3), 2006, 40-49.

Waters-Adams, S.: 2006, ‘The Relationship between Understanding the Nature of Science and Practice: The Influence of Teachers’ Beliefs about Education, Teaching and Learning’, *International Journal of Science Education* **28**(8), 919-944.
Smith, C.L. & Wenk, L.: 2006, ‘Relations among Three Aspects of First-Year College Students’ Epistemologies of Science’, *Journal of Research in Science Teaching* **43**(8), 747-785.

6. Book Review

Eric R. Scerri *The Periodic Table-Its Story and Its Significance***,** Oxford, Oxford University Press, 2007. 346 pages.

By: Kevin C. de Berg, Avondale College, NSW, Australia

This is undoubtedly a book that every practising chemist and chemistry educator should read because of its far-reaching implications for understanding the nature of the periodic law and the challenges it presents to contemporary portrayals of the Periodic Table. The book has an introduction and ten chapters with the following titles: C1 *The Periodic System*: *An Overview*; C2 *Quantitative Relationships among the Elements and the Origins of the Periodic Table*; C3 *Discoverers of the Periodic System*; C4 *Mendeleev*; C5 *Prediction and Accomodation*: *The Acceptance of Mendeleev’s Periodic System*; C6 *The Nucleus and the Periodic Table*: *Radioactivity, Atomic Number, and Isotopy*; C7 *The Electron and Chemical Periodicity*; C8 *Electronic Explanation of the Periodic System Developed by Chemists*; C9 *Quantum Mechanics and the Periodic Table*; C10 *Astrophysics, Nucleosynthesis, and More Chemistry*.

The author, Eric Scerri, gives historical and philosophical background to issues involved in the development of the Periodic Table and reminds the reader that philosophical considerations have only received serious attention since the middle of the 1990’s. While the author warns the reader not to treat the book as a work of historical scholarship, many of the conclusions drawn by the author rely on the findings of serious historical research. While a multitude of issues is raised by the author, I summarize below what I think are the main issues addressed in the book. This is followed by a section on common illusions about the Periodic Table that are highlighted and clarified by Scerri. Some personal reflections on the implications of this study for chemistry education are given in the conclusion.

Main Issues

1. <u>The Nature of the Chemical Elements</u>

The author highlights the significance of this concept by suggesting that, “This issue (the nature of the chemical elements) forms the basis of what is perhaps the most philosophical aspect of the periodic system, and one that has been almost completely neglected by books and articles....on the periodic system generally”(p102). The emphasis on philosophy in the book is not surprising given the fact that the author is a philosopher of chemistry, but the reader should keep in mind that this book has significant material for historians and chemists as well. Scerri discusses two important ways of thinking about an element; the element as a *basic substance* and the element as a *simple substance*. The significance of this distinction assumes some importance when one considers, for example, the reaction between sodium (a white soft reactive metal) and chlorine (a yellowish poisonous gas) to form common table salt, sodium chloride. The elements sodium and chlorine obviously do not exist in their natural form as a soft reactive metal and a yellowish poisonous gas in common salt. In what sense then, can sodium and chlorine be said to exist in common salt?

The view of an element as a *simple substance* is the one with which all chemists are familiar and is the view that first received serious attention in the work of Lavoisier who saw a *simple* *substance* as one that could not be decomposed by any known means. Thinking of an element as a *basic substance* can be traced back to the philosophy of Aristotle. Scerri briefly sketches this philosophy where, “the elements themselves were to be regarded as abstract even though they gave rise to all the physical variety that is observed. The four elements (fire, earth, water, air) were considered as property bearers, responsible for the tangible features of substances although they were themselves unobservable. The elements were immaterial qualities impressed on an otherwise undifferentiated primordial matter and were present in all substances”(p113). From the early 19th century, the view was established that simple substances do not survive in a compound but abstract elements do survive. However, inorder to deal with the law of the conservation of matter demonstrated in Lavoisier’s experiments, the nature of the abstract element had to change from an ‘immaterial ingredient’ to a ‘material ingredient’.

Scerri summarizes this change as follows. “However, in a major departure from the Aristotelian view, the abstract elements were also regarded as being ‘material ingredients’ of simple bodies and compounds. This concept of material ingredient thus served to link the metaphysical world of abstract elements and the observable, material realm of simple substances. For example, the stoichiometric relationships observed in chemical changes were explained in terms of amounts of abstract elements present in the reacting substances through the agency of the material ingredient....There are thus *three* important concepts regarding elements carried over into the 19th century: abstract element as property bearer owing its heritage to Aristotle; indestructible material ingredient of substances behaving according to Lavoisier’s law of the conservation of matter; abstract element as unobservable whereas simple substances can be observed. In contemporary chemistry only the notion of simple substance has been retained in the concept of element”(p114).

Scerri demonstrates that Mendeleev had this dichotomous view of an element by quoting from Mendeleev’s *Principles of Chemistry*. “It is useful in this sense to make a clear distinction between the conception of an element as a separate homogeneous substance, and as a material but invisible part of a compound. Mercury oxide does not contain two simple bodies, a gas and a metal, but two elements, mercury and oxygen, which, when free, are a gas and a metal. Neither mercury as a metal nor oxygen as a gas is contained in mercury oxide; it only contains the substance of the elements, just as steam only contains the substance of ice, but not ice itself, or as corn contains the substance of the seed but not the seed itself”(p115). Mendeleev*’s* preoccupation with atomic weight can now be understood in terms of his understanding of the nature of the elements. Scerri makes this point when he says, “Mendeleev’s genius now lay in recognizing that just as it was the ‘(basic) element’ that survived intact in the course of compound formation, so atomic weight was the only quantity that survived in terms of measureable attributes”(p115).

Of all the issues that Scerri raises in his book this one relating to the nature of the chemical elements is probably one of the most helpful from a chemistry education viewpoint. There is an early hint of this in his book when he says, “If a novice chemist were asked to group these elements (halogens) according to their appearances, it is inconceivable that he or she would consider classifying together fluorine, chlorine, bromine, and iodine. This is one instance where the subtle distinction between the observable and the abstract sense of the concept of an element can be helpful. The similarity between them lies primarily in the nature of the abstract elements and not the elements as substances that can be isolated and observed”(p16).

2. <u>Reductionism</u>

The author has given considerable attention to this question over a number of years and it is therefore not surprising that the concept is woven through the whole book and could almost be said to be the stitching holding the book together. The concept of reductionism is made manifest in a variety of ways. One of the fundamental premises of the book appears in the introduction in the words, “The extent to which quantum mechanics reduces the periodic system is frequently overemphasized”(pxiv). Scerri is reacting to the view sometimes expressed that electron structure and the concept of periodicity follow naturally from the solution of the Shrödinger equation in quantum mechanics and is therefore a much more reliable guide than experimental evidence which is, by nature, open to error and misinterpretation. The following extracts are indicative of his position.

p232: The Pauli Exclusion Principle and the use of four quantum numbers only provide a deductive explanation of the total number of electrons that any electron shell can hold. The correspondence of these values with the number of elements that occur in any particular period is something of a coincidence. The lengths of successive periods have not yet been strictly deduced from the theory. However, most chemistry and physics textbook authors do not emphasize this point or even mention it. As a result, they imply that quantum mechanics does indeed provide a perfectly satisfactory deductive explanation of the periodic system.

p233: The Aufbau principle (where) orbitals are occupied in order of increasing values of ($n+l$)......does not in fact refer to the ordering of energies of atomic orbitals but to the order of filling them....The ($n+l$) rule has not yet been derived from the principles of quantum mechanics. This failure has been described as one of the outstanding problems in quantum mechanics by the leading quantum chemist Per-Olav Lowdin. It emerges that all three of these principles (Aufbau, Hund, Pauli) are essentially empirical, and none of them has been strictly derived from the principles of quantum mechanics.

p237: A feature that seems to generally go unnoticed is the need to assume the empirical order of shell filling rather than trying to derive it from the theory. The order in which orbitals are occupied with electrons is not derived from first principles. It is justified *post facto* and by some complex calculations.

p242: In most of the configurations considered it has been possible to use quantum mechanics to calculate the particular configuration that possesses the lowest energy. However, in performing such calculations, the candidate configurations that are subjected to the calculation are themselves obtained from the Aufbau principle and other rules of thumb such as Hund's principle, or by straightforward appeal to experimental data. Theoretical calculations cannot predict the electronic configuration for any element....The quantum mechanical calculations on ground-state energies involve the initial selection of a basis set, which in simple terms is the electronic configuration of the atom in question. Quantum mechanical calculations do not actually generate their own basis sets.

Scerri also shows that electronic configurations could not be derived from the old quantum theory either. He quotes the case of element 72 (Hafnium) as follows.

p224: In a matter of years, several chemists, including Lewis, Langmuir, and Bury, had obtained detailed electronic configurations for all the known elements, including the more complicated transition elements. Bury had realized that the atoms of the transition elements do not fill their electron shells in sequential order and had predicted that element 72 would be a transition metal that would show chemical similarities with zirconium. All this was achieved without any arguments based on theoretical physics, or, more specifically, without using quantum theory. The chemists' configurations were obtained inductively on the basis of the chemical properties of the elements. This aspect of the history of the periodic system is seldom emphasized, with most accounts promoting the view that electronic configurations resulted entirely from the work of theoretical physicists such as Bohr. In truth, Bohr had also reached electronic configurations inductively, frequently drawing on chemical evidence, as the chemists themselves had done....Bury gave chemical arguments for his own assignment of configurations, whereas the prevailing reductionist climate implied that quantum mechanics inevitably provides a more fundamental explanation for the periodic system.

There is a second way in which Scerri discusses reductionism and that is in the distinction he draws between chemistry and physics. Some examples of this are as follows.

pxvii: The Period Table is philosophically important because it is a testing ground for whether chemistry is nothing but physics deep down or whether chemistry reduces to physics.

p25: The popular view reinforced in most textbooks is that chemistry is nothing but physics "deep down" and that all chemical phenomena, especially the periodic system, can be developed on the basis of quantum mechanics. There are some problems with this view...

p163: Some authors believe that the interpretation of the properties of the elements passed from chemistry to physics as a result of the discovery of radioactivity. They speak of "the redefinition of Mendeleev's chemical element, which would lead to its appropriation by physics". I believe this view to be overly reductionist, as presumably did Fritz Paneth, who formulated his 'intermediate position' in order to uphold the integrity of the chemical view of the elements and of the periodic system.

p173: The clarification that Moseley brought to the Periodic Table represents one of the finest examples of the reductive power of physics in the field of chemistry.

While it is clear that derivations from quantum mechanical theory can be seen to be more fundamental than experimental evidence I am not sure whether this should always be seen as chemistry being reduced to physics. Quantum mechanical theory is as much a part of modern chemistry as it is part of modern physics. In fact, the 1998 Nobel Prize in Chemistry was awarded to John Pople and Walter Kohn for their fundamental work in quantum mechanics which has led to the depiction of molecular structures in new and creative ways. Even on p220 Scerri draws a distinction between "chemical, as well as X-ray diffraction data". This distinction was certainly a prominent view at the end of the 19^{th} century and early 20^{th} century. Henry Armstrong criticised the Bragg's X-ray diffraction work on sodium chloride as chessboard evidence not fitting for a chemist wanting chemical evidence. But I think this view is difficult to sustain in today's scientific environment. X-ray diffraction is as much a part of a chemistry laboratory as it is part of a physics laboratory. The conjoint enterprise engaging physicists and chemists is evidenced in the way new scientific fields opened to investigation. Such fields as physical chemistry and chemical physics bear witness to this development. Nevertheless, it is clear what Scerri is trying to demonstrate provided one is familiar with the ancestry of modern chemistry and physics.

3. <u>Rehabilitation of old concepts</u>

This is discussed by Scerri particularly in terms of Prout's Hypothesis and the notion of Triads. Prout's Hypothesis proposed that all the elements were compound forms of hydrogen and thus if hydrogen's atomic weight was taken as 1 then all the atomic weights of other elements should be whole numbers. While the Belgian chemist, Jean Servais Stas, was originally attracted to this idea, he grew increasingly suspicious of it as atomic weight determinations became more empirically reliable and consistent. Scerri notes this and quotes Stas' conclusion in the statement that follows. "Almost 25 years later, however, after measuring the atomic weights of numerous elements with as yet unheard of precision, Stas drastically changed his opinion and declared, 'One must consider Prout's Hypothesis as pure illusion' "(p41). However, if one identifies the elements according to atomic number rather than atomic weight, Prout's Hypothesis again makes some sense. Scerri notes this and the philosophical implications of it for the nature of science in the following extracts.

p42: So Prout's hypothesis turned out to be incorrect in that the elements are not composites of hydrogen according to their atomic weights, and yet there is a sense in which his idea can be said to have now been vindicated by modern physics. In terms of numbers of protons, the nuclei of all the elements are indeed composites of the nucleus of the hydrogen atom, which contains just a single proton. But, even at the time it was first proposed, Prout's hypothesis proved to be very fruitful, because it encouraged the determination of accurate atomic weights by numerous chemists who were trying to either confirm or refute it. From the point of view of Karl Popper's philosophy of science, this all makes perfect sense. A useful scientific idea need not necessarily be correct, but it is essential that it should be refutable in the light of experimental evidence.

p61: It is rather surprising that both Prout's hypothesis and the notion of triads are essentially correct and appeared problematic only because the early researchers were working with the wrong data.

p179: Some pioneers including Mendeleev made it a point to turn their backs on the two original concepts of Prout's hypothesis and the existence of numerical triads. This attitude certainly seems to have paid dividends for Mendeleev in that he made progress where others had failed to do so. The problem with triads and Prout's hypothesis is easy to discern in retrospect. It is simply that atomic weight, which both concepts draw upon, is not the most fundamental quantity that can be used to systematize the elements.

p182: The philosopher of science Imre Lakatos used the example of Prout's hypothesis to illustrate a theory making a 'comeback' after being apparently refuted.

Scerri uses the term "rehabilitated" to describe the return of Prout's Hypothesis and Triad relationships to the thinking of chemists on the discovery of atomic number.

The idea of the triad is illustrated on p42 using Dobereiner's triad where the weight of SrO is calculated from the average of the oxide above (CaO) and that below (BaO) in the Periodic Table as follows.

$$SrO = (CaO + BaO)/2 = (59 + 155)/2 = 107$$

The atomic or molecular weight of the middle member of the triad was the average of the other two. Other triads identified in early forms of the Periodic Table were: (S, Se, Te); (Cl, Br, I); and (Li, Na, K). While Mendeleev was critical of his colleagues' obsession with finding triad relationships whether or not this had chemical significance, Scerri concludes that, "the recognition of triads represented the first important step toward the eventual construction of the modern periodic system"(p57). While the triad relationship is not always exact when accurate atomic weights are used, "It emerges that in certain parts of the modern Periodic Table the triad relationship turns out to be exact if atomic numbers are used instead of atomic weights ….About 50% of all possible vertical triads, using atomic numbers, are in fact exact"(p58).

Scerri demonstrates the exactness of the triad relationship by considering elements from rows 1, 2, and 3 of the long form of the Periodic Table. He illustrates the relationship with (He, Ne, Ar); (P, As, Sb); and (Y, Lu, Lr). It is noted that triads taken from rows 2, 3, and 4 or 4, 5, and 6 do not give perfect triads because the length of each period, apart from the first, repeats just once. "All one needs to do is pick a middle element from the first of a repeating pair of periods"(p180).

4. Periodic Table-Periodic System-Periodic Law

Scerri distinguishes these terms in the following extracts.

p18: How is a periodic table different from a periodic system? The term 'periodic system' is the more general of the two. The periodic system is the more abstract notion that holds that there is a fundamental relationship among the elements.

p21: What is fundamental to all these attempts is the periodic *law* itself, which exists in only one form. None of the multitude of displays changes this aspect of the periodic system. Many chemists stress that it does not matter how this law is physically represented, provided that certain basic requirements are met. Nevertheless, from a philosophical point of view, it may still be relevant to consider the most fundamental representation of the elements, or the ultimate form of the periodic system, especially as this relates to the question of whether the periodic law should be regarded in a realistic manner or as a matter of convention. The usual response that representation is only a matter of convention would seem to clash with the realist notion that there may be a fact of the matter concerning the points at which the repetitions in properties occur.

p77: As mentioned before, the periodic *law*, though not a fashionable term nowadays, is perhaps the most important aspect of the periodic table. The Periodic Table in all its many forms is, after all, just an attempt to represent this law graphically.

What Scerri seems to be saying here is that there is a philosophical advantage in using a form of the Periodic Table that demonstrates a fundamental relationship among the elements rather than just selecting a form by convention. To this end he favours a form of the Periodic Table that views the elements as basic substances rather than simple substances and calls upon Mendeleev as a colleague in this respect. "Mendeleev realized that abstract elements were to be regarded as more fundamental than simple substances. The explanation of 'why' elements persist in their compounds was to be found in abstract elements and not simple substances, and as a consequence, if the periodic system were to be of fundamental importance, it would primarily have to classify the abstract elements"(p117).

Scerri also supports his use of elements as basic substances in a Periodic Table because of the way this solves the problem of the isotope controversy. "Paneth's recommendation for the retention of the chemist's Periodic Table depended on the notion of the elements as basic substances and not as simple substances. If the chemists had focussed on simple substances, they would have been forced to recognize the new elements in the form of isotopes that were being discovered in rapid succession. By choosing to ignore these elements in favour of the elements as basic substances, chemists could continue to uphold that the fundamental units of chemistry, or its natural kinds, remained as the entities that occupied a single space in the periodic system"(p280).

Given his philosophical concern that fundamental properties be represented in a Periodic Table, Scerri chooses the left-step form of the Periodic Table shown in his Figure 10.13 (page 283 in his book) which organizes the elements according to atomic number and the periods according to the sum of the quantum numbers *n* and *l*, that is,
($n + l$). This might seem a little unusual given the negative comments made about the incapacity of quantum mechanics to derive the Periodic Table. However, Scerri's position is an intermediate one that recognizes both the strength and limitations of quantum mechanics. This is illustrated in the following extracts.

p285(1): Reductionism has provided an undeniably successful approach to the acquisition of scientific knowledge. The thrust of this book has been directed against exaggerated claims made on behalf of reductionism...It is rather the limitations of reductionism that are of interest to philosophers of science and that should be taken more seriously by science educators.

p285(2): The aim should be to obtain a classification that primarily classifies elements as basic substances, while also recognizing aspects of the elements as simple substances...It is suggested that an optimal classification can be obtained by identifying the deepest and most general principles that govern the atoms of the elements, such as the (n+l) rule, and by basing the representation of the elements on such principles.

p286: The left-step table (Fig. 10.13), I suggest, embodies the elements entirely as basic substances since it relegates the chemical and physical properties of elements such as helium and places greater importance upon more fundamental aspects. From a philosophical point of view, I believe that the left-step table may provide an optimal periodic system in showing the greatest degree of regularity while also adhering to the deepest available principles relating to the elements as basic substances....But the argument between the relative virtues of utility and beauty in science is not an easy one to resolve.....

All periods appear in duplicates in the left-step table with periods of 2, 8, 18, and 32. What chemists may find difficult to accept in the left-step table is the grouping of helium, He, with the alkaline earth metals rather than with the noble gases. Scerri recognizes the value of considering the elements from both the basic and simple point of view but chooses the left-step table as the one more correctly representing the fundamental properties of the elements-a position he recognizes is controversial.

Illusions highlighted in the book

(i) It is often said that equivalent weight was preferred by chemists over atomic weight because equivalent weight did not depend on a knowledge of the chemical formula. Scerri dismisses this belief by referring to the arguments of Alan Rocke showing that equivalent weights also rested on the assumption of particular formulas for compounds (p19).

(ii) The periodic law was not discovered by just one or two people but at least six people independently discovered the periodic system within the one decade. Scerri chooses De Chancourtois, Newlands, Odling, Hinrichs, Lothar Meyer, and Mendeleev.

(iii) The idea of using atomic weights to predict the existence of unknown elements did not originate with Mendeleev. Although Mendeleev made more predictions than any other only about 50% of his predictions proved correct (pp52; 123).

(iv) Mendeleev gained the primary position amongst the six discoverers of the periodic system not because his table was more accurate than the others, but most likely because he was the most active in promoting the periodic system and his view of elements as basic substances was unique amongst the six (pp98; 114).

(v) Mendeleev was not the first to anticipate or predict the existence of germanium. It was clearly anticipated in 1864 by Lothar Meyer(p96).

(vi) Mendeleev was not the first to reverse the order of tellurium and iodine. They were reversed prior to Mendeleev by Odling, Newlands, and Lothar Meyer (p130).

(vii) The real discoverer of atomic number was not Rutherford or Moseley but Anton van den Broek (p165).

(viii) Scientific claims for Henry Moseley far outpace the truth (p174). Scerri relates that, "In 1920 James Chadwick....reanalysed Moseley's work. He discovered that the choice of value for the constant b = 7.4 was not as inevitable as Moseley had claimed. It was still possible in principle for an atomic number not to equal the number of positive charges in the nucleus...Chadwick therefore decided to make some independent measurements of the charges on various nuclei using a refined version of Geiger and Marsden experiment with alpha rays. Only after this work had been carried out and atomic charges been successfully measured by a second method did Chadwick announce the confirmation of Moseley's simple idea (p175).

(ix) Bohr did not deduce the Periodic Table from quantum theory and it was John David Main Smith who produced more accurate electron configurations than Bohr (p220).

(x) The number of outer shell electrons is neither a necessary nor sufficient condition for membership of a vertical group of the Periodic Table. This point is emphasized by Scerri through a number of examples. Helium has the same number of outer shell electrons as the alkaline earth metals but is normally placed with the noble gases because of its inert characteristics (p243). Ni, Pd, and Pt are in the same group but have a different number of outer shell electrons. Li and Mg have similar chemical properties but are in different groups and have a different number of outer shell electrons as do Si and Ti; Zn and Sn; Al^{3+} and Fe^{3+}; and Al and Si (p265).

Conclusion

I found this book most enlightening and challenging and highly recommend it. Some of the ideas presented will prove controversial as I have mentioned but this is even a better reason for the chemistry community to give study to it. There are a number of errors in the text and figures (for example, the elements Pm and Np are missing from Figure 10.13) but these do not detract from the overall message of the book. The book has a very informative set of notes and references for each chapter which will assist the reader in exploring more deeply some of the ideas presented. Given some of the suggestions in the book it is obvious that the story of the Periodic Table is not completed but will likely undergo future revision if philosophers have their way with practising chemists.

One issue which will ultimately present itself to the reader relates to the extent to which practising chemists will be tempted to take philosophical ideas seriously particularly in a climate where the utility of chemical ideas tends to take precedence over the meaning of chemical ideas.

There is a similar issue for chemistry educators. Because of time constraints, an overloaded curriculum, and the nature of the student, priority tends to be given to how to use chemical ideas to solve problems rather than to explore the meaning of chemical ideas. I sense this challenge in my own teaching and suggest that collectively wrestling with this issue at IHPST conferences and other venues might be worth

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7. Contextual Teaching Anthology

Peter Heering, Daniel Osewold (eds.), *Constructing Scientific Understanding through Contextual Teaching*, Frank & Timme Publishers, Berlin

346 pages, 29,80 €, Paperback, ISBN 978-3-86596-118-1

Contents

This volume includes a selection of contributions to the 6th International Conference for the History of Science in Science Education held at the Carl-von-Ossietzky Universität Oldenburg in July 2006. The conference was devoted to discussing the function of historical contexts in science education. Some of the papers in this collection discuss this issue from a theoretical point of view, others describe practical teaching experiences; they cover examples from the fields of astronomy, biology, mathematics, and physics. Bringing them together should make manifest the potential of using historical contexts in science education, in particular in teaching not only science but also the nature of science.

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The Editors

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