IHPST www.ihpst.net	**International History, Philosophy and Science Teaching Group** **NEWSLETTER** **April-May 2014**

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3. *Science & Education* Journal Report

(a) Rationale and Purpose of the Journal

All involved with *Science & Education* journal are concerned to improve school and university science education by publishing substantial research that utilises historical, philosophical and sociological scholarship.

The journal promotes the engagement of these fields with theoretical, curricular and pedagogical issues in science education. It has a particular interest in bringing these fields of knowledge into teacher-education programmes. The journal welcomes contributions that examine and extend the liberal or humanistic tradition of science teaching. It welcomes serious cross-disciplinary approaches to theoretical, curricular and pedagogical issues. It seeks to promote discussion of the philosophy and purposes of science education, and its contribution to the intellectual and ethical development of individuals and cultures. In this latter endeavour it recognises that many of the major decisions facing science teachers, curriculum writers and administrators have their roots and solutions in fundamental philosophy of education.

(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 journal's home page: www.springer.com/journal/11191. The home page has provision for signing up for 'Table of Contents Alert', which means each time an issue of the journal is published, the Contents are contents are conveyed by email.

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.

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.

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.

(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.

(d) Copyediting Assistance Required for Manuscripts from Non-English Authors

The journal publishes many works by scholars whose native language is not English. Copyediting of these papers is very time-consuming and assistance would be greatly appreciated. The papers would all be ones that have passed review and are in reasonable linguistic shape, but they do need refinement. Volunteers would be asked to copyedit no more than one paper per year. Such assistance is one tangible way of promoting good non-English background research to the international community.

If any colleagues are able to assist in this important task, please email the editor.

(e) Article Downloads

Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Down-loads	21,373	22,500	23,584	37,593	48,634	65,152	88,220	108,650	73,664

These figures are most gratifying especially for a 'niche' journal in science education. They indicate the amount of worldwide interest in the utilization of historical and philosophical studies in addressing the numerous theoretical, curricular and pedagogical problems in contemporary science and mathematics teaching.

The usage reflects the quality of manuscripts submitted to the journal, and the rigor and competence of the journal's reviewers (normally three per manuscript, often four or five).

One 'lesson' from the download figures is the need to incorporate history and philosophy of science material, if not courses, in science teacher education programmes. The download figures demonstrate a clear interest in HPS-related material by science teachers, educators, and researchers more widely, but unfortunately HPS is rarely included in either undergraduate or graduate teacher education programmes.

(f) Thematic Issues

Since its inception in 1992 the journal has regularly published thematic issues that bring together historical, philosophical and educational scholarship on particular theoretical or pedagogical themes related to History, Philosophy and Science Teaching.

These thematic issues have included:

1994, 'Science and Culture', **3**(1).
1995, 'Hermeneutics and Science Education', **4**(2).
1996, 'Religion and Science Education', **5**(2).
1997, 'Philosophy and Constructivism in Science Education', **6**(1-2).
1997 'The Nature of Science and Science Education', **6**(4).
1999, 'Values in Science and in Science Education', **8**(1).

1999, ‘Galileo and Science Education’, **8**(2).
1999, ‘What is This Thing Called Science?’, **8**(4)
1999, ‘Children’s Theories and Scientific Theories’, **8**(5).
2000, ‘Thomas Kuhn and Science Education’, **9**(1-2).
2000, ‘Constructivism and Science Education’, **9**(6).
2003, ‘History, Philosophy and the Teaching of Quantum Theory’, **12**(2-3)
2004, ‘Science Education and Positivism: A Re-evaluation’, **13**(1-2)
2004, ‘Pendulum Motion: Historical, Methodological and Pedagogical Aspects’, **13**(1-2,7-8)
2006, ‘Textbooks in the Scientific Periphery’, **15**(7-8)
2005, ‘Science Education in Early Modern Europe’, **14**(3-4)
2007, ‘Models in Science and in Science Education’, **16**(7-8)
2008, ‘Teaching and Assessing the Nature of Science’, **17**(2-3)
2008, ‘Studies in Historical Replication in Psychology’, **17**(5)
2008, ‘Social and Ethical Issues in Science Education’, **17**(8-9)
2008, ‘Women, Science Education, and Feminist Theory’, **17**(10)
2009, ‘Politics and Philosophy of Science’, **18**(2)
2009, ‘Constructing Scientific Understanding through Contextual Teaching’, **18**(5)
2009, ‘Science, Worldviews and Education’, **18**(6-7)
2010, ‘Darwin and Darwinism: Historical, Philosophical, Cultural and Pedagogical Studies’, **19**(4-5, 6-8)
2011, ‘Science and Pseudoscience in Society and School’, **20**(6-7)
2012, ‘The History of Experimental Science Teaching’, **21**(2)
2012, ‘Popular Science between News and Education: A European Perspective’, **21**(3)
2012, ‘“Popularizing and Policing ‘Darwinism’ 1859-1900”, **21**(7)
2012, ‘Mario Bunge: An Evaluation of His Systematic Philosophy, **21** (10)
2013, ‘Philosophical Considerations in the Teaching of Biology: Pts.I, II, **22** (1, 2).
2013, ‘Cross-National and Comparative History of Science Education’, **22**(4)
2013, ‘Philosophy and Chemistry Education’, **22**(7)
2014, ‘History, Philosophy and Mathematics Education’, **23**(1)
2014, ‘Genetics and Society’, **23**(2)
2014, ‘Science and Literature’, **23**(3)

The Contents of all the above issues can be downloaded from the journal’s Springer site: http://www.springer.com/education/science+education/journal/11191

(g) Reviewing

Informed and competent reviewing is a time-consuming and arduous task, but it is crucial to the integrity and quality of published work. Editors, authors, readers, and the scholarly enterprise more generally, benefit from this mostly anonymous and un-rewarded labour of dedicated scholars.

The journal policy is to send only strong papers to review, and then to seek multiple (3-6 and sometimes more) reviewers for these papers. About one-third of strong papers sent to review are nevertheless rejected, with the balance being asked to revise in the light of reviewers’ comments. Reviewers’ time is precious and already over-committed with their own research, writing and teaching responsibilities. Given a limited pool of high-quality reviewers, it is best that their energy is concentrated into improving strong papers, rather than being spread thinly across numerous papers many of which are far from publishable quality. Authors of these latter papers are encouraged to improve them and make a new submission that is developed enough for review.

The journal is noteworthy for having so many competent reviewers from the disciplines of Education, Science, Mathematics, Philosophy of Science, History of Science, Sociology and Psychology. Manuscripts are usually reviewed by three scholars, and often by four, five and sometimes more established scholars from these different disciplines.

A list of the 920+ reviewers who have contributed their time and expertise over the past six years to making the journal so successful can be found at:

http://ihpst.net/journal/reviewers/list-of-reviewers/

Apologies to any journal reviewer inadvertently left off this list. Please inform the editor so that the posted list can be corrected.

The following are comments from authors about the reviewing process:

> *# We would like to thank the seven reviewers for their inspiring comments and suggestions. By taking them into account we certainly have improved our paper. Below, we explain how we addressed each specific comment.*
>
> *# I have never been provided with such a comprehensive body of criticism to any paper I have submitted to press. Furthermore I agree with most of the criticism and believe it will help me to improve on the paper. There are some issues I do not agree with, but I will argue this in detail in my response.*
>
> *# We are thankful for the decision of sending the manuscript to eight competent reviewers. Despite the bigger amount of work, we are sure that it has greatly improved the quality of the paper. The decision demonstrates your awareness of the complexity and interdisciplinary character of our proposal. This is confirmed by noticing that the reviews address different issues, which are related to different parts of the article. It also attests your commitment to the quality of the papers published in* Science & Education.
>
> *In any case we would like to express our very many thanks to all the referees for what they have done for us. They surely helped us in a way that is quite uncommon in the scientific community. Even better, we have to state that there are no words to express our gratitude to them. We are proud to have such competent and helpful colleagues.*
>
> *# Thank you for sending the manuscript to four senior scholars for review. ...I have never received comments and criticisms from such wide perspective. This will definitely help to improve on the overall quality of the paper.*

One reviewer has written:

> *I have reviewed for other journals. I certainly must say that you provide excellent support to the authors. You are providing excellent service to researchers. Reading other reviewers comments is also a great learning experience for me.*

The editor of another research journal has pleasingly written:

> *Your review process is exemplary.*

Scholars with research interests in areas of history, philosophy and science/mathematics education are most welcome to apply to join the journal's reviewer group. Please send email with brief Curriculum Vitae and mention of particular areas of competence and interest to the journal editor: Michael R. Matthews (m.matthews@unsw.edu.au)

4. Journal Thematic Issue, Call for Papers: The Interplay of Physics and Mathematics: Historical, Philosophical and Pedagogical Considerations

There has been a profound historical and epistemological interplay between physics and mathematics; however in educational contexts the two subjects are often treated quite independently. In physics education, it is not unusual to find mathematics being seen as a *mere tool to describe and calculate*, whereas in mathematics education, physics is commonly viewed as a *context for the application of mathematical concepts* that were previously defined abstractly. This separation extends from classrooms to the physics and mathematics education research communities.

This problem demands a systematic research effort from experts in different fields, especially the ones who aim at informing educational practices by reflecting on historical, philosophical and sociological aspects of scientific knowledge. We therefore invite mathematicians, physicists, historians, philosophers and educators to contribute to this special issue of *Science & Education*. Both theoretical and empirical studies are welcome.

Examples of topics:

Historical case studies that highlight the mutual interplay between physics and mathematics (especially for the genesis of theories and concepts) and possible applications in education.

Philosophical issues concerning the physics-mathematics relationship (e.g. Wigner's puzzle, Explanation vs. Description, Induction vs. Deduction) and their educational implications.

Theoretical frameworks for integrating physics and mathematics in educational settings (e.g. integrated courses, curricular concerns).

Sociological and/or cultural aspects of this interplay: Differences and similarities between the aims and methods of mathematicians and physicists.

Cognitive and/or psychological issues associated with the use of mathematical representations (e.g. equations, diagrams) for the learning of physics.

Classroom experiments and/or teaching-learning sequences that propose integrated approaches for teaching mathematics and physics.

Analysis of students' difficulties and conceptions concerning the relationship between physics and mathematics.

Implications of the physics-mathematics interplay for pre- and in-service teacher education.

Deadline for Submissions: July 1st, 2014

Submissions to: www.editorialmanager.com/sced
Choose *Physics & Mathematics* as mss type.
Journal *Style Guide* is on web page and needs to be followed.
Notification of intention to submit and subject matter is appreciated as it assists coordination and planning of the issue.

Questions and inquiries should be directed to the guest editor:

Ricardo Karam
Alexander von Humboldt Postdoctoral Research Fellow
Physics Education, University of Hamburg Germany
ricardo.karam@uni-hamburg.de

5. The 3rd Latin American Regional IHPST Conference, November 17-19, 2014, Santiago, Chile

The *3rd Latin-American Regional Conference of the International History, Philosophy, and Science Teaching Group*, *IHPST-LA 2014*, will be held in Santiago, Chile, from the 17th to the 19th, November 2014. The conference follows earlier successful regional IHPST conferences in Brazil (2010) and Argentina (2012).

The Conference is organised by the "Laboratorio GRECIA", Laboratory of Research and Innovation in Science Education, from the Pontificia Universidad Católica de Chile (PUC), and sponsored by IHPST, the "Bellaterra Society" for research in didactics, history and philosophy of science in Chile, and several public and semi-public Chilean Universities.

Head of the Organising and Scientific Committees is Dr. Mario Quintanilla, Director of the "Laboratorio GRECIA", and Professor at the PUC (mariorqg@gmail.com)

The venue for the Conference will be the Facultad de Educación (School of Education) of the PUC, located in the San Joaquín Campus, District of Macul, conveniently connected to the city centre by metro and bus.

Activities include plenary lectures, oral and poster presentations, and symposia. As it was instituted in the previous Latin-American Conferences (Maresias 2010 and Mendoza 2012), the official languages will be Spanish, Portuguese, and English.

More information on important dates, fees, forms of participation, venue, accommodation, contact is available at the web-site of the Conference:

http://sociedadbellaterra.cl/congreso2014 /

6. The 2nd Asian Regional IHPST Conference, December 4 –7, 2014, Taipei, Taiwan

The second Asian Regional IHPST conference will be held in Taipei, Taiwan, December 4-7, 2014. The Conference Chair is Prof. Dr. Chen-Yung Lin (lcy@ntnu.edu.tw) and the Secretary is Shiang-Yao Liu (liusy@ntnu.edu.tw) both from National Taiwan Normal University.

Conference theme

Re-examining Science: Historical, Philosophical, and Sociological Approach to Public Engagement with Science.

The conference will be held at the Howard Civil Service International House, located alongside the university.

Keynote speakers

John Dupré is Professor of Philosophy of Science and Director of Egenis, the Centre for the Study of Life Sciences, at the University of Exeter.
Mansoor Niaz is a Professor of science education at the Universidad de Oriente, Venezuela.
Kuang-Tai Hsu is a professor of history at National Tsing Hua University, Taiwan.

C. Kenneth Waters is currently the Samuel Russell Chair of he Humanities and Director of the Minnesota Center for Philosophy of Science at the University of Minnesota.
Otávio Bueno is Professor of Philosophy and Chair of the Philosophy Department at the University of Miami.
Alan Love is Associate Professor of Philosophy at the University of Minnesota and a member of the Minnesota Center for Philosophy of Science.
Szu-Ting Chen is a professor in graduate institute of philosophy in National Tsing Hus University, Taiwan.

Important Dates

- Submission system available on 31 March, 2014
- Deadline of submission: 15 July, 2014
- Notification of abstract acceptance: 1 September, 2014
- Early bird registration deadline: 30 September, 2014
- Registration deadline: 15 October, 2014

Registration fee:

		Before September 30	*After September 30*	*On-site (cash only)*
Regular	member	180 USD	220 USD	245 USD
	Non-member	225 USD	265 USD	290 USD
Student		125 USD	155 USD	175 USD

Further information about the conference can be found at:

http://www.sec.ntnu.edu.tw/ihpst2014/.

7. European Society of History of Science, 6th International Conference, Lisbon, 4-6 September 2014

The 6th International Conference of the European Society of History of Science will be held in Lisbon, **4-6 September 2014** and is organized by the Interuniversity Centre for the History of Science and Technology (CIUHCT), a research centre associated with the Faculty of Sciences of the University of Lisbon and the Faculty of Sciences and Technology of the New University of Lisbon.

The 6th ESHS aims at stimulating historical and historiographical studies and debates on the communication of science, technology and medicine along the following sub-thematic clusters.

1) Human and non-human agents: experts, amateurs, and institutions;
2) Networks of circulation and communication of knowledge;
3) Means of communication: correspondence, papers, books, textbooks, popularization outlets, newspapers, radio, theatre, films, cartoons and internet;
4) Spaces and modes of communication: conferences, classrooms, public demonstrations, exhibitions, instruments, collections and museums;
5) Audiences: lay and specialized audiences, consumers;
6) Rhetorical devices;
7) Communication in the European Periphery;
8) Communication in a globalized world: challenges and constraints; ideology of communication, hegemonic values and commercialized science, technology and medicine

For any other information please contact the local secretariat:
Fátima de Haan (occoe@occoe.pt)

On behalf of the Local Organizing Committee
Ana Simões (aisimoes@fc.ul.pt)

Maria Paula Diogo (mpdiogo@netcabo.pt)

8. 15th Congress of Logic, Methodology, and Philosophy of Science (CLMPS 2015), University of Helsinki, Finland, 3-8 August 2015

Submission deadline: 30 November 2014

The Congress of Logic, Methodology and Philosophy of Science (CLMPS) is organized every four years by the Division of Logic, Methodology and Philosophy of Science (DLMPS) of the International Union of the History and Philosophy of Science.

The Philosophical Society of Finland, the Academy of Finland Centre of Excellence in the Philosophy the Social Sciences (TINT) and the Division of Theoretical Philosophy (Department of Philosophy, History, Culture and Art Studies) are proud to host the 15th Congress of Logic, Methodology and Philosophy of Science (CLMPS 2015). CLMPS 2015 is supported by University of Helsinki and the Federation of Finnish Learned Societies.

CLMPS 2015 calls for **contributed papers, contributed symposia,** and **affiliated meetings** in thematic sections:

A. Logic
B. General Philosophy of Science
C. Philosophical Issues of Particular Disciplines

Contributed papers: Please submit an abstract of 300 words prepared for autonomous review.

Contributed symposia: Please submit an abstract of max. 1700 words prepared for autonomous review.

The abstract should include:

a. a general description of the format and the topic of the proposed symposium and its significance (up to 500 words)
b. a 300-word abstract of each paper (3-4 papers)

Abstracts should be submitted by using the CLMPS 2015 registration form:
http://ilmo.contio.fi/academiceventsabstract/

Authors are kindly asked to consult the detailed submission guidelines before submitting: http://helsinki.fi/clmps/materials/guidelines.pdf

All questions about submissions should be directed to the congress sectary, Ms. Päivi Seppälä (clmps-2015@helsinki.fi).
The members of the programme committee, DLMPS committees and the local organising committee are listed here http://clmps.helsinki.fi/committees.php

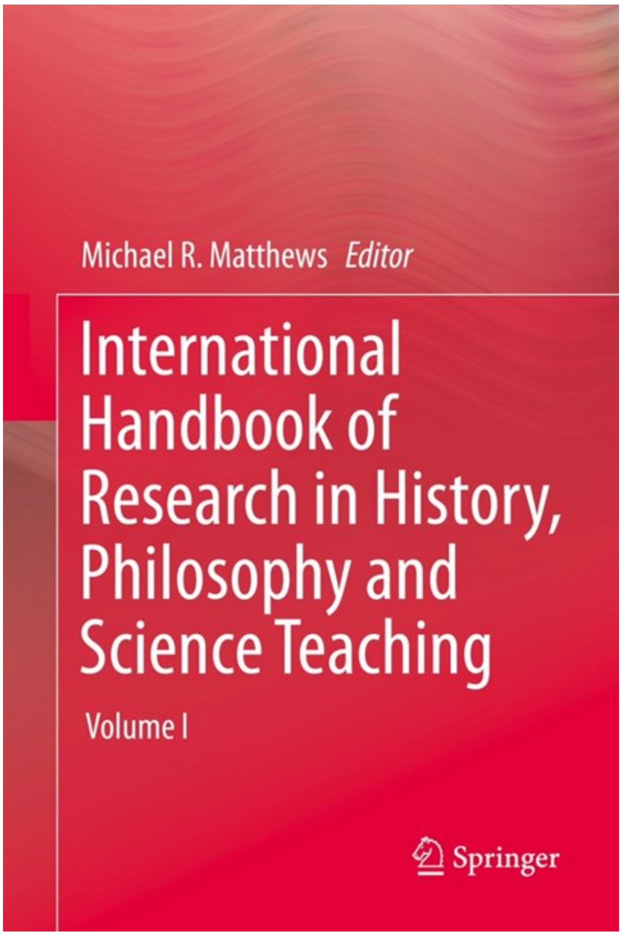
Important dates

30 November, 2014	Deadline for abstract submissions
15 January, 2015	Congress registration opens
30 January, 2015	Notifications of acceptance
3-8 August, 2015	CLMPS 2015, University of Helsinki

Website: http://www.helsinki.fi/clmps

9. International Handbook of Research in History, Philosophy and Science Teaching

In July the first handbook devoted to the appraisal and synthesis of past and current Research in History, Philosophy and Science and Mathematics Teaching will be published by Springer. It consists of 2,544 pages in 3-volumes, with76 chapters, written by 125 authors from 30 countries.



The extensive scope of the work is reflected in the Subject Index which has 2,000 entries, the Name Index which has 3,600 entries, and in the 10,200 references cited.

Recognising the intimate historical connection between science and mathematics, and between students' learning of science and learning mathematics, seven chapters are devoted to historically and philosophically-informed research in mathematics education.

The handbook is structured in four sections: pedagogical, theoretical, national, and biographical research. Each chapter sets the relevant literature in its historical context, and engages in an assessment of the strengths and weakness of the research addressed, and suggests potentially fruitful avenues of future research.

The Handbook lays out the rich tradition of historical and philosophical engagements with science and mathematics teaching, and that lessons can be learnt from these engagements for the resolution of current theoretical, curricular and pedagogical questions that face teachers and administrators.

Where institutions have purchased the Handbook, their staff and students can download individual chapters gratis. Further, such staff and students utilising the Springer *MyBook* scheme can purchase the whole 3-volume printed work for EUR25 or USD35. An e-Book version will be available for general purchase.

Gerald Holton, Physics Department, Harvard University

> Science educators will be grateful for this unique, encyclopaedic handbook, which provides a balanced guide to the whole spectrum of research on the inclusion of history and philosophy in science teaching.

Fabio Bevilacqua, Physics Department, University of Pavia

> This handbook is the most comprehensive attempt at bridging the worldwide "two cultures" gap in education. It gathers the fruits of over thirty years' research by a growing international and cosmopolitan community

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978-94-007-7654-8 (e-book)

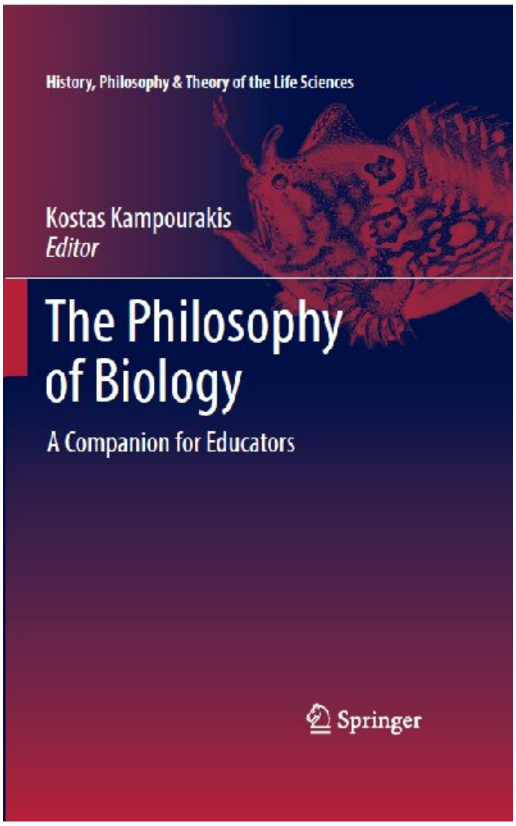
http://www.springer.com/education+%26+language/book/978-94-007-7653-1

10. Book Reviews

(i) Kostas Kampourakis (ed.) (2013) *The Philosophy of Biology: A Companion for Educators*, Springer, Dordrecht.
ISBN: 978-94-007-6536-8, 762 pages, price: US $ 219.00

Reviewed by: Charbel N. El-Hani, Institute of Biology, Federal University of Bahia, Salvador, Brazil. e-mail: charbel.elhani@pq.cnpq.br

General appraisal



The Philosophy of Biology: A Companion for Educators, edited by Kostas Kampourakis, is a most useful addition to the scholarly resources available to both science educators and science education researchers. The volume gathers several well-known scholars in the philosophy of biology, addressing a large range of topics in good quality and generally accessible chapters. There are some chapters, however, that pose more difficulties to the readers, particularly those not acquainted with philosophy of science, more generally, or philosophy of biology, in particular. But we can see through the whole volume the results of Kampourakis' focused editorial work in the efforts evidently made by the authors to make their arguments more accessible to an audience that is not the usual one they address.

A nice resource provided by the book is the glossary at the end of the volume, which will be useful for the science educators and other readers to which some concepts used in the chapters are not familiar. We could dispute one or another definition provided for the concepts, but this would miss the more important aspect, the relevance of the editorial work of putting together such a glossary. This is yet another indication of all the care that was taken for the volume to be useful for educators. Finally, cross-references to other chapters are found throughout each chapter in the book, contributing to an integrated reading. This is important because there are many and significant connections between the issues discussed in each chapter. In sum, this is a highly commendable book, which will find a natural and deserved place in the library of educators, researchers, and students alike.

Michael Ruse's foreword is justifiably enthusiastic. This is indeed a volume that can give us a feel of how to see the world through biology informed by philosophy, to paraphrase Ruse's last sentence in the foreword. We live in challenging times where biological knowledge is a key factor for our survival and life quality, where the increasingly integrated world has to face serious problems for producing enough resources in a sustainable manner in order to maintain humans now and in the future, and in a more equitable manner than in the past. If we ever succeed in making progress towards overcoming our present situation, this involves and will involve science and technology, and, consequently, scientific and technological education. And as the HPST community always stressed, our pupils need to know not only the outcomes of scientific research, the conclusions reached, but also what is science, how it represents the world, how it poses problems, how it struggles to solve them, how (and complexly) it is related to technology, society, and the environment. Despite the judgment of a number of scientists who do not value philosophy, we still have those that see clearly how much it contributes to science. One argument might be enough to show the value of philosophy to science: no knowledge is ever produced without epistemological underpinnings, and, thus, if a scientist doesn't take philosophy seriously, this means that his or her underpinnings are epistemological unchecked luggage. Thus, it cannot be subjected to criticism and appraisal, and we know that where no critical eyes are ever cast, naivety finds a fertile terrain to grow.

Therefore, I am quite sure that the volume edited by Kampourakis, even though targeted at biology educators and teachers, at both secondary school and undergraduate-level university courses, can have – indeed should have – a broader audience. Science education researchers can surely benefit from it. But also biologists, and, taking a more general perspective on the role of biology in current science and society, also educators dedicated to other disciplines, curriculum developers, researchers from other scientific fields. Moreover, philosophers can also benefit from the book, as a way of pondering about how philosophical work can contribute to education.

The anthology was conceived as an extension of a thematic issue Kampourakis edited for *Science & Education* in 2013 (vol.22 nos.1, 2) and presents philosophical analyses of important topics in biological education. It includes 30 chapters dealing with a diversity of topics in the philosophy of biology, written by philosophers of biology or philosophically minded biologists. All chapters highlight contributions from the philosophy of biology to two domains put into focus by the editor, conceptual understanding and NOS understanding. The intention was that they could be characterized by both high quality philosophical scholarship and a sense of usefulness in biological education. The topics were selected based on educational criteria framed by Kampourakis' personal view on what would be an ideal biology curriculum taking into account philosophical issues raised by this science. They answer, thus, to five characteristics discussed in the introduction to the volume:

- An evolutionary framework, given that evolutions plays a central unifying role in biology;
- A developmental perspective, which avoids focusing on DNA and genes and then leaping to organisms and phenotypes, so that development ends up in a black box;
- An integrative approach, focused on the integration of disciplines in the understanding of living systems;
- A socio-ethical dimension, given the direct implication of the life sciences to several aspects of human life, putting their social and ethical implications in the foreground;
- A contemporary view, not in the sense that biological education might follow all current developments in biology, but that an updated view is in many senses needed to educate citizens capable of taking informed decisions about key aspects of our individual and social lives.

Kampourakis consistently refers to gene-centric views when explaining these characteristics. He mentions, for instance, that concepts like genes and phenotypes seem outdated in a period where biological researchers rather talk about genomes and life cycles. This is well taken. In the current scenario in biological education, the developmental perspective shows particular importance given the prevalence of gene-centric views (see, e.g, Gericke et al. 2014). As stated in the causal parity claim, genes and other material causes are on a par in development (see Griffiths & Knight 1998). From this perspective, there is indeed more to biology than nucleotide sequences, as there is more to language than just letter sequences, as Kampourakis writes (p. 3). If we try to understand life only on molecular terms, we fall prey to exercises in meaninglessness, as discussed in Hofstadter's dialogue *...Ant Fugue*, in *Gödel, Escher, Bach* (1979):

> *Anteater:* … imagine trying the following game: you must find a way of mapping letters onto ideas, so that the entire *Pickwick Papers* makes sense when you read it letter by letter.
>
> *Achilles:* ... you mean that every time I hit a word such as 'the', I have to think of three definite concepts, one after another, with no room for variation?

> *Anteater:* Exactly. They are the 't'-concept, the 'h'-concept, and the 'e'-concept – and every time, those concepts are as they were the preceding time.
>
> *Achilles:* Well, it sounds like that would turn the experience of "reading" *The Pickwick Papers* into an indescribably boring nightmare. It would be an *exercise in meaninglessness*, no matter what concept I associate with each letter (Hofstadter 1979, p. 326).

The idea underlying the project was that the chapters were readable and comprehensible by people without formal training in philosophy of science. Thus, when I was invited to write this book review, I thought that it would be relevant to use part of the chapters in an undergraduate course to verify to what extent my students could really understand and benefit from them. I did so in the second semester of 2013, when I taught a course for biology undergraduates on philosophy of biology in Federal University of Bahia, in Brazil. The course was attended by 10 students, half of them preparing to become biology teachers, half aiming at following scientific careers. Methodologically, it was based on seminars and paper discussions. In my comments on the chapters below, I will make thus comments resulting from the use of some of them in the classroom, but will also consider if they could be used in secondary school or at least by teachers working in this educational level.

2. A chapter-by-chapter walk through the book

2.1. The science of life

Using the same grouping of chapters employed by Kampourakis in his introduction, let us begin with those that tackle more general issues related to the life sciences.

The first chapter, entitled "What is life?", written by Carol Cleland and Michael Zerella, discusses the difficulties for clearly answering this question, considering how the philosopher endeavor to do so is useful for students to appreciate science as an ongoing process of critical investigation. For them, to rely on definitions as a guide for scientific research is a mistake. Definitions of life do more harm than good, in their view, because they intend to determine what counts as a living thing before scientists have enough information in hand to justify such a generalization. After all, up to now we only investigated life-as-we-know-it in its Earthly instances, not knowing about possible life forms in other planets, and, perhaps, even here, as the "shadow" life the authors interestingly discuss in the chapter. If we rely on definitions of life based on our limited understanding, we may hinder rather than help the search for new forms of life, including those that might exist on Earth.

Biology students are usually limited in their experience to familiar forms of life, typically plants and animals, and that's part of the reason why to tell what is living or not seems easier than it is in fact. Biology textbooks tend to define life in terms of particular characteristics and do not deal with difficult cases such as viruses. To take into consideration the difficulties that arise when we try to explain life in more general terms and, also, to look for other forms of life are helpful to bring students closer to the nature of scientific investigation.

This is one of the chapters I used in the classroom with good results, since it fostered a useful discussion, showing to be accessible for the students. Moreover, it seems to be understandable and useful to teachers working in secondary school, and, perhaps, also to their students.

In the second chapter, "Biological Explanation", Angela Potochnik discusses explanation in biology, considering how explanatory practice in this science influenced philosophical accounts of scientific explanation. She summarizes different explanatory strategies used in biology, but instead of resting content with a pluralist solution, she strives for a unitary account of biological explanation, based on the idea that causal information is explanatory. At the end of the chapter, she offers suggestions for teaching about biological explanation that are indeed useful, at both secondary and university teaching:

- Do not overly emphasize laws when thinking (and, we can add, teaching) about biological explanations.
- Explicitly motivate forms of explanation that are common in biology.
- Resist the temptation to simplify the diversity of approaches in biology and their apparent incompatibility.
- Explicitly consider the role of models.
- Emphasize methodological differences over seemingly ideological differences.

These suggestions are well taken and can be helpful for an approach to biological education that gives a more prominent role for explaining rather than classifying concepts and providing definitions, as usually stressed in biology teaching.

Using this chapter in the classroom was also quite helpful, even though the students had more difficulty, given the lack of a philosophical background that could help them understand topics like Hempel and Oppenheim's deductive-nomological model. Nevertheless, by reading and discussing Potochnik's chapter they could grasp at least part of the issues and arguments related to explanation in biology. Thus, I think this chapter plays the role intended by the editor in offering undergraduate students and preservice and in-service teachers an accessible avenue for understanding biological explanations in their diversity. It doesn't seem fit, however, for secondary students, albeit it can help their teachers in preparing themselves to consider the topic when planning their lessons, perhaps integrating some ideas here and there while teaching other topics.

The third chapter, "What would Natural Laws in the Life Sciences be?", by Marc Lange, is a different matter. Philosophically, it is a highly competent discussion about what scientists are arguing about when they discuss whether there are laws in the life sciences. Or, to put it differently, on the features of scientific reasoning captured by the notion of a natural law, whether these features are relevant in the life sciences and if there are laws in this field to fulfill the relevant roles. But I doubt a biology educator, let alone an undergraduate student or preservice teachers, can follow the intricate arguments in the chapter. My feeling in the classroom was that the students initially didn't have a clue about what was going on in those pages, and thus I needed to engage in developing the argument step by step. That's really a pity because Lange's approach is a refreshing and powerful blow in the long discussion on biological laws. His claim that statements can play the roles ascribed to physical laws, despite exceptions and contingencies, if they are invariant under a broad range of counterfactual antecedents that are relevant for the purposes of a field, showing enough stability to be reliable for those purposes, is indeed convincing. If and when this volume reaches a second edition it would be worthwhile reworking this chapter so that it can realize its full potential contribution to biology educators and other readers.

2.2. The nature of evolutionary theory

Massimo Pigliucci discusses the combination of experimental and historical elements in evolutionary biology in the chapter "The Nature of Evolutionary Biology: at the Borderlands between Historical and Experimental Science". A major part of the chapter is devoted to the examination of debates on the epistemic status of evolutionary theory, particularly those involving the dichotomy between chance and necessity (Monod 1971). Thus, Pigliucci addresses, for instance, the Fisher-Wright debates on the role of genetic drift and selection in evolution. He also considers the polemics about the gradual or punctuated pattern of evolution and the role of developmental constraints in limiting the power of selection, both provoked by Stephen Jay Gould writings (with different colleagues). On the educational side, his main argument is that evolutionary biology is taught from a narrow perspective, without considering its historical and philosophical contexts in an appropriate manner. As Kampourakis stresses in his introduction, to discuss historical and experimental aspects of evolutionary biology is important, because in school science evolution is often explained as change in gene frequencies, without due attention to its historical nature. This chapter was also discussed by my students, with rewarding results. It seems appropriate for both undergraduates and teachers, and can certainly inform in-service teachers in the construction of their practice in evolution education.

Evolutionary theory (and, more specifically, Darwinian evolutionary theory) has been (and still is) a target of criticism. Kevin McCain and Brad Weslake discuss these criticisms from an epistemological perspective, addressing, for instance, the claims that it is not falsifiable, that it has been falsified, that it does not make predictions, among others. This is another important chapter, since we still find people saying that there is no evidence for natural selection, despite the wealth of positive evidence derived from experimental studies in both natural and laboratory conditions, along with mathematical modeling and computer simulation studies. This chapter was not put to test in my classroom, but it doesn't seem to pose major difficulties for undergraduate and preservice and in-service teachers.

David Depew's chapter, "Conceptual Change and the Rhetoric of Evolutionary Theory. 'Force Talk' as a Case Study and Challenge for Science Pedagogy", begins by claiming that Darwin reached in the first edition of *Origin of Species* a subtle and delicate balance between determinism, contingency, and teleology. He shows how Darwin used a series of interacting metaphors to combine the functional and goal-directed quality we see in living beings, an element of chance in their origins, and the deterministic role of environmental agencies in shaping them. This delicate explanatory balance was misapprehended by friend and foe, and was eventually broken in subsequent editions of *Origin* through changes Darwin did to answer critics and to follow supporters' suggestions. A particularly harmful change is discussed in more detail by Depew, the introduction of Spencer's expression "survival of the fittest", which favors a Spencerian version of natural selection as an eliminative force that reap off individuals except those with advantageous traits. There is an important difference, however, between this view and Darwin more subtle understanding of natural selection as a more positive force, which does not only eliminate the unfit (although this happens for Darwin, in some specific conditions he examined, such as very hard climatic conditions), but also produces the fit through a long process of discrimination among variants, no matter if they are just slightly advantageous. This subtle distinction between the eliminative and positive roles of selection is gone from popular interpretations of Darwinism, because Spencer's version prevailed, as Depew shows. An important note to be remembered in studies on evolution education is found here, and more inquiry can be fruitfully directed to both diagnosing students' views about these two meanings of selection, and how they can be changed through interventions sensitive to this subtle distinction. Depew also considers subsequent history of evolutionary thought, for instance, how the creative role attributed by Darwin to natural selection was revived by the population genetic theory of natural selection, particularly by Fisher, in a key development for the modern synthesis. He also discusses how contemporary Darwinism begins to look more like Darwin's version than the modern synthesis, even though more in rhetorical than conceptual terms. Depew also argues that biology textbooks should point to the different conceptual frameworks of evolution along its history (including, we can add, non-Darwinian frameworks), instead of conflating every idea in a cumulative version that reads a lot back into Darwin. Another important aspect to bring to the classroom in both secondary school and university is the discussion of the balance between determinism, contingency, and teleology in Darwin's original theory. After all, this goes against common criticisms that do not capture the meaning of Darwin's accomplishment, for instance, the claim that his theory is all about chance resulting in the diversity of life, with all its awesome adaptations. Moreover, in current evolutionary thinking, it will be consequential to ponder about that balance. In my experience in using chapters of the book edited by Kampourakis in the classroom, this was a rewarding chapter, leading to a rich discussion that the students could follow. It is helpful for philosophically minded researchers and biology teachers alike, and, if properly edited, can also find its way to the readings assigned to students in the secondary level.

A discussion about adaptation, as a central concept in evolutionary thinking since Darwin, and adaptationism is an important addition to school treatments of evolution, including those at the secondary school. As a testimony to the impact of Gould and Lewontin's "spandrels of San Marco" (1979), different kinds of adaptationism unfolded in the subsequent years, and philosophers of biology clarified the distinction between empirical, methodological, and explanatory adaptationism (e.g., Godfrey-Smith 2001). Patrick Forber's chapter, "Debating the Power and Scope of Adaptation", deals with these topics, discussing the issues raised by each kind of adaptationism. One thing is to discuss empirical questions related to the prevalence of adaptation in the biological world, where the key element is how to test adaptationist hypotheses with different models. This topic was hotly discussed by philosophers of biology, and Forber shows us the conclusion that determining whether natural selection provides a sufficient explanation for a trait is no walk in the park, but a rather difficult task. Another thing is to consider the methodological question about whether and how we should investigate the world by looking for adaptations and their explanations based on natural selection. Methodological adaptationism seems to be the stronger position, but also faces a difficulty discussed by Forber, namely, that model testing should not only provide evidence for some hypothesis, but also against rival hypotheses. After all, if adaptationist explanations were accepted with insufficient or even no evidence, as pointed out by Gould and Lewontin (1979), the same is true of exaptationist hypotheses, as discussed by Andrews et al. (202), including those proposed by Gould himself. The case of the spotted hyena sexual mimetism provides a good example of both adaptationist and exaptationist hypotheses accepted without enough evidence (Sepulveda et al. 2011). Finally, explanatory adaptationism concerns the adoption of a particular perspective for explaining life more generally. This version of adaptationism is a defense that the apparent design of organisms – i.e., the intrinsic complexity of biological structures and mechanisms and their apparent functionality in dealing with environmental challenges – is the most intriguing fact in biology. Despite its limits (for instance, due to constraints), natural selection has a unique explanatory power for those defending this position because it provides the only satisfying explanation for the problem of apparent design (e.g., Dennett, 1995; Dawkins, 1996). The challenge here is to justify in scientific terms the priority given to design complexity as the key problem in evolution, given the diversity of evolutionary phenomena. Evidently, there are also difficulties in the relation between scientific and pseudoscientific endeavors such as Intelligent Design, which also favors design complexity as the problem to be solved when it comes to understanding the living world. But there is no objective manner of deciding which natural phenomena is more intriguing, and explanatory adaptationism seems to be reduced to a matter of personal preference (Godfrey-Smith 1999). In authors like Dawkins and Dennett, this preference is not rooted in biological evidence *per se*, but in an intellectual project of defending a secular worldview, with a central role for natural selection. But explanatory adaptationism cannot be subjected to empirical testing and, moreover, as an strategy to defend a secular worldview, it seems to backfire, as Intelligent Design appeal to irreducible complexity in the design of living beings shows.

To differentiate these forms of adaptationism is important, since the arguments to either support or attack them are importantly different. Moreover, to discuss them in the classroom provides a good platform for NOS instruction, since it raises several relevant questions: empirical questions about the prevalence and power of natural selection; methodological questions about the testing of evolutionary hypotheses; questions about the importance and status of core concepts in evolutionary theory; and questions about the relation between evolutionary thinking and other worldviews. Forber's chapter helps students and teachers to understand this complex issue, and using it in the classroom showed that, despite some initial difficulty with terminology, undergraduates and preservice and in-service teachers can benefit from reading it.

2.3. Evolutionary theory and religion

Three chapters on the relation between evolutionary biology and religion are included in the companion. Generally speaking, they are accessible to undergraduate students and teachers, and, if properly edited, can also be used with secondary school students (with the possible exception of Brigandt's arguments against the probabilistic claim for ID, which will be probably harder for all these audiences). All in all, these chapters are helpful for teachers working on multicultural classrooms, as most of them are (El-Hani & Mortimer 2007), particularly when they need to enter into dialogue with religious students, something also very common. Part of these students can be fundamentalist rather than liberal religious people, depending on the sociocultural circumstances where the teacher works. Thus, to give educators a proper philosophical (and also historical and sociological) background to deal with the complex relations between science and religion is a key element in teacher education. This anthology brings a relevant contribution to the task.

In Francisco Ayala's chapter, the argument from design is the starting point, particularly in the version provided by William Paley in his *Natural Theology*, a book that exerted important influence on Darwin's thinking (illustrating Alexander's argument, in the next chapter in the book, that religious belief has played in some cases a positive role in the history of the biological sciences). Darwin, however, explained the argument from design away, by providing an account of the adaptations of organisms as the outcome of natural processes (both internal co-adaptation, more focused by Paley - see Caponi 2011 - and adaptation to the conditions of existence, as formulated by Darwin). If we conceive Darwin's work as a naturalization of the explanation of design, we will be able to see how futile are Behe's arguments in his *Darwin's Black Box* (1996) for design as indicating the existence of a designer, even if we don't state who or what the designer was (see his chapter 9, "Intelligent design"). Even if his irreducible complexity argument was correct (albeit it is not, as shown by Brigandt in his chapter in the companion), it would miss completely the point, since to show that there is design does not dismiss at all Darwin's *explanans*, only reinforces his *explanandum*, to which he provided an entirely natural *explanans*, dispensing with any intelligent designer.

Evidence for evolution is abundant, and among them, Ayala focuses on fossils and molecules, providing useful discussions of recent fossil discoveries that fills missing links so cherished by creationist books and pamphlets. Consider *Tiktaalik* and its implications to the history of land conquest by vertebrates, or the wealth of hominin fossils that clarify several aspects of the history of our lineage. All these developments are very exciting and it is a pity that some students miss the opportunity to learn about them because of fundamentalist positions. Molecular evidence for evolution and, also, evolutionary relationships between clades is also remarkable, as Ayala calls attention to. He also devotes part of the chapter to an interesting discussion about how the problem of evil in the world can be convincingly explained by natural selection. In the end he assumes a position about the relation between science and religion that seems to align with the complementarity model, as discussed by Denis Alexander.

This leads us to the next chapter, "The Implications of Evolutionary Biology for Religious Beliefs", where Alexander both describes the historical background for contemporary discussions about the relation between Christian religion and evolutionary biology, but also charts the current proposals to frame those relationships, addressing four positions found in the literature: (1) the conflict model, according to which science and religion are in fundamental opposition (in 1996, in a thematic issue of *Science & Education* on religion and science education - issue 5(2) -, the conflict model was much debated); (2) the "non-overlapping magisteria" (NOMA) model, popularized by Gould (2002), which claims that there can be no conflict between science and religion because they address different types of question; (3) the fusion models, which blur the distinction between science and religion, even arguing for an "interdisciplinary" approach combining both; and (4) the complementarity model, considering that science and religion address the same reality from different perspectives and, thus, offer non-rival but complementary explanations. Ayala's position in the previous chapter seems to be more related to the complementary view, even though it might be conceptualized in terms of the NOMA model.

Anyway, both perspectives on the relations between science and religion neglect the fact that conflicts indeed happen when religions make cognitive statements about the natural world (as they typically do, since they have to deal with the problem of God's - or gods' - action in the world), or when science is taken as a point of departure to make sweeping claims for a scientific worldview, as we see in explanatory adaptationism, discussed above. Thus, perhaps the conflict model would be the best one. Not so. Because just as there are conflicts between science and religion in some quarters, religious thinking has played also a positive role in the development of some scientific interpretations of the world. Either an entirely conciliatory or entirely conflictive account of the relations between science and religion falls short of capturing their complexity. Are we left then with the fusion models? Not at all. They neglect that there are fundamental distinctions between the assumptions made by science and religion and, thus, to construct an integrating framework drawing on both sides may be nothing but constructing a building over inconsistent foundations. Perhaps our only choice here will be an ethics of coexistence (rather than conflict or consensus), as discussed by El-Hani and Mortimer (2007). In these terms, we should accept cultural differences and the fact that dialogue and confrontation of arguments will be inevitable in the search of possible solutions, and, if no solution is reached and conflict threatens to reign, we need an effort to (co-)live with differences in the absence of a negotiated outcome. Education has a key role to play in nurturing individuals capable of coexistence, something much needed in our contemporary world, and science education cannot escape this role. Among the requirements for educating people for coexistence, El-Hani and Mortimer highlight understanding of each others' ideas, since no true dialogue and confrontation of arguments will be possible if the parties involved don't understand what the others are saying. This is one of the reasons why they argue for understanding (scientific theories, models, and concepts) as a major goal of science education.

This connects with Ingo Brigandt's chapter, "Intelligent Design and the Nature of Science: Philosophical and Pedagogical Points", since ID harms precisely this goal of understanding. We shouldn't have any problem with creationism *per se*, as a religious position, which can be taught in religious classes (but not in the same manner in private religious schools and in public schools, where a comparative rather than indoctrinating approach to religious education, when present, should be taken). Creationism in itself is non-science, not pseudoscience, and provided it is not proposed as a goal of science education, we, as scientists, are not in a position to fight it. Thus, let us guide our efforts in the right direction, namely, proposals for including religious ideas in the science classroom, and, even worse, religious ideas disguised as (pseudo)science.

As Kampourakis claims, ID is unquestionably religiously founded. We can see the basic motivation driving ID in statements found in essays written by well-known creationist authors, such as Philip Johnson. Back in 1993, he wrote: "What the situation requires is a critique of evolutionary naturalism that puts aside the biblical issues for the time being and concentrates on the scientific and philosophical weaknesses in the established Darwinist orthodoxy" (Johnson 1993/2001, p. 438). What is this other than a call for developing something like ID? Notice that what Johnson proposes is a one-sided argument, aiming at showing that what he calls "Darwinist orthodoxy" is wrong. No word is said about proposing a positive account of what might explain evolution. This is not surprising because God would take the role of explanation, when biblical issues are brought back to the scene. So, what ID theorists do? They disguise God in allegedly scientific arguments. He would come back if they succeeded in showing that evolutionary and naturalist views are wrong. But if this success ever comes, it will not be for the quality of their arguments, evidence, and so forth. A further look at Behe's book is instructive here.

In this book, what we read is not much more than Paley's argument clothed in biochemical detail. But, while Paley puts forth a honest religious argument (even if one disagrees with it), Behe wants to talk about designs without stating the designer, as if this was an argument against Darwinist theories. The argument is not only insidious, but logically fallacious: it is a *non sequitur* argument, assuming a very gradualist account of evolution (let's call it *g*) and arguing that it does not function, thus showing – accepting that it shows such for the sake of the argument – that non-*g*; but, as everyone familiar with logic knows, showing that non-*g* does not amount to showing that *g*. Thus, ID advocates are left with the burden of providing a positive account of what they mean, not only a negative argument against a very schematic idea of evolution by natural selection. But what can they say then? Either they follow Paley in his honesty and declare their account to be religious, and, thus, without place in the science classroom, or they appeal to some extraterrestrial intelligent design (leading just to an infinite regression of designers), or they claim that "nature" is the designer, whatever this means ("nature" is a vague term and, if we follow the argument, albeit vague, I suspect that in the end the means for "designing" will be those proposed by evolutionary theory, leading us back to design naturalization).

Brigandt offers other arguments against Behe, and they are convincing, focusing on how evolution can produce complex systems through consecutive functionally different stages, or through redundant systems where parts diverge in their function, and so forth. He also criticizes the machine metaphor that provides a background for Behe's argument, advocating the view that organisms are flexible developmental systems, which indeed makes it much easier to understand the evolution of complex systems and subsystems in the living world. He also builds arguments against the claim that organisms are so complex that their natural origins are extremely improbable, as put forward by Dembski, among others. The core of his argument is that nothing can be inferred about the probable truth or probable falsity of a hypothesis based on its small probability, no matter how small. We can only ascertain something about the epistemic status of a hypothesis by comparing its probability with the probability of another hypothesis, and, here, as Kampourakis emphasizes in the introduction, evolutionary explanations of the origins of organisms have higher probability to be accurate than those advanced by ID proponents, particularly if we consider how little they have to say on a positive tone, rather than just arguing against the Darwinist views.

2.4. Evolution at the molecular level

The chapters on molecular evolution can play an important role in providing students and teachers with an entry to the complexities of the interplay between selection and drift and evolution at the genomic level. This is important because organismal selection strongly prevails in school science, with little to no attention been paid to molecular evolution.

Michael Dietrich's chapter, "Molecular Evolution", explains why this is an important process, which is not the domain of drift only. He argues against the divide between organismal-level and molecular-level evolution that was established after the neutralist challenge to selectionism. The situation is not so simple that one can say that selection prevails at organismic evolution, and drift, in molecular evolution. Certainly, any conclusion reached in this issue will depend on how drift is explained. Therefore, Dietrich provides an account of drift as a causal process interacting with selection, presented as a key point in understanding the divide. The outcome is an account of molecular evolution in terms of a complex interplay of drift and selection acting upon sites ranging from strictly neutral to strongly selected. This chapter is written in a manner that makes this challenging issue accessible to undergraduate students and pre-service and in-service teachers, and, perhaps, some passages can be selected to be used with secondary students.

John Avise offers the other chapter on molecular evolution, "Educational Lessons from Evolutionary Properties of the Sexual Genome", which is as accessible as the previous one. The most interesting aspect here is the discussion of conflict between levels of selection, a key idea that is lacking in the education of many biologists and teachers. Besides providing comments on natural theology before Darwin and ID in our times, Avise explains how gene-centered evolution in sexually reproducing organisms allows us to explain several observations about their genomes. As Reeve and Keller (1999) summarized fifteen years ago, the units of selection debate was overcome by a conception of multilevel selection, which recognizes the hierarchical character of natural selection. Thus, to recognize that selection on genes is important does not entail any denial of the importance of selection at other levels, but rather put in the foreground the relevance of investigating and understanding how selection at different levels can and do conflict. As Sterelny and Griffiths (1999, p. 43) write, "what's good for General Motors is not necessarily good for GM's office cleaner", and vice-versa. The same is true of organisms and their genes (or, for that matter, any other levels of selection). Avise shows us how sexual reproduction leads to selection at the level of genes. After all, genes in recombining genomes sometimes can increase their odds of survival and proliferation by acting to increase their fitness to the detriment of the fitness of the host organism. By considering this conflict, many otherwise enigmatic molecular aspects of sexual genomes can be clarified, including the evolution of mobile elements.

2.5. Evolution and development

Development was black-boxed in the modern synthesis and explanations of this complex process have been formulated in an entirely genetic basis (for instance, though the genetic program metaphor) in the second half of the twentieth century. Consequently, development was neglected in several quarters of biology, where to leap from genotype to phenotype, taking development for granted, became a common habit. If this leap was justifiable as a simplifying assumption of models such as those proposed in population genetics, the reification of such models led to simplistic explanations of phenotypes and the processes through which they are generated (Pigliucci & Muller 2010). In biological education, development was similarly neglected, both in secondary and university levels. Genes in DNA are described at both educational levels as controllers of cellular processes, programs for development, determiners of phenotypes (see, e.g., Gericke et al. 2014), sometimes to such an extent that the only way they could play the roles ascribed to them is if they were some kind of homunculus or micro-consciousness embedded in the nucleus. Not surprisingly, genetic determinism can be seen as a preformationist account of development rewritten in molecular terms.

Three chapters in the anthology call attention to development and its complex nature, and, by extension, to the complex mapping from genotype to phenotype. In Tobias Uller's chapter, entitled "Non-genetic Inheritance and Evolution", an entirely neglected topic in secondary education and, more often than desirable, in university-level education is considered. Beginning with a brief description of how heredity became an object of scientific study during the nineteenth century, initially in the context of development, Uller goes on to show how Mendelian genetics displaced heredity from its developmental grounds through a gene-centered perspective. More recently, however, the role of development in heredity came back to central focus, to such an extent that we can argue that we inherit developmental systems, in which genes are as important as other factors (the causal parity principle, mentioned above). Non-genetic systems of inheritance, for instance, play key roles in development, as shown by the epigenetic system, for instance, DNA methylation, which can silence genes and affect the phenotype so that it can be different from the one we would predict from DNA sequences. Other non-genetic inheritance systems affect the organisms mostly (but not only) after birth, such as the behavioral and symbolic ones.

When it comes to evolution, the influence of non-genetic inheritance can follow – as Uller argues – from (1) affecting individual fitness; (2) modifying the relationship between what is selected and what is inherited; and (3) modifying selection on future generations. Evolution education cannot neglect anymore the role of non-genetic inheritance. Uller helps in this task by providing an accessible chapter for both undergraduate students, preservice and in-service teachers, and, properly edited, even secondary students.

The concept of "Homology" is topic of the chapter by Alessandro Minelli and Giuseppe Fusco. They begin by describing the evolution of this concept through three phases. Initially, the concept of homology was non-historical, with shared characters being conceived as simply variants of the same archetype. With the advent of evolutionary thinking, the concept became historical, and shared characters were taken to be inherited from a common ancestor. More recently, with the discovery of deep homologies related to shared developmental genes, a proximal-cause concept of homology appeared, in which characters are taken to be homologous if they share the same generative gene network module. Minelli and Fusco argue for a context-dependent concept of homology, going beyond a simple relationship between two structures, to adopt a factorial interpretation, in which homology is not an all-or-nothing relation, but can come in several degrees. For instance, structurally non-homologous characters can be developmentally homologous if they independently co-opted the same developmental module. This interpretation can indeed lead to breakthroughs in homology studies. Moreover, teaching about homology – which is an important but often neglected element in evolution education – can benefit from Minelli and Fusco's chapter, which seems readable by teachers and undergraduate students, but not by pupils in secondary school.

Alan Love's chapter, "Teaching Evolutionary Developmental Biology: Concepts, Problems, and Controversy", was also used in my classroom, with nice results in students' discussion. It is understandable by students and teachers, and provides, also, a good example of the benefits of a philosophically grounded approach to a biological problem. Love departs from a consideration of problems as guides to and organizers of inquiry, inspired by Popper. For him, it is crucial, thus, to incorporate a problem-based image of science in teaching, highlighting the organizing role of problems. Evolutionary developmental biology provides him with a case study to defend this image of science and its role in education. He first considers the two-fold elucidation intended by evo-devo research: how development evolves and how development structures evolution. To consider both elucidations means to go beyond the picture of evo-devo mostly emphasized in popular and professional presentations, focused on the comparative developmental genetics of metazoans, to encompass paleontology, comparative embryology and morphology, investigations of epigenetic dynamics in different organizational levels, and computational or simulation oriented inquiry. That is, a broad rather than narrow view of evo-devo (Arthur 2011).

Love explains the conceptual foundations of evo-devo and the meaning of key concepts, such as constraints, modularity, and evolvability. He argues that the famous controversy around the relative explanatory power of natural selection and developmental constraints was not a clash of rival explanations, but of distinct explanatory endeavors, regarding adaptation and variation, respectively. A genuine controversy is found, however, in attempts to explain the origin of novelty. On the one hand, developmental genetic explanations account for novelty based on genetic regulatory networks (GRNs), so that novelty comes from changes in patterns of gene expression (e.g, Shubin et al. 2009),. On the other, generic physical explanations focus on self-organization and geometry (as generic properties of cells and tissues) and changes in physical processes with the advent of multicellular beings (leading to developmental patterning modules, DPMs) to explain basic (and novel) metazoan morphologies with minimal developmental genetic machinery (e.g., Newman et al. 2006).

By explaining the role of problems such as that of novelty in guiding inquiry through problem agendas, Love distinguishes between empirical and epistemological elements in the debates around the origins of novel structures in living systems. This allows him to pinpoint where precisely are the matters of disagreement among supporters of those rival hypotheses, and, also, to stress the possibilities of synthesis. After all, advocates of generic physical explanations argue that the emergence of multicellular organisms with very plastic morphologies dependent on the interactions between DPMs and environmental conditions set the stage for a selective regimen favoring mechanisms that could stabilize them. Thus, genetic assimilation would be involved in the cooption of genes shared by protists and metazoans to new developmental roles and in the construction of the GRNs involved in the regulation of development in current metazoans. In this manner, developmental genetic and physical generic explanations can be seen as components of a broader model for explaining metazoan evolution and development.

In the end of the chapter, having explored the guiding role of problems in the case of evo-devo and, in particular, the search for an explanation of novelty in evolution, Love argues for teaching a multifaceted image of scientific reasoning, including theory confirmation, hypothesis testing, problem agendas, styles of reasoning, and modeling. This can be fruitfully related to appeals in the recent literature on science education to a richer account of the nature of science, for instance, by changing the focus from NOS to features of science (Matthews 2012), or developing a family resemblance approach to NOS (Irzik & Nola 2011).

2.6. Integrating levels: considering ecology and microbiology

James Justus, in the chapter “Philosophical Issues in Ecology”, considers how limited attention is given to ecology in philosophical analysis and teaching, despite its central importance for biology. He argues that Darwin’s theory was shaped by an ecological perspective, which gave emphasis to intraspecific and interspecific interactions in the evolution of organisms. In fact, Darwin repeatedly highlights in *Origin* the complex interrelations between species: “many cases are on record showing how complex and unexpected are the checks and relations between organic beings which have to struggle together in the same country” (Darwin 1859, p. 71). He would envision, as in the case of the cattle, horses or dogs that never run wild in Paraguay, “ever-increasing circles of complexity” in the relations between organisms from different species, and yet claim that “not that in nature the relations can ever be as simple as this” (p. 73). Justus moves on to consider the debate about the character and reality of biological communities, mentioning how difficulty it is to decide whether communities actually exist. The controversy about the existence of laws in ecology is also discussed. Finally, he also attempts to clarify the concept of ecological stability based on a combination of resistance, resilience, and tolerance. The chapter seems adequate for undergraduates and teachers, who will probably have more difficulty in the section on stability.

Microbiology is the focus of the chapter titled “Small Things, Big Consequences: Microbiological Perspectives on Biology”, by Michael J. Duncan, Pierrick Bourrat, Jennifer DeBerardinis and Maureen O’ Malley. They stress how all life on Earth relies on microbes, and also use a microbiological perspective to discuss core biological concepts, such as life (the case of viruses is discussed), biological individuality (challenged by the difficulty to individualize a multicellular organism from its microbial symbionts), and levels of selection (since group selection was shown in many studies to be very important in microbial evolution). Considering all these aspects, we can see how neglected microbes are in school science, an unfortunate situation that needs change. This accessible text brings a nice contribution to change this state of affairs.

2.7. Conceptual obstacles to understanding evolution: essentialism and teleology

John Wilkins’ chapter on “Essentialism in Biology” offers a philosophical analysis that may be challenging for some students and teachers (and doesn’t seem to be readable by secondary students), but will be also helpful for them to understand better what essentialism is and why the history of Darwinism as simply misplacing essentialism from biology is mythic and triumphalist. Essentialism is the view that things, and particularly kinds of things, have essences, i.e., a set of properties that all members of the kind must have. The claim that Darwin’s influence shifted biology from an essentialist to a non-essentialist view is demystified by Wilkins, who argues that the notion that pre-Darwinian biology was essentialist resulted from casual and inaccurate reading by twentieth century philosophers (and, for that matter, also scientists). Students and teachers will be probably surprised to discover that it is a misconception to attribute essentialism to Linnaeus.

Wilkin's distinction between different meanings (psychological, human, logical, metaphysical, scientific, and biological) given to the word "essentialism" is very useful. This is equally true of his distinction between three general forms of essentialism: Constitutive essentialism, according to which objects in a given class are what they are because of invariant properties; Diagnostic essentialism, claiming that a class of objects is recognizable because all members share some salient properties; and Definitional essentialism, taking kinds as possessing necessary and jointly sufficient defining properties. Educational considerations are derived from Wilkins' analysis, which gives us a more nuanced view of essentialism with consequences to evolution teaching and learning, and, also, research on evolution education.

James Lennox and Kostas Kampourakis, in their chapter "Biological Teleology: The Need for History", begins with a historical account of teleology, from Plato and Aristotle, through Ray and Boyle, and up to Cuvier and Paley. They explain the debate before Darwin over teleological explanation in the natural sciences, opposing those who championed a theistic, creationist teleology and those arguing for the elimination of teleology from scientific explanations. Even though they don't discuss Kant's perspective on teleology, it is interesting to consider how in his *Critique of Judgment* he argued for a teleological explanation of living beings in terms of an inherent circularity leading to their self-organization and autonomy (Mossio & Moreno 2010):

> In such a product of nature each part, at the same time as it exists throughout all the others, is thought as existing with respect to the other parts and the whole, namely as instrument (organ). That is nevertheless not enough (because it could be merely an instrument of art, and represented as possible only as a purpose in general); the part is thought of as an organ producing the other parts (and consequently each part as producing the others reciprocally). Namely, the part cannot be any instrument of art, but only an instrument of nature, which provides the matter to all instruments (and even to those of art). It is then – and for this sole reason – that such a product, as organized and organizing itself, can be called a natural purpose (Kant 1790/1987, p. 253).

Still it seems correct to argue, as Lennox (1993) does, that Darwin's selective explanations were teleological in a sense that couldn't be properly grasped by his contemporaries. With Darwinism, a key distinction between two types of teleological explanations came to the fore: (1) teleological explanations based on design, claiming that a feature exists for some purpose because it was intentionally designed to fulfill it, and (2) teleological explanations based on natural selection, explaining why a trait spreads and is maintained in a population in terms of its selection due to its beneficial consequences for the organisms possessing it. Kant's approach to teleology is another kind of explanation that remained influential in biological thinking, recently leading, for instance, to an organizational account of function (Mossio et al. 2009; Mossio & Moreno 2010).

After arguing about how Darwin's explanations harbor teleological reasoning, Lennox and Kampourakis review conclusions from conceptual development research on children's intuitive teleological explanations, propose questions for further research, and offer educational suggestions. Their chapter is quite useful and readable by teachers and undergraduate students alike, and it may be the case that adequately selected parts could be used as readings for secondary school.

These chapters give us reason to be careful about both identifying children's and teenagers' ideas with views held by past naturalists or scientists, and claiming that they are obstacles for science learning. Both conclusions are stressed by Kampourakis in his introduction. Psychological essentialism found in children and adults now is different from the past essentialist views. As it is often argued in the science education literature (but seems to be a persistent notion), individual conceptual development is not parallel to the historical development of concepts, although some clues about the former can be derived from the latter. Wilkins shows several different ways in which a view can be described as essentialist and they are not all obstacles to understanding evolution. This means that more care should be exercised when qualifying students' views as essentialist and then going on to argue that they pose obstacles.

Lennox and Kampourakis' chapter leads precisely to the same conclusions regarding teleology, despite the widespread fear of teleological reasoning among biologists (just to let it enter into their explanations through the back door, given their important role in life sciences). That teleology is no necessary obstacle can be seen in the fact that Darwin repeatedly appealed to teleological language, looking for the "final cause" of traits, and this helped rather than hindered his search for explaining the origins of adaptations and species (Lennox 1993). In itself teleology is not illegitimate in biology, but is rather inherent in all explanations based on natural selection. It is not necessarily wrong, thus, when a teacher or student states that hearts in humans are for pumping blood. What we need to check in this case is what causal processes are invoked to explain the origin of the feature, if natural selection or some kind of intentional design (typically, supernatural). It is the latter that makes the claim incompatible with biological knowledge, not the teleological language *per se*. Again, this recommends more care in arguments about students' teleological claims in the science education literature, so that a more nuanced reading can be done.

2.8. Functions, mechanisms, information, and the systemic approach in biology

In school science we often talk of functions, mechanisms, and information, but the meanings of these terms are often unclear. Three chapters of the book address these concepts. Arno Wouters discusses biological functions in his chapter "Biology's Functional Perspective: Roles, Advantages and Organization". The functional perspective is quite important in biology and, contrary to what some think, does not necessarily assume design. Wouters argues that the existence of the features that perform a function is explained in terms of their contribution to the survival of their bearers. The concept of function is distinct, however, from the concept of adaptation and, thus, functional from selective explanations, because the former are independent from assumptions about the origins of the features. He also discusses how function might be disentangled from teleology. This is a useful and accessible chapter, which brings a contribution to clarify a concept that is often used but rarely explained in either biology or biological education.

William Bechtel argues, in the chapter "Understanding Biological Mechanisms: Using Illustrations from Circadian Rhythm Research", that explanation means, in many contexts, to look for the mechanism responsible for a phenomenon. To build mechanistic explanations, scientists use a number of strategies to uncover four aspects: (1) phenomenal; (2) componential; (3) causal; and (4) organizational (Craver & Bechtel 2006). Briefly, the phenomenal aspect concerns the phenomena explained by the working of the mechanism; the componential aspect, the working parts of the mechanism; the causal aspect, the relevant causal relations among those parts; and the organizational aspect, the spatial and temporal organization of the components and causal relations in the production of the phenomenon explained by the mechanistic model.

Thus, the key tasks in developing mechanistic explanations are: (1) delineating the phenomenon, (1) identifying and decomposing the mechanism underlying the phenomenon, and (3) recomposing and situating the mechanism in a higher level, of which the whole mechanism is just a part. Although the decomposition of the mechanism into component parts and the localization of causal roles in those parts are often characterized as reductionist, the organizational aspect of a mechanistic model brings a different, integrating side to mechanistic explanation. Just studying the phenomenon at a lower level may be insufficient for an adequate explanation because components may operate differently in isolation than when they belong to a whole, or they may operate differently in systems showing different organizations (El-Hani 2014a). Thus, we can be able to formulate a sort of mechanistic explanation that is not necessarily reductionist.

Bechtel uses circadian rhythms in his chapter to provide an example of how a mechanistic explanation is constructed. He concludes by claiming that an understanding of mechanisms in biological education may contribute to a better understanding of biological phenomena. Moreover, it seems that the basic ingredients to use mechanistic explanation are already there in biological education, just waiting to be integrated into a single perspective that can lead to explanations formulated by means of mechanistic models. Bechtel's chapter is an important aid for this integration, accessible as it is for in-service and preservice teachers and undergraduate students.

As Kampourakis mentions in the introduction, the idea that DNA contains some kind of information in its structure is often the take-home message for biology students. However, genetic information is far from being a simple concept, as Alfredo Marcos and Robert Arp show in their chapter "Information in the Biological Sciences". The reading may pose some difficulty for the intended audience of the book, but not to such an extent that educators will not benefit from it. Marcos and Arp offer a historical introduction to the concept and nature of information, and discuss several examples of bioinformation. They also consider debates about whether talk about information in biology is metaphorical or not, taking the view that information is a distinctive characteristic of organisms. It should be understood, however, not as a property, but in their view as a relationship between entities, more specifically, as a triadic relationship, involving three entities: a message, a receiver, and a system of reference which the message informs the receiver about. This conception of information as a relationship stresses that DNA can only be "informational" in relation to a given cellular context, not in itself (see also El-Hani et al. 2009), an idea that relates to the criticism of gene-centric views in biology, also discussed in other chapters of the book.

In the chapter "Systems Biology and Education", Pierre-Alain Braillard offers a discussion of this growing perspective in contemporary biological research. He argues that systems biology challenges the prevailing view of biology in the twentieth century, affecting both its explanatory practices and philosophical foundations. Although doubt has been expressed that systems biology indeed challenges reductionism (e.g, Keller 2005), Brailllard argues for this consequence of the systemic perspective. Molecular biology was dominated by an explanatory reductionism focused on discovering molecular mechanisms underlying biological phenomena and identifying genes as fundamental causes of phenotypes. However, part of the reason why the systemic perspective attracted much attention lies in that even if genes are involved in some process, in order to explain the process we need to understand how all cellular components and mechanisms are interconnected and affect each other in complex networks. Systems biology intends, thus, to provide a better understanding of how cells and organisms operate through multi-level modeling of networks and mechanisms, using methods and approaches from other fields, such as physics, mathematics, and computer science, in interdisciplinary efforts. In education, the systemic approach is often absent, but it is important to incorporate it, because it offers an opportunity to overcome an oversimplified, reductionist approach to biological phenomena that still prevails in school science. Braillard's accessible and useful chapter helps in this effort.

2.9. Beyond Mendel and genetic determinism in genetics teaching

One important aspect of the anthology is that it makes clear and justified calls to revise the biology curriculum. We discussed above chapters proposing changes in evolution education so that development and its relations with evolution are taken into account. The next three chapters in the book puts forth calls for changing genetics teaching. It is certainly not the case of introducing in the curriculum all the details we currently know about inheritance and its relations with development for the sake of updating science education. That's not the point, but rather that genetics as currently taught, strongly dominated by Mendelian genetics and DNA- and gene-centered views, contributes to maintain "gene talk" in society (Keller 2000), with a strong genetic determinism, which looks intuitive given the misconceived ideas about what genes are and what they can do that prevail in school science.

As argued above, genes are not all-powerful controllers of cell physiology (or for that matter the nucleus) and are not programs for development. They do not control anything by themselves, but cells are rather characterized by much more diffuse networks of control, so that genes themselves only operate, get expressed, play functions (by means of their products) within cellular environments that affect their structure and dynamics. That's why we need to teach development alongside genetics when we consider the emergence of phenotypes, as the three chapters discussed below emphasize. Outcomes produced by developmental processes can be different from those one might expect from DNA sequences alone. Any teacher or biology undergraduate reading these texts will realize how much her view needs to be changed, and, also, how much what she teaches her students also needs change. Fortunately, these are all quite readable chapters for both audiences.

Mendel is a mythic figure in biological education (Allchin 2000). He is often portrayed as the first scientist to propose a theory of heredity, while scientists who studied inheritance in the 19th century and paved the way to the emergence of Genetics are typically ignored (Kampourakis 2013). The historical description of Mendel's works found in school science is inaccurate in some respects, while in some other respects at least not consensual, if we consider debates among historians of science (Kampourakis 2013; El-Hani 2014b). Moreover, although the study of heredity in the nineteenth century is limited to a supposedly isolated and heroic friar, Mendel was not truly isolated and was not primarily interested in inheritance, but in hybridization. Mendel's laws are probably one of the pieces of biological knowledge that every person will remember for his whole life, but it is controversial if they are found in Mendel's original work as stated in Mendelian genetics, referring to gene that are potentials for traits. There is much to be revised, thus, in Mendel's story as narrated in school science, and this is unfortunate since it is one of those rare moments in schooling where most students will have a glimpse of the history of science.

Annie Jamieson and Greg Radick brings a remarkable contribution to revise teaching on Mendelian genetics in his chapter "Putting Mendel in His Place: How Curriculum Reform in Genetics and Counterfactual History of Science Can Work Together". Mendelian concepts are misconceived in school science and are at odds with current knowledge. For instance, dominance is taught as if it was a causal property, rather than a pattern of relation between characters, and if it was the most frequent pattern, overshadowing other patterns more common in nature, such as incomplete dominance (Allchin 2000). In fact, this is not even incompatible with Mendel's ideas, since he did not think that dominance was always observed (Corcos & Monaghan 1985). As typically taught in our schools, Mendelian genetics has to do with fixed hereditary properties determined by genes. This is related to the "genes for" concept, which will be discussed below. Jamieson and Radick points to the misconceptions in these ideas, since they both overlook the complexities of development and does not provide a model that generalizes to all kinds of traits. And then the most interesting suggestion in their chapter comes: to turn to W.F.R. Weldon's work to change how classical Genetics is taught.

Weldon expressed concerns about the dogmatic nature of Mendelism and adopted a much more contextualized interpretation of dominance in the first decade of the twentieth century. He studied hybrid pea varieties and, instead of describing discrete characters as Mendel, concluded that peas showed continuous variation, for instance, ranging from greenish yellow to yellowish green. Evidently, this is embedded in the famous "Mendelian-biometrician debate", which also involved other figures such as Karl Pearson and William Bateson, and crucially hinged upon the discontinuous or continuous nature of variation, and the explanatory powers of Darwinism and Mendelism in relation to evolution. Anyway, if we turn to Genetics teaching nowadays, Weldon did something that is necessary for our school science, namely, to draw attention to the natural variability ignored in Mendel's model.

Jamieson and Radick suggest, thus, an alternative approach to teach basic Genetics along Weldonian lines that could help in solving some problems present in current approaches: begin by teaching that gene-environment interactions are pervasive and primary, focusing on development (and its complexities) rather than inheritance, and then move on to teach about Mendel and his peas, with Mendelian genetics being taught as a special case, not as the norm. This is an interesting and potentially powerful suggestion, which deserves testing in real classrooms, so that we can check what are the learning outcomes of such approach.

Richard Burian and Kostas Kampourakis discuss the "genes for" concept in their chapter "Against 'Genes For': Could an Inclusive Concept of Genetic Material Effectively Replace Gene Concepts?" They consider recent developments both in science and philosophy related to genes, and, thus, the proposal of other concepts of gene that try to capture the complexity of inheritance and development. Both the concept of a "gene for" and, generally speaking, the gene concept have been recently put into question, leading to a diversification of proposals for reformulation. Burian and Kampourakis describe various gene concepts used by scientists since the term was proposed by Johannsen in 1909. They point to inconsistencies in how gene definitions are used and provide a classification of gene concepts. In their view, the gene concept should be replaced by the concept of genetic material, at least in educational contexts and the public discourse about genetics, because the latter is more inclusive and compatible with complex phenomena such as epistasis, pleiotropy, alternative splicing, etc. They claim that this is a way to provide an accurate description of phenomena and to challenge the widespread notion of "genes for", which contributes to genetic determinist views.

When it comes to an analysis of this latter notion, it can be also important to take into account Moss' (2003) distinction between gene-P and gene-D. Gene-D is the gene as a developmental resource, which is, in itself, indeterminate with respect to the phenotype, while gene-P is the gene as a determinant of phenotypes or phenotypic differences. This is an instrumental concept, not accompanied by any hypothesis of correspondence to reality, and this may allow us to accept the simplifying assumption of preformationist determinism. This concept is useful to perform a number of relevant tasks in genetics, such as pedigree analysis or genetic improvement by controlled crossing methods. Thus, it may be acceptable to use and teach about the "genes for" notion, provided that it is embedded into a historically and philosophically-grounded approach to models of gene function, so that students can understand what is the utility and what are the limits of this concept, as part of a Mendelian model of gene function (Gericke & Hagberg 2007).

For this approach to work, it would be quite important to avoid the introduction by the students of those deterministic assumptions in molecular models of genes when they come to learn them. Perhaps, it is difficult to design a learning progression that deals with gene function models in such a manner that students do not simply conflate features from different models. Anyway, it is worth considering that it might be possible to deal with genes-P (in its relation with the "genes for" notion) in such a manner that it would not contribute to genetic deterministic views, because determinism would be seen as just a simplifying assumption in a model using a certain instrumental view of genes.

The distinction between nature and nurture is examined in David Moore's chapter "Current Thinking about Nature and Nurture". He argues that this is a mistaken distinction, which comes from the eugenics conceptual framework (particularly, from Galton), despite its rejection after the World War II. Instead of trying to answer how much nature or nurture influences the development of a characteristic, we should rather ask how genetic and environmental factors interact to produce the organism's traits during development. Moore also discusses the concept of heritability, mistakenly perceived to be a measure of the relative importance of nature and nurture in the development of phenotypes. But heritability estimates does not provide information about influences on trait development. They rather inform how one can account for variation in a population. Moore also comes to a conclusion that applies to Genetics teaching, suggesting that instead of teaching Mendelian genetics with Punnett squares, which can support genetic determinism, a pedagogical approach encouraging the study of the emergence of phenotypes during development would be more appropriate.

2.10. Biology and ethics

Biology teachers need to deal with the ethical implications of the topics they teach, what requires a better ethical background than preservice education courses usually offer them. This adds importance to the chapters included in the book that deal with ethical issues.

In a chapter entitled "Genomics and Society: Why 'Discovery' Matters", Lisa Gannett argues that the fact that genomic research is carried out in a commercial social context raises concerns about whether scientists' objectivity is compromised. She discusses several distinctions proposed by philosophers of science to support the idea of a value-free, objective science: between theory and practice, between the context of discovery and the context of justification, and between facts and values. Several criticisms raised against these distinctions are examined, leading to the conclusion that they cannot be held, because theory is embedded in practice, discovery matters for justification, and facts and values are interconnected. Gannett finishes the chapter by presenting a case study of the concept of biogeographical ancestry, proposed as a substitute for "race" in population genomics, in order to show that in this case we have no value-free science taking place. This is a chapter from which teachers and undergraduate students can benefit, given its relevant implications for biology education.

Andrew Siegel's chapter, "Philosophical Issues in Human Pluripotent Stem Cell Research", considers the controversies about research using human embryonic stem cells. His argument is that biological education should go beyond just presenting the biological properties of stem cells to address philosophical questions that metaphysical, ethical, and political aspects. Among them, we find questions like when a human life begins, if human embryos have a moral status, whether there is a moral distinction between creating embryos for research and creating them for reproductive ends, what are the ethical issues related to the creation of human/non-human chimeras, among others. It is important to increase students' awareness of the disagreements around these questions. Both secondary and university students can take advantage of reading this accessible text, which will also play a relevant role in teachers' preparation to address these complex issues in the classroom.

Anya Plutynski, in the chapter "Ethics in Biomedical Research and Practice", distinguishes between ethical questions "intrinsic" to biomedical research, for instance, about what kind of research is ethically acceptable, and "extrinsic" questions, say, about funding. Research ethics, the branch of biomedical ethics dealing with responsible conduct of research, is introduced. It has to do with the ethical treatment of human and non-human subjects, conflicts of interest that appear in research and how they might be avoided, the social responsibility of scientists, among other issues. These are all "intrinsic" ethical questions. An example of "extrinsic" question is that of neglected diseases, most of them tropical diseases, whose research is much less funded than investigations on diseases affecting the wealthy. The fact that a significant part of biomedical research is privately funded raises important issues about conflicts of interest. Plutynski argues that addressing these ethical issues is important to biological education, and her chapter indeed contributes for this to happen, given their general accessibility for preservice and in-service teachers, and university and secondary students alike.

Roberta Millstein addresses, in the last chapter in the volume, “Environmental Ethics” in an accessible manner. She identifies three main areas in which environmental ethics can contribute to biological education: (1) concerning the question about what our moral community includes: humans only, all life, or whole ecosystems?; (2) the application of the answers to this first question to environmental issues and problems; (3) the exploration and evaluation of students’ conceptions on key concepts such as biodiversity, sustainability, species, and ecosystems. These topics should be explicitly discussed in the classroom, so that students have an opportunity to think about arguments for and against different positions. In this manner, biological education can educate students to be more reflective and thoughtful citizens, as Kampourakis argues in the introduction.

3. Concluding remarks

A good manner of finishing this review is to stress once again the consequential contribution *The Philosophy of Biology: A Companion to Educators* brings to the practice of biology teachers, and, also, to our task of preparing both a new generation of philosophically minded biology teachers, educators, and researchers, and pedagogically sensitive philosophers of biology, as pointed out by Kampourakis (p. 4). It is no doubt a book to be carefully read and, above all, put to good use in our classrooms and inquiries.

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(ii) Sally Gregory Kohlstedt (2010): *Teaching Children Science: Hands-on Nature Study in North America, 1890-1930*. The University of Chicago Press, Chicago. ISBN-13: 978-0-226-44990-6 (cloth) ISBN-10: 0-226-44990-4 (cloth), 363 p., price: $ 50.00.

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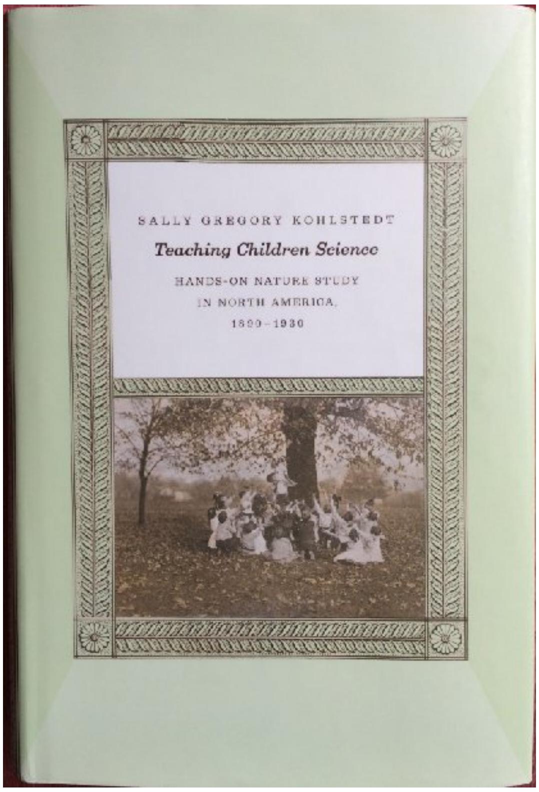
The development of science teaching programs in schools is an important and yet relatively unexplored subject in history of education in general. The intricate ways by which scientific ideas about nature were first organized for presentation to children also arouse interest in the history of science. They reflect the natural sciences community's growing authority and the recognition that knowing more about nature is fundamentally important for future generations. The approaches used by the anonymous teachers who initiated the implementation of a specific science curriculum for children, in turn, are inspiring to those involved with science education, whether in research or in the classroom practice.



Teaching Children Science: Hands-on Nature Study in North America, 1890-1930 is a vivid and strongly documented narrative that has much to reveal for all these three specific audiences. Each one will find its own focus within the narrative of how American children in that period learned about the natural world, how they were taught, and who taught them. Additionally, the book provides an impressive "institutional account of the circumstances that brought the idea of nature study into prominence" (p. 1-2) in American school systems at the beginning of the twentieth century. Although the nature study movement was well investigated before, with the production of iconic works such as Kevin Connor Armitage's *The Nature Study Movement: The Forgotten Popularizer of American's Conservation Ethics* (2009), Kohlstedt's exhaustive research sheds new light on this subject.

Sally Gregory Kohlstedt is a professor in The Program of History of Science and Technology at the University of Minnesota. With a long and active role in the History of Science Society, Kohlstedt has a steady production of books and papers in this field of study. Her previous monographs demonstrate an outstanding expertise in the history of scientific institutions, such as *The Formation of the American Scientific Community: The American Association for the Advancement of Science* (1976) and *The Establishment of Science in America* (1999), co-authored with Michael Sokal and Bruce Lewenstein. Her approach links the dynamics of science with culture to expose how social, political, and intellectual matters can influence scientists and contrariwise. To do this, the historian of science looks for the intersections "where scientific practitioners cross paths" with another audiences, as she states in her curriculum vitae. This research program is precisely what she delivers in *Teaching Children Science.* The book brings out the frame of institutions that engendered the connections between leading scientists, educational reformers, and science instructors—particularly women, who were mostly responsible for implementing the new curriculum in schools.

The book has eight chapters that cover different perspectives on a movement that introduced science—"nature study," as it was named at the time—into public schools in U.S. From the 1880s onwards, as several examples in the book illustrate, the reader learns how the nature study curriculum spread throughout the country after flourishing in the North-East, the upper Midwest, and the Far West. From major urban cities in these regions, such as New York, Chicago, and Los Angeles, the program spread into suburbs, small towns, and rural one- and two-room schools in the public, private, and parochial school systems. Kohlstedt briefly mentions the introduction of the nature study in other countries, but only for English-speaking ones such as Canada (Ontario, Guelph, and Montreal), Britain, Scotland, Ireland, and a very quick mention to Australia and New Zealand. So a pertinent criticism can be made to the "North America" of the title of the book, which creates the expectation of a thorough approach to Canada and Mexico, and this last country is not even mentioned.

This panorama is constructed from an immense mass of documents selected from two decades of research. The archive list draws from 39 different institutions, including the United States National Archives, museum and academic society archives, many university libraries, and some public libraries in the key regions she inspects. Some special collections of children's textbooks and popular books, government reports and bulletins, biographical dictionaries, as well as 26 pages of secondary sources indicate the extent of Kohlstedt's careful research. However, what is so important as the hard work of fishing relevant information from all that material is the subtle narrative that emerges from the lives of the teachers, scientists, and others engaged in nature study education in the USA during the four decades covered by the book.

And what was the nature study movement, and what was the tendency of that curriculum? Finding herself obliged to avoid a simple and comprehensive definition of the nature study movement, the author concludes that it was precisely its rich and varied expressions that helped explain its success. Basically, nature study assembled a curriculum devoted to teaching hands-on and age-specific activities that related to the students' personal experience. Students should be acquainted to current scientific thinking, they believed, through close observation and face-to-face contact with the natural world, which would furnish them with an appreciation for the processes of living things in their environment. Nature study also had a strong association with themes of civic and moral uplift.

The nature study movement is presented as deeply rooted in the American enthusiasm for natural science and commitment to education for all children. To account for this history the author was guided by some general concerns that cross the whole text, such as connecting "some of the key advocates who framed" the fundamental principles of the nature study program, the "threads of preparation by teachers and supervisors who implemented it," and the "multiple ways that the concept continued to resound long after the term had receded from school usage" (p. 2).

In the Introduction we learn about the two main theoretical aspects that informed nature study in the USA. One of them was the thought developed in the 1870s by reforming educational philosophers who were trained in German pedagogy and psychology. They had a strong commitment to a child-centered curriculum that took the developmental stage of the child into consideration. And this aspect connects with the second one, which was documented by nature study practices in a great number of urban and rural schools, namely the development of theories and methods concentrated in learning about nature outside with materials close at hand. Not coincidentally, the conception of "Educating with Nature's Own Book" provides the title for the book's first chapter. Leading scientists such as Louis Agassiz and educators like Horace Mann are mentioned side by side with the teachers who criticized traditional methods of teaching botanical or zoological terms.

The overview of the meaning and values pursued by the nature study movement at the time gradually appears in *Teaching Children Science* through the titles of a vast collection of materials mentioned throughout the book. Diverse textbooks, handbooks, pamphlets, leaflets, and journals on the subject were written by naturalists and practicing educators of the time. Outstanding are the thirteen guides for science teaching published under the auspices of the Boston Society of Natural History between 1876 and 1896. One of these guides, *A First Lesson in Natural History* (1879), written by Elizabeth Cary Agassiz in the form of a familiar conversation with young women, presents the seashore life in eastern Massachusetts. *Botany for Young People and Common Schools: How Plants Grow* (1858), written by Asa Gray, reached numerous editions. *Child's Book of Nature* (1885) by Worthington Hooker was addressed to "the mother and the teacher." Reading these books and the others mentioned below should not be of interest to historians of science only; taking into account the context in which they were written, they can still provide inspiration for science and biology teachers today.

In the second chapter, "Devising a Curriculum for Nature Study," readers are acquainted with some of the intricate relationships between researchers at leading universities, from Massachusetts to Chicago, and the US school system. Above all, in this chapter more so than in the others, we can see the extent of the contribution of Kohlstedt's book, even compared to revisionist historiography that largely concentrated on "governing education and issues of consolidation, standardization, and requirements" (p. 9) by focusing on those who had social or political power or on how parents and teachers discussed and defined programs. Instead, Kohlstedt focuses on how curriculum was negotiated among administrators, teachers, parents, political leaders, community activists, and educational theorists. Illuminating all these different characters, the historian of science reveals "how gender, class, and ethnicity were inevitably woven" (p. 9) in the nature study practices, as she promised in the Introduction.

Chapters three and four illustrate the diversity of the initiatives that introduced nature study in urban and rural areas, both in public and parochial school systems. The spirit of teaching with the world in which the child lives and its natural environment, reinforced by direct observation and cultivation of sympathetic acquaintance with nature, narrowed the relationships or "cross paths" between scientific educators, urban schools, and a variety of institutions, predominantly but not exclusively scientific, such as natural history museums, botanical gardens, zoological parks, and aquariums.

It is striking that the most remote cities across the country were working to find "the one best system" (p. 40) of education in "standardized programs intended to produce moral citizens able to work in their communities" (p. 68). The distinctive ways in which nature study was implemented emerged as opportunities to promote, for instance, community projects for eliminating mosquitoes and thus stem the incidence of malaria or to encouraging gardens with edible and flowering plants in local schools in Worcester, Massachusetts. Here, as throughout the book, the author deeply explores some inspiring examples while simultaneously mentioning many other cases that illustrate the national scope of nature study.

In rural areas, courses that were intended for future farmers, which focused on topics like entomology and agriculture, kept the face-to-face approach to nature, the use of natural specimens, and field excursions. The *Handbook of Nature Study* (1911) by Anna Comstock went through more than twenty editions and translation into eight languages (and remains in print today). It is an outstanding example of that direct approach to nature colored by a clear ecological sensibility and a commitment to the growing conservation movement. Another influential and widely distributed book was *The Nature-Study Idea* (1909), by Liberty Hyde Bailey, which influenced the implementation of a child-centered curriculum and guided teachers in exploring the intricacies of plant and animal life.

Throughout the book criticism and resistance to the nature study curriculum are also examined. This criticism related to various aspects of the curriculum, such as the extra time and attention required from the teacher in preparation for the new task and the organization of materials for practical classes. In addition to nature study, other educational "fads" that were criticized included music and drawing, because they "distracted students from basic studies and led to failure on standard tests" (p. 64). The press sarcastically criticized schools for "forcing pupils to take to the woods" to become naturalists "of the Robinson Crusoe type" (p. 43). Even inside universities that were engaged with educational research and preparing graduates to become instructors in normal schools, authorities advised to not let it become known that the chief interest was in the primary school because it represented something "beneath the dignity of any university to identify itself with the training for the instruction of young children" (p. 39), such as documented by an educator in University of Illinois in Urbana. The "feminine" face, soft and sentimental, lacking "rigor," was pointed out by some of the critics as responsible for the nonscientific character of the nature study and as a reason to drag it out of school curricula.

The fifth chapter is in some ways the most exciting one; its departure from the format of the previous chapters means that it could be read separately as a summary of the theoretical trends that the previous chapters explore in more detail. The chapter lists the four aforementioned educational approaches in nature study and explores how each one influenced the implementation of the curriculum, not without some overlapping between the different approaches. The first was that of initial foundations for nature study, established under the instructor Wilbur Jackman and his Chicago colleagues; they combined their own scientific interests with child-centered pedagogy and ideas from some European educational philosophers. The second approach, compatible with the former, was developed by Charles and Frank McMurry based on the educational philosophy of Johann Friedrich Herbart, who, among other things, recommended integrating different subjects, such as pairing discussion of natural objects with painting, clay modeling, and written self-expression. The third approach was that of the Worchester' schools, where Clifton Hodge's projects focused on empirical and pragmatic aspects of the everyday life of children and citizens in an industrial context. The fourth outlook, expressed in Bailey and Comstock's works, assumed that despite the familiarity of rural children with nature, it was necessary to attune them to more aesthetic and scientific ways of understanding both the domesticated and the wild landscapes in which they lived. The syntheses made in this chapter shows that these theoretical engagements gave rise to the multiple facets that characterized the nature study movement.

The rest of the chapter, in a series of smaller sections, resumes and expands new perspectives on nature study applications. Despite the emphasis on "nature, not books" that was advocated everywhere, one section shows how initiatives that enabled elementary teachers to teach the new curriculum resulted in an exponential growth of educational market in the latter decades of the century. Nature study curricula spread as a result of that broadening market for different pedagogical materials, from books and manuals to leaflets, pamphlets, illustrations, hanging wall charts, and even games. Another section resumes the debate over traditional classrooms and shows that nature study incorporated the reforming educators' emphasis on the importance of the child as the center of the teaching process. They focused on activating children's inner potential for observation and reason and on linking all the sciences to and through life experiences. Following Herbart's ideas, the active correlation of subjects like art, literature, and geography, was proposed within an integrated curriculum. A new section discusses how, after the turn of the century, psychological approaches took place that were derived from the psychology of Wilhelm Wundt. These approaches inspired the research of G. Stanley Hall at Clark University as well as Clifton Hodge's projects on "out-of-door life." Other sections also resume the aforementioned theoretical debate by focusing on different aspects of it, such as the particular development of illustrations, animal stories, and connection between nature study and civic reform. As the author concludes, the multiple strands of nature study meant that it was never standardized in a single, prescriptive curriculum. And it could not have been different, since the only common point was the use of local materials by a creative and autonomous teacher.

The sixth chapter, “Establishing Professional Identities,” turns its attention to the system of teacher preparation. Describing the specificities of normal schools and college departments, the author shows that these two institutions were progressively defining agenda in public schools, producing materials, and educating the best-trained teachers and future administrators. But only progressively, because up to the first quarter of the twentieth century, normal school students were a privileged minority. Here the book again takes up initiatives mentioned earlier, such as the highly experimental program developed by John Cook and Charles McMurry in the Northern State Normal School in DeKalb, Illinois. The core idea was that of supervised teaching, meaning that normal school should be the place for “observation and experience of actual teaching in a standard classroom” (p. 150). Nature study moved quickly across the country, and the chapter describes the conditions and particularities of teacher preparation in normal schools in the 1880s and 1890s in the West Coast (Los Angeles), in the South (Nashville, expanding out to other cities in the first two decades of the twentieth century), in the upper Midwest, and in the Northwest.

A clear sign of the new curriculum’s prominence was the establishment of a distinct “supervisor” position for nature study in a significant number of schools by the turn of the twentieth century. The supervisor’s function was to visit schools to advise on curricula, train teachers, and provide local materials. Here, as in other parts of the book, the methodological choice for a kind of narrative related to “history of life” positions the reader as an eyewitness of particular and thought-provoking experiences. Additionally, the author supplies an appendix with a partial but undoubtedly meaningful list of individuals “noted in a wide range of ephemeral sources” (p. 239) that contains 42 nature study supervisors in schools, 16 in museums, and 38 in normal schools, training, or practice schools in different regions of the country between the 1890s and 1930s.

Nature study reflects the gendered division of labor in teaching. Despite being dominated by women, statistical analysis reveals that men, on average, taught older rather than younger students (more on college or normal schools faculties), taught more boys than girls, taught “harder” subjects, were more encouraged to teach about ideas, and to organize the profession. Men also published more articles on the definition of nature study, while women wrote more reports on classroom practices. That bias was not only a social construction; it was also rooted in the work of leading psychologists such as Edward Thorndike, who thought women were not suited for the rigors of science but were appropriate for teaching young children. Nature study critics even blamed women for the failure of nature study. As Kohlstedt summarizes, such gendered and hostile rhetoric was “widely used in educational journals and contributed to the attack on the so-called feminization of education in the early twentieth century” (p. 172). Despite the prejudices, among all members of the Nature Study Society, women represented about a quarter of the teachers who taught at normal schools and colleges of education. Despite the resistance of editors, women continued publishing textbooks, readers, manuals, and leaflets. In fact, commitment and creativity were present in nature study teachers in general, both female and male.

Chapters seven and eight deal with the historical accounts of *Nature-Study Review*, launched in 1905, and the still-existing American Nature Study Society, created in 1907. The first editor of *Nature-Study Review* was Maurice A. Bigelow, a faculty member at Teachers College in New York. Aiming to present education as an emerging academic discipline, with sound research practices and theory, he invited well-known contributors to nature study with academic credentials to join its advisory board. The first three volumes were clearly more theoretical and intended to clarify what had become “controversial among academics and remained a challenge to teachers” (p. 177). The articles were mainly devoted to discussing the theory and pedagogy of nature study, as well as discussions about its relation to natural science itself. The editor was looking for common principles of nature study, even given the diverse views and definitions of it. At the same time, while the *Review* was initially conceived to address the concerns of teachers, administrators, educational psychologists, and educational philosophers and to provide a forum for discussion that balanced theory and practice, it gradually expanded to include space for teachers to present their own experiences. The journal passed through the hands of several editors, including Anna Comstock, but the efforts to maintain it were not sufficient. After merging with a new journal in 1923, it tried to restart under the name *Nature and Science Education Review*; however, both sunk and the nature study movement eventually lost its official communication channel. Around the same time, supporters of nature study connected to the Society had turned their "attention toward the broadening inclusion of nature study in other venues" (p. 214). In its place, gradually and definitively, concern shifted to elementary science, the new science project for schools.

All of this rich material makes reading *Teaching Children Science* inspiring and profitable. Not only because the author redeems nature study from its former naïve appearance and displaces the marginal position assigned to it in the curriculum by previous analyses, which directly concerns historians of education and historians of science. The book is also valuable because science education (still) has to face strong students' unawareness about the natural beings in the place where they live. Today disinterest of the young in science studies in school and in scientific careers is frightening to the community of educators. Maybe some of the ideas espoused by educators and teachers of the nature study movement, recontextualized by current educational knowledge and redirected to the current goals of science teaching in primary school, may provide some fruitful clues. At least, Sally Gregory Kohlstedt fulfilled her part of that bigger challenge.

(iii) Carl F. Craver and Lindley Darden (2013) *In Search of Mechanisms: Discoveries across the Life Sciences.* University of Chicago Press, Chicago. ISBN: 978-0-226-03979-4, 228 pages, USD 75.00 (Hardcover), USD 25.00 (Softcover)

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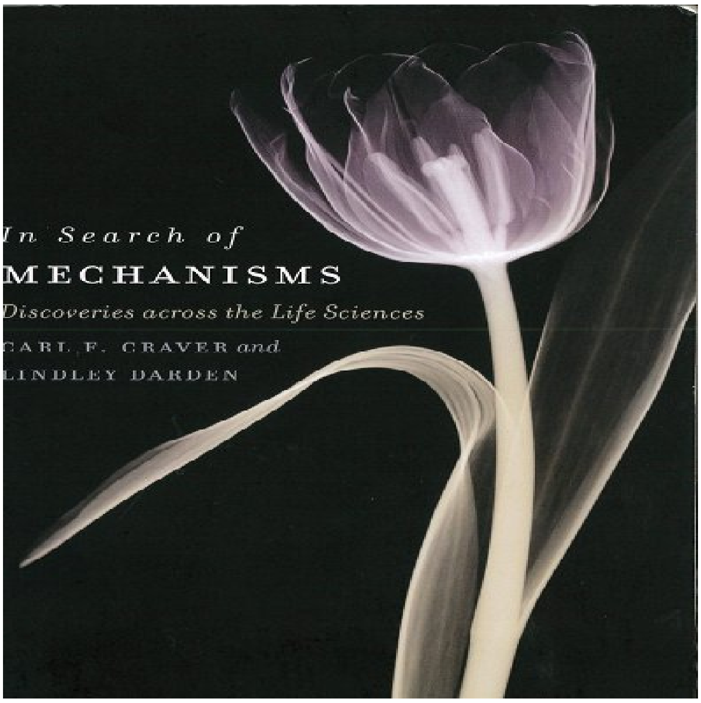

Carl Craver and Lindley Darden are two of the foremost proponents of a recent approach to the philosophy of biology that is often called the New Mechanicism. In this book they seek to make available to a broader readership insights gained from more than two decades of work on the nature of mechanisms and how they are described and discovered. The book is not primarily aimed at specialists working on the New Mechanicism, but rather targets scientists, students and teachers who are looking for a broad, philosophically and historically informed image of discovery in the life sciences.

The best feature of this book is its thoughtful use of examples to illustrate what mechanisms are and how scientists search for them. Craver and Darden draw examples from across biology and the life sciences and from the birth of mechanistic approaches in the 17th century to the present day. Many of these examples will be familiar to readers of Craver and Darden's other works – synaptic transmission, the action potential, protein synthesis and spatial memory – but there are others which are new to this book. There is for instance a careful description of William Harvey's investigation of the mechanisms responsible for circulation of the blood as well as a discussion of contemporary research on the mechanisms responsible for cystic fibrosis. Craver and Darden have taken care to describe their examples thoroughly, while at the same time offering enough background to allow readers unfamiliar with the relevant biology to understand their points. Collectively these examples provide an inductive basis for the claim that much of the scientific activity across the life sciences can be understood as a search for mechanisms.

In their attempt to make this book accessible to this audience, Craver and Darden have written the book in a style that eschews many philosophical conventions. Their first rule, as they put it, is that they will "stay positive" (p. xviii), which is to say that they do not frame their mechanistic approach in opposition to other models of science and scientific discovery, nor do they discuss or respond to the many commentaries upon and criticisms of their work or of the work of the New Mechanists more generally. Except for brief bibliographic essays at the end of each chapter, the book is very light on references and without footnotes.

Another of Craver and Darden's principles is to "avoid when possible the proprietary jargon of philosophy and favor plain descriptive terms." Here they are only partially successful. While the book does indeed avoid many specialized philosophical discussions, the book is largely organized around the elaboration of terms of art within the New Mechanicism, especially the terminology originally introduced in "Thinking about Mechanisms"(2000), the seminal paper Craver and Darden co-authored with Peter Machamer, which remains the most widely cited paper in the literature of the New Mechanicism. Their account of what a mechanism is begins with the well-known characterization from that original paper: "Mechanisms are entities and activities organized such that they are productive of regular changes from start or set- up to finish or termination conditions" (p. 15). Similarly, their account of scientific representation is formulated within their proprietary terminology of mechanism schemas and sketches, and their account of strategies for mechanism discovery is organized around concepts Darden and Craver have developed over the years (e.g., Craver & Darden, 2001; Darden & Craver, 2002; Darden, 2002).

While use of this terminology is neither unexpected nor inappropriate, I wish that Craver and Darden had used this opportunity to revise some of their original language in light of what has been learned in the last decade of discussion. For instance, the original (Machamer et al., 2000) formulation required that mechanisms operate from "start-up to termination conditions", but this requirement has been widely criticized as being too restrictive, and in the text Craver and Darden readily point out that "not all mechanisms work like that" (p. 18). Similarly, Craver and Darden would have been better off to build into their basic characterization of a mechanism the idea that a mechanism is always *for some phenomenon*. This idea is widely established in the literature (e.g., Craver, 2007; Glennan, 1996; Illari & Williamson, 2012) and accepted by the authors themselves, and it would be helpful if their account of what a mechanism started with this key feature.
In fact, one of the most illuminating themes of Craver and Darden's book is their exploration of the interplay between phenomena and the mechanisms responsible for them – or better, between our representations of the phenomena and our representations of those mechanisms. As Craver and Darden show, the proper characterization of the phenomenon is a non-trivial achievement that is a central preliminary to searching for a mechanism; also they show how phenomena are often mischaracterized and how in the process of mechanism discovery, they often need to be re-characterized.

One new and helpful aspect of their discussion of phenomena is their identification of three different kinds of relationships between mechanisms and their phenomena: Some mechanisms *produce* their phenomena, while others *underlie* their phenomena and others *maintain* their phenomena. The production relation is the one most closely connected to Machamer et al's original formulation of production from start-up to termination conditions; the underlying relation characterizes the sort of inter-level relation between mechanisms and phenomena explored at length in Craver (2007), while the maintaining relation is one that has not been as prominent in earlier work. In a maintaining mechanism, a system is, with respect to some properties or aspects of its functioning, in a steady state – for instance, a steady body temperature or metabolic rate within an organism--and the maintaining mechanism is responsible for keeping the system in this state in the face of environmental or other perturbations. Such mechanisms, while they do require activities, dampen or prevent change rather than produce it. Given that mechanisms of this kind are ubiquitous within living systems, Craver and Darden are wise to explicitly show how this kind of mechanism-phenomenon relation fits within their account.

Craver and Darden's account of mechanism schemas (what are more commonly called models) starts with the claim that schemas vary on four dimensions – completeness (from sketch to schema), detail (from abstract to specific), support (from how-possibly to how-actually) and scope (from narrow to wide) (p. 30). These ideas are central to their account of discovery, as their story about mechanism discovery is a story about how various kinds of observations and experiments, as well as other considerations such as inter-field integration, lead one from sketches to schemas and from accounts of how-possibly to how-actually. While they assert at one point in the book that these dimensions are independent, much of the value of their account lies in showing the ways in which these dimensions are *not* independent. For instance, evidential support grows as we fill in the black boxes to make them more transparent– which is a matter of completing the sketch and adding details. Similarly, detail is often bought at the expense of scope.

One of the most interesting questions raised by Craver and Darden's book concerns the scope of the New Mechanicism. The authors are careful not to claim too much. Science, they say, "is not defined as the search for mechanisms" (p. 7) because there are many worthy scientific pursuits that are not obviously mechanistic. It is possible to describe and predict patterns in phenomena without knowing the mechanisms that are responsible for those patterns. But at the same time, the account they have given is one that naturally leads to a view that suggests that the search for mechanism is and should be the central activity of modern science. As they put it:

> The fact that biology has become a search for mechanisms is not merely a matter of fashion. Biologists look for mechanisms because they serve the three central aims of science: prediction, explanation and control (p. 6).

Here they echo the words of the ecologist Simon Levin who says of biology, and of science generally, that "the key to prediction and understanding lies in the elucidation of mechanisms underlying observed patterns" (Levin, 1992, p. 1943). You can find patterns without mechanisms, but unless you have mechanisms, you don't understand why the patterns are there, whether they will continue to hold, and how, if you wish, you might change them.

Craver and Darden's brief is to argue for the centrality of mechanisms in biology, not across the wider expanse of science. But while there evidence is drawn from biological examples, there is little in their characterization of mechanisms and how we look for them that is specifically biological. The entities and activities may be different, but that is not essential – indeed the diversity of entities and activities is a central and attractive part of their story. The strategies they discuss – from experimental design to anomaly resolution – are relevant across a range of sciences. For this reason, this book will be of interest not just to those interested in biology and the life sciences, but to anyone interested in the process of scientific discovery generally.

Craver and Darden cannot resist the self-referential application of their account of discovery to their own project. The first sentence in their preface (echoed in the last paragraph of the book) asserts that "science is an engine of discovery." This means, of course, that science is a mechanism that produces discoveries. If they have rightly characterized the phenomena – as I think they have -- *In Search of Mechanisms* offers us a model (or, as they might say, say a partially filled in schema) of how this mechanism works. That model is not, as they would be the first to agree, a wholly new invention. It involves refinements and revisions of earlier models, including those of philosophical luminaries like Popper, Hempel, Hanson and Kuhn. That is how the engine of the history and philosophy of science works.

It is one of the truisms in the philosophical literature that all models involve trade-offs. The point is emphasized in Craver and Darden's own discussion of mechanism schemas, and we can apply it to the model of mechanism discovery they give us in their book. Theirs is a model of wide scope; it sometimes trades philosophical precision for cross-disciplinary accessibility; it contains idealizations and approximations that do not apply everywhere. Still, in my view, they succeed admirably in their main explanatory purpose – to illuminate for a larger public, the workings of the engine of scientific discovery.

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(iv) Virginia Berridge and Martin Gorsky (eds.) (2012) *Environment, Health and History.* Palgrave Macmillan, Basingstoke. ISBN: 978-0-230-23311-9 HB, 320 pages, price: $100.00

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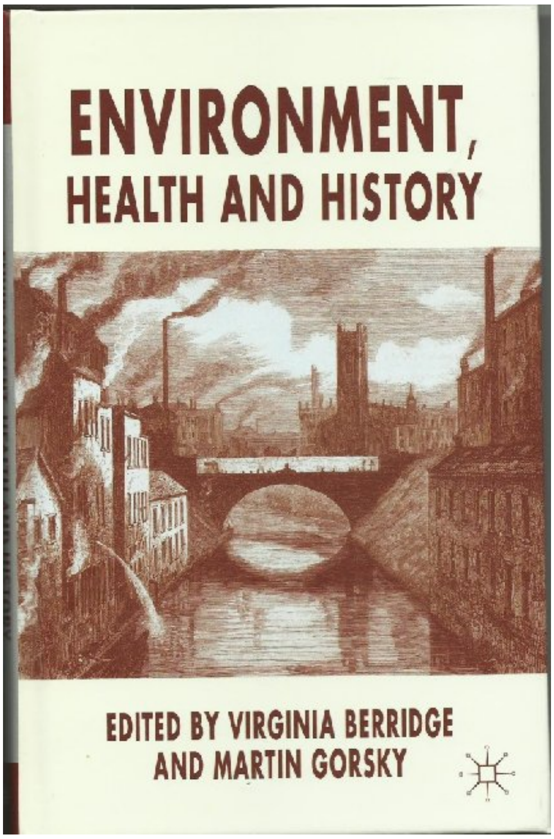
Constructing a book review that is concerned with a theme that is not a natural part of my current research provokes, on my part, a very deep reflective process. Although I have undertaken work for the European Commission in History and Philosophy in Science Teaching (the HIPST project), my previous efforts were seen through the lenses of my scientific disciplinary knowledge. Berridge and Gorsky have approached their task as historians, dealing with issues that link the environment and health with historical studies. I have had to interpret the chapters, written by various authors, from my general knowledge of history, but avoiding the trap of not appreciating the historical and social contexts of the time (whiggishness). Fortunately, some of the chapters make this very easy, setting the evidence in its historical context, and being very open in the face of absence of some helpful data or of the data being limited.



Occasionally, a chapter that may have been interesting has been written in an unhelpful style by an academic clearly thoroughly immersed in his field, but unable to write for other academics like myself.

The HIPST project mentioned earlier (http://hipst.eled.auth.gr/) had the 'general objectives: a better integration of science in society and society in science, the promotion of young people's interest in science, to encourage their critical and creative ways of thinking and to improve science education, and the uptake of scientific careers.' We discovered that science teaching was deficient in the non-content areas of science education, particularly history and philosophy of science education.

The book arose out of papers given at a conference held at the London School of Hygiene and Tropical Medicine, a widely respected institute with much valuable research on disease in the developing world.

Chapters

1. Berridge V. & Gorsky M., Introduction: Environment, health and history.

Berridge and Gorsky provide an overview of the book, elaborating on the theme of links between health and the environment in a historical context. They note that health and environment have established a place in recent times, making the point that the *Lancet* published a special issue on the impact of climate change on health in 2009. While this position is becoming stronger, the early Greeks considered that the two issues were intertwined but the two separated after that until the early twentieth century. Public policies directed at treatment of infectious diseases such as tuberculosis, and the control of urban sprawl leading to regulation of building expansion, and the establishment of national parks and access to the countryside, have resulted from this development.

2. Harding V., Housing and health in early modern London.

Harding's chapter is given a more detailed appraisal below but focuses on changes in the population of London associated with the quality of housing, sanitation and accessibility of clean water. The impact of social class on morbidity rates is investigated here, together with a fascinating discussion about the quality of data on health at the time. Harding links uncertainty in medical knowledge, and descriptions of the causes of mortality in official records to limitations on interpretation of that data.

3. Hamlin C., Environment and disease in Ireland.

Hamlin's work takes the ideas of political impact of the ruling classes in the Irish famines of the mid-nineteenth century ascribing these to colonial callousness and links them to the medical effects of starvation that lays the population open to infectious diseases. He places doctors at the nexus of providing poor relief, while being aware of the effects of land policy that, at the very least, exacerbated the famine and left the doctors relatively powerless. The doctors had to work within the constraints of the Irish poor law, while social and political reforms were too slow in coming. Hamlin notes that infection killed more than starvation but this is a moot point in communities where the direct and indirect causes of morbidity are difficult to separate but have the same outcome, the deaths of individuals.

4. Schott D., The Handbuch der Hygeine: a manual of proto-environmental science in Germany of 1900?

Schott's study is firmly placed at the start of the twentieth century, although the Handbuch was published in the 1890s. It was a time when scientific ideas of bacteriology were replacing earlier vague notions of miasma as the cause of disease and ill-health. Slum clearance programmes resulted from these ideas.

5. Carter S., Leagues of sunshine: sunlight, health and the environment.

'Carter's subject is sunshine, and that short, distinctive period when bodily exposure to solar rays were considered medically desirable' (p.13). So, the search for masculine perfection, identified (in white cultures) by a tanned skin, linked to living in the countryside (where, of course, higher social classes were generally more healthy) and opening up urban spaces by housing demolition.

6. Adams J. M., Healthy places and healthy regimes: British Spas 1918 – 50.

Adams takes the British spa town and water cures as the theme for her study.
Promotion of spas worked in opposition to more traditional seaside towns, with concomitant inflated claims for curative benefits of hydrotherapies, particularly for crippling disease such as rheumatism. The driver for this was an improvement in economic performance.

7. Clarke S., Rethinking the post-war hegemony of DDT: insecticides research and the British Colonial empire.

It is commonly thought that the pesticidal approach to malaria eradication set back critical research in malariolgy. Clarke posits that a complex of military and colonial forces created a practical programme for killing mosquitoes and their larvae in the field. However, Clarke interrogates documents from the late 1950s to show that the financial basis of the heavy spraying programme was not viable, and that the spraying induced resistance in subsequent mosquito populations.

8. Bonah C., 'Health crusades': environmental approaches as public health

strategies against infections in sanitary propaganda films, 1930 – 60.

There were many films produced on the problem of dealing with malaria infections with industrial, military, governmental or international sponsorship. These included oil spraying on water to kill off mosquito larvae and well as pesticides to deal with the adult mosquitoes. Bonah unearths the military metaphor of war on the pests, used to motivate action at the time, with the consequent effect of construing the environment as a dangerous place, swarming with creatures that must be targeted and destroyed.

9. Sellers C., Cross-nationalising the history of industrial hazard.

Lead is the toxic material in Seller's paper. He raises the issue of outsourcing production to jurisdictions where occupation health regulation is more lax compared with that in Western countries, through the context of the US/Mexico lead mines. Such a chapter contains the issues that beset us still in our unequal world, whether in resource extraction, or in waste treatment of electronic devices.

10. Warren C., The gardener in the machine: biotechnological adaptation for
life indoors.

Linking the increasing prevalence of rickets through inadequate sunlight, our discomfort with temperature extremes through air conditioning that limits environmental temperature ranges indoors, and social isolation in our private lives by electronic media, Warren argues for the possibility of an enfeebled human future.

11. Rumiel L., Exposing the Cold War legacy: the activist work of physicians for social responsibility and international physicians for the prevention of nuclear war 1986 and 1992.

Development of movements of scientists devoted to prevention of nuclear war drives the study of Rumiel. She notes the parallel of two groups of scientists concerned with the health effects of nuclear radiation with earlier medics looking at the health effects of the environment. She is strident about the need for scientists to have a voice in creating policies.

12. Palmlund I., The impacts on human health and environment of global climate change: a review of international politics.

Global climate change is an issue that is at the centre of recent political news, whether it is extreme weather conditions such as floods, or acidification of the oceans. I have noted, from my personal experience, the tendency of natural scientists to dominate the climate change landscape and propose instrumental solutions. Palmlund notes the absence of a medical response in recent writings.

13. Wilkinson P., Epilogue: the co-benefits for health meeting global environmental challenges.

Wilkinson's conclusion is that the place of health considerations must have a more prominent place in the global environmental challenges that are the problems of today.

Appraisal

My review will be selective, in that I will choose a few chapters in detail to illustrate my thinking.

Harding (Chapter 1) provides an excellently written historical account of links between location and density of housing in London and disease, especially death through the plague in the seventeenth century and later. I note the challenges in attributing mortality to specific diseases in an age where the causes of disease were not well understood and where the recorders of death, in parish and other records, were not specifically written to help researchers of today! Nevertheless, while admitting that her databases are not perfect, she provides examples of data, as well as interpretations of that data. She suggests that: poor water provision, often at communal water supplies serving many families in crowded areas is linked with the growth of gastro-enteric disease; that overcrowding was a factor in the spread of infection; and that damp and poor building quality impacted on the spread of 'consumption' or TB. Housing is a causal factor in high mortality rates. Harding's paper highlights the uncertainty of her analyses caused by the partial nature of the evidence, paralleling climate science today in some respects.

Carter's contribution (Chapter 3) takes the case of the effect of sunshine as a treatment of illnesses such as consumption. As a Professor of Sociology, though, he is keen to interpret these in the light of tanned bodies and the outdoor life. This links clearly with Harding's work on urban development mentioned earlier, since the treatments were carried out in the countryside. He points out a relationship between social class (those who could afford such expensive treatments) and location. Putting a distance between the polluted environments of the slums, with their sulphurous coal fires, was seen as a major benefit in creating a more healthy population. He claims that this was a forerunner of actions such as slum clearances and regulating housing, a form of government control and intervention in favour of the down-trodden.

The case of DDT in dealing with malaria in the tropics by killing mosquitoes, and the subsequent negative effects on wildlife such as egg-shell thinning leading to crashes in bird populations is a well known case study in biology in schools. Clarke (Chapter 7) unpicks this topic through an examination of alliances between malariologists and the UK Colonial Office. She notes that sufficiently heavy and sustained spraying was financially unviable and risked breeding resistance, and that this was known by the late 1950s. There was not the blind faith in technology to deal with human conditions that we might imagine. The complexity of the story, as well-explained by Clarke, would be an excellent case study of complexity in life sciences in secondary schools.

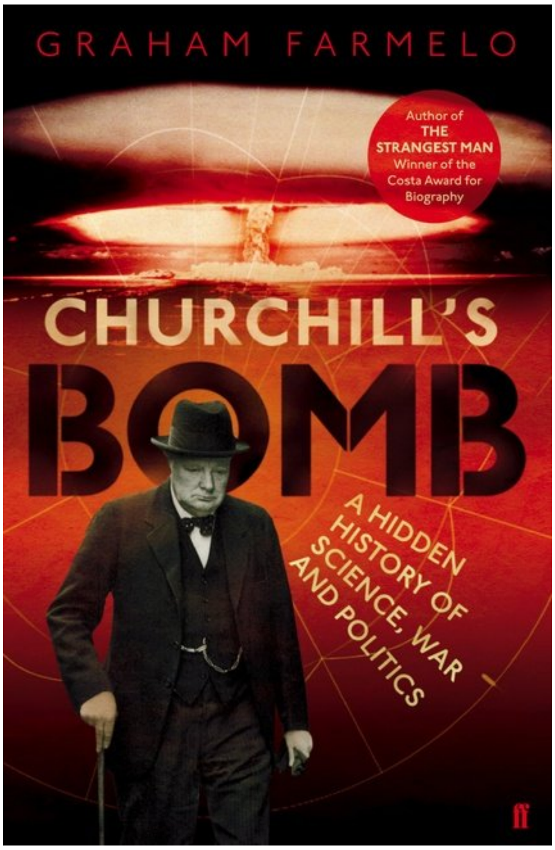
The final section brings us more up to date, with chapters on more recent pollution impacting on health (Sellers, Chapter 9) and climate change (Palmlund, Chapter 12). Sellers takes the example of lead pollution, particularly through a study of smelting works on the US/Mexico border serviced by the Mexico lead mines. Despite Texan distaste of external regulation, engineers, epidemiologists and toxicologists combined to produce the idea of 'a safe level of lead', leading to regulation on the effects of lead on the workers, and working practices to safeguard the heath of these workers. There are parallels today, of course, as technology develops. The notion of 'safe levels' can then spread to other countries, especially resource producers, since we note the inter-connection with improving communications. Palmlund's study investigates the chronology of climate change links with political discourses, as the international community has sought to establish strong global action over climate change. She notes the delay in even considering impacts on health, such as heat wave mortality, water-borne diseases and health impact of extreme weather events. As I write in the UK, unprecedented floods are spreading sewage through urban residential environments, increasing the impact of pathogens on humans. I have noticed that the natural scientists are still dominating school issues in the topic of climate change, in a European Network (Changing with the Climate), ignoring complex human issues and political action, and focusing more on individual action. Palmlund's work sets the problems I have encountered against a much broader historical context.

Overall, then, I have developed my appreciation of a historical approach to environment and health matters through this collection of papers, and my thinking about some of the more complex issues I am engaged with at this stage in my career. The book has also improved my critical reflection. I can therefore recommend it as a valuable library asset, linking history with life sciences.

(v) Graham Farmelo, *'Churchill's Bomb-A History of Science, War and Politics'*, Faber & Faber, (2013), p 3-554, London, ISBN 978-0-571-24978-7, UK £ 25 RRP.

Reviewed by: Martin Underwood, Sub-Department of Particle Physics, University of Oxford and Department of The History and Philosophy of Science, University of Cambridge

Graham Farmelo is the author of a remarkable book on Paul Dirac, *The Strangest Man* (Faber & Faber, 2009) and has now followed this with a fascinating study of William Churchill's involvement with the development of The Bomb (as I will refer to it throughout). The book begins towards the end of the life of Churchill, when he confided in his doctor in 1955 'I am more worried by [The Bomb] than all the rest of my problems put together'. Churchill had a fascination for science, in particular physics which was driven by a passion for the work of H. G. Wells, reading all of his novels. In particular, Churchill was struck by Wells's novel 'The World Set Free', published in 1921 which speculates about the consequences of radioactivity and effects upon mankind.



Churchill was a prolific journalist and writer and remarkably wrote a pamphlet 'Shall We All Commit Suicide', in 1924 and speculated that a bomb could be made, 'no bigger than an orange....with the explosive power of tons of cordite'. Thinking ahead to The Bomb, this was an astonishingly prescient insight. Churchill later published 'Fifty Years Hence' in 1931 speculating on science and the possibility of nuclear weapons.

One of the key individuals who features throughout this book is Frederick Lindemann (to become Viscount Cherwell), a teetotal, vegetarian theoretical physicist who knew Einstein, worked in Berlin and became Professor of Physics and Head of The Clarendon Laboratory, University of Oxford in 1919. Churchill met Lindemann or 'The Prof' as he came to refer to him in 1921 and by 1932 was a regular visitor to Chartwell, Churchill's country house. Churchill said of Lindemann that 'he is one of the best scientists and best brains in the country'. Fermalo points out that this was a view not shared by many other physicists, especially Rutherford. 'The Prof' became to be known as Churchill's lap dog and said of Churchill 'a scientist who missed his vocation'. Lindemann had a hold over Churchill concerning science related matters for around 30 years. When Lindemann published 'The Physical Significance of Quantum Theory' in 1932, Churchill delayed writing a Budget speech, reading it from cover to cover, becoming fascinated by quantum theory. Others, including Rutherford stated, as Fermalo points out that Lindemann had little grasp of the subject. Fermalo details how despised Lindemann became, especially in Oxford with the eminent philosopher Isaiah Berlin saying '[Lindemann] is a genuinely a horrible figure...he is the only person, I think, whom I have ardently wished to murder'.

However, Lindemann's wish was to increase the reputation of The Clarendon, believing it to be (as indeed it was) in the shadow of The Cavendish at The University of Cambridge, under the direction of Rutherford. From 1933 onwards, many gifted Jewish scientists felt the need to leave Germany, and later other countries as the threat posed by Hitler became apparent. The Government set up 'The Academic Assistance Council' to try and place them in short term jobs, with the hope of finding more permanent positions. Lindemann toured Germany in his chauffer driven limousine searching for talented physicists. He attracted gifted physicists to The Clarendon by simply paying them more, as he had managed to attract significant funding from industry. Lindemann even arranged for Einstein to have a short stay, arranging rooms in the more than congenial surroundings of Christ Church College.

One such émigré physicist was the Hungarian Leo Slizard, who fled to Vienna and was the first to point out how nuclear energy might be harnessed to make a bomb. Slizard began, what Fermalo describes as a career as 'an itinerant nuclear ambassador', and 'a strolling player in the field of nuclear theory' arriving in London in 1933. Slizard worked initially for The Academic Assistance Council and while crossing a road in London had an epiphany moment and envisaged a nuclear chain reaction.

When Churchill became First Lord of The Admiralty he appointed Lindemann as his personal advisor. War broke out and in May 1944 Churchill became Prime Minister, with Neville Chamberlain stepping down being made President of The Board of Trade, crucially with responsibility for science. Inevitably, Lindemann came to run the show and as Fermalo points out became the most influential scientist ever to work at the heart of British Government. The importance of nuclear energy was becoming clearer and a 'Uranium Committee' was set up under G. P. Thompson of Imperial College to coordinate nuclear work across Cambridge, Oxford, Liverpool, Birmingham and Bristol Universities. Lord Hankey was appointed Chair of 'The Scientific Advisory Committee' to investigate the possibility of nuclear weapons. A committee, named MAUD was set and a final report, written largely by James Chadwick concluded that a Uranium fuelled bomb was possible and should be pursued as a matter of priority.

There was, however, disagreement as to where a bomb should be built and more importantly should Britain go it alone. Henry Tizard, Scientific Advisor to The Air Ministry was one critic and argued that it would be 'absurd' to try and construct a bomb on British soil and advocated collaboration with The Americans. Also, highly critical was the brilliant physicist Patrick Blackett, who had been one of the so called 'Rutherford boys' at The Cavendish. Chadwick disagreed. Lindemann persuaded Churchill to become the first national leader to approve the development of nuclear weapons. Sir John Anderson became overseer of The British Bomb and realised that the MAUD Committee's estimate of a bomb being available within about two and a half years was overly optimistic. Nuclear related work became essentially Churchill's thiefdom, with Lindemann as his willing henchman The proposal was that ^{235}U be produced in Canada, with the Americans acting as consultants, with the British and American efforts being separate, but linked. President Roosevelt personally made an offer of cooperation.

Mark Oliphant, another 'Rutherford boy' was working on radar, and while on a visit to America 'let slip' the conclusions of The MAUD Report, to the consternation of others. Oliphant argued for British, American cooperation and was the first to mention, what became The Bomb, to Robert Oppenheimer, who was to become Scientific Director of The Manhattan Project (more later). President Roosevelt even wrote to Churchill saying that a nuclear project 'may be coordinated or even jointly conducted'. A move was then made that turned out to be highly controversial, when the Chairmanship of The MAUD Committee was handed over to the industrial giant ICI, under ICI's

Technical Director, Walter Akers. Roosevelt and Churchill met over Christmas 1944/5 but Roosevelt did not inform Churchill of America's decision to pursue a nuclear weapons programme.

The conclusions arising from The MAUD Report resulted in the setting up of Britain's nuclear weapons programme code named 'Tube Alloys' under Akers, who quickly started to win over some of the sceptics. Akers decided to fuse the activities of Tube Alloys with the American nuclear effort, along the lines suggested by Oliphant. (Around this time, the fission properties of ^{239}Pu were being investigated, which as we shall see presented a different set of problems). So, Roosevelt approved what was to be known as 'The Manhattan Project' to manufacture a nuclear bomb with General Leslie Groves as the Project Director and Robert Oppenheimer as Director of Science. Groves was instantly highly suspicious of the involvement of ICI, who Groves believed was in Tube Alloys to gain vital information to pursue a domestic nuclear power programme after the war. The exchange of information ceased. Lindemann was now persuaded to take up a seat in The Cabinet as Paymaster General and an American/US joint venture was agreed where:

1. neither country would use weapons against each other
2. neither country would pass on information to a third party without the permission of the other
3. the President would have a veto over any British venture into nuclear power.

So, Churchill at a conference in Quebec in 1945, to be later known as 'The Quebec Conference' gave the President an unprecedented veto on the development of nuclear power in the UK. Churchill believed that this was the only way of collaborating with the American Bomb Project and ensure that British scientists had learned enough to build 'our own' weapon after the war.

Fermalo then introduces the great Danish theoretical physicist, Niels Bohr into the debate. Niels Bohr, known as 'The Great Dane made a dramatic escape from Denmark in the unpressurised bomb bay of a fighter bomber aircraft. Bohr had worked at Los Alamos and became very friendly while there with Joseph Rotblat. Rotblat, notably walked out of The Manhattan Project, going on to campaign against nuclear weapons and winning The Nobel Prize for Peace. Bohr was very fearful of a nuclear arms race and believed that 'nuclear secrets' should be shared, including the Soviet Union. Bohr believed that this 'would bring a new era of harmony and trust'. Bohr made a tour of US nuclear weapons related facilities and was astonished by the huge industrial effort underway. John Cockcroft was put in charge of the Chalk River facility in Canada, where a heavy water moderated reactor was constructed and could make useable quantities of ^{239}Pu. This posed a problem as the fission properties of ^{239}Pu required a different detonation technique. Rudolph Peierls, who together with Otto Frisch had produced the absolutely crucial 'Memorandum' in 1940, showing that that The Bomb was feasible and could be constructed with much smaller quantities of ^{235}U than had been believed- in old units about 11 pounds. Not only that, they suggested that bringing two sub-critical masses of ^{235}U together by an explosive technique, essentially a gun barrel method would result in a huge explosion. They also speculated on the consequences of such an explosion.

The Frisch-Peierls Memorandum can be seen as the document that led to The Bomb and in my view, one of the most important pieces of scientific work (and speculation) to have ever been produced. Fermalo does stress the importance of their work, but could perhaps have said even more about the significance and ultimate consequences of their Memorandum. Peierls ran the Implosion Group at Los Alamos and together with James Tuck developed an implosion technique that involved completely surrounding a spherical ball of ^{239}Pu with explosives and imploding the material totally uniformly. Fermalo then introduces Klaus Fuchs a theoretical physicist, who shared an office with Peierls at Los Alamos, was a close friend of the family and even lodged with them. Fuchs turned out to be a Soviet spy, was exposed after the war having passed on a vast amount of information to the Soviets, including, quite incredibly the blueprint of the ^{239}Pu fuelled bomb that was used to destroy Nagasaki. Fuchs was tried, pleaded guilty and was jailed. He was later released having not served the whole of his sentence and became a Professor in East Germany. Peierls was devastated and the Americans incensed.

Roosevelt died on 12 April, 1945 and Harry S. Truman assumed the Presidency and as we shall see had significant consequences. Following the successful testing of The Bomb, The Trinity Test, Fermalo tellingly points out that Churchill was 'completely carried away' and that this 'would now redress our position, we could blow out Moscow'. What Churchill did not know was that Stalin was very well informed about nuclear weapons, even having a copy of The MAUD report, leaked by the spy John Cairncross. It is telling that Patrick Blackett, now Professor at Manchester University, who joined The Maud Committee in 1940 and after the absorption of the British nuclear effort with that of the US had 'nothing to do with it' was appalled, as were other key physicists.

In 1945, Clement Attlee took over as Prime Minister, Churchill being severely rebuffed at the polls. Attlee needed a nuclear policy using the expertise gained by British scientists working on The Manhattan Project and set up 'The Advisory Committee on Nuclear Energy', which included Blackett but notably excluded Lindemann. In January 1947, a Cabinet Committee authorised the 'research and development of nuclear weapons'. William Penny, a theoretical physicist who had worked on The Manhattan Project was to lead on armaments development with Cockcroft leading research. Farmelo points out that Truman was unaware of the Quebec Agreement and could not even find a copy. Truman simply threw it aside. In August 1954, Congress passed 'The McMahon Act' which made 'it illegal for any American to share nuclear information with any other country'. Blackett, typically, asserted that we should renounce nuclear weapons and be politically neutral. However, Attlee wanted The Bomb. When Congress was made aware of the terms of The Quebec Agreement, there was consternation that the British had a veto over US use of The Bomb. This was revoked along with the US having the power to halt the development of a UK nuclear power industry. The Quebec Agreement was dead.

Bill Penney had witnessed the Nagasaki bomb as an ariel observer. When appointed to set up the UK bomb programme he based his work at Aldermaston, to become 'The Nuclear Weapons Establishment'. Penney concentrated on developing a ^{239}Pu fuelled bomb, with an implosion mechanism of British design. Churchill was re-elected in 1951making his first speech on 6 November, 1951 and was the first British leader to be potentially armed with nuclear weapons. Not surprisingly, Lindemann returned to The Cabinet as Paymaster General. There was, however, differences of opinion with Churchill saying that the UK should use US made weapons, not make our own and simply 'be skilled in the art of 'The Bomb'.

'Churchill's Bomb' was successfully tested on 30 October, 1952 and eight days later America exploded the first Hydrogen Bomb, or H-bomb. Churchill acted, having had a change of view and appointed Sir Christopher Hinton to build factories to make ^{235}U and ^{239} Pu in significant quantities and manufacture nuclear weapons. Reactors were to be built at Windscale (now known as Sellafield) and Springfields Laboratory, where Uranium was extracted and enriched at Capenhurst. Crucially, this weapons programme was aligned with a domestic nuclear power programme. However, on both sides of the Atlantic nuclear power was low on the political agenda, being dominated by the H-bomb. This aroused division, with some scientists arguing for a halt in H-bomb testing as it would escalate the arms race with the Soviets, with Oppenheimer calling for a review of US nuclear strategy and came under severe scrutiny.

Churchill believed that he could do business with Stalin and when he died, The Prime Minister believed that he could work with the new Soviet leadership. Churchill underwent an epiphany, however, when he fully understood the potential impact of a nuclear conflict. Churchill heard in mid-August 1953 that the Soviets had tested an H-bomb. Now, with the UK, US and the Soviet Union able to blow each other and the world to bits, it was the time to pursue peace. Churchill, while reading The Guardian newspaper on 18 February, 1954 an article that said of the H-bomb '.. the heat and blast generated in the 1952 hydrogen test would cause absolute destruction over an area extending three miles in all directions.....the Russians would be able to deliver [such an attack on the US] in ‘one or two years’. From that moment Churchill became obsessed by the H-Bomb and became determined that ‘The Big Three’ leaders should meet to reduce the likelihood of nuclear war.

John Cockcroft was summoned to advise Whitehall on the hydrogen bomb. Cockcroft had accepted the job of running the Government’s nuclear research establishment, Harwell (while still being Director of the Chalk River facility in Canada). Cockcroft was on good terms with most nuclear scientists and administrators. He believed Churchill had been foolish to hand over Tube Alloys to ICI, was concerned about the influence of Lindemann and deprecated the sidelining of scientists such as Blackett. Cockcroft could not understand why the Americans did not demonstrate the first nuclear weapons on an uninhabited island. However, after nuclear weapons proved viable, Cockcroft believed his country needed them in order to defend itself. Cockcroft met Churchill and was invited to tour the Harwell and Aldermaston facilities. Commons debated the H-bomb on 5 April, 1954 and Churchill wanted a summit but President Truman disagreed. The Cabinet was amazed to hear that Churchill had approved the decision to build the H-bomb. Churchill explained that it was essential Britain acquire the H-bomb to preserve its global influence, make defence cuts and avoid giving the impression of disarmament and doing anything to ‘weaken our power to influence United States policy’ Fermalo points out that Churchill was looking for a grand exit from politics, with his government simply treading water towards the end of 1954, but in February 1955, the Government publishes a White Paper to explain why the UK should acquire the H-bomb. When the issue was debated in the Commons, Churchill argued that the H-bomb was an unavoidable reality, but disarmament ‘must not cloud our vision’. The only sane policy was ‘defence through deterrence’. Churchill stood down on 6 April that year and never spoke in the Commons again.

Fermalo finishes his book with an account of the later activities of Rutherford’s ‘boys’. Mark Oliphant, an Australian was appointed a research director of The Australian National University in Canberra. Blackett was now at Imperial College and re-established his influence with Attlee and the new Labour administration. Blackett turned down a ministerial appointment, but did eventually accept a place in The House of Lords. James Chadwick became Master of his former Cambridge College, Gonville and Caius and G.P. Thompson Master of Corpus Christi College. Frisch became Professor of Physics at Cambridge University, but never talked about his time on The Manhattan Project. Peierls became Professor of Physics at Oxford University, was always willing to talk about the development of The Bomb and committed himself to an international movement campaigning for a freeze on nuclear armaments. On every Saturday morning, whatever the weather , he was to be seen dressed in shirt and tie at local shopping centres ready to explain his views to anyone interested enough to listen.

Graham Fermalo has produced a fine narrative and explains in a clear, lucid manner Churchill’s often confused views on The Bomb and possible deployment. A very fine book.

(vi) Alexander Bird & James Ladyman, 2013, *Arguing about Science*, Routledge, Oxon., ISBN 978-0-415- 49230-0, pp 796 + xii, Paperback £29,99

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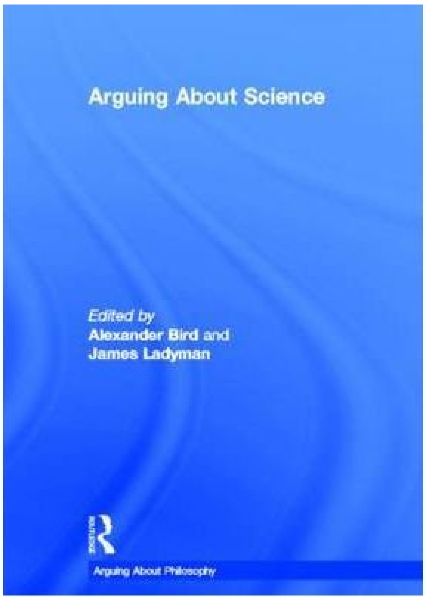
1. Introduction



I have two aims in this review: I wish to illustrate plainly the content of the collection and its value for the instructor that may wish to adopt it for undergraduate or postgraduate courses in philosophy of science; I will also articulate a justification for my evaluation of the text. By the end of the review it should be clear why I find the collection of great pedagogical and cultural interest. In the following I proceed commenting on each part of the collection highlighting details of interest or for improvement. In the conclusion I proceed to draw some general considerations.

2. The collection

Before getting down to the details of each single section let me spend a word on what seems to me an important characteristic of the collection. The editors blend novel and classical contributions in classical areas of philosophy of science and provide influential pieces on new areas of interest in the discipline. Their strategy in the selection of papers offers the possibility to address three culturally and pedagogically important features: a) classical problems in philosophy of science are seen mostly in direct contact with scientific practice; b) they are seen as relevant to the practitioner and not only to the philosopher of science; c) in certain cases the contributions allow to see such issues in their societal dimension and hence as important to people beyond the boundaries of the professional communities. Points a) and b) reflect a general trend in current philosophy of science but one that is more frequent in the rhetoric of the discipline that in its actual practice. Bird and Ladyman actually offer a selection of sources that do not suffer this problem: in each case in which a healthy contact with scientific practice is in point the selection punctually offers it. Point c) might seem secondary to scholars interested to feed in their students the taste for the purity of the philosophical pursuit. After all, the conceptual problems concerning our use of evidence to support a hypothesis, for example, are and should be seen as epistemologically interesting *per se*. Nevertheless, in my experience as a teacher, the lack of motivation in undertaking intellectual endeavors seen as devoid of pragmatic content is one of the most arduous obstacles to face for students in the philosophy of science. In this collection some of the readings, for instance in the medicine and in the forensic science parts, show not only how those epistemological problems trouble the philosopher of science but also how their treatment is an on-going concern both for the scientist and for the general public. Such general aspects of the collection constitute its major strength and its most valuable contribution to education in philosophy of science.

2.1 Part 1 What is science?

The readings in this part are classics on the problem of demarcation and as such they do not require particular discussion. I will nonetheless go back to Gould's piece at the end of this paragraph. In general, the introduction is quite helpful and detailed but it contains a historical inaccuracy[1] that I

[1] I will allow myself a further historical observation. Harvey's findings about the circulation of the blood and

would like to flag. The idea that the romantic tradition was profoundly anti-scientific rests on a commonplace that historically misrepresents that tradition (for instance, Hegel was well aware of the program of the *Energetics* in physics and he took it very seriously into account in his work).

Coming back to the readings, I found the choice of Gould brilliant for the clarity of the piece, its pertinence to the section, for Gould's ability to show both how scientific methodologies can be biased and how they can themselves help to rectify their very use. Finally, from a pedagogical perspective this piece allows to see the connection with other issues presented in other parts of the collection (inductive and causal reasoning in particular).

2.2 Part 2 Science Race and Gender

The introduction gives a very nice insight into a debate in which the most deceitful issue is to map concepts of race and gender employed in scientific context onto ones that come from our commonsensical intuition about such matters. The editors do a very good job at placing this core problem right under the eyes of the reader and they give a very alive take on the debate through their selection of contributions. Such selection brings out issues of bias in science in a rich and profound way. Glymour's piece on factor analysis is again a brilliant choice as it goes back, from a different perspective, to preoccupations that we have seen discussed by Gould in the previous section.

The Authors clearly and explicitly adhere to the dominant view in analytic philosophy of science that admits cultural, social and economical biases still conceiving of science as an activity enjoying a privileged epistemic status. The selection of readings offers in this sense a very nuanced take on that view as it is structured around contributions that approach very seriously the challenges posed by the biases.

I found the final page or so of the introduction to this section somehow overdoing the introductory task. The reference to the science wars here concerns me a bit. On one hand, it is surely pedagogically useful that the editors mention that debate and declare their loyalties making clear that by no means they sit neutrally with respect to it. On the other hand, because of the way the wars are presented, ironically, the reader gains the *biased* idea that the opponents have very little of useful to say. In particular, not all the parties taking part to that debate are identifiable with the postmodernist scholars targeted by Sokal's hoax and the few lines of report about the hoax itself are not entirely fair to the journal that hosted Sokal's piece.

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the motion of the heart are deemed revolutionary in the introduction to this part. I think that the revolutionary character of Harvey's work should be presented more carefully. His conception of the circulation of the blood and the function of the heart was essentially rejected *by the physicians of his own generation* - most of them actually took it to be plainly wrong for its evident conflict with Galenism. Now, the rejection was not simply based on sheer endorsement of Galenism. Harvey's view was that the blood moves in a circuit and such motion was due to the pumping action of the heart. Nevertheless he missed a crucial knock-down evidence for his view: he was never able to observe the passage of the blood from veins to arteries. He *inferred* such a passage from his theory and his observations. Harvey's conclusions came to be accepted as a *discovery* by the successive generation of physicians who accepted Harvey's arguments in the *De Motu Cordis* (). On the other hand, such a result was obtained through a comparative anatomical study of the function of the heart in animals (and humans). This was the approach core to Harvey's anti-Galenism, endorsed in open opposition to the views that were also shared by the main figures of the scientific revolution (e.g. Descartes). Harvey's anatomical methodology was Aristotelian and it was never accepted neither by his contemporaries nor by the successive generations of physicians who took his results very seriously.

2.3 Part 3 Scientific Reasoning

This part offers a rich provision of classics blended very effectively with more recent pieces. The core point is clearly whether or not a common pattern of reasoning is identifiable in science and what such a pattern might be. This issue is usually entrenched with that of providing justification for the beliefs arrived at by applying such patterns. In this sense I found pedagogically particularly effective the choice of presenting Mill's and Whewell - both in different ways conceiving of science as depending on inductive methodologies and reflecting on their nature and features - with that of authors that critically introduce alternative views or analysis of scientific reasoning. In the introduction logical positivism is used as a contrastive case and I would have appreciated a more nuanced presentation of this movement with some reference to appropriate sources.

2.4 Part 4 Scientific Explanation

This section takes seriously the most recent aspects of the debate concerning the notion of explanation. As I already stressed above I generally sympathise with this policy and the introduction helpfully puts the readings in the broad context of the various views on explanation. Nevertheless, I think this part would have gained from the inclusion of two pieces, respectively on unification and on functions. Some classics on these two subjects are aptly mentioned in the introduction and fully referenced in the further readings. In general, I think that the selection of readings as it stands is too closely reflective of the role played by explanatory issues in the debate between scientific realists and anti-realists. Finally, I found the part that refers to van Fraassen's piece a little poor in terms of introductory details.

2.5 Part 5 Laws and Causation

The choice of papers without any doubt is top quality but the topic of laws of nature alone would have absorbed a much larger section. So the construction of selection criteria for the papers in this case is surely arduous. The introduction is clear and very helpful both in introducing the actual readings and in providing guidance for further research on the topics. The editors, as already stressed, favour papers that keep some contact with scientific practice and philosophy of science. This criterion is fulfilled even in this definitely metaphysical part. Nonetheless, the achievement comes with some cost that I would like to be considered. First, it is not entirely clear to me why the editors did not devoted two separate sections to causation and laws. Given the amount of potential primary sources on each topic, I cannot help thinking that this would have been pedagogically wiser. Secondly, the debate on laws of nature has recently gained novel interesting contributions coming specifically from philosophers of science (Maudlin (2007) and Roberts (2008)) just to name a couple) that would have enriched the provision of readings giving an interesting sense of the direction that the scrutiny of scientific practices is currently taking.

2.6 Part 6 Science and Medicine

This section explores the complex relationship between philosophy and medicine from a philosophically interesting and fruitful angle. A classical topic that has been widely discussed in this area is that of characterising the notion of disease (and its counterpart "health"). The editors take a different route focusing on the scientific status of medicine and the philosophically interesting and yet complex and troubling connection between knowing and healing in medicine. I found this section one of the most attractive because it is certainly one in which it is most evident the importance of the reflection of philosophers of science not only for disciplinary (or more generally medical) practitioners but also for the ones embarked in reading and managing the social implication of certain health policies (for instance, should we fund more and more EBM because of its evident reliance on testing over clinical skills and medical training in handling issues of therapeutic efficacy? Is it more "scientific" to proceed this way in medicine?). The readings in the section bring brilliantly these implications of the philosophical debate to the attention of the student - and to some extent to the scholar too - and the introduction provides a clear and effective connection with further readings.

2.7 Part 7 Probability in action: forensic science

This is section through two stimulating and fascinating readings carries on the same policy of the previous one: we deal with instances not only of *probability in action*, as the title suggests, but with instances of effective philosophical reflection in action on probabilistic reasoning in forensic scenarios. The seriousness and significance of these contexts can hardly be overestimated. It is not that the problems under consideration are novel - the philosopher of science is used to deal with the treacheries of probabilistic reasoning and the dangers of its fallacies. Precisely for this reason, the use of this section is recommendable when the aim of the instructor is to give students (both PGs and UGs) both the opportunity to test their understanding of basic epistemological skills on probabilistic reasoning and to appreciate the significance for scientific work and for concrete problems of such skills.

2.8 Part 8 Risk, uncertainty and science policy

This part happily concludes the line of sections devoted to explore the fruitful applications of philosophical analysis to scientific context. This time under the scrutiny of the philosophers are the tools commonly employed to close the gap between scientific knowledge and scientifically informed decision making. As the editors emphasise in their brief but helpful introduction, there are a number of context in which scientific knowledge is expected to give policy makers a level of certainty on future scenarios (e.g. public health, climate change etc) which science cannot really give. Science cannot tell us what to do. To compensate for this gap various criteria, such like the *precautionary principle* are introduced. The section offers a sharp, lively, profound discussion on this topics and in doing so gives, in a vein similar to the previous one, the opportunity for a discussion of risk assessment that is both conceptually rich and clearly entrenched with practical (and moral) issues.

2.9 Part 9 Scientific Realism and Antirealism

This section is by and large the most conventional of the lot. It benefits from the adoption of a set of absolute classics that any student in the scientific realism debate should sooner or later make contact with. Also, in choosing Worrall's and Hacking's versions of scientific realism it surely anticipates the path that the debate has since taken in the realist camp. Realists have in general opted for a piecemeal defence of their views abandoning the idea that the commitment to unobservable parts of a successful theory has anything to do with the defense of the whole theory. Still, I would have liked that editors conceded some space to Stanford "un-conceived alternatives" (Stanford, 2006). I think it would have surely enriched the collection in many respects especially because of the way in which it combines a reasonable attention to the history of science with an instrumentalist perspective.[2]

3. General Conclusion

[2] I wish to add a historical observation concerning the ether and especially its role in physics after Fresnel and after Maxwell. Differently from what the editors claim when Duhem was writing his philosophical work on physical theories (Duhem 1906), the dominant view in the scientific community was, with some qualifications, still in favour of the existence of the ether. The most influential theory in that period is the theory of the electron of H.A. Lorentz (Lorentz 1905) published in its final version in 1905 and developed between 1892 and 1905. This theory of the electron is based on a dualist on ontology of charged particles and stationary ether.

Recently, there has been an increased attention to the connection between philosophy of science and the single sciences. This it has been perceived for the good of philosophy of science that should maintain a close contact with the scientific disciplines and their practices. Sometimes such attention has also led to consider certain issues somehow less worth the attention of the philosopher of science because of their generality. This collection is surely constructed in keep with the view that contact with the practice should never be lost. On the other hand, it offers a wide sampling of cases in which certain philosophical issues of general scope are still relevant and entrenched with the specific disciplinary practices. It also shed an interesting light on how tackling certain problems from a purely conceptual perspective may impact on social and political issues and how such issues may in turn find a legitimate place in seemingly abstract and conceptual contexts. The anthology offers a nuanced, rich and complex image of contemporary philosophy of science in its relationship with scientific practices. I think that *Arguing about Science* can constitute an extremely valuable aid to teach philosophy of science both at undergraduate and postgraduate level.

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All newsletter readers are invited to submit Book Notes or Reviews. Book Reviews should follow the format and style as used in this newsletter. Reviews of books in the areas of science education and history and philosophy of science should be sent as Word attachments to the Review Editor:

Charbel N. El-Hani, *Institute of Biology, Federal University of Bahia, Brazil.*
charbel.elhani@gmail.com

Reviews should provide full bibliographic details, some brief account of the content of the book as well as commentary, in 3,000-4,000 words, and ideally a scanned file of its cover.
Reviews are published both in the Newsletter and the journal *Science & Education.*

Book Notes are briefer versions of Reviews for publication in the Newsletter. They are submitted in the same way and in the same format.

Offers to join the reviewers' pool are welcome. Please send details of interest areas and CV to Charbel N. El-Hani, above.

11. Coming Conferences

June 29-July 2, 2014, Nurturing Genetics: Reflections on a Century of Scientific and Social Change: An International and Interdisciplinary Symposium
Details at:
http://www.leeds.ac.uk/arts/info/125175/genetics_pedagogies_project/2094/events)
To register contact Dr Annie Jamieson, at A.K.Jamieson@leeds.ac.uk

July 3-6, 2014, British Society for the History of Science Annual Conference, University of St Andrews
Details at: http://www.bshs.org.uk/conferences/annual-conference/2014-StAndrews

July 7-9, 2014, International Society for the Philosophy of Chemistry, annual meeting, London School of Economics
Details at:
http://www.philsci.org/images/docs/2014%20Conference%20of%20the%20International%20Society%20for%20the%20Philosophy%20of%20Chemistry%20ISPC.pdf

July 10-11, 2014, International Conference on *Science & Literature*, Athens, Greece
Details at: www.coscilit.org

July 14-18, 2014, Seventh European Summer University on the History and Epistemology in Mathematics Education.
Details at: http://conferences.au.dk/ESU-7/

August 18-22, 2014. International Congress for Physics Education, Cordoba, Argentina
Details at: http://www.icpe2014.org/

August 27-30, 2014, Second International Congress of Science Education, Foz do Iguaçu, Parana State, Brazil
Details at: http://congresso.unila.edu.br/icse2014/images/dados/2dICSE2014-2stCircular.pdf

September 4-6, 2014, European Society of History of Science, 6th International Conference, Lisbon
Details from: Fátima de Haan (occoe@occoe.pt)

October 17-19, 2014, 3rd Latin American Regional IHPST Conference, Santiago de Chile
Details from: Mario Quintanilla Gatica (mquintag@puc.cl).
www.sociedadbellaterra.cl/congreso2014

October 30 - November 2, 2014, International Society of Educational Research Conference, Cappadocia, Turkey: 'Science, Mathematics, and Technology Education in the 21st Century: Emerging Paradigms, Pedagogies, and Technologies'
Details at: www.i-ser.net/iser2014/

November 6-9, 2014, Conjoint Biennial Meeting of the Philosophy of Science Association and History of Science Society, Chicago, USA
Details at: http://www.philsci.org/ and http://www.hssonline.org

December 4-6, 2014, Second IHPST Asian Regional Conference, Taipei.
Details from: Dr Shiang-Yao Liu, liusy@ntnu.edu.tw
And: http://www.sec.ntnu.edu.tw/ihpst2014/

August 3-8, 2015, 15th Congress of Logic, Methodology, and Philosophy of Science, Helsinki
Details at: http://www.helsinki.fi/clmps

12. IHPST Council (2013-15)

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13. Newsletter Items

This IHPST Electronic *Newsletter* goes direct to about 6,500 email addresses on the IHPST 'colleagues' list (which is considerably larger than the membership list), and it is also posted to various science education, philosophy of education, and HPS lists. Items for inclusion in the *Newsletter* are appreciated. These can be items for the 'Opinion', 'Recent Research', 'Recent Books', 'Books' or 'Conferences' sections.

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