HPS&ST NEWSLETTER

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The HPS&ST NEWSLETTER is emailed monthly to about 9,000 individuals who directly or indirectly have an interest in the contribution of history and philosophy of science to theoretical, curricular and pedagogical issues in science teaching, and/or interests in the promotion of innovative, engaging and effective teaching of the history and philosophy of science. The NEWSLETTER is sent on to different international and national HPS lists and international and national science teaching lists. In print or electronic form, it has been published for 25+ years.

The NEWSLETTER seeks to serve the diverse international community of HPS&ST scholars and teachers by disseminating information about events and publications that connect to concerns of the HPS&ST community.

Contributions to the NEWSLETTER (publications, conferences, opinion pieces, &.) are welcome and should be sent direct to the editor: Michael R. Matthews, UNSW (m.matthews@unsw.edu.au).

The NEWSLETTER, along with RESOURCES, OBITUARIES, OPINION PIECES and more, are available at the website: http://www.hpsst.com/

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Vale Norman Lederman (1952-2021)

Norman Lederman, an internationally known and respected science educator, died after a short illness on February 2021 in Rhode Island, USA. Norm and Judy, his wife and research partner of many years, had recently relocated from Chicago to enjoy retirement years with their family and Norm's stepchildren. Pleasingly Judy was at his side when he passed away. There is no best way to go, but that is a good way.

Norm well embodied in his 47-year career the oft-sought goal of bridging the worlds of science teachers, science teacher educators, and academic researchers. Over the past 30 years he also engaged with the HPS&ST research community.

HPS&ST Involvement

In 1992 the journal *Science & Education: Contributions from HPS* was founded and from the earliest years, Norm was a valued Editorial Committee member and reviewer. In the same year Norm published an article that comprehensively reviewed the research literature on teaching NOS.

Lederman, N.G.: 1992, 'Students' and Teachers' Conceptions of the Nature of Science: A Review of the Research', *Journal of Research in Science Teaching* 29(4), 331-359.

It was published in a JRST thematic issue jointly edited by Rodger Bybee, James Ellis and myself. It deservedly became one of the most cited articles published in the journal.

In 1995 I invited Norm to respond to a substantial article on 'The Nature of Scientific Thought' by the Australian philosopher Wallis Suchting who had been one of my philosophy teachers at University of Sydney. Norm's thoughtful response was:

Lederman, N.G.: 1995, 'Suchting and the Nature of Scientific Thought: Are we Anchoring Curricula in Quicksand?', *Science & Education* 4(4), 371-377.

In the article he concluded:

> There is little doubt that many will wish to quibble with Suchting's philosophical analysis and ultimate conclusions. However, his analysis does raise serious questions regarding our current approach …to science instruction and curriculum. Failure to carefully consider the concerns raised by his analysis of scientific thinking may result in science curricula and approach to science instruction that clearly misrepresents the scientific enterprise.

Norm contributed to the 1995 IHPST Minneapolis

conference and his paper was subsequently published:

Lederman, N. G. (1999). Teachers' understanding of the nature of science and classroom practice: Factors that facilitate or impede the relationship. *Journal of Research in Science Teaching*, 36(8), 916-929.

With a number of his colleagues and students he contributed to the IHPST 1999 Lake Como conference.

Abd-El-Khalick, F., & Lederman, N. (1999, September). *Success of the attempts to improve science teachers' conceptions of nature of science: A review of the literature.*

Lederman, N., Bell, R., & Abd-El-Khalick, F. (1999, September). *Developing and acting upon one's conceptions of the nature of science.*

In 2012 he was a plenary speaker at the IHPST regional conferences in Seoul; and he participated in other IHPST international and regional conferences.

As is documented below, Norm put 'Nature of Science' or NOS on the international science education curriculum, teaching and research agenda. He was a welcomed lecturer and teacher in countless countries. Norm and co-workers elaborated and defended a seven-point characterisation of NOS. They maintained that the list was framed in accord with three principles: accessibility to school students; wide enough consensus among historians and philosophers; and being useful for citizens to know. There are nearly 40,000 citations of Norm's authored and co-authored NOS publications.

There were, of course, critiques of minor and major parts of his research programme; but these debates were healthy, clarifying and advanced the main field. For instance, the 12 contributions to Myint Swe Khine's anthology *Advances in Nature of Science Research* (Springer 2012) include critical pieces. One of these is my own chapter that has a section titled 'The Devil is in the Detail: The Need for Philosophical Articulation'. The matter of philosophical sophistication in NOS debate was a topic that Norm and myself discussed in numerous convivial meetings in many lands, usually over a beer, or for Norm a whiskey. The anthology also contains elaborations by Norm, Judy and other well-known NOS researchers, including two of his earliest students Renee' Schwartz and Randy Bell.

Career

Shortly after earning his B.S. and M.S. degrees in biology from Bradley University (1971) and New York University (1973), respectively, Norm taught biology for a decade to high school and community college students in Illinois and New York, as well as college students at Syracuse University. During those years, he earned an M.S. in secondary education from Bradley (1977) and Ph.D. in science education from Syracuse University (1983), studying under Dr. Marvin Druger. Norm held assistant professor positions in science education and teacher education at Syracuse University, State University of New York–Albany, and Oregon State University (OSU). In 2001, he chaired OSU's Department of Mathematics and Science Education, and left that year to establish and chair the Illinois Institute of Technology's (IIT) new Mathematics and Science Education Department.

In 2011, Norm was named an IIT Distinguished Professor. By the time of his retirement in 2020, his IIT department had become a local, national,

and international force in discipline-based mathematics and science education. Along the way, Norm was a Visiting Research Professor at National Changhua University of Education, Taiwan; Fulbright Scholar at the University of Pretoria, South Africa; Honorary Professor at the Hong Kong Institute of Education; Guest Professor at Beijing Normal University, China; and Distinguished Foreign Expert at the State Administration of Foreign Affairs, China. At the time of his death, Norm was a "virtual" visiting professor at the University of Science and Technology of China.

Research and Publications

Norm was an intellectual force and prolific researcher. He studied preservice and inservice science teachers' knowledge structures of subject matter and pedagogy, pedagogical content knowledge, and teachers' concerns and beliefs. Norm is best known for his research on teaching and learning about nature of science (NOS), a robust domain of research in science education that is inextricably linked with his name. Norm's 1992 review of the research literature on NOS published in the *Journal of Research in Science Teaching* (JRST) continues to be one of the top five most cited papers in our field. This paper has shaped research on NOS in science education for the past 30 years.

Over his distinguished career, Norm published more than 200 articles in professional refereed journals and 46 book chapters. He authored or edited 11 books, including an elementary science teaching methods textbook. Norm co-edited with Sandra Abell the *Handbook of Research on Science Education: Volume I* (2007) and *Volume II* (2014), and was editing *Volume III* of the handbook, with Dana Zeidler and Judy Lederman, at the time of his passing. Norm has given more than 1000 presentations, invited talks, and keynote addresses at regional, national and international professional conferences and meetings, as well as universities around the globe.

His work has been heavily cited with 38,000+ citations on Google Scholar (h-index = 70; i10-index = 153) and 6,400+ citations on the Web of Science® (h-index = 33; i-10 index = 45).

Editorship

Norm's research leadership extended to shaping the field through extensive engagement in the editorship of professional journals. He served as co-editor of the *School Science and Mathematics Journal*, and *Journal of Science Teacher Education* (JSTE), as well as associate editor for JRST, JSTE, and *International Journal of Science Education*, among many other journals. Norm served on the editorial boards of some 15 science education journals across the globe.

Teaching and Supervision

Norm taught and mentored hundreds upon hundreds of science students, preservice and inservice science teachers, and graduate students in science education in the United States and across the globe. He was major professor to 51 doctoral students, mentoring them into successful careers of their own. These included: Fouad Abd-El-Khalick, Valarie Akerson, Selena Bartels, Randy Bell, Huey-Por Chang, Julie Gess-Newsome, Shiang-Yao Liu, Tisha Morrell, Judy Morrison, Gary Holliday and Reneé Schwartz. Norm was an exceptional mentor and treated his doctoral students as family; in turn he was con-

sidered as family by all.

For his work, Norm received the Illinois Outstanding Biology Teacher Award from the National Association of Biology Teachers (1979), as well as the Presidential Citation for Distinguished Service (1986) and Outstanding Mentor Award (1998) from the Association for the Education of Teachers in Science (AETS).

Recognition

Additionally, Norm provided significant service and leadership to major national and international organisations across science teaching, science teacher education, and science education research. He was elected president of AETS (1994), member of the board of directors (1994–1998) and director of teacher education (1996–1998) of the National Science Teachers Association (NSTA), and NARST executive board of directors (1997–2000) and then NARST president (2002). He also served as the North American representative to the International Council of Associations for Science Education (2004–2010). For this extensive service and leadership, NSTA recognised Norm in 2017 with the Distinguished Service to Science Education Award.

For his scholarship, Norm was elected Fellow of the American Association for the Advancement of Science (2009) and American Education Research Association (2010). He was recognised with an honorary doctorate from the University of Stockholm, Sweden (2008). In 2011 NARST honoured him with the Distinguished Contributions to Science Education through Research Award for his outstanding and continuing contributions, notable leadership, and substantial impact in the area of science education.

Norm will be sorely missed by Judy, his family, and so many close friends around the world. But his special contributions in making HPS&ST research engaging and interesting for science teachers will surely live on.

Michael R. Matthews
School of Education
University of New South Wales

Why Trust Science and Science Education? Call for Papers *Science & Education* Journal

Public debates around issues such as climate change and vaccination have put into question the public trust in science (Oreskes, 2019). Some science education researchers have adopted positions that science is fundamentally shaped by ideology (Mackenzie, Good, & Brown, 2014). The emerging lines of research in science and science education have been based on claims that science suffers from a systematic bias through sexism, racism, capitalism, colonialism and other ideological interests. The methodological approaches such as ethnomethodology, deconstructionism and critical theory have mediated the propagation of such lines of research along with showcasing of historical case studies of misuse of and abuse by science in society.

In the broad context of social justice causes including efforts to combat structural racism and sexism, such framing of science as an oppressive endeavour would appear to garner support. Yet, the explanatory and predictive power of scientific knowledge as well as contributions of science to society, are undeniable, as evidenced by the current anticipation of an effective vaccine to tackle the

Covid-19 pandemic.

Science has a history of not only contributing to society, for instance, through medical and technological innovations but also through rational and evidence-based debate on social issues. In the post-truth era where the legitimacy of expertise and evidence-based claims are increasingly eroded, the consequences of science denial can be fatal. For example, climate change denial is likely to lead to a planetary emergency where the natural world and the environment will suffer an irreversible destruction.

The complex interaction between science and society points to some key tensions: tensions between uncertainty in scientific knowledge versus the capacity to build powerful explanatory and predictive models; tensions between democratic values versus undemocratic decision-making given priority of evidence; tensions between science as an economics-driven enterprise versus a knowledge-driven enterprise.

At a time when science education needs to instil in future citizens robust evidence-based reasoning skills for the sake of social and planetary justice, how can such tensions be reconciled? The Editors of *Science & Education* invite papers that address this fundamental question through theoretical and empirical studies in a special issue with the theme of "Why Trust Science and Science Education?". Some example themes that papers can explore are the following:

- Why should science be trusted? How is trust established in scientific communities? How can science education foster trust in science? For example, what examples of curricula are available that support trust in science and what impact do they have on science teaching and learning?
- How can science learning environments be shaped to acknowledge the power and the limitations of science? What evidence is there that such learning environments improves students' understanding of and engagement with science?
- Can approaches based on critiques of science help students appreciate evidence-based discussions, contribute to their understanding of policy-debates, and the need for scientifically informed regulatory practices? If so, how?
- If science is inherently oppressive (ie. sexist, racist, imperial), how can it be salvaged from its exploitative nature and legacy? How can learning environments be designed to foster understanding of how science should work?
- What role can informal and non-formal learning environments play in educating the public about why and when trust in science is warranted?
- How do the political landscapes of different nations and communities foster public trust or mistrust in science? What are some examples from history of science as well as contemporary science? What implications do they present for education?

Submission deadline: **April 30th, 2021**

Science & Education publishes research using historical, philosophical, and sociological approaches in order to improve teaching, learning, and curricula in science and mathematics. In addition, the journal disseminates accounts of lessons, units of work, and programs at all levels of science and mathematics that have successfully utilised history and philosophy. The journal promotes the inclusion of history and philosophy of science and mathematics courses in

science and mathematics teacher education programs. Moreover, it promotes the discussion of the philosophy and purpose of science and mathematics education and their place in and contribution to the intellectual and ethical development of individuals and cultures.

Instructions for the preparation and submission of manuscripts can be accessed here.

References

Mackenzie J., Good R., & Brown J.R. (2014). Postmodernism and Science Education: An Appraisal. In, M. Matthews (Eds), *International Handbook of Research in History, Philosophy and Science Teaching*. Dordrecht: Springer.

Oreskes, N. (2019). *Why Trust Science?* Princeton, NJ: Princeton University Press.

History of Science YouTube Channel

The channel on YouTube is an initiative of Brazilian and Portuguese scholars. It disseminates various areas of knowledge related to the history of science, technology, and scientific education through brief conversations with specialists, professors, and researchers from all over the world. There are currently about 100 presentations available on the channel. The bulk in Portuguese, but some in English.

The channel was created by two Ph.D. students of the Doctoral Program in the History of Sciences and Scientific Education promoted jointly by the University of Coimbra and the University of Aveiro. The videos, typically 10-15 minutes, are reviewed and approved by the interviewees themselves and by an editorial board of professors from the Doctoral Program.

The most recent addition to the channel is a brief presentation on 'HPS-informed Teaching of Pendulum Motion' by Michael Matthews, UNSW.

The presentation draws on his contribution to the recent Springer anthology *Nature of Science in Science Instruction Rationales and Strategies*.

The History Channel administrators can be contacted direct at:

historyofscienceuc@gmail.com

Proposals for presentations would be warmly received.

IHPST 2021 Webinars

The planned IHPST July International Conference in Calgary has been postponed till 3-7 July 2022. In lieu of the conference there will be a series of webinars available to IHPST members.

FIRST: Towards a Research Agenda in Nature of Science for Social Justice April 13, 2 pm-3.30 pm GMT

Abstract: The purpose of this webinar is to explore a possible research agenda in the area of "Nature of Science for Social Justice" (NOS for SJ). It draws upon a recently edited volume of the same title (Yacoubian & Hansson, Springer 2020) as its starting point. In the volume, 20 science education scholars initiated a research-based dialogue on what NOS for SJ can mean and what should characterise NOS teaching contributing to the educational aim of social justice.

Panelists: Douglas Allchin, Lucy Avraamidou,

Jesse Bazzul, Larry Bencze, Zoubeida Dagher, Sibel Erduran, Andreia Guerra, Lena Hansson, Ebru Kaya, Lotta Leden, Cristiano Moura, Hagop Yacoubian

SECOND: Importance of Research on History, Philosophy and Sociology of Science in Science Education: Reflections from the Editor-in-Chief of *Science & Education*
May 7th 2 p.m. – 3:30 p.m GMT

Sibel Erduran, the Editor-in-Chief of *Science & Education* about the research on History, Philosophy, and Sociology of Science in Science Education. After the talk, the webinar will be opened to the audience to leave comments and pose questions.

THIRD: Teaching Aspects of the Nature of Science
Date and time to be announced.

William McComas will introduce and discuss contributions to the anthology *Nature of Science in Science Instruction Rationales and Strategies* (McComas 2020)

The webinars are open only to members of the IHPST Group. Further details, including Abstracts of the webinars and IHPST membership details are available at here.

Philosophy of Science Association (PSA) Covid Teaching Resources

Teaching Philosophy in the Time of COVID is a new resource page on the PSA website. It features syllabi, articles, videos, podcasts, and other resources related to philosophy and the coronavirus. If you've found an interesting source on philosophy and the coronavirus, we invite you to submit it. The page will be updated weekly with new materials that are useful for professors teaching philosophy and COVID in the classroom or for whomever is trying to think philosophically about the pandemic.

Details are available here.

Dibner Award, Society for the History of Technology

Nominations are open for the Society for the History of Technology's Dibner Award. In general, online, screen-based and physical exhibits are eligible. However, in 2021 because of the restrictions on refereeing imposed by the pandemic, only online exhibits will be considered eligible. So, if you have a suitable online exhibit please do apply! The closing date for applications is 30 April 2021.

The Dibner Award for Excellence in Museum Exhibits was established in 1985, through the generosity of Bern Dibner, to recognise excellence in museums and museum exhibits that interpret the history of technology, industry, and engineering to the general public. Winning exhibits, in addition to being well designed and produced, should raise pertinent historical issues. Artefacts and images should be used in a manner that interests, teaches, and stimulates both the general public and historians. The award consists of a plaque and up to $1,000 to cover expenses for a member of the design team to accept the award at the SHOT awards banquet.

Exhibits are eligible for this award if they have been open to the public for no more than 24 months before the deadline for nominations. The Society especially encourages nominations from

local and regional museums and historical societies.

Further information about the prize, including the nomination form, a list of past recipients, and the members of the Dibner Award Committee can be found on the SHOT website here.

US History of Science Society: Joseph H. Hazen Education Prize, Nominations

The Joseph H. Hazen Education Prize is awarded in recognition of outstanding contributions to the teaching of history of science. Educational activities recognised by the award are to be construed in the broadest sense and should include but not be limited to the following: classroom teaching (K-12, undergraduate, graduate, or extended education), mentoring of young scholars, museum work, journalism, organisation and administration of educational programs, influential writing, educational research, innovation in the methodology of instruction, preparation of pedagogical materials, or public outreach through non-print media.

Nominations may be made by any HSS member and should include a curriculum vitae of the nominee, a statement of not more than 1000 words describing her or his educational contributions, and not more than two seconding letters. All nominations remain active for three years. Check the nomination form below for the deadline.

Submit a Nomination for this Prize

Opinion Piece: *The Beauty and Pleasure of Understanding* Igal Galili

The Hebrew University of Jerusalem, Israel

(Words of Introduction for the ESERA 2019 Meeting in Bologna)

Igal Galili studied physics in the former USSR and later at the Hebrew University of Jerusalem where he got his B.Sc, M.Sc.in physics and Ph.D. in theoretical physics. After his post-doctorate in the San Diego State University with Professor Fred Goldberg he became researcher in physics education and joined the staff of the science teaching department of the Hebrew University of Jerusalem.

He has published research papers in various educational journals *American Journal of Physics*, *International Journal of Science Education*, *Science Education* and *Science & Education*. And has developed a textbook in optics in broad cultural perspective that displayed the historical development of theories of light and vision from the ancient Greece to the modern physics.

I am greatly obliged to the organisers of this conference in Bologna for their invitation, especially in relation to the conference theme "The beauty and pleasure of understanding". I agree with the organisers that this theme is an expression of an essential aspect of science and thus also important for science education. I also agree that there are plenty of other important aspects of science and science education captured in the second part of the conference theme, "engaging with contemporary challenges through science education", an all-inclusive and popular claim about the significance of science education. Both parts are, of course, complementary.

The broad public recognises the existential need for science for our very survival, and to help us live effective and comfortable lives. Let us begin by noting these "pragmatic" benefits, listed in the lefthand column of Table 1. They are often sufficiently attractive to many students to interest them in science. Yet, the Bible hints at the fact that this list of benefits is incomplete; humans need more:

> Deuteronomy 8:3: …to teach you that man does not live on bread alone but on every word that comes from the mouth of the Lord.

In the righthand column of Table 1, I tried to enumerate benefits of another kind that could be considered "spiritual". While they may appear more esoteric, I argue they actually encourage us to construe science as its own distinctive cultural. This distinguishes science from a craft that has specific rules that must be followed to be successful.

The pragmatic claims in the left-hand column are taken for granted and commonplace. Their objective validity draws on the great achievements of our society. The "spiritual" features in the right-hand column, however, are often considered to be emotional and illusive and therefore, optional, subjective, secondary, causing merely affective impact that may enhance the effect of teaching but dilutes, misleads and detracts attention from the "true" content of science learning, and results in the loss of valuable time.

Let me begin my argument by observing that science itself did not start for the purpose of providing practical benefits. Science started with searching for objective causes of natural phenomena, law-like regularities, and then introducing abstract concepts and models of the natural order. Rational objective knowledge – *episteme* – was invented in Classical Greece. There was no obvious need to do that since technological knowledge – *techne* – was not immediately related to natural philosophy. Why know about the arrangements of stars and planets in multiple spheres with complex structure? Why know about "effective" causes for seasons and the mechanism behind their cycle? Why know about elements and structure of matter? Why know how vision works? Yet, these and other questions about reality emerged very early and continue to provoke people through the ages without immediate and obvious practical benefits.

Table 1. Pragmatic (left) versus Spiritual (right) benefits of science education

Science education…	Science education…
is required to develop, understand and use technology that promises to support personal and social well-being	provides an understanding of how Nature is organised as a whole, its law-like design, explaining "how it all works". This understanding is pleasing for its cosmic universal perspective (and is often poorly expressed as "fun").
enables reliable solving of problems across the great variety of human activities	reveals to students a special beauty of causal design, the architecture of Nature as theory based, an intellectual edifice of perfect harmony (aesthetic value). These aspects remain unknown to those who do not learn science.
stimulates development of individual skills and abilities, creativity, the art of logic	introduces students to the beautiful idea of unified, inductive and deductive logic by which an infinite variety of phenomena can be reduced to a few governing principles. That is to say science expresses the amazing unity across variety and variety in unity.
familiarises students with the rules of effective activity and knowledge that are objective and rational. It stimulates students' critical thinking, being responsible, cooperative, modest, open to criticism.	provides its students with intellectual depth, appreciation of sophisticated symmetry, the fundamental complementarity and parsimony in our grasp of reality
is faithful to science's aspiration to objectivity, offers a universal picture of the world	through historical examples, promotes the non-pragmatic values of altruism, romanticism, devotion to the needs of society, learning from others.
provides a solid basis for individual prosperity, social respect, and successful careers	
introduces ethical norms of social behaviour and rules of productive cooperation	

Skipping a comprehensive analysis, we may listen to the scientists themselves[1] who, from the dawn of science, continuously addressed their drive, motivation and intention. For example, in modern times, this is how James Peebles, who won the Nobel Prize in physics in 2019, reacted to the announcement:

> The prizes and awards, they are charming, much appreciated, but that's not part of your plans. You should enter science because you are fascinated by

[1] "To learn from the horse mouth" (Wong & Hodson, 2009).

it.

"Prizes" can be understood in a broader sense as practical benefits. Scientists continuously repeat the idea which Leonardo expressed as: *The noblest pleasure is the joy of understanding*.

The renowned scientist of the recent past, Henry Poincaré (1908), refined it while reflecting on the history of science:

> The scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it, and he takes pleasure in it because it is beautiful. If nature were not beautiful it would not be worth knowing, and life would not be worth living. (p. 22)
>
> Is it merely that things which seem to us beautiful are those which are best adapted to our intelligence, and that consequently they are at the same time the tools that intelligence knows best how to handle? (p. 23)
>
> …the Greeks loved the intellectual beauty hidden behind sensible beauty, and that it is this beauty which gives certainty and strength to the intelligence. (p. 24)

The history of science abounds with such confessions emphasising the pleasure of understanding as a special type of emotional excitement caused by revealing the special type of beauty the world possesses. Thus, pleasure and beauty are components of science as practiced. But are they essential? Let us proceed.

For centuries, the concept of beauty has been considered emblematic of Italian culture. Beauty attracts people universally; including beauty as revealed through science. But this reaches a level of refinement in Italy, in particular, that is noteworthy. Consider Florence, the place where people especially venerated beauty. In the 16th century, they placed the statue of David by Michelangelo in the central square of the city as a symbol of beauty (Fig. 1a). It stays there now – a lovely young fighter of perfect proportions. Yet, the youth was neither Apollo nor Alexander the Great, but the Biblical hero, King David.

What is remarkable about this choice is the fusion of a warrior, demonstrating the power of force, courage and devotion to his people with something very different. David was a poet whose poetry, *The Book of Psalms*, talking to and about God, has been in continuous use for three thousand years by people around the world in their everyday prayers. David apparently symbolised the symbiosis of internal and external beauty in ultimate harmony which seemingly left no place to add anything else. Was it so?

In fact, the people of Bologna did not agree with Florence and pointed to another dimension of beauty missing in the Florencian set – the beauty and pleasure of understanding, not less and possibly more divine in its nature. In the 11th century, the people of Bologna established a new type of temple, the temple of knowledge, the university – *Alma Mater Studiorum*. Their heroes were people of knowledge and understanding: students and professors. Within the national tradition of artistic visualisation, they produced the image of a student (Fig. 1b). In parallel to David, a young warrior-poet and emblem of the beautiful inside and out, the figure of the young student is delighted by the knowledge revealed to him; this became emblematic of Bologna. It is this image that we may consider as a visualisation of the title of our conference – *The beauty and pleasure of understanding*.

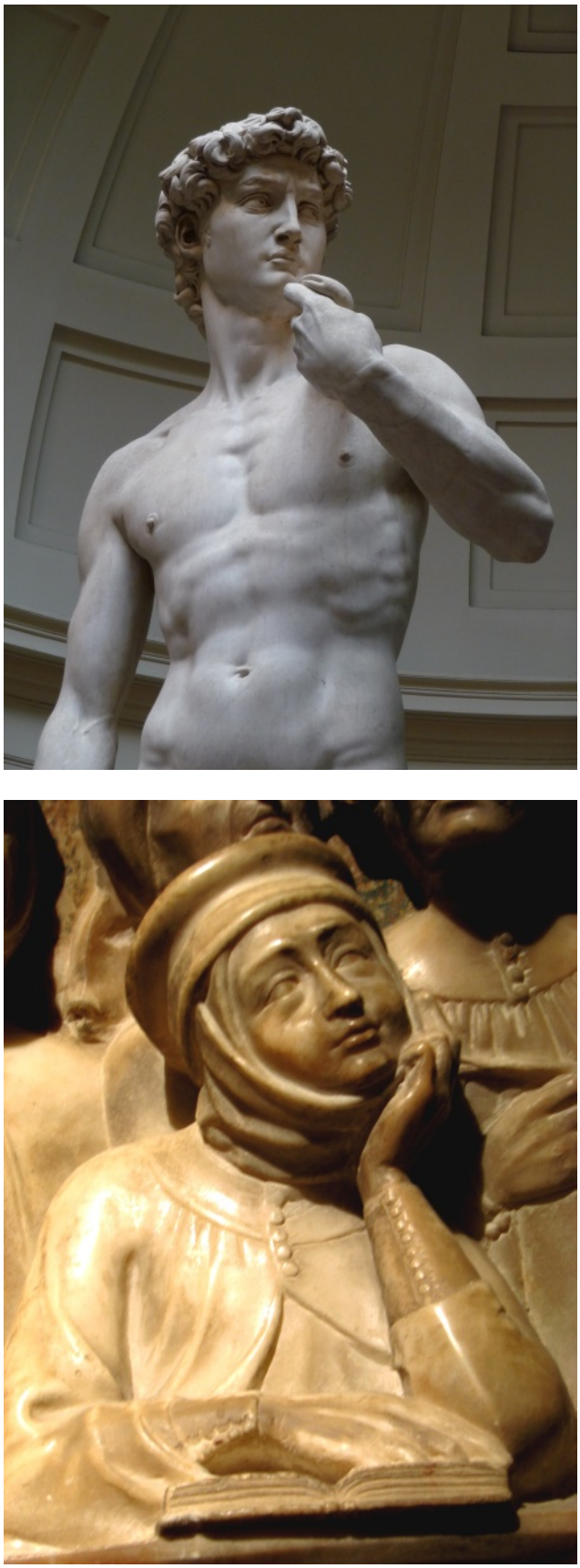

Figure 1. (a) A fragment of the statue of David by Michelangelo (c. 1504) in Florence. (b) A fragment from the bas-relief on the sarcophagi of a professor in Bologna University by Masegne (c. 1383).

Over the course of one thousand years, this university was decorated by a long gallery of renowned scholars of which I mention a few whose names I encountered: Giovanni di Casali, Giovanni Battista Riccioli, Francesco Maria Grimaldi, Giovanni Domenico Cassini, Luigi Galvani, Guglielmo Giovanni Maria Marconi and of course, Umberto Eco. They all illuminated the minds of numerous students who were introduced here to the unique beauty and pleasure of understanding. In line with this tradition, in 2002, the journal *Physics World* announced the choice made by its readers to consider the physics experiment performed in 1974 by three Bologna professors (Pier Giorgio Merli, Gian Franco Missiroli, and Giulio Pozzi) as the most…beautiful of all time. From all the possible characteristics that could be used to describe scientific products, a rather unusual description, "beautiful", was chosen for the experiment providing evidence of the amazing interference of an electron with…itself.

As we turn to science education, it is my special pleasure to pay tribute to University of Bologna professor Nella Grimelini-Tomasini (Lella) who has raised the flag of the *Pleasure of Understanding* in physics education. Many people certainly join me now in sending her our deep appreciation, sincere gratitude and wishes of health and prosperity that she so much deserves.

It seems to me that the location of this meeting and the idea of highlighting the "spiritual" aspects of science education, which was made explicit in the title of our meeting, is as surprising as blossoms in springtime. It is therefore paramount to capture this moment and draw attention to the importance of encouraging this perspective in science education[2]. This spiritual commitment of the physics education group in Bologna (established by Lella) encourage us to explore this intellectual direction in science education. They have raised the flag however, profound questions emerged regarding its implications. What should we actually do to encourage students to experience the pleasure of understanding of science? What content should we specifically address? Is there something teachers can do in addressing this content beyond the general claims of Table 1?

We need to show that even if pragmatic values may prevail for their existential benefits, their spiritual extensions are vital for science *understanding*. Such recognition cannot be spontaneous or intuitive. It requires clarification and specific restructuring of numerous curricular components and their underpinnings be they disciplinary, cognitive, philosophical, historical and sociological, which all contribute to our understanding of understanding. What should be included and how? To provide my answer, let me briefly present results of a comprehensive study dealing with this topic[3]. This line of work suggested a special organisation of the science curriculum, which I call *discipline-culture*. Within this perspective, I intend to answer those questions raised above.

Scientific knowledge is comprised of big clusters of knowledge elements which are internally coherent. These clusters can be structured and hierarchically ordered. The elements of each cluster share a certain historical thread, methodological tools of production of new elements, adopting some and rejecting others. They create a colony or a culture. These groups comprise the fundamental theories known to us, each providing a specific picture of the world (mechanics, electromagnetism, quantum, etc.). One may imagine science as a polyphony of different perspectives on Nature, together comprising the Book of Nature as Galileo put it. In a sense, the situation can be well animated by the artistic image of angels singing in divine, but different, voices from the same book (Fig. 2). Scientific theories create a family of cognate knowledge systems describing nature. They share certain concepts and differ in others[4]. We may identify this dialogue of theories as a special culture – the culture of science[5].

Furthermore, the traditional disciplinary per-

[2]It is a pleasure to mention the students and colleagues of Lella whom I had the honour to cooperate with in research: Olivia Levrini, Barbara Pecori, Marta Gagliardi, Eugenio Bertozzi, Paola Fantini, Giulia Tasquier.

[3]Tseitlin & Galili (2005, 2006), Levrini et al. (2014), Galili (2017)

[4]The idea of family resemblance is due to L. Wittgenstein, while the many-faceted somewhat contradictive accounts of nature in the discourse regarding the world may remind the idea of carnival by M. Bakhtin in his literature critique.

[5]The concept of culture ascribed to a family of fundamental theories may remind the culture used in biology to designate a colony of micro-organisms of the same kind.

spective considers a scientific theory to be structured by its nucleus (fundamental principles, concepts, paradigmatic model) and its body (derivations, implications, working models, conceptions, experiments) coherent with the nucleus. The discipline-culture perspective upgrades the disciplinary perspective with the third type of knowledge elements, the periphery. The latter includes elements sometimes at odds with the nucleus, representing open problems, competitive principles and accounts by other theories. In this way, a culture includes the potential to change itself. In a way, the presented approach bridges the opposition between discipline and culture as defined by Kant in 1781.

Figure 2. Singing angels from the Ghent Altarpiece (c. 1432) by van Eyck brothers

My colleagues and I have argued that the obtained triadic structure, nucleus-body-periphery, is more faithful to the reality of knowledge exploration. It also happens to be effective in representing scientific knowledge in the context of education.

This discipline-culture perspective implies a pertinent restructuring of introductory curricula. It will emphasise principles, connect them to phenomena and guide the construction of explanations beyond technical manipulation. It will encourage us to make explicit the limits of the validity of each theory by pointing to alternative accounts, either correct (from the more advanced theories) or wrong (from the rejected theories). For instance, the ideas of mechanics of Aristotle, Einstein and Bohr all appear in the periphery of the theory in which the nucleus incorporates the Newtonian laws of motion. The triadic identification of curricular elements can match variation in the interests, skills and preferences students naturally display, expanding their willingness to learn and explore. Being exposed to the subject matter of all three aspects, each individual combines his/her interests in different proportions of efforts and desire.

Thus, in Figure 2, the first group of students shows a special interest to the nucleus, the theoretical paradigm. These students are interested in the big ideas, and they take a holistic perspective on what that theory tells us about the world, a kind of philosophical standpoint. They are not much interested in solving standard problems. They easily decide to leave that to others and rely on scientists to justify this knowledge. It looks as if such students ask us ”Show me God”, the overall design of the world. Einstein, Newton, Kepler, Aristotle shared the same focus in their interest with respect to understanding. In a sense, we could call such students ”philosophers”.

In contrast, the second group shows interest and readiness to deal primarily with concrete problems, mastering the power of control over nature, and seeking immediate benefits. They show much less interest in the justification of the principles used as long as they help them to reach the goal. They are interested in the *body* knowledge as a tool box for experimenting, solving new problems, realisation of knowledge potential. Using simplified examples: understanding and addressing climate change – yes; the analysis of the nature of inertia and principle of equivalence (as interested Mach and Einstein) – no. In a sense, we may call these students "practitioners".

Finally, the students of the third group take a sort of critical stance. They question the claims of the nucleus: "Why these principles not the others? Where did you get them from? Was there any choice?" This was Einstein's and Leibnitz' interest. "Are these principles universal, unique, applied outside of science? Where do these laws fail?" If we, as their teachers, ignore this kind of questions, those students are disappointed and lose their interest: "I do not like science, I prefer something more human…" They may dream easily, miss their teacher's instructions, and fail on exams. They "do not care" and could be "trouble-makers" in class. They could be referred to as – "revolutionaries". This all may change if the teacher addresses the *periphery*. We may, then, observe a radical change in their attitude and witness them joining the rest of the class equipped with a different motivation.

As to the attitude of science teachers, they often ironically patronise the "philosophers" trying to encourage them to be more serious, invest more effort…We are often satisfied with the "practitioners" and usually provide them with all available support. As for the "revolutionaries" (who loves trouble makers?!), they disturb the smoothness of lecturing. Their questions may puzzle us and they might expose us unprepared. We call them to order, trying to explain that such questions lead us astray, impede understanding, break the thread of explanation and take time away from what they need most training in. We may promise answers in some unclear future, just not now.

These are contrasting preferences and each individual combines all three of them in some proportions. Looking back over my own experience in teaching introductory physics courses for many years, I may mention that the students who identify strongly as "philosophers" usually became scientifically literate, enlightened citizens able to consider problems of the society saturated with scientific content. The students whom we identified as "practitioners" normally became involved in technology and applied sciences and medicine. They became proficient consumers of science, "normal" explorers (Kuhn called them "puzzle resolvers"). As to the "trouble-makers", some of them indeed switched to humanities and activities outside of science, but there were a few among them, who proceeded to higher degrees and joined the researchers at the frontiers of science and high-tech. These were the students who produced new knowledge (Kuhnian "revolutionaries").

In any case, I do not intend to create a fully deterministic picture, but just to share my experience. Reading the memoirs of scientists, especially those known for their contributions to modern science (e.g. Galileo, Heisenberg, Einstein, Poincare, Weinberg), may provide additional support to this three-part perspective on a scientific theory as a *discipline-culture*.

I return now to the question how science teaching can stimulate, encourage and instigate the per-

ception of pleasure in understanding and a sense of the beauty of science and scientific knowledge. For that, we need to recognise the structure of science as a culture and recognise the preferences in the non-homogeneous population of students at schools and universities. Accordingly, our curricula and teachers should talk in three voices addressing the nucleus, body and periphery of the theories considered. This equally addresses ontological (content) and epistemological (methodology) aspects. The new approach discharges the claim of "two cultures" (science versus humanities) (Snow, 1959) which implied a simple dichotomy of students, good and bad at science. The reality is much richer and more interesting, allowing a wider population to enjoy learning science.

Cognitive resonance between the emphasis of instruction with their intellectual preferences will allow students to enjoy science class, appreciate the beauty of scientific knowledge and identify their own areas of interest. This approach involves various aspects of the humanities (epistemology, logic, history, aesthetics, world view) intertwined with the science content; an approach that will help more of our students have deep experiences of pleasure in understanding. This approach suggests a framework for addressing the dual nature of science mentioned in Table 1. The enjoyment of learning cannot be of the same kind for all, and it is not unique for each.

A final comment on the colloquial claim "Science is fun". Its rather uncertain meaning may easily miss the intellectual depth of *the pleasure of understanding science*. "Fun" has the connotation of being light, amusing, superficial, and fleeting, which poorly matches being analytic, appreciating aesthetics, and delighting in the beauty of science and experiencing pleasure with the understanding of complexity. Though there is no need to engage in a crusade against casual "fun", it would be good if a teacher who proclaims that "Science is fun!" is aware of what is deeply enjoyable about science that is not captured by this phrase (similar to us when enjoying cola not forgetting about good wine).

I conclude with the belief that the paradigm of *discipline-culture*, by revealing the structure of scientific knowledge, the nature of knowledge elements and scientific dialogue, can transform the *pressure for understanding* to the *pleasure of understanding* of science. It creates a bridge between the realms of science (related to objective pragmatic benefits) and the humanities (related to subjective and spiritual values) often perceived to be in opposition. Understanding the formal disciplinary content does not exclude but is enormously enriched by the relevant philosophical background. Together, they result in the pleasure of understanding science. Indeed, science can bring fun, but mainly, it can enrich us with much more – *the pleasure of understanding* which is a serious business, because it reveals us the genus of science, and this is truly exciting.

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Invitation to Submit Opinion Piece

In order to make better educational use of the wide geographical and disciplinary reach of this HPS&ST NEWSLETTER, invitations are extended for readers to contribute opinion or position pieces or suggestions about any aspect of the past, present or future of HPS&ST studies.

Contributions can be sent direct to Michael Matthews or Nathan Oseroff-Spicer.

Ideally, they might be pieces that are already on the web, in which case a few paragraphs introduction, with link to web site can be sent, or else the pieces will be put on the web with a link given in the NEWSLETTER.

They will be archived in the OPINION folder at the HPS&ST web site: http://www.hpsst.com/.

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Recent HPS&ST Research Articles

Capkinoglu, E., Cetin. P. S., & Peten, D.M (2021) How do pre-service science teachers evaluate the persuasiveness of a socioscientific argument? *International Journal of Science Education*, doi:10.1080/09500693.2021.1876273 online first

Chakraborty, D., Kidman, G. (2021) Inquiry Process Skills in Primary Science Textbooks: Authors and Publishers' Intentions. *Res Sci Educ.*,

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Childers, G., Governor, D., Osmond, D. et al.(2021) Science Cafés: Exploring Adults' Motivation to Learn Science in a Community Space. *Res Sci Educ*, 1-19. doi:10.1007/s11165-020-09982-2 online first

Gopalkrishnan, S., Galande, S. (2021) Scientific temper and nehruvian influence: how the millennials are handling the mythologization of science in India. *Cult Stud of Sci Educ*, 1-19. doi:10.1007/s11422-020-10001-z online first

Hecht, D.K. (2021) Embracing Mystery: Radiation Risks and Popular Science Writing in the Early Cold War. *J Hist Biol*, 1-15. doi:10.1007/s10739-021-09629-6 online first

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Ioannidou, O., Erduran, S. (2021) Beyond Hypothesis Testing. *Sci & Educ.*, 1-20. doi:10.1007/s11191-020-00185-9 online first

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Leuschner, A., & Fernández Pinto, M. (2021) How Dissent on Gender Bias in Academia Affects Science and Society: Learning from the Case of Climate Change Denial. *Philosophy of Science*. doi:10.1086/713903 just accepted

Mantzavinos, C. (2020) Science, institutions, and values. *European Journal of Philosophy*, 1-14. doi:10.1111/ejop.12579

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Noushin Nouri, Maryam Saberi, William F. McComas & Mehdi Mohammadi (2021) Proposed Teacher Competencies to Support Effective Nature of Science Instruction: A Meta-Synthesis of the Literature. *Journal of Science Teacher Education*, doi:10.1080/1046560X.2020.1871206

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Poznic, M., & Hillerbrand, R. (2021). Scenarios as Tools of the Scientific Imagination: The Case of Climate Projections. *Perspectives on Science* 29(1), 36-61. https://www.muse.jhu.edu/article/783040

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Recent HPS&ST Related Books

Bschir, K., & Shaw, J. (Eds.). (2021). *Interpreting Feyerabend: Critical Essays*. Cambridge: Cambridge University Press. ISBN: 978-1-108-57510-2

"This collection of new essays interprets and critically evaluates the philosophy of Paul Feyerabend. It offers innovative historical scholarship on Feyerabend's take on topics such as realism, empiricism, mimesis, voluntarism, pluralism, materialism, and the mind-body problem, as well as certain debates in the philosophy of physics. It also considers the ways in which Feyerabend's thought can contribute to contemporary debates in science and public policy, including questions about the nature of scientific methodology, the role of science in society, citizen science, scientism, and the role of expertise in public policy. The volume will provide readers with a comprehensive overview of the topics which Feyerabend engaged with throughout his career, showing both the breadth and the depth of his thought." (From the Publisher)

More information available here.

Darwin, C., & The Editors of the Darwin Correspondence Project. (2021). *The Correspondence of Charles Darwin* (F. Burkhardt & J. Secord, Eds.). Cambridge: Cambridge University Press. ISBN: 978-1-108-88459-4

"This volume is part of the definitive edition of letters written by and to Charles Darwin, the most celebrated naturalist of the nineteenth century. Notes and appendixes put these fascinating and wide-ranging letters in context, making the letters accessible to both scholars and general readers. Darwin depended on correspondence to collect data from all over the world, and to discuss his emerging ideas with scientific colleagues, many of whom he never met in person. The letters are published chronologically. In 1880, Darwin published On The Power of Movement in Plants, and began writing his final book, The Formation of Vegetable Mould through the Action of Worms. He was engaged in controversy with Samuel Butler, following publication of his last book, Erasmus Darwin. At the end of the year, he succeeded in raising support for a Civil List pension for Alfred Russel Wallace, co-discoverer of the theory of natural selection." (From the publisher)

More information available here.

Lyons, Timothy D. & Vickers, Peter (Eds.) (2021) *Contemporary Scientific Realism: The Challenge from the History of Science*. Oxford, UK: Oxford University Press. ISBN: 978-0-190-94681-4

"Scientific realists claim we can justifiably believe that science is getting at the truth. But they have long faced historical challenges: various episodes across history appear to demonstrate that even strongly supported scientific theories can be overturned and left behind. In response, realists have developed new positions and arguments. As a result of specific challenges from the history of science, and realist responses, we find ourselves with

an ever-increasing dataset bearing on the (possible) relationship between science and truth.

"The present volume introduces new historical cases impacting the debate and advances the discussion of cases that have only very recently been introduced. At the same time, shifts in philosophical positions affect the very kind of case study that is relevant. Thus, the historical work must proceed hand in hand with philosophical analysis of the different positions and arguments in play. It is with this in mind that the volume is divided into two sections, entitled "Historical Cases for the Debate" and "Contemporary Scientific Realism."

"All sides agree that historical cases are informative with regard to how, or whether, science connects with truth. Defying proclamations as early as the 1980s announcing the death knell of the scientific realism debate, here is that rare thing: a philosophical debate making steady and definite progress. Moreover, the progress it is making concerns one of humanity's most profound and important questions: the relationship between science and truth, or, put more boldly, the epistemic relation between humankind and the reality in which we find ourselves." (From the Publisher)

More information available here.

Nugayev, Rinat M. (2020). *The Planck-Einstein Breakthrough: Reconciliation of the Pivotal Research Programs of Classical Physics*. Montreal: Minkowski Institute Press, Montreal. ISBN: 978-1-989-97016-4

"The aim of the book is to explain why classical mechanics and classical electrodynamics were 'refuted' almost simultaneously at the beginning of the XX-th century. It is contended that the Quantum and the Relativistic revolutions were simultaneous since they had the common origin - the clash between the fundamental theories of the second half of the XIX-th century that constituted the 'body' of Classical Physics. The revolution's most dramatic turning point was Einstein's 1905 light quantum paper.

"Though Einstein's efforts sprung out of Max Planck's pioneering attempts to comprehend electromagnetic phenomena through the lenses of conceptual structures of statistical thermodynamics. It was Planck, who clearly realised the cross-contradiction between 'the physics of material bodies' and 'the physics of the ether' and outlined the sketch of its withdrawal: the paradigms 'must be modified to remain compatible'. And it was Planck who took the first step in modifying the physics of the ether and contending that 'not only matter itself but also the effects radiated from matter possess discontinuous properties'. Einstein's part consisted in that he took the second step in modifying the second component of the encounter - the physics of material bodies.

"Einstein's foolhardy light quanta hypothesis and distinctive special theory of relativity turn out to be mere milestones of the unwinding of Maxwellian electrodynamics and statistical thermodynamics reconcilement research program. The notorious conception of luminiferous ether was a substantial obstacle for Einstein's wayward statistical thermodynamics in which the pivotal lead was played by flagrant light quanta paper. Einstein was aware that his enticing light quanta hypothesis was too audacious to be taken literally and he laid out his version of 'electrodynamics of moving bodies' in a markedly Machian/ Duhemian, phenomenological way. As a result of the revision of the second scientific revolution key episode, the arguments are exhibited in favour of the necessity to modify the history of the genesis of general relativity; correspondingly, the process of unification of electromagnetic and weak interactions that took place in the second half of the XX-th century is scrutinised. Eventually, the encounter and interpenetration of the two dominating research traditions of modern physics – that of general relativity and quantum field theory – is eli-

cited." (From the Publisher)

More information available here.

Peterson, M., & Venema, D. (2021). *Biology, Religion, and Philosophy: An Introduction*. Cambridge: Cambridge University Press. ISBN: 978-1-139-38176-5

"The intersection of biology and religion has spawned exciting new areas of academic research that raise issues central to understanding our own humanity and the living world. In this comprehensive and accessible survey, Michael L. Peterson and Dennis R. Venema explain the engagement between biology and religion on issues related to origins, evolution, design, suffering and evil, progress and purpose, love, humanity, morality, ecology, and the nature of religion itself. Does life have a chemical origin - or must there be a divine spark? How can religious claims about divine goodness be reconciled with widespread predation, suffering, and death in the animal kingdom? Peterson and Venema develop a philosophical discussion around such controversial questions. The book situates each topic in its historical, scientific, and theological context, making it the perfect introduction for upper-level undergraduates, graduate students, scholars, and the interested general reader." (From the Publisher)

More information available here.

Preston, J. (Ed.). (2021). *Interpreting Mach: Critical Essays*. Cambridge: Cambridge University Press. ISBN: 9781108564311

"This volume presents new essays on the work and thought of physicist, psychologist, and philosopher Ernst Mach. Moving away from previous estimations of Mach as a pre-logical positivist, the essays reflect his rehabilitation as a thinker of direct relevance to debates in the contemporary philosophies of natural science, psychology, metaphysics, and mind. Topics covered include Mach's work on acoustical psychophysics and physics; his ideas on analogy and the principle of conservation of energy; the correct interpretation of his scheme of 'elements' and its relationship to his 'historical-critical' method; the relationship of his thought to movements such as American pragmatism, realism, and neutral monism, as well as to contemporary figures such as Friedrich Nietzsche; and the reception and influence of his works in Germany and Austria, particularly by the Vienna Circle." (From the Publisher)

More information available here.

van Helvert, Paulo & van Wyhe, John (2021) *Darwin: A Companion*. London, UK: World Scientific

"This is the ultimate guide to the life and work of Charles Darwin. The result of decades of research through a vast and daunting literature which is hard for beginners and experts alike to navigate, it brings together widely scattered facts including very many unknown to even the most ardent Darwin aficionados. It includes hundreds of new discoveries and corrections to the existing literature. It provides the most complete summaries of his publications, manuscripts, lifetime itinerary, finances, personal library, friends and colleagues, opponents, visitors to his home, anniversaries, hundreds of flora, fauna, monuments and places named after him and a host of other topics. Also included are the most complete lists (iconographies) ever created of illustrations of the Beagle, over 1000 portraits of Darwin, his wife and home as well as all known Darwin photographs, stamps and caricatures. The book is richly illustrated with 350 images, most previously unknown."

(From the Publisher)

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Coming HPS&ST Related Conferences

July 11-16, 2021, Biennial meeting of the International Society for the History, Philosophy, and Social Studies of Biology, Milwaukee, WI
Details available here.

July 19-23, 2021 'Objects of Understanding: Historical Perspectives on Material Artefacts in Science Education' will take place at the Europa-Universität Flensburg (Germany)
Details: Roland Wittje, roland.wittje@gmail.com and here.

July 25-31, 2021, 26th International Congress of History of Science and Technology (DHST), Prague. (WEB CONFERENCE)
Information: https://www.ichst2021.org/

September 20-22, 2021, 'Developing Mario Bunge's Scientific-Philosophical Programme', Huaguang Academy of Information Science, Wuhan, China
Details from Zongrong LI 2320129239@qq.com.

July 3rd-7th, 2022, IHPST 16th International Conference, University of Calgary, Canada
Details from Glenn Dolphin: glenn.dolphin@ucalgary.ca.

July 24-29, 2023, 17th DLMPST Congress, University of Buenos Aires Information: Pablo Lorenzano, pablo@unq.edu.ar.

HPS&ST Related Organisations and Websites

IUHPST – International Union of History, Philosophy, Science, and Technology

DLMPST – Division of Logic, Mathematics, Philosophy, Science, and Technology

DHST – Division of History, Science, and Technology

IHPST – International History, Philosophy, and Science Teaching Group

NARST – National Association for Research in Science Teaching

ESERA – European Science Education Research Association

ASERA – Australasian Science Education Research Association

ICASE – International Council of Associations for Science Education

UNESCO – Education

HSS – History of Science Society

ESHS – European Society for the History of Science

AHA – American History Association

ISHEASTME – International Society for the History of East Asian History of Science Technology and Medicine

BSHS – British Society for History of Science

EPSA – European Philosophy of Science Association

AAHPSSS - The Australasian Association for the History, Philosophy, and Social Studies of Science

HOPOS – International Society for the History of Philosophy of Science

PSA – Philosophy of Science Association

BSPS – The British Society for the Philosophy of Science

SPSP – The Society for Philosophy of Science in Practice

ISHPSB – The International Society for the History, Philosophy, and Social Studies of Biology

PES – The Philosophy of Education Society (USA)

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