HPS&ST NEWSLETTER

HPS&ST NEWSLETTER

OCTOBER2021

The HPS&ST NEWSLETTER is emailed monthly to about 9,500 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 40+ 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/

ISSN: 2652-2837

CONTENTS

The 16th Biennial International History and Philosophy of Science and Science Teaching Group (IHPST) Conference, Calgary, Canada. 3-7 July, 2022

Conference Theme: Energising Education with the History, Philosophy, and Sociology of Science

The province of Alberta is the oil-sands energy centre of Canada. It has been the locale for debate about fossil fuel usage, environmental impacts, renewal energy production, First Nations relations and much else.

Plenary Speakers:

- Dr. Alison Wylie, of the University of British Columbia, is a philosopher of social and historical sciences. She is currently President of the Philosophy of Science Association, and Past-President of the American Philosophical Association, Pacific Division. Dr. Wylie works on philosophical issues raised by archaeological practice, and by feminist research in the social sciences.
- Dr. Carol Cleland, of the University of Colorado Boulder and current Director of UC Boulder's Center for the Study of Origins, focusses her research on issues concerning scientific methodology (historical science vs. experimental science, the role of anomalies in scientific discovery), biology (microbiology, origins of life, the nature of life, and astrobiology), and the theory of computation. She is the inventor of the term 'shadow biosphere,' a subject on which she has written and lectured extensively.
- Optional field trips to Burgess Shale, Royal Tyrell Museum, and Frank Slide/Bellevue mine
- Original dramatic production, *Formations*, about four important women earth scientists, their discoveries and their experiences of being a woman in a male dominated career field. Written by Meg Braem and directed by Christine Brubaker
- Graduate student Summer School session
- Undergraduate virtual poster presentation
- Practicing teacher symposium
- Conference dinner at Heritage Park

First call for abstract submission for early decision- 31 October 2021–15th December 2021

Last call for abstract submission - 28 February 2022 - decision until 30th March 2022

Please visit www.ihpst.net for submission instructions and further information.

Faraday Institute Seminars

The Faraday Institute will be holding research seminars at 1pm on Tuesdays. This term's Research Seminars are:

Tues 12th October – Professor **Sibel Erduran** (Oxford) – *Teaching and learning of science and religion in schools: Perspectives from research on argumentation*
Tues 26th October – Dr **Joanna Leidenhag** (St Andrew's) – *The Place of Science Among the Sources of Theology*
Tues 9th November – Professor **Jeff Hardin** (Wisconsin) – *Self-Made People: The Emerging Embryo, Biology, and Belief*
Tues 23rd November – Professor **Stephen Williams** (Belfast) – *Thinking Machines? A Christian Perspective*

These will be held online as well as, we hope, in person, at 1pm UK time. Free for all.

We will be hosting an online lecture: *Varieties of Atheism in Science*, given by Prof. **Elaine Howard Eklund** and Prof. **David Johnson** (Rice University, USA), 10th November, 7.30pm GMT. This lecture will explore what everyday atheist scientists think about religion and the limits to what science can explain, atheist scientists' views on meaning and morality, pathways that led to atheism in science, and more. Held in collaboration with Ian Ramsey Centre for Science & Religion, Oxford and Rice University, USA. See here to register.

The material from our Summer Course, *Interaction of Science and Faith in a Challenging World*, is now available for any-time online access, for individual study, or for in-person group screenings and discussion events. See faraday.institute/interaction

Dr Zoe Binns
The Faraday Institute
zcl21@faraday.cam.ac.uk

Wilhelm Weber Main Works on Electrodynamics Translated into English

The following four Aperion Books are available as free pdf files.
Volume 1: Gauss and Weber's Absolute System of Units.
Volume 2: Weber's Fundamental Force and the Unification of the Laws of Coulomb, Ampere and Faraday.
Volume 3: Measurement of Weber's Constant c, Diamagnetism, the Telegraph Equation and the Propagation of Electric Waves at Light Velocity.
Volume 4: Conservation of Energy, Weber's Planetary Model of the Atom and the Unification of Electromagnetism and Gravitation.

They are freely available in PDF format at:

Volume 1
Volume 2
Volume 3
Volume 4

These translations include Weber's 8 major Memoirs on Electrodynamic Measurements. There are also English translations of 5 papers by Carl Friedrich Gauss, translations of part of the correspondence between Gauss and Weber, one paper by Weber and Friedrich Wohler, 2 papers by Weber and Rudolf Kohlrausch, 1 paper by Gustav Theodor Fechner, 1 paper by Johann Christian Poggendorff, 1 paper by François Felix Tisserand, 2 papers by Carl Neumann, and 3 papers by Gustav Kirchhoff.

Most of these works had never been translated before. They allow a broad overview of the main original publications related to Weber's Electro-

dynamics.

The translators include Laurence Hecht, David H. Delphenich, Peter Marquardt, Hermann Haertel, Jonathan Tennenbaum, Peyman Ghaffari, Joa Weber and Urs Frauenfelder.

The printed versions are available through Amazon:

Volume 1
Volume 2
Volume 3
Volume 4

Andre Koch Torres Assis
http://www.ifi.unicamp.br/~assis
Institute of Physics University of Campinas – UNICAMP, Brazil
assis@ifi.unicamp.br

Bonn History and Philosophy of Physics Research Seminar

12 Oct 2021 - 2 Feb 2022, Tuesdays 16:15-17:45 CE(S)T, i.e. German time zone. Schedule available here.
All sessions may be joined online via Zoom; some sessions are hybrid and may also be attended in person.

Besides the regular research presentations we'll have four special treats: debates on the merits of semi-classical gravity, on whether we should build a new particle collider, and on the relevance of history of physics for philosophy of physics; and a dialogue on the philosophy of the historical sciences (astronomy, geology, archeology, palaeontology, cosmology).

Zoom-links and "in-person location" announced via https://listen.uni-bonn.de/wws/info/hpp

For questions, please contact
nmartens@uni-bonn.de

Niels Martens
PostDoc, Philosophy of Physics

University of Leeds History & Philosophy of Science seminars

Autumn Semester 2021. These seminars take place alternate Wednesdays 3.15-5pm, online via Teams.
Please register via the Eventbrite links given below. All are welcome!

October 13th **Paloma Moral de Calatrava** (University of Murcia, Spain/Visiting Fellow School of LCS) 'Midwives, Hermaphroditism, and Sex Identity: Medieval Female Authority in Sexual Issues'.
Register for this via seminar via Eventbrite

October 27th **Jutta Schickore** (Indiana University, USA) 'Rigor checks: Methodologies of inquiry in late 18th-century German writings about experimentation'
Register for this via seminar via Eventbrite

November 10th **Animesh Chatterjee** (Technical University Darmstadt, Germany) 'Weathering Colonial Calcutta: A Cultural History of the Weather, 1800-1945'
Register for this via seminar via Eventbrite

November 24th **Erika Millam** (Princeton University, USA) 'Philosopher Kings of the Rocky Mountains: Marmots, Time, and Animal Behaviour'
Register for this via seminar via Eventbrite

December 8th **Doreen Fraser** (University of Waterloo, Canada) 'Formal analogical reasoning in quantum theories'
Register for this via seminar via Eventbrite

Graeme Gooday, (Acting) Director of HPS Research Centre
g.j.n.gooday@leeds.ac.uk

2021 Du Châtelet Prize in Philosophy of Physics

The topic for this year's prize was "Measurement practices in the physical sciences: correlation, calibration and stabilization". The winners are:

Jamee Elder, for her paper "On the 'direct detection' of gravitational waves". She completed her PhD at the University of Notre Dame and is currently a Postdoctoral Fellow at the Black Hole Initiative, Harvard University.

Miguel Ohnesorge, for his paper "Pluralising measurement". He is a PhD student at the University of Cambridge.

Congratulations to them, and many thanks to everyone who submitted their wonderful papers for this year's prize.

The winners each receive $1000, an invitation to participate in a workshop to be held at Duke University (provisionally scheduled for April 7-9, 2022), and an invitation to have their paper considered for publication in *Studies in History and Philosophy of Science*.

The members of this year's prize committee were: Alisa Bokulich, Hasok Chang, Daniel Mitchell and Wendy Parker. Grateful thanks to them for all their hard work.
The Du Châtelet Prize in Philosophy of Physics is supported by Duke University in collaboration with *Studies in History and Philosophy of Science*.

HPS&ST in Latin America

- Call for papers The *Revista Brasileira de História da Ciência* (Brazilian Journal of History of Science) calls for papers about "Sciences and the Independences of Brazil". More information (Portuguese and English) is available here.

- Call for proposals of special issues The *Revista Brasileira de História da Ciência* (Brazilian Journal of History of Science) calls for proposals of special issues related to History of Science and other interdisciplinary themes that dialogue with History of Science. More information (only in Portuguese) is available here.

- 2021 *Simpósio Nacional de Ensino de Física* (2021 National Symposium of Physics Teaching) In July 2021 the National Symposium of Physics Teaching in Brazil was held. The event was dedicated to different themes in Physics teaching, also encompassing History and Philosophy in Physics Teaching. Information about the event and the link to speeches (including the speech of the Nobel Laureate Carl Weiman) may be found here.

Science & Education Open Access Articles

Science & Education journal currently has 73 HPS&ST articles available gratis as Open Access. These can be seen and individually downloaded here.

One article available here is Damian Fernandez-Beanato 'Feng Shui and the Demarcation Project'. This is a contribution to a coming (December 2021) 8-article thematic issue of the journal on

'Feng Shui: Philosophical, Cultural and Educational Perspectives'.

The thematic issue addresses the subject matter of the book: *Feng Shui: Teaching About Science and Pseudoscience* (Springer 2019).

Material related to Feng Shui and the thematic issue are available here.

Nuncius Prize 2022

The 2022 *Nuncius* Prize, which is supported by Brill Publishing and Museo Galileo in Florence, will be awarded to the best original essay related to the material and visual history of science, technology and medicine in any period.

The prize is intended for those who are currently graduate and doctoral students, or have been awarded their PhD (or equivalent) within the past six years.

The opening date for entries is 00.01 (CET) on 15 September 2021. The closing date of the Prize is 23.59 (CET) on 30 April 2022. Authors should submit their manuscript via the Editorial Manager (EM) online submission system here.

Essays must be:

- unpublished and not submitted to any other competition at the same time
- written in English
- no more than 9,000 words in length (including footnotes)
- referenced in accordance with *Nuncius* guidelines

The winner will receive a cash prize of €500 and the open-access publication in *Nuncius*. Three honourable mentions (€100 of Brill book tokens each) will also be provided.
Non-winners may be invited to publish their work in *Nuncius*, if the judges of the essay award and the journal consider them to be suitable for publication.

More information available here.
Further queries: Prof. Elena Canadelli, at elena.canadelli@unipd.it

Varia

- **Vale, James Marshall (1937-2021)**. Jim made significant contributions to Australasian philosophy of education and, while Head of Education at University of Auckland, was instrumental in establishing New Zealand's first chair in science education. An obituary can be read here.
- **Mario Bunge Obituaries**. The *Journal of General Philosophy of Science* has published an obituary for Mario Bunge written by the German philosopher Martin Mahner: 'Conjoining Philosophy of Science and Scientific Philosophy' Vol.52, 2021, pp.3-23. It is available here. An earlier obituary for Bunge written by Michael Matthews is available here.

  Bunge's library, including the scores of his own books, plus correspondence, manuscripts. prizes, and related material will, at the end of October, all go to the Biblioteca Nacional Mariano Moreno in Buenos Aires. The library has connection with all Argentinian university, and other libraries.
- **ESERA 2021** addition to published 2021 programme: History and Philosophy of Science in

Biology Education.

Chair Person/Organizer: Thomas McLouglin
Vaccine Hesitancy: A Role for the History and Philosophy of Science in Science Education. Michael Reiss University College, London

Organisms: Why and What to Learn About Them. Charbel El-Hani – Federal University of Bahia

History and Philosophy in Biology: The Case of Learning About Transpiration. Thomas McLouglin – Dublin City University

Aristotle's ways to study animals: a historical case study to teach how to observe living beings. Maria Elice de Brzezinski Prestes – University of São Paulo

Opinion Piece: Mathematics as a science of the real world: Aristotelian realist philosophy of mathematics

James Franklin, School of Mathematics and Statistics, University of New South Wales

James Franklin is a philosopher, historian of ideas and mathematician who taught at the University of New South Wales in the School of Mathematics and Statistics from 1981 until his retirement in 2019. His undergraduate study in mathematics and philosophy was at the University of Sydney (1971–74), where he was influenced by philosophers David Stove and David Armstrong. He completed his PhD on algebraic groups in 1981 at the University of Warwick. He founded the "Sydney School" in the philosophy of mathematics, whose view is explained in his 2014 book *An Aristotelian Realist Philosophy of Mathematics*. His 2003 book *Corrupting the Youth* is a polemical history of Australian philosophy. His 2009 book *What Science Knows: And How It Knows It* presents an objective Bayesian, realist philosophy of science.

Introduction

Mathematics can seem to scientists and science teachers a confusing pile of formulas, methods and calculations, not a genuine science with a subject matter of its own. Aristotelian realist philosophy of mathematics holds on the contrary that mathematics is as much a science of an aspect of reality – physical reality and any other reality there might be – as physics, biology and sociology. Mathematics, it says, is about the quantitative aspects of the world (such as ratios) and the structural ones (such as symmetry). Those properties are as real as mass or biodiversity.

That view of mathematics has important implications for both mathematics teaching and science

teaching. For mathematics teaching, it suggests the need for more attention to mathematical modelling and less to the more internal techniques of calculation and manipulation of formulas. For science teaching, it suggests an approach that highlights an awareness of mathematical properties in science, rather than sweeping mathematics under the carpet as maths teachers' business.

Aristotelian realism versus Platonism and nominalism

What is mathematics about? We know what biology is about; it's about living things. Or more exactly, the living aspects of living things – the motion of a cat thrown out of a window is a matter for physics, but its physiology is a question of biology. Oceanography is about oceans; sociology is about human behaviour in the mass long-term; and so on. When all the sciences and their subject matters are laid out, is there any aspect of reality left over for mathematics to be about? That is the basic question in the philosophy of mathematics.

The field of philosophy of mathematics is mainly occupied by two longstanding traditions, Platonism and nominalism, which have opposite answers to this question. Both answers are problematic and Aristotelian realism offers a "third way" that is more closely aligned to how mathematics works in science (Franklin, 2014a, Jacquette, 2014, Gillies, 2015; quick introduction in Franklin, 2014b, survey in Franklin, 2021).

According to Platonism – the name deriving from Plato's view that eternal realities exist in a non-physical realm – the "objects" named in mathematical discourse, such as numbers, sets and functions, are fully real but not part of our (physical) world. They exist in a Platonic heaven of "abstract objects", eternal, non-physical and non-causal.

What makes Platonism attractive is our solid feeling that mathematics discovers truths about a pre-existing terrain. Take the subtleties of the distribution of primes. Some numbers are prime, some not. A dozen eggs can be arranged in cartons of $6{\times}2$ or $3{\times}4$, but eggs are not sold in lots of 11 or 13 because there is no neat way of organising 11 or 13 of them into an egg carton: 11 and 13, unlike 12, are prime, and primes cannot be formed by multiplying two smaller numbers. The idea is very easy to grasp. But there is a lot to discover about it.

It is found that the way in which the primes are distributed among numbers involves a complex interplay of pattern and irregularity. On the small scale, the latter is most evident: there are long stretches without any primes at all – indefinitely long stretches, in fact. (For example, there are none between 113 and 127.) At the same time, it is widely believed that there are infinitely many "prime pairs"; that is, pairs of numbers only two apart that are both prime, such as 41 and 43.

When we turn to the large scale, the impression of disorder fades and a pattern starts to emerge after all. Primes become gradually less dense as one counts up: the density of primes around a large number is inversely proportional to its order of magnitude. The density of primes around a trillion (10^{12}), for example, is about half what it is around a million (10^6). It's all "out there", and it appears to be about a realm of abstract numbers. It is not about anything physical, but neither did we make it up. We have a sense of a non-physical reality, in some sense not our choice and waiting for us to discover it.

Platonism is also suggested by role of idealisation in mathematical applications in science. Ar-

istotle himself describes Protagoras "refuting" the geometers by pointing out that a hoop touches a straight line at more than one point, unlike the perfect circles that geometers study. (Metaphysics 997b35-998a4). The perfect circles, it seems, must live in a realm other than the physical one we sense and measure.

Nominalism has been Platonism's main rival in the philosophy of mathematics. Taking its name from *nomina*, meaning names, it says that mathematical entities do not exist at all and the words apparently referring to them are "mere names". Only physical objects really exist, and the mathematical language that appears to refer to mathematical objects is just a language of science, or manipulation of formal symbols, or fictions, or methods of deriving one contentful truth from another (nominalism divides into several schools such as formalism, logicism and fictionalism, the differences among which are not important here).

An often implicit version of nominalism rife among scientists thinks of mathematics as a toolkit of methods, formulas, tables of Laplace transforms and the like, or as a "theoretical juice extractor" for getting predictions from theories, but not itself actually about any aspect of reality. Sadly that view, understandable enough in physicists and engineers, is reinforced by the rule-based style of teaching mathematics that often fills the traditional school curriculum. ("Minus times minus equals plus/ The reason for this we need not discuss."). That reinforces a view of mathematics as detached from real science. Einstein, though one of the most mathematical of physicists, was typical of them in claiming a divorce between mathematics and physical reality, saying "As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality" (Einstein, 1954, 233).

Nominalism has two problems. First, it fails to explain our felt sense of exploring a pre-existing territory, as in the distribution of primes. Secondly, it fails to answer the problem raised in the celebrated essay of 1960 by the physicist Eugene Wigner, of the "unreasonable effectiveness of mathematics in the natural sciences" (Wigner, 1960). How could a mere language deliver such extraordinarily effective and unexpected results in so many natural sciences?

Aristotelian realism offers to break the deadlock between Platonism and nominalism. It holds that mathematics *is* a contentful science of realities (as the Platonist says) but that those realities – at least many of them – are literally part of, or realised in, physical reality (Franklin, 2014a).

But Aristotelian realism is not just an answer to an existing philosophical debate. If we just look at how mathematics works (especially applied mathematics), free of philosophical preconceptions, it is possible to see what properties of reality are mathematical (rather than physical, biological and so on) and form the true subject-matter of mathematics. Imagine the Earth in the Jurassic Era, before there were humans to think mathematically and write formulas.

An artist's impression can be seen here.

There were dinosaurs large and small, trees, volcanoes, flowing rivers and winds …Were there, in that world, any properties that we would recognize as being of a mathematical nature (to speak as non-committally as possible)? That is, were there, among the properties of the real things in that physical world, some that we would naturally recognise as mathematical (over and above physical, chemical and biological properties)?

There were many such properties. Symmetry, for

one. Like most higher animals, the dinosaurs had approximate bilateral symmetry. The trees and volcanoes had an approximate circular symmetry with random elements—seen from above, they look much the same when rotated around their axis. But symmetry, whether exact or approximate, is a property that is not exactly physical. Non-physical things can have symmetry; arguments and palindromes, for example, have symmetry if the last half repeats the first half in the opposite order. Symmetry is an uncontroversially mathematical property, and a major branch of pure mathematics—group theory—is devoted to classifying its kinds. When symmetry is realized in physical things, it is often very obvious to perception—even animals as primitive as bees can perceive symmetry. Symmetry, like other mathematical properties, can have causal powers, unlike abstracta as conceived by Platonists.

Another mathematical property, which like symmetry is realizable in many sorts of physical things, is ratio. The height of a big dinosaur stands in a certain ratio to the height of a small dinosaur. The ratio of their volumes is different—in fact, the ratio of their volumes is much greater than the ratio of their heights, which is what makes big dinosaurs ungainly and small ones sprightly. A given ratio is something that can be the relation between two heights, or two volumes, or two time-intervals; a ratio is just what those relations between different kinds of physical entities share, and is thus a more mathematical property than the physical lengths, volumes, and times themselves. Ratio is what we measure when we determine how a length (or volume, or time, etc) relates to an arbitrarily chosen unit (Michell, 1994). It is one of the basic kinds of number.

Properties of reality like symmetry and ratio and others (such as flows, order relations, continuity and discreteness, alternation, linearity, feedback, network topology)—which are measurable, perceivable and causal, like other scientific properties—must be the subject of some science. That science is mathematics (or at least part of mathematics). Aristotelian realist philosophy of mathematics has consequences for both mathematics teaching and science teaching.

Mathematics teaching: Mathematical modelling

Mathematics teachers cannot allow themselves be trapped into a servicing role, as if their task is to supply students with methods which will help when the student comes to subjects that really grapple with the world, like physics. (Applied) mathematics is about the real world too. School and college mathematics education needs to include a component of mathematical modelling, the process (as Aristotelian realists would put it) of finding the mathematical structure of the real world that is relevant to solving some problem.

A simple problem is: could a water shortage in a location like Los Angeles or Adelaide be alleviated by towing an iceberg from Antarctica? Anyone – or any class of students divided into groups – can usefully brainstorm ideas on what quantitative information is needed to address the problem. (How big are icebergs down there? How long would it take to tow them? How much would melt on the way? Would the amount left be a worthwhile proportion of the city's water consumption? What can be done with them when they arrive?) Given an hour, groups can report out to a class on a plan of attack. Given a week, they can do research and write a respectable feasibility study (Banks, 2013, ch. 6). A report lays out the mathematical structure of the case, with a view to making recom-

mendations.

As the example shows, the teaching of mathematical modelling is very different in style as well as content from pure mathematics. Where pure mathematical skills are usually assessed by exams in which individuals solve short discrete puzzles which they get right or wrong, modelling is most naturally done collaboratively over a considerable time period, using outside research, and communicating via a written or oral joint report. That is similar to how mathematics is really done in industrial settings.

As in pure mathematics, mathematical modelling is not all bare hands from a standing start, as in the icebergs problem. Education needs to provide tools to think with. Population modelling has proved a good test bed for explaining basic mathematical models like exponential growth.

Example: Suppose a lake has some lily pads in it and suppose each pad replicates itself once a week. If it takes half a year for half the lake to become covered in lily pads, how long will it take for the entire lake to be covered? (Vandermeer and Goldberg, *Population Ecology*, 3)
Answer: 1 week.
Conclusion: Exponential growth can pick up speed.

Exponential growth has the typical "rising graph" shape, with typical formula $P = Aa^t$ (with a > 1) In the lily-pad example, $a = 2$ (where time t is in weeks).

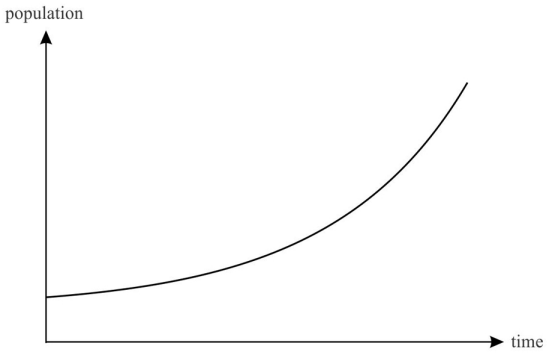

Fig 1: Graph of exponential growth of population against time

A model such as this formula means a mathematical description of the (possible) structure of a situation (such as how a population grows over time). To say that it is a possible structure, or a tool to think with, is not to say that actual populations must fit the model. Given observations of a real population, some inference is needed to see if its growth approximately fits an exponential shape.

An example is: Observations of the number of aphids on a typical corn plant in a field are given in the table below. Action must be taken when the number of aphids per plant reaches 40. At what date should that be predicted? (Vandermeer and Goldberg, 6-7)

Table 1 Number of Aphids Observed per Plant in a Milpa (Corn and Beans) in the Highlands of Guatemala (Morales, 1998)

If the growth is close to exponential, then the logarithms of the number of aphids (last column) should be approximately on a straight line. We can then plot the logarithms against time, check (by eye or by statistical software) if the five points are approximately on a straight line. In fact they are. We can then project forward to estimate the approximate date when 40 aphids per plant will be reached.

What about the world population of humans? In the 1960s there were many alarmist predictions that exponential growth of the world's population would lead to disaster in a few decades. But the world's birth rate has fallen dramatically since that time. The UN's predictions for world population out to 2100 can be seen here. It is a good lesson on the need to fit models to data with care.

Excellent educational resources for mathematical modelling are available from COMAP(The Consortium for Mathematics and Its Applications). Since 1985 they have run an undergraduate Mathematical Contest in Modeling and have recently begun one for high schools.

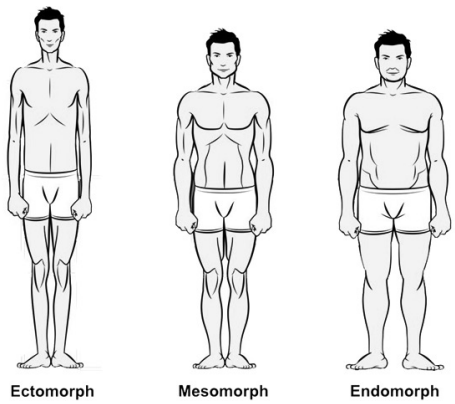

Fig 2. The classic body types: different height-width proportions are easily perceived (Image credit: Granito Diaz, Wikimedia file Body-types.jpg)

Science teaching: Awareness of mathematical properties

Philosophy of science and science teaching are incomplete without some sense of the difference between physical properties and mathematical properties. Physical properties, like mass, colour, being gold and being a possum, are observable realities which must be studied, at least in part, observationally. Mathematical properties, like ratio, symmetry, alternation and randomness, are also observational realities, but they are studied by the a priori methods of mathematics. Appreciating the mathematical aspects of physical reality is a matter of calling attention to mathematical commonalities between different physical situations.

Take as an example perhaps the most basic purely mathematical property, ratio or proportion, such as the proportion of length to height of a page or computer screen or image (the "aspect ratio"). It is an easily observable property of reality. Our visual systems are well set up to perceive immediately differences in ratio such as those in the classic body types (Fig 2)

But ratios are much more mathematical and abstract than lengths themselves. A given ratio can exist between two lengths, or two masses, or two time intervals. The truths about ratios are provable truths of mathematics, such as the very ancient Greek result of the incommensurability of the ratio of the diagonal and side of a square.

Despite their abstractness, ratios have practical scientific consequences, as we saw above in the case of the explanation of why small animals can scurry but large ones lumber. Another place where the scientific role of proportion is easily appreciated comes from the central role in scientific education played by the laws of proportion that formed a key part of the Scientific Revolution. In the high period of the Scientific Revolution, a number of laws were discovered which were mathematical in one sense, in that they ascribed to nature simple formulas – indeed, formulas in general of simple proportion. They were not purely mathematical, in the sense that (to the disappointment of some) they are not derivable solely from mathematical axioms. They needed some input –

however small – of empirical and observationally-derived fact.

A list of the Scientific Revolution's laws of proportion, with approximate dates, includes:

- Kepler's Second Law: The area swept out by a radius from the sun to a planet is proportional to the time taken (1609).
- Snell's Law: When light is refracted at a surface, the sine of the angle of refraction is proportional to the sine of the angle of incidence (1602, 1621, 1637).
- Galileo's Law of Uniform Acceleration: The speed of a heavy body falling from rest is proportional to the time from dropping (1638).
- Pascal's Law: The pressure in an incompressible fluid is proportional to depth (1647).
- Hooke's Law: The extension of a spring is proportional to the force exerted to stretch it (1660).
- Boyle's Law: For a fixed quantity of gas at constant temperature, pressure is inversely proportional to volume (1662).
- Newton's proposition on the prism: there is some kind of proportionality between refrangibility and colour of light (1672).
- Newton's Second Law of Motion: The acceleration of a body is proportional to the total force acting on it (1687).
- Newton's Law of Gravity: The force of gravity exerted by one body on another is proportional to the masses of each and inversely proportional to the square of the distance between them (1687).
- Newton's Law of Cooling: The rate of temperature loss from a body is proportional to the difference in temperature between the body and its surroundings (1701).

It was remarkable how tractable Nature proved to be not only to being mathematised, but mathematised in the simplest way possible, by laws of simple proportionality. That allows calculation of results with very simple mathematics, fortunately for both early scientists and for modern science students. What science teachers should emphasize is that the proportionalities are not in formulas imposed on reality, but in physical nature itself. The formulas merely describe a pre-existing reality.

Many other examples could be given of purely mathematical properties of things that play a crucial role in science. Symmetry has become crucial to science, especially physics, and the ability of symmetry arguments to generate contentful scientific truths is extraordinary. (Franklin 2017) Alternation, as in stripes and wallpaper patterns, is another recurrent mathematical theme in science; for example, in pendulum motion the gravitational cause is a matter of physics but oscillation itself is a mathematical property. Continuous variation (whether over time or in space), studied so successfully by the calculus, is a central theme in most of classical science, such as planetary motion and fluid flow. Randomness, in the sense of patternlessness, is central to any stochastic process from coin-throwing to traffic flow and stock markets.

What is essential for science teaching and for any appreciation of the big picture of how science works is some feel for the difference between a physical property and a mathematical one. That gives one some grasp of which methods will be

needed to study the property: in particular, that for mathematical properties, mathematical methods such as conceptual analysis, definition and proof of theorems will play the main role.

Science teaching: Awareness of mathematical necessities in reality

Science and science teaching rightly highlight the laws of nature, such as the law of gravity. It is generally understood that such laws have only an "empirical necessity", less than absolute. Indeed, the original point of calling them "laws", as became popular in the time of the early Royal Society, was to suggest they were commands laid down by God to which there could in principle be miraculous exceptions (Oakley 1961). But there are stronger, more absolute, necessities than that, also found directly in the real world. Scientists and science teachers need to be aware of the difference.

Consider what tiles I should order for my bathroom floor, which is close to a flat Euclidean plane. I can order square ones or hexagonal ones, as in the figures: the plane can be tiled in a regular fashion with those two shapes.

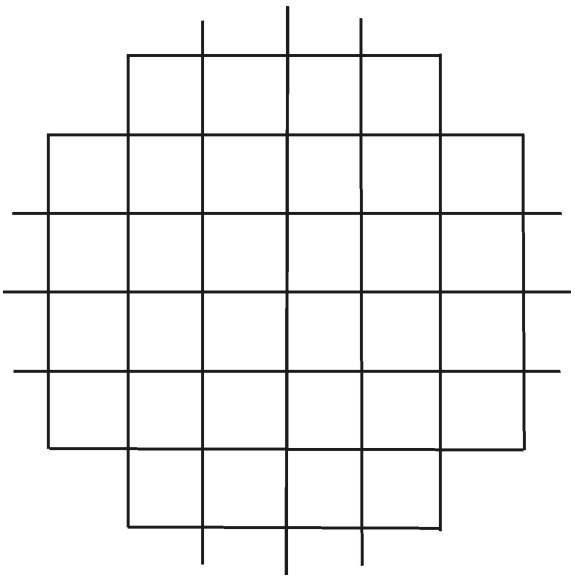

Fig 3. Tiling of the plane by identical squares

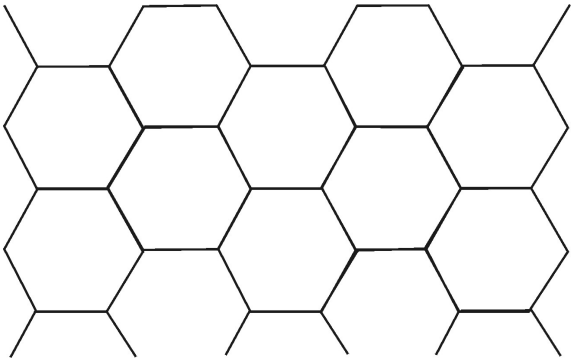

Fig 4. Tiling of the plane by identical regular hexagons

But there is no point ordering a load of regular pentagonal tiles. They just cannot be fitted to tile the bathroom floor. There are big pieces of floor left over between the tiles no matter how they are laid down, which defeats the purpose of tiling.

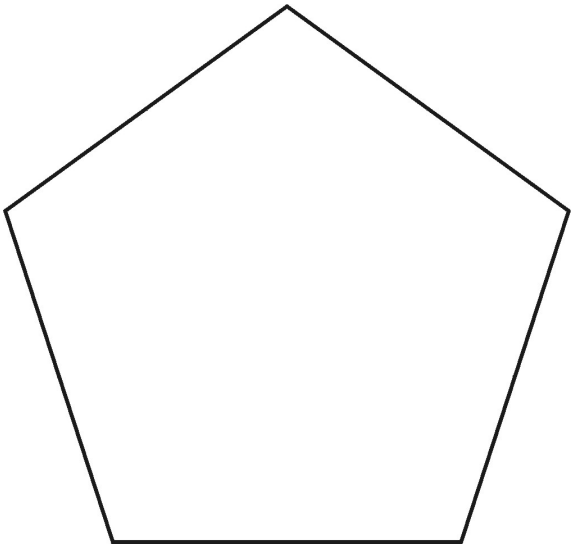

Fig 5. A regular pentagon, which cannot tile the plane

The necessity with which bathroom floors can be tiled with regular square or hexagonal tiles but not with pentagonal ones is stronger than that of the laws of nature. It is mathematical (Franklin 2014a, ch. 5).

Another example of an absolute, mathematical necessity (more exactly, impossibility) in the real world was discovered by Galileo during his efforts to establish the law of free fall. It is one of the most remarkable demonstrations of the power of a priori mathematical reasoning in dynamics. When first considering what law should be followed by falling heavy bodies (given they go faster as they fall), he wondered about how to distinguish between the two simplest theories: the perhaps most natural one that speed is proportional to distance travelled from the start, and the equally simple but perhaps less natural one that speed is proportional to time from the start (that is, the body is uniformly accelerated, which is the correct answer). Galileo realised, and was able to demonstrate, that the first theory needs no observations to refute it. It is absolutely impossible that acceleration should be proportional to the distance travelled (Norton and Roberts 2012).

From the falsity of the theory of the proportionality of speed to distance there does not follow, of course, the truth of the (true) alternative theory of the proportionality to time. There are other possible laws. But it leaves that theory as the natural simple alternative, thus guiding confirmation by experiment.

A third example has become well-known. It is a beautiful problem often used to introduce students to graph theory, Euler's eighteenth-century explanation of why it is impossible to walk over all of the seven bridges of Königsberg once and once only. The bridges connected two islands and two riverbanks as shown in the diagram. The citizens of Königsberg suspected from trial and error that it was not possible to walk over all the bridges, without walking over at least one of them twice.

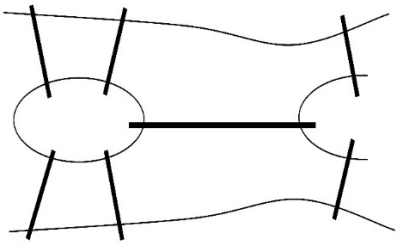

Fig 6. The seven bridges of Königsberg, connecting two banks and two islands

Euler proved they were right. His proof is purely in terms of a very general aspect of geometry – the topology or interconnections of the bridges and land areas. (Euler begins his paper by noting it belongs to a new, non-quantitative part of geometry, the "geometry of site"; the field is now called network topology.) There is no idealisation or approximation involved in drawing the diagram; although a simplified representation of the city, it contains all the relevant geometrical features and the proof applies directly to the system of real bridges and land areas, demonstrating an impossibility about physical reality (Franklin 2014a, ch. 13).

The necessities involved in tiling, in Galileo's discovery about speed and distance, and the Königsberg bridges, are mathematical ones and are not subject to miraculous exception. Science teaching is not complete unless such necessities are distinguished from the weaker "necessities" of natural laws, such as the law of gravity.

Science teaching: Idealisation and approximation

Although we cannot go into it at length here, Aristotelian realism raises important questions about the nature of idealisation in science. In saying that mathematical laws of science are literally true

of the observable world, modern Aristotelians to some extent make common cause with the Aristotelians of Galileo's day who objected that his ideal world of frictionless falling bodies was a fiction with no relevance to the real world. Modern Aristotelians do agree that idealisation is useful, but only on certain conditions. They can only work when the idealisation is an approximation to the real (usually more complicated) system, and the ideal model is "structurally stable", in the sense that results about it carry across, approximately, to the real situation that it approximates (Franklin, 2014a, 224-9).

Something of that idea was visible even in Galileo himself. In explaining Galileo's method of idealisation, Matthews (2006) records the objections of his Aristotelian patron, Guidobaldo del Monte: "When del Monte tells Galileo that he has done an experiment with balls in an iron hoop and the balls do not behave as Galileo asserts, Galileo replies that the hoop must not have been smooth enough, that the balls were not spherical enough and so on." That is only a sufficient reply if in fact making the hoop more smooth and the balls more spherical will cause the observed results to approximate more closely to those of the ideal model. Approximation is essential to idealisation.

Conclusion

Aristotelian realism gives a new perspective (or rather, a very old perspective revived) on both mathematics itself and the role of mathematics in science. In holding that mathematics can apply directly to physical reality, it brings mathematics in closer contact with science. Its vision of mathematics as a contentful science of the world we live in, and one with necessary truths, allows mathematics to regain its rightful place at the centre of civilisation's achievements (Franklin, 2018). Its explanation of which properties exactly are mathematical (namely, quantitative and structural ones) allows philosophy of science and science teaching to properly understand the division of labour between mathematics and science, and hence the true role of mathematics in science.

References

Robert B. Banks, 2013, *Towing Icebergs, Falling Dominoes and Other Adventures in Applied Mathematics* (Princeton University Press, Princeton).

Albert Einstein, 1954, *Ideas and Opinions* (Random House, New York).

James Franklin, 2014a, *An Aristotelian Realist Philosophy of Mathematics: Mathematics as the Science of Quantity and Structure* (Palgrave Macmillan, Basingstoke)

James Franklin, 2014b, The mathematical world, *Aeon* 7 Apr.

James Franklin, 2017, *Early modern mathematical principles and symmetry arguments, in The Idea of Principles in Early Modern Thought: Interdisciplinary Perspectives*, ed. P. Anstey (Routledge, New York, 2017), ch. 1.

James Franklin, 2018, Mathematics, core of the past and hope of the future, in *Reclaiming Education: Renewing Schools and Universities in Contemporary Western Society*, ed. C. Runcie and D. Brooks (Edwin H. Lowe Publishing, Sydney), 149-162.

James Franklin, 2021, Mathematics as a science of non-abstract reality: Aristotelian realist philosophies of mathematics, *Foundations of Sci-*

ence 26 (2021).

Donald Gillies, 2015, An Aristotelian approach to mathematical ontology, in E. Davis and P.J. Davis, eds, *Mathematics, Substance and Surmise* (Springer, Cham), 147–176.

Dale Jacquette, 2014, Toward a Neoaristotelian inherence philosophy of mathematical entities, *Studia Neoaristotelica* 11, 159-204.

Michael R. Matthews, 2006, Idealisation and Galileo's Pendulum Discoveries: Historical, Philosophical and Pedagogical Considerations, in *The Pendulum: Scientific, Historical, Philosophical and Educational Perspectives*, ed. Michael R. Matthews, Colin F. Gauld and Arthur Stinner (Springer, Berlin), 209-235.

Joel Michell, 1994, Numbers as quantitative relations and the traditional theory of measurement, *British Journal for the Philosophy of Science* 45, 389-406.

John D. Norton and Bryan W. Roberts, 2012, Galileo's refutation of the speed-distance law of fall rehabilitated, *Centaurus* 54, 148-64.

Francis Oakley, 1961, Christian theology and the Newtonian science: The rise of the concept of the laws of nature, *Church History* 30, 433-457.

John Vandermeer and Deborah Goldberg, 2013 *Population Ecology: First Principles*, 2nd ed (Princeton University Press, Princeton).

Eugene Wigner, 1960, The unreasonable effectiveness of mathematics in the natural sciences, *Communications on Pure and Applied Mathematics* 13, 1–14.

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/`.

Bad Writing in Education?

In the September HPSST Newsletter two Opinion Pieces on Bad Academic Writing were published:

Denis Dutton, Professor of Philosophy, editor of the Arts & Letters Daily.
Language Crimes: A Lesson in How Not to Write, Courtesy of the Professoriate
Text available here.

Victor Moberger, Stockholm University, Sweden
Pseudophilosophy encourages confused, selfindulgent thinking
Text available here.

Both opinion pieces distinguish simple, ordinary, everyday poor writing from bad writing. While all bad writing is poor writing, not all poor writing is

bad; sometimes it can be just lazy, careless or untutored.

The opinion pieces deal with Bad Writing in the fields of Philosophy and English Studies. The question can be raised whether Bad Writing is a disciplinary problem in Education. This, for the very reasons that Moberger and Dutton advance above, deserves attention. Could Education sustain a comparable Bad Writing Contest?

Stephen Shapin touches on this blight in history of science writing:

> But the problem to which it is worth drawing attention is the particular species of bad writing that is, so to speak, institutionally intentional. Initiates learn to write badly as a badge of professionalism; they resist using the vernacular because it doesn't sound smart enough; they infer from obscurity to profundity. Some things are indeed hard to say in ordinary English, but not nearly so many as academics pretend. ('Hyper-professionalism and the crisis of readership in the history of science', *Isis*, 2005, 96(2), 238–243).

The HPS&ST NEWSLETTER is an appropriate vehicle to mull over the question. If readers have examples of what they regard as Bad Writing in Education, or HPS, please do send the instances, with full bibliographic details to the Editor.

If such examples are sent, and are judged to meet the rigorous standards for Bad Writing, they would be published *sans* authorship. The issue can be, with benefit, aired without identification of author. That a piece of bad writing has been published in an established journal, or book series, suffices to show that the discipline has a problem; that the author has a particular writing problem is unfortunate but is a separate matter that is not of immediate concern to newsletter readers. If any reader would care to take on responsibility for overseeing the Bad Writing exercise, that would be appreciated. Please contact the Editor.

PhD Theses in HPS&ST Domain

The HPS&ST NEWSLETTER is the ideal medium for publicising and making known submitted and awarded doctoral theses in the HPS&ST domain.

The following details should be submitted to the editor at m.matthews@unsw.edu.au:

- Candidate's name and email
- Institution
- Supervisor
- Thesis title
- Abstract of 100-300 words
- Web link when theses are required to be submitted for open search on web.

Recent HPS&ST Research Articles

Bischi, G. I. (2021). Dante Alighieri Science Communicator. *Substantia: An International Journal of the History of Chemistry*, 5(2), 7-17. doi:10.36253/Substantia-1329

Brohinsky, J., Sonnert, G. & Sadler, P. (2021). The Devil's Advocate: Dynamics of Dissent in Science Education. *Sci & Educ.*, 1-22. doi:10.1007/s11191-021-00264-5

Chimisso, C., & Jardine, N. (2021). Hélène Metzger on Precursors: A Historian and Philosopher of Science Confronts Her Evil Demon.

HOPOS: The Journal of the International Society for the History of Philosophy of Science. doi:10.1086/715155 [Ahead of Print]

Daneshpour, H., Kwegyir-Afful, E.(2021). Analysing Transdisciplinary Education: A Scoping Review. *Sci & Educ*. doi:10.1007/s11191-021-00277-0 online first

Davidson, S.G., Jaber, L.Z. & Southerland, S.A. (2021). Cultivating Science Teachers' Understandings of Science as a Discipline. *Sci & Educ*, 1-27. doi:10.1007/s11191-021-00276-1 online first

Erumit, B. A., Akerson, V.L. (2021). Using Children's Literature in the Middle School Science Class to Teach Nature of Science: Preservice Teachers' Development of Sources. *Sci & Educ*. doi:10.1007/s11191-021-00274-3 online first

Fleck, R. (2021). The Scientific Revolution in Art. *Phys. Perspect*. 1-31. doi:10.1007/s00016-021-00274-4 online first

Flório, V., Freire Júnior, O. (2021). The Past Looks Like an Onion: The Centennial "Great Debate" Through Journalists' Testimonies. *Phys. Perspect*. 1-19. doi:10.1007/s00016-021-00275-3 online first

García-Carmona, A.(2021). Spanish Science Teacher Educators' Preparation, Experiences, and Views About Nature of Science in Science Education. *Sci & Educ*, 1-27. doi:10.1007/s11191-021-00263-6 online first

Gori, P. (2021). Ernst Mach's Contribution to the Philosophy of Science in Light of Mary B. Hesse's Postempiricism. *HOPOS: The Journal of the International Society for the History of Philosophy of Science*. doi:10.1086/715876 [Ahead of print]

Hopster, J. (2021). Climate Uncertainty, Real Possibilities and the Precautionary Principle. *Erkenn*, 1-17. doi:10.1007/s10670-021-00461-2

Hudson, R. (2021). Explicating Exact versus Conceptual Replication. *Erkenn*, 1-22 . doi:10.1007/s10670-021-00464-z online first

Lotze, KH., Simionato, S. (2021). Henry Cavendish and the effect of gravity on propagation of light: a postscript. *EPJ H* 46, 24. doi:10.1140/epjh/s13129-021-00027-4

Mc Ewen, B. (2021). Construction of a Review About Epigenetics for Biology Teachers and Other Non-experts. *Sci & Educ*, 1-30. doi:10.1007/s11191-021-00278-z online first

Matthews, M.R. (2021) Feng Shui in Science Programmes, *Sci & Educ*, doi:10.1007/s11191-021-00281-4

Pronskikh, V., Sorina, G.V. (2021) Expert Text Analysis in the Inclusion of History and Philosophy of Science in Higher Education. *Sci & Educ*, 1-15. doi:10.1007/s11191-021-00280-5 online first

Rao, M. B. (2021). The Use of Examples in Philosophy of Technology. *Found Sci*, 1-23. doi:10.1007/s10699-021-09819-9 online first

Ryde, H. (2021). Chronicle of the discovery of the back-bending phenomenon in atomic nuclei: a personal recollection 50 years on. *EPJ H* 46, 23. doi:10.1140/epjh/s13129-021-00023-8

Salimpour, S., Fitzgerald, M.T. (2021). The Cosmic Interaction: A review of the Literature on Cosmology, Religion, and the Big Questions

in the Context of Astronomy Education Research. *Sci & Educ*. doi:10.1007/s11191-021-00250-x online first

Recent HPS&ST Related Books

Berman, S. (2020). *Platonism and the Objects of Science*. New York, NY: Bloomsbury.
ISBN: 978-1-350-27606-2 [Paperback]

"What are the objects of science? Are they just the things in our scientific experiments that are located in space and time? Or does science also require that there be additional things that are not located in space and time?

"Using clear examples, these are just some of the questions that Scott Berman explores as he shows why alternative theories such as Nominalism, Contemporary Aristotelianism, Constructivism, and Classical Aristotelianism, fall short. He demonstrates why the objects of scientific knowledge need to be not located in space or time if they are to do the explanatory work scientists need them to do. The result is a contemporary version of Platonism that provides us with the best way to explain what the objects of scientific understanding are, and how those non-spatiotemporal things relate to the spatiotemporal things of scientific experiments, as well as everything around us, including even ourselves." (From the Publisher)

More information available here.

Briggs, A., & Reiss, M. J. (2021). *Human Flourishing. Scientific insight and spiritual wisdom in uncertain times*. Oxford, UK: Oxford University Press. ISBN: 978-0-198-85026-7

"For thousands of years, humans have asked 'Why we are here?' and 'What makes for a good life?' At different times, different answers have held sway. Nowadays, there are more answers proposed than ever. Much of humanity still finds the ultimate answers to such questions in religion. But in countries across the globe, secular views are widely held. In any event, whether religious or secular, individuals, communities and governments still have to make decisions about what people get from life.

"This book therefore examines what is meant by human flourishing and see what it has to offer for those seeking after truth, meaning and purpose. This is a book written for anyone who wants a future for themselves, their children, and their fellow humans - a future that enables flourishing, pays due consideration to issues of truth and helps us find meaning and purpose in our lives.

"At a time when most of us are bombarded with messages about what we should or should not do to live healthily, attain a work-life balance and find meaning, a careful consideration of the contributions of both scientific insight and spiritual wisdom provides a new angle. This is therefore a book that not only helps readers clarify their views and see things afresh but also help them improve their own well-being in an age of AI and other new technologies." (From the Publisher)

More information available here.

Darrigol, O. (2021). *Atoms, Mechanics, and Probability: Ludwig Boltzmann's Statistico- Mechanical Writings - An Exegesis*. Oxford, UK: Oxford University Press.
ISBN: 978-0-192-84471-2 [Paperback]

"One of the pillars of modern science, statistical mechanics, owes much to one man, the Austrian physicist Ludwig Boltzmann (1844-1906). As a result of his unusual working and writing styles, his enormous contribution remains little read and poorly understood. The purpose of this book is

to make the Boltzmann corpus more accessible to physicists, philosophers, and historians, and so give it new life. The means are introductory biographical and historical materials, detailed and lucid summaries of every relevant publication, and a final chapter of critical synthesis.

"Special attention is given to Boltzmann's theoretical tool-box and to his patient construction of lofty formal systems even before their full conceptual import could be known. This constructive tendency largely accounts for his lengthy style, for the abundance of new constructions, for the relative vagueness of their object—and for the puzzlement of commentators. This book will help the reader cross the stylistic barrier and see how ingeniously Boltzmann combined atoms, mechanics, and probability to invent new bridges between the micro- and macro-worlds." (From the Publisher)

More information available here.

Dupuy, J.-P. (2021). *The Mechanization of the Mind: On the Origins of Cognitive Science* (Trans. M. B. De Bevoise) Princeton, NJ: Princeton University Press. ISBN: 978-1-400-82381-9 [ebook]

"In March 1946, some of the greatest minds of the twentieth century — among them John von Neumann, Norbert Wiener, Warren McCulloch, and Walter Pitts — gathered at the Beekman Hotel in New York City with the aim of constructing a science of mental behavior that would resolve at last the ancient philosophical problem of mind and matter. The legacy of their collaboration is known today as cognitive science. Jean-Pierre Dupuy, one of the principal architects of cognitive science in France, reconstructs the early days of the field here in a provocative and engaging combination of philosophy, science, and historical detective work. He shows us how the ambitious and innovative ideas developed in the wake of that New York meeting prefigured some of the most important developments of late-twentieth-century thought. Many scholars, however, shunned the ideas as crude and resented them for being overpromoted. This rejection, Dupuy reveals, was a tragic mistake and a lost opportunity.

"As Dupuy explains, the founders of cognitive science — or, as they called it, "cybernetics" — drew passion and energy from two convictions: that the mind operates like a machine and that physical laws explain how nature can appear to have meaning. Armed with these convictions, they laid the foundations not only for cognitive science but also artificial intelligence, and foreshadowed the development of chaos theory, complexity theory, and a variety of other major scientific and philosophical breakthroughs. Today, their ideas speak directly to controversies that rage between cognitivists and connectionists, eliminative materialists and Wittgensteinians, functionalists and anti-reductionists. However, despite their genuine achievements, the cyberneticians had too much confidence in the power of their theories and made serious mistakes that led the next generation of thinkers to ignore their work. The development of a scientific theory of mind was thus significantly delayed.

"A profound and beautifully written book, The Mechanization of the Mind brings back to life the intellectual brilliance and excitement that attended the birth of cognitive science more than fifty years ago, and recasts our understanding of the history of the twentieth century thought."

More information available here.

Fallon, R. (2021). *Reimagining Dinosaurs in Late Victorian and Edwardian Literature: How the 'Terrible Lizard' Became a Transatlantic Cultural Icon* (Cambridge Studies in Nineteenth-Century Literature and Culture). Cambridge: Cambridge University Press. ISBN: 978-1-108-98900-8

"When the term 'dinosaur' was coined in 1842, it referred to fragmentary British fossils. In subsequent decades, American discoveries—including Brontosaurus and Triceratops—proved that these so-called 'terrible lizards' were in fact hardly lizards at all. By the 1910s 'dinosaur' was a household word. Reimagining Dinosaurs in Late Victorian and Edwardian Literature approaches the hitherto unexplored fiction and popular journalism that made this scientific term a meaningful one to huge transatlantic readerships. Unlike previous scholars, who have focused on displays in American museums, Richard Fallon argues that literature was critical in turning these extinct creatures into cultural icons. Popular authors skilfully related dinosaurs to wider concerns about empire, progress, and faith; some of the most prominent, like Arthur Conan Doyle and Henry Neville Hutchinson, also disparaged elite scientists, undermining distinctions between scientific and imaginative writing. The rise of the dinosaurs thus accompanied fascinating transatlantic controversies about scientific authority." (From the Publisher)

More information available here.

Galili, I. (2021). *Scientific Knowledge as a Culture: The Pleasure of Understanding*. Dordrecht: Springer. ISBN: 978-3-030-80200-4

"This book, in its first part, contains units of conceptual history of several topics of physics based on the research in physics education and research based articles with regard to several topics involved in teaching science in general and physics in particular. The second part of the book includes the framework used, the approach considering science knowledge as a special type of culture – discipline-culture. Within this approach, scientific knowledge is considered as comprised of a few inclusive fundamental theories each hierarchically structured in a triadic pattern: nucleus-body-periphery. While nucleus incorporates the basic principles and body comprises their implementations in the variety of laws, models, and experiments, periphery includes concepts at odds to the nucleus. This structure introduces knowledge in its conceptual variation thus converting disciplinary knowledge to cultural-disciplinary one.

The approach draws on history and philosophy of science (HPS) necessary for meaningful learning of science. It is exemplified in several aspects regarding teaching physics, presenting history in classes, considering the special nature of science, and using artistic images in regular teaching. The revealed conceptual debate around the chosen topics clarifies the subject matter for school students and teachers encouraging construction of Cultural Content Knowledge. Often missed in teachers' preparation and common curriculum it helps genuine understanding of science thus providing remedy of students' misconceptions reported in educational research." (From the Publisher)

More information available here.

Garrett, D. (Ed.). (2021). *The Cambridge Companion to Spinoza* (2nd ed., Cambridge Companions to Philosophy). Cambridge: Cambridge University Press. ISBN: 978-1-316-15618-6

"Benedict (Baruch) de Spinoza (1632–1677) was one of the most systematic, inspiring, and influential philosophers of the early modern period. From a pantheistic starting point that identified God with Nature as all of reality, he sought to demonstrate an ethics of reason, virtue, and freedom while unifying religion with science and mind with body. His contributions to metaphysics, epistemology, psychology, ethics, politics, and the analysis of religion remain vital to the present day. Yet his writings initially appear forbidding to contemporary readers, and his ideas have often been misunderstood.

This second edition of *The Cambridge Companion to Spinoza* includes new chapters on Spinoza's life and his metaphysics, epistemology, philosophy of religion, and biblical scholarship, as well as extensive updates to the previous chapters and bibliography. A thorough, reliable, and accessible guide to this extraordinary philosopher, it will be invaluable to anyone who wants to understand what Spinoza has to teach." (From the Publisher)

More information available here.

Gochberg R. (2021). *Useful Objects: Museums, Science, and Literature in Nineteenth- Century America*. Oxford, UK: Oxford University Press. ISBN: 978-0-197-55348-0

"*Useful Objects* examines the history of American museums during the nineteenth century through the eyes of visitors, writers, and collectors. Museums of this period included a wide range of objects, from botanical and zoological specimens to antiquarian artifacts and technological models. Intended to promote "useful knowledge," these collections generated broader discussions about how objects were selected, preserved, and classified. In guidebooks and periodicals, visitors described their experiences within museum galleries and marveled at the objects they encountered. In fiction, essays, and poems, writers embraced the imaginative possibilities represented by collections and proposed alternative systems of arrangement. These conversations interrogated many aspects of American culture, raising deep questions about how objects are interpreted—and who gets to decide their value.

"Combining literary criticism, the history of science, and museum studies, *Useful Objects* examines the dynamic and often fraught debates that emerged during a crucial period in the history of museums by drawing on a wide range of archival materials and accounts in fiction, guidebooks, and periodicals. As museums gradually transformed from encyclopedic cabinets to more specialized public institutions, many writers, including J. Hector St. John de Crèvecoeur, Jane Johnston Schoolcraft, William Wells Brown, Walt Whitman, and Henry David Thoreau, questioned who would have access to collections and the authority to interpret them. Throughout this period, they considered loss and preservation, raised concerns about the place of new ideas, and resisted increasingly fixed categories. Their reflections shaped broader debates about the scope and purpose of museums in American culture that continue to resonate today." (From the Publisher)

More information available here.

Green, B. P. (2021). *Space Ethics*. Lanham, MD: Rowman & Littlefield. ISBN: 978-1-786-60026-4

"Throughout history, humans have explored new places, making both good and bad moral decisions along the way. As humanity proceeds to explore space, it is important that we learn from the successes and not repeat the mistakes of the past. This book provides the first comprehensive introduction to ethics as it applies to space exploration and use. It examines real-world case studies that exemplify the ethical challenges we face in exploring beyond Earth: space debris, militarization in space, hazardous asteroids, planetary protection, the search for extraterrestrial life, commercial and private sector activities in space, space settlements, very long duration missions, and planetary-scale interventions. Major themes include human health, environmental concerns, safety and risk, governance and decision-making, and opportunities and challenges of multidisciplinary and international contexts. Ideal for classroom use and beyond, the book provides ways of thinking that will help students, academics and policymakers examine the full range

of ethical decisions on questions related to space exploration."

Heath, J. (2021). *Philosophical Foundations of Climate Change Policy*. Oxford, UK: Oxford University Press. ISBN: 978-0-197-56798-2

"There is widespread agreement that something must be done to combat anthropogenic climate change. And yet what is the extent of our obligations? It would clearly be unjust for us to allow global warming to reach dangerous levels. But what is the nature of this injustice? Providing a plausible philosophical specification of the wrongness of our present inaction has proven surprisingly difficult. Much of this is due to the temporal structure of the problem, or the fact that there is such a significant delay between our actions and the effects that they produce. Many normative theories that sound plausible when applied to contemporaneous problems generate surprising or perverse results when applied to problems that extend over long periods of time, involving effects on individuals who have not yet been born. So while states have a range of sensible climate change policies at their disposal, the philosophical foundations of these policies remains indeterminate.

"By far the most influential philosophical position has been the variant of utilitarianism most popular among economists, which maintains that we have an obligation to maximize the well-being of all people, from now until the end of time. Climate change represents an obvious failure of maximization. Many environmental philosophers, however, find this argument unpersuasive, because it also implies that we have an obligation to maximize economic growth. Yet their attempts to provide alternative foundations for policy have proven unpersuasive. Joseph Heath presents an approach to thinking about climate change policy grounded in social contract theory, which focuses on the fairness of existing institutions, not the welfare of future generations, in order to generate a set of plausible policy prescriptions." (From the Publisher)

More information available here.

Kampourakis, K. (2021). *Understanding Genes (Understanding Life)*. Cambridge: Cambridge University Press. ISBN: 978-1-108-81282-5

"What are genes? What do genes do? These questions are not simple and straightforward to answer; at the same time, simplistic answers are quite prevalent and are taken for granted. This book aims to explain the origin of the gene concept, its various meanings both within and outside science, as well as to debunk the intuitive view of the existence of 'genes for' characteristics and disease. Drawing on contemporary research in genetics and genomics, as well as on ideas from history of science, philosophy of science, psychology and science education, it explains what genes are and what they can and cannot do. By presenting complex concepts and research in a comprehensible and rigorous manner, it examines the potential impact of research in genetics and genomics and how important genes actually are for our lives. Understanding Genes is an accessible and engaging introduction to genes for any interested reader." (From the Publisher)

More information available here.

Kirksey, E. (2021). *The Mutant Project: Inside the Global Race to Genetically Modify Humans*. Bristol, UK: Bristol University Press.
ISBN: 978-1-529-21729-2 [Longlisted for the Baillie Gifford Prize 2021]

"An anthropologist visits the frontiers of genetics, medicine, and technology to ask: whose values are

guiding gene-editing experiments, and what are the implications for humanity?

"At a conference in Hong Kong in November 2018, Dr. Jiankui He announced that he had created the first genetically modified babies—twin girls named Lulu and Nana—sending shockwaves around the world. A year later, a Chinese court sentenced Dr. He to three years in prison for "illegal medical practice."

"As scientists elsewhere start to catch up with China's vast genetic research programme, gene editing is fuelling an innovation economy that threatens to widen racial and economic inequality. Fundamental questions about science, health, and social justice are at stake. Who gets access to gene-editing technologies? As countries loosen regulations around the globe, can we shape research agendas to promote an ethical and fair society?

"Professor Eben Kirksey takes us on a groundbreaking journey to meet the key scientists, lobbyists, and entrepreneurs who are bringing cutting-edge genetic modification tools like CRISPR to your local clinic. He also ventures beyond the scientific echo chamber, talking to doctors, hackers, chronically ill patients, disabled scholars, and activists and who have alternative visions of a genetically modified future for humanity.

"*The Mutant Project* empowers us to ask the right questions, uncover the truth, and navigate this new era of scientific enquiry." (From the Publisher)

More information available here.

Munévar, G. (2021). *A Theory of Wonder: Evolution, Brain and the Radical Nature of Science*. Wilmington, DE: Vernon Press.
ISBN: 978-1-648-89197-7

"*A Theory of Wonder* aims to determine the best way science can satisfy our sense of wonder by exploring the world. Empiricism tells us that science succeeds because it follows the scientific method: Observation passes judgment on Theory – supporting or rejecting it.

"Much credit is given to the inventor of the method, Galileo, but when historically-minded philosophers of science like Kuhn and Feyerabend called our attention to what Galileo actually wrote and did, we were shocked to find out that Galileo instead drives a dagger through the heart of empiricism; he strikes down the distinction between theory and observation. Plain facts, like the vertical fall of a stone, ruled out the motion of the Earth. To conclude that the stone really falls vertically, however, we must assume that the Earth does not move. If it does move, then the stone only "seems" to fall vertically. Galileo then replaced the "facts" against the motion of the Earth with "facts" that included such motion. This process is typical during scientific revolutions.

A good strategy for science is to elaborate radical alternatives; then, and on their basis, reconsider what counts as evidence. Feyerabend was called irrational for this suggestion; but looking at the practice of science from the perspective of evolution and neuroscience shows that the suggestion is very reasonable instead, and, moreover, explains why science works best as a radical form of knowledge. It also leads to a sensible biological form of relative truth, with preliminary drafts leading to exciting discussions with other researchers in the philosophy of science.

"This book will be of particular interest to university students, instructors and researchers in history or philosophy of science, as well as those with a general interest in the nature of science." (From the Publisher)

More information available here.

Musto, R. (2021). *The Attack on Higher Education: The Dissolution of the American University*. Cambridge: Cambridge University Press.

ISBN: 978-1-108-55935-5

"American higher education is under attack today as never before. A growing right-wing narrative portrays academia as corrupt, irrelevant, costly, and dangerous to both students and the nation. Budget cuts, attacks on liberal arts and humanities disciplines, faculty layoffs and retrenchments, technology displacements, corporatization, and campus closings have accelerated over the past decade. In this timely volume, Ronald Musto draws on historical precedent - Henry VIII's dissolution of British monasteries in the 1530s - for his study of the current threats to American higher education. He shows how a triad of forces - authority, separateness, and innovation - enabled monasteries to succeed, and then suddenly and unexpectedly to fail. Musto applies this analogy to contemporary academia. Despite higher education's vital centrality to American culture and economy, a powerful, anti-liberal narrative is severely damaging its reputation among parents, voters, and politicians. Musto offers a comprehensive account of this narrative from the mid-twentieth century to the present, as well as a new set of arguments to counter criticisms and rebuild the image of higher education." (From the Publisher)

More information available here.

Perovic, S. (2021). *From Data to Quanta: Niels Bohr's Vision of Physics*. Chicago, IL: The University of Chicago Press. ISBN: 978-0-226-79833-2

"Niels Bohr was a central figure in quantum physics, well known for his work on atomic structure and his contributions to the Copenhagen interpretation of quantum mechanics. In this book, philosopher of science Slobodan Perović explores the way Bohr practiced and understood physics, and analyzes its implications for our understanding of modern science. Perović develops a novel approach to Bohr's understanding of physics and his method of inquiry, presenting an exploratory symbiosis of historical and philosophical analysis that uncovers the key aspects of Bohr's philosophical vision of physics within a given historical context.

"To better understand the methods that produced Bohr's breakthrough results in quantum phenomena, Perović clarifies the nature of Bohr's engagement with the experimental side of physics and lays out the basic distinctions and concepts that characterize his approach. Rich and insightful, Perović's take on the early history of quantum mechanics and its methodological ramifications sheds vital new light on one of the key figures of modern physics." (From the Publisher)

More information available here.

Richards, J. N. (2021). *Generations of Reason: A Family's Search for Meaning in Post- Newtonian England*. New Haven, CT: Yale University Press ISBN: 978-0-300-25549-2

"This book recounts the story of three Cambridge-educated Englishmen and the women with whom they chose to share their commitment to reason in all parts of their lives. The reason this family embraced was an essentially human power with the potential to generate true insight into all aspects of the world. In exploring the ways reason permeated three generations of English experience, this book casts new light on key developments in English cultural and political history, from the religious conformism of the eighteenth century through the Napoleonic era into the Industrial Revolution and prosperity of the Victorian age. At the same time, it restores the rich world of the essentially meditative, rational sciences of theology, astronomy, mathematics, and logic to their proper place in the English intellectual landscape. Following the development of their views over the course of an eventful

one hundred years of English history illuminates the fine structure of ways reason still operates in our world."

More information available here.

Sarasohn, L. T. (2021). *Getting Under Our Skin: The Cultural and Social History of Vermin*. Baltimore, MD: Johns Hopkins University Press. ISBN: 978-1-421-44138-2

"For most of our time on this planet, vermin were considered humanity's common inheritance. Fleas, lice, bedbugs, and rats were universal scourges, as pervasive as hunger or cold, at home in both palaces and hovels. But with the spread of microscopic close-ups of these creatures, the beginnings of sanitary standards, and the rising belief that cleanliness equaled class, vermin began to provide a way to scratch a different itch: the need to feel superior, and to justify the exploitation of those pronounced ethnically—and entomologically—inferior.

"In *Getting Under Our Skin*, Lisa T. Sarasohn tells the fascinating story of how vermin came to signify the individuals and classes that society impugns and ostracizes. How did these creatures go from annoyance to social stigma? And how did people thought verminous become considered almost a species of vermin themselves? Focusing on Great Britain and North America, Sarasohn explains how the label "vermin" makes dehumanization and violence possible. She describes how Cromwellians in Ireland and US cavalry on the American frontier both justified slaughter by warning "Nits grow into lice." Nazis not only labeled Jews as vermin, they used insecticides in the gas chambers to kill them during the Holocaust.

"Concentrating on the insects living in our bodies, clothes, and beds, Sarasohn also looks at rats and their social impact. Besides their powerful symbolic status in all cultures, rats' endurance challenges all human pretentions. From eighteenth-century London merchants anointing their carved bedsteads with roasted cat to repel bedbugs to modern-day hedge fund managers hoping neighbors won't notice exterminators in their penthouses, the studies in this book reveal that vermin continue to fuel our prejudices and threaten our status. Getting Under Our Skin will appeal to cultural historians, naturalists, and to anyone who has ever scratched—and then gazed in horror." (From the Publisher)

More information available here.

Sutherland, D. (2021). *Kant's Mathematical World: Mathematics, Cognition, and Experience*. Cambridge: Cambridge University Press. doi:10.1017/9781108555746
ISBN: 9781108555746

"Kant's *Mathematical World* aims to transform our understanding of Kant's philosophy of mathematics and his account of the mathematical character of the world. Daniel Sutherland reconstructs Kant's project of explaining both mathematical cognition and our cognition of the world in terms of our most basic cognitive capacities. He situates Kant in a long mathematical tradition with roots in Euclid's *Elements*, and thereby recovers the very different way of thinking about mathematics which existed prior to its 'arithmetization' in the nineteenth century. He shows that Kant thought of mathematics as a science of magnitudes and their measurement, and all objects of experience as extensive magnitudes whose real properties have intensive magnitudes, thus tying mathematics directly to the world. His book will appeal to anyone interested in Kant's critical philosophy – either his account of the world of experience, or his philosophy of mathematics, or how the two inform each other." (From the Publisher)

More information available here.

Thomas, J. M. (2021). *Albemarle Street: Portraits, Personalities and Presentations at The Royal Institution*. Oxford, UK: Oxford University Press. ISBN: 978-0-192-89800-5

"The Royal Institution of Great Britain is renowned the world over, first, because it is a premier arena for the advancement of new scientific and technological knowledge; and second because it highlights the advance of knowledge of all kinds. It bridges the sciences and the humanities, and as much publicity is given to advances in the arts, archaeology, architecture, drama and literature as to the pure and applied sciences. More famous scientists have lived and worked in the Royal Institution than in any other laboratory in the world. A roll-call includes Rumford, Davy, Faraday, Tyndall, Dewar, Rayleigh, W. H. Bragg, W. L. Bragg and George Porter. Nor is it only the home of continuous electricity, it is also the birthplace of many aspects of molecular biology and viruses and enzymology. Some fifteen scientists who have won the Nobel Prize have, at one time or another, worked or lectured at the RI. And eminent individuals, like Howard Carter and Coleridge, have lectured there.

"*Albemarle Street - Portraits, Personalities and Presentations at The Royal institution* is a lively and compelling personal selection of the remarkable personalities and achievements of some of the extraordinary scientists and individuals who, during the nineteenth and twentieth centuries, worked or lectured at 21 Albemarle Street in Mayfair, central London. John Meurig Thomas offers a unique and valuable insight into the history of this prestigious address, having himself lived and worked at the Royal Institution for some twenty years." (From the Publisher)

More information available here.

Veck, W., & Gunter, H.M. (Eds.) (2021). *Hannah Arendt on Educational Thinking and Practice in Dark Times: Education for a World in Crisis*. New York, NY: Bloomsbury. ISBN: 978-1-472-98743-3

In her renowned and provocative essay, *The Crisis in Education*, Hannah Arendt observed that a 'crisis becomes a disaster only when we respond to it with preformed judgements, that is, with prejudices'. Taken as a whole, Arendt's work provides an enduring provocation to think and to make judgements about education and the issues that impact on it, such as political, economic and cultural disruption and uncertainty. Drawing together the leading thinkers on Arendtian ideas and education, this collection explores the role and promise education can have in preparing the future generation to understand, to think about and to act within the world. Concluding the same essay on the crisis in education, Arendt declared education to be the point at which love for the world meets love for those who are newcomers to it. The authors respond to Arendt's call for responsibility and authority in education, providing a leading edge thinking, analysis and agenda setting for public education systems and the world in dark times." (From the Publisher)

More information available here.

Weidman, N. (2021). *Killer Instinct: The Popular Science of Human Nature in Twentieth- Century America*. Cambridge, MA: Harvard University Press. ISBN: 978-0-674-98347-2

"Are humans innately aggressive or innately cooperative? In the 1960s, bestselling books enthralled American readers with the startling claim that humans possessed an instinct for violence inherited from primate ancestors. Critics responded

that humans were inherently loving and altruistic. The resulting debate—fiercely contested and highly public—left a lasting impression on the popular science discourse surrounding what it means to be human.

"*Killer Instinct* traces how Konrad Lorenz, Robert Ardrey, and their followers drew on the sciences of animal behavior and paleoanthropology to argue that the aggression instinct drove human evolutionary progress. Their message, spread throughout popular media, brought pointed ripostes. Led by the anthropologist Ashley Montagu, opponents presented a rival vision of human nature, equally based in biological evidence, that humans possessed inborn drives toward love and cooperation. Over the course of the debate, however, each side accused the other of holding an extremist position: that behavior was either determined entirely by genes or shaped solely by environment. Nadine Weidman shows that what started as a dispute over the innate tendencies of animals and humans transformed into an opposition between nature and nurture.

"This polarized formulation proved powerful. When E. O. Wilson introduced his sociobiology in 1975, he tried to rise above the oppositional terms of the aggression debate. But the controversy over Wilson's work—led by critics like the feminist biologist Ruth Hubbard—was ultimately absorbed back into the nature-versus-nurture formulation. Killer Instinct explores what happens and what gets lost when polemics dominate discussions of the science of human nature." (From the Publisher)

More information available here.

Wilkenfeld, D. A., & Samuels, R. (Eds.) (2021). *Advances in Experimental Philosophy of Science*. New York, NY: Bloomsbury.
ISBN: 978-1-350-25006-2

"This volume gathers together leading philosophers of science and cognitive scientists from around the world to provide one of the first book-length studies of this important and emerging field. Specific topics considered include learning and the nature of scientific knowledge, the cognitive consequences of exposure to explanations, climate change, and mechanistic reasoning and abstraction. Chapters explore how experimental methods can be applied to questions about the nature of science and show how to fruitfully theorize about the nature and role of science with well-grounded empirical research.

"*Advances in Experimental Philosophy of Science* presents a new direction in the philosophical exploration of science and paves a path for those who might seek to pursue research in experimental philosophy of science." (From the Publisher)

More information available here.

Woodward, J. (2021). *Causation with a Human Face: Normative Theory and Descriptive Psychology*. Oxford, UK: Oxford University Press. ISBN: 978-0-197-58541-2

"The past few decades have seen an explosion of research on causal reasoning in philosophy, computer science, and statistics, as well as descriptive work in psychology. In *Causation with a Human Face*, James Woodward integrates these lines of research and argues for an understanding of how each can inform the other: normative ideas can suggest interesting experiments, while descriptive results can suggest important normative concepts. Woodward's overall framework builds on the interventionist treatment of causation that he developed in *Making Things Happen*. Normative ideas discussed include proposals about the role of invariant or stable relationships in successful causal reasoning and the notion of proportionality. He argues that these normative ideas are reflected in the causal judgments that people actually make as a descriptive matter.

"Woodward also discusses the common philosophical practice-particularly salient in philosophical accounts of causation—of appealing to "intuitions" or "judgments about cases" in support of philosophical theses. He explores how, properly understood, such appeals are not different in principle from appeals to results from empirical research, and demonstrates how they may serve as a useful source of information about causal cognition." (From the Publisher)

More information available here.

Coming HPS&ST Related Conferences

November 11-14, 2021, Philosophy of Science Association biennial conference, Baltimore
Details: here.

March 27-30, 2022, NARST Annual Conference, Vancouver, BC
Details: here.

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

July 18-22, 2022, 'Objects of Understanding: Historical Perspectives on Material Artefacts in Science Education', Europa-Universität Flensburg, Germany
Details: Roland Wittje, roland.wittje@gmail.com and here.

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)

The above list is updated and kept on the HPS&ST website HERE.

HPS&ST-related organisations wishing their web page to be added to the list should contact assistant editor Paulo Maurício (paulo.asterix@gmail.com)

The NEWSLETTER is typeset in XeLaTeX.
The font is Minion Pro.
The cover image is used with permission from https://pixabay.com/, free for commercial use.