HPS&ST Note

March 2019

Introduction

This HPS&ST monthly note is sent direct to about 7,450 individuals who directly or indirectly have expressed 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 and more engaging and effective teaching of the history and philosophy of science. The note 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 20+ years.

The note 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 note (publications, conferences, opinion pieces, etc.) are welcome and should be sent direct to the editor:

Michael R. Matthews, UNSW, m.matthews@unsw.edu.au.

The Note, along with RESOURCES, OBITUARIES, OPINION PIECES and more, are lodged at the website:

http://www.hpsst.com/

International Congress on the History of Science in Education, May 30 – June 1, 2019, Vila Real, Portugal

The International Congress on the History of Science in Education is a joint organization of the University of Trás-os-Montes and Alto Douro (UTAD), University of Porto (UP), University of Coimbra (UC) and University of S. Paulo (USP), and it will take place on May 30, 31 and June 1, 2019, at Polo 1 of the School of Human and Social Sciences of UTAD, Portugal.

The 1ICHSE rises following the 1st Meeting of History of Science in Teaching and 2nd Meeting of History of Science in Teaching held at UTAD and UC, in 2015 and 2017, respectively, and it will take place every two years alternating between the universities involved.

The 1ICHSE aims to bring together researchers, professors and students, interested in the history and teaching of Biology, Geology, Chemistry, Physics and Mathematics, as well as Educational Sciences, Engineering, Medicine, Pharmacy, Biochemistry, Anthropology, Astronomy, Psychology, Economics, Sociology, Ecology, Molecular Biology and Nanosciences, among others, in a multi-centered and multidisciplinary debate.

In addition to works focused on teaching, education, didactics and dissemination of sciences, 1ICHSE seeks to bring together reflections and studies of a more general, disciplinary or interdisciplinary nature, in the history of culture, technology and industry, as well as epistemological, historiographic, biographical or prosopographic. Other topics relevant to the history of science and teaching, such as gender studies, the teaching of science in a foreign language and, in general, the various aspects of the interactions between science, technology and the humanities are very important welcome to the dialogue space that 1ICHSE seeks to create.

Plenary Speakers:

- Carlos Fiolhais, Physics, Universidade de Coimbra

- Jorge Varanda, Anthropology, University of Coimbra
- Maria Elice Prestes, Biology, Universidade de São Paulo
- Michael Matthews, Education, University of New South Wales

Abstract submission: January 31, 2019

Full text submission; March 31, 2019

Conference Chair:

- Isilda Rodrigues, isilda@utad.pt

  Depart. Education and Psychology,

  University of Trás-os-Montes e Alto Douro, UTAD, Vila Real, Portugal.

Information available here.

15th International History, Philosophy and Science Teaching Group (IHPST) Biennial Conference, Thessaloniki, July 15-19, 2019

12th Cent. White Tower

School of Education, Aristotle University

The conference will take place at the Aristotle university of Thessaloniki which was founded in 1925 and occupies an area of 33 hectares in the city centre.

The conference will open on Monday afternoon with registration, an opening session and a welcome reception. On Tuesday, Wednesday and Thursday there will be full-day presentations. There will be scheduled opportunity to visit cultural sites and events in Thessaloniki.

Important Dates:

Abstract submission: January 20, 2019

Final paper submission: March 20, 2019

Full conference information available here.

Conference Chair: A/Professor Fanny Seroglou: ihpst2019@eled.auth.gr

Springer Lecture at IHPST Thessaloniki Conference

The Springer Lecture at the 15th IHPST Conference will be given by Professor Andrea Woody who is Department Chair and Professor of Philosophy at the University of Washington.

She is Editor-in-Chief of *Philosophy of Science* and a member of the Editorial Board of *Foundations of Chemistry*. She received her bachelor's degree, in chemistry, and certification in Theater and Dance, from Princeton. After a period of high school physics teaching she received her doctorate in history & philosophy of science, from the University of Pittsburgh.

Her research interests include philosophy of science, history of science, aesthetics, and feminist perspectives in philosophy.

In philosophy of science, much of her research concerns explanation, modeling, and representation, with special interest in diagrammatic, graphical, and pictorial representations. She explores the roles explanatory discourse plays in scientific practice as well as the strategic and pragmatic factors that influence scientists' representational choices.

She is supervising or has supervised dissertations on science and values, theory reduction, the social nature of science, naturalizing metaphysics, and the roles of consensus in science. In addition to her work with dissertation students, she has advised MFA research in dance and honors theses for the History & Philosophy of Science undergraduate major.

As a graduate student her first publication in *Science & Education* was with her supervisor Peter Machamer:

Machamer, P. & Woody, A.: 1994, 'The Balance as a Model for Understanding the Motion of Bodies: Galileo and Classroom Physics', *Science & Education* 3(3),

215-244.

New Editor of Science & Education Journal

A successor to Dr Kostas Kampourakis as editor of the journal *Science & Education* has been chosen by the IHPST Council and approved by Springer Publishers.

Sibel Erduran is Professor of Science Education at Oxford University. After a transition period working with Dr. Kampourakis, she will assume editorship at the beginning of 2020. Prior to her appointment at Oxford, she was the Chair of STEM Education at University of Limerick, Ireland. She held a Distinguished Chair Professor position at National Taiwan Normal University as well as Visiting Professorships at Kristianstad University, Sweden, and Bogazici University, Turkey.

She has worked at University of Pittsburgh, King's College, University of London and University of Bristol, United Kingdom. She is an Editor for *International Journal of Science Education*, and a Section Editor for *Science Education.*

She completed her higher education in the USA at Vanderbilt (PhD Science Education & Philosophy), Cornell (MSc Food chemistry) and Northwestern (Biochemistry) Universities. She was a chemistry teacher in a high school in northern Cyprus. Her research interests focus on the applications in science education of epistemic perspectives on science in general and in chemistry in particular. Her work on argumentation has received awards from NARST and EASE.

Opinion Page

Beware the Greeks: Sources for the History of Gravity in Science Teaching

Thomas J.J. McCloughlin
School of STEM Education, Innovation & Global Studies, Dublin City University, Ireland

Galileo did not discover gravity, and neither did Newton, however for a variety of reasons their contributions were formalised as the discoverers of gravity and all that came before naive, archaic or backward. Their stories became the legends which all scholars had to learn, and the precise historical events forgotten and hidden. Galileo in 1591 (Hilliam, 2005), who had been working on the trajectory of cannonballs for some time allegedly dropped two cannonballs from the bell-tower of Pisa cathedral in the presence of the professors and demonstrated that Aristotle was incorrect (Viviani, 2008).

Newton had his *annus mirabilis* in 1666 where it was alleged that have observed an apple falling from a tree, and in which he hit upon the law of universal gravitation (Anon., 1998-2019). However, their main contribution to science was to help to unify a variety of other disparate issues, especially the movement of heavenly and earthly bodies, within a new systematic physics.

Prior to Galileo and Newton, there were, of course, both notions of gravity and inertia, but they functioned somewhat differently. Ancient and medieval authors certainly had a notion of gravity which was integrally related to their understanding of the earth as spherical, it simply wasn't a Newtonian understanding of gravity.

Unlike the post Newtonian understanding of gravity as a force independent of the falling body, ancient and medieval authors conceived of gravity as a product of the weight of a falling or rising object – which is how we got the term from the Latin *gravitas*, meaning 'weight'. Their notion was that all things in the universe had a "proper place" which they sought to reach. Now, since earth is the heaviest element, it naturally tries to amass itself at the bottom, ie. centre, of the universe in a uniform manner. Whereas, on the contrary, fire, being lighter than air, always tries rise above the air. This is why, if we accidentally dislocate an object from its natural position, it will be drawn to its natural position. Hence, things composed of mostly earth and water tend towards the centre of the earth whereas things made mostly of air and fire tend away from the centre of the earth. The problem of centres is an important point for Ancient commentators.

Plato and Aristotle

When Plato introduces the topic of gravity, motion and sphericity in his *Timaeus*, this is how he contextualises it:

> The nature of the light and the heavy will be best understood when examined in connexion with our notions of above and below; for it is quite a mistake to suppose that the universe is parted into two regions, separate from and opposite to each other, the one a lower to which all things tend which have any bulk, and an upper to which things only ascend against their will. For as the universe is in the form of a sphere, all the extremities, being equidistant from the centre, are equally extremities, and the centre, which is equidistant from them, is equally to be regarded as the opposite of them all. […] the tendency of each towards its kindred element makes the body which is moved heavy, and the place towards which the motion tends below, but things which have an opposite tendency we call by an opposite name (Plato, 360 BC).

As we are well aware, one of the key ancient texts is Aristotle's *On the Heavens* (Aristotle, 350 BC) in which issues of weight and relative position are key concern. He uses this idea of gravity to explain both the sphericity and immobility of the earth. He argues that, if all things have a natural movement, and, under pain of incoherence, can't have two opposite natural movements, it follows that the earth must be immobile, since the earth is simply the accumulation of all the mass in the universe which tends towards the centre, it would require a greater force than that totality of mass to move it, which is absurd:

> For a single thing has a single movement, and a simple thing a simple: contrary movements cannot belong to the same thing, and movement away from the centre is the contrary of movement to it. If then no portion of earth can move away from the centre, obviously still less can the earth as a whole so move. For it is the nature of the whole to move to the point to which the part naturally moves. Since, then, it would require a force greater than itself to move it, it must needs stay at the centre (Aristotle, 350 BC).

This also demonstrates that the earth must be spherical since the sphere is the only shape in which the extremities are all equidistant to the centre. Likewise, were the earth unequally distributed, it would then shift so that its centre of gravity matched the centre of the universe:

> The earth, it might be argued, is at the centre and spherical in shape: if, then, a weight many times that of the earth were added to one hemisphere, the centre of the earth and of the whole will no longer be coincident. So that either the earth will not stay still at the centre, or if it does, it will be at rest without having its centre at the place to which it is still its nature to move. Such is the difficulty. A short consideration will give us an easy answer, if we first give precision to our postulate that any body endowed with weight, of whatever size, moves towards the centre. Clearly it will not stop when its edge touches the centre.

> The greater quantity must prevail until the body's centre occupies the centre. For that is the goal of its impulse. Now it makes no difference whether we apply this to a clod or common fragment of earth or to the earth as a whole. The fact indicated does not depend upon degrees of size but applies universally to everything that has the centripetal impulse. Therefore earth in motion, whether in a mass or in fragments, necessarily continues to move until it occupies the centre equally every way, the less being forced to equalize itself by the greater owing to the forward drive of the impulse (Aristotle, 350 BC).

Titus Lucretius Carus: ca. 99 - 55 BC

But this idea of a centre to the universe is central to classical criticism of the sphericality of the earth. Lucretius' poetic-form argument against the spherical earth centres on the counter-intuition of the idea of there being a cosmic centre:

> And in these problems, shrink, my Memmius, far / From yielding faith to that notorious talk: / That all things inward to the centre press; / And thus the nature of the world stands firm / With never blows from outward, nor can be / Nowhere dis-parted since all height and depth / Have always inward to the centre pressed / If thou art ready to believe that aught / Itself can rest upon itself; or that / The ponderous bodies which be under earth / Do all press upwards and do come to rest / Upon the earth, in some way upside down, / Like to those images of things we see / At present through the waters. They contend, / With like procedure, that all breathing things / Head downward roam about, and yet cannot / Tumble from earth to realms of sky below, / No more than these our bodies wing away / Spontaneously to vaults of sky above; / That, when those creatures look upon the sun, / We view the constellations of the night; / And that with us the seasons of the sky / They thus alternately divide, and thus / Do pass the night co-equal to our days, / But a vain error has given these dreams to fools,

> / Which they've embraced with reasoning perverse / For centre none can be where world is still / Boundless, nor yet, if now a centre were, / Could aught take there a fixed position more / Than for some other cause 'tmight be dislodged. / For all of room and space we call the void / Must both through centre and non-centre yield / Alike to weights where'er their motions tend. / Nor is there any place, where, when they've come, / Bodies can be at standstill in the void, / Deprived of force of weight; nor yet may void / Furnish support to any,- nay, it must, / True to its bent of nature, still give way. / Thus in such manner not at all can things / Be held in union, as if overcome / By craving for a centre (Lucretius, ca 55 BC) Book 1: 1052 – 1082

The Lucretian notion did not survive antiquity. Rather, both the sphericality of the earth and the notion of natural movement towards proper place were adopted into the middle ages more or less universally. But this is only really the beginning of the story, and in particular, Aristotle's discussion of the matter received no end of discussion.

John Philiponos the Grammarian - ca. 490 – 570

Galileo is credited with refuting Aristotle's theory of falling bodies. Aristotle thought that heavier bodies fall faster, in proportion to their weight (Aristotle, 350 BC). But, as Galileo knew, skepticism about this theory had been expressed by Ioannes Philoponos - Ἰωάννης ὁ Φιλόπονος - also known as John of Alexandria a teacher, Christian theologian, and philosopher in Alexandria.

Philoponus became one of the earliest thinkers to reject Aristotle's dynamics and propose the theory of impetus - ἐνέργεια τις ἀσώματος κινητική (p. 642) - i.e., an object moves and continues to move because of an energy imparted in it by the mover and ceases the movement when that energy is exhausted. This insightful theory was the first step towards the concept of inertia in modern physics, although Philoponus' theory was largely ignored at the time because he was too radical in

his rejection of Aristotle.

> But this [view of Aristotle] is completely erroneous, and our view may be completely corroborated by actual observation more effectively than by any sort of verbal argument. For if you let fall from the same height two weights, one many times heavier than the other you will see that the ratio of the times required for the motion does not depend [solely] on the weights, but that the difference in time is very small... (Philiponi, 1888) v17, p. 683)

John Philoponus' refutation of the Aristotelian claim that the elapsed time for a falling body is inversely proportional to its weight. Philoponos denied that the speed of motion was proportional to the weight of the bodies.

> This is a complete error, as we can see through observation better than through any abstract proof If you drop two bodies of vastly different weight.from the same height, you will see that the difference in the time that it takes for them to foll is not at all proportional to their difference in weight; it is, in fact, a small difference (Philiponi, 1888) v17, p. 683)

Philoponos rarely receives credit for this breakthrough, made over one thousand years before Galileo.

John Buridan: ca. 1300 – 1358 AD

Consider now two issues discussed by one of the most prominent late medieval Master of Arts, John Buridan. First, concerning the movement of the earth, Buridan approaches this problem through the question of whether the earth is actually the centre of the universe. As part of his discussion he nicely recapitulates his understanding of the Aristotelean mechanics of the problem - when these they say 'world' these authors normally mean what we would call the the 'universe':

> For we suppose that the place designated absolutely as "upward", insofar as one looks at this lower world, is the concave surface of the orb of the moon. This is so because something absolutely light, ie. fire, is moved towards it. For since fire appears to ascend in the air, it follows that fire naturally seeks a place above the air, and this place above the air is at the concave [surface] of the orb of the moon; because no other element appears to be so swiftly moved upwards as fire. Now the place downward ought to be the maximum distance from the place upward, since they are contrary places. Now that which is the maximum distance from the heaven is the middle of the universe. Therefore the middle of the universe is absolutely downward. But that which is absolutely heavy – and earth is of this sort – ought to be situated absolutely downward. Therefore, the earth naturally ought to be in the middle of the universe or be the middle of the universe. (Grant, 1974, p. 502).

Secondly, Buridan also discusses the problem of falling bodies and acceleration. He begins by addressing and rejecting three other views on why this happens:

1. that a falling object heats the air around it, rarifying the air and reducing overall friction;
2. that objects are attracted to their proper position to a greater degree the closer they are, hence as an object falls its velocity increases with the increased attraction; and
3. that as an object falls there is less air to get in the way so it falls faster.

He then sets out his own idea, that objects have a certain impetus (an early notion of inertia). Thus as they fall they are not only moved by their gravity, but also by their impetus and while the former is constant, the latter accumulates:

> It is my supposition that the natural gravity of a stone remains always the same and similar before the movement, after the movement, and

> during the movement. ... I suppose also that the resistance which arises from the medium remains the same or is similar ... Third, I suppose that if a moving body is the same, the total mover is the same, and the resistance also is the same or similar, the will remain equally swift, since the proportion of mover to moving body and to the resistance will remain [the same]. Then I add that in the movement downwards of the heavy body the movement does not remain equally fast but continually becomes swifter. From these [suppositions] it is concluded that another moving force concurs in the movement beyond the natural gravity ... And you have an experiment [to support this supposition]: If you cause a large and very heavy smith's mill [ie. a wheel] to rotate and you then cease to move it, it will still move a while longer by this impetus it has acquired. Nay, you cannot immediately bring it to rest, but on account of the resistance from the gravity of the mill, the impetus would be continually diminished until the mill would cease to move. And if the mill would last forever without some diminution or alteration of it, and there were no resistance corrupting the impetus, perhaps the mill would be moved perpetually by that impetus. (Grant, 1974, p. 282)

Nicholas Oresme: ca. 1351 – 1382 AD

As we have seen, the Aristotelean account of centres demands a geocentric cosmology. However, as we saw with Buridan, this was eroding in the late middle ages, with the suggestion that actually the earth was indeed subject to rectilinear motion, albeit very slightly. Likewise both Buridan and Nicholas Oresme argued that, while they did not think that the earth rotates on its axis, there is no good reason on offer to think that it doesn't, besides this conflict with the general Aristotelean system. Oresme ends his discussion of the matter noting, perhaps in faint prelude to the problems Galileo would face 250 years later, that:

> [A]fter considering all that has been said, one could then believe that

> the earth moves and not the heavens, for the opposite is not clearly evident. Nevertheless, at first sight, this seems as much against natural reason as, or more against natural reason than, all or many articles of our faith. (Grant, 1974, p. 510)

Although his concern for matters of faith may be driven in this case by the fact that Oresme has written this work in French, not Latin. But I digress, with Nicholas Copernicus (1473-1543) and the relocation of the centre of the universe at the sun, the Aristotelean account of gravity must give way:

> For the apparent irregular movement of the planets and their variable distances from the Earth – which cannot be understood as occurring in circles homocentric with the Earth – make it clear that the Earth is not the centre of their circular movements. Therefore, since there are many centres, it is not foolhardy to doubt whether the centre of gravity of the Earth rather than some other is the centre of the world. I myself think that gravity or heaviness is nothing except a certain natural appetency implanted in the parts by the divine providence of the universal Artisan, in order that they should unite with one another in their oneness and wholeness and come together in the form of a globe. It is believable that this affect is present in the sun, moon, and the other bright planets and that through its efficacy they remain in the spherical figure in which they are visible, though they nevertheless accomplish their circular movements in many different ways. Therefore if the Earth too possesses movements different from the one arounds its centre, then they will necessarily be movements which similarly appear on the outside in the many bodies; and we find the yearly revolution among these movements. (Grant, 1974, pp. 515-516)

This lack of real explanation makes sense, as with the breakdown of Aristotelean final causation in physics, which explained the need for things to return to their proper place, gravity became a very mysterious force. Even with Newton, it isn't really explained, it is only described. But it is enough that his laws adequately account for the observable motions of bodies. To finish, and come full circle, we resort to Cicero to state the cause of gravity:

> For all its [ie. the universe's] parts in every direction gravitate with a uniform pressure towards the centre. Moreover busy conjoined maintain their union most permanently when they have some bond encompassing them to bind them together; and this function is fulfilled by that rational and intelligent substance which pervades the whole world as the efficient cause of all things and which draws and collects the outermost particles towards the centre. Hence if the world is round and therefore all its parts are held together by and with each other in universal equilibrium, the same must be the case with the earth, so that all its parts must converge towards the centre (which in a sphere is the lowest point) without anything to break the continuity and so threaten its vast complex of gravitational forces and masses with dissolution. And on the same principle the sea, although above the earth, nevertheless seeks the earth's centre and so is massed into a sphere uniform on all sides, and never floods its bounds and overflows (Cicero, 1933) 2.45. 115-6)

Very generally this is all appears to be an implication of Lucretius's broader atomic theory, according to which the universe is constituted by an infinity of infinitesimal entities called atoms, whose seemingly random activity underlies all the higher order features of the universe. One of the constituent features of this view is that space is both infinite and homogeneous, in opposition to much of the ancient tradition, as is seen in Plato, Aristotle, and in this Stoic position expressed by Cicero.

According to Aristotle, the cosmic centre - at the centre of the earth - is a different sort of space than, say, the upper atmosphere, which is a different sort of space from the heavenly spheres - outer space. Each of these spaces is characterised by different fundamental elements: earth/water for the centre; air/fire for the atmosphere; special-fire/aether for outer space; and different sorts of motion: downward for the centre; upward for the atmosphere; circular for outer space.

Conclusion to the sources

Lucretius, on the other hand, there is only really one sort of matter, atoms, whose natural state is linear motion of some sort, and only one sort of space, similar to the Cartesian expanse that we are familiar with. As such, he doesn't think that atoms discriminate between different bits of space: "all place and space …must yield a passage through middle or not-middle equally to weights [ie. atoms], wherever their movements tend". Instead everywhere they tend 'downwards' or move erratically as a result of their constant interactions. The implication of this is that there can't be a privileged centre in relation to which where some elements properly rest, since all atoms are constantly in motion regardless of location: "Nor is there any place in which bodies …can lose the force of weight and stand still in the void". Newton didn't "discover gravity." He "discovered" or "constructed" the inverse square law of gravitational force, and used this as a way to unite a lot of physical ideas that had previously been separate.

Teaching Gravity

A typical demonstration I give whenever I lecture on this is as follows. Imagine I am in front of you, and I drop something. Usually it is a ball, pen or other item at hand, because you work with what you have. I ask: "What do you see?" The phenomenological answer is: "the object moved from my hand to the ground / table." This is essentially a "non-theoretical observation" or a naive observation, it is merely a description of the phenomena. I then ask why did it do this? Here's

where different theories come into play.

If you asked Aristotle what happened, he might say that the object is mostly made out of earth - one of the four elements, and so it moves in the direction that is natural for earth, which is to say, on the ground. If the object was made out of air it would have floated away. You can tell that an object is made out of earth because it will also fall through water, whereas things made out of water will not. So in short: the object traveled "down" because "down" is the direction that is naturally associated with things made of earth. There is more to it, but this gets at the gist of Aristotle's notions of gravity. He also thought the speed of falling was connected to the mass of the object, for example.

Now many other authors worked on the question of falling bodies between Galileo did not address key questions – he sought only a numerical way of estimating what would happen in this case, *not* an underlying *cause* or philosophical or metaphysical explanation. As he wrote in 1605: "What has philosophy got to do with measuring anything?" Galileo's approach in much of his non-Copernican work was as a self-styled mathematician, not as someone searching for deep causes. In the work he is most famous for – relating to his Copernicanism, he of course *was* making philosophical/metaphysical arguments. In most of his other work, he was exclusively *kinematical*, e.g., explaining *how* things happen but deliberately NOT *why* they happen.

Newton's specific contribution was to say: all objects with mass exert an attractive force, called gravity. This force is directional proportional to the mass of the object, and falls off at an inverse square rate. This same force accounts not only for the pen moving towards the center of the Earth's mass, but also is used to explain the orbits of comets, planets, and even the association of the tides with the rotation of the Moon around the Earth. This, in other words, is a vastly *larger* claim that just saying, "things will fall when dropped." It's wrapping a lot of different ideas into a new idea, and posits a specific *force* as the cause of them.

It is of note that in his time, the fact that Newton could not explain how this force worked, or what it was "made of," was controversial. The physics of Descartes had

essentially worked to expel "occult" notions from scientific work, and Newton – an occultist – was claiming a mysterious force was acting on everything. Newton's law of gravity was invoked even in his lifetime, and certainly in the 18th century, as the "model" of what scientific theories ought to be: simple, broadly applicable, a piece of information that seemed to unify a wide variety of phenomena into one common understanding. This is why Newton was so impressive then and now. It's not that people didn't think that falling bodies would fall before Newton: it's that they didn't really understand what was going on when they saw such things, or that it was the same force responsible for so many other things.

Some teachers like to point out to the students that when they say that gravity is pulling the object down, they are *completely wrong*, which often shocks them. The modern answer is that Einstein actually came up with a totally *different* explanation for what is happening when we see that object fall: it is traveling along the shortest path through space-time, which is warped by the presence of mass. This explanation is really no more familiar or alien sounding that Aristotle's answer, or even Newton's, if you are not accustomed to it.

Because we teach gravity as a "force" idea in most educational contexts – you have to get pretty far along in science before they start really talking about General Relativity, even in basic terms – most students find Newtonian concepts so "natural" that they find it very hard to imagine they were ever "constructed" or "discovered." All of this is to say: it is not that Newton said, "there is a thing called *gravity*, and no one has used a name like this before." Plenty had people had used the concept of gravitas to denote "heaviness", and a corresponding quality of levitas to denote "floatiness," but their use of the term is not at all the same as Newton's. Newton's concept of gravity would have been as alien to Aristotle as Einstein's is to most people today – and certainly Einstein's would have been alien to Newton. Newton's concept of gravity is *not an observation of a phenomena* but *an explanation for how it works* – a theory – as well as a unifying principle that explained a wide variety of phenomena.

Crease (2003) notes that falling-body experiments continue to be very popular, and they were, for example, voted into the top 10 "most beautiful experiments".

He believes that the answer is related to the fact that, as everyday experience suggests, heavier bodies do fall faster than light ones. Whereas Aristotle had codified this observation into an entire framework that was oriented by the everyday observations he was seeking to explain, involving an agent that exerted a force against resistance. Although this framework fails to incorporate acceleration, it is still the one that we mainly live in and that mainly works for us. However, some mention or full explanation of Galileo's Pisa experiment also features as the architypal falling-body experiment and it finds its way into textbooks Figure 1., and websites for school science Figure 2, or even tourist websites, Figure 3, and finally in revision books, Figure 4.

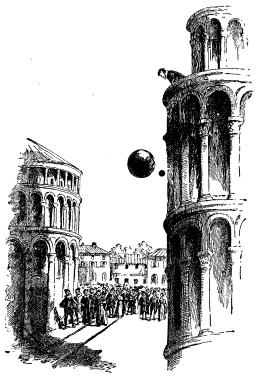

Figure 1. A rather impossible depiction of Galileo's Pisa experiment

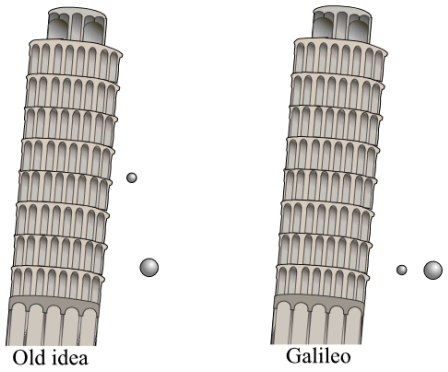

Figure 2. Galileo's Pisa experiment in wikibooks

Modern educators have fabricated Galileo's Pisa experiment and some teachers have tried to replicate the fabrications in their teaching laboratories. However, it does remain an important 'thought experiment' which follows the opinion of Settle (1983, 1992)[1] on the experiment as a historical event. Segre (1989) points out that nowhere in all his writings did Galileo himself describe the event and that it does appear to be a 'construct' of Viviani.

1. Reprinted in *The Galileo Project*

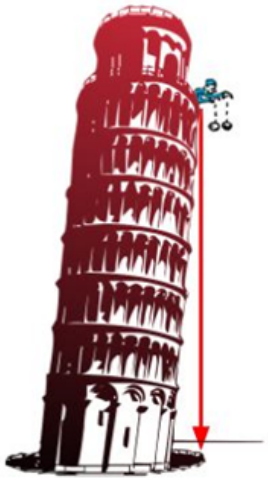

Figure 3. Galileo's Pisa experiment from leaningtowerpisa.com

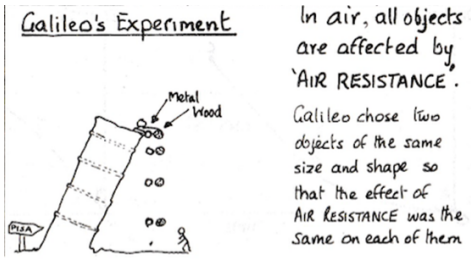

Figure 4. Galileo's Pisa experiment in an O Level Physics book

The Irish government-funded Discover Primary Science & Mathematics / ESERO teachers' activity on Gravity claims the following:

Until Galileo's time (around 1600 AD) people thought that heavier things fell faster than light things. Galileo was an Italian scientist who experimented (up to then they mainly just thought!) and found that things with different weight fell at approximately the same speed.

This segment is grossly incorrect as it assumes lack of experimentation prior to Galileo, which the Ancient and Byzantine Greeks were well known for, and that Aristotle was unquestioned, either in his own time or since. It seems to mirror the position of de Grijs (2017) that Aristotle was held to be some kind of demigogue, which Galileo would replace, and be more acceptable as a scientist:

> The turn of the 17th Century saw a step change in scientific thinking, from blindly following the Aristotelian worldview to the first critical attempts at pursuing the modern scientific method, from the Middle Ages to the Enlightenment.

Unfortunately, this perspective is a 'western' European perspective which tends to

ignore the wider reality in history and assumes the milieu in 16th /17th century Florence / Papal States to be the universal condition everywhere at all times. It is somewhat surprising that such a view prevails and is encouraged even today. We also have to be careful that 'blindly following the Aristotelian worldview' can be code for singling-out any particular religious group turning Galileo into a *cause célèbre* for something that Galileo himself would not have contemplated. It is also possible as Bolotin (1997) has argued that Aristotle never intended his writings to be taken as finally polished theories of how the world works, rather they were rhetorically coated. There is a great need to reevaluate what we teach in science - regardless of the level and it is our duty to teach the correct version. The Ancient and Byzantine Greeks were experimentalists and thinkers both. So long as history is disembodied from science, and science content not taught, teachers are doomed to blindly follow ignorance. We may indeed fear the Greeks, but they do bear gifts.

Acknowledgement

I am indebted to various blog writers for their alerting me to Nicholas Oresme and John Buridan originally, whom I have been unable to cite correctly. Their alertness opened new avenues for me to think about the western medieval views on motion.

References

Anon. (1998-2019). Universal Gravitation. In G. Elert (Ed.), *The Physics Hypertextbook*. Retrieved from https://physics.info/.

Aristotle. (350 BC). *On the Heavens* (J. L. Stocks, Trans.). In D. C. Stevenson (Ed.), The Internet Classics Archive. Retrieved from http://classics.mit.edu/Aristotle/heavens.html.

Bolotin, D. (1997). *Approach to Aristotle's Physics, An: With Particular Attention to the Role of His Manner of Writing*. New York: SUNY Press.

Cicero, M. T. (1933). *De natura deorum* (H. Rackham, Trans.). London: W. Heine-

mann. Retrieved from https://archive.org/details/denaturadeorumac00ciceuoft/page/232.

Crease, R. P. (2003). *The Prism and the Pendulum: The Ten Most Beautiful Experiments in Science* London: Random House.

de Grijs, R. (2017). Early insights inspired by Galileo Galilei. In R. de Grijs (Ed.), *Time and Time Again: Determination of longitude at sea in the 17th Century*. London: IOP Publishing Ltd.

Grant, E. (1974). *A Sourcebook in Medieval Science*. Harvard: Harvard University Press.

Hilliam, R. (2005). *Galileo Galilei: Father of Modern Science*. New York: The Rosen Publishing Group.

Lucretius. (ca 55 BC). De rerum natura (E. P. Dutton, Trans.). In W. E. Leonard (Ed.), *Greek and Roman Materials*. Tufts University: Perseus Digital Library. Retrieved from http://data.perseus.org/citations/urn:cts:latinLit:phi0550.phi001.perseus-eng1:1.1052-1.1082.

Philiponi, I. (1888). in Aristotelis Physicorum Libros Quinque Posteriores Commentaria. In H. Vitello (Ed.), Commentaria in *Aristotelem Graeca*. Berlin: Reimeri, G.

Plato. (360 BC). Timaeus. In C. D. Green (Ed.), *Classics in the History of Psychology* Retrieved from http://www.yorku.ca/pclassic/Plato/Timaeus/timaeus2.htm.

Segre, M. (1989). Galileo, Viviani and the tower of Pisa. *Studies in the History & Philosophy of Science Part A*, 20(4), 435-451.

Settle, T. B. (1983). Galileo and Early Experimentation. In R. A., T. Davis, & R. H. Stuewer (Eds.), *Springs of Scientific Creativity: Essays on Founders of Modern Science*. Minneapolis, MINN: University of Minnesota Press.

Settle, T. B. (1992). Experimental Research and Galilean Mechanics. In M. Baldo-

Ceolin (Ed.), *Galileo Scientist: His Years at Padua and Venice*. Padua: Istituto Nazionale di Fisica Nucleare; Venice: Istituto Veneto di Scienze, Lettere ed Arti; Padua: Dip artimento di Fisica.

Viviani, V. (2008). *Racconto istorico della vita del Sig.r Galileo Galilei: Edizione* IntraText CT. Retrieved from http://www.intratext.com/ixt/ITA1686/.

Invitation to Submit Opinion Piece

In order to make better educational use of the wide geographical and disciplinary reach of this HPS&ST Note, 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 editor. 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 Note.

They will be archived in the OPINION folder at the HPS&ST web site:

`http://www.hpsst.com/`.

Previous HPS&ST Note Opinion Pieces at http://www.hpsst.com/

Bettina Bussmann, University of Salzburg, Austria & Mario Kötter, University of Muenster, Germany Between Scientism and Relativism: Epistemic Competence as an Important Aim in Science and Philosophy Education (February 2019)

Robin Attfield, Philosophy Department, Cardiff University, Climate Change and Philosophy (January 2019)

Dhyaneswaran Palanichamy & Bruce V. Lewenstein, School of Integrative Plant

Science, Cornell University, How History can Enable Better Teaching of Statistics in Introductory Biology Courses (December 2018)

Frederick Grinnell, Biology Department, University of Texas, Teaching research integrity – Using history and philosophy of science to introduce ideas about the ambiguity of research practice (November 2018)

New York Times, Creeping Bias in Research: Negative Results Are Glossed Over (October 2018)

Michael Matthews, School of Education, UNSW, An Occasion to Celebrate: Mario Bunge's 99th Birthday (September 2018)

Cormac Ó Raifeartaigh, Waterford Institute of Technology, Ireland, History of Science in Schools (July 2018)

Hugh Lacey, Philosophy Department, Swarthmore College, Appropriate Roles for Ethics and Social Values in Scientific Activity (June 2018)

Gerald Holton, Physics Department, Harvard University, Tracing Tom Kuhn's Evolution: A Personal Perspective (April/May 2018)

Monica H. Green, History Department, Arizona State University, On Learning How to Teach the Black Death (March 2018).

Stephen Pinker, Psychology Department, Harvard University, The Intellectual War on Science (February 2018).

Michael Ruse, Philosophy Department, Florida State University, Does Life Have Meaning? Or is it Self-Deception at Best and Terrifyingly Absurd at Worst? (January 2018).

Mario Bunge, Philosophy Department, McGill University, In Defence of Scientism (December 2017).

Susan Haack, Philosophy and Law Departments, University of Miami, The Future

of Philosophy, the Seduction of Scientism (November 2017).

Nicholas Maxwell, University College London, What's Wrong with HPS and What Needs be Done to Put it Right? (June 2017).

Heinz W. Drodste, An Interview with Mario Bunge (May 2017).

Nicholas Maxwell, University College London, The Crisis of Our Times and What to do About It (April 2017).

Eric Scerri, UCLA, Bringing Science Down to Earth (March 2017).

Robert Nola, University of Auckland, Fake News in the Post-Truth World, (February 2017).

Michael D. Higgins, President of Ireland, The Need to Teach Philosophy in Schools (December 2016).

Philip A. Sullivan, University of Toronto, What is wrong with Mathematics Teaching in Ontario? (July 2016).

Gregory Radick, Leeds University, How Mendel's legacy holds back the teaching of science (June 2016).

Matthew Stanley, New York University, Why Should Physicists Study History?

PhD Theses in HPS&ST Domain

This is a new section of the monthly HPS&ST Note. The Note is the ideal medium for publicizing 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

Alanazi, F.H. (2019) The Perceptions of Students in Secondary School in Regard to Evolution-Based Teaching: Acceptance and Evolution Learning Experiences–The Kingdom of Saudi Arabia. *Research in Science Education*, 1-39. doi:10.1007/s11165-019-9827-y online first

Ariely, M., Livnat, Z. & Yarden, A. (2019) Analyzing the Language of an Adapted Primary Literature Article: Towards a Disciplinary Approach of Science Teaching Using Texts *Science & Education*, 1-23. doi:10.1007/s11191-019-00033-5 online first

Billingsley, B. & Nassaji, M. (2019) Exploring Secondary School Students' Stances on the Predictive and Explanatory Power of Science. *Science & Education*, 1-21. doi:10.1007/s11191-019-00031-7 online first

Caiman, C. & Jakobson, B. (2019)The Role of Art Practice in Elementary School Science. *Science & Education*, 1-23. doi:10.1007/s11191-019-00036-2 online first

Çimen, Ü. (2018) On Saving the Astronomical Phenomena: Physical Realism in Struggle with Mathematical Realism in Francis Bacon, al-Bitruji, and Averroës. *HOPOS: The Journal of the International Society for the History of Philosophy of Science*, 1-17. doi:10.1086/701058 online first

Donovan, B.M., Stuhlsatz. M.A.M., Edelson, D.C, & Bracey, Z. E. B. (2019) Gendered genetics: How reading about the genetic basis of sex differences in biology textbooks could affect beliefs associated with science gender disparities. *Science Education*, 1-31. doi:10.1002/sce.21502 online first

Flynn, S. & Hardman, M. (2019) The Use of Interactive Fiction to Promote Conceptual Change in Science: A Forceful Adventure. *Science & Education*, 1-26. doi:10.1007/s11191-019-00032-6 online first

Herman, B.C., Owens, D.C., Oertli, R.T. et al. (2019) Exploring the Complexity of Students' Scientific Explanations and Associated Nature of Science Views Within a Place-Based Socioscientific Issue Context. *Science & Education*, 1-38 doi:10.1007/s11191-019-00034-4 online first

Khelfaoui, M. & Gingras, Y.(2019) Physical Review: From the Periphery to the Center of Physics. *Physics in Perspective*, 1-20. doi:10.1007/s00016-019-00235-y online first

Murphy, C., Smith, G. & Broderick (2019). A Starting Point: Provide Children Opportunities to Engage with Scientific Inquiry and Nature of Science. *Research in Science Education*, 1-35. doi:10.1007/s11165-019-9825-0

Nakamura, K. & Gunji, Y.P. (2019) Entanglement of Art Coefficient, or Creativity *Foundations of Sciences*, 1-11. doi:10.1007/s10699-019-09586-8 online fist

Özer, F., Doğan, N., Yalaki, Y. et al. (2019) The Ultimate Beneficiaries of Continuing Professional Development Programs: Middle School Students' Nature of Science Views. *Research in Science Education*, 1-26. doi:10.1007/s11165-019-9824-1 online first

Schellinger, J., Mendenhall, A., Alemanne, N. et al. (2019) Using Technology-Enhanced Inquiry-Based Instruction to Foster the Development of Elementary Students' Views on the Nature of Science. *Journal of Science Education and Technology*, 1-12. doi:10.1007/s10956-019-09771-1 online first

Wan, Y. & Bi, H. What Major "Socio-Scientific Topics" Should the Science Curriculum Focused on? A Delphi Study of the Expert Community in China. *International Journal of Science and Mathematics Education*, 1-17. doi:10.1007/s10763-018-09947-y online first

Recent HPS&ST Related Books

Bernard, Julien, Lobo, Carlos (Eds.) (2019) *Weyl and the Problem of Space: From Science to Philosophy*. Dordrecht: Springer. ISBN 978-3-030-11527-2

> "This book investigates Hermann Weyl's work on the problem of space from the early 1920s onwards. It presents new material and opens the philosophical problem of space anew, crossing the disciplines of mathematics, history of science and philosophy. With a Kantian starting point Weyl asks: among all the infinitely many conceivable metrical spaces, which one applies to the physical world? In agreement with general relativity, Weyl acknowledges that the metric can quantitatively vary with the physical situation. Despite this freedom, Weyl "deduces", with group-theoretical technicalities, that there is only one "kind" of legitimate metric. This construction was then decisive for the development of gauge theories. Nevertheless, the question of the foundations of the metric of physical theories is only a piece of a wider epistemological problem.
>
> "Contributing authors mark out the double trajectory that goes through Weyl's texts, from natural science to philosophy and conversely, always through the mediation of mathematics. Readers may trace the philosophical tradition to which Weyl refers and by which he is inspired (Kant, Husserl, Fichte, Leibniz, Becker etc.), and explore the mathematical tradition (Riemann, Helmholtz, Lie, Klein) that permitted Weyl to elaborate and solve his mathematical problem of space. Furthermore, this volume analyzes the role of the interlocutors with whom Weyl discussed the nature of physical space (Einstein, Cartan,

De Sitter, Schrödinger, Eddington).

"This volume features the work of top specialists and will appeal to postgraduates and scholars in philosophy, the history of science, mathematics, or physics."

More information available here.

Dardashti, Radin, Dawid, Richard, & Thébault, Karim (Eds.) (2019) *Why Trust a Theory? Epistemology of Fundamental Physics*. Cambridge, UK: Cambridge University Press. ISBN: 9781108470957

"Do we need to reconsider scientific methodology in light of modern physics? Has the traditional scientific method become outdated, does it need to be defended against dangerous incursions, or has it always been different from what the canonical view suggests? To what extent should we accept non-empirical strategies for scientific theory assessment? Many core aspects of contemporary fundamental physics are far from empirically well-confirmed. There is controversy on the epistemic status of the corresponding theories, in particular cosmic inflation, the multiverse, and string theory. This collection of essays is based on the high profile workshop 'Why Trust a Theory?' and provides interdisciplinary perspectives on empirical testing in fundamental physics from leading physicists, philosophers and historians of science. Integrating different contemporary and historical positions, it will be of interest to philosophers of science and physicists, as well as anyone interested in the foundations of contemporary science." (From the Publishers)

More information at: https://tinyurl.com/y86ecb4a

Farber, Paul Lawrence (2019) *Finding Order in Nature: The Naturalist Tradition from Linnaeus to E. O. Wilson*. Baltimore, MD: John Hopkins University Press

> "Since emerging as a discipline in the middle of the eighteenth century, natural history has been at the heart of the life sciences. It gave rise to the major organizing theory of life–evolution–and continues to be a vital science with impressive practical value. Central to advanced work in ecology, agriculture, medicine, and environmental science, natural history also attracts enormous popular interest.
>
> "In Finding Order in Nature Paul Farber traces the development of the naturalist tradition since the Enlightenment and considers its relationship to other research areas in the life sciences. Written for the general reader and student alike, the volume explores the adventures of early naturalists, the ideas that lay behind classification systems, the development of museums and zoos, and the range of motives that led collectors to collect. Farber also explores the importance of sociocultural contexts, institutional settings, and government funding in the story of this durable discipline." (From the Publisher)

More information available here.

Forrester, John & Cameron, Laura (2019) *Freud in Cambridge*. Cambridge, UK: Cambridge University Press. ISBN: 9781108713023

> "Freud may never have set foot in Cambridge - that hub for the twentieth century's most influential thinkers and scientists - but his intellectual impact there in the years between the two World Wars was immense. This is a story that has long languished untold, buried under different accounts of the dissemination of psychoanalysis. John Forrester and Laura Cameron present a fascinating and deeply textured history of the ways in which a set of Freudian ideas about the workings of the human mind, sexuality and the unconscious affected Cambridge men and women - from A. G. Tansley and W. H. R. Rivers to Bertrand Russell, Bernal, Strachey and Wittgenstein - shaping their thinking across a range of disciplines, from biology to anthropology,

> and from philosophy to psychology, education and literature. Freud in Cambridge will be welcomed as a major intervention by literary scholars, historians and all readers interested in twentieth-century intellectual and scientific life." (From the Publishers)

More information available here.

Gascoigne, John (2019) *Science and the State: From the Scientific Revolution to World War* II. Cambridge, UK: Cambridge University Press. ISBN: 9781316609385

> "Was it coincidence that the modern state and modern science arose at the same time? This overview of the relations of science and state from the Scientific Revolution to World War II explores this issue, synthesising a range of approaches from history and political theory. John Gascoigne argues the case for an ongoing mutual dependence of the state and science in ways which have promoted the consolidation of both. Drawing on a wide body of scholarship, he shows how the changing functions of the state have brought a wider engagement with science, while the possibilities that science make available have increased the authority of the state along with its prowess in war. At the end of World War II, the alliance between science and state was securely established and, Gascoigne argues, is still firmly embodied in the post-war world." (From the Publisher)

More information available here.

Gimbel, Steven (2019) *Einstein: His Space and Times*. New Haven, CT:Yale University Press. ISBN: 9780300244373

> "The commonly held view of Albert Einstein is of an eccentric genius for whom the pursuit of science was everything. But in actuality, the

> brilliant innovator whose Theory of Relativity forever reshaped our understanding of time was a man of his times, always politically engaged and driven by strong moral principles. An avowed pacifist, Einstein's mistrust of authority and outspoken social and scientific views earned him death threats from Nazi sympathizers in the years preceding World War II. To him, science provided not only a means for understanding the behavior of the universe, but a foundation for considering the deeper questions of life and a way for the worldwide Jewish community to gain confidence and pride in itself.
>
> "Steven Gimbel's biography presents Einstein in the context of the world he lived in, offering a fascinating portrait of a remarkable individual who remained actively engaged in international affairs throughout his life. This revealing work not only explains Einstein's theories in understandable terms, it demonstrates how they directly emerged from the realities of his times and helped create the world we live in today." (From the Publisher)

More information available here.

Kusch, Martin, Kinzel, Katherina, Steizinger, Johannes, & Wildschut, Niels (Eds.) (2019) *The Emergence of Relativism: German Thought from the Enlightenment to National Socialism*. London, UK: Routledge. ISBN: 9781138571877

> "Debates over relativism are as old as philosophy itself. Since the late nineteenth century, relativism has also been a controversial topic in many of the social and cultural sciences. And yet, relativism has not been a central topic of research in the history of philosophy or the history of the social sciences. This collection seeks to remedy this situation by studying the emergence of modern forms of relativism as they unfolded in the German lands during the "long nineteenth century"– from the Enlightenment to National Socialism. It focuses on relativist

and anti-relativist ideas and arguments in four contexts: history, science, epistemology, and politics.

"The Emergence of Relativism will be of interest to those studying nineteenth- and twentieth-century philosophy, German idealism, and history and philosophy of science, as well as those in related disciplines such as sociology and anthropology." (From the Publisher)

More information available here.

Maudlin, Tim (2019) *Philosophy of Physics: Quantum Theory*. Princeton, New Jersey: Princeton University Press

"In this book, Tim Maudlin, one of the world's leading philosophers of physics, offers a sophisticated, original introduction to the philosophy of quantum mechanics. The briefest, clearest, and most refined account of his influential approach to the subject, the book will be invaluable to all students of philosophy and physics.

"Quantum mechanics holds a unique place in the history of physics. It has produced the most accurate predictions of any scientific theory, but, more astonishing, there has never been any agreement about what the theory implies about physical reality. Maudlin argues that the very term "quantum theory" is a misnomer. A proper physical theory should clearly describe what is there and what it does–yet standard textbooks present quantum mechanics as a predictive recipe in search of a physical theory.

"In contrast, Maudlin explores three proper theories that recover the quantum predictions: the indeterministic wavefunction collapse theory of Ghirardi, Rimini, and Weber; the deterministic particle theory of deBroglie and Bohm; and the conceptually challenging Many Worlds theory of Everett. Each offers a radically different proposal for the nature of physical reality, but Maudlin shows that none of them are what they are generally taken to be." (From the Publisher)

More information available here.

Maxwell, Nicholas (2019) *Science and Enlightenment: Two Great Problems of Learning*. Dordrecht: Springer. ISBN: 3030134199

> "This book describes two great problems of learning that confront humanity: learning about the nature of the universe and about ourselves and other living things as a part of it, and learning how to become civilized.
>
> "The author proposes that with the creation of modern science in the 17th century, the first problem was essentially solved.
>
> "However, the Enlightenment of the 18th century blundered, and this defective version, inherited from the past, is still built into academia. The book describes a new Enlightenment, in which the current dominance of Knowledge-Inquiry progresses toward what the author terms Wisdom-Inquiry.
>
> "The book discusses how wisdom-inquiry would help, and addresses questions and objections engendered by the new Enlightenment.
>
> "This approach, argues the author, would allow us to succeed where the Enlightenment failed: to learn from scientific progress how to make social progress towards the best possible world.
>
> "Science and Enlightenment: Two Great Problems of Learning will interest a broad audience, ranging from academics, university students and teachers; journalists, politicians and general readers concerned about global problems and the fate of the world." (From the Publisher)

More information available here.

McLeish, Tom (2019) *The Poetry and Music of Science: Comparing Creativity in Science and Art.* Oxford, UK: OUP

"What human qualities are needed to make scientific discoveries, and which to make great art? Many would point to 'imagination' and 'creativity' in the second case but not the first. This book challenges the assumption that doing science is in any sense less creative than art, music or fictional writing and poetry, and treads a historical and contemporary path through common territories of the creative process. The methodological process called the 'scientific method' tells us how to test ideas when we have had them, but not how to arrive at hypotheses in the first place. Hearing the stories that scientists and artists tell about their projects reveals commonalities: the desire for a goal, the experience of frustration and failure, the incubation of the problem, moments of sudden insight, and the experience of the beautiful or sublime.

"Selected themes weave the practice of science and art together: visual thinking and metaphor, the transcendence of music and mathematics, the contemporary rise of the English novel and experimental science, and the role of aesthetics and desire in the creative process. Artists and scientists make salient comparisons: Defoe and Boyle; Emmerson and Humboldt, Monet and Einstein, Schumann and Hadamard. The book draws on medieval philosophy at many points as the product of the last age that spent time in inner contemplation of the mystery of how something is mentally brought out from nothing. Taking the phenomenon of the rainbow as an example, the principles of creativity within constraint point to the scientific imagination as a parallel of poetry." (From the Publisher)

More information available here.

Oppenheimer, Michael et al. (2019) *Discerning Experts: The Practices of Scientific Assessment for Environmental Policy*. Chicago, IL: The University of Chicago Press. ISBN: 9780226602158

> "Discerning Experts assesses the assessments that many governments rely on to help guide environmental policy and action. Through their close look at environmental assessments involving acid rain, ozone depletion, and sea level rise, the authors explore how experts deliberate and decide on the scientific facts about problems like climate change. They also seek to understand how the scientists involved make the judgments they do, how the organization and management of assessment activities affects those judgments, and how expertise is identified and constructed.
>
> "Discerning Experts uncovers factors that can generate systematic bias and error, and recommends how the process can be improved. As the first study of the internal workings of large environmental assessments, this book reveals their strengths and weaknesses, and explains what assessments can–and cannot–be expected to contribute to public policy and the common good." (From the Publisher)

More information available here.

Timberlake, Todd, & Wallace, Paul (2019) *Finding our Place in the Solar System: The Scientific Story of the Copernican Revolution*. Cambridge, UK: Cambridge University Press. ISBN: 9781107182295

> "Finding our Place in the Solar System gives a detailed account of how the Earth was displaced from its traditional position at the center of the universe to be recognized as one of several planets orbiting the Sun under the influence of a universal gravitational force. The transition from the ancient geocentric worldview to a modern understanding of planetary motion, often called the Copernican Revolution, is one of the great intellectual achievements of humankind. This book provides a deep yet accessible explanation of the scientific disputes over our place in the solar system and the work of the great scientists who helped settle them. Readers will come away knowing not just

that the Earth orbits the Sun, but why we believe that it does so. The Copernican Revolution also provides an excellent case study of what science is and how it works."

More information available here.

Authors of HPS&ST-related papers and books are invited to bring them to attention of the Note's assistant editors, Paulo Maurício at paulo.asterix@gmail.com or Nathan Oseroff-Spicer at nathanoseroff@gmail.com for inclusion in these sections.

Coming HPS&ST Related Conferences

March 29-30, 2019, The Philosophy of Ian Hacking. Institute of Philosophy, Research Centre for the Humanities, Hungarian Academy of Sciences
Inquiries to Dr. Akos Sivado, akos.sivado@gmail.com

March 31 – April 3, 2019, NARST Annual Conference, Baltimore, USA
Details at: https://www.narst.org/

April 1-4, 2019, Evolution Evolving: Process, Mechanism and Theory, Churchill College, University of Cambridge, UK
Details at: https://evolutionevolving.org/

April 11-13, 2019, Formal Methods and Science in Philosophy III, Dubrovnik, Croatia
Details at: https://www.iuc.hr/conference-details.php?id=326

April 24-26, 2019, British Society for the History of Philosophy Annual Conference, King's College London. Strand Campus, London, UK.
Details available here.

May 13-16, 2019, Second Hermann Minkowski Meeting on the Foundations of

Spacetime Physics, Albena, Burgaria
Details available here

May 27-29, 2019, Eddington Conference, Paris, France.
Details at: https://www.eddingtonstudies.org/

May 29-31, 2019, Plastics Heritage: History, Limits and Possibilities. Museu da Famácia (Pharmacy Museum) in Lisbon, Portugal
Details available here

July 7-12, 2019, International Society for the History, Philosophy and Social Studies of Biology meeting (ISHPSSB), Oslo, Norway.
Abstracts deadline: 18 January 2019
Details available here

July 10-13, 2019, British Society for the History of Science meeting, Edinburgh, UK.
Details at: http://www.bshs.org.uk

July 15-19, 2019, International History, Philosophy and Science Teaching Group, Biennial Conference, Thessaloniki, Greece.
Details from conference chair, Fanny Seroglou, fannyseroglou@gmail.com

July 25-27, 2019, Learning From Empirical Approaches to HPS 2019 (LEAHPS 2019), Leibniz University, Hannover, Germany
Details at: https://leaphs2019.wordpress.com/

July 22-26, 2019, The 46th Annual Hume Society Conference, University of Nevada, Reno, NV, USA.
Details available here.

July 26-28, 2019, 4th International Periodic Table Conference: 'Mendeleev 150', ITMO University, St Petersburg, Russia
Details available here.

August 5-10, 2019, 16th Congress of Logic, Methodology and Philosophy of Sci-

ence and Technology (CLMPST), Prague, Czech Republic.
For updates and details see here.

September 2-4, 2019. European Conference for Cognitive Science (EuroCogSci 2019), Ruhr-Universit'Ät Bochum, Germany.
More information: EuroCogSci2019@rub.de.