GLOBAL JOURNAL
OF HUMAN SOCIAL SCIENCES - H: INTERDISCIPLINARY
Volume 26 | 2026 | Article ID: GJHSS-258726 | Language: English

Subversive Analogies

Online First

Dr. Yemima Ben-Menahem§*

*Corresponding Author

§ The Hebrew University of Jerusalem, Jerusalem, Il (OA)

RECEIVED	ACCEPTED	ONLINE PUBLISHED	PEER REVIEW
2026-06-18	2026-06-26	2026-07-27	Double Blind

Abstract

The paper calls attention to a type of analogy that, despite its fruitfulness, harbors an internal tension that exposes a significant disanalogy. I focus on cases in which this disanalogy turned out to lead to the solution of the problem that the original analogy had failed to solve. I call such analogies subversive and, by means of two examples from the history of science — the Rutherford-Bohr model of the atom and Darwin's concept of natural selection — illustrate how they work.

Analogy | Scientific Discovery | Rutherford Atomic Model | Darwinian Evolution | Natural Selection | Epistemology | History of Science

AI USE STATEMENT
No generative AI was used for analysis or results.

FUNDING
No external funding was declared for this work.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

DATA AVAILABILITY
Not applicable for this article.

ETHICS
No ethics committee approval was required for this article type.

CONSENT
Not applicable for this article.

TRIAL REG.
Not applicable.

Crossref DOI: 10.34257/GJHSSH258726

How to Cite: Ben-Menahem (2026). Subversive Analogies. Global Journal of Human-Social Science, Ahead of Print, 1-15. DOI: 10.34257/GJHSSH258726

AR Experience Web Page DOI

Print ISSN 0975-587X

9 770975 587004

Online ISSN 2249-460X

9 772249 460013

METADATA CONTINUATION

AUTHOR CONTACT QR LEDGER

Dr. Yemima Ben-Menahem§*

ARCHIVAL RECORD

GJHSS · Vol 26 · 2026

Article ID GJHSS-258726 · DOI 10.34257/GJHSSH258726

Print ISSN 0975-587X · Online ISSN 2249-460X

Global Journal of Human-Social Science - Section H
GJHSS

Subversive Analogies

Dr. Yemima Ben-Menahem[§*]

Affiliations
§ The Hebrew University of Jerusalem, Jerusalem, Il (OA)

Abstract
The paper calls attention to a type of analogy that, despite its fruitfulness, harbors an internal tension that exposes a significant disanalogy. I focus on cases in which this disanalogy turned out to lead to the solution of the problem that the original analogy had failed to solve. I call such analogies subversive and, by means of two examples from the history of science — the Rutherford-Bohr model of the atom and Darwin's concept of natural selection — illustrate how they work.

Keywords: *Analogy, Scientific Discovery, Rutherford Atomic Model, Darwinian Evolution, Natural Selection, Epistemology, History of Science, Disanalogy*

* Corresponding Author
Dr. Yemima Ben-Menahem

DOI
10.34257/GJHSSH258726

I'LL TEACH YOU DIFFERENCES*

Consider, to begin with, a simple elegant analogy that has nothing subversive about it and will help us to see the contrast between analogies of this 'normal' kind and the subversive ones that are the subject of this paper. In *The Act of Creation*, Arthur Koestler cites a famous riddle[1]:

> One morning, exactly at sunrise, a Buddhist monk began to climb a tall mountain. The narrow path... spiraled around the mountain to a glittering temple at the summit. The monk ascended the path at varying rates of speed, stopping... along the way to rest and to eat...He reached the temple shortly before sunset. After several days...he began his journey back along the same path, starting at sunrise and again walking at variable speeds, with many pauses along the way. His average speed descending was, of course, greater than his average climbing speed. Prove that there is a spot along the path that the monk will occupy on both trips at precisely the same time of day.

While the problem could be solved mathematically, it is easier, and arguably more elegant, to reason by analogy. Instead of a single monk on different days, imagine two monks taking the journey on the same day, one ascending the other descending. If they start walking at the same time, they will necessarily meet at some point along the path, regardless of their speeds or length of interruptions. Their meeting point is the point which the single monk would occupy at the very same time on the two days of his journey. This is a perfect illustration of the power of an analogy to enable us to think of one problem in terms of a different one, analogous to the former in the parameters essential for the solution. What characterizes examples of this kind is that once we hit on the analogy, the problem is solved. The analogy, as it has first appeared to us is perfect; it does not require any further modification or adjustment. Discovery and justification work in tandem. Cases like this are not the majority, however; typically, the gap between discovery and justification is notable.

Analogies are sometimes said to be essential to thinking in general: Even the use of general nouns like 'flower' could be said to invokes analogies between individual flowers, not to mention other general patterns of subsuming individual cases under laws, logical, mathematical, scientific legal and so on.[2] My scope is more limited: I examine analogies that have led to significant scientific discoveries and, like the solution to the above riddle, enable a translation of one problem, or situation, into another, that is more tractable. While science is similar to other domains in its frequent use of analogical thinking, it is also distinct in its demand for empirical confirmation; the justification of a scientific analogy is the empirical confirmation of the theory it gives rise to. This means that even when an analogy seems strong in terms of the similarities it is based on, it must nonetheless pass the additional test of the empirical implications it points to. By contrast, if, in a legal context, abortion would be considered comparable to murder, or intellectual property to concrete property (and thus plagiarism to theft), there would be no independent way of justifying these analogies except for the assessment of similarities (the positive analogy) and differences (the negative analogy) between the cases.[3] This would be an assessment of the strength of the analogy itself but would not constitute an external confirmation. To the extent that here too acceptance of analogies depends on their implications, the implications themselves are judged by moral and judicial intuitions and can therefore vary

[1]* Shakespeare, *King Lear* Act I Scene 4; reported (Drury 1996, p. 157) to have been entertained by Wittgenstein as motto to his *Philosophical Investigations*. Indeed, Wittgenstein often warns against deceptions of grammar that make us compare cases that are actually distinct.
Koestler refers to the June (1961) issue of the Scientific American and to Carl Duncker (1945).

[2]For this wide-ranging view of analogies, see, for example, Peirce on signs, icons in particular, in Peirce (1894).

[3]The terms 'positive analogy' and 'negative analogy' referring to similarities and differences respectively, were introduced by Keynes (1921).

among individuals as well as societies. It is for this reason that criminal law (in many contemporary legal systems) places serious restrictions on the use of analogies, for example, they cannot create new offenses that the legislator has not specified and are allowed only when they are advantageous for the defendant.[4]

On the one hand, the demand for empirical justification puts an extra burden on scientific analogies; on the other, it alleviates the need for criteria that enable assessment of an analogical argument solely on the basis of the strength of the similarity it points out or the nature of this similarity (observable, causal, structural, and so on). As a result of this difference between science and other domains, it makes sense to put less emphasis on the initial plausibility of an analogy than its eventual explanatory and predictive fruitfulness.[5] I will not seek to identify criteria that make an analogy reasonable or justified at the moment of birth. There is no recipe for the creation of a good analogy.[6] A successful analogy, much like successful scientific hypotheses in general, will prove its strength when the predictions it entails are confirmed. Even so, we will see that discovery cannot always be separated from justification — when an analogy contains internal difficulties (this type becomes central as we proceed), the discovery is hampered by considerations that belong in the context of justification.

I will set aside mathematical analogies because typically, they develop into demonstrable isomorphisms or even identities, both of which are stronger types of relation than analogy. Descartes' invention of analytic geometry by providing an algebraic representation of Euclidean plane geometry is a case in point. The Euler's miraculous relation between complex exponentials and trigonometric functions $e^{ix} = cos\ x + isinx$ is another. The analogies I examine differ from these mathematical cases in that the similarity they identify is partial: it pertains to certain aspects of the compared entities, while leaving other aspects distinct. Unlike the Descartes and Euler examples, they cannot be said to be representations of the same entity in a different language. Thus, although symmetry breaking at phase transition is structurally analogous in various systems, the substances in question and the processes they undergo - freezing water and a disordered ferromagnet becoming magnetized in a single direction, say - remain distinct. Another kind of analogy that will not concern me here is an analogy that, rather than triggering, or leading to, a new theory, is actually an *outcome* of that theory and would not make sense before the theory itself was in place. I am thinking, for instance, of the falling apple and the falling moon which do indeed become analogous under Newton's law of universal gravitation. To present Newton (as is sometimes done) as having been led to the law on the basis of the analogy, is putting the cart before the horse. The following example from physics may illustrate the usefulness of analogies that do not end up as identities and at the same time are not merely post factum analogies, but constitute genuine vehicles of discovery.

The theory of semiconductors, transistors in particular, is based on an analogy between the motion of a negatively charged electron and the 'motion' of the 'hole' left by the moving electron. The 'hole' is thus considered as a positive charge, creating a current that moves in the opposite direction than the electron current.[7] The analogy is useful in lattices where, due to Pauli's exclusion principle, different electrons cannot occupy (or move freely into) the same quantum state/orbit. Only when an electron is kicked out of its orbit, a neighboring electron can take its place, leaving a 'hole' that can again be 'filled' by another electron, and yet another, generating a 'current' of 'holes'. To visualize the idea —a further analogy to illustrate the previous one – think of a theatre row in which a middle seat is left vacant. The neighbor may then move to that seat, leaving her seat unoccupied and so on. Rather than following the movement of different members of the audience from one seat to another (from the end of the row to the middle), we can think of an empty seat moving in the opposite direction, from the middle of the row to its end.[8] The 'hole' framework has both practical and computational advantages. A more familiar example, pertaining to the relation between a physical domain and abstract logic, is Shannon's striking analogy (in his 1937 Master's thesis) between Boolean logic operations and electric circuits, an analogy that inaugurated digital computing (Shannon 1938). In both of these cases, the analogy is based on specific properties and does not presume to be an identity. In the hole analogy the relevant characteristic is charge, while mass is ignored; in the Shannon analogy, abstract properties of circuits are relevant while their physical constitution is not. Note that the features that are ignored do not undermine the analogy; to the contrary, the analogy points to the *insensitivity* of the process or property one wishes to explain to the features which it ignores. Unlike the subversive analogies I introduce in the next section, here the dissimilarities are not detrimental to the analogy. Both the hole analogy and the Shannon analogy are not merely first steps in a process of discovery, but retain their force throughout numerous theoretical and practical applications.

Not all scientific analogies, however, are of this perfect nature. Even analogies that are quite successful in some respects, often have their limits and must be patched up, or used only under specific conditions, or viewed as idealizations.[9] But the cases that I wish to highlight here are more extreme. They involve analogies --let me call them subversive analogies –that have two properties: a. although they are instructive, they also expose their own failure and b. It is that very failure that leads the way to, and sometimes even constitutes, the crucial result of the investigation that was supposed to benefit from the analogy. Both of these features make subversive analogies special. In the garden variety kind of analogy there are both similarities – positive analogies – and differences – negative analogies between the domain and target of the analogy (see examples in footnote no 10). In subversive analogies, however,

[4]See, for example, Salmond (1957), MacCormick (1978), and Cross and Harris (1991) for the importance and intricacies of analogical thinking in legal reasoning, especially in the context of the use of precedents.

[5]The *Stanford Encyclopedia of Philosophy* entry "Analogy and Analogical Reasoning" proposes the following characterization of an argument from analogy: "It is plausible that [a property] Q holds in the target domain *because* of certain known (or accepted) similarities with the source domain, *despite* certain known (or accepted) differences" (italics in the original). My argument in this passage is that in science, the presumed plausibility is only tentative and treated as a conjecture. An analogical argument must be augmented by a clause to the effect that the conjectured similarity between source and target domains must stand the further test of experience. Hence, there is less epistemic pressure on scientific analogies with regard to the degree of similarity and the plausibility it supports, than on analogies in other domains, where similarity is generally the focus. See Bartha (2019) for quotes from Aristotle, Hume, and many later writers (most of them, according to Bartha) that in one way or another endorse the degree of similarity criterion.

[6]I agree with John Norton (2010) whose paper is entitled "There Are No Universal Rules for Induction". Scientific analogies share this predicament of inductive arguments.

[7]Although the hole analogy was noticed earlier by Rudolf Peierls (1929) its detailed application to semiconductors and transistors was developed by William Shockley (1950).

[8]I wasn't able to identify the source of this widely used analogy

[9]Sound waves and light waves are analogous in some respects, e.g. in manifesting reflection, refraction and interference, but not in others - light can, for instance propagate in vacuum, while sound only propagates though a medium. The analogy is therefore only partial and must be used with care. The analogy between molecules and billiard balls is treated as an idealization that, for ideal gases, provides a good approximation, but in other cases must be adjusted to account for various interactions between the molecules. Even the hole analogy is not complete; according to the quantum mechanical principle of uncertainty, electrons are not as localized as the analogy suggests. What distinguishes these cases from the case of subversive analogies introduced in the next sentence is that the differences are not in themselves a significant vehicle of progress.

the difference points to an essential drawback of the analogy, and at the same time, provides the key to a new approach that profits from both the similarity and the difference. The initial analogy is not expunged, but because of the problem it encounters, becomes a foundation of a novel theory. In short, subversive analogies have a two-fold significance, first in the similarity they point to and second (often crucially), in the disanalogy they harbor.

Consider the transition from Rutherford's classical model of the atom to Bohr's quantum mechanical model. Rutherford's model construed the atom by analogy to the solar system: a compact heavy mass – the nucleus – occupying a tiny space within the mostly empty atom, surrounded by much lighter electrons orbiting it at arbitrary distances.[10] The advantage of this model over J.J. Thomson's previous one, the so-called plum pudding model, was that it could explain the results of a series of scattering experiments performed by Geiger and Marsden under Rutherford's guidance[11]. Thomson's model considered the positive charge to be outspread in the atom, which implied that scattered α particles would at most suffer small deflection. The Geiger-Marsden results cast doubt on this model by showing that, while most of the incoming particles just pass through the atom without suffering any significant deflection (which is compatible with the atom being mostly empty), for a very small fraction (roughly 1 in 20,000), the deflection was much larger than allowed by Thomson's model (around 90^0). These results, Rutherford argued, could only be explained by the collision of the small number of deflected particles with the very heavy, concentrated, and positive mass of the nucleus. Like the planetary system that is held together by the attractive force of the sun, Rutherford's atom is held together by the attractive force of the nucleus, which keeps the electrons revolving around it.

While Thomson's model was challenged by experiments, Rutherford's model faced an *inherent* problem that proved to be fatal - it had to be unstable! Unlike a planetary system, controlled by gravitation, the dominant force between the nucleus and the electrons is the electrostatic force given by Coulomb's law. The difference between these forces is that electrons accelerating in the electric field of the nucleus (circular, or any other non-linear motion is accelerated) suffer a continuous loss of energy through radiation, and are therefore getting closer and closer to the nucleus until they end up 'falling' into it. As atoms are known to be tremendously stable, a theory that yields instability cannot be true, not even approximately true. Rutherford was aware of the problem, but, since it was the validation of the nucleus that in his view constituted the salient result of the paper, he thought the question of electron orbits could be set aside. "The question of the stability of the atom proposed need not be considered at this stage, for this will obviously depend upon the minute structure of the atom and on the motion of the constituent charged parts" (1911) 671.[12]

We know, of course, that the solution of the stability problem did not come from a more detailed analysis of the 'minute structure' of the atom within the framework of classical physics; it took the radical break with that framework proposed by Bohr in 1913 and further developed by him, Sommerfeld and many others in subsequent years.[13] Bohr's model retained the basic structure of Rutherford's model, but, seeking to harness quantization to the resolution of the difficulties of Rutherford's model, he introduced a set of quantum conditions that constrain electron orbits and certify their stability. First, the range of angular momenta allowed to the electron is discrete rather than continuous; only integer multiples of $h/2\pi$ (where h stands for Planck's constant) are allowed. Second, and in stark contrast with the then consensual electromagnetic theory, the permitted orbits are declared to be stable, that is, electrons moving in these orbits do not lose energy through radiation. Third, energy is being emitted or absorbed by the orbiting electrons during transitions between the discrete, stable, energy levels that the model allows. To move to a higher energy level (further away from the nucleus), the electron must absorb a photon whose energy corresponds to the energy difference between these levels. Similarly, in transitions from higher to lower permitted energy levels, electrons emit photons in accordance with the energy balance between the levels. [14]

On its own, Bohr's stability postulate had neither theoretical justification nor empirical confirmation. Nonetheless, with the prediction of well-defined spectral lines ensuing from transitions between stable energy levels, the model received striking confirmation by patterns of atomic spectra that had been accurately described by Johann J. Balmer and Johannes Rydberg in the late 1880s. The success of the model in showing the relevance of quantum considerations to the understanding of the atom was a crucial step in the development of quantum mechanics towards its formalization by Heisenberg and Schrodinger in 1925-6. The solar system analogy had both of the features that I identified as characteristic of subversive analogies: It had an internal tension that pointed to the need of revision and the revision turned out to be of fundamental significance for developments of the subject. In other words, the underlying disanalogy was at least as important as the analogy. And yet, the analogy was significant, not only because it yielded the discovery of the nucleus, but also because it is unlikely that without the Rutherford model, the leap to a quantum mechanical description of the atom would have been made at this point.

My second example of a subversive analogy, the central analogy of Darwin's theory of evolution by natural selection, is probably more familiar and, because it is conceptual rather than technical, perhaps even more telling. As is well known, it was not the idea of evolution *per se* that constituted Darwin's innovation, but the idea that the mechanism that drives evolution is natural selection.[15] Upon his

[10]The mass of an electron is 1/1836 that of a proton and a very similar relation holds for neutrons. A nucleus can of course consist of many protons and neutrons.

[11]The origin of the plum-pudding appellation and its adequacy as describing Thomson's model is a matter of debate; see Heilbron (1968) and Hon & Goldstein (2013). Geiger and Marsden experiments are described in their (1909) and Rutherford's interpretation of their results via the nuclear model, in his (1911)

[12]Rutherford's hope for a solution provided by the "minute structure" of the atom probably referred to ideas about different forces exerted on the electrons balancing one another so that the collapse through radiation is prevented, but for various reasons (e.g. it was realized that the hydrogen atom had only one electron) these rudimentary ideas did not lead to the hoped-for result. It is difficult to decide whether Rutherford's decision to publish his theory despite the problem he was aware of is typical. The problem refers not only to analogies, but to theories in general. Examples point in different directions and the differences between the various cases make it hard to find a common denominator that allows generalization. Schrödinger postponed the publication of his relativistic wave equation (known as the Klein-Gordon equation) because of some discrepancies with experiments, while Feynman published his elementary particle model despite his doubts about its details. One can explain these decisions (as well as many others), but I would be reluctant to offer a general characteristic of the two kinds of scientist or the two kinds of decision.

[13]The actual history is more complicated than this schematic summary. The insight that quantum considerations might be relevant to the structure of the atom came up before Bohr in the work of Arthur E. Haas and John, W. Nicholson and was discussed during the 1911 Solvay conference. The solar analogy was drawn before Rutherford by Hantaro Nagaoka. None of these anticipations matured to the stage of the Rutherford-Bohr model. It should also be noted that Bohr's model only gave (approximately) accurate predictions for the hydrogen atom and further, it did not incorporate fundamental quantum mechanical tenets such as the uncertainty principle. In fact, it underwent so many later adjustments that it can hardly be conceived as a realistic model of the atom. Neither its prehistory, however, nor its ever-changing future, affect the point I am making regarding the subversive nature of the solar system analogy.

[14]The energy of the photon is given by its frequency multiplied by Planck's constant - Einstein's 1905 equation.

[15]There were a number of anticipations of this idea, but they came nowhere near Darwin's developed theory. One such anticipation is due to Pierre-Louis Moreau de

return from the five-year Beagle voyage, Darwin is known to have devoted himself to intensive research into breeding techniques. In the Introduction to the Origin of Species (Darwin 1859), he says:

> It is, therefore, of the highest importance to gain a clear insight into the means of modification and coadaptation. At the commencement of my observations, it seemed to me probable that a careful study of domesticated animals and of cultivated plants would offer the best chance of making out this obscure problem. Nor have I been disappointed; in this and in all other perplexing cases I have invariably found that our knowledge, imperfect though it be, of variation under domestication, afforded the best and safest clue. I may venture to express my conviction of the high value of such studies, although they have been very commonly neglected by naturalists.
> From these considerations, I shall devote the first chapter of this Abstract to Variation under Domestication. We shall thus see that a large amount of hereditary modification is at least possible, and, what is equally or more important, we shall see how great is the power of man in accumulating by his selection successive slight variations.

Just as the solar system analogy in Rutherford's case, the breeding analogy could not be the whole story. If Darwin aimed at a natural explanation, he had to replace the farmer, the conscious agent acting to achieve well-defined goals, with a causal process that could produce similar results to those of the farmer. In other words, he needed a mechanism of selection without a selector. What could that mechanism be? Darwin realized that he was stuck. As he explains in the passage following the previous one, it was Malthus's *Essay on the Principle of Population* (Malthus 1798) that led him out of this impasse.

> In the next chapter the Struggle for Existence amongst all organic beings throughout the world, which inevitably follows from their high geometrical powers of increase, will be treated of. This is the doctrine of Malthus, applied to the whole animal and vegetable kingdoms. As many more individuals of each species are born than can possibly survive; and as, consequently, there is a frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be naturally selected. From the strong principle of inheritance, any selected variety will tend to propagate its new and modified form.

Here it is even clearer than in the previous example that Darwin went through the two stages typical of thinking in terms of a subversive analogy. (By contrast with the previous case in which there are two protagonists, Rutherford and Bohr, here it is Darwin himself who went through these stages.) He was first guided by the breeding analogy, investing great efforts to convince himself that intentional selection could indeed result in inherited modification of the properties of a plant or animal. But he also realized that this analogy was deeply flawed because unless God is called upon to oversee the process of selection, he had no clue as to how this process could work. He was thus held back for a couple of years before hitting on the natural, non-intentional solution to his problem. The breeding analogy was an essential step and yielded results of its own, but it was the disanalogy it exposed that turned it into an epoch-making theory. We are so used to the concept of natural selection that we tend to forget its paradoxical nature — nearly an oxymoron, but an immensely fruitful one.

It is important not to conflate subversive analogies as characterized and exemplified here with analogies that are simply inadequate, or outlandish, or useful at first and eventually discarded. Kepler mentions an analogy that was very close to his heart throughout his life: The sun, the fixed stars, and the space between them stand for the Father, the Son, and the Holy Ghost, respectively. Though this connection may have had great psychological value for him, it does not have the inter-subjective meaning that is necessary to make it suggestive to others. And even when an analogy is initially useful, it is not always the case that the differences that are later discovered put scientists on the right path to the solution. The flow of heat from a hot body to a body of lower temperature was compared to water falling from higher to lower elevation. The analogy, which seemed to reinforce the idea that heat is a substance, turned out to be imperfect, but it did not possess the characteristic of inherent tension typical of the subversive type. Moreover, its failure was not in itself instrumental to the reception of motion theory of heat. Rather, it was the motion theory of heat, which was already extant as a rival to the substance theory, that weakened the appeal of the analogy.

One may wonder whether the order in which subversive analogies unfold is always as manifest in the examples we have looked at, namely, from analogy to disanalogy, from a suggestive similarity to a fatal difference that inspires the next stage of discovery. My conjecture is that the answer is positive. Seeing one thing as another, noticing the similarity between them, is typically prior to discerning their differences. We meet a person, her face reminds us of another face, it's her eyes, we say to ourselves, that are so similar, but then the nose is so very different... Unless we first have a basis for comparison - a similarity - it makes no sense to look for differences between a face we see for the first time and other faces we know. Analogies therefore seem to me to come first.[16]

To conclude, in my examples of subversive analogies, the criteria identified above are both satisfied - our understanding is enhanced first by a discovered affinity and then by its breakdown. We have examined two analogies that were important in their own right; Rutherford discovered the nucleus and Darwin's work on breeding established the connection between selection and inherited modification. Thus, when an analogy turns out to be subversive, it does not mean it was futile all along. And yet, what is special about subversive analogies is that the light thrown on a problem by their internal collapse is often brighter than the light of their success.

Maupertuis, who is his *Essai de Cosmologie* (1750) explained that a vast number of creatures were created by chance, but as only a few of them were well-enough structured to survive, the majority perished. It was thus blind chance, he maintained, rather than God's design, that produced the living world as we know it.

[16] By their nature, analogies bridge differences so in that respect the similarity they draw attention to is new, whereas the difference had been there all along and taken for granted. This kind of difference, however, had not been a subject of investigation, not a problem to grapple with. We would not inquire whether abortion is different from murder or plagiarism from theft, unless we first saw a similarity between them. We could also wonder why Pamela looks so different from her brother Peter (suggesting that noticing the difference came first), but in fact even in this case, we are puzzled about the difference only because we expected similarity.

REFERENCES

[1] Balmer, J. J. (1885) Balmer, J. J. ”Notiz über die Spectrallinien des Wasserstoffs” Annalen der Physik und Chemie. 3rd series **25** 80–87.

[2] Bartha, P. (2019) “Analogy and Analogical Reasoning” *Stanford Encyclopedia of Philosophy*

[3] Bohr, N. (1913) “On the Constitution of Atoms and Molecules” *Philosophical Magazine*, series 6, **26** 1-25**.**

[4] Cross, R. and Harris, J. (1991) *Precedent in English Law*, 4th edition, Oxford: Oxford University Press

[5] Darwin, C. (1859) The Origin of Species (London: John Murray)

[6] Drury, M. O'C (1996) *The Danger of Words & Writings on Wittgenstein* (Bristol: Thoemmes Press).

[7] Duncker, K. (1945) *On Problem-Solving*, *Psychological Monographs*, **58**, 1-113.

[8] Koestler, A. (1964) *The Act of Creation* (London, New York: Hutchinson Macmillan).

[9] Geiger, H. and Marsden E. (1909). ”On a Diffuse Reflection of the α-Particles”. *Proceedings of the Royal Society of London* **A**. **82** (557): 495–500.

[10] Geiger, H. and Marsden E. (1913). ”The Laws of Deflexion of α Particles through Large Angles” *Philosophical Magazine*, Series 6. **25** (148): 604–623.

[11] Heilbron, J. L. (1968). ”The Scattering of α and β Particles and Rutherford's Atom”. *Archive for History of Exact Sciences.* **4 (4)**: 247–307.

[12] Hon, G. and Goldstein, B.R. (2013) “J.J. Thomson's Plum-Pudding Atomic Model: The Making of a Scientific Myth” *Annalen der Physik.* **525** (8–9): A129 – A133.

[13] Keynes, J.M. (1921) *A Treatise on Probability*, London: Macmillan.

[14] MacCormick, N. (1978) *Legal Reasoning and Legal Theory* (Oxford: Clarendon Press)

[15] Malthus T.R. (1998) *An Essay on the Principle of Population* (London: J, Johnson)

[16] Maupertuis, P.L.M.de (1751) *Essai de Cosmologie* (Leide: s.n.)

[17] Norton, J., 2010, “There Are No Universal Rules for Induction,” *Philosophy of Science*, 77: 765–777.

[18] Peierls R. (1929) ”Zur Theorie der galvanomagnetischen Effekte” Zeitschrift für Physik **53** 255–266

[19] Peirce, C. S. (1894) “What is a Sign” in: *The Essential Peirce* **II** *Peirce Edition Project* (Bloomington: Indiana University Press) (1998) pp. 4-10.

[20] Rutherford, E. (1911) “The scattering of alpha and beta particles by matter and the structure of the atom” *Philosophical Magazine*, series 6 **21** 669-688.

[21] Rydberg, J.R. (1890) (Englisg summary of the original 1889 publication in Swedish) ”On the structure of the line-spectra of the chemical elements” *Philosophical Magazine,* series 5 **29**: 331–337.

[22] Salmond, G. W. (1957) *Jurisprudence*, 11th edition (London: Sweet and Maxwell)

[23] Shannon, C.E. (1938) “A symbolic Analysis of Relay and Switching Circuits” *Transactions Institute of American Electrical Engineers* **57** 471-495.

[24] Shockley, W. (1950) *Electrons and Holes in Semiconductors with Applications to Transistor Electronics* (New York: Van Nostrand).