Truth, Beauty and the Pursuit of Science

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1. Introduction

Science is often perceived as impartial, rational, and at times, cold. Beauty, a fundamentally subjective concept, is not something the layman would associate with science. Scientists, however, have long described science as beautiful. Many cite beauty as a guide in their scientific pursuits even. How are science and beauty related? What is the role of beauty in science? Through exploring different notions of beauty as proposed by scientists and philosophers throughout history, this essay hopes to provide answers to these questions and to find a place for beauty in science.

2. Beauty as Motivation

Poincaré argued that beauty is what motivates scientists in their work, "The scientist does not study nature because it is useful to do. He studies it because he takes pleasure in it, and he takes pleasure in it because it is beautiful" (165). What is this beauty that enchants scientists into "long and painful labours" in pursuit of it (166)?

Aesthetics, the study of beauty, has long interested western philosophers. In *Metaphysics*, when talking about mathematics, Aristotle stated that "the chief forms of beauty are order and symmetry and definiteness" (1705). And in *Poetics*, he said, "to be beautiful, a living creature, and every whole made up of parts, must . . . present a certain order in its arrangement of parts" (2321). These quotes provide insight into Aristotle's conception of beauty, as one that is timeless and definite, one that seeks a special order and harmony between parts of a whole. This classical conception of beauty, while diverging from our conventional subjective, intangible notions of beauty, finds a place in the natural sciences.

Poincaré's "intellectual beauty" shares striking similarities with Aristotle's views on beauty. Poincaré saw nature as possessing a "more intimate beauty which comes from the harmonious order of its parts", which only "a pure intelligence can grasp"; a beauty that provides "the sense of harmony of the world" (165–166). What does Poincaré mean by "harmony of the world", and where does one find it? While Poincaré never gave an explicit answer, he did say a scientist's aim is to "discover similarities hidden under apparent discrepancies" (165). One would thus assume this intellectual beauty Poincaré speaks of lies in the "similarities", or the rules underlying nature. In the words of Francis Hutcheson, a philosopher of aesthetics, beauty arises from "uniformity amidst variety" (28). At first glance, nature is diverse and chaotic. Yet, through a scientist's careful observation, the unifying principles behind nature could be discovered, providing a sense of harmony and order from which beauty arises.

A classic example of nature's beauty is seen through Newton's laws of motions. With Newton's laws and its mathematical derivations, nearly all motions, from the celestial motions of planets to the miniscule motions

of small particles can be described using the same principles, presenting a beautiful, orderly "rule of nature" (Cohen 61). It should be noted, however, that this beauty stems not from the ever-changing[1] scientific theories proposed by scientists, but from the timeless harmony of nature. The beauty of harmony and order rests in nature, and scientific theories are merely the means through which this beauty becomes accessible to scientists. The intellectual beauty seen from Newton's laws could also be presented by Einstein's general relativity, perhaps more so even, with its broader applications, explaining phenomena unaccounted for in Newton's laws.

The above analysis, however, presumes that nature is inherently orderly and thus beautiful. What if there is no order among all the chaos? To prove the existence of such a natural order (or lack thereof) is a philosophical question beyond the scope of this essay. However, I would argue that whether there is an inherent order in nature is irrelevant; so long as scientists believe in such an order, beauty serves as a motivation for scientists, and an ideal to be achieved. "Beautiful" was how Newton described the system of orbiting planets and comets, which, while having vastly different orbits, are governed by the same gravitational laws he proposed (388). It was a beauty so immense to Newton he considered it divine, possible only through the deliberations of God. Nobel prize laureate Steven Weinberg described his expectations for "beautiful answers" when studying "truly fundamental problems", referencing his work on elementary particles (107). He believes that ultimately, "a few . . . principles of compelling beauty" could be found in nature (107). It is the strong belief in a beautiful, harmonious and orderly

1 Newton's laws were superseded by Einstein's general theory of relativity.

nature that compelled Poincaré, Newton, Weinberg to dedicate their lives to developing scientific theories, and to uncover the universal, orderly rules governing the seemingly chaotic world of nature; the sense of order and harmony among chaos provides an aesthetic satisfaction that drives these scientists, and countless more in their scientific pursuits.

3. Beauty as an Indicator of Truth

In the above section, I have briefly explored the idea of nature having an inherent beauty, embodied in its order and harmony. Many scientists and philosophers, building on similar claims, argue that scientific theories, as conveyors of natural beauty, must possess certain aesthetic values, i.e. be beautiful, to be true[2] (McAllister 174). Poincaré claimed that "care for the beautiful leads us to the same selection as care for the useful," (166) while Heisenberg argued "if nature leads us to mathematical forms of great simplicity and beauty . . . , we cannot help thinking that they are 'true'" (68) Thus, beauty here becomes a criterion upon which scientific theories are compared, judged and subsequently chosen.

When evaluating the beauty of scientific theories, aesthetic values like harmony, symmetry, simplicity and unity are often cited by scientists. As such, proponents have given extensive examples of beautiful theories enjoying much empirical success, the most prominent example being Einstein's general theory of relativity, hailed as "probably the most beautiful of all existing theories" (Chandrasekhar 3). The beauty of his theory lies in the "simplicity of his central idea about the equivalence of gravitation and

2 "True" here is defined as being empirically adequate.

inertia" (Weinberg 83), and how it unites the geometry of spacetime with matter and motion (Chandrasekhar 5). Apart from possessing these aesthetic properties, Einstein's theory is also undoubtedly successful empirically. It may well seem as if beauty and truth are linked.

However, the mere existence of one false theory possessing the aforementioned aesthetic values would have falsified the idea of beauty as a predictor for truth. Kepler, in an attempt to introduce beauty into his cosmology, constructed a model of the Solar System by inscribing and circumscribing the five Platonic solids with the orbital spheres of the six known planets at the time (Weinberg 106). The ratio of the radii of the spheres inscribed and circumscribed by the Platonic solids approximately corresponds to the ratio of the planetary orbits' radii. Revered by the Greeks for their symmetry and beauty, Platonic solids are three dimensional structures with their faces composed entirely by regular, identical polygons (Weisstein). By incorporating them into his theory, Kepler presented a sense of geometrical harmony and symmetry among the planets. With this beautiful model, he explained why there are only six planets, a claim easily disproved with the discovery of Uranus and Neptune. Data gathered after his death also showed larger discrepancies between his model and radii of planetary orbits in reality. While beautiful in a classical sense, Kepler's model was embarrassingly wrong for such an accomplished physicist like Kepler, effectively proving the beauty of a theory need not indicate its truthfulness.

Another argument against beauty as a truth indicator lies in the fundamental subjectivity of beauty. What one scientist considers beautiful could be ugly in another's eyes. An example would be Paul Dirac calling quantum electrodynamics "ugly" (291), when Richard Feynman considered

it the "jewel of physics" (Feynman 4). Both physicists are highly regarded, yet their aesthetic feelings on the same theory differ, showing the potential diversity of opinions regarding the beauty of a theory. It is impossible to apply subjective beauty as an indicator for objective truth. The notion of beauty also changes considerably over time. For Aristotle, the harmony of the cosmos lied in how the planets have "the most perfect of motions", referring to their perfect circular motions described through a series of concentric spheres (Lindberg 32–33). However, as noted above, Newton saw harmony and beauty in the variation of orbits: while the comets have eccentric orbits, the planets have regular orbits, yet both are governed by the same laws (388). The same aesthetic value of harmony has different interpretations through time, illustrating just how malleable the notion of beauty is. This begs the question: is beauty really an intrinsic property of certain true scientific theories, or do scientists retroactively assign beauty to empirically validated theories, creating the illusion of beauty in truth?

4. Conclusion

Ultimately, beauty in science is probably a romanticized ideal. The fickleness of beauty renders it an inadequate indicator of truth in science. What a beautiful theory embodies, however, is scientists' firm belief in the beauty of nature, their belief that there is inherently some order hidden behind physical phenomena, waiting to be discovered. Beauty is an "end" to a means, an ideal to strive towards, but not a reliable "means" to truth. The anticipation for a higher beauty in nature motivates countless scientists to work tirelessly in pursuit of beauty and truth, and that in itself, is beautiful.

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Teacher's comment:

Science is often regarded as impartial and rational. However, beauty is a fundamentally subjective concept. Brandon discusses the inseparable relationship between science and beauty based on a number of solid evidences. His arguments are clear, accurate and eloquent. I deeply appreciate his strong, impressive and well organized analysis. (YANG Jie Jasmine)