Artistic Side of Science

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The first American woman to work as a professional astronomer, Maria Mitchell once said, "We especially need imagination in science. It is not all mathematics, nor all logic, but it is somewhat beauty and poetry." After reading different texts in this course, I agree with her statement. In the following paragraphs, I will explain my stance from two directions, namely, the significance of imagination in science and why science is not all mathematics nor all logic; then I will illustrate what "beauty" and "poetry" refer to, with reference to the texts.

Before our discussion, a definition for "science" is required to avoid misunderstanding. "Science is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence." (Science Council). However, our discussion will not cover the "social world" from the above definition by the Science Council.

First of all, imagination is critical for doing science, especially at the frontier of this field. Einstein once said "Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution." It wasn't

without reason for Einstein to assert that imagination is important, from the success of Newton and Watson, we can understand the significance of imagination in science.

In the seventeenth century, there were a lot of remarkable physicists and mathematicians, the reason Newton outshined the others and demonstrated the System of the World that Galileo couldn't (Cohen 61), was imagination. Although Galileo had once imagined a ball rolling along a plane and stated that the ball would move forever if the plane were of infinite extent (58), he didn't continue with his imagination, as he was too "down to Earth" (59). However, as a mathematician, Newton dared to think of the concept of "forever", which only exists in imagination (60). This allowed Newton to generalize the law of inertia, which Galileo cannot because he focused on experience, while pure inertial motion does not exist in reality (60). Newton had revolutionized science by bringing in mathematics, which increased the predictability of science (62). However, only with imagination can mathematics unleash its potential.

In modern days, inspired by Schrödinger's book *What Is Life?*, many scientists went to investigate "the secret of life"; James Watson was one of them (Watson 115). In the field of finding the structure of DNA, only four scientists tried to seek the 3-D structure of DNA, who were Watson, Crick, Franklin, and Pauling (133). Watson's vision on DNA had no doubt contributed to his success, but there was another major factor that allowed him to get the Nobel Prize, which was his imagination. After comprehending different experiment data, Watson started building his two-chained DNA model with cardboards (130–131). Watson was building a model of DNA which had unknown structure at that time, it required an enormous amount of imagination and brain work to compare with the experiment data. At

last, when other chemists were stuck on doing chemical analysis on DNA (133), Watson and Crick had already concluded that DNA is a double helix. And Watson's "imagination" was found to be true by the Meselson-Stahl experiment (137–138).

The reason for Newton's and Watson's success echoes with what Einstein said. A quote from Cohen can conclude why imagination is critical for science, "science advances by heroic exercises of the imagination, rather than by patient collecting and sorting of myriads of individual facts." (62).

After the rationalization and mathematization of human's understanding of nature, it was natural to think that science is all about mathematics and logic. However, I do not agree, because the most important part of science, making inquiries or hypothesis, requires the fusion of imagination and logic; a hypothesis is scientific only if it is testable, an inquiry is groundbreaking only if it is insightful. While logic and mathematics are the tools for proving the hypothesis and for making predictions, the fusion of different ingredients beside logic and mathematics in science can be shown by using Watson and Darwin as examples.

Watson and Crick developed the 3-D model of DNA with experiment data, e.g. DNA density-measurement and X-ray photos of DNA (Watson 129–130), past literature, e.g., Chargaff's research (127), and their professional intuitions as a biologist and a physicist (130–131) respectively. Even though they have not proved it with an experiment, they believed it to be right. Watson said, "Anything that simple, that elegant just had to be right." (131) It reflected the combination of mathematics, logic, imagination and beliefs in science. The Meselson-Stahl experiment that proved Watson's and Crick's idea was also another example of blending imagination and logic. The two bright young men thought of a feasible

experiment to show DNA replication and it was being described as “the most beautiful experiment in biology” (137). Without creativity, there will not be new experiments; without logic, the experiment will not work.

From Darwin’s natural selection, it is clearer that science is not all mathematics and logic. Darwin had proposed a lot of new ideas in biology, e.g. species that are more numerous have a higher chance to prolong, species that have closer characteristics will have more severe competition with each other (84), nature preserves favorable variations and rejects injurious variations (74), etc. Although his ideas didn’t have mathematical proof and there were no data or experiment that can support his point of view, as natural selection requires a thousand generations for species to diverge (Darwin 89), his ideas are persuasive even till today because it is logical and he gave plenty of examples (76, 77, 85). But it wasn’t all logic that helped him think of natural selection and the origin of species, it requires a huge amount of imagination to think of and picture such large-scale event, with the time scale of few thousand generations (88–89). It also requires different knowledge, like geology (83) and history, for Darwin to draw such conclusions.

In spite of the fact that mathematics and logic are important in science, from the famous scientists above, we can see that science is composed of different ingredients, including imagination, beliefs, and cross-disciplinary knowledge. The beliefs mentioned above are actually related to the beauty and poetry that Mitchell was talking about. In the following, the point of view of Poincaré will be used to illustrate why Watson was convinced his model was right (Watson 131) and what “beauty” refers to.

In my opinion, “beauty” refers to simplicity. According to Poincaré, scientists take pleasure when studying nature because it is beautiful (163), and scientists have the preference to select simple facts as simplicity is

beautiful (164). Watson's model of DNA was simple and recurring (Watson 131), everything seemed to be settled in the right place, like a finished puzzle, so Watson was confident about his model because it is beautiful, it fits the beauty that all scientists are pursuing. In Mathematics, simplicity is also beauty. From Euclid's *Element*, many propositions were very obvious, one of them was even being viewed as not smarter than an ass (Dunham 269): the proof of the sum of the length of two sides of a triangle must be larger than the length of the remaining side (Euclid 287). However, Euclid did not add those propositions as postulates, because it would make his postulates less simple which violates an aesthetic principle (Dunham 264).

On the other hand, I think "poetry" refers to the sense of harmony. As Poincaré pointed out that the sense of harmony makes scientists select facts that are best suited to contribute to harmony (164). He also compared scientists with artists, artists also choose specific features that could complete the portrait and give the artwork life (164). This is analogous to "poetry", poetry is a form of literature that uses aesthetic and rhythmic qualities of language ("Poetry"). Poets choose words that fit the rhythm and that rhyme, just as scientists choose facts that fit the harmony of nature. Take Euclid's *Element* as an example, Euclid used 23 definitions, 5 postulates and 5 common notions (Euclid 273–275) to create a total of 465 propositions. As mentioned above, there are some "very obvious" propositions which could be put into the postulates or common notions, while Euclid didn't. Euclid chose his axioms carefully so that no more can be added, no less can be removed, to make his work elegant. Euclid was writing a poem with Mathematics as the language.

To conclude, science requires imagination, it is not all mathematics and logic, but somewhat beauty and poetry. It coincides with my experience in studying physics, as I gradually understand what all famous physicists

have in common; they all have a superior sense of mathematics and precise intuition, which helped them bring breakthroughs in science by making audacious postulates.

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Teacher's comment:

Many people believe that science is the marriage between logic and mathematics only. Sheung Chit argues that logic and mathematics are merely the tools for proving the hypothesis and making prediction. There are other essence in science too. To uncover the complexity of science, Sheung Chit studies the alliances across imagination, cross-disciplinary knowledge and beliefs conscientiously. His paper helps explore an alternative view in interpreting the nature of science. (YIP Lo Ming Amber)