Hend Wagdi Nashaat

Seeing Invisible

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Mathematics, for a lot of people, is nothing more than arithmetic. Mathematics is not only numbers and equations, but it is also the science of understanding the patterns governing these numbers. Keith Devlin, an executive director of Stanford University's Center for the study of language and information and a consulting professor of mathematics at Stanford, clarifies this issue in his book "Life by Numbers":

As mathematics became more and more complicated, people concentrated more and more on the numbers, the formulas, the equations, and the methods, and lost sight of what those numbers, formulas, and equations were really about and why those methods were developed. They lost sight of the fact that mathematics is not about manipulating symbols according to arcane rules but is about understanding patterns; patterns of nature, patterns of life, patterns of beauty (206).

Mathematical equations and formulas are developed in order to help us in understanding an ambiguity and seeing the invisible. Most people are aware of the importance of mathematics in astronomical discoveries; for instance, Newton's "inverse square law" of universal gravitation describes the force that keeps all the planets in their orbits. Moreover, this law was used to predict that a planet (later named Neptune) existed due to the motion of Uranus. Then, the mathematician Urbain Le Verrier used mathematical calculations and astronomical observations to predict the position of Neptune. The calculated position of Neptune finally led to its discovery by Johann Galle, a German astronomer. In addition to the well known use of mathematics in the field of astronomy, there are more surprising applications of mathematics such as in the field of economics where mathematics is used to identify intangible concepts. The economist Graciela Chichilnisky sees mathematics as the "raw material," which she explains as the "energy that drives the system." Chichilnisky uses topology, a branch of mathematics, in the visualization of national economies' growth. In order to understand the operation of markets for individuals and the development of world trade, Chichilnisky uses cone diagrams and the topology of these diagrams (Devlin 198).

Mathematics is not only useful for astronomy and economics, but is also applied in a lot of other fields such as oceanography, computer science, cartography, etc. The most surprising and exciting application of mathematics is in biology where this field is called mathematical biology, and its target is to model natural and biological processes by applying mathematical tools and techniques. This application of mathematics illustrates that mathematics is more than discrete numbers and equations; it's a tool that makes the invisible seen.

While there has been a long history of contribution between mathematics and biology where the use of mathematical techniques has resulted in tremendous effects in the field of biology, one of the most important developments, that occurred by the help of mathematics has been in the field of genetics during the early years of the 1900's. The Hardy-Weinberg law (where G. Hardy was a mathematician and William Weinberg was a medical doctor) is considered as one of the mathematical contributions to classical genetics (Malkevitch). The law states that under the assumptions that a random mating occurred in an infinite population while no immigration and/or emigration or no mutation took place, the phenotypic and allelic frequency remain constant with respect to time. Hence, the belief that after many generations a rare trait in a population will disappear is not right under the assumptions of the Hardy-Weinberg law (Malkevitch). Mathematics also played a crucial role in population genetics, such as in the study of allele frequency distribution and change over long periods of time under the effect of natural selection and mutation, where one of its main founders is Ronald A. Fisher, who is a statistician and geneticists. Fisher used mathematical structures, later called block designs, in order to understand the characteristics and yields of various plants (Malkevitch). Moreover, the development of molecular biology, with the support of physics and mathematics, has lead to the emergence of molecular genetics during the twentieth century where mathematics has had a significant role to genetics in general (Mackey and Santillán, Malkevitch).

Although the contribution of mathematics to biology is not recent, the interest in this field has increased lately due to certain factors that are related to the development of new technologies. The main reason for the interest in mathematical biology is the genomics revolution that has resulted in the increase of data information sets, which are hard to explore without the help of analytical tools. Another important reason is the discovery of new mathematical tools that have aided biologists in comprehending "non-linear mechanisms." Moreover, doing calculations and stimulation, nowadays, has become more possible since the computing power has increased. Finally, experiments done on computers or by computer stimulation have become more preferred because of the complexity of human and animal research.

Mathematical theories that were developed in the past, turn out to be effective tools to biologists in their researches. For instance, the Knot Theory, which developed initially in the middle of the nineteenth century as a study of abstract patterns, has helped in developing the understanding of viruses' behavior since the early 1980s. When a virus is injected inside a cell, it creates enzymes that change the DNA knot structure in order to be in control of the cell (Devlin). In order to replicate and transcribe, DNA must be unknotted; otherwise, the cell that contains the knotted DNA will die (Kolata). The understanding of the DNA knots will help the biologists in understanding how the DNA was knotted and how to unknot the DNA (Kolata). Moreover, the knot theory aids in discovering the needed properties of enzymes that will unknot the DNA and thus, in finding new ways to fight the virus (Kolata). Because of the development of the Knot Theory, mathematicians have enabled biologists to see the invisible; they have invented a tool that is helping the biologists to understand the characteristics of the DNA knots which biologists only see by the use of the electron microscope. The collaborative work of both fields will hopefully end the battle against viruses with a success.

While in the case of understanding the virus behavior, biologists apply mathematical theories developed in the past in their current research, other biologists use mathematical models made specifically to understand the disease. Through the field of mathematical biology, new knowledge about certain diseases and viruses has been discovered; for instance, in 1999, new characteristics of the HIV virus were revealed that had not been perceived before. By using dynamic modeling and techniques of parameter estimation, the dynamic nature of the HIV virus was discovered, which was opposite to what people had thought. It was believed that the disease components are very slow due to the slow development of the disease which takes an average of ten years. The various time scales, "running from hours to days to weeks to months" that were shown by experimentation and mathematical modeling explained important biological processes that are behind the HIV infection. The quick evolution of the HIV helped in understanding the unsuccessful effect of previous single drug treatment, and in proposing multiple drug treatment that was proven to lengthen patients' lives. Moreover, it showed the importance of continuation of the drugs for two to three years after the disappearance of the virus from the blood (Perelson).

Neither mathematics nor biology alone worked it out. It is the combination of both efforts that led to a success. Mathematical modeling helped in seeing the invisible, while the biological experimentation and knowledge aided in explaining the nature of the disease. Without the mathematics, biology was unable to reveal the facts about the HIV virus, while, without the biological knowledge, the mathematics would only be theory on paper without application.

Another main area of research in mathematical biology is cancer modeling and simulation. Lisette De Phillis, a professor of mathematics in Harvey Mudd College is leading a team from the same college, which is carrying out a research called "curing cancer with mathematics." This research was introduced in the thirteenth annual meeting of the Coalition for National Science Funding in 2007. The team was able to develop mathematical models that explain the division rates of cancer cells. By using the mathematical models and computational techniques, they will be able to understand "the complex cascade of biological tumor-immune interactions," and to decide on the effective combination of treatment that encompasses chemotherapy, immunotherapy and vaccine therapy. They can also "tailor" a combination of treatment for individuals. Moreover, by "evaluating stimuli scenarios," their techniques can "potentially" give clinical guidance for new treatments for cancer (Curing Cancer with Mathematics).

Because of mathematical biology, a new hope has risen to end a disease that is believed to be "incurable" and to end a disease that has a high death rate, which as estimated by the World Health Organization (WHO) in 2007 has been thirteen percent of all deaths. According to the American Cancer Society, cancer was the cause of death to 7.6 million people in the whole world during 2007. It is the coordination of both mathematics and biology that will hopefully eradicate the disease.

Although mathematics lies behind a lot of fields, and has a tremendous effect on a field that studies life and can improve human's health, mathematics is not considered as a worthwhile study for a lot of people in Egypt. If people start to appreciate the importance of mathematics in their life, they will be on the first step toward change. If people start to take the study of mathematics more seriously, they can really make a change. The more mathematics they can produce and apply to other fields, the better the quality of life will be.

Works Cited

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