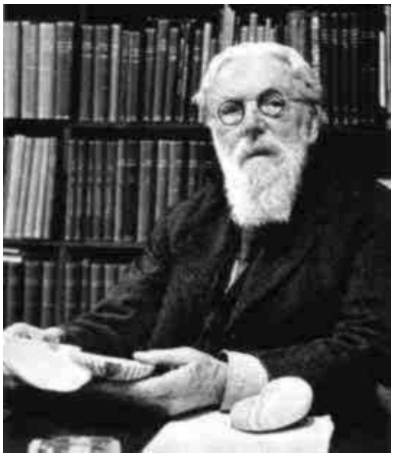
D'ARCY WENTWORTH THOMPSON



Mathematically trained maverick zoologist **D'Arcy Wentworth Thompson** (May 2, 1860 –June 21, 1948) was among the first to cross the frontier between mathematics and the biological world and as such became the first true biomathematician. A polymath with unbounded energy, he saw mathematical patterns in everything – the mysterious spiral forms that appear in the curve of a seashell, the swirl of water boiling in a pan, the sweep of faraway nebulae, the thickness of stripes along a zebra's flanks, the floret of a flower, etc. His premise was that "everything is the way it is because it got that way… the form of an object is a 'diagram of forces', in this sense, at least, that from it we can judge of or deduce the forces that are acting or have acted upon it." He asserted that one must not merely study finished forms but also the forces that mold them. He sought to describe the mathematical origins of shapes and structures in the natural world, writing: "Cell and tissue, shell and bone, leaf and flower, are so many portions of matter and it is in obedience to the laws of physics that their particles have been moved, molded and conformed. There are no exceptions to the rule that God always geometrizes."

Thompson was born in Edinburgh, Scotland, the son of a Professor of Greek. At ten he entered Edinburgh Academy, winning prizes for Classics, Greek Testament, Mathematics and Modern Languages. At seventeen he went to the University of Edinburgh to study medicine, but two years later he won a scholarship to Trinity College, Cambridge, where he concentrated on zoology and natural science. He received a B.A. in Zoology in 1883 without a fellowship and would not obtain a doctorate until 1923. In 1884, he was offered the choice between being professor of Latin, Mathematics or Zoology at the University College, Dundee, which later was incorporated as part of the University of

St. Andrews. Thompson chose Zoology and held the Chair of Natural Science for sixty-four years. A massive man, with a great white spade beard, Thompson became a familiar figure as he rushed through the town, wearing a wide-brimmed black fedora and a billowing cape.

During his lifetime Thompson built up a vast collection of specimens that are housed in the Zoological Museum in Dundee. According to his eldest daughter and biographer Ruth D'Arcy Thompson, "Every main zoological group was worthily represented, the collection of crustacean, certain families of insects, mollusks, starfishes and their allies and birds, being commonly rich in number and variety of species." The collection contains more than 2500 specimens. Of equal interest are Thompson's papers, consisting of over 30,000 items, ranging from research pieces, annotated monographs and correspondence with many of the greatest minds and most prominent figures of the day. Thompson wrote some 300 articles and books but is best known for his seminal work, the magnificent *On Growth and Form*, published in 1917. He explained it was intended to be,

> "… as an easy introduction to the study of organic form, by methods which are commonplaces of physical science, which are by no means novel in their application to natural history, but which nevertheless naturalists are little accustomed to employ."

Albrecht Dürer's studies of human proportion influenced Thompson's theory of coordinates, which stated that the basic processes of evolution and development could be understood mathematically by the employment of certain topological transformations. In this theory the shape of an organism is continuously transformed into another physically similar organism. With his thesis of evolutionary changes during the lifetime of an animal form, Thompson broke away from the Darwinists who postulated evolution as the sum total of modifications made in successive generations. He believed that natural selection had a limited function because it does not account for significant progress in the

development of new structures. He saw form as a mathematical problem and growth as a physical problem. In his 1942 revision of *Growth and Form*, Thompson admitted the difficulty of explaining away the cumulative effect of physical and mental adaptations that, it would seem, could not result in a single generation. Yet he wrote: "So long and so far as 'fortuitous variation' and 'the survival of the fittest' remain ingrained as fundamental and satisfactory hypothesis in the philosophy of biology, so long will these satisfactory and specious causes tend to stay severe and diligent enquiry…. To the great arrest of future discovery."

One form of living mathematics that Thompson studied was the spiral. Most marine shells are based around a spiral form. The shell of a small snail is identical to the shell of a larger one of the same species, except for its size. The snail enlarges its shell by adding only to its open end, that is "terminal growth," and not by uniform expansion. In this way the old shell is an exact scale model of the new one. Perhaps the most elegant spiral is the *Nautilus* (Figure 5.1), whose shape resembles the mathematical curve known as the logarithmic spiral (Figure 5.2). Jacob Bernoulli, who first understood the geometry of the logarithmic spiral, was so impressed with its beauty that he had it engraved on his tombstone. The reason the *Nautilus's* spiral is logarithmic is that the animal's pattern of growth increases by a fixed proportion as the growing shell turns through a fixed angle.

Figure 5.1

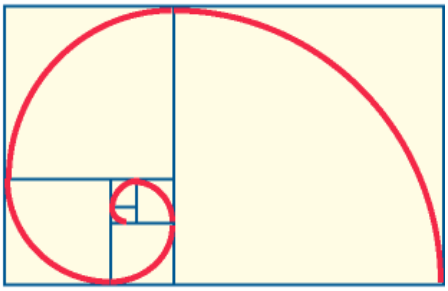


Figure 5.2

Thompson's other works include a bibliography of world literature on protozoa, sponges, coelenterates and worms; and a *Glossary of Greek Birds* and a *Glossary of Greek Fishes*. As he grew older he both loved and hated the idea of death, saying when he was eighty-one, "The world does not grow tedious to us, and yet we are prepared to acknowledge that the long and happy holidays have been enough." Toward the end, he confessed that he longed for release, "My day is over, I have done what I could, I have drawn my pay, I have had my full share of modest happiness. … The old world, that I knew how to live in, has passed away." And age 87, he passed away.

Quotation of the Day: "The perfection of mathematical beauty is such … that whatsoever is most beautiful and regular is also found to be the most useful and excellent." – D'Arcy Wentworth Thompson