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Life sciences is altering the idea of living systems forever

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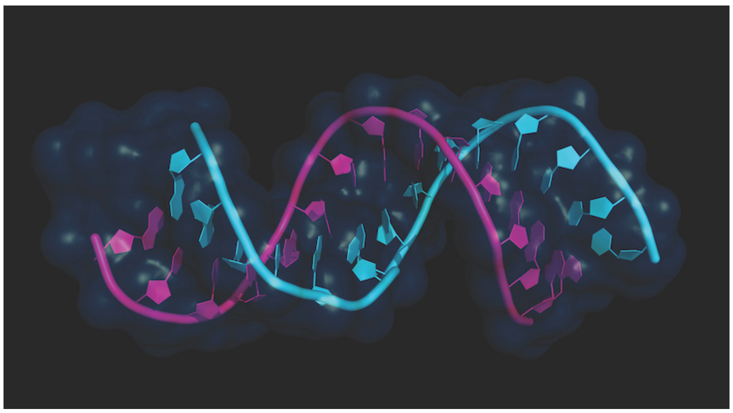

What is life? Humans have wondered about this question from the time of the ancients. While no answer is complete enough for such a question, a scientist might attempt to formulate the question thus. What is a living organism? A simpler, more pragmatic question; but not one without its own complexities. Since living organisms are extremely complex collections of molecules, we could further simplify the question by asking: “What is the simplest possible living organism?”

One way of looking at the above question would be to define essential properties that a living organism must have and then find a system with the smallest number of molecules that could implement such an essential property. One property that most people would agree to be an undeniable characteristic of living systems is the ability to replicate, create copies of themselves. How a complex molecular machine - be it a virus, a bacterium, a small cell, or an entire organism made up of small cells - could replicate itself occupied scientific thought for centuries. The breakthrough came in 1953 when Francis Crick and James Watson, using the experimental results of Rosalind Franklin and Raymond Gosling, deduced the structure of deoxyribonucleic acid, DNA for short, and the information-carrying molecule of most life forms on earth.

DNA is a long thread-like molecule that consists of four constituent molecules (usually abbreviated as A, T, C, and G) which are strung together like beads on a string. It is in the precise sequence of this molecule that much of the code of life, the instruction to make other molecules lies. It is a double-stranded helix, with each strand coiled around the other. For successful and continued replication of cells, its blueprint – the DNA molecule must be replicable as well. What is the blueprint for the replication of the blueprint, you might ask? It turns out that each strand of DNA serves as a template for the synthesis of the other strand. The blueprint can replicate itself.

Once the structure of DNA was understood, there began a wellspring of foundational work in molecular biology which, over the next few decades, ushered in a study of the molecular underpinnings of life in health and disease. These efforts continue to increase in sophistication and impact to this day. A couple of developments over the last two decades have allowed us to discover aspects of living systems, including in the human organism, that seem straight out of science fiction.

The first of these developments is the rapid development of instrumentation at the micro and nanoscale and them being directed specifically to solving the problem of reading the sequences of DNA present inside cells. Consider that the size of the human genome, the total length of all the DNA contained inside a human cell, is approximately four billion letters – that is four billion molecules (A,T, C and G) strung together into giant strings. Deciphering this with both accuracy and speed is no easy task. Yet we have desktop DNA sequencing machines today that read out the entire sequence of DNA in a single individual human or of any other species. A true feat of technology.

Coupled with this ability to probe the material structure of the genome is the availability of affordable computing infrastructure of great power, high-speed multi-core computer processors that would have counted as supercomputers half a century ago. We can not only generate data but look through it rapidly to find hidden patterns inside.

If you were to take DNA from cells on and inside a human being and then sequence it you would find, that not only have you come up with a lot of human DNA but surprisingly a lot of DNA belonging to other organisms as well. Such investigations have led researchers to find that the 'human' body is composed of more microbial cells than it is of human cells. These findings have been verified repeatedly via other more direct methods such as microscopy to establish that even a single organism, a human being, is a microcosm of different organisms. These results have made scientists reconsider the role that microbes play in maintaining our health and not just in threatening it. Investigations into the microbiome continue to advance the frontiers of human health, giving us hope that at least some previously un-understandable diseases may have their basis in the balance of human and microbial cells inside us. These findings, put on a firm scientific grounding, are changing what we consider life itself.

In the years to come, these ideas will play a key role in motivating that the earth is a combination of intricately woven systems and that destroying other life forms and their habitats will have consequences for even the most technologically advanced of them all.

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