Dear (potential) prospective Nanobiology student,

When reading this salutation, you might wonder what this even entails. What does it mean to be a Nanobiology student – or a Nanobiologist? Studying a field that is as relatively unknown and novel as this one might seem daunting, not in the least because it is difficult to imagine. *"Nanobiology uses the language of Mathematics within the context of Physics to understand the complexity of Biology."* As abstract as this may seem, scientists have already made very real and incredible discoveries right on the edge of physics, mathematics, biology and chemistry. Even better, some of them envision many more to come. Fortunately for us, a few of these researchers have put pen to paper to describe their ideas. In the subsequent list, you will find five books that can be classified as "nanobiological popular science." They contain examples, explanations, and theories that, all in their own way, represent this field of study. Every book is accompanied by a rating of the four core disciplines (biology, chemistry, mathematics, and physics), which illustrates to what extent the authors involve them in their explanations. Additionally, you will find an indication of subjects in the Nanobiology bachelor that cover the concepts introduced by the book. Finally, you'll find some questions that might help you think about the theories and ideas of the author.

If you decide to read one or more of these books, please take a few things into account. Firstly, you may notice that many books do not score high on mathematics, nor are the math subjects represented. The main reason for this is that science authors generally believe that their public will be scared off if they include too much mathematics. Whether or not this is correct, it results in books that are relatively mathematics-light. Do not be deceived, however: much of the ideas require mathematics for their rigorous definition. This means that most of the subjects that are represented, do in fact involve mathematics to some degree.

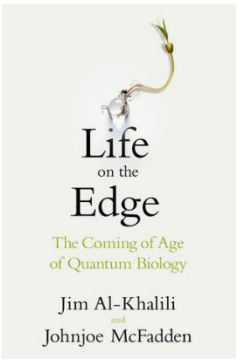
Secondly, realise that these books are written by scientists – all with their own ideas, beliefs, and visions. Some of the ideas in these books are disputed, and some of them are speculative and will turn out to be incorrect. It can be hard to evaluate this information. This is a skill you will hone during your studies, in subjects such as Journal Club and Philosophy & Ethics. For now, be aware of the fact that not all the information in these books is well-established. If you are interested in the problems raised, be sure to research them! All books include a further reading section that will allow you to form a more complete view of its contents.

As a final remark: although this list is by no means exhaustive, it reflects the incredible diversity of this field quite well. I hope you enjoy reading about the ways in which science can be impacted by Nanobiology – and by you.

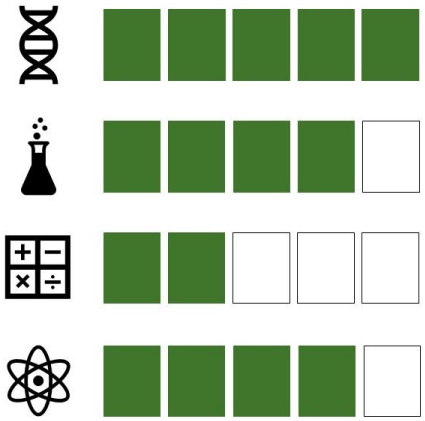
Life on the Edge: The Coming of Age of Quantum Biology

2015

by Jim Al-Khalili and Johnjoe McFadden



As much as the link between life at the smallest scale and quantum theory seems obvious, this book explains it is anything but. The applicability of this generally successful theory is limited by the chaos of life. In spite of this, scientists have discovered multiple areas of biology where quantum phenomena might provide explanations to age-old questions: how can DNA replication be so faithful? What is this mechanism behind our sense of smell? And, if the authors are to be believed, scientists have only scratched the surface. If life really turns out to exist on quantum edge, it will have far-reaching implications for biological problems.



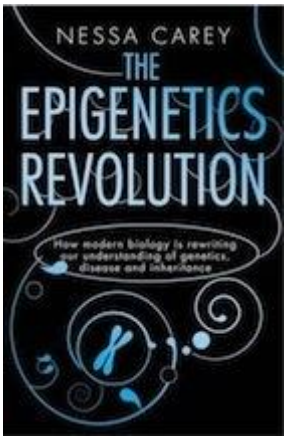
Link to Nanobiology

Quantum biology involves the direct application of a physical theory to living systems. It therefore utilizes knowledge from both physics and biology. Many of the concepts introduced in this book are discussed during the first two years of the Bachelor program, including enzyme mechanics in biochemistry, DNA damage in molecular biology, and quantum mechanics in physics 2.

Y1	biochemistry
Y1	molecular biology
Y2	physics 2
Y3	quantum mechanics in nanobiology

Food for thought

- Why is the relation between quantum mechanics and biological systems disputed? How is this related to the principle “order from disorder” mentioned in the book?
- The authors introduce the philosophical argument that since quantum physics allows for very efficient mechanisms, it is very unlikely that life did not seize the opportunity to utilize it as a tool to expand and improve. In the light of scientific progress so far, how valid do you think this argument is?
- This book mentions many phenomena, all of which involve quantum mechanics according to the authors. Which ones are likely to be regulated by quantum rules, in your opinion? Which ones are more speculative?



The Epigenetics Revolution

2011

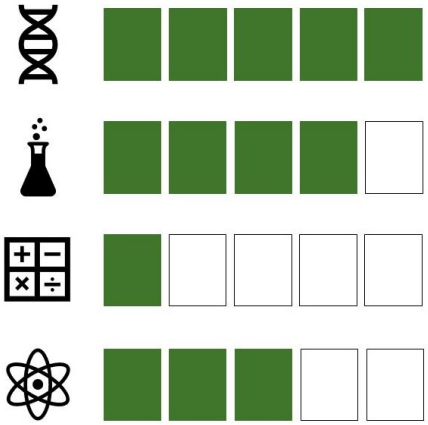
by Nessa Carey

Only 2% of our genome codes for proteins: this is a well-known, but mind-blowing fact. Simultaneously, it poses the million dollar question: what is the remaining 98% doing? The revolution described by the title of this book references the quest to answer exactly this question. Aided by striking examples and detailed scientific explanations, Carey expands on the research that is uncovering the numerous purposes of this so-called junk DNA. Everything points in one direction: we have not unravelled the genome's secrets just yet – instead, it harbours a complexity far above and beyond its four bases.

- Y1 genetics
- Y1 physical biology of the cell 2
- Y2 evolutionary and developmental biology
- Y3 epigenetics

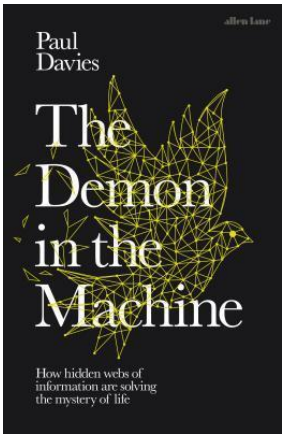
Link to Nanobiology

One motif we see time and again in Nanobiology is that of the genome. Now its general characteristics are clear, some research focuses on the physical and chemical organisation of DNA and its consequences – such as epigenetics. This is explored during physical biology of the cell 2, in which signalling pathways are treated, and the elective epigenetics in the third year.



Food for thought

- The field of epigenetics is sometimes heralded as the revival of Lamarck's evolutionary theory. What are the similarities and the differences between the two?
- The first mammal cloned by somatic-cell nuclear transfer was a sheep with the name Dolly. Apart from the transfer of nuclear DNA, what type of processes must have occurred for Dolly to be born? How does this relate to the epigenetic markers on the donor DNA? How can we apply this to optimize lab-made stem cells (iPSCs)?
- This book muses on the involvement of epigenetics in the development of mental trauma and mental illnesses. Since this book was written, a more solid foundation for this theory was built. How do you think this could influence treatment of mental illnesses?



The Demon in the Machine: How Hidden Webs of Information Are Solving the Mystery of Life

2019

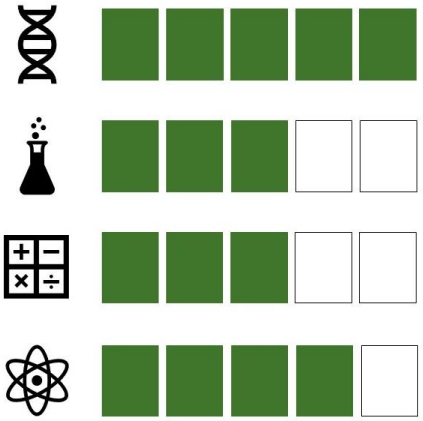
by Paul C.W. Davies

In 1943, physicist Erwin Schrödinger delivered a series of lectures revolving around a single question: *What is life?* Although science has advanced greatly in the meantime, we are arguably no closer to answering this question. Davies proposes that life only makes sense when regarding it as networks of information. Science has long doubted what gives life its complexity. Information theory has the potential to connect the gene to its regulatory network, the cell to its electric field – piecing together the network of life.

- Y1 physics 1A
- Y1 physical biology of the cell 1
- Y2 thermodynamics and transport
- Y2 bioinformatics

Link to Nanobiology

This book applies information theory – a mathematics-heavy physical theory – to one of biology's most fundamental questions. The history of and research into this question is one of the subjects treated in physical biology of the cell 1, which also treats the genetic networks of information that this book references. Thermodynamics, too, are treated in multiple subjects.

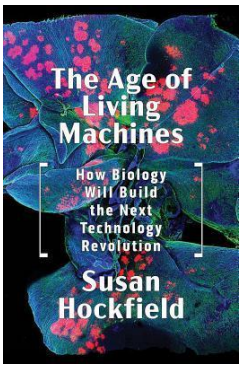


Food for thought

- Can you think of a biological system which can be modelled as a flow of information?
- As is explained in this book, the second law of thermodynamics is a rigid boundary that no physical theory can escape. At first glance, the demon in James Maxwell's thought experiment seems to be able to do this regardless. How do the attempted practical implementations of this thought experiment show that even this demon could never break the second law? How could you implement it in a different way?
- In chapter 6, Davies defends the theory that cancer is an 'atavism', or a genetic preservation, from unicellular organisms. This theory is much disputed – scientists argue that it actually has no biological foundation. What do you think about this theory? Can you think of an experiment or a result that would confirm or falsify it?

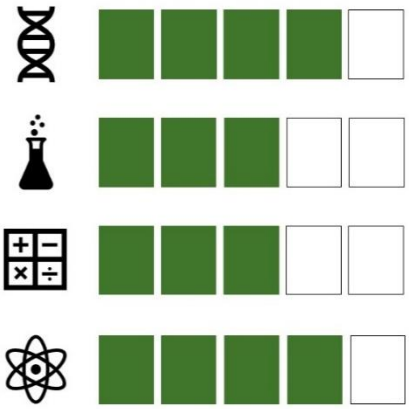
The Age of Living Machines: How Biology Will Build the Next Technology Revolution

2019



by Susan Hockfield

When chemistry and engineering joined forces years ago, it brought forth previously unknown advances in technology. If Hockfield is to be believed, the convergence of biology and engineering will have similar impact. Five outstanding scientists are introduced, who are inextricably linked to their research, which spans nanoparticles and bionic limbs, but also aquaporins and more efficient batteries. The narrative of this book is crystal clear: convergence will lift technology to new heights, solving problems all around.



Link to Nanobiology

The study programme Nanobiology is a direct result of the collaboration between the TU Delft and the Erasmus MC – also referred to as convergence, the central concept of this book. In one of the first subjects, introduction to studying Nanobiology, the purpose of this project is explored. Additionally, some of the methods discussed in this book are explored in the programme.

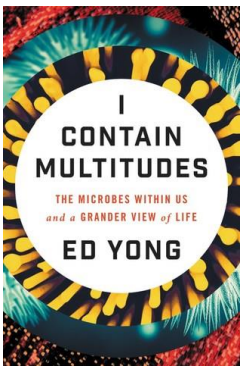
Y1	introduction to studying Nanobiology
Y1	physics 1B
Y2	electronic instrumentation
Y3	nanomedicine

Food for thought

- Which of the projects introduced in this book do you think is most interesting? How could this concept become more scientifically or societally useful?
- The stories in this book describe solutions to fundamental problems in human society, such as clean water supply, sustainable energy, and increasing demand for food. It also shows how biology can be harnessed to solve these problems. Which other issues can you think of that could be solved by combining engineering and biology?
- Hockfield has long been president of MIT, an American university of technology. In what ways has this influenced this book?
- To what extent do you agree with Hockfield's pleas for more fundamental research?

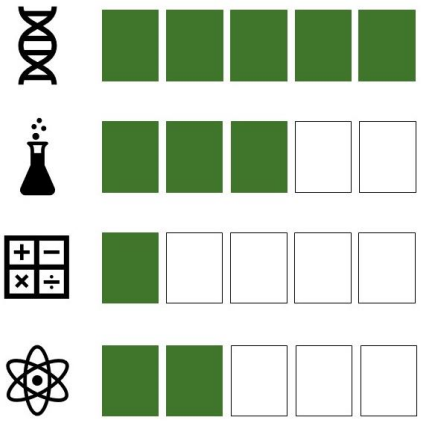
I Contain Multitudes: The Microbes Within Us and a Grander View of Life

2016



by Ed Yong

Us humans are team players down to our very bones – or gut, really. Every single gut contains an incredible number of microbes, and they execute tasks that are vital to us. Since their discovery, humans have had a difficult relation with microbes. We have thought them good, and bad, and everything in between. Yong argues that no microbe can be called such, but has an identity that depends on the context; on the partnerships, which not only determine the microbe's identity, but also that of any organism it partners with.



Link to Nanobiology

As much as Nanobiology concerns the smallest building blocks of multicellular organisms, it also concerns organisms that exist on the smallest scale themselves. The biology of microbes is discussed in genetics and molecular biology, and their practical uses are at the forefront of both labcourse 1 and 2. The technical aspects of their evolution are explored in the course evolution.

- Y1 genetics
- Y1 labcourse 1+2
- Y1 molecular biology
- Y2 evolution

Food for thought

- *"Perhaps it is less that I contain multitudes and more that I am multitudes."* This quote references the fact that the nature of our symbionts has a direct influence on our character. Combined with knowledge of how nutrition can alter our microbiome, how can we apply this? To what extent can we say that the emergence of our 'fast-food-society' is changing humanity for the worse?
- Many different examples of symbiosis with microorganisms are mentioned in this book – including humans, plants and other species of microorganisms. Which one of these did you find most striking?
- Yong argues that there are no 'good' and 'bad' bacteria, as their disposition depends on the environment. How could we apply this knowledge to combat bacterial infections?