Want to learn biology?

recommended texts from beginner to advanced

By Logan Thrasher Collins

Preface:

I have seen a variety of online resources which recommend books for learning physics and mathematics (e.g. Chicago undergraduate mathematics bibliography, Susan Fowler's So You Want To Learn Physics, How to Learn Math and Physics, etc.), yet there seems to be a paucity of similar resources for biological fields. To help fill this gap, I have compiled a handpicked list of textbooks which may aid those with a desire to learn biology.

I have also included books from fields such as mathematics, computer science, chemistry, physics, imaging, and nanotechnology which are important in biology. The books from adjacent fields which I recommend here are mostly targeted towards those readers who come from backgrounds which are not greatly quantitative. For this reason, books filled with lots of detailed mathematics are located in the advanced category. That said, I do assume some familiarity with mathematics and physics in the lower levels also.

Though this page so far does not include resources beyond textbooks, there are many other useful tools for learning about biology. Video lectures, educational books which are not textbooks (e.g. Thieme FlexiBooks, Lippincott's Illustrated Reviews, etc.), scientific journal articles (especially review papers), reputable scientific news articles (e.g. Nature News and Views, Science Daily, Neuroscience News, etc.), Wikipedia, other educational websites, and research experience come to mind.

While this list is certainly not comprehensive, I have tried to cover as much ground as possible for the interested autodidact. These books represent the ones that I personally feel are the best for the given subjects at the given levels (beginner, lower intermediate, upper intermediate, and advanced). There are a lot of texts related to microbiology, biochemistry, and neuroscience. This bias reflects my own background in synthetic biology, nanobiotechnology, and connectomics. My list is currently lacking in ecology and evolutionary biology texts. If anyone is interested in contributing their own recommendations for these or other missing topics, feel free to contact me and we can figure out how to incorporate your texts.

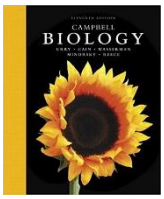
One point that I would like to make is that you by no means need to read these books from cover to cover. It is much more efficient to learn biology by creating a curriculum for yourself and reading selected chapters and sections as they interest you. Over time, the knowledge will build up and you will start to see how it all connects. You will eventually begin to gain the ability to think critically about biological mechanisms and how perturbing them may influence the systems. I would recommend practicing this kind of thinking early on. You can begin to do thought experiments even when you are starting out. As you carry out these thought experiments, you can explore your books and the internet to try and figure out any missing pieces. This will exercise your ability to understand and make predictions about biological systems.

Biology is an expansive, interdisciplinary, and extremely exciting field. I hope that you enjoy your journey into the biological sciences!

Beginner:

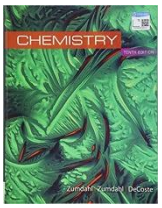
These represent foundational texts which introduce biology and associated fields which are essential for understanding biology (i.e. chemistry, physics, and mathematics). They are at a high school or maybe college freshman level.

Biology



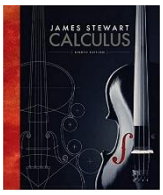
Campbell Biology – by Urry, Cain, Wasserman, Minorsky, Reece || An authoritative introduction to biology and its subdisciplines. It features clear explanations, good organization, and helpful illustrations. Though lengthy, you can often read desired subsections in any order. That said, I would recommend reading some molecular biology and genetics chapters before diving into physiology. It should be noted that this text is a primary source for the high school Biology Olympiad competition.

Chemistry



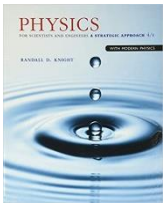
Chemistry – by Zumdahl, Zumdahl, and DeCoste || An introductory chemistry text which has good organization and illustrations. Though other general chemistry books could work just as well, I have a mild personal preference for this one.

Mathematics



Calculus – by Stewart || Though lengthy, this book is a good introduction to calculus. It explains single-variable calculus and multivariable calculus and even gives a small taste of differential equations. This is excellent since calculus and differential equations are so central to computational modeling of biological systems.

Physics



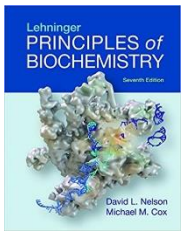
Physics for Scientists and Engineers: A Strategic Approach with Modern Physics – by Knight || While I have not used this book personally, I have heard good things with regards to its applicability for biology. As such, I picked out Knight's text for this list entry because of its organization, its inclusion of modern physics, and its emphasis on practical applications.

Lower intermediate:

These books introduce a range of key subfields in biology. Though some of the texts are quite long (e.g. 800+ pages), I will say again that they do not need to be read cover to cover. These do not require greatly specialized knowledge to understand. They are typically used for first year or second year university courses. As with the previous section, I have included some non-biology texts covering fields adjacent to biology. Note that, because biology is an interdisciplinary enterprise, these adjacent fields are vitally important for understanding and applying biological knowledge.

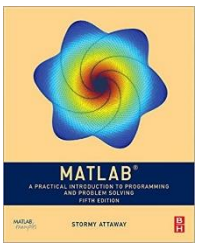
Biochemistry

Lehninger's Biochemistry – by Nelson and Cox || Great textbook which discusses biochemistry with both depth and breadth. It is not as detailed as Voet's book (see the upper intermediate section), but it is not a light treatment either. This text features beautiful illustrations which are very helpful for gaining a deeply visual appreciation of how biochemistry works. In my opinion, it also has well-written treatments of the mathematics of enzyme kinetics and related topics.

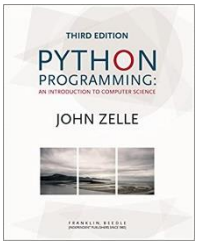


Computer science

MATLAB: A Practical Introduction to Programming and Problem Solving – by Attaway || Since computer science is an integral part of biology research, it is important to have at least some understanding of programming and modeling. For those who are not already familiar with programming, Attaway's MATLAB book provides an excellent entry point. It instructs on how to use MATLAB in a clear and concise way and also discusses essential mathematics that come up in scientific computing. Another strength of this text is its clean organization, which allows one to jump around the different sections more easily as required by one's explorations in MATLAB coding. MATLAB is one of the most user-friendly programming languages and so it is great for beginners. Though MATLAB is not as grounded in the fundamentals of computational logic as some languages, it is quite useful as a tool for many scientific computing applications such as modeling, image processing, and data analysis. It should be noted that MATLAB itself is not free, though if you are affiliated with a university, the school will probably pay for your license.

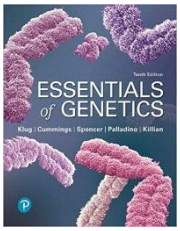


Python Programming: An Introduction to Computer Science – by Zelle || This text provides another excellent entry point into programming. Zelle acts as a well-organized reference for learning the basics of Python. It is clear and reasonably concise. By contrast to MATLAB, Python is freely available. Another benefit of Python is the wide array of user-created software packages that you can easily install into your Python infrastructure. Many of these packages provide tools that handle specific areas of computational biology such as nucleic acid sequence analysis or biologically realistic neuron simulation.

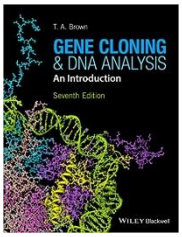


Genetics

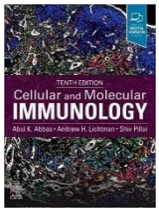
Essentials of Genetics – by Klug, Cummings, Spencer, Palladino, Killian || A standard text which introduces the various branches of genetics. Though there is perhaps not enough focus on modern techniques for my personal taste, I do appreciate the clarity of this book's molecular genetics sections.



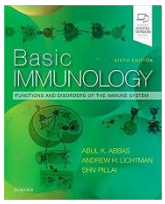
Gene Cloning and DNA Analysis: An Introduction – by Brown || Excellent book which describes molecular genetics techniques. It is concise and clear and yet still covers a lot of important methods in sufficient detail to convey real understanding.



Immunology

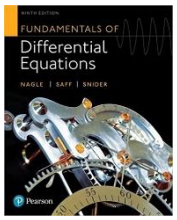


Cellular and Molecular Immunology – by Abbas, Lichtman, Pillai || Explains immunological principles in a through yet digestible way. It features very consistent diagrams which carefully represent specific molecules and cell types with the same images throughout the book.

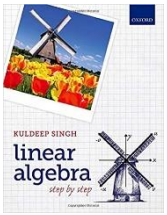


Basic Immunology: Functions and Disorders of the Immune System – by Abbas, Lichtman, Pillai || This text is essentially a more concise version of Cellular and Molecular Immunology. Since it is written by the same authors, it also features its sister text's helpfully consistent diagrams.

Mathematics

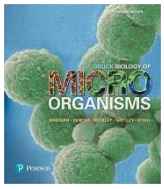


Fundamentals of Differential Equations and Boundary Value Problems – by Nagle, Saff, and Snider || Differential equations are vitally important for modeling and simulation in biology, so if you want to go into any kind of biotechnology-related field, you should learn about this branch of mathematics. This text covers differential equations in a clear manner, provides lots of good exercises, and focuses on application rather than theory.

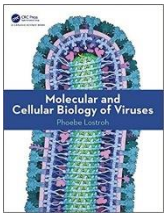


Linear Algebra: Step by Step – by Kuldeep Singh || Linear algebra is another area of mathematics which is vitally important for modeling and simulation in biology and bioengineering fields. This book goes over linear algebra in a clear fashion, has some illustrations to aid intuitive understanding, includes many good exercises, and emphasizes application rather than theory.

Microbiology

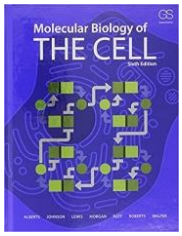


Brock Biology of Microorganisms – by Madigan, Bender, Buckley, Sattley, Stahl || For those who want to explore infectious disease and/or synthetic biology, it can be valuable to get acquainted with microbiology. This authoritative text is friendly to beginners in biology and has strong illustrations.



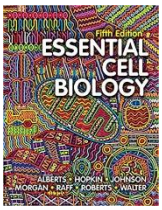
Molecular and Cellular Biology of Viruses – by Lostroh || This is a good book for virology in general. It has very pretty illustrations which are quite helpful to the reader. I do think that the book meanders too much in its explanations. The organization of the book as a whole seems a little haphazard as well. Nonetheless, this text can serve as a good reference if you want to read up on a specific type of virus and are looking for intuitive comprehension of its mechanisms.

Molecular biology



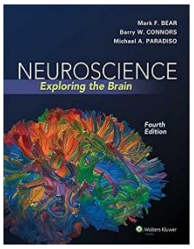
Molecular Biology of the Cell – by Alberts, Johnson, Lewis, Raff, Roberts, Walter || A comprehensive and yet approachable book on molecular biology. It has numerous excellent illustrations, a crucial feature in any molecular biology text. It thoroughly covers a large array of important topics. There are even supplemental digital chapters on further topics in molecular biology for interested readers.

Essential Cell Biology – by Alberts, Hopkin, Johnson, Morgan, Raff, Roberts, Walter || Though this book is somewhat less detailed and thorough than the Molecular Biology of the Cell, it provides a more concise introduction to cell biology, while still covering enough detail to grant a good understanding of the subject. It also has great illustrations.



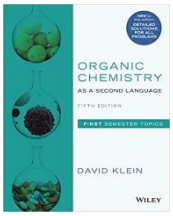
Neuroscience

Neuroscience: Exploring the Brain – by Bear, Connors, Paradiso || This book talks about a wide range of topics in neurobiology, so it is useful for introducing neuroscience as a broad field of study. I found the chapters on sensory neuroscience to be especially strong. In my admittedly biased opinion, the book neglects computational neuroscience and modern neuroscientific techniques. If you are coming from a highly mathematical background and/or wanting to go into a mathematically-focused field of neuroscience, you might want to supplement this text with some computational neuroscience books (see the intermediate and advanced sections of this page).

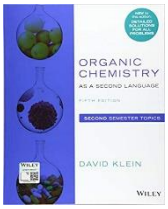


Organic chemistry

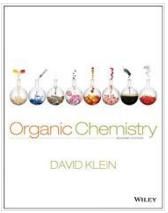
Organic Chemistry as a Second Language: First Semester Topics – by Klein || Klein's short books on organic chemistry are amazing at helping the reader to understand the core principles of the subject. The first semester topics text is especially good for explaining the principles governing structure and mechanisms in organic chemistry.



Organic Chemistry as a Second Language: Second Semester Topics – by Klein || The second installment in Klein's short texts on organic chemistry is similarly fantastic for gaining intuitive understanding. It goes into more depth on why certain reaction mechanisms happen as well as covering spectroscopy topics.

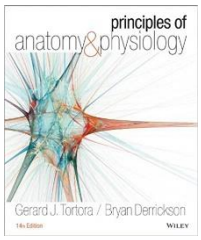


Organic Chemistry – by Klein || Klein's full-length textbook provides further detail on organic chemistry while still emphasizing skills and principles rather than memorization.



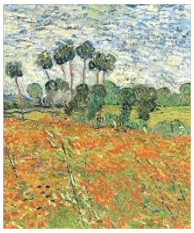
Physiology

Principles of Anatomy and Physiology – by Tortora and Derrickson || Very long book, but wonderfully illustrated, clearly explained, and highly informative. I really appreciate how this text discusses molecular biology and biochemistry in the context of human physiology. It includes a wealth of fascinating details on how physiology works from the molecular level on up to the whole body. I especially enjoyed the chapter on endocrinology. For those who are medically inclined, there is also a lot of detail on the anatomical terminology (but this can easily be skimmed if you are not planning on going into medicine). Finally, there are numerous boxes which discuss specific diseases and other clinical subjects of special interest.



Plant biology

Raven Biology of Plants – by Evert and Eichhorn || An authoritative text on plant biology. Though I never got into this book much, I have heard great reviews from others. It covers a wide range of topics in botany and offers clear explanations as well as very nice illustrations and photographs. It spends a lot of time reviewing content from other areas of biology, which can be good or bad depending on your level of background.

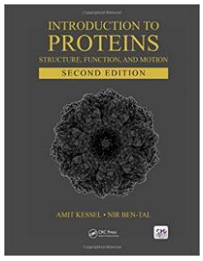


Upper intermediate:

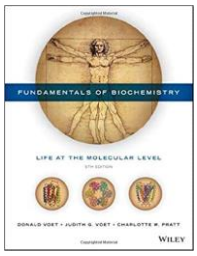
Books which cover more specialized topics in various subfields of biology or cover broader fields of biology in more depth. In contrast to the previous texts, these books tend to go into more detail and assume that the reader has more background. They are often employed in upper-level undergraduate elective courses. It should be noted that the degree of background required for my "lower intermediate" and "upper intermediate" categories is a matter of opinion. People may find certain texts more challenging or less challenging depending on their background and learning style. That said, I think that these categories can still serve as a rough guide for those seeking to expand their knowledge of the biological sciences.

Biochemistry

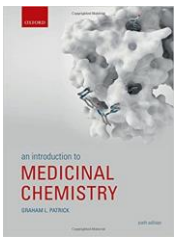
Introduction to Proteins: Structure, Function, and Motion – by Kessel and Ben-Tal || Discusses protein biochemistry and biophysics. This text does not go into great mathematical detail (it only includes relatively simple equations), but it does discuss the conceptual underpinnings of biophysical phenomena in a lot of detail. As an example, it contains some excellent biophysical explanations of why protein folding is such a challenging computational problem. The book also provides a wealth of information about how proteins operate in the larger cellular and physiological contexts. The illustrations are only moderately attractive, but still helpful from a practical perspective.



Biochemistry – by Voet and Voet || Though I have not personally used this book much, I have heard it is an excellent text from a number of sources, so I wanted to include it here. Voet's textbook is known for going into a lot of detail, so it should serve you well if you are looking for a comprehensive discussion of general biochemistry. It also has very good illustrations.



An Introduction to Medicinal Chemistry – by Patrick || Beautiful book on drug design, drug development, and how drugs interact with the body. This textbook is really great because it clearly explains the fundamental principles of medicinal chemistry in a highly generalizable fashion. Its writing and diagrams really help the reader to understand the "why" underlying pharmacology. The text is also quite concise, direct, and practical in its presentation.

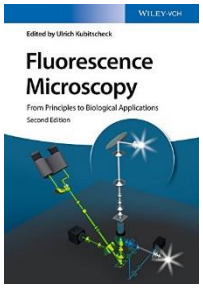


Developmental biology

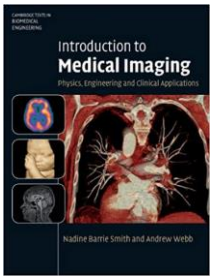
Developmental Biology – by Gilbert and Barresi || This book contains impressive details on the development of various organisms. It has beautiful diagrams and describes complicated signaling pathways in an engaging and meaningful manner. When I read Gilbert's text, I get excited about how the

process of organismal development follows a gorgeously complex extrapolation of fundamental chemical logic.

Imaging

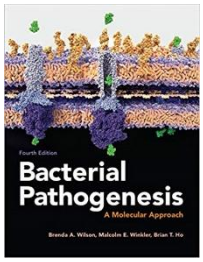


Fluorescence Microscopy: From Principles to Biological Applications – edited by Ulrich Kubitscheck || An excellent introduction to the engineering principles of fluorescence microscopy. This book provides background on optical physics, explains the physical mechanisms behind key types of modern fluorescence microscopy systems (e.g. confocal microscopy, light-sheet microscopy, etc.), and discusses how fluorescence itself works and is applied. While the text does not shy away from using the necessary mathematical tools to properly explain the subject, it is clear enough that even readers with relatively light backgrounds in physics should find it reasonably understandable.

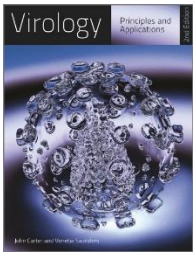


Introduction to Medical Imaging: Physics, Engineering and Clinical Applications – by Barrie Smith and Webb || Clear and well-organized introduction to the main modalities of medical imaging. This text explains physical principles behind the operation of technologies such as magnetic resonance imaging, x-ray computed tomography, ultrasound, and more. It also discusses some important concepts in computational image processing. While mathematics certainly plays a key role in this book, it is overall fairly light on quantitative aspects. Depending on your goals, this can be advantageous or a drawback. The illustrations are helpful from a practical perspective, though not especially lush.

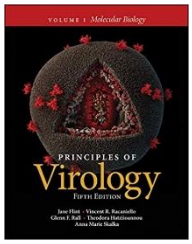
Microbiology



Bacterial Pathogenesis: A Molecular Approach – by Wilson, Winkler, Ho || Really nice book on the molecular mechanisms of bacterial pathogenesis. This book has a fair amount of detail on the subject but explains clearly. I own the 3rd edition rather than the more recent 4th edition, but I have had a chance to look through the 4th edition. It should be noted that the 4th edition has major updates including beautiful full-color illustrations which greatly enhance its explanatory power. The 3rd edition already had quite helpful diagrams, but the 4th edition appears to have taken this to a new level entirely.



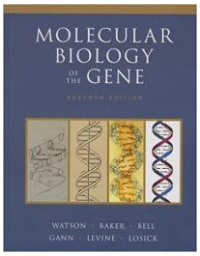
Virology: Principles and Applications – by Carter and Saunders || This virology text is less comprehensive than many other virology books, but it makes up for this in that it explains viruses in a highly concise and pragmatic manner. The sections on bacteriophages and HIV are especially strong. For the reader who seeks to gain clear and direct understanding of the key molecular mechanisms used by viruses, this text is excellent.



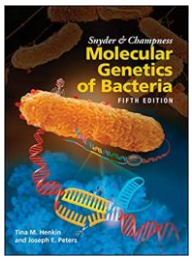
Principles of Virology – by Flint, Racaniello, Rall, Skalka, Enquist || This book comes in two volumes. The first emphasizes molecular biology of viruses and the second emphasizes the pathogenesis and control of viruses. The diagrams are quite consistent, beautiful, and helpful. The text explains clearly and covers a lot of valuable topics. As a result of its thoroughness, this

book may seem somewhat overwhelming, but it still is excellent as a reference and as a general source of virology knowledge.

Molecular biology and genetics

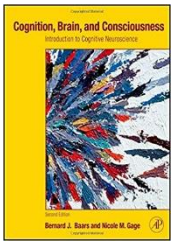


Molecular Biology of the Gene – by Watson, Baker, Bell, Gann, Levine, Losick || Classic text which discusses molecular genetics at a somewhat higher level than a typical introductory molecular biology book. Great illustrations and clear explanations aid the reader's understanding of the intricate molecular machines which tirelessly carry out the myriad of tasks necessary to run the genome and transcriptome. The book is fairly long, but if you already know some molecular biology, you can certainly jump around to learn more details about specific areas of interest.

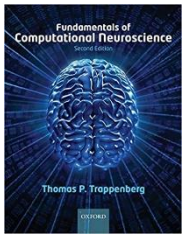


Molecular Genetics of Bacteria – by Snyder, Peters, Henkin, Champness || Similar to Watson's text (above), but specifically covering bacterial molecular genetics rather than molecular genetics in general. In the 4th edition, the illustrations convey strong understanding of molecular mechanisms, though they are not as sumptuous as the diagrams in some biology books. In the 5th edition, the illustrations are both sumptuous and convey strong understanding of molecular mechanisms. There is a lot of great material here which can be especially useful for biohackers (and other researchers) who want to use the bacterial cell as a chassis for synthetic biology.

Neuroscience



Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience – by Baars and Gage || Discusses cognitive neuroscience from both neuropsychological and neurophysiological perspectives. This text goes over a lot of psychological experiments for those who are interested in behavioral neuroscience, but also discusses mechanisms for those who want to focus more on the underlying ways that the brain operates. In my opinion, the largest drawback of this book is that it is weak on cellular neurophysiology.

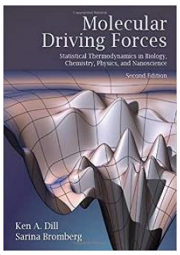


Fundamentals of Computational Neuroscience – by Trappenberg || An excellent introduction to computational neuroscience for someone coming into the area from a less quantitatively-focused background. You will still need to know calculus and maybe a small amount of differential equations, but the book is less mathematically intense than most other computational neuroscience texts. Furthermore, the book explains key ideas from areas of mathematics such as linear algebra and probability so that the reader does not necessarily have to already know these subjects. It is fairly concise yet still clearly explains a wide variety of topics from the field.

Physical chemistry

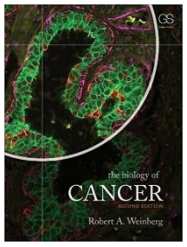
Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience – by Dill and Bromberg || This book features elegant explanations of how statistical thermodynamics and molecular physics apply to biology and nanotechnology. In my opinion, one of its strengths is its excellent organization. The text also features very

clean formatting which makes it a smoother read. Though this text is mathematics-focused, it reviews key concepts in probability and multivariable calculus for readers who have less quantitative backgrounds. There are some great chapters on foundational topics (e.g. entropy, the Boltzmann distribution, electrostatics, etc.) as well as numerous chapters on exciting applications such as polymer physics, biochemical machines and nanomachines, and cooperative binding.



Physiology

The Biology of Cancer – by Weinberg || This book provides an amazing introduction to the molecular biology, genetics, biochemistry, and treatment of cancer. Lots of great content on tumor pathogenesis from perspectives of cell signaling, DNA repair and recombination, tissue microenvironment, immunobiological aspects, virology, and more. The book features a wealth of breathtaking diagrams and histological photographs which are colorful, detailed, and highly informative. Though some of the book goes through a lot of basic molecular biology review, readers who feel comfortable with that material can easily skip to more advanced sections.

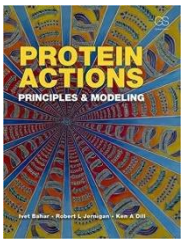


Advanced:

Books that cover specialized topics in depth and books that involve somewhat complicated mathematics are listed here. These texts typically assume that you have a fair amount of background. They are usually employed at the senior undergraduate level or at the graduate level (but please do not let this discourage you from trying them out regardless). Note that a few of these might be called monographs rather than textbooks. Because of the breadth of the biological sciences, there are many thousands of possible titles to include in this section, so please realize that these texts represent a small sampling.

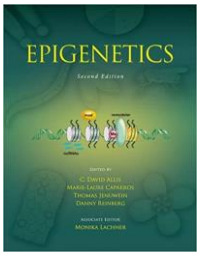
Biochemistry

Protein Actions: Principles and Modeling – by Bahar, Jernigan, Dill || Excellent text on the biophysics of proteins. This book goes through a lot of challenging content on physical chemistry and computational modeling, yet it is presented in a very understandable way. Full color illustrations, clearly organized equations, and elegant explanations contribute to its pedagogical strength.

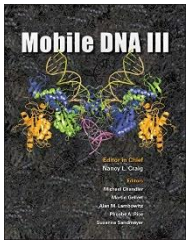


Genetics

Epigenetics – by Allis, Caparros, Jenuwein, Reinberg || Very detailed but also very rewarding, this book goes over epigenetics in a series of engaging chapters written by expert authors. Despite having different authors for different chapters, the book uses consistent illustrations throughout. The illustrations are also of high quality and are in full color, which helps to motivate the reader and aids understanding. This text covers the epigenetics of a series of model organisms as well as a myriad of key topics in mammalian epigenetic research.

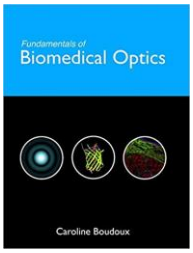


Mobile DNA III – edited by Craig, Chandler, Gellert, Lambowitz, Rice, Sandmeyer || Very long and highly technical, this monograph delves deep into research on topics such as transposons, recombination, and programmed DNA rearrangements. Despite its technical character, this book still includes a myriad of helpful (and colorful) diagrams and usually has good explanations. I especially enjoyed the chapter on integrons.



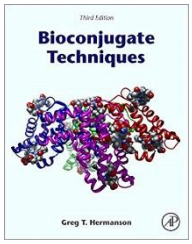
Imaging

Fundamentals of Biomedical Optics || A good text on microscopy and other forms of imaging as well as the underlying optical physics involved in the engineering of imaging systems. The book is well-organized, engagingly illustrated, detailed, and emphasizes generalizable principles. Many parts of this text can be a struggle for a reader without a strong physics background, but this makes sense given the subject matter and level of depth.

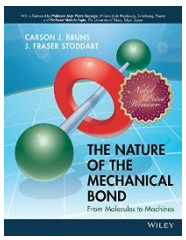


Nanotechnology

Bioconjugate Techniques – by Hermanson || A great reference text for those interested in nanobiotechnology, drug delivery, contrast agents, and other areas involving bioconjugates. This book is filled with beautiful diagrams which aid understanding. The explanations are a less concise than would be ideal, though they are still effective. The text also provides lots of clear laboratory protocols for interested researchers.

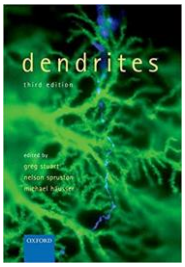


The Nature of the Mechanical Bond: From Molecules to Machines – by Bruns and Stoddart || Beautiful and comprehensive text on supramolecular chemistry, an area which is highly relevant to bioengineering disciplines. It focuses on the synthesis and dynamics of supramolecular structures which perform desired mechanical actions. The book is somewhat long due to its high level of detail and coverage, but it is gorgeously illustrated and well-written. There is a fair amount of historical content included throughout and the first chapter discusses some connections between supramolecular chemistry and art. I would recommend having a strong understanding of your chemical thermodynamics, chemical kinetics, organic chemistry, and perhaps even some organometallic chemistry when reading this book. While this kind of background knowledge is not absolutely necessary, it can certainly help to get more out of the text.



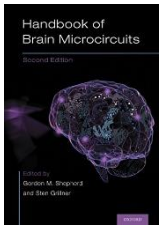
Neuroscience

Dendrites – edited by Stuart, Spruston, Häusser || Beautiful text which goes through the biology of dendrites in a series of engaging chapters by expert authors. Exceptionally well-made diagrams (with full color also) help the reader to understand concepts and useful tables facilitate referencing of detailed information. One drawback of the book is that it is lacking in concision, though this is partly due to the need to discuss ambiguity in content at the frontiers of dendrite research.

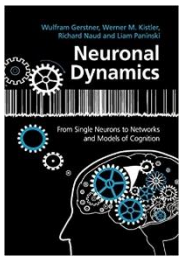


Handbook of Brain Microcircuits – edited by Shepherd and Grillner || This book provides a series of short reviews on the mechanistic workings of neuronal microcircuits in both vertebrate and invertebrate systems. Though brief, each chapter packs in a lot of

interesting information. As with many of the texts I have chosen for this list, the text features many full color diagrams to aid the reader. If you want to see a myriad of examples of the precise mechanisms which produce cognition and behavior, this book is excellent. Of course, the book is far from comprehensive; there are many papers which examine other neural circuits and there remains a vast universe of neural circuits still waiting to be uncovered.



Neuronal Dynamics: From single neurons to networks and models of cognition – by Gerstner, Kistler, Naud, Paninski || An elegantly-written computational neuroscience book which has been made freely available by the authors online. Lots of mathematical modeling is discussed in this text, but it explains the mathematics clearly and does not muddle understanding through unnecessary digressions. Note that this book focuses much more on the mathematical models than on actual coding (depending on your goals, you may find this beneficial or detrimental). This textbook is great for facilitating deeper understanding of computational neuroscience.



Fundamentals of Brain Network Analysis – by Fornito, Zalesky, Bullmore || An excellent text on using graph theory in neuroscience. It is beautifully illustrated, well-organized, and clearly explained. The mathematical tools of graph theory and complex networks are made accessible to those coming from a biological background. My only complaint about this book is that it is somewhat lacking in conciseness. My personal view is that it would have been possible to explain the subject more concisely without losing out on the depth and other beneficial qualities. Nonetheless, the book can be very rewarding (and enjoyable).