Bionanotechnology

Connecting theory with real-life applications, this is the first ever textbook to equip students with a comprehensive knowledge of all the key concepts in bionanotechnology. By bridging the interdisciplinary gap from which bionanotechnology emerged, it provides a systematic introduction to the subject, accessible to students from a wide variety of backgrounds. Topics range from nanomaterial preparation, properties and biofunctionalisation, and analytical methods used in bionanotechnology, to bioinspired and DNA nanotechnology, and applications in biosensing, medicine and tissue engineering. Throughout the book, features such as ‘Back to Basics’ and ‘Research Report’ boxes enable students to build a strong theoretical knowledge and to link this to practical applications and up-to-date research. With over 200 detailed, full-colour illustrations and more than 100 end-of-chapter problems, this is an essential guide to bionanotechnology for any student or researcher exploring this exciting, fast-developing and interdisciplinary field.

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Bionanotechnology
Concepts and Applications

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Preface

Bionanotechnology is a field at the intersection of nanotechnology and biology. It employs nanomaterials and biomolecules (and increasingly also whole organisms) to design new functional materials and devices. At the same time, it also learns from biological systems and turns what evolution has perfected over the past millennia into solutions we can apply to resolve some of the challenges we are facing now.

In simple terms, bionanotechnology is a bit of everything: there is lots of chemistry (synthesis and modification of nanomaterials), physics (rules of the nanoworld and principles of analytical methods), biology (all those proteins and microorganisms), medicine (drug delivery, diagnostics) and engineering (device and material design). However, bionanotechnology is not just a mix-and-match collection of concepts, but it has, over the past decades, continuously grown into a field with a clear identity and goals.

This textbook aims to combine the concepts and bridge the gaps between different disciplines from which bionanotechnology emerged, and give a more systematic view of the basics and application across the field. Knowing that there will be students and researchers from a wide range of disciplines reading the book, we often give broad description of a particular principle, and provide literature sources for those who want to learn more. The book begins with the an overview of basic physics and chemistry behind nanomaterial engineering, then moves onto the composition of the cell and scales of biomolecules, and continues with chapters on topics such as DNA nanotechnology, nanomaterial biofunctionalisation, bioinspired nanotechnology and nanomedicine. Throughout the book, we summarise basic concepts from different scientific fields in the form of Back to Basics boxes and highlight the latest scientific developments in
Research Reports. Important terms are highlighted in bold throughout and certain Key Concepts are gathered at the end of each chapter as a revision aid before the Problem sections. We hope that our book will be used as a reference book not only by lecturers and undergraduate students, but also postgraduates and researchers working in the field and trying to refresh their knowledge or learn basic concepts to help them in their projects. We wanted to make sure that concepts are clearly presented, and of huge help was our collaboration with an engineer and talented graphic designer Dr Nan Li from the University of Cambridge. She helped design many of the figures and provided valuable input that eased our creative process.

In the past decades, interdisciplinarity has been embraced as a more natural way to enable technological and scientific advances in various research fields. Students, however, still start by studying traditional scientific disciplines and move into more interdisciplinary areas in their final undergraduate year and postgraduate research. While working in German and UK universities, we have witnessed an increased number of undergraduates and graduates venturing into the fields only remotely related to their first degree. The bionanotechnology and chemical product design classes in Cambridge are often attended by engineers working on their biomedical devices and trying to learn some chemistry and biology, and biologists working with nanoparticles but struggling to understand how to modify the surface to prevent their aggregation. That means that a good part of the lecture is spent introducing basic terminology and concepts before moving onto the developments in bionanotechnology and recent applications and challenges. Students with physics and engineering background often struggle with the basic bionano principles, since they have not been taught organic synthesis, protein structure or genetics. The other way around, those with a background in medicine or chemistry might be challenged by instrumental design or physics behind the nanophenomena. Students are also often encouraged to consult a particular chapter written by a group of experts in an edited collection, which can be too advanced for their background or simply too difficult for them to grasp. We believe that one of the ways to resolve these challenges is to provide them with a textbook that would ease their journey through various disciplines, and combine the basic concepts with the most recent applications in the fields of drug design, biomimetics, biosensing, optoelectronics, just to name a few.

We hope that Bionanotechnology will manage to bridge some gaps between the basic scientific concepts and advanced applications, and inspire a new generation of researchers to embrace interdisciplinarity as the natural way of finding the most sustainable innovative solutions to ongoing challenges.