Scanning Electron Microscopy Physics Of Image Formation And Microanalysis Springer Series In Optical Sciences

Derived from the successful three-volume Handbook of Microscopy, this book provides a broad survey of the physical fundamentals and principles of all modern techniques of electron microscopy. This reference work on the method most often used for the characterization of surfaces offers a competent comparison of the feasibilities of the latest developments in this field of research. Topics include: * Stationary Beam Methods: Transmission Electron Microscopy/ Electron Energy Loss Spectroscopy/ Convergent Electron Beam Diffraction/ Low Energy Electron Microscopy/ Electron Holographic Methods * Scanning Beam Methods: Scanning Transmission Electron Microscopy/ Scanning Auger and XPS Microscopy/ Scanning Microanalysis/ Imaging Secondary Ion Mass Spectrometry * Magnetic Microscopy: Scanning Electron Microscopy with Polarization Analysis/ Spin Polarized Low Energy Electron Microscopy Materials scientists as well as any surface scientist will find this book an invaluable source of information for the principles of electron microscopy.

This book contains proposals to redesign the scanning electron microscope, so that it is more compatible with other charged particle beam instrumentation and analytical techniques commonly used in surface science research. It emphasizes the concepts underlying spectrometer designs in the scanning electron microscope, and spectrometers are discussed under one common framework so that their relative strengths and weaknesses can be more readily appreciated. This is done, for the most part, through simulations and derivations carried out by the author himself.The book is aimed at scientists, engineers and graduate students whose research area or study in some way involves the scanning electron microscope and/or charged particle spectrometers. It can be used both as an introduction to these subjects and as a guide to more advanced topics about scanning electron microscope redesign.

Scanning transmission electron microscopy has become a mainstream technique for imaging and analysis at atomic resolution and sensitivity, and the authors of this book are widely credited with bringing the field to its present popularity. Scanning Transmission Electron Microscopy(STEM): Imaging and Analysis will provide a comprehensive explanation of the theory and practice of STEM from introductory to advanced levels, covering the instrument, image formation and scattering theory, and definition and measurement of resolution for both imaging and analysis. The authors will present examples of the use of combined imaging and spectroscopy for solving materials problems in a variety of fields, including condensed matter physics, materials science, catalysis, biology, and nanoscience. Therefore this will be a comprehensive reference for those working in applied fields wishing to use the technique, for graduate students learning microscopy for the first time, and for specialists in other fields of microscopy.

The Beginnings of Electron Microscopy - Part 1, Volume 220 in the Advances in Imaging and Electron Physics series highlights new advances in the field, with this new volume presenting interesting chapters on Electron-optical Research at the AEG Forschungs-Institut 1928-1940, On the History of Scanning Electron Microscopy, of the Electron Microprobe, and of Early Contributions to Transmission Electron Microscopy, Random Recollections of the Early Days, Early History of Electron Microscopy in Czechoslovakia, Personal Reminiscences of Early Days in Electron, Megavolt Electron Microscopy, Cryo-Electron Microscopy and Ultramicrotomy: Reminiscences and Reflections, and much more. Provides the authority and expertise of leading contributors from an international board of authors Presents the latest release in "Advances in Imaging and Electron Physics" series

This volume expands and updates the coverage in the authors' popular 1992 book, Electron Microdiffraction. As the title implies, the focus of the book has changed from electron microdiffraction and convergent beam electron diffraction to all forms of advanced transmission electron microscopy. Special attention is given to electron diffraction and imaging, including high-resolution TEM and STEM imaging, and the application of these methods to crystals, their defects, and nanostructures. The authoritative text summarizes and develops most of the useful knowledge which has been gained over the years from the study of the multiple electron scattering problem, the recent development of aberration correctors and their applications to materials structure characterization, as well as the authors' extensive teaching experience in these areas. Advanced Transmission Electron Microscopy: Imaging and Diffraction in Nanoscience is ideal for use as an advanced undergraduate or graduate level text in support of course materials in Materials Science, Physics or Chemistry departments.
Scanning Electron MicroscopyPhysics of Image Formation and MicroanalysisSpringer
As a complement to The Beginnings of Electron Microscopy, Advances in Imaging and Electron Physics is pleased to present Volume 96, The Growth of Electron Microscopy. This comprehensive collection of articles surveys the accomplishments of

various national groups that comprise the International Federation of Societies of Electron Microscopy (IFSEM).

Scanning and stationary-beam electron microscopes are indispensable tools for both research and routine evaluation in materials science, the semiconductor industry, nanotechnology and the biological, forensic, and medical sciences. This book introduces current theory and practice of electron microscopy, primarily for undergraduates who need to understand how the principles of physics apply in an area of technology that has contributed greatly to our understanding of life processes and "inner space." Physical Principles of Electron Microscopy will appeal to technologists who use electron microscopes and to graduate students, university teachers and researchers who need a concise reference on the basic principles of microscopy.

Adopting a didactical approach from fundamentals to actual experiments and applications, this handbook and ready reference covers real-time observations using modern scanning electron microscopy and transmission electron microscopy, while also providing information on the required stages and samples. The text begins with introductory material and the basics, before describing advancements and applications in dynamic transmission electron microscopy and reflection electron microscopy. Subsequently, the techniques needed to determine growth processes, chemical reactions and oxidation, irradiation effects, mechanical, magnetic, and ferroelectric properties as well as cathodoluminiscence and electromigration are discussed.

An up-to-date edition of the indispensable guide to electron microscopy and analysis.

The go?to resource for microscopists on biological applications of field emission gun scanning electron microscopy (FEGSEM) The evolution of scanning electron microscopy technologies and capability over the past few years has revolutionized the biological imaging capabilities of the microscope—giving it the capability to examine surface structures of cellular membranes to reveal the organization of individual proteins across a membrane bilayer and the arrangement of cell cytoskeleton at a nm scale. Most notable are their improvements for field emission scanning electron microscopy (FEGSEM), which when combined with cryo-preparation techniques, has provided insight into a wide range of biological questions including the functionality of bacteria and viruses. This full-colour, must-have book for microscopists traces the development of the biological field emission scanning electron microscopy (FEGSEM) and highlights its current value in biological research as well as its future worth. Biological Field Emission Scanning Electron Microscopy highlights the present capability of the technique and informs the wider biological science community of its application in basic biological research. Starting with the theory and history of FEGSEM, the book offers chapters covering: operation (strengths and weakness, sample selection, handling, limitations, and preparation); Commercial developments and principals from the major FEGSEM manufacturers (Thermo Scientific, JEOL, HITACHI, ZEISS, Tescan); technical developments essential to bioFEGSEM; cryobio FEGSEM; cryo-FIB; FEGSEM digital-tomography; array tomography; public health research; mammalian cells and tissues; digital challenges (image collection, storage, and automated data analysis); and more. Examines the creation of the biological field emission gun scanning electron microscopy (FEGSEM) and discusses its benefits to the biological research community and future value Provides insight into the design and development philosophy behind current instrument manufacturers Covers sample handling, applications, and key supporting techniques Focuses on the biological applications of field emission gun scanning electron microscopy (FEGSEM), covering both plant and animal research Presented in full colour An important part of the Wiley-Royal Microscopical Series, Biological Field Emission Scanning Electron Microscopy is an ideal general resource for experienced academic and industrial users of

electron microscopy—specifically, those with a need to understand the application, limitations, and strengths of FEGSEM.
Originally published in 2005, this book covers the closely related techniques of electron microprobe analysis (EMPA) and scanning electron microscopy (SEM) specifically from a geological viewpoint. Topics discussed include: principles of electron-target interactions, electron beam instrumentation, X-ray spectrometry, general principles of SEM image formation, production of X-ray 'maps' showing elemental distributions, procedures for qualitative and quantitative X-ray analysis (both energy-dispersive and wavelength-dispersive), the use of both 'true' electron microprobes and SEMs fitted with X-ray spectrometers, and practical matters such as sample preparation and treatment of results. Throughout, there is an emphasis on geological aspects not mentioned in similar books aimed at a more general readership. The book avoids unnecessary technical detail in order to be easily accessible, and forms a comprehensive text on EMPA and SEM for geological postgraduate and postdoctoral researchers, as well as those working in industrial laboratories.
Part of the Wiley-Royal Microscopical Society Series, this book discusses the rapidly developing cutting-edge field of low-voltage microscopy, a field that has only recently emerged due to the rapid

developments in the electron optics design and image processing. It serves as a guide for current and new microscopists and materials scientists who are active in the field of nanotechnology, and presents applications in nanotechnology and research of surface-related phenomena, allowing researches to observe materials as never before. Of the many techniques that have been applied to the study of crystal defects, none has contributed more to our understanding of their nature and influence on the physical and chemical properties of crystalline materials than transmission electron microscopy (TEM). TEM is now used extensively by an increasing number of earth scientists for direct observation of defect microstructures in minerals and rocks. Transmission Electron Microscopy of Rocks and Minerals is an introduction to the principles of the technique and is the only book to date on the subject written specifically for geologists and mineralogists. The first part of the book deals with the essential physics of the transmission electron microscope and presents the basic theoretical background required for the interpretation of images and electron diffraction patterns. The final chapters are concerned with specific applications of TEM in mineralogy and deal with such topics as planar defects, intergrowths, radiation-induced defects, dislocations and deformation-induced microstructures. The examples cover a wide range of rock-forming minerals from crustal rocks to those in the lower mantle, and also take into account the role of defects in important mineralogical and geological processes.

The Beginnings of Electron Microscopy presents the technical development of electron microscope. This book examines the mechanical as well as the technical problems arising from the physical properties of the electron. Organized into 19 chapters, this book begins with an overview of the history of scanning electron microscopy and electron beam microanalysis. This text then explains the applications and capabilities of electron microscopes during the war. Other chapters consider the classical techniques of light microscopy. This book presents as well the schematic outline of the preparation techniques for investigation of nerve cells by electron microscopy. The final chapter deals with the historical account of the beginnings of electron microscopy in Russia. This book is a valuable resource for scientists, technologists, physicists, electrical engineers, designers, and technicians. Graduate students as well as researcher workers who are interested in the history of electron microscopy will also find this book extremely useful.

The book focuses on advanced characterization methods for thin-film solar cells that have proven their relevance both for academic and corporate photovoltaic research and development. After an introduction to thin-film photovoltaics, highly experienced experts report on device and materials characterization methods such as electroluminescence analysis, capacitance spectroscopy, and various microscopy methods. In the final part of the book simulation techniques are presented which are used for ab-initio calculations of relevant semiconductors and for device simulations in 1D, 2D and 3D. Building on a proven concept, this new edition also covers thermography, transient optoelectronic methods, and absorption and photocurrent spectroscopy.

This book describes how to see atoms using electron microscopes. This new edition includes updated sections on applications and new uses of atomic-resolution transmission electron microscopy. Several new chapters and sources of software for image interpretation and electron-optical design have also been added.

The aim of this book is to outline the physics of image formation, electron specimen interactions and image interpretation in transmission electron mic roscopy. The book evolved from lectures delivered at the University of Munster and is a revised version of the first part of my earlier book Elek tronenmikroskopische Untersuchungs- und Priiparationsmethoden, omitting the part which describes specimen-preparation methods. In the introductory chapter, the different types of electron microscope are compared, the various electron-specimen interactions and their applications are summarized and the most important aspects of high-resolution, analytical and high-voltage electron microscopy are discussed. The optics of electron lenses is discussed in Chapter 2 in order to bring out electron-lens properties that are important for an understanding of the function of an electron microscope. In Chapter 3, the wave optics of elec trons and the phase shifts by electrostatic and magnetic fields are introduced; Fresnel electron diffraction is treated using Huygens' principle. The recogni tion that the Fraunhofer-diffraction pattern is the Fourier transform of the wave amplitude behind a specimen is important because the influence of the imaging process on the contrast transfer of spatial frequencies can be described by introducing phase shifts and envelopes in the Fourier plane. In Chapter 4, the elements of an electron-optical column are described: the electron gun, the condenser and the imaging system. A thorough understanding of electron-specimen interactions is essential to explain image contrast.

Advances in Imaging and Electron Physics, Volume 215, merges two long-running serials, Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. The series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science, digital image processing, electromagnetic wave propagation, electron microscopy and the computing methods used in all these domains. Contains contributions from leading authorities on the subject matter Informs and updates on the latest developments in the field of imaging and electron physics Provides practitioners interested in microscopy, optics, image processing, mathematical morphology, electromagnetic fields, electrons and ion emission with a valuable resource Features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing

This book features reviews by leading experts on the methods and applications of modern forms of microscopy. The recent awards of Nobel Prizes awarded for super-resolution optical microscopy and cryo-electron microscopy have demonstrated the rich scientific opportunities for research in novel microscopies. Earlier Nobel Prizes for electron microscopy (the instrument itself and applications to biology), scanning probe microscopy and holography are a reminder of the central role of microscopy in modern science, from the study of nanostructures in materials science, physics and chemistry to structural biology. Separate chapters are devoted to confocal, fluorescent and related novel optical microscopies, coherent diffractive imaging, scanning probe microscopy, transmission electron microscopy in all its modes from aberration corrected and analytical to in-situ and time-resolved, low energy electron microscopy, photoelectron microscopy, cryo-electron microscopy in biology, and also ion microscopy. In addition to serving as an essential reference for researchers and teachers in the fields such as materials science, condensed matter physics, solid-state chemistry, structural biology and the molecular sciences generally, the Springer Handbook of Microscopy is a unified, coherent and pedagogically attractive text for advanced students who need an authoritative yet accessible guide to the science and practice of microscopy.

Aberration-Corrected Imaging in Transmission Electron Microscopy provides an introduction to aberration-corrected atomic-resolution electron microscopy imaging in materials and physical sciences. It covers both the broad beam transmission mode (TEM; transmission electron microscopy) and the scanning transmission mode (STEM; scanning transmission electron microscopy). The book is structured in three parts. The first part introduces the basics of conventional atomic-resolution electron microscopy imaging in TEM and STEM modes. This part also describes limits of conventional electron microscopes and possible artefacts which are caused by the intrinsic lens aberrations that are unavoidable in such instruments. The second part introduces fundamental electron optical concepts and thus provides a brief introduction to electron optics. Based on the first and second parts of the book, the third part focuses on aberration correction; it describes the various aberrations in electron microscopy and introduces the concepts of spherical aberration correctors and advanced aberration correctors, including correctors for chromatic aberration. This part also provides guidelines on how to optimize the imaging conditions for atomic-resolution STEM and TEM imaging. This second edition has been completely revised and updated in order to incorporate the very recent technological and scientific achievements that have been realized since the first edition appeared in 2010.

The aim of this book is to outline the physics of image formation, electron specimen interactions, imaging modes, the interpretation of micrographs and the use of quantitative modes "in scanning electron microscopy (SEM). It forms a counterpart to Transmission Electron Microscopy (Vol. 36 of this Springer Series in Optical Sciences) . The book evolved from lectures delivered at the University of Münster and from a German text entitled Raster-Elektronenmikroskopie (Springer-Verlag), published in collaboration with my colleague Gerhard Pfefferkorn. In the introductory chapter, the principles of the SEM and of electron specimen interactions are described, the most important imaging modes and their associated contrast are summarized, and general aspects of eiemental analysis by x-ray and Auger electron emission are discussed. The electron gun and electron optics are discussed in Chap. 2 in order to show how an electron probe of small diameter can be formed, how the elec tron beam can be blanked at high frequencies for time-resolving exper iments and what problems have tobe taken into account when focusing.

The aim of this monograph is to outline the physics of image formation, electron–specimen interactions, and image interpretation in transmission el- tron microscopy. Since the last edition, transmission electron microscopy has undergone a rapid evolution. The introduction of monochromators and -proved energy ?lters has allowed electron energy-loss spectra with an energy resolution down to about 0.1 eV to be obtained, and aberration correctors are now available that push the point-to-point resolution limit down below 0.1 nm. After the untimely death of Ludwig Reimer, Dr. Koelsch from Springer- Verlag asked me if I would be willing to prepare a new edition of the book. As it had served me as a reference for more than 20 years, I agreed without hesitation. Distinct from more specialized books on speci?c topics and from books intended for classroom teaching, the Reimer book starts with the basic principles and gives a broad survey of the state-of-the-art methods, comp- mented by a list of references to allow the reader to ?nd further details in the literature. The main objective of this revised edition was therefore to include the new developments but leave the character of the book intact. The presentation of the material follows the format of the previous e- tion as outlined in the preface to that volume, which immediately follows. A few derivations have been modi?ed to correspond more closely to modern textbooks on quantum mechanics, scattering theory, or solid state physics.

This book brings a broad review of recent global developments in theory, instrumentation, and practical applications of electron microscopy. It was created by 13 contributions from experts in different fields of electron microscopy and technology from over 20 research institutes worldwide.
This text is a companion volume to Transmission Electron Microscopy: A Textbook for Materials Science by Williams and Carter. The aim is to extend the discussion of certain topics that are either rapidly changing at this time or that would benefit from more detailed discussion than space allowed in the primary text. World-renowned researchers have contributed chapters in their area of expertise, and the editors have carefully prepared these chapters to provide a uniform tone and treatment for this exciting material. The book features an unparalleled collection of color figures showcasing the quality and variety of chemical data that can be obtained from today’s instruments, as well as key pitfalls to avoid. As with the previous TEM text, each chapter contains two sets of questions, one for self assessment and a second more suitable for homework assignments. Throughout the book, the style follows that of Williams & Carter even when the subject matter becomes challenging—the aim is always to make the topic understandable by first-year graduate students and others who are working in the field of Materials Science Topics covered

include sources, in-situ experiments, electron diffraction, Digital Micrograph, waves and holography, focal-series reconstruction and direct methods, STEM and tomography, energy-filtered TEM (EFTEM) imaging, and spectrum imaging. The range and depth of material makes this companion volume essential reading for the budding microscopist and a key reference for practicing researchers using these and related techniques. Electron Microscopy and Analysis 1997 celebrates the centenary anniversary of the discovery of the electron by J.J. Thomson in Cambridge and the fiftieth anniversary of this distinguished Institute group. The book includes papers on the early history of electron microscopy (from P. Hawkes), the development of the scanning electron microscope at Cambridge (from K. Smith), electron energy loss spectroscopy (from L.M. Brown), imaging methods (from J. Spence), and the future of electron microscopy (from C. Humphreys). Covering a wide range of applications of advanced techniques, it discusses electron imaging, electron energy-loss and x-ray analysis, and scanning probe and electron beam microscopies. This volume is a handy reference for professionals using microscopes in all areas of physics, materials science, metallurgy, and surface science to gain an overview of developments in our understanding of materials microstructure and of advances in microscope interrogation techniques.

This book has evolved by processes of selection and expansion from its predecessor, Practical Scanning Electron Microscopy (PSEM), published by Plenum Press in 1975. The interaction of the authors with students at the Short Course on Scanning Electron Microscopy and X-Ray Microanalysis held annually at Lehigh University has helped greatly in developing this textbook. The material has been chosen to provide a student with a general introduction to the techniques of scanning electron microscopy and x-ray microanalysis suitable for application in such fields as biology, geology, solid state physics, and materials science. Following the format of PSEM, this book gives the student a basic knowledge of (1) the user-controlled functions of the electron optics of the scanning electron microscope and electron microprobe, (2) the characteristics of electron-beam-sample inter actions, (3) image formation and interpretation, (4) x-ray spectrometry, and (5) quantitative x-ray microanalysis. Each of these topics has been updated and in most cases expanded over the material presented in PSEM in order to give the reader sufficient coverage to understand these topics and apply the information in the laboratory. Throughout the text, we have attempted to emphasize practical aspects of the techniques, describing those instru ment parameters which the microscopist can and must manipulate to obtain optimum information from the specimen.

Certain areas in particular have been expanded in response to their increasing importance in the SEM field. Thus energy-dispersive x-ray spectrometry, which has undergone a tremendous surge in growth, is treated in substantial detail.

Scanning Transmission Electron Microscopy: Advanced Characterization Methods for Materials Science Applications The information comprised in this book is focused on discussing the latest approaches in the recording of high-fidelity quantitative annular dark-field (ADF) data. It showcases the application of machine learning in electron microscopy and the latest advancements in image processing and data interpretation for materials notoriously difficult to analyze using scanning transmission electron microscopy (STEM). It also highlights strategies to record and interpret large electron diffraction datasets for the analysis of nanostructures. This book: Discusses existing approaches for experimental design in the recording of high-fidelity quantitative ADF data Presents the most common types of scintillator-photomultiplier ADF detectors, along with their strengths and weaknesses. Proposes strategies to minimize the introduction of errors from these detectors and avenues for dealing with residual errors Discusses the practice of reliable multiframe imaging, along with the benefits and new experimental opportunities it presents in electron dose or dose-rate management Focuses on supervised and unsupervised machine learning for electron microscopy Discusses open data formats, community-driven software, and data repositories Proposes methods to process information at both global and local scales, and discusses avenues to improve the storage, transfer, analysis, and interpretation of multidimensional datasets Provides the spectrum of possibilities to study materials at the resolution limit by means of new developments in instrumentation Recommends methods for quantitative structural characterization of sensitive nanomaterials using electron diffraction techniques and describes strategies to collect electron diffraction patterns for such materials This book helps academics, researchers, and industry professionals in materials science, chemistry, physics, and related fields to understand and apply computer-science–derived analysis methods to solve problems regarding data analysis and interpretation of materials properties.

1997 was the 'Year of the Electron' because it marked the centenary pf the celebrated discovery of the smallest of the fundamental particles that make up ordinary matter, and which has proved to have so many remarkable properties that, after light, it has become the most widley used of the particles in scientific and technogical applications. STEM is a discipline of importance to a growing number of microscopists. This book is essential reading for undergraduates, postgraduates and researchers requiring an

up-to-date and comprehensive introduction to this rapidly growing, state of the art technique.
This book was developed with the goal of providing an easily understood text for those users of the scanning electron microscope (SEM) who have little or no background in the area. The SEM is routinely used to study the surface structure and chemistry of a wide range of biological and synthetic materials at the micrometer to nanometer scale. Ease-of-use, typically facile sample preparation, and straightforward image interpretation, combined with high resolution, high depth of field, and the ability to undertake microchemical and crystallographic analysis, has made scanning electron microscopy one of the most powerful and versatile techniques for characterization today. Indeed, the SEM is a vital tool for the characterization of nanostructured materials and the development of nanotechnology. However, its wide use by professionals with diverse technical backgrounds—including life science, materials science, engineering, forensics, mineralogy, etc., and in various sectors of government, industry, and academia—emphasizes the need for an introductory text providing the basics of effective SEM imaging.A Beginners' Guide to Scanning Electron Microscopy explains instrumentation, operation, image interpretation and sample preparation in a wide ranging yet succinct and practical text, treating the essential theory of specimen-beam interaction and image formation in a manner that can be effortlessly comprehended by the novice SEM user. This book provides a concise and accessible introduction to the essentials of SEM includes a large number of illustrations specifically chosen to aid readers' understanding of key concepts highlights recent advances in instrumentation, imaging and sample preparation techniques offers examples drawn from a variety of applications that appeal to professionals from diverse backgrounds.

Scanning Electron Microscopy provides a description of the physics of electron-probe formation and of electron-specimen interactions. The different imaging and analytical modes using secondary and backscattered electrons, electron-beam-induced currents, X-ray and Auger electrons, electron channelling effects, and cathodoluminescence are discussed to evaluate specific contrasts and to obtain quantitative information.

Advances in Imaging and Electron Physics merges two long-running serials--Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. This series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing, electromagnetic wave propagation, electron microscopy, and the computing methods used in all these domains. This particular volume presents several timely articles on the scanning transmission electron microscope. Updated with contributions from leading international scholars and industry experts Discusses hot topic areas and presents current and future research trends Provides an invaluable reference and guide for physicists, engineers and mathematicians

Electron microscopy has revolutionized our understanding the extraordinary intellectual demands required of the mi of materials by completing the processing-structure-prop croscopist in order to do the job properly: crystallography, erties links down to atomistic levels. It now is even possible diffraction, image contrast, inelastic scattering events, and to tailor the microstructure (and meso structure) of materials spectroscopy. Remember, these used to be fields in them to achieve specific sets of properties; the extraordinary abili selves. Today, one has to understand the fundamentals ties of modem transmission electron microscopy-TEM of all of these areas before one can hope to tackle signifi instruments to provide almost all of the structural, phase, cant problems in materials science. TEM is a technique of and crystallographic data allow us to accomplish this feat. characterizing materials down to the atomic limits. It must Therefore, it is obvious that any curriculum in modem mate be used with care and attention, in many cases involving rials education must include suitable courses in electron mi teams of experts from different venues. The fundamentals croscopy. It is also essential that suitable texts be available are, of course, based in physics, so aspiring materials sci for the preparation of the students and researchers who must entists would be well advised to have prior exposure to, for carry out electron microscopy properly and quantitatively.

In the continuing quest to explore structure and to relate struc tural organization to functional significance, the scientist has developed a vast array of microscopes. The scanning electron microscope (SEM) represents a recent and important advance in the development of useful tools for investigating the structural organization of matter. Recent progress in both technology and methodology has resulted in numerous biological publications in which the SEM has been utilized exclusively or in connection with other types of microscopes to reveal surface as well as intracellular details in plant and animal tissues and organs. Because of the resolution and depth of focus presented in the SEM photograph when compared, for example, with that in the light microscope photographs, images recorded with the SEM have widely circulated in newspapers, periodicals and scientific journals in recent times. Considering the utility and present status of scanning electron microscopy, it seemed to us to be a particularly appropriate time to assemble a text-atlas dealing with biological applications of scanning electron microscopy so that such information might be presented to the student and to others not yet familiar with its capabilities in teaching and research. The major goal of this book, therefore, has been to assemble material that would be useful to those students beginning their study of botany or zoo logy, as well as to beginning medical students and students in advanced biology courses.