

Most of the references listed here are in the **Biosciences library** in Lilly Hall of Life Sciences and several have been put on reserve (see list on page 7). Those marked with the '⇒' symbol are good places to start. The Library call numbers are given at the end of each reference (these should be the same for Biosciences or the VET, ENG, PHYS libraries). Unless otherwise specified, assume all citations are located in the Biosciences library. "TSB" and "LSMF" signify that T. S. Baker or the Life Science Microscopy Facility in Whistler Hall has a copy or copies that you may borrow temporarily if you can't find a copy in one of the Purdue libraries.

### ELECTRON MICROSCOPY AND OPTICS: GENERAL TEXTBOOKS

#### WHERE TO START:

- ⇒ **Introduction to Electron Microscopy.** S. Wischnitzer. 1st ed. **1962**, 2nd ed. **1970**, 3rd ed. **1981**. Excellent survey of the principles and practice of electron microscopy. (1962: 578.15 W753i; 1970: TSB; 1981: 502.825 W753i & TSB)
  - ⇒ **Practical Electron Microscopy for Biologists.** G. A. Meek. 1st ed. **1970**, 2nd ed. **1976**. Excellent general reference, more comprehensive than Wischnitzer. (1970: 578.15 M471p & TSB; 1976: 578.45 M471p & TSB)
  - ⇒ **Principles and Practice of Electron Microscope Operation.** A. W. Agar, R. H. Alderson and D. Chescoe. In Practical Methods in Electron Microscopy, Vol. 2, **1976**, A. M. Glauert (ed.). Excellent coverage of most aspects of the operation of a TEM. (502.8 P881 & TSB)
- Electron Microscopy: Principles and Techniques for Biologists.** J. J. Bozzola and L. D. Russel. **1992, 1999**. Comprehensive and well-illustrated text of biological TEM and SEM and specimen preparation (mostly histological samples). (578.45 B719e & TSB)
- Light and Electron Microscopy.** E. M. Slayter and H. S. Slayter. **1992**. Basic text covering a wide range of topics including LM, TEM, STEM, SEM, STM, AFM, etc.. (578.4 SL19L & TSB)
- The Principles and Practice of Electron Microscopy.** I. M. Watt. 1st ed. **1985, 1989**, 2nd ed. **1997**. Basic text covering TEM and SEM. (1985: 502.825 W34p & TSB; 1989: VET only; 1997: TSB only)

#### OTHER GENERAL REFERENCES: (Chronological list)

- Introduction to Electron Microscopy.** C. E. Hall. 1st ed. **1953**, 2nd ed. **1966, 1983**. Classic reference on electron optical theory and design. (1953: 578.1 H14i; 1966: TSB; 1983: 502.82 H14i)
- Electron Microscopy of Cells and Tissues.** Vol. 1. Instrumentation and Techniques. F. S. Sjostrand. **1967**. Classic text on electron microscopy with emphasis on thin sectioning techniques. (578.15 Sj56e & TSB)
- The Electron Microscope in Biology.** A. V. Grimstone. **1968**. Short, basic introduction to EM. Easy reading. (578.15 G884e & TSB)
- Fundamentals of Optics and Modern Physics.** H. D. Young, **1968**. Introductory physics textbook that covers wave theory and physical and geometrical optics. (530 Yo85fu PHYS & TSB)
- Optical Methods in Biology.** E. M. Slayter. **1970**. General text covering a wide range of topics involving optical methods. (578.4 SL19o & TSB)
- The Beginnings of Electron Microscopy.** P. W. Hawkes (ed.). **1985**. From the series: *Advances in Electronics and Electron Physics*. Fascinating recollections of the beginnings of the discipline by the key participants. (621.38Ad9s. v.16; PHYS & ENG & LSMF)
- Using the Transmission Electron Microscope in the Biological Sciences.** R. L. Griffin. **1990**. Basic, introductory text of biological TEM. (578.45 G875u)

**OTHER TEM TEXTS / ANNUAL REVIEWS** (alphabetical list)

**Advanced Techniques in Biological Electron Microscopy.** J. K. Koehler (ed.). Invited review articles. Springer-Verlag, Berlin, Germany. (578.45 Ad95; 1973: TSB)

Vol	Date	Contents
1	1973	Embedding media - old and new; Freeze-etching and freeze-fracturing; EM autoradiography, SEM techniques in biology; Computer processing of electron micrographs; High voltage EM
2	1978	Ultrastructural localization of lectin receptors; Antibody labeling techniques; Cell surface labeling for the SEM; Low temperature biological SEM; Quantitative EM of nucleic acids; EM of specific proteins: 3D mapping of ribosomal proteins using antibody labels; EM and electron diffraction studies on hydrated membranes.
3	1986	3D reconstruction of nonperiodic macromolecular assemblies from electron micrographs; High resolution biological X-ray microanalysis of diffusible ions; Metal deposition by high-energy sputtering for high magnification electron microscopy; Computer programs for biological stereology; A guide to fracture label: cytochemical labeling of freeze-fractured cells; Preparation of colloidal gold probes and their use as markers in EM;

**Advances in Optical and Electron Microscopy.** R. Barer and V. E. Cosslett (eds.). Vol. 1-12 (1966-1991). Academic Press, London. (578.405 Ad95) Review articles.

**Analytical and Quantitative Methods in Microscopy.** G. A. Meek and H. Y. Elder (eds.). 1977. Cambridge Univ. Press, Cambridge. (578.4 An13) Reviews of quantitative methods.

**Arabidopsis: An Atlas of Morphology and Development.** J. Bowman (ed.). 1994. Springer-Verlag. (583.123 Ar105 1994 & LSMF) Comprehensive atlas of SEM, TEM, and LM images from Arabidopsis wild-type and mutant plants.

**Artifacts in Biological Electron Microscopy.** R. F. Crang and K. L. Klomparens (eds.). 1988. Contributed chapters on artifacts in: Sampling specimens for biological EM; Fixation for TEM; dehydration and epoxy embedding in TEM; Ultrathin sectioning; Staining procedures; Specimen preparation for SEM; Transmission and scanning-transmission EM operation; SEM operation; Photographic and interpretive artifacts; Cryo electron microscopy; Analysis in biological EM. Plenum Press, N.Y. (578.45 Ar78 & TSB)

**Biological Electron Microscopy: Theory, Techniques, and Troubleshooting.** M. J. Dykstra. 1992. Plenum Press, New York. Practical guide to techniques of specimen preparation for TEM and SEM. (578.45 D991b)

**Biomedical Electron Microscopy: Illustrated Methods and Interpretations.** A. B. Maunsbach and B. A. Afzelius. 1999. Academic Press, San Diego. Lots of beautiful illustrations, mostly of histological samples, and includes practical tips. (570.2825 M444b & VET & TSB)

**Biophysical Electron Microscopy: Basic Concepts and Modern Techniques.** P. W. Hawkes and U. Valdre (eds.). 1990. Several chapters by different authors covering a wide range of topics of interest to those doing TEM. (578.45 B524 & TSB)

**Colloidal Gold: Principles, Methods, and Application. Vol 1.** M. A. Hayat. 1989. (574.876042 c698 1989)

**Cryopreparation of Thin Biological Specimens for Electron Microscopy: Methods and Applications.** N. Roos and A. J. Morgan. 1990. Handbook with chapters on: Water, cells and EM; Freezing methods; Cryoultramicrotomy; Transfer of cryosections to the TEM for morphological examination and X-ray microanalysis; Imaging and analysis of frozen-hydrated specimens in the TEM: vitrified thin films and cryosections; Use of ultrathin cryosections in immunocytochemistry; Other low temperature methods; Safety considerations and concluding remarks. Oxford Univ. Press, Royal Microscopical Society. (578.6 R676c & TSB)

**Cryotechniques in Biological Electron Microscopy.** R. A. Steinbrecht and K. Zierold (eds.). 1987. Invited chapters on Physics of water; Physics of specimen cryopreparation; Electron beam damage to cryospecimens; Cryofixation without pretreatment at ambient pressure; cryoEM of vitrified specimens; Cryoultramicrotomy; Freeze-substitution and freeze-drying;

High pressure freezing; Freeze-etching of dispersions, emulsions and macromolecular solutions; High resolution metal replication of freeze-dried specimens; Immunogold labeling of cryosections and cryofractures; Cryoultramicrotomy for autoradiography and enzyme cytochemistry; SEM and X-ray microanalysis of frozen-hydrated bulk samples; Cryofixation of dynamic processes in cells and organelles; Cryofixation of diffusible elements in cells and tissues for electron probe microanalysis; Safety rules for cryopreparation. (578.45 C889)

**Electron Microscopy:** B. R. Jones. **1983.** 39 laboratory exercises in EM techniques. (TSB)

**Electron Microscopy in Biology: A Practical Approach.** R. Harris (ed.). **1991.** Invited chapters on a variety of specimen preparation techniques including fixation; Embedding and thin section preparation; Freeze-substitution and other low temperature embedding methods; Immunogold labeling; Autoradiography; Enzyme histochemistry; High resolution shadowing; Freeze-fracturing; Negative staining; TEM of vitrified macromolecular assemblies; Quantitative X-ray microanalysis; 3D EM of tissues and cells. (578.45 EL253 & TSB)

**Electron Microscopy in Molecular Biology: A Practical Approach.** J. Sommerville and U. Scheer (eds.). **1987.** Chapters on Preparation of nucleic acids for electron microscopy; Denaturation and hybridization of nucleic acids; Binding of protein to nucleic acids; Chromatin spreading; Visualizing active genes; Negative staining of protein molecules and filaments; Rotary metal shadowing for visualizing rod-shaped proteins; EM immunolabeling; Autoradiography of spread molecular complexes; Hybridization to chromatin and whole chromosome mounts. Oxford, England ; Washington, DC: IRL Press. (578.45 EL255; 1981: TSB)

**Electron Microscopy of Plant Cells.** J. L. Hall and C. Hawes (eds.). **1991.** Covers basic preparation, low temperature methods and immunocytochemistry with solutions to problems unique to plant tissue. (LSMF only)

**Electron Microscopy of Proteins.** Vols. 1-4, J. R. Harris (ed.); Vols. 5-6, J. R. Harris & R. W. Horne (eds.). Academic Press, London. (574.19245 EL25 & TSB)

Vol	Date	Contents
1	1981	Haemocyanins; Nuclear envelope and nuclear pore complex; Intermediate filaments; Protein synthesis in prokaryotes and eukaryotes; Glycoproteins; Coated vesicles; Cilia and flagella
2	1982	Multienzyme complexes; Nonenzymic proteins; Bacterial appendages; Plasma lipoproteins; Fibrous proteins of connective tissue; HREM of unstained, hydrated protein crystals; Specialized membranes
3	1982	Algal cell walls; Bacterial cell walls and membranes; Chromatin and chromosomal proteins; Extracellular haemoglobins/chlorocruorins of annelids; Amyloid; Tubulin & tubulin associated proteins
4	1983	Actin and thin filaments; Myosin molecules, thick filaments and the actin-myosin complex; Erythrocyte membrane proteins; Plasma membrane intercellular junctions
5	1986	Bacteriophage T7; Bacteriophage morphogenesis; Crystalline arrays of adenovirus and their components; Influenza virus; Filamentous plant viruses; Human hepatitis viruses; Reoviruses; Immunoelectron microscopy of extracts of virus-infected plants; Structure and assembly of herpesviruses
6	1987	Freeze fracture of integral membrane proteins; Plasma membrane and cell wall of yeast; Microvillar membrane hydrolases of small intestine; Bacterial surface layers; Photosynthetic membranes and membrane proteins; Phycobilisomes and thylakoids; Sarcoplasmic reticulum

**Histological Techniques for Electron Microscopy.** D. C. Pease. **1964.** Practical techniques in specimen preparation. (578.9P321h2 VET & LSMF)

**Hybridization Techniques for Electron Microscopy.** G. Morel (ed.). **1993.** In situ hybridization techniques for RNA and DNA including probe preparation and application. (LSMF only)

**Immuno-gold labeling in Cell Biology.** A. J. Verkleij and J. L. M. Leunissen (eds.). **1989.** This book is intended to serve as a bridge between cell biologists and electron microscopists. Chapters deal with preparation of probes, labeling methods for electron microscopy and application in molecular cell biology. (LSMF only)

**Immunogold-silver Staining: Principles, Methods and Applications.** M. A. Hayat (ed.). **1995.** Emphasizes methods for silver amplification of gold probes for immunocytochemistry.

(LSMF only)

**Methods in Plant Electron Microscopy and Cytochemistry.** W. V. Dashek, (ed.). **2000.** Humana Press, Inc. (580.2825 M566 2000 & LSMF). Source of information on current techniques applicable to higher plant tissue including ones for sample preparation and evaluation by electron microscopy and light microscopy (including fluorescence, confocal and dark-field).

**Methods of Preparation for Electron Microscopy: An Introduction for the Biomedical Sciences.** D. G. Robinson, U. Ehlers, R. Herken, B. Hermann, F. Mayer, and F.-W. Schurmann. **1987.** Chapters on: Introduction to EM; Methods for TEM; Methods for SEM; Evaluation of micrographs. Springer-Verlag, New York. (TSB only)

**Negative Staining.** M. A. Hayat and S. E. Miller. **1990.** Chapters on negative staining, virological methods, specific methods, and support films. (616.0194 H323n VET & TSB only)

**Positive Staining for Electron Microscopy.** M. A. Hayat. **1975.** Van Nostrand Reinhold Co., New York. Chapters on stains and staining. (578.64 H323p)

**Practical Electron Microscopy: A Beginner's Illustrated Guide.** E. E. Hunter. **1993.** Practical guide to techniques of specimen preparation (578.45 H916p)

**Practical Methods in Electron Microscopy.** A. M. Glauert (ed.). (502.8 P881 & TSB has Vols. 1(II),2,3(I & II),4,7,12; VET has Vol. 14)

Vol	Date	Title
1	1972	Part 1: Specimen Preparation in Materials Science Part 2: Electron and Optical Diffraction Techniques
2	1974	Principles and Practice of EM Operation
3	1974	Part 1: Fixation, Dehydration and Embedding Part 2: Ultramicrotomy
4	1975	Design of the Electron Microscope Laboratory
5	1977	Part 1: Staining Methods for Sectioned Material Part 2: X-Ray Microanalysis in the Electron Microscope
6	1977	Part 1: Autoradiography and Immunocytochemistry Part 2: Quantitative Methods in Biology
7	1978	Image Analysis, Enhancement and Interpretation
8	1980	Replica, Shadowing and Freeze-Etching Techniques
9	1981	Dynamic Experiments in the EM
10	1985	Low Temperature Methods in Biological EM
11	1985	Thin Foil Preparation
12	1987	Electron Diffraction: An Introduction for Biologists
13	1991	Sectioning and Cryosectioning for Electron Microscopy
14	1992	Cytochemical Staining Methods for Electron Microscopy
15	1994	Vacuum Methods in Electron Microscopy
16	1997	X-Ray Microanalysis for Biologists
17	1998	Biological Specimen Preparation for Transmission Electron Microscopy

**Principles and Techniques of Electron Microscopy: Biological Applications.** M. A. Hayat (ed.). 1st ed., Van Nostrand Reinhold Co., N.Y. (578.4 H323p & TSB has Vols.3,5,6,8)

Vol	Date	Contents
1	1970	Fixation, dehydration, embedding, sectioning, staining, support films. 2nd edition 1981.
2	1972	Freeze substitution, freeze drying and freeze etching, negative staining, shadow casting and replication, high resolution and shadowing, autoradiography. Not in library.
3	1973	The electron microscope, selectively stained molecules, high resolution dark-field EM, in-focus phase contrast EM, evaluation of subcellular fractions obtained by ultracentrifugation, stereological techniques for EM morphometry, critical point drying.
4	1974	Optical shadowing, relative mass determination in dark-field EM, correlative light and EM of single cultured cells, denaturation mapping of DNA, examination of polysome profiles from cardiac muscle, virus particle counting, ultramicroincineration of thin-sectioned tissue, preparatory methods for electron probe analysis.

5	1975	Quantitative mapping, photographic aspects of EM, environmental devices, optical diffractometry, analytical EM.
6	1976	High voltage EM, high resolution EM, contrast and image formation of biological specimens, analysis of biological structures with x-ray diffraction, tilting experiments in the EM, autoradiography of free specimens, cryo-ultramicrotomy, electron interference microscope.
7	1977	Specimen damage, freeze drying, image reconstruction using equidensite integration analysis, G-banding of chromosomes, autoradiographic localization of DNA, optical analysis and reconstruction of images, mirror EM, EM of banded mammalian chromosomes, neurobiological applications of equidensitometry.
8	1978	Specimen supports, preparation and analysis of serial sections, magnification calibration, contrast enhancement using two micrographs, interference phenomenon on OsO <sub>4</sub> fixed specimens, computer processing of micrographs.
9	1978	EM of atoms, EM of DNA, techniques to visualize genetic material, localization of acetylcholine receptors, EM of actin, EM of glycoproteins by high resolution metal replication, EM of thyroglobulin, electron optical measurement of surface charges.

**Principles and Techniques of Electron Microscopy: Biological Applications.** M. A. Hayat (ed.). 1989. 3rd ed., CRC Press, Inc., Boca Raton, Florida. Chapters on chemical fixation; rinsing, dehydration, and embedding; sectioning; positive staining; negative staining; support films; low-temperature methods. (578.4 H323p & VET & TSB)

**Principles and Techniques of Electron Microscopy: Biological Applications.** M. A. Hayat (ed.). 2000. 4th ed., CRC Press, Inc., Boca Raton, Florida. Update of 1989 edition with additional chapters on: immunocytochemistry; antigen retrieval; Applications of microwave irradiation to microscopy; Processing of plant tissues. (578.4 H323p)

**Principles of Analytical Electron Microscopy.** D. C. Joy, A. D. Romig Jr., and J. I. Goldstein (eds.). 1986. Plenum Press, N.Y. (502.825 P935)

**Rapid Freezing, Freeze Fracture, and Deep Etching.** N. J. Severs and D. Shotton (eds.). 1995. (578.45 R181 VET only)

**Royal Microscopy Society Handbooks:** Oxford University Press (LSMF only)

Vol	Date	Title, Author and Content
5	1985	X-ray microanalysis in Electron Microscopy for Biologists. A.J. Morgan
8	1986	Maintaining and Monitoring the Transmission Electron Microscope. S. K. Chapman. Short, concise text to prepare the reader to monitor and optimize microscope performance and understand routine maintenance procedures.
11	1987	An introduction to Immunocytochemistry: Current Techniques and Problems. J.M. Polak and S. Van Noorden. Introduces the reader to the use of labeled immune reagents to localize antigens <i>in situ</i> .
20	1990	The Operation of Transmission and Scanning Electron Microscopes D. Chescoe and P.J. Goodhew. 1990. Simplified treatment of the principles and operation of electron microscopes with advise on choosing appropriate kV, condenser lens settings, apertures, magnification, etc.
35	1997	Negative Staining and Cryoelectron Microscopy. J. Robin Harris. Methods for investigation of thinly spread specimens of biological particulates.

**Transmission Electron Microscopy: Methods of Application.** D. K. Racker. 1983. Practical guide to techniques of specimen preparation. (578.45 R115t)

**Transmission Electron Microscopy: Physics of Image Formation and Microanalysis.** L. Reimer. 1989. (502.825 R273t ENG only)

**PERIODICALS**

Technical aspects of transmission electron microscopy are mainly covered in the following journals:

<b>Journal</b>	<b>Call number (Library)</b>	<b>Vols. and Year(s)</b>
Electron Microscopy Reviews	578.4505 EL25 (BIO)	v.1-5; 1988-1992
Journal of Electron Microscopy	578.1505 J826 (BIO)	v.1-; 1953-
Journal of Electron Microscopy Technique (Continued as Microsc. & Res. Tech.)	578.4505 J8265 (BIO)	v.1-19; 1984-1991
Journal of Microscopy	578.06 R81 (BIO)	v.89-; 1969-
Journal of Structural Biology	610.5 J827 (BIO)	v.103-; 1990-
Micron (also Micron and Microscopia Acta)	578.4505 M583 (BIO)	v.10-; 1979-
Microscopy and Research Technique	578.4505 J8265 (BIO)	v.20-; 1992-
Optik	535.05 Op72 (PHYS)	v.10-; 1946-
Ultramicroscopy	578.405 U8 (BIO)	v.1-; 1975-

Journals containing a significant number of articles of biological interest pertaining to results obtained by electron microscopy (and image analysis) include:

Biophysical Journal	Journal of Structural Biology
Cell	Journal of Virology
Current Opinion in Structural Biology	Molecular Cell
EMBO Journal	Nature
Experimental Cell Research	Nature Structural Biology
FEBS Letters	Proceedings of the Nat'l Academy of Sciences USA
Journal of Bacteriology	Protoplasma
Journal of Cell Biology	Science
Journal of Cell Science	Seminars in Virology
Journal of General Microbiology	Structure
Journal of General Virology	Virology
Journal of Molecular Biology	

The above list is incomplete in the sense that virtually every discipline in biology has its own journal or journals that include a significant electron microscopy emphasis.

**BOOKS ON RESERVE IN BIOSCIENCES LIBRARY**

<b>AUTHOR(S)</b>	<b>TITLE</b>	<b>CALL #</b>	<b>YEAR</b>
Glauert, A. M.	Practical Methods in Electron Microscopy	Vol. 2	1974
		Vol. 3	1974
		Vol. 5	1977
		Vol. 6	1977
		Vol. 8	1980
		Vol. 13	1991
		Vol. 17	1998
Hawkes, P. W. & U. Valdre	Biophysical Electron Microscopy: Basic Concepts and Modern Techniques	578.45 B524	1990
Hayat, M. A.	Principles and Techniques of Electron Microscopy: Biological Applications, 1st ed.	Vol. 1	1970
		Vol. 3	1973
		Vol. 5	1975
		Vol. 8	1978
Hayat, M. A.	Principles and Techniques of Electron Microscopy: Biological Applications, 3rd ed.	578.4 H323p	1989
Hayat, M. A.	Principles and Techniques of Electron Microscopy: Biological Applications, 4th ed.	578.4 H323p	2000
Meek, G. A.	Practical Electron Microscopy for Biologists, 2nd ed.	578.45 M471p	1976
Watt, I. M.	The Principles and Practice of Electron Microscopy	502.825 W34p	1985
Wischnitzer, S.	Introduction to Electron Microscopy, 3rd ed.	502.825 W753i	1981





The SEM requires an electron optical system to produce an electron probe, a specimen stage to place the specimen, a secondary-electron detector to collect secondary electrons, an image display unit, and an operation system to perform various operations (Fig. 1). The electron optical system consists of an electron gun, a condenser lens and an objective lens to produce an electron probe, a scanning coil to scan the electron probe, and other components. The electron optical system (inside of the microscope column) and a space surrounding the specimen are kept at vacuum. There are essentially four important parts to an ordinary microscope: The source of light. The specimen. The lenses that makes the specimen seem bigger. The magnified image of the specimen that you see. In an electron microscope, these four things are slightly different. The light source is replaced by a beam of very fast moving electrons. The specimen usually has to be specially prepared and held inside a vacuum chamber from which the air has been pumped out (because electrons do not travel very far PDF | Electron optics was born in 1927, when Hans Busch showed that the elementary lens equation is applicable to electron image formation. Interest was | Find, read and cite all the research you need on ResearchGate. We draw attention to the highlights of electron optics and microscopy over the decades, with particular reference to aberration correction, and to some little known French contributions to the story of the scanning electron microscope and to Fourier optics. Discover the world's research. 17+ million members. We shall now describe some general methods based on the techniques of. Fourier transforms, relating to imaging of extended objects. These methods. This book looks at electron microscopy in a comprehensive way covering different types of microscope and operating mode. It is not a textbook but a student companion. The complex mathematics behind electron microscopy is avoided but explained in a simplified way. The students are referred to original ideas and related sources. They are advised to look at textbooks to broaden knowledge. Introduction. Historical Timelines.