The lecture notes provide a fairly complete introduction to the principles and practice of transmission electron microscopy, **BUT** they are **NOT** comprehensive. The following optional reading list is meant to guide you to other places to obtain additional and more detailed descriptions of appropriate topics. To maximize the value derived from this course, it is most helpful to supplement the lectures and lecture notes with some outside reading. Those references identified with the '•' symbol are recommended starting points. **Notes:** This list is far from complete: when possible, updates will be posted on the Web site (http://bilbo.bio.purdue.edu/~baker/). Check the Book List for full citations for textbooks like Watt, Wischnitzer, Meek, etc..

**INTRODUCTORY MATERIAL**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>•Meek</td>
<td>1976</td>
<td>Chap. 1-2, pp.1-59 (pp.1-65 in 1970 edition)</td>
</tr>
<tr>
<td>Agar</td>
<td>1974</td>
<td>Chap. 1, pp.1-37</td>
</tr>
<tr>
<td>Slayter</td>
<td>1970</td>
<td>Chap. 16, pp.341-350</td>
</tr>
<tr>
<td>Sjostrand</td>
<td>1967</td>
<td>Chap. 2-3, pp.15-128</td>
</tr>
<tr>
<td>Hall</td>
<td>1966</td>
<td>Chap. 1-2, pp.1-43</td>
</tr>
</tbody>
</table>

**HISTORY OF THE ELECTRON MICROSCOPE**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>•Meek</td>
<td>1976</td>
<td>Chap. 2, pp.55-59 (49-54 in 1970 edition)</td>
</tr>
<tr>
<td>Hall</td>
<td>1966</td>
<td>Chap. 1, pp.1-6</td>
</tr>
<tr>
<td>Burton, E. F. and W. H. Kohl</td>
<td>1942, 2nd ed. 1946.</td>
<td>Historical accounts of very early electron microscopy. (1942: 578.1 B95; 1946: 578.1 B95e2)</td>
</tr>
</tbody>
</table>

**GENERAL OVERVIEW OF THE MICROSCOPE**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slayter</td>
<td>1992</td>
<td>Chap. 1, pp.4-5</td>
</tr>
<tr>
<td>Agar</td>
<td>1974</td>
<td>Chap. 1, pp.8,14</td>
</tr>
<tr>
<td>Slayter</td>
<td>1970</td>
<td>Chap. 18, pp.377-379</td>
</tr>
<tr>
<td>Sjostrand</td>
<td>1967</td>
<td>Chap. 3, pp.63-66</td>
</tr>
<tr>
<td>Hall</td>
<td>1966</td>
<td>Chap. 7, pp.136-138</td>
</tr>
</tbody>
</table>

**ANALOGY BETWEEN ELECTRON AND LIGHT MICROSCOPY**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slayter</td>
<td>1992</td>
<td>Chap. 1, pp.4-5</td>
</tr>
<tr>
<td>Agar</td>
<td>1974</td>
<td>Chap. 1, p.8</td>
</tr>
<tr>
<td>Slayter</td>
<td>1970</td>
<td>Chap. 18, pp.377-379</td>
</tr>
</tbody>
</table>
PHOTONS/ELECTRONS: Diffraction/Interference/Coherence/Resolution
Slayter (1992) Chap. 2, pp.7-22; Chap. 4, pp.39-49; Chap. 9, pp.118-130
Watt (1985) Chap. 1, pp.6-10 (Chap. 1, pp.7-14 in 1997 edition)
Agar (1974) Chap. 1, pp.2-9; Chap. 3, pp.96-99
Sjostrand (1967) Chap. 2, pp.24-31; Chap. 4, pp.97-106,112-118

OPTICS (Lens Theory)
Slayter (1992) Chap. 2, pp.10-13; Chap. 6, pp.65-73; Appendix, pp.298-301
Agar (1974) Chap. 1, pp.4-9
Sjostrand (1967) Chap. 2, pp.15-24
Hall (1966) Chap. 1, pp.6-12; Chap. 3, pp.44-57

•HANDOUT: Oriel - Geometrical Optics - A very short course.

Most physics textbooks have a chapter on geometrical optics

ELECTRON BEAMS/OPTICS AND MAGNETIC AND ELECTROSTATIC LENSES
Slayter (1992) Chap. 6, pp.73-79
•Meek (1976) Chap. 2, pp.49-54; Chap. 4, pp.75-80; Chap. 6, pp.103-107 (45-49,66-71,93-97 in 1970 ed.)
Agar (1974) Chap. 3, pp.98-99; Chap. 8, pp.277
Slayter (1970) Chap. 3, pp.70-71; Chap. 16-17, pp.349-363
Sjostrand (1967) Chap. 2, pp.31-56
Hall (1966) Chap. 2, pp.26-43; Chap. 4-5, pp.58-117; Chap. 7, pp.154-157

TRANSMISSION ELECTRON MICROSCOPE INSTRUMENTATION

General References
Wischnitzer (1970) Chap. 4, pp.38-81,102-103; Appendix E, pp.220-222
•Meek (1976) Chap. 5, pp.97-99; Chap. 6-8, pp.111-191; Chap. 15, pp.354-355.
Meek (1970) Chap. 4, pp.87-88; Chap. 5-7, pp.101-176; Chap. 14, pp.372-373.
Agar (1974) Chap. 1-2, pp.9-82; Chap. 6, pp.168-169,177,186
Sjostrand (1967) Chap. 2-3, pp.56-92
Hall (1966) Chap. Chap. 1, pp.6-7; Chap. 6-7, pp. pp.118-166
TRANSMISSION ELECTRON MICROSCOPE INSTRUMENTATION (Cont’d)

A. Electron Gun
Sjostrand (1967) Chap. 3, pp.66-75

Field Emission Gun Technology

B. Condenser Lens
Agar (1974) Chap. 1, pp.21-26; Chap. 2, pp.46-50
Slayter (1970) Chap. 18, pp.388-391
Sjostrand (1967) Chap. 3, pp.75-78
Hall (1966) Chap. 7, pp.151-154

C. Lens Aberrations
Slayter (1992) Chap. 6, pp.79-87
Sjostrand (1967) Chap. 2, pp.56-62
Hall (1966) Chap. 6, pp.118-135
TRANSMISSION ELECTRON MICROSCOPE INSTRUMENTATION (Cont’d)

D. Objective Lens/Aperture and Specimen Stage

Slayter (1992) Chap. 14, pp.201-204
Agar (1974) Chap. 1, pp.26-28; Chap. 2, pp.50-67; Chap. 6, pp.168-169
Slayter (1970) Chap. 18, pp.391-394
Sjostrand (1967) Chap. 3, pp.78-80

E. Projector Lens

Slayter (1992) Chap. 14, p.204
Agar (1974) Chap. 2, pp.28-37,69
Sjostrand (1967) Chap. 3, pp.80-81
Hall (1966) Chap. 6-7, pp.132-135,163-166

F. Camera and Viewing System

Slayter (1992) Chap. 14, pp.204-206
Agar (1974) Chap. 2, pp.69-72; Chap. 6, p.177
Slayter (1970) Chap. 18, pp.396-397
Sjostrand (1967) Chap. 3, pp.82-83

G. Vacuum System

Watt (1997) Chap. 3, pp.76-78; Appendix 1, pp.379-400
Watt (1985) Chap. 2, pp.29-31; Appendix 1, pp.228-241
Agar (1974) Chap. 2, pp.73-77; Chap. 6, p.186

H. Electrical System

Agar (1974) Chap. 2, pp.78-82
CONTRAST AND IMAGE FORMATION

A. Depth of Field/Focus

Slayter (1992) Chap. 16, p.235
Slayter (1970) Chap. 18, pp.413-415
Sjostrand (1967) Chap. 4, pp.118-122
Hall (1966) Chap. 7, pp.142-145

B. Elastic/Inelastic Scattering

•Slayter (1992) Chap. 8, pp.102-109
Sjostrand (1967) Chap. 4, pp.93-97
Hall (1966) Chap. 8, pp.200-216

C. Phase/Amplitude Contrast/Contrast Transfer Theory

•Slayter (1992) Chap. 7, pp.88-94; Chap. 8, pp.95-102,109-117
Sjostrand (1967) Chap. 4, pp.106-110
Hall (1966) Chap. 9, pp.262-264


CONTRAST AND IMAGE FORMATION (Cont'd)

C. Phase/Amplitude Contrast/Contrast Transfer Theory (Cont'd)


MICROSCOPE DISTURBANCES AND ALIGNMENT

Agar (1974) Chap. 3, pp.98-99; Chap. 8, pp.277
Sjostrand (1967) Chap. 10-11, pp.311-361

OPERATION OF THE TRANSMISSION ELECTRON MICROSCOPE

General References
Slayter (1992) Chap. 16, pp.238-246
Agar (1974) Chap. 6, pp.166-190

A. Choice of Voltage
• Meek (1976) Chap. 11, p.228 (252-253 in 1970 edition)
Agar (1974) Chap. 6, pp.166-167

B. Choice of Apertures
Agar (1974) Chap. 6, pp.167-169

C. Specimen Stage
Agar (1974) Chap. 6, pp.169-171
Sjostrand (1967) Chap. 3, pp.81-82
OPERATION OF THE TRANSMISSION ELECTRON MICROSCOPE

D. Choice of Magnification


E. Focusing

- Watt  (1997) Chap. 3, pp.75-77; Chap. 5, pp.197-199
- Watt  (1985) Chap. 2, pp.29-30; Chap. 4, pp.169-172
- Sjostrand (1967) Chap. 4, pp.106-110

F. Magnification Calibration

- Slayter (1992) Chap. 16, pp.242-244
- Agar  (1974) Chap. 5, pp.159-165
- Sjostrand (1967) Chap. 12, pp.362-365


OPERATION OF THE TRANSMISSION ELECTRON MICROSCOPE (Continued)

G. Resolution Tests
Slayter (1992) Chap. 16, p.244
Agar (1974) Chap. 5, pp.142-150
Sjostrand (1967) Chap. 12, pp.366-369
Hall (1966) Chap. 10, pp.292-298

H. Image Intensifier/TV Display
Hall (1966) Chap. 9, pp.275-277

I. Microscope Maintenance
Sjostrand (1967) Chap. 3, pp.91-92

J. Photography
•Agar (1974) Chap. 7, pp.191-276 (This is a good, comprehensive description)
Slayter (1970) Chap. 18, pp.396-397; Chap. 21, pp.460-479
Sjostrand (1967) Chap. 5, pp.129-137
OTHER MODES OF TRANSMISSION ELECTRON MICROSCOPE OPERATION

A. Electron Diffraction

Slayter (1970) Chap. 18, pp.398-399
Hall (1966) Chap. 8, pp.223-229


B. Dark Field

Hall (1966) Chap. 9, pp.254-257

OTHER MODES OF TEM OPERATION (Continued)

C. High Resolution


D. Tilting and Stereo Microscopy

Watt (1997) Chap. 4, pp.175,178-179; Chap. 5, pp.238-244,250-255
Agar (1974) Chap. 6, pp.177-180


E. Electron Energy Loss Spectroscopy (EELS)

Agar (1974) Chap. 9, pp.316-319
Hall (1966) Chap. 8, pp.229-234


OTHER MODES OF TEM OPERATION (Continued)

E. Electron Energy Loss Spectroscopy (EELS) (Continued)


F. Energy Filtering

Watt (1997) Chap. 3, pp.80-83


G. Low Temperature

Agar (1974) Chap. 6, p.186


OTHER MODES OF TEM OPERATION  (Continued)

H. X-ray Microanalysis

Agar  (1974) Chap. 9, pp.313-316


Electron Probe Microanalysis in Biology (1978) (D. A. Erasmus, ed.). Contributed chapters on various aspects of X-ray microanalysis in electron microscopy. (578.4 EL252)


OTHER TYPES OF ELECTRON MICROSCOPES

A. High and Intermediate Voltage

Watt (1997) Chap. 3, pp.54-56,85-89; Chap. 6, p.266; Appendix 4, pp.443-444
Slayter (1992) Chap. 14, pp.210-211
Watt (1985) Chap. 2, pp.33-36; Chap. 4, pp.122; Appendix 4, pp.282-283
Agar (1974) Chap. 6, pp.186-187; Chap. 9, pp.301-313


B. Scanning Electron Microscopy (SEM)

Slayter (1992) Chap. 15, pp.212-221
Hall (1966) Chap. 7, pp.195-197


OTHER TYPES OF ELECTRON MICROSCOPES (Continued)

B. Scanning Electron Microscopy (SEM) (Continued)


C. Scanning Transmission Electron Microscopy (STEM)

Watt (1997) Chap. 3, pp.124-130; Chap. 6, p.274
Slayter (1992) Chap. 15, pp.221-227
Watt (1985) Chap. 2, pp.70-76; Chap. 4, pp.133-134
Agar (1974) Chap. 9, pp.320-326


D. Electrostatic Electron Microscope


E. Field Emission/Emission/Ion/Shadow/Reflection/Mirror EM

Slayter (1992) Chap. 18, pp.270-271
Watt (1985) Chap. 2, p. 73; Chap. 4, pp.183-187
Hall (1966) Chap. 7, pp.182-199


SPECIMEN PREPARATION TECHNIQUES

A. Specimen Support Grids for TEM

B. Specimen Support Films for TEM
Watt (1985) Chap. 3, p.84 (Chap. 4, p.139 in 1997 edition)
Slayer (1970) Chap. 18, pp.391-393; Chap. 19, pp.441-444
Sjostrand (1967) Chap. 9, pp.294-297
Hall (1966) Chap. 10, pp.283-288

SPECIMEN PREPARATION TECHNIQUES (Continued)

C. Thin-sectioning (Fixation/Dehydration/Embedding/Staining)

Watt (1997) Chap. 4, pp.144-156; Case study 10, p.364-365
Watt (1985) Chap. 3, pp.87-88; Chap. 4, pp.149-154; Chap. 5, pp.216-218
Sjostrand (1967) Chap. 6-7, pp.138-187; Chap. 9, pp.222-303
Hall (1966) Chap. 10, pp.337-346


D. Negative Staining

Watt (1997) Chap. 4, pp.153-156; Case study 3, pp.350-351
Watt (1985) Chap. 4, pp.165,167; Chap. 5, pp.200-201
Slayter (1970) Chap. 9, pp.303-308
Sjostrand (1967) Chap. 9, pp.303-308


SPECIMEN PREPARATION TECHNIQUES (Continued)

D. Negative Staining (Continued)


E. Metal Shadowing

Watt (1997) Chap. 4, pp.140-144; Chap. 5, pp.192-195; Appendix 2, pp.400-406

Watt (1985) Chap. 3, pp.84-87,91-95; Appendix 2, pp.241-247


Hall (1966) Chap. 10, pp.298-309


F. Unstained Specimens

To my knowledge, general textbooks have yet to include discussion about the preparation and microscopy of unstained specimens. Hence, to acquire any in-depth knowledge about preparation and imaging such specimens, it is important to read at least one or two of the articles listed below.

1. Unstained Specimens (Room Temperature)


SPECIMEN PREPARATION TECHNIQUES (Continued)

1. Unstained Specimens (Room Temperature) (Continued)


2. Unstained Specimens (Frozen-Hydrated)


SPECIMEN PREPARATION TECHNIQUES (Continued)

2. **Unstained Specimens (Frozen-Hydrated) (Continued)**


G. **Freeze Drying/Etching/Fracture**


Sjostrand (1967) Chap. 8, pp.188-221

Hall (1966) Chap. 10, pp.371-376


SPECMEN PREPARATION TECHNIQUES (Continued)

G. Freeze Drying/Etching/Fracture (Continued)


H. Electron Autoradiography

Sjostrand (1967) Chap. 17, pp.413-435
Hall (1966) Chap. 10, pp.337

Meek does not discuss autoradiography.

RADIATION EFFECTS

Agar (1974) Chap. 6, pp.181-186; Chap. 8, p.294
Hall (1966) Chap. 9, pp.267-275

Most general texts tend to ignore problems associated with radiation induced specimen damage. Consequently, you are encouraged to read AT LEAST ONE of the articles marked with the "•".

•Glaeser, R. M. (1971) Limitations to significant information in biological electron microscopy as a result of radiation damage. J. Ultrastruc. Res. 36:466-482.
RADIATION EFFECTS (Continued)


