



## **MICROSCOPY SOCIETY OF AMERICA**

**Affiliate Society of American Institute of Physics - Affiliate Society of AAAS**

MSA Association Management Office, 11130 Sunrise Valley Dr., Suite 350, Reston, VA 20191

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### **GENERAL INFORMATION**

The Microscopy Society of America (MSA)<sup>1</sup>, the world's largest professional association of microscopists, provides the only certification of technologists in biological transmission electron microscopy available in the Americas. The program was initiated in 1978 to establish standards of technical skills. In addition to insuring employers that certified technologists are technically proficient, certification can be important in determining job classification, salary level, and potential for advancement or promotion. Many consider certification to be a key benchmark in their professional development.

The program is administered by the [Certification Board](#) which is appointed by the Council of the Society. The Board develops regulations, formulates and evaluates examinations, and interprets policies.

Individuals with the requisite educational and/or occupational qualifications can attain certification by completing and passing both written and practical examinations. Two [examination cycles](#) are offered each year. Complete regulations and an application form appear on the following pages.

The initial period of certification is one year, the calendar year indicated on the certificate furnished to all successful candidates. Certification may be renewed on a 10- year cycle by payment of the appropriate fee (\$75 for MSA members, \$150 for non -members<sup>2</sup>). Certified Technologists who allow their certification to lapse for one year may have it reinstated by paying the appropriate fees; if certification lapses for two or more years, the technologist must submit a new application and take both written and practical examinations again.

Communication with the Society, about certification, should be addressed to:

Microscopy Society of America  
[Certification Board](#)  
11130 Sunrise Valley Rd., Suite 350  
Reston, VA 20191  
Phone: (800) 538-3672  
(703) 234-4115

<sup>1</sup>Before January 1, 1993, the Microscopy Society of America was the Electron Microscopy

Society of America (EMSA). "Electron" was dropped from the name to reflect the Society's broadened scope that has come to include all kinds of microscopy and microanalysis. Nevertheless, most of the membership and scientific program still is concerned primarily with electron microscopy.

<sup>2</sup>The Society reserves the right to modify these and other fees from time to time to reflect changes in service, dues, etc.

## **APPLICATION AND REQUIREMENTS**

An application for certification consists of:

1. A completed application form (included in this package).
2. An application fee of \$75.00 for MSA members<sup>3</sup> or \$150.00 for non-members.<sup>4</sup>
3. Transcripts and/or documentation of **ONE** of the following:

Two years (60 credits) college or equivalent education, including at least 4 semesters of science that include chemistry, physics, biology, and mathematics and two semesters transmission electron microscopy (TEM). The TEM course must include extensive hands-on experience in sample preparation and microscope operation

**OR**

One year (30 credits) college or equivalent education, including at least one semester of laboratory courses each in chemistry and physics **AND** one year of recent<sup>5</sup> full-time work experience doing biological TEM, as a volunteer, internship or paid employee.

**OR**

A high school diploma **AND** two years of recent<sup>5</sup> full-time work experience doing biological TEM

**OR**

Three years of recent<sup>5</sup> full-time work experience doing biological TEM

4. Letters of recommendation from two (2) experienced electron microscopists in supervisory positions having substantial records of research publication. At least one of them must be a member of MSA. The letters may either be enclosed with the application or sent separately, but the application will not be considered complete until the letters are received by the Society.

All application materials must be sent to the Association Management Office:

Microscopy Society of America

Certification Board

11130 Sunrise Valley Rd., Suite 350

Reston, VA 20191

Applicants are responsible for seeing that all requirements are sent in time and should check with the Office to make sure their applications are complete. Applications completed after the deadline date will automatically be considered for the next examination cycle.

Completed applications are evaluated by the Certification Board Chair to determine whether the applicant is qualified to take the examinations. Applicants not approved for examination will receive a written explanation and their certification application fee will be refunded (although MSA dues, if any, will not be refunded). Fees for applicants approved for

examination are not refundable.

<sup>3</sup>Application for membership in MSA is separate from application for certification. Candidates for certification may pay the lower member's fee by submitting an application for membership, along with one year's annual MSA dues, at the same time they submit the application and fee for certification.

<sup>4</sup>Payment can be by check (US funds, drawn on a US bank) payable to MSA, or by credit card (Visa or Master Card only). If paying by credit card, supply the complete credit card number and expiration date.

<sup>5</sup>"recent" is interpreted to mean within the five years prior to application.

### **EXAMINATIONS: GENERAL**

Candidates whose applications are approved must pass both a written and a practical examination in order to be certified. The candidate must pass the written exam before s/he may submit the materials for the practical exam. Both examinations usually are taken during the same cycle in which application was made; however, candidates may request deferring either or both examinations until the next cycle. Candidates who fail an examination in the cycle in which they applied may take it again in the next cycle without penalty.

All requirements for certification must be completed by the cycle after the one in which application is made. Otherwise the candidate must submit a new application, including the application fee and letters of recommendation (transcripts need not be re-submitted unless they have become outdated). Examinations taken prior to re-application must be taken again, even if previously passed.

### **Written Examination**

The written examination is of the objective type (multiple choice, true-false, etc.); three hours are allotted for completion of the written examination. In most cases the examination is conducted in or near the candidate's home institution. A score of 80% is required to pass. The material covered includes:

- A. Instrumentation including electron optics (approx. 25%)
- B. Tissue processing (fixations, resin chemistry etc.) (approx. 25%)
- C. Sectioning and staining (approx. 15%)
- D. Special techniques (Immuno, shadowing, cryo, etc.) and imaging (approx. 20%)
- E. General: chemistry, safety (approx. 15%)

## Written Examination Study Syllabus

### A. Instrumentation

Accessory Equipment: Principles, components, alignment and routine maintenance of:

- Ultramicrotomes,
- Knifemakers
- Light microscopes
- Transmission electron microscope fundamentals:
  - Operation; illumination; imaging systems; focusing; maintenance; test specimens; astigmatism; resolution, calibration, contamination
- Scanning electron microscopes: general principles; operation
- Vacuum systems:
  - Vacuum evaporator, sputter coaters, mechanical, diffusion, turbomolecular, ion pumps, vacuum gauges

Other Lab Equipment:

- Incubators
- Ovens
- Balances
- pH meters
- Osmometers
- Centrifuges
- Photographic techniques (digital and film)

### B. Sample/Tissue procurement for TEM processing

Fixation & Processing

- General principles and purpose
- Types, composition, & preparation [glutaraldehyde, paraformaldehyde, OsO<sub>4</sub>, KMnO<sub>4</sub> and others]
- Buffers [eg: phosphate, cacodylate, PIPES, HEPES, s-collidine, veronal- acetate];
- Factors affecting fixation [fixative concentration, time, temperature, pH, osmolarity, buffer, additives, penetration]
- Methods of fixation [immersion, perfusion, vapor]
- Criteria for good fixation
- Washing: general principles and purpose
- En bloc staining
- Dehydration: general principles and purpose
- Dehydrating agents [ethanol, acetone, ethylene glycol, propylene oxide, acetonitrile]
- Factors affecting dehydration [concentration, time, temperature]
- Infiltration: general principles and purpose
- Embedding: general principles and purpose
- Types, composition and preparation of plastics [acrylics, polyesters, epoxies, catalysts, hardeners, plasticizers]
- Methods of embedding [capsules, flat, cell culture, vacuum]
- Polymerization: general principles and purpose
- Safety

### **C. Sectioning and Staining**

Sectioning: general principles and purpose

- Block Preparation: trimming; facing; re-mounting
- Knife preparation: glass breaking, inspection, troughs (boats)
- Diamond knives: use & handling
- Grid Preparation: types; cleaning; coating [Formvar, Butvar, collodion, carbon]
- "Thick" (semi-thin) sectioning; collection, mounting
- Thin sectioning: orientation, flotation [liquid and meniscus], flattening, collection, thickness [interference colors], problems, factors affecting quality

Staining: General principles and purpose

- Thick Section Staining: Toluidine blue-O, methylene blue, Paragon, azure II, Giemsa
- Thin sections: specific stains [uranyl acetate, lead citrate, phosphotungstic acid, osmium, ruthenium, silver] factors affecting staining quality
- Safety

### **D. Digital Imaging/ Power Point**

- General principles and purpose.
- Image processing,
- Use of computers
- Illustrations: labeling, magnifications

### **E. Special Techniques**

- Negative staining
- Shadow casting and replication
- Cytochemistry and immunolocalization
- High Pressure freezing and freeze substitution

### **F. General**

- Basic cytology, cell morphology, ultrastructure
- Reagents: solvents, solutions, normality, molarity, percentage, acids, bases, salts
- Cleanliness: glassware, distilled and deionized water
- Basic math: metric system, trigonometry, measurements
- Safety: radiation, chemical, biological, fire

## Written Examination

### Sample Questions (from past examinations)

#### Multiple Choice

1. If a cell structure is 60  $\mu\text{m}$  long on a micrograph at 20,000X, its actual length is:
  - (a) 6  $\mu\text{m}$
  - (b) 3  $\mu\text{m}$
  - (c) 2  $\mu\text{m}$
  - (d) 0.33  $\mu\text{m}$
  - (e) 0.16  $\mu\text{m}$
2. Proper lab attire includes:
  - (a) lab coat or jacket
  - (b) open toed shoes or sandals
  - (c) full length slacks
  - (d) shorts
  - (e) a and c above
3. Negative staining is often done with:
  - (a) lead citrate
  - (b) uranyl acetate
  - (c) phosphotungstic acid
  - (d) Toluidine blue-O
  - (e) b and c above
4. Astigmatism in a TEM can be caused by:
  - (a) contamination of an aperture
  - (b) improperly aligned filament
  - (c) a vacuum leak in the camera chamber
  - (d) a bent grid
  - (e) b and c above
5. How much 25% glutaraldehyde is needed to make 50 ml of 3% glutaraldehyde?
  - (a) 5 ml
  - (b) 10 ml
  - (c) 6 ml
  - (d) 3 ml
  - (e) 2.5 ml

## Practical Examination

The practical examination consists of preparing blocks, sections, and micrographs from three **different samples/tissues** and submitting them for evaluation by two (or sometimes three) members of the Certification Board having experience with specimens similar to those submitted. The examiners base their scoring on the usability of the specimens and grids in everyday practice in a research or clinical setting. **Thus, the work submitted should represent the candidate's BEST work. Material submitted should be publication quality and should include image labels that identify key features of the tissues used. Procedures should be written so that anyone familiar with biological electron microscopy procedures could replicate the work.** The relative weight given to various

aspects of the submitted material is indicated on the *MSA Practical Exam Grading Sheet* included in this packet. An average (mean) score of 80 is required to pass.

All work must be done by the candidate alone. However, a supervisor or other qualified individual may assist in obtaining the gross tissue specimens. A signed *Pledge of Independent Workmanship* (included in this package) must accompany the examination materials. Normal (**not pathological and not human**) materials and common processing methods should be used.

**Identify all submitted materials with the examination ID number** you were assigned when your application was approved. *Do not label items with either your name or your lab or institution's name.*

The bullet-points outlined in the syllabus above are indicative of the grading points used in evaluating the practical exam materials. ALL aspects of sample preparation and presentation are considered.

Detailed instructions follow:

1. Prepare three different tissues for transmission electron microscopy, from fixation through sectioning and uranyl acetate-lead staining, on uncoated 200 or 300 mesh copper grids. The tissues may be plant, animal, cell culture or microorganism, as the candidate chooses, except that at least one tissue must be from a mammal, cell culture or higher plant. *Be aware that the embedding resin you choose will affect the quality of your final images.*
2. Submit the following:
  - a. one trimmed tissue block from each tissue
  - b. four grids with good quality sections cut from each of the submitted blocks
  - c. one slide of “thick” ( ca. 1  $\mu$ m) sections for light microscopy, appropriately stained, from each submitted block
  - d. a detailed description, no longer than one page for each tissue, of the preparation methods used. **Procedures should be written so anyone else could replicate the work.** Be sure to indicate whether a glass or diamond knife was used. This should be modeled after the “Materials and Methods” sections of refereed journals.
  - e. There are three acceptable methods to submit images based on the technology the applicant has available to them in their lab. Submit six (6) images of each sample at 3 magnifications within the microscope magnification range of 2,500x to 30,000. Submit at least one at low magnification (survey), at least one at intermediate magnification featuring a single cell, and at least one at higher magnification showing subcellular/organelle features). Image data may be submitted on a CD, DVD or flash drive.

#### 1. Digital Image Submission

- A. Submit raw images as acquired at the microscope in a folder labeled “raw images”. Create a subfolder for each sample. If images are acquired with proprietary software, submit raw images as acquired and also submit raw images in TIFF format in a file labeled “raw images TIFF”.
- B. In a file labeled “annotated images” create a subfolder for each sample. Annotated images must be submitted as TIFF files. Annotated images must include a scale bar.
- C. Create a power point presentation with two images from each sample using the annotated images. Include a figure legend. Do not use any “special effects”.

2. **Photographic Film/Print Submission** (for labs without digital acquisition or scanner only)

- A. Submit original negatives
- B. Submit an annotated 8x10 photographic print of each micrograph. Include a scale bar on each print and a figure legend.

3. **Hybrid Film and Digital Submission**

- A. Record images on film and submit all negatives.
- B. Scan images into digital format as TIFF images. Place in a folder labeled "scanned raw images".
- C. Follow steps B & C Digital Image Submission above.

**In the Methods Section:**

- Identify the digital camera; manufacturer, model and pixel array (eg: 2K x 2K; 11 megapixel).
  - For film/print images, show how you calculated the length of the scale bar for each magnification used. Use three different magnifications.
  - Identify the scanner; manufacturer, model pixel array and dpi, if used.
  - Create a power point presentation with two images from each sample using the annotated images. Include a figure legend. Do not use any "special effects".
- f. Complete figure legends for each micrograph should be printed on a separate sheet. They should be concise (journal style: e.g. *Microscopy and Microanalysis*) and should describe any labeled structures and scale bars that appear on the micrographs.
3. Separate the grids into three groups of four and place them in a grid box (slide-type preferred) secured with a rubber band or tape. We recommend packing all materials in a sturdy box or padded shipping envelope. Use packing material so that the contents can't shift during transport.
  4. Send all materials (do not forget the *Pledge of Independent Workmanship*) to the **Chair of the Certification Board to arrive on or before the deadline date.** [Sending the practical exam to the Association Management Office delays the grading of the exam and increases shipping costs.] The Certification Board Chairman will provide you with the appropriate shipping address when you are informed of passing the written examination. We recommend using a courier like UPS or Federal Express; if you use the U.S. Postal Service, send the exam by express, certified, or registered mail. MSA is not responsible for damage to examination materials in transit.
  5. Submitted examination materials are held confidential, become the property of MSA, and are not returned to the applicant. If one or two grids per tissue are damaged or not usable, grades will be based on the remaining grids; if there are more than two damaged grids per sample or unlabeled or missing material, or other deficiencies, the examination may be returned for re-submission in a later cycle.

## Reference Books on Transmission Electron Microscopy

- Bozzola, J. J. and Russell, L. D. *Electron Microscopy*, Jones and Bartlett, Boston, (1999)
- Dykstra, Michael J. and Reuss, Laura E. *Biological Electron Microscopy: Theory, Techniques, Troubleshooting*, Springer- (2003 ).
- Griffiths, G. *Fine Structure Immunocytochemistry*, Springer-Verlag (1993).
- Hajibagheri, M. A. Nasser, *Electron Microscopy: Methods and Protocol*, Springer (1999 ).
- Hayat, M. A. *Basic Techniques for Transmission Electron Microscopy*, Academic Press, New York (1986)
- Hayat, M. A. *Correlative Microscopy in Biology. Instrumentation and Methods*, Academic Press, New York (1987)
- Hayat, M. A. *Principles and Techniques of Electron Microscopy. Biological Applications*, Cambridge University Press (2000)
- Kuo, John, *Electron Microscopy: Methods and Protocols*, Second Edition, Springer (2007)
- Maunsbach, Arvid, and Björn Afzelius, *Biomedical Electron Microscopy: Illustrated Methods and Interpretations*, Academic Press (1998).

**MICROSCOPY SOCIETY OF AMERICA**

**CERTIFICATION BOARD**

**Practical Examination**

**Pledge of Independent Workmanship**

**Applicant's Name:** \_\_\_\_\_

**Applicant's Examination Number:** \_\_\_\_\_

*I hereby state that all the procedures carried out in the preparation of the enclosed grids, microscope preparations and micrographs were performed exclusively by me and without any assistance.*

**Applicant's Signature:** \_\_\_\_\_

**Witness' Name (print):** \_\_\_\_\_

**Witness' Signature:** \_\_\_\_\_

**Date:** \_\_\_\_\_

**Location(s) where work was performed:**

**MSA PRACTICAL EXAM GRADING SHEET**

ID# \_\_\_\_\_ Cycle# \_\_\_\_\_ For Certification as Technologist (Biological)

1st Submission\_\_\_\_ Retake\_\_\_\_

**BIOLOGICAL SCIENCE TISSUES (NONPATHOLOGICAL)**

1. \_\_\_\_\_  
(Name of Specimen)

POINTS		SCORE	<u>TOTAL</u>
BLOCK	3	_____	
SLIDE	3	_____	
SECTION	6	_____	
IMAGES	6	_____	
POWERPOINT	6	_____	
LEGEND	3	_____	
OVERALL IMPRESSION	6	_____	
	(33)	_____	

2. \_\_\_\_\_  
(Name of Specimen)

BLOCK	3	_____	
SLIDE	3	_____	
SECTION	6	_____	
IMAGES	6	_____	
POWERPOINT	6	_____	
LEGEND	3	_____	
OVERALL IMPRESSION	6	_____	
	(33)	_____	

3. \_\_\_\_\_  
(Name of Specimen)

BLOCK	3	_____	
SLIDE	3	_____	
SECTION	6	_____	
IMAGES	6	_____	
POWERPOINT	6	_____	
LEGEND	3	_____	
OVERALL IMPRESSION	6	_____	
	(33)	_____	

**TOTAL SCORE** \_\_\_\_\_

Date: \_\_\_\_\_  
Grader's Signature: \_\_\_\_\_

**MICROSCOPY SOCIETY OF AMERICA**

**Application for Certification  
Electron Microscopy Technologist  
Biological Transmission Electron Microscopy**

Name: \_\_\_\_\_

Mailing Address: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Is this address your residence? \_\_\_\_\_ Work? \_\_\_\_\_

Company/University (only if not part of above address): \_\_\_\_\_

Daytime Phone: ( \_\_\_\_ ) \_\_\_\_\_ FAX: ( \_\_\_\_ ) \_\_\_\_\_

E-mail address: \_\_\_\_\_

I have read and understand the regulations pertaining to MSA Certification.

Your signature: \_\_\_\_\_ Date: \_\_\_\_\_

**EDUCATION** (Start with High School)

School/Location/Years Attended Credit Hours Major Field Degree

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**EMPLOYMENT** (EM Related)

**Current** employer (name and address):

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Position/Title: Years employed there: \_\_\_\_\_

Supervisor's name: \_\_\_\_\_

**Previous employer (name and address):**

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Position/Title: \_\_\_\_\_ Years employed there: \_\_\_\_\_

Supervisor's name: \_\_\_\_\_