MICROSCOPY SOCIETY OF AMERICA
Affiliate Society of American Institute of Physics - Affiliate Society of AAAS
MSA Association Management Office, 401 Edgewater Place, Suite 600, Wakefield, MA 01880
Tel: (703) 234-4115
E-mail: AssociationManagement@microscopy.org

GENERAL INFORMATION

The Microscopy Society of America (MSA)[1], 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 ensuring 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 passing both a written and practical examination. Two examination cycles are offered each year. Complete regulations and an application form appear on the following pages. (https://microscopy.org/cemt-certification-program)

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[2]). 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 regarding certification, should be addressed to:

Microscopy Society of America
CEMT Processing
401 Edgewater Place, Suite 600
Wakefield, MA 01880
Phone: (703) 234-4115

[1] 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.

[2] 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:

- A completed application form (included in this package).
- An application fee of $75.00 for MSA members[3] or $150.00 for non-members[4]
- One of the following:
  - Transcript of two years (60 credits) college or equivalent education, including at least 4 semesters that include: chemistry, physics, biology, mathematics, and two semesters transmission electron microscopy (TEM). The TEM course must include extensive hands-on experience in sample preparation and microscope operation.
  - Transcript of 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 [5] full-time work experience in biological TEM as a volunteer, intern, or paid employee.
  - A high school diploma AND two years of recent [5] full-time work experience in biological TEM as a volunteer, intern, or paid employee.
  - Three years of recent [5] full-time work experience in biological TEM as a volunteer, intern, or paid employee.
- Letters of recommendation from two (2) people in supervisory positions having substantial records of research publication, ideally utilizing electron microscopy. Preferably, at least one of them should be a member of the 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 Microscopy Society of America.
  - All transcripts and documents (e.g., letters of recommendation) must be in English or translated into English by a certified translator or organization. If translations are mailed, the original documents must also be supplied.

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

Microscopy Society of America
CEMT Processing
401 Edgewater Place, Suite 600
Wakefield, MA 01880

Applicants are responsible for seeing that all requirements are submitted in time and should confirm with the Association Management 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

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[3] 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.

[4] 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.

[5] Within five years prior to application

will receive a written explanation and their certification application fee will be refunded (although MSA member dues, if any, will not be refunded). Fees for applicants approved for examination are not refundable.

EXAMINATIONS

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 they may submit the materials for the practical exam. Both examinations usually are taken during the same cycle in which application was submitted; 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.
If this occurs, all requirements for certification must be completed by the end of the following cycle. 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 at or near the candidate's home institution. A score of 80% is required to pass. The material covered includes:
Instrumentation including electron optics (approx. 25%)
Sample/Tissue processing (fixations, resin chemistry etc.) (approx. 25%)
Sectioning and Staining (approx. 15%)
Special techniques (Immuno, shadowing, cryo, etc.) and imaging (approx. 20%)
General: chemistry, safety (approx. 15%)

Written Examination Study Syllabus

1) Instrumentation
    a. Transmission electron microscope fundamentals – operation, illumination, imaging systems, alignment, focusing, maintenance, test specimens, astigmatism, resolution, calibration, and contamination
    b. Scanning electron microscope – general principles, operation
    c. Accessory equipment - principles, components, alignment and routine maintenance of:
        i. Ultramicrotomes
        ii. Knifemakers
        iii. Light microscopes
    d. Vacuum systems – principles
        i. Vacuum evaporator
        ii. Sputter coater
        iii. Pumps – mechanical, diffusion, turbomolecular, ion
        iv. Vacuum gauges
    e. Other lab equipment: incubators, ovens, balances, pH meters, osmometers, centrifuges, photographic techniques (digital)
2) Sample/Tissue Processing
    a. Fixation and processing
        i. General principles and purpose
        ii. Types, composition, and preparation [eg: glutaraldehyde, paraformaldehyde, OsO_4, $KMnO_4$]

iii. Buffers [eg: phosphate, cacodylate, PIPES, HEPES]
iv. Factors affecting fixation - fixative concentration, time, temperature, pH, osmolarity, buffer, additives, penetration
v. Methods of fixation - immersion, perfusion, vapor
vi. Criteria for good fixation
vii. Washing - general principles and purpose
viii. En bloc staining
ix. Dehydration – general principles and purpose
x. Dehydration agents [ethanol, acetone, ethylene glycol, propylene oxide, acetonitrile]
xi. Factors affecting dehydration – concentration, time, temperature
xii. Infiltration – general principles and purpose
xiii. Embedding – general principles and purpose
xiv. Types, compositions and preparations of plastics [acrylics, polyesters, epoxies, catalysts, hardeners, plasticizers]
xv. Methods of embedding – capsules, flat, cell culture, vacuum
xvi. Polymerization – general principles and purpose

3) Sectioning and Staining
    a. Sectioning – general principles and purpose
        i. Block preparation – trimming, facing, remounting
        ii. Glass knife preparation – glass breaking, inspection, troughs (boats)
        iii. Diamond knives – use and handling
        iv. Grid preparation – types, cleaning, coating [Formvar, Butvar, collodion, carbon]
        v. Thick (semi-thin) sectioning – collection, mounting
        vi. Thin sectioning – orientation, flotation [liquid and meniscus], flattening, collection, thickness [interference colors], problems, factors affecting quality
    b. Staining – general principles and purpose
        i. Thick section staining – Toluidine blue-O, methylene blue, Paragon, azure II, Giemsa etc. (Specialty Stains)
        ii. Thin sections
            1. Specific stains [uranyl acetate, lead citrate, phosphotungstic acid, osmium, ruthenium, silver]
            2. Factors affecting staining quality
4) Digital Imaging/ Power Point
    a. General principles and purpose
    b. Image processing
    c. Use of computers
    d. Illustrations: labelling, magnifications, scale bars
5) Special techniques
    a. Negative staining
    b. Shadow casting and replication
    c. Cytochemistry and immunolocalization
    d. High-pressure freezing and freeze substitution
6) General
    a. Basic cytology, cell morphology, ultrastructure
    b. Reagents - solvents, solutions, normality, molarity, percentage, acids, bases,

salts
   c. Cleanliness - glassware, distilled and deionized water
   d. Basic math - metric system, trigonometry, measurements
   e. Safety - radiation, chemical, biological, fire

Sample Questions (from past examinations)

1. 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

2. Negative staining is often done with:
   a. Lead citrate
   b. Uranyl acetate
   c. Phosphotungstic acid
   d. Toluidine blue-O
   e. (b) and (c) above

3. Astigmatism in a TEM can be caused by:
   a. Contamination of an aperture
   b. Improperly aligned filament
   c. Vacuum leak in the camera chamber
   d. A bent grid
   e. (b) and (c) above

4. How many milliliters of 25% glutaraldehyde is needed to make 50ml of 3% glutaraldehyde?
   a. 2.5
   b. 3
   c. 5
   d. 6
   e. 10

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. 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 could replicate the work. The relative weight given to various aspects of the submitted material are 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.

Standard (non-pathological and non-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 samples for transmission electron microscopy from fixation through sectioning and uranyl acetate-lead staining, Use uncoated 200 or 300 mesh copper grids to mount thin sections. The samples may be plant, animal, cell culture, or microorganism, as the candidate chooses. At least one sample 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 block from each sample (three blocks in total)
    b. Four (4) grids with high quality thin sections cut from each of the submitted blocks
    c. One slide of "thick" sections (~1um) for light microscopy that have been appropriately stained and labelled from each submitted block
    d. A detailed description, no longer than one page for each sample, 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. If the same methods were used for all 3 samples, one copy of the methods may be submitted. It should specify that the methods apply to all submitted samples. The methods may be submitted as printed copy or as a Word document included on the USB drive that contains the images.
    e. Submit six (6) images of each sample at 3 magnifications within the microscope magnification range of 2,500x to 30,000x. Submit at least one low magnification

(survey), at least one intermediate magnification featuring a single cell, and at least one higher magnification showing subcellular/organelle features.

f. Signed Pledge of Independent Workmanship

Digital Image Submission

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”.

In a file labeled “annotated images” create a subfolder for each sample.
Annotated images must be submitted as TIFF files. Annotated images must include labelled structures of interest within the tissue and a scale bar. Figure legends for each submitted image should all be on a separate page. (see “f” below)

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”.

Image data should be submitted on a USB (flash) drive.

Note: If the candidate does not have access to a digital photography system and wants to submit with film micrographs, please contact the Chair for further instructions.

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 the length of the scale bar was calculated for each magnification used. Use three different magnifications.
Identify scanner, manufacturer, model, pixel array and dpi.
Create a power point presentation with two images from each sample using the annotated images. Include figure legend. Do not use any “special effects”.

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.

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.

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.

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)

Hurbain, I. and Sachse, M. (2011), The future is cold: cryo-preparation methods for transmission electron microscopy of cells. Biology of the Cell, 103: 405-420. https://doi.org/10.1042/BC20110015

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#:** _____ Certification as a technologist (Biological)

1st Submission ☐ Retake ☐

Biological Science Tissues (Nonpathological)

Numbers listed next to grading parameters are total possible points. Input your score next to them

1. Name of specimen: _____

Block	3	
Slide	3	
Sections	6	
Images	6	
PowerPoint	6	
Legend	3	
Overall impression	6	
Total possible points	**33**	

2. Name of specimen:_____

Block	3	
Slide	3	
Sections	6	
Images	6	
PowerPoint	6	
Legend	3	
Overall impression	6	
Total possible points	**33**	

3. Name of specimen:_____

Block	3	
Slide	3	
Sections	6	
Images	6	
PowerPoint	6	
Legend	3	
Overall impression	6	
Total possible points	**33**	

TOTAL SCORE:_____

DATE: _____ **GRADER'S SIGNATURE:**_____

Application for Certification

Electron Microscopy Technologist

Biological Transmission Electron Microscopist

Name:	
Mailing address:	
Is this your residence? ☐	Work? ☐
Company/University (if different from above):	
Phone:	
I have read and understand the regulations pertaining to MSA Certification	
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):	
Position/Title:	Years employed there:
Supervisor's name:	
Previous employer (name and address):	
Position/Title:	Years employed there:
Supervisor's name:	