PROGRAM OVERVIEW
The Microscopy Program at Delta College is a unique 2 year program that offers exceptional employment opportunities for both men and women. It is a unique and interesting field where the certificate graduate works in microscopy with research scientists in industry, research laboratories, medical schools, hospitals, colleges and universities. Jobs are available in microscopy for laboratory work, as well as in technical sales and marketing. There are abundant jobs available with good starting salaries and continued opportunities for advancement. The program only requires a high school diploma for admission and no further prerequisites. It is to the student’s advantage to take high school courses in math, science and computers.

Graduates of the program work in a variety of fields e.g. metallurgy, ceramics, computer and electronics industries, biology, environmental areas, biotechnology, geology, forensics, food & cosmetic industries, and medicine, to mention just a few.

CAREER OPPORTUNITIES
The SJDC Microscopy Program is nationally recognized in the microscopy industry for providing students that are well trained not only in microscopy skills but people skills that are required in the work place. Job placement for program certificate graduates is often 100% and averages over the program’s history about 85%. The program, because of its low cost to the student, is accessible to the diverse population served by SJDC.

SJDC has an active Career Development Center which helps in job placement, resume writing, interviewing, etc. Hundreds of our graduates are located in hospitals, industry and academia throughout the entire nation.

A CAREER IN MICROSCOPY
• Excellent Salaries
• Abundant Job Opportunities
• Unlimited Advancement Possibilities
• High Tech Training
• Rewarding
• Challenging
• State of the Art

STUDENTS ARE TrAINED IN
• Instrumentation
• Specimen Preparation
• Digital Imaging/Photography
• Equipment Maintenance
• Experimental Design
• Critical Thinking
• Data Interpretation
• Communication
• Teamwork and Leadership

Don’t let the name intimidate you.
If you can operate a computer, you can be trained to operate an electron/ion/laser microscope.
GRADUATE PLACEMENT
Our graduates are presently employed throughout the United States. A few examples are as follows:

- **Large Corporations** e.g. Xerox Corp, General Electric, General Chemical, Intersil/TriQuint, Seal Corp, Signetics, Weyerhaeuser Corp, Raychem, Chevron, Northrup Aircraft, Lockheed, Dow Chemical, Aerospace Corp, Boeing, DuPont, Pittsburgh Paint and Glass (PPG), United Defense, etc.
- **Smaller Corporations and Service Labs** e.g. Charles Evans Labs, Indy Electronics, Smith Tool Irvine, Cedar Products, Xicor, Variety of Asbestos Analysis Labs, etc.
- **Computer Related** e.g. IBM (several sites), Data General, Motorola (several sites), Tektronics, National Semiconductor, Electro-Delta Corp, Intel Corp sites all over country, Apple Computers, Hewlett Packard (several sites), KOMAG Inc, Aradigm, Texas Instruments (several sites), Integrated Device Technology (IDT, several sites), AMD (several sites) etc.
- **National Labs** e.g. Lawrence Livermore Labs, Sandia Labs, Lawrence Berkeley Labs, NASA, National Ctr for Microscopy (Berkeley and Madison, Wisc.), National Institute of Health (NIH), Argonne National Labs, etc.
- **Microscope and Related Companies** e.g. Philips, Hitachi, JEOL, Zeiss, FEI Inc., CAMSCAN, RJ Lee Group, Inc., Oxford Instr., PGT, EDAX, Thermoran, Gatan Instr., EM Sciences, EMSL, Ted Pella, Inc., Ladd Research, Nikon Instr., etc.
- **Universities/Med Schools/Hospitals/Research Institutes:** e.g. UC, Berkeley, Davis, San Francisco, Irvine, LaJolla, Several CSU Campuses, Stanford Univ., Univ. of Denver, Univ. of Penn, City of Hope Med. Ctr., UOP Dental School and Sch of Pharmacy, Sutter Memorial Hospital, Sharp's Cabrillo Hospital, Medical College of Wisc., Baylor Sch. of Medicine, St. Louis Univ. Med Sch, Univ. of FL, Univ. of SC Med Sch., etc.
- **Biotechnology** e.g. Genentech Inc., Roche Pharmaceutical, Gladstone Inst (SF), Barnham Cancer Inst.(La Jolla), Stanford Research Inst., Bethesda Eye Institute (St. Louis), etc.

THE TRAINING PROGRAM
Students can be accepted with no prerequisites other than a high school diploma or equivalent and a keen interest in this exciting profession. Individuals will spend 2 years in preparation for certification as a Microscope Technologist either in Biological or Materials.

The program teaches the student theory and extensive hands-on training, giving the student a strong background and working knowledge of specimen preparation, electron/ion/light/scanned probe microscope operation and data interpretation. Necessary job skills such as, organization, team work, oral and written communication, critical thinking etc. are integrated throughout the program. Research and practical approaches to problem solving are stressed, making SJDC graduates a valuable asset to any microscopy lab. Students are encouraged to take a few additional courses necessary for the AA degree at the same time.

The Microscopy Program includes all disciplines that require information based on seeing and analytically investigating the microworld. It covers areas from Anthropology to Zoology. Students are involved in learning to solve “real world” challenges e.g. finding faults in an integrated circuit which may cause everyday minor mishaps as simple as a failing coffee maker to a major crisis situation of a rocket ship not launching, the effect of new drugs on cells, preventing crop losses in walnuts by early bacteria detection which allows the farmer to take immediate action before the walnut meat is damaged, or determining the make up of pottery from “lost civilizations”, or if a painting is authentic.

PROGRAM HISTORY AND FACILITIES
The Microscopy Technology Center at San Joaquin Delta College was established in 1970. Since its first certificated graduates in 1972, it produces a skilled group of technologists each year that have gone on to rewarding professional careers.

The SJDC Microscopy Technology Center is the most complete training facility in the US dedicated to the training of microscopy technologists. It currently houses 3 Transmission Electron Microscopes (TEM), 3 Scanning Electron Microscopes (SEM), Focused Ion Beam (FIB) and Atomic Force Microscopes (AFM), a variety of Light Microscopes (LM), Energy Dispersive X-ray analysis equipment (EDS), Image Processing/analysis equipment and ancillary equipment necessary to train technologists for biological or materials specimen preparation, instrumentation and data interpretation. The Microscopy Technology Center is building a separate facility specifically made for microscopy needs. It will be located in a separate building just behind its current location. (Fig on page 1)

STUDENT ORGANIZATION
The microscopy student organization, Delta Microscopy Society (DMS) is active in developing team work, organizational, and leadership skills among the students by organizing fund raisers for scholarships, field trips, mentor program, program marketing to community, job board and various other activities. DMS is a local affiliate society (LAS) of the Microscopy Society of America. DMS is also active in the Northern California Regional Microscopy Society. The students publish a 24-32 page newsletter several times a year, which is sent to all known SJDC graduates as well as all major microscopy labs throughout the country.

SUMMER INTERNSHIPS
Students have several opportunities for summer internships or part-time jobs working inside major companies/institutions e.g. IBM, Lawrence Berkeley National Lab, Genentech, Intel, and several other Failure Analysis/Semiconductor and Biotechnology Companies as well as, UC System Schools, CSU System Schools, etc., while obtaining their two year certificate and Associates degree.

PROGRAM AWARDS
- In testament to its success, the SJDC Microscopy Program was selected the #1 program in the State and awarded the 1987 Governor’s Citation for Excellence in California Vocational Education.
- In 1992, the Microscopy Program was one of the two SJDC programs to be included in a national publication listing the best and most innovative program and services in community, junior and technical colleges.
- In 1999, the Microscopy Program was awarded the Student Success Award by the Governor’s Board and Chancellor’s Office. This award chose the 10 programs in the State that would be the most likely to ensure student success into the new millennium.
- In 2001, the Microscopy Program was awarded the Excellence in Partnership Award by the California Council for Community Colleges. This was presented for the program’s continuous successful interactions with a variety of industries.
Brief Introduction to Microscopy

MICROSCOPE INSTRUMENTATION

Microscope imaging allows us to see small objects at both high resolution and high magnification. There are many types of microscopes. They differ in their illumination source and detection system which gives each unique features to describe the variety of materials that are examined. Our program introduces the student to the broad variety of imaging techniques with hands-on practical knowledge as well as theory.

There are two basic types of electron microscopes i.e. the Scanning Electron Microscope (SEM) and the Transmission Electron Microscope (TEM). The SEM is generally used for 3 dimensional surface information while the TEM is used to obtain information from inside the sample using thin samples.

Electrons are emitted from a tungsten filament similar to a light bulb filament and accelerated down a column towards the specimen with voltages from 10,000 to 125,000 volts. Magnetic lenses are used to focus the electron beam.

Magnifications up to 100,000 are used in the SEM and up to a million times in the TEM. So that the electrons are not scattered and lost by air molecules, the microscopes are operated under vacuum with mechanical and diffusion/ion/turbomolecular pumps being used to rid the column of air. Because of the high magnifications used, cleanliness is a must in all areas of the Microscopy Lab complex. Each of these microscopes takes up an entire 16 ft x 16 ft room. The sophisticated electronics and pumping systems require constant temperature control as well. Environmental SEMs are also available which allow us to look at “wet” samples.

In the TEM, the electron beam is transmitted through the specimen where an image is formed, magnified and projected on a fluorescent screen for visual observation. The screen can be raised to take a photograph or sent directly to a computer for digitization and printing. The specimen must be thin enough for the electrons to go through, on the order of 50 nanometers which equals about two millionth of an inch (.000 001 965 in.). Resolution as low as 0.2 nanometers (3 billionth of an inch) can be achieved with a modern TEM. The resolution of the unaided eye equals 0.25 mm or .0098 in.

In the SEM, the electron beam is scanned across the surface of the specimen. A signal is given off from the surface and fed into a cathode ray tube (CRT) similar to a TV screen. One advantage of the SEM is depth of field; most of the specimens can be viewed in-focus at the same time. The resolution of a modern SEM is 5 nanometers (.000,000,03 in.). A picture of the cathode ray tube can be taken to obtain a permanent record, or sent directly to a computer, digitized, and printed.

An x-ray analyzer can be fitted on the electron microscopes so elemental composition can be studied to find out what chemically is inside the sample. X-ray systems for microscopes can detect almost the full range of atomic numbers.

Metallurgical light microscopes (OLM) require advanced light optics and camera systems and provide several different modes of operation e.g. brightfield, darkfield, interference, reflected, etc. The mode chosen depends on what type of information is necessary. We have two metallurgical microscopes each requiring 7 ft x 4 ft for the microscope alone.
**Brief Introduction to Microscopy**

**MICROSCOPE INSTRUMENTATION**

In addition to light and electron microscopes, other types of microscopes can be used to obtain information from a sample. Some examples are listed. Atomic Force Microscopes (AFM) glide across the surface of the sample with a fine tip and obtain information down to the atom level. Because of the atomic resolution provided, the AFM requires absolute minimum vibration. The Focused Ion Beam Instrument (FIB) utilizes gallium ions to probe and etch the surface, very useful in detecting defects in integrated circuits. All of these microscopes and associated computer equipment require separate rooms.

Computers play a big part in microscopy as all of the images can be fed into a computer through digitization, processed, and used as needed to obtain quantitative data or to be printed. We save our images into an image database for retrieval via the internet with password protection.

**SPECIMEN PREPARATION**

The data from the microscopes is no better than the samples observed, thus knowledge of specimen preparation and preparation equipment is absolutely necessary. Much of this equipment requires vibration free, temperature controlled areas. Some of the equipment is rather large and requires much space.

Generally (except for the Environmental SEM), the specimen must be specially prepared to put in an electron microscope so it can withstand the vacuum and the electron beam.

Biological samples must be fixed to stabilize the structure, dehydrated and dried. Fixation of the specimen requires a lab to be set up for perfusion of the animal, making solutions (pH meter, balances, osmometer, centrifuges, rotary shakers), etc.

For biological thick sections for the OLM, one must use special equipment for paraffin embedding and sectioning.

For TEM, many samples must be embedded in plastic then cut into thin sections (50 nanometers or 2 millionth of an inch) so that the electron beam can go through them. The sample is then mounted on a 3 mm grid to support the sample for insertion in the TEM. The instrument used to cut these thin sections is called an ultramicrotome. Before the ultramicrotome, one must also use a pyramitome for thick sectioning, knifemaker for making glass knives, etc. Because of the thinness of the sample required, vibrations and air currents must be at a minimum and because of the thermal advance in some of the instruments, constant temperatures must be maintained at all times. We have 10 ultramicrotomes. Both biological as well as materials samples are ultramicrotomed.

For SEM, biological samples are freeze- or critical point dried then mounted on a specimen stub. Samples are coated with a metal such as gold to make them conductive so they can be viewed in the SEM. This requires freeze dryers, critical point dryers, sputtering devices, and vacuum evaporators.
## Electron Microscopy

### Biological

**Total Units Required: 53-57**  
**Recommended Sequence:**  

**First Semester (Fall)**  
- **C S 18B** Microcomputers and Small Business: Apple Macintosh 3
- **E M 11** Photography for Laboratory Technicians 2
- **E M 21** Introductory Techniques of Electron Microscopy 3
- **B I O L 1** Core Biology 4
- **M A T H 80** Elementary Algebra 4

**Second Semester (Spring)**  
- **E M 22** Ultramicrotomy for Electron Microscopy 4.5
- **C H E M 3A** Introduction to Chemistry 4
- **P H Y S C 10** Introduction to Physics 4
- **M A T H 82** Intermediate Algebra 4

**Third Semester (Fall)**  
- **E M 28** Biological Ultrastructure 2
- **E M 37** Advanced Techniques in Biological Electron Microscopy 3.5
- **E M 38** Scanning Electron Microscopy 3
- **E M 53** Electron Microscopy Equipment Maintenance 3
- **E M 58** Digital Imaging for Microscopy 2
- **M A T H 31** Trigonometry 3

**Fourth Semester (Spring)**  
- **E M 30** Current Microscopies, Optics, and Imaging 3
- **E M 39** Advanced Biological SEM 2
- **E M 59** Advanced Projects in Electron Microscopy 2

**Group I (Mathematics Requirement)**  
- **Option I:** MATH 80, MATH 82, and MATH 31  
- **Option II:** MATH 80 and MATH 87*

*Suggested Electives:  
- **E M 79** Applied Applied Microscopy Principles 1-3  
- **E M 34** Introduction to Materials Electron Microscopy 4  
- **E M 41** Analytical SEM 3  
- **E M 50H** Special Studies: Electron Microscopy 1-2  
- **E M 62** Focused Ion Beam (FIB) Operation/Use 2  
- **E M 60** TEM Align/Use 2  
- **E M 61** SEM Align/Use 2  
- **E TECH 20** Materials & Measurements 3  
- **E TECH 13** Engineering Drafting Skills 3  
- **E L E C T 11** AC and DC Network Analysis 4.5  
- **E L E C T 12** Introduction to Probability and Statistics 4  
- **B I O L 33** Anatomy and Physiology 6  
- **B I O L 2** General Zoology 5

Required Certificate Courses must be completed with at least a “C” grade. All EM Courses in the certificate program must have been completed within four (4) years or have permission of the instructor.

Equivalent courses may be accepted by transfer from other colleges but at least 12 units of the certificate must be completed at San Joaquin Delta College. Students who desire equivalency/transfer course(s) credit for courses taken elsewhere must have the courses approved before taking it for certificate credit.

**NOTE:** It is recommended that during the summer, required core courses (Non-EM) be taken.

### Crystalline

**Total Units Required: 49.5-53.5**  
**Recommended Sequence:**  

**First Semester (Fall)**  
- **C S 18** Microcomputers and Small Business: Apple Macintosh 3
- **E M 11** Photography for Laboratory Technicians 2
- **E M 21** Introductory Techniques of Electron Microscopy 3
- **B I O L 1** Core Biology 4
- **M A T H 80** Elementary Algebra 4

**Second Semester (Spring)**  
- **E TECH 20** Materials & Measurements 3  
- **C H E M 3A** Introduction to Chemistry 4  
- **P H Y S C 10** Introduction to Physics 4  
- **E M 34** Introduction to Materials Electron Microscopy 3  
- **M A T H 82** Intermediate Algebra 4

**Third Semester (Fall)**  
- **E M 35** Physical Electron Microscopy Laboratory 3.5  
- **E M 38** Scanning Electron Microscopy 3  
- **E M 53** Electron Microscopy Equipment Maintenance 3  
- **E M 58** Digital Imaging for Microscopy 2  
- **M A T H 31** Trigonometry 3

**Fourth Semester (Spring)**  
- **E M 30** Current Microscopies, Optics, and Imaging 3
- **E M 39** Advanced Biological SEM 2  
- **E M 59** Advanced Projects in Electron Microscopy 2  
- **E M 79** Applied Microscopy Principles 1-3  
- **E M 62** Focused Ion Beam (FIB) Operation/Use 2  
- **E M 60** TEM Align/Use 2  
- **E M 61** SEM Align/Use 2  
- **C S 17** Computer Logic 3  
- **E L E C T 11** AC and DC Network Analysis 4.5  
- **E L E C T 12** Introduction to Probability and Statistics 4  
- **E M 50H** Special Studies: Electron Microscopy 1-2

Required Certificate Courses must be completed with at least a “C” grade. All EM Courses in the certificate program must have been completed within four (4) years or have permission of the instructor.

Equivalent courses may be accepted by transfer from other colleges but at least 12 units of the certificate must be completed at San Joaquin Delta College. Students who desire equivalency/transfer course(s) credit for courses taken elsewhere must have the courses approved before taking it for certificate credit.

**NOTE:** It is recommended that during the summer, required core courses (Non-EM) be taken.
Metalurgical samples are thinned for TEM viewing, and generally viewed directly after cleaning for SEM. For the preparation of thin metalurgical samples we have 4 jet thinners, a dimpler, an ion mill, several polishing wheels and tripod polishers, slow speed saws, etc.

For FIB, the samples can be put directly into the FIB instrument and ion bombarded to the desired level. In this manner, cross sections depicting information about fatal integrated circuit flaws can be detected and can even be repaired in this instrument.

Samples can be viewed directly with the AFM, because no vacuum is required, giving detailed surface information at the atomic level.

**EXAMPLES**

- TEM of Bacteria, *Escherichia coli*, Chromium Shadowed, 5,300X
- TEM of Lung, Type II Cell, 7,000X
- SEM of Fractured Cherry Bud, 120X
- SEM of Integrated Circuit, Tripod Polished, 15,000X
- SEM of Human Hair
- AFM of 3D Rendering of Human Hair 100µm
- SEM of Flea, 500X
- OLM of memory chip, 225X

For further information about Microscopy Program, contact:

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**San Joaquin Delta College** • **5151 Pacific Avenue** • **Stockton, CA 95207**

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For information on SJD C Registration or AA Requirements, Contact Guidance & Counseling at (209) 954-5650 or [College Website](http://www.deltacollege.edu/ElectMicro/sjdc.html)