Clinical Laboratory Science — B.S.

Program director
Alicia M. Triplett

Clinical coordinator
Alicia M. Triplett

Medical director
Paul C. Herrmann

A student who has an interest in science, an investigative mind that enjoys the challenge of solving problems quickly and accurately, and a desire to help others should consider a career as a clinical laboratory scientist.

Clinical laboratory scientists examine and analyze body fluids, tissues, and cells. They look for bacteria, parasites, or other microorganisms; analyze the chemical content of fluids; match blood for transfusions; and test for drug levels in the blood to show how a patient is responding to treatment.

Clinical laboratory scientists perform complex chemical, biological, hemotlogical, immunologic, microscopic, and bacteriologic tests. They use, maintain, and troubleshoot sophisticated laboratory equipment that is used to perform diagnostic tests. The clinical laboratory scientist possesses the scientific and diagnostic skills required for DNA and biomolecular technology and genetic engineering applications, analyzes these test results, and discusses them with the medical staff.

Opportunities

Employment of clinical laboratory workers is expected to parallel the growth of other health-care occupations through the year 2018, particularly as the volume of laboratory tests increases with population growth and with the development of new technology. Employment opportunities are excellent, with current vacancy rates of 14 percent. The twenty-first century is offering clinical laboratory scientists new avenues for test development, experimental design, administration, and education. Clinical laboratory scientists work in hospitals or similar medical facilities, clinical and reference laboratories, home health diagnostics, transfusion services, physicians’ offices, and private medical clinics. Employment is also available in pharmaceutical and biotechnology companies, health information systems, DNA technology and genetic engineering corporations, research laboratories, federal government agencies, forensics and crime investigation, veterinary hospitals, U.S. Public Health Service facilities, areas of medical product development, and customer and patient education.

The program

The two-year Clinical Laboratory Science Program includes clinical training and culminates in a Bachelor of Science degree. Prerequisite courses may be taken at any regionally accredited college or university and are completed during the freshman and sophomore years. Accepted students transfer into the program at the junior year level, which begins in August. After satisfactory completion of the program, the student is awarded a Bachelor of Science degree and is eligible to take the national board examination and become a licensed clinical laboratory scientist in California.

The ten-month junior year includes lecture and laboratory. Emphasis is on the basic clinical science courses, including theory and correlations.

The ten-month senior year comprises a clinical practicum that provides professional clinical experience in the hospital laboratory environment. Emphasis is on technical proficiency, application of theory to patient care, laboratory organization, and managerial skills.

Senior students must coordinate their time with the operation of Loma Linda University Medical Center’s clinical laboratory and with supplemental affiliate training laboratories in the community.

Program objectives

The Clinical Laboratory Science Program endeavors to present a complete educational experience that culminates in the Bachelor of Science degree. The education and clinical experience obtained in this program will give the student the eligibility to take the clinical laboratory scientist examination offered by the ASCP Board of Certification and other entities approved by the state of California. The bachelor’s degree in clinical laboratory science is granted independently of any external certification or licensing examinations. The graduate will demonstrate professional entry-level competencies in chemistry, hematology, immunohematology, immunology, and microbiology; as well as their respective subsections.

Program learning outcomes

1. Demonstrate basic knowledge and technical ability essential to the practice of clinical laboratory science.
2. Practice professionalism through ethical behavior and attitudes.
3. Demonstrate leadership and administrative skills in laboratory practice and the community consistent with the mission of the School of Allied Health Professions.
4. Adhere to rules and regulations promoting workplace and patient safety and continuous quality improvement (CQI).
5. Exhibit analytical and critical-thinking skills necessary to succeed in laboratory medicine.

Clinical affiliations

Multiple clinical affiliations enrich the student’s clinical training by providing exposure to procedures in different types of medical facilities. During the forty-week clinical practicum, supplemental training may be scheduled at any of the following clinical sites:

Primary affiliation
Loma Linda University Medical Center
Loma Linda, California

Loma Linda University Medical Center
Murrieta, California

Supplemental affiliations
LifeStream
San Bernardino, California

Community Hospital of San Bernardino
San Bernardino, California

Jerry L. Pettis Memorial Veterans Medical Center
Loma Linda, California

Kaiser Permanente Medical Center
Fontana, California
Redlands Community Hospital
Redlands, California

Transportation to scheduled assignments
Transportation to training laboratories is the responsibility of the student. Depending on the clinical assignment, commuting times may be up to two hours one way. Senior students must coordinate their time with the operational schedules of the Loma Linda University Medical Center Clinical Laboratory and affiliate laboratories in the community. The senior schedule is a full-time week (forty hours) arranged on a Monday-through-Friday schedule. A special calendar schedule different from the University academic calendar is followed.

Professional certification and licensure
Completion of the required sequence of academic course work and directed professional experience prepares the graduate to take the certifying examination of the ASCP Board of Certification and obtain licensure by the state of California. Information regarding the examination can be obtained from the Web site: <http://ascp.org/boc>.

Academic progression
A minimum grade of C (2.0) is required for all courses in the program. C- grades are not acceptable. A student who receives a grade of less than C in any academic course that is part of the professional curriculum is automatically placed on probation. A student who receives an Unsatisfactory (U) in any segment of a clinical practicum is automatically placed on clinical probation. Continued enrollment for the next quarter, term, or rotation segment of a student on probation or clinical probation is subject to the recommendation of the department.

If continued enrollment is not recommended, the department will notify the student in writing. If continued enrollment is recommended, the student will be required to institute a learning assistance program contract and meet regularly scheduled appointments with the academic advisor. A student on probation is automatically dismissed from the program if a second grade of less than C is received in any academic course that is part of the professional curriculum; or if a second Unsatisfactory is received during any subsequent rotation segment. A student on clinical probation is automatically dismissed from the program if a second Unsatisfactory is received during any subsequent rotation segment. Readmission to the program will require reapplication.

CPR certification
Students are required to have current health-care provider cardiopulmonary resuscitation (CPR) certification (adult, child, and infant) for all scheduled clinical experiences. This certification must be completed at the American Heart Association health-care provider level. Certification may be completed prior to beginning the program of study or may be obtained at Loma Linda University. Classes are available on campus at Life Support Education, University Arts Building, 24887 Taylor Street, Suite 102.

Accreditation
The program is accredited by the National Accrediting Agency for Clinical Laboratory Sciences (NAACLS), 5600 North River Road, Suite 720, Rosemont, IL 60018; telephone: 773/714-8800; fax: 773/714-8886; e-mail: <naaclsinfo@naacls.org>; Web site: <http://www.naacls.org>.

The program also satisfies the requirements in medical laboratory science of the American Society of Clinical Pathology Board of Certification for Medical Laboratory Science, P.O. Box 12277, Chicago, IL 60612-0277. The program is approved by the California Department of Public Health (CDPH), Laboratory Field Services (LFS), 850 Marina Bay Parkway, Richmond, CA 94804-6403; telephone: 510/873-6327; Web site: <http://www.cdph.ca.gov/programs/lfs>.

Admissions
In addition to Loma Linda University (http://llucatalog.llu.edu/about-university/admission-policies-information/#admissionrequirementstext) and School of Allied Health Professions admissions requirements (http://llucatalog.llu.edu/allied-health-professions/#generalregulationstext), the applicant must also complete the following requirements:

- A minimum G.P.A. of 2.75 for science is required.
- A minimum of 96 quarter units or 64 semester units at an accredited college or university. Note: A minimum grade of C (2.0) is required for all transfer courses; C- grades are not acceptable for transfer.
- Prerequisites and transfer patterns may be viewed at <llu.edu/allied-health/sahp/transfer>.
- Projected course work that will be completed before beginning the program will be considered in the application process.

Application deadlines
Applications to the Clinical Laboratory Science Program are accepted beginning January 1. Early submission of application is recommended. Preference will be given to applicants whose completed applications and transcripts are received by March 1.

Prerequisites
Humanities and religion, 20 quarter or 14 semester units total, selected from at least three of the humanities and religion areas:

- Art/Music (performing arts limited to 2 quarter units)
- Civilization/History, foreign language, literature, philosophy, religion:
  - a maximum of 8 quarter units of religion may be applied to the above 20 quarter/14 semester units; for students who attended or are enrolled in an Adventist college, 4 quarter units of religion are required per year attended

College mathematics (algebra or higher level)
General chemistry with laboratory, complete sequence
Organic chemistry with laboratory, complete sequence

* Introductory physics with laboratory, complete sequence (must include principles of light and electricity)
* General biology with laboratory, one course
Cultural diversity or cultural anthropology (one course); (select remainder of social sciences units to total 10 quarter units from these areas: anthropology, economics, geography, political science, psychology, sociology)

English composition, complete sequence; select remainder of communication units to total 9 quarter units from these courses: computers, public speaking, critical thinking

Health education, personal health, or nutrition (one course)
Two physical education courses

Electives, as necessary, to meet the minimum total requirement of 96 quarter units; recommended: anatomy and physiology, biochemistry, cellular or molecular biology, genetics, speech, computer applications, critical thinking

For total unit requirements for graduation, see LLU General Education Requirements (http://llucatalog.llu.edu/about-university/division-general-studies/#courserequirements).  

*Students planning to apply to advanced degree programs should verify current admission requirements.

**Program requirements**

**Junior Year**

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<tr>
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<th>Units</th>
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<tr>
<td>AHCJ 328</td>
<td>Wholeness Portfolio I</td>
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<tr>
<td>AHCJ 418</td>
<td>Physiology I</td>
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<tr>
<td>CLSM 105</td>
<td>Procedures in Phlebotomy</td>
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<tr>
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<td>Urine and Body Fluid Analysis I</td>
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<td>CLSM 307</td>
<td>Medical Parasitology</td>
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<tr>
<td>CLSM 309</td>
<td>Quantitative Analysis (Chemical)</td>
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<td>CLSM 321</td>
<td>Hematology I</td>
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<td>CLSM 325</td>
<td>Clinical Immunology</td>
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<tr>
<td>CLSM 327</td>
<td>Clinical and Pathogenic Microbiology I</td>
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<td>RELT 457</td>
<td>Christian Ethics and Health Care</td>
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<td>RELT 423</td>
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**Senior Year**

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<td>CLSM 411</td>
<td>Urine and Body Fluid Analysis II</td>
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<td>CLSM 413</td>
<td>Diagnostic Microbiology</td>
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<td>CLSM 414</td>
<td>Clinical Parasitology</td>
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<td>CLSM 422</td>
<td>Hematology III</td>
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<td>CLSM 434</td>
<td>Clinical Chemistry III</td>
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<td>CLSM 435</td>
<td>Immunoassay and Molecular Diagnostic Techniques</td>
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<td>CLSM 442</td>
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**Units**

- CLSM 474C: Clinical Correlations 1
- CLSM 496: Clinical Laboratory Science Seminar I 1
- CLSM 497: Clinical Laboratory Science Seminar II 1
- CLSM 498: Clinical Laboratory Science Seminar III 2
- RELR 415: Christian Theology and Popular Culture 2
- RELT 416: God and Human Suffering 2

**Total Units:** 126

**Normal time to complete the program**

2 years (20 months) at LLU — full-time enrollment required

**Courses**

**CLSM 105. Procedures in Phlebotomy. 4 Units.**
Training in venipuncture and skin puncture, medical terminology, laboratory safety, CPR, basic anatomy and physiology, specimen-collection techniques, hazards/complications, quality assurance methods, and medicolegal issues of phlebotomy. Clinical rotation arranged at Loma Linda University Medical Center and affiliates. CPR training and certificate arranged for students not already certified.  
Prerequisite: Current CPR certificate.

**CLSM 303. Urine and Body Fluid Analysis I. 2 Units.**

**CLSM 307. Medical Parasitology. 3 Units.**
Medically important parasites: life cycles, clinical features, infective diagnostic stages. Demonstrations, slide studies, and diagnostic procedures. Lecture and laboratory.

**CLSM 309. Quantitative Analysis (Chemical). 4 Units.**
Provides a rigorous background in chemical principles particularly important to analytical clinical chemistry. Develops an appreciation for the task of judging the accuracy and precision of experimental data and the application of statistical methods. Covers both fundamental and practical aspects of chemical analysis; neutralization titrations; acid-base titrations; spectrophotometric methods; and electrochemical and chromatographic methodologies. Lecture and laboratory.

**CLSM 321. Hematology I. 4 Units.**
Examines normal hematologic physiology, cellular development, and hemostasis in the human. Introduces pathophysiology, with emphasis on clinical and laboratory evaluation of hematologic status. Theory and background of laboratory procedures used in diagnosis and treatment of hematologic and other diseases. Stresses proficiency in evaluation of normal and abnormal cellular morphology. Lecture and laboratory.

**CLSM 322. Hematology II. 4 Units.**
Theory and background of routine and special laboratory procedures used in diagnosis and treatment of hematologic and other diseases. Emphasizes peripheral blood-cell morphology, hematopoieses, maturation, and kinetics. Pathophysiology of hematologic disorders, including anemias and hematologic malignancies. Correlation of hemostasis testing with clinical hemostatic disorders. Lecture and laboratory. Prerequisite: CLSM 321.

**CLSM 325. Clinical Immunology. 3 Units.**
Presents the basic principles of immunology. Topics covered include humoral and cell-mediated immunity, complement, autoimmunity, immunodeficiency, hypersensitivity, tumor immunology, transplant immunology, virology, syphilis serology, and immunologic laboratory techniques. Emphasizes principles, laboratory procedures, and clinical significance. Lecture and laboratory.
CLSM 327. Clinical and Pathogenic Microbiology I. 5 Units.
Introduces microbiological concepts, leading to an in-depth study of the major groups of pathogenic bacteria and their relationship to human disease. Emphasizes clinical laboratory identification methods and procedures. Lecture and laboratory.

CLSM 328. Clinical and Pathogenic Microbiology II. 5 Units.
Nature and control of microorganisms encountered in clinical material and various anatomical sites. Emphasizes antimicrobial agents, mycology, and virology, including hepatic viruses and HIV/AIDS. Lecture and laboratory. Prerequisite: CLSM 327; or consent of instructor.

CLSM 331. Biochemistry. 5 Units.
Chemical structure and metabolism of carbohydrates, amino acids, lipids, and nucleic acids. Protein synthesis, functions, and analysis. Enzymes and their structure, function, kinetics, and regulation. Lecture and laboratory.

CLSM 332. Clinical Chemistry I. 4 Units.
Clinical chemistry procedures and their clinical significance in medicine, with focus on the following areas: fluids and electrolytes, acid-base balance, carbohydrates and diabetes mellitus, and proteins. Presents quality assurance, method evaluation, and establishment of reference ranges. Lecture and laboratory. Prerequisite: CLSM 331; or consent of instructor.

CLSM 333. Clinical Chemistry II. 4 Units.
Clinical chemistry procedures and their clinical significance in medicine, with focus on the following areas: lipids, lipoproteins, cardiovascular disease, enzymes, liver function, the endocrine system; thyroid, parathyroid, adrenal cortex and catecholamines, and steroids; reproduction, pregnancy, and fetal well-being; therapeutic drug monitoring and toxicology. Lecture and laboratory. Prerequisite: CLSM 332.

CLSM 341. Immunohematology I. 3 Units.

CLSM 342. Immunohematology II. 3 Units.

CLSM 396. CLS Junior Seminar. 1 Unit.
Prepares student for entry into the senior year clinical practicum. Introduces student to the clinical laboratory and its operations by direct observation and discussions to include pre-analytical, analytical, and postanalytical areas. Students expected to apply knowledge acquired from all disciplines within the junior year curriculum. Visits to off-site locations may be required.

CLSM 411. Urine and Body Fluid Analysis II. 1 Unit.
Correlates theory and clinical experience with and applies them to analytical techniques. Assesses and interprets data. Evaluates and compares methodologies. Urinalysis screening procedures and applications in the diagnosis of renal, systemic, and metabolic diseases. Processing, analysis, and morphologic evaluation of body fluids. Prerequisite: CLSM 303.

CLSM 413. Diagnostic Microbiology. 6 Units.
Correlates theory and clinical experience with, and applies them to, analytical techniques. Assesses and interprets data. Evaluates and compares methodologies. Directed study and review of diagnostic bacteriology, mycology and virology. Emphasizes isolation and identification of pathogenic microorganisms. Includes susceptibility testing, instrumentation, and rapid identification methods. Prerequisite: CLSM 307, CLSM 327, CLSM 328.

CLSM 414. Clinical Parasitology. 2 Units.
Correlates theory and clinical experience with and applies them to analytical techniques. Assesses and interprets data. Evaluates and compares methodologies. Directed study and review of medical parasitology. Emphasizes testing for and identification of pathogenic parasites. Prerequisite: CLSM 307.

CLSM 422. Hematology III. 6 Units.
Correlates theory and clinical experience with and applies them to analytical techniques. Assesses and interprets data. Evaluates and compares methodologies. Directed study and review of hemostasis, cellular quantification and identification techniques, and clinical hematology. Includes white cell, red cell, platelet, and hematostatic disorders. Prerequisite: CLSM 321, CLSM 322.

CLSM 434. Clinical Chemistry III. 5 Units.
Correlates and applies theory and clinical experience with analytical techniques. Assesses and interprets data. Evaluates and compares methodologies. Directed study and review include: carbohydrates, proteins, lipids, enzymology, electrolytes, acid-base balance, endocrine system, and therapeutic drug monitoring. Prerequisite: CLSM 333.

CLSM 435. Immunoassay and Molecular Diagnostic Techniques. 3 Units.
Reviews common immunoassay and molecular diagnostic assay methodologies utilized in the clinical laboratory. Discusses immunoassay technologies, including: EIA, ELISA, EMIT, FPIA, and chemiluminescence. Discusses molecular diagnostic techniques, including: nucleic acid extraction and purification, gel electrophoresis, nucleic acid hybridization and blots, DNA sequencing, and amplification technologies. Compares and contrasts several signal and target amplification technologies, including real-time technologies. Discusses and applies the clinical uses of the foregoing methods to clinical laboratory science. Addresses laboratory design and safety issues. Prerequisite: CLSM 325; or consent of the instructor.

CLSM 442. Immunohematology III. 3 Units.
Introduces management theory, including: management styles, professional communications, business ethics, group theory, team building, process management, process control, and personnel.

CLSM 451. Clinical Laboratory Management I. 2 Units.
Introduces management theory, including: management styles, professional communications, business ethics, group theory, team building, process management, process control, and personnel.

CLSM 452. Clinical Laboratory Management II. 2 Units.
Financial management, with emphasis on concepts, tools, and strategies underlying financial decision making. Topics include health-care reimbursement systems, coding, billing, development of operating budgets, and financial reports. Concepts of financial negotiations, inventory management, and financial planning. Integrates and applies analytical techniques used in the service industries.
CLSM 453. Clinical Laboratory Management III. 2 Units. 
Introduces theories of quality management, organization, strategic planning, and the decision-making process. Reviews and analyzes government agencies, legislation, and regulatory bodies that impact laboratory management. Compares quality systems-management philosophies.

CLSM 455. Special Procedures. 4 Units. 
Correlates and applies theory and clinical experience requiring assessment and interpretation of data. Evaluates and compares methodologies. Directed study and review include the following immunoassays: chemiluminescence, enzyme and radioisotopic assays, microparticle enzyme immunoassay, and fluorescence polarization and nephelometry. Also includes thin-layer and high-pressure liquid chromatography, electrophoresis, spectrophotometry, toxicology, amino acids assay, rapid-detection testing for bacteria and viruses, polymerase and ligase chain reactions, Western blot assays, serology, and current immunologic techniques. Prerequisite: CLSM 324, CLSM 333.

CLSM 471. Clinical Practicum I. 5 Units. 
Thirteen weeks of supervised clinical laboratory experience in selected areas, including parasitology, hematology, urinalysis, and body fluids. Student performs tests routinely done in these areas of the clinical laboratory.

CLSM 472. Clinical Practicum II. 5 Units. 
Thirteen weeks of supervised clinical laboratory experience in selected areas, including: microbiology and immunohematology, with experience in transfusion services and in a blood-collection facility. Student performs tests routinely done in these areas of the clinical laboratory. Emphasizes clinical-laboratory quality-control procedures and evaluation.

CLSM 473. Clinical Practicum III. 5 Units. 
Thirteen weeks of supervised clinical laboratory experience in selected areas, including: chemistry and special procedures. Student performs tests routinely done in these areas of the clinical laboratory. Incorporates experience in administrative duties.

CLSM 474A. Clinical Correlations. 1 Unit. 
Interactively bridges knowledge from textbook to clinical practice and decision making. Stimulates students' intellectual curiosity as it applies to laboratory medicine—including interpretation of laboratory data, case study analysis, impact on patient treatment and prognosis, assessment of validity of laboratory data, and administration of mock board examinations.

CLSM 474B. Clinical Correlations. 1 Unit. 
Interactively bridges knowledge from textbook to clinical practice and decision making. Stimulates students' intellectual curiosity as it applies to laboratory medicine—including interpretation of laboratory data, case study analysis, impact on patient treatment and prognosis, assessment of validity of laboratory data, and administration of mock board examinations.

CLSM 474C. Clinical Correlations. 1 Unit. 
Interactively bridges knowledge from textbook to clinical practice and decision making. Stimulates students' intellectual curiosity as it applies to laboratory medicine—including interpretation of laboratory data, case study analysis, impact on patient treatment and prognosis, assessment of validity of laboratory data, and administration of mock board examinations.

CLSM 496. Clinical Laboratory Science Seminar I. 1 Unit. 
Introduces an assigned capstone project designed to incorporate skills developed and knowledge obtained in the Clinical Laboratory Science Program junior year. Project must be of current interest to the laboratory field. Topics related to the project include literature-search methods, research methods, presentation skills, team building, assessment of impact on clinical outcomes, and analysis and implementation of clinical applications. Prerequisite: Satisfactory completion of Clinical Laboratory Science Program junior-year courses, or consent of instructor.

CLSM 497. Clinical Laboratory Science Seminar II. 1 Unit. 
Continues assigned capstone project. Presents relevant contemporary topics. Prerequisite: CLSM 496; or consent of instructor.

CLSM 498. Clinical Laboratory Science Seminar III. 2 Units. 
Students apply educational methodologies and objective writing to the capstone presentation, incorporating skills developed and knowledge obtained during the Clinical Laboratory Science Program junior and senior years. Project-related topics include presentation skills, assessment of impact on clinical outcomes, and analysis and implementation of clinical applications. Requires regular meetings with faculty advisors to formulate plans and provide status reports on the progress of the capstone project, as well as additional time outside regular class periods. Culminates with submission and presentation of the assigned capstone project to faculty and administration. Prerequisite: CLSM 496, CLSM 497; or consent of instructor.

CLSM 499. Clinical Laboratory Science Independent Study. 1-5 Units. 
Project or paper to be submitted on a topic of current interest in an area related to medical technology. Regular meetings provide student with guidance and evaluation. Elected on the basis of need or interest.