CLINICAL LABORATORY SCIENCE — B.S.

Program director
Alicia M. Triplett

Clinical coordinator
Alicia M. Triplett

Medical director
Paul C. Herrmann

A student who is interested in science, has an investigative mind that enjoys the challenge of solving problems quickly and accurately, and has 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, hematomal, 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; and, analyzes and discusses test results with the medical staff.

Opportunities
Overall employment of medical laboratory professionals is projected to grow 13 percent through 2026, faster than the average for all occupations, particularly as the volume of laboratory tests increases with population growth and with the development of new technology. Employment opportunities are excellent, with average vacancy rates of seven 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 is comprised of clinical practicum and seminar courses. These provide professional clinical experience in the hospital laboratory environment with emphasis on technical proficiency, application of theory to patient care, laboratory organization, and managerial skills.

Senior students' clinical experience is balanced between Loma Linda University Medical Center's clinical laboratory and supplemental affiliate training laboratories in the community.

Program objectives
The Clinical Laboratory Science Program provides a complete educational experience that culminates in the bachelor of science degree and eligibility for licensure. California state licensure is obtained through the medical 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
By the end of the program, the graduate should be able to:

1. Demonstrate basic knowledge essential to the practice of clinical laboratory science.
2. Demonstrate technical ability essential to the practice of clinical laboratory science.
3. Practice professionalism through ethical behavior and attitudes.
4. Demonstrate leadership and administrative skills in laboratory practice and the community consistent with the mission of the School of Allied Health Professions.
5. Adhere to rules and regulations promoting workplace and patient safety and continuous quality improvement.
6. Exhibit analytical 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 40-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

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 (40 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 website: <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 or who receives an Unsatisfactory (U) in any segment of a clinical practicum is automatically placed on 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. Also, 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 the terms of the learning assistance program contract are not met.

CPR certification
Students are required to have current health-care provider adult, child, and infant cardiopulmonary resuscitation (CPR) certification 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.

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 complete the following requirements:

- A minimum G.P.A. of 2.75 for science courses.
- 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.

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 not to exceed four quarter units)
- Civilization/History, foreign language, literature, philosophy, religion:
  - a maximum of eight 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, four quarter units of religion are required per year attended

General chemistry with laboratory, complete sequence

Organic chemistry with laboratory, complete sequence

* Introductory or general physics with laboratory (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

Personal health or nutrition (one course)

Two physical education (activity) courses

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

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

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

## Program requirements

### Junior Year

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<th>Course Code</th>
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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>CLSM 105</td>
<td>Procedures in Phlebotomy</td>
<td>4</td>
</tr>
<tr>
<td>CLSM 303</td>
<td>Urine and Body Fluid Analysis I</td>
<td>2</td>
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<td>CLSM 307</td>
<td>Medical Parasitology</td>
<td>3</td>
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<tr>
<td>CLSM 309</td>
<td>Quantitative Analysis (Chemical)</td>
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<tr>
<td>CLSM 315</td>
<td>Physiology</td>
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<tr>
<td>CLSM 321</td>
<td>Hematology I</td>
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<td>CLSM 325</td>
<td>Clinical Immunology</td>
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<td>CLSM 327</td>
<td>Clinical and Pathogenic Microbiology I</td>
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<td>CLSM 328</td>
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<td>CLSM 341</td>
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<td>CLSM 396</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>Immunohematology III</td>
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<td>CLSM 471</td>
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<td>CLSM 473</td>
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<td>CLSM 497</td>
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<tr>
<td>CLSM 498</td>
<td>Clinical Laboratory Science Seminar III</td>
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### 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 315. Physiology. 4 Units.**
Physiology of the human body including cellular, neuromuscular, cardiovascular, respiratory, gastrointestinal, renal, and endocrine systems.

**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 323. Biochemistry. 4 Units.**
Provides a rigorous background in chemical principles particularly important to analytical clinical chemistry. Development of 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 325. Immunology. 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 327. Clinical and Pathogenic Microbiology I. 5 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 328. Clinical and Pathogenic Microbiology II. 5 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 331. Clinical Immunology. 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 332. Clinical Chemistry I. 5 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 333. Clinical Chemistry II. 5 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 334. Clinical Correlations. 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 396. Medical Parasitology. 3 Units.**
Medically important parasites: life cycles, clinical features, infective diagnostic stages. Demonstrations, slide studies, and diagnostic procedures. Lecture and laboratory.

**CLSM 473. Clinical Practicum III. 5 Units.**
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 325. Clinical Immunology. 3 Units.
Prepares student for entry into the senior year clinical practicum. Correlates theory and clinical experience with and applies them to practical and analytical techniques. Assesses and interprets data. Includes susceptibility testing, instrumentation, and rapid identification methods. Prerequisite: CLSM 307.

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 virology, including hepatitis 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.
Blood collection, donor testing, component preparation, and quality management in the collection facility. Identification of multiple antibodies, typing discrepancies, hemotherapy, hazards of transfusion, and investigation of autoimmunity. Lecture and laboratory. Prerequisite: CLSM 341.

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 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.
Clinical and theory-based assessment and interpretation of data. Evaluation and comparisons of methodologies including immunoassays, 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 325, 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 capstone projects which incorporate skills developed and knowledge obtained in the Clinical Laboratory Science Program junior year. Project must be of current interest. Topics may 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.
Preparation of capstone project with application of educational methodologies and objective writing 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. 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.