

CLINICAL LABORATORY SCIENCE — B.S.

Program director

Alicia M. Triplett

Clinical coordinator

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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 in clinical laboratory science.

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, hematological, immunologic, microscopic, and bacteriologic tests. They operate, 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 7 percent through 2029—much 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. 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 institutionally 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 as well as co-requisite 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 experiences are 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 American Society for Clinical Pathology (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.
5. Adhere to rules and regulations promoting workplace and patient safety.
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. The senior schedule is based on a full-time week (40 hours) arranged on a Monday-through-Friday schedule within a non-standard term. During the 40-week clinical practicum, training may be scheduled at any of the following clinical sites:

Loma Linda University Medical Center
Loma Linda, California

Loma Linda University Medical Center
Murrieta, 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

LifeStream
San Bernardino, California

Pomona Valley Hospital Medical Center
Pomona, California

Transportation to scheduled assignments

Transportation to training laboratories is the responsibility of the student. Depending on the clinical assignment, travel to affiliate sites may be up to 80 miles, 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.

Professional certification and licensure

Completion of the required sequence of academic coursework 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> (<http://ascp.org/boc/>).

Academic progression

A minimum grade of C (2.0) is required for all courses in the program. A C- grade is 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 for a student on 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.

Accreditation

The Clinical Laboratory Science 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; email: info@naacls.org; website: <http://www.naacls.org>.

The program meets the requirements in medical laboratory science of the American Society for Clinical Pathology, Board of Certification for Medical Laboratory Science, 33 West Monroe Street, Suite 1600, Chicago, IL 60603; telephone: 312/541/4998; fax: 312/541/4998. 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; website: <https://www.cdph.ca.gov/Programs/OSPHLD/LFS/Pages/Approved-CLS-Training-School-Programs.aspx>.

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.
 - For total unit requirements for graduation, see LLU General Education Requirements (<http://llucatalog.llu.edu/about-university/division-general-studies/#courserequirementstext>).
- Projected coursework that will be completed before beginning the program will be considered in the application process.
- Note: Students planning to apply to advanced degree programs should verify current admission requirements for those programs.

Application deadlines

Applications to the Clinical Laboratory Science Program are accepted between March 1 and May 15. Early submission of application is recommended.

Prerequisites

Courses are listed in general education domain order. To determine which courses meet the requirements, see the transfer patterns for selected colleges and universities at llu.edu/allied-health/sahp/transfer (<http://www.llu.edu/allied-health/sahp/transfer/>).

Domain 1: Religion (8 quarter units)

(completed during enrollment at LLU)

Domain 2: Arts and Humanities (minimum of 16 quarter or 11 semester units)

Units must be selected from at least three of the following content areas: civilization/history, art, literature, language, philosophy, religion, or general humanities electives. A minimum of 3 quarter units in an area is required to meet a "content area."

Domain 3: Scientific and Quantitative Reasoning

Each course or sequence listed below:

- College Algebra or Calculus (one course)
- General Biology (one course with lab)
- General Chemistry (complete sequence with labs)
- Organic Chemistry (complete sequence with labs)
- Physics with lab (must include principles of light and electricity)

Domain 4: Social Sciences (minimum of 12 quarter or 8 semester units)

Select units from at least two content areas listed below:

- Anthropology, economics, geography, political science, psychology, and sociology

- Note: One course (or components integrated into several courses) dealing specifically with issues of human diversity.

Domain 5: Written and Oral Communication (minimum of 9 quarter or 6 semester units)

- English composition, complete sequence that meets the baccalaureate degree requirements of a four-year college or university
- Additional courses may include courses in computer information systems, critical thinking, and public speaking.

Domain 6: Health and Wellness (minimum of 2 quarter or 1.5 semester units)

- A didactic course in health or nutrition (e.g., personal health, personal nutrition, population health, global health, and community nutrition) minimum of 2 units
- Physical education. Must include at least two separate physical activity courses totaling a minimum of one quarter unit.

Electives

Some students may need to complete additional elective coursework to bring their overall course unit total to a minimum of 192 quarter units, including units taken at Loma Linda University, to meet graduation requirements.

Program requirements

Junior Year

AHCJ 328 ¹	Wholeness Portfolio I
CLSM 105	Procedures in Phlebotomy
CLSM 303	Urine and Body Fluid Analysis I
CLSM 307	Medical Parasitology
CLSM 309	Quantitative Analysis (Chemical)
CLSM 315	Physiology
CLSM 321	Hematology I
CLSM 322	Hematology II
CLSM 325	Clinical Immunology
CLSM 327	Clinical and Pathogenic Microbiology I
CLSM 328	Clinical and Pathogenic Microbiology II
CLSM 331	Biochemistry
CLSM 332	Clinical Chemistry I
CLSM 333	Clinical Chemistry II
CLSM 341	Immunohematology I
CLSM 342	Immunohematology II
CLSM 396	CLS Junior Seminar
RELE 457	Christian Ethics and Health Care
RELT 423	Loma Linda Perspectives

Senior Year

AHCJ 498	Wholeness Portfolio II	1
CLSM 411	Urine and Body Fluid Analysis II	1
CLSM 413	Diagnostic Microbiology	6
CLSM 414	Clinical Parasitology	2
CLSM 422	Hematology III	6
CLSM 434	Clinical Chemistry III	5
CLSM 435	Immunoassay and Molecular Diagnostic Techniques	3
CLSM 442	Immunohematology III	3

CLSM 451	Clinical Laboratory Management I	2
CLSM 452	Clinical Laboratory Management II	2
CLSM 453	Clinical Laboratory Management III	2
CLSM 455	Special Procedures	4
CLSM 471	Clinical Practicum I	5
CLSM 472	Clinical Practicum II	5
CLSM 473	Clinical Practicum III	5
CLSM 474A	Clinical Correlations	1
CLSM 474B	Clinical Correlations	1
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
RELT 415	Christian Theology and Popular Culture	2
RELT 416	God and Human Suffering	2

Total Units: 126

¹ Fulfills service learning requirement

Normal time to complete the program

Four (4) years – Two (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.
Urinalysis screening procedure and its application in the diagnosis of renal, systemic, and metabolic diseases. Analysis and morphology of body fluids. Lecture and laboratory.
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, hematopoiesis, 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.

Fundamentals of antigen-antibody reactions. Studies major blood-group systems, compatibility testing, and antibody-identification techniques. Clinical analysis of hemolytic disease of the newborn. Lecture and laboratory.

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 autoimmune hemolytic disease. 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 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 hemostatic 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. Includes immunoassay technologies (EIA, ELISA, EMIT, FPIA), and chemiluminescence; and, molecular diagnostic techniques (nucleic acid extraction and purification, gel electrophoresis, nucleic acid hybridization and blots, DNA sequencing, and amplification technologies). Examines signal, target amplification, and real-time technologies. Addresses laboratory design and safety issues. Prerequisite: CLSM 325; or consent of the instructor.

CLSM 442. Immunohematology III. 3 Units.

Applies theory and techniques routinely used in transfusion medicine. Emphasizes correlation with clinical experience. Directed study and review include type and screen, antibody identification, investigation of hemolytic disease of the newborn, hemotherapy, and hazards of transfusion. Assesses and interprets data. Overview of donor facilities: donor criteria, records management, component preparation, blood storage, and infectious disease testing. Prerequisite: CLSM 341, CLSM 342.

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.

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.

Explores topics such as medical research design and implementation, test method selection and evaluation, and laboratory instrumentation. 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 with test method selection and evaluation. Incorporates skills developed and knowledge obtained in the Clinical Laboratory Science Program into a project. Prerequisite: CLSM 496; or consent of instructor.

CLSM 498. Clinical Laboratory Science Seminar III. 2 Units.

Introduces credentialing mechanisms and roles of the clinical laboratory professionals, as well as membership in professional organizations, network building, professional development and lifelong learning, and educational methodologies. Prerequisite: 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.