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A Review of Bachelor's Degree Medical Laboratory Scientist Education and Entry Level Practice in the United States

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Abstract

The baccalaureate degree is generally the degree that provides the laboratory professional with the greatest level of general scientific background, training, job flexibility, and advancement opportunities. It is widely considered the requirement for entry-level work in the field of medical laboratory science, especially for those that covet work in management or specialty areas. This paper focuses on the educational models and levels of practice for MLS professionals including the entry level competencies of new professionals at the baccalaureate level. The accreditation of MLS programs and professional certification serve as important quality management systems to ensure program quality and professional competency prior to the start of entry level work.

Introduction

The foundation of medical laboratory science education rests with the complexity model of clinical practice. During the early formations of what has become the modern clinical lab, professionals were trained on the job (1). As the clinical laboratory has become more sophisticated over the last 100 years, it became clear that on-the-job training was not totally sufficient. This job complexity led to advanced training at the associates, baccalaureate, and graduate degree levels to increase the professionals' fundamental science knowledge. Subjects such as biology, chemistry, mathematics, and advanced laboratory concepts became increasingly important as part of a rapidly advancing field. No longer was it enough to simply perform laboratory testing; it was expected professionals would understand and contribute to the development, performance, assessment, and interpretation of laboratory results. As the science of laboratory medicine became increasingly more complex, a breadth and depth of knowledge was required prior to beginning entry level work. This ultimately led to the utilization of the higher education system in the United States for training different levels of practice in the United States.

Baccalaureate Education and Levels of Practice in the United States

The clinical laboratory has various entry points depending on the professionals' training and level of work complexity. Using the complexity model as the basis for the laboratory profession, there are three main entry points requiring specific training or degrees. These entry points are based on on-the-job training (OJT), associate degreed medical laboratory technicians (MLT), and baccalaureate degreed medical laboratory scientists (MLS) (2).

Generally, phlebotomists and medical laboratory assistants attend training programs measured in weeks, or learn under the guidance of other professionals in the laboratory. These professionals have a limited but necessary skill set in collecting patient samples and ensuring proper specimen collection and processing. The laboratory's results are only as good as the quality of specimens and its processing techniques, but phlebotomists' and medical assistants' expertise is limited and narrowly focused to these duties without additional training in supportive science courses.

The MLT trained professionals have a broader scope of practice in understanding the basic concepts of laboratory work. This consists of a basic understanding of human anatomy and physiology, college chemistry, English writing, computer competency, and applied courses in medical laboratory science. These courses include use of modern laboratory equipment, basic testing concepts, and the ability to perform routine laboratory testing on a day-to-day basis.

All baccalaureate degreed MLS can perform tasks at the previous two levels and handle non-routine and advanced practice concepts, specialized testing, and serve as supervisors in the laboratory. Additionally, MLS are introduced to research concepts, educational techniques, and management skills in their training. The depth of scientific knowledge, study of advanced laboratory concepts and supervision, and medical laboratory training give MLS professionals a large general scope of practice and various job opportunities within the laboratory.

Additional professional opportunities for MLS exist in industry, research laboratories, pharmaceuticals, performance-enhancing drug testing, biotechnology, medical instrumentation, and other medical laboratory science-based fields. More recently MLS have found positions in forensic science laboratories and human genetic testing. This is due in part to possessing a baccalaureate degree which grants access to many scientific fields and the specialized training in quality management and accuracy desired by various industries.

Educational Models of United States MLS programs

There are several educational models in wide use to reach the baccalaureate degree MLS certification. In general they fall into two main models: the "2+2" and the "3+1" models. The "2+2" models focus on completing the general education courses in the first two years. These generally consist of the courses shown in Table 1. These general education requirements form the well-rounded core of the U.S. college degree including biology, chemistry, mathematics, social science, English, communication

Table 1
General curriculum plan for baccalaureate degree in MLS

Year 1 (30 credits)	
Semester 1	**Semester 2**
English Composition I	English Composition II
Anatomy & Physiology I	Anatomy & Physiology II
Math	Communication
General Chemistry I	General Chemistry II
Year 2 (30 credits)	
Semester 1	**Semester 2**
Literature	General Microbiology
History I	History II
Social Science I	Social Science II
Organic and/or Biochemistry I	Organic and/or Biochemistry II
Year 3 (30+ credits)	
MLS courses such as Fundamentals of Microbiology, Hematology, Clinical Chemistry, Immunology Support courses in biology, such as genetics, physiology, molecular biology	
Year 4 (30+ credits)	
Advanced MLS courses in Microbiology, Hematology, Immunohematology, Clinical Chemistry, Urinalysis Additional MLS courses in Management, Education, Research, Quality Assessment Clinical Practicum	

skills, history, and literature. While the exact set of courses varies by institution, generally MLS students must show reasonable proficiency in written and spoken communication, broad knowledge of scientific concepts in human biology, chemistry, and mathematics at the pre-calculus level, knowledge of world or U.S. history, and an introduction to social sciences, which may include psychology, sociology, economics, or geography.

Upon completion of the first 60 credits, students apply for admission to the final two years of the medical laboratory science program. The remaining 2 years of the "2+2" model consists of upper division chemistry courses such as organic chemistry and biochemistry, upper division biology courses such as genetics or molecular biology, medical laboratory science courses in all areas of the laboratory including immunohematology, immunology, hematology, microbiology, clinical chemistry, urinalysis, hemostasis and coagulation, management, education, research, and laboratory operations. Additionally, programs require clinical practicums where students train in medical laboratories under the supervision of practicing and certified medical laboratory scientists, averaging a period of 6 months (although this is now decreasing). The practicum is equally divided among the 4 major areas of the laboratory. The last two years ranges between 60-70 credits. Thus, all graduates meet the 120 credit minimum required for the baccalaureate degree in the United States.

The "3+1" model of education is a variation of the "2+2" model that requires all pre-requisite college courses to be completed (excluding MLS courses) prior to the start of the final year of the program. Thus students apply to the final year of the program that is a full 12 months in length, with courses in the summer, fall, and spring semesters. This final year focuses exclusively on the MLS training during an intense year of instruction that usually consists of 6 months of classes and 6 months of clinical practicum.

A variation of the "3+1" is a "4+1" model where students receive a degree in a related science such as biology, chemistry, or other area while completing the course pre-requisites for the MLS program. The student then applies and is accepted to the final year of the program at a college or hospital-based certificate program. Hospital-based programs are medical laboratory science programs run directly from a training site, where the MLS educational program and clinical practicum are conducted at the same hospital site. The hospital is not a degree-granting institution so students must already have a degree or will receive one upon completion of the training program. In these cases students receive a certificate of completion from the hospital-based program.

Required Coursework

The required coursework for all programs generally stems from the NAACLS 22B Unique Standards Requirement for MLS programs, presented in Table 2 (3). Prior to beginning an MLS program, students need adequate training in biology, chemistry, and other foundational science courses. It is widely accepted that all students will complete a two semester series of chemistry courses that include basic chemical principles, structures, kinetic theory, stochiometry, balancing chemical equations, gas laws, acid-base chemistry, electrochemistry, thermodynamics, rudimentry organic chemistry and other basic concepts that provide the foundation for advanced chemical work. Students are also required to take either an organic or biochemistry class to fulfill upper division chemistry requirements. Many programs tackle this differently, but most require a brief one semester organic chemistry course (although the standard two semester series also works) and at least one semester of biochemistry. The goal of these chemistry courses is to provide functional knowledge of organic functional groups, reactions, mechanisms, and stereochemistry that is essential for the understanding of human biochemical reactions and microbial metabolism, enzyme chemistry, and human genetics. This knowledge provides a solid academic foundation for the understanding of biochemical test development, various chemical testing methods, and human homeostasis.

Biology coursework provides the general foundation for understanding the anatomy and physiology of the human body and its biochemical reactions. Generally programs require the completion of two semesters of comprehensive anatomy and physiology courses. This helps students identify important parts of the body, understand the structure and function of organ systems, and integrate biochemical principles in the metabolism of the human body. Since the functional assessment of organ systems is vital to the medical laboratory field, students are expected to understand all major organ systems and their effects on human homeostasis that will lead to normal or abnormal laboratory results.

In addition to anatomy and physiology, students also take a variety of other biology classes that usually include genetics, introductory microbiology, and immunology. Genetics courses provide the basic understanding of our genetic code, genetic disease, and the fundamental principles of genetics in modern diagnostic biotechnology such as DNA probes, polymerase chain reaction, genome sequencing, and other useful tools. Introductory microbiology courses vary in their precise content from general environmental microbiology to medical microbiology. The general purpose is to teach the fundamental concepts of modern sterility, safe specimen handling, basic identification of pathogens, streaking for bacterial isolation, selective and differential media, and rudimentary identification skills in preparation for MLS program diagnostic microbiology courses. Immunology courses provide greater background in the function of the human innate and adaptive immune system. Ultimately a large segment of the medical laboratory relies on a solid foundation of immunology based on the number and type of immune cells, antibody titers, and our ability to manipulate it for protection from disease. This allows the MLS professional to identify various pathologies, deficiencies in immunity, and our resistance to infections through exposure and vaccination.

Table 2
NAACLS Standard 22B

Standard 22B1
Anatomy/physiology
Immunology
Genetics/molecular biology
Organic/biochemistry
Microbiology
Statistics
Standard 22B2
Pre-analytical, analytical, and post-analytical components of laboratory services
Hematology
Hemostasis
Chemistry
Microbiology
Urinalysis
Microscopy
Molecular diagnostics
Immunology
Immunohematology
Standard 22B3
Principles and practices of quality assurance/quality improvement as applied to the pre-analytical components of laboratory services
Standard 22B4
Application of safety to laboratory practice
Application of governmental regulations and standards as applied to laboratory practice
Standard 22B5
Principles of interpersonal and interdisciplinary communication and team-building
Standard 22B6
Principles and application of ethics
Principles and applications of professionalism to address ongoing professional career development
Standard 22B7
Education techniques and terminology sufficient to train/educate users and providers of laboratory services
Standard 22B8
Knowledge of research design/practice sufficient to evaluate published studies as an informed consumer
Standard 22B9
Critical pathways and clinical decision making
Performance improvement
Dynamics of healthcare delivery systems as they affect laboratory service
Human resource management to include position description, performance evaluation, utilization of personnel, and analysis of workflow and staffing patterns
Financial management: profit and loss, cost/benefit, reimbursement requirements, materials/inventory management

Ultimately a solid foundation of mixed biology coursework focused on the structure and function of the human body allows for the development and assessment of laboratory testing and provides the basis for our advanced coursework. NAACLS standard 22B (3) provides a much broader context of prerequisite courses that outlines requirements for educational programs.

Medical Laboratory Science Specific Courses and Entry Level Competencies

The Medical Laboratory Scientist needs a variety of courses to prepare them for entry level work. This broad base of knowledge provides a solid foundation in all areas of the laboratory allowing the graduates to perform work in a specific section or as a generalist. It is important to note the basis for educational training and entry level competencies are established by professionals through their work on the body of knowledge and position papers through professional organizations. While the basic information within our profession does not require citation, there are several documents that support the need for modern educational programs and competencies (2, 3, 4, 5, 6).

Phlebotomy and Specimen Collection

This coursework provides students with the tools necessary to collect various types of specimens and perform venipuncture techniques for the collection of blood. Additionally, the student can assess and perform collections with proper order of draw, knowledge of the use of preservatives and anticoagulants, and apply basic principles of specimen rejection when necessary. The entry level competency for phlebotomists and medical laboratory scientists includes the ability to perform venipuncture successfully on most patients and discuss and use alternative methods for patients with special complications such as the very young or old, cancer patients, and morbidly obese patients. This includes appropriate specimen collection for the type of test ordered and recognizing collection errors such as non-sufficient quantities, hemolysis, or other problems. Proper identification and labeling of specimens along with proper use of personal protective equipment is vital to phlebotomy and specimen collection.

Hematology

The hematology coursework required in MLS programs focuses on normal and abnormal production, structure and function of blood cells and the pathophysiology of malignant and non-malignant hematological disorders. Students identify organ systems of hematopoiesis and immunogenesis and the function of the lymphoid organs. Additionally they will correlate normal and abnormal states of erythropoeisis, granulopoeisis, red blood cell poikilocytosis, and non-hematopoietic cells. This includes issues of iron storage, vitamin B12 and folate deficiencies, cellularity, and other disorders of the bone marrow or red blood cell production. The medical laboratory scientist must possess the ability to perform automated and manual differentials with identification of all stages of red and white blood cells, evaluation of bone marrow, and the use of various cytochemical stains for the identification of cellular material and potentially pathogenic conditions reflected in blood, bone marrow, and body fluid smears. All new professionals should also be able to evaluate and analyze red blood cell indicies such as mean cell hemoglobin (MCH), mean cell volume (MCV), red cell distribution width (RDW), and mean cell hemoglobin concentration (MCHC) and their relationship to various pathologic conditions. Entry level competencies in hematology also require knowledge of normal and abnormal assembly and function of hemoglobin, altered hemoglobin derivatives, and qualitative and quantitative disorders of hemoglobin.
Besides red blood cell and white blood cell abnormalities, the entry level medical laboratory scientist working in the coagulation section must be familiar with coagulation factors for the intrinsic, extrinsic, and common pathways, as well as platelet function and vitamin deficiency in hemostasis. This also includes common problems with specimen collection as they relate to anticoagulants and other factors that may influence coagulation testing. The entry level professional must utilize prothrombin time, INR, activated partial thromboplastin time, activated clotting time, thrombin clotting time, fibrinogen assays, and factor assays to correlate clinical significance, run controls, and identify errors in testing. Medical laboratory scientists must be able to perform testing using automated techniques in coagulation and flow cytometry to identify disorders of the blood.

Microbiology

Microbiology ultimately involves the identification of various microbes that cause human disease. While broad concepts span basic principles in human, veterinary, environmental, and industrial microbiology, the focus for medical laboratory scientists are on the medically relevant techniques for identification. Coursework requires knowledge of basic bacteriology such as microbial genetics, cell structure, and pathogenic factors, including toxins, adhesion molecules, capsules, growth requirements, and immune evasion. Training includes principles of bacterial isolation, antimicrobial resistance, antimicrobial testing, antibiograms, and tests designed to determine minimum inhibitory and bactericidal concentration of isolates. Additionally, the MLS programs include biohazard safety, sterilization, and infection control methods for the safe handling and culture of microorganisms.
Most programs have at least two courses with one being bacteriology and the other a combined parasitology, virology, and mycology course. The bacteriology course focuses on the identification of organisms by growth conditions, shape, and Gram stain reactions. These groups include aerobic gram-positive cocci, gram-negative cocci, gram-positive bacilli, mycobacteria, and anaerobes. Generally more importance is placed on the more commonly isolated microganisms, including those with potentially high drug resistance, high pathogenicity, high potential for spread, and those considered possible biological weapons.
The MLS must also be trained in techniques for the isolation of fungi and parasites. This includes the identification of diagnostic forms in samples and basic information on the spread of each. Virology education is focused mainly on the use of culture in conjunction with immunoassays for identification of viruses, but also includes cytopathic effect as a mechanism for identification. Entry level competency in the microbiology lab requires new professionals to differentiate, classify, and characterize bacteria phenotypically by colony morphology, shape, Gram stain reaction, and biochemical characteristics through classical and molecular techniques. They need to examine specimens for proper source and acceptability, and identify proper storage conditions for various body fluids. Microbiologists will also select appropriate media and tests for primary and specialized isolation of bacteria including proper technique for inoculation, atmospheric conditions required for growth, and correct incubation time for each specimen. Upon direct examination or from culture the new professional must prepare, stain, and interpret microscopic smears of specimen using a variety of stains and methods (some examples include Gram stain, acid fast, KOH, fluorescent and dark field microscopy). This includes differentiating normal flora from potentially pathogenic organisms based on body site and specimen

type cultured through colony morphologies and other reactions on all general and specific microbial media. New MLS professionals are required to evaluate growth on primary isolation media and apply principles of identification to identify pathogens of significance and relate them to diagnosis and pathology through the use of commercial and immunologic methods to identify pathogenic bacteria. They must apply standard performance principles and quality control methods to antimicrobial susceptibility tests to identify susceptible, intermediate, or resistant isolates of various bacteria.
In addition to bacteria, professionals must describe the basic characteristics of fungi including various forms, specialized structures, growth requirements, and various morphologic features and select appropriate media and tests for primary and specialized isolation of fungi. To identify fungi, laboratorians must select proper technique for inoculation, isolation media, and atmospheric conditions for growth, including the correct incubation time for each specimen and differentiate normal flora from potentially pathogenic organisms based on body site and specimen type.
Additionally all entry level professionals must recognize diagnostic structures, diagnostic stages, and pathology associated with all major classes of human parasites. Besides bacteriology, mycology, and parasitology they must differentiate the requirements and characteristics of viruses from other microbes including the molecular, immunological, and culture techniques for isolation and diagnosis along with the pathologies associated with each viral infection.

Clinical Chemistry

Clinical chemistry focuses on the study of chemical analyses of body fluids including the blood, cerebral spinal fluid, urine, and other specimens. This involves assessment of the endocrine system, metabolism, lipids and lipoproteins, carbohydrate metabolism, enzymes, electrolyte balance, blood gases, therapeutic and drug abuse monitoring, and correlation of results with normal or pathological states of homeostasis. This training includes the use of laboratory instrumentation and total quality management of such processes using modern statistical analysis.
The entry level competency in clinical chemistry includes basic calculations in percentage, normality, osmolarity, unit conversion, dilutions, and statistical analysis of data such as mean, mode, median, standard deviation, coefficient of variation, confidence limits, correlation, variation, and reference intervals. These calculations provide the basic skills needed for interpretation of tests and quality control of instrumentation.
The laboratory professional is competent in the use of spectrophotometers, fluorimeters, osmometers, pH meters, blood gas instruments, refractometers, balances, centrifuges, and heating units. This includes the maintenance, performance, quality controls, and standard curves required for these pieces of laboratory equipment and instrumentation. In clinical chemistry the entry level professional also must use various techniques such as electrophoresis, chromatography, densitometry/nephalometry, coulometric, amperometry, and other automated instrumentation.
While entry level professionals may not always use the same brand or technique for various assays they must be familiar with the techniques and how they apply to new instruments. Due to the tremendous advances in automation in this laboratory area, there is increased emphasis in evaluating quality control data to assure instrumentation is within established parameters and that samples are within standard reference ranges. The new professional will need to create standards and take corrective action when instrumentation fails to meet acceptable standards.

Body Fluids and Urinalysis

The study of body fluids and urinalysis involves the proper collection of urine and body fluids, and the assessment of the chemical, physical, and microscopic properties of these fluids. Training includes the microscopic finding of various cellular elements such as casts, crystals, RBCs, and WBCs in fluids as they relate to human pathology. The entry level professional clearly can identify and discuss the macroscopic and microscopic anatomy of the renal system, its physiology, and normal changes to the urine in different physiologic conditions such as hyperhydration and dehydration. This includes the function and effects of hormones such as renin, angiotensin, and aldosterone. Besides the normal functions, the professional must relate laboratory findings to acute and chronic renal pathology, and genetic disorders that manifest in the urine.
In addition to basic anatomy and physiology of the renal system, new professionals must be able to collect and/or advise collection personnel on urine collection techniques and specimen preservation for collections such as first morning urine, clean catch, suprapubic aspirations, pediatric collections, and timed specimens. Once the specimen is received, the MLS entry level professional must be able to perform macroscopic and microscopic evaluations of the physical and chemical characteristics of the urine like density, bilirubin, ketones, glucose, pH, proteins, blood, and white blood cells. Additionally the entry level MLS professional should be able to perform the basic quality control steps as they relate to pre-analytical, analytical, and post-analytical errors and use of instrumentation.

Immunohematology

All baccalaureate MLS programs require mastery of the content guidelines in immunohematology. These areas include ABO and Rh typing, antibody screen and identification, cross-match, blood donation, transfusion therapy, evaluation of transfusion

reactions and hemolytic disease of the fetus and newborn, and special testing such as DAT, phenotyping and genotyping, elution/adsorption, antibody titer, pre-warm techniques, Rosette, and Kleihauer-Betke. This includes the use and release of all blood products and the FDA guidelines associated with the use of such products.

Entry level competencies include physical and patient history requirements of the blood donor, assessment for adverse reactions in blood donors, and testing of units for infectious diseases like Human Immunodeficiency Virus, Hepatitis virus, and West Nile Virus. Professionals must know the basics of specimen processing for isolation and use of cellular and plasma components of donor blood like red blood cells, platelets, granulocytes, plasma, cryoprecipitate, and other components including proper storage. Due to the high risk of adverse reactions in immunohematology, entry level competency is strict. New professionals must be able to assess and prevent pre-analytical errors related to sample labeling, sample handling, and use of anticoagulant. All entry level scientists must be able to recognize hemagglutination and hemolysis using automated and manual methods such as tube, gel, and solid phase technologies. This includes type and screen for antibodies and methods used to identify antibodies affecting blood transfusion. The entry level scientist will be able to identify common antibodies and cold agglutinins, or refer more complicated situations to senior staff or to reference laboratories. In general the most important functions are to identify blood type, any antibodies present and to cross-match units effectively that will benefit patients needing packed red blood cells.

In order to assess and release units of blood, a basic understanding of the genetics of various red blood cell antigens is required, including issues like secretor and non-secretor status, situational exposure events to red blood cell antigens, and dose dependence. Given the urgency of this area, all new professionals must be able to troubleshoot discrepant results of ABO typing, agglutinations, autoantibodies, and other discrepancies, including investigation of transfusion reactions. Additionally all MLS professionals must be aware of and comply with Food and Drug Administration (FDA), American Association of Blood Banks (AABB), and College of American Pathologists (CAP) regulations.

Education, Research, Management, and Laboratory Operations

All MLS programs require students and graduates to show competency in the ability to read, interpret, and critically analyze research including papers, posters, and other scientific data. Each graduate should be able to teach peers and other personnel adequately using modern teaching techniques and guidelines such as preparation and assessment of measurable objectives. Each MLS professional requires education in general laboratory management including labor laws, safety laws, budget preparation, cost controls, and management techniques critical to staff supervision in the laboratory. Since laboratories are highly regulated; it is a must that new professionals are familiar with basic governmental and accreditation agencies that oversee laboratory testing. The entry level professional is not expected to have a large degree of management experience but they should be able to critically think about problems affecting the laboratory, read and interpret a basic budget, and educate other trainees or new professionals.

Clinical Practicum

Clinical Practicum experiences in all areas of the laboratory are completed at the laboratory bench under the guidance of trained and certified professionals working in hospitals and clinics. All MLS programs use clinical practica to assure that each graduate completes the minimum competency standards of a new professional employee. University-based programs affiliate with various hospitals to provide training in the four major areas of the laboratory. Both hospital and university programs use the clinical experience as a time to polish professional skills, establish competency prior to taking a certification exam, and create uniform experiences for all students. Ultimately, coursework provides the opportunity to learn and make mistakes, while the clinical practicum provides real world experience in the laboratory that is difficult to produce in university programs. The clinical practicum along with course competencies assures that graduating students will meet the entry level qualifications for new graduates.

Certification

Certification is a vital step for the new professional. It establishes professional competency and a universal standard of expertise for all MLS professionals. This assists hiring managers and medical facilities in identifying expertise and establishing position requirements. In the United States, there are a few certification agencies that establish professional qualifications. These include the American Society for Clinical Pathology's Board of Certification (BOC), the American Medical Technologists (AMT), and the American Association of Bioanalysts (AAB). All three of these organizations require the MLS professional to pass a competency examination that contains questions over all areas of MLS practice. The examination content guidelines correspond to the required curriculum in NAACLS Standard 22B and to the accepted entry level skills required for MLS positions.

In order to become eligible to take the certifying examination most students attend and graduate from a NAACLS-accredited program which is designed to ensure appropriate coverage of relevant topics, assure program quality, and establish fair practices for students. Upon completion of an accredited program, professionals receive their degree and/or certificate of completion which is submitted to the certification organization. Occasionally there are situations where professionals with baccalaureate

degrees in related fields and several years of laboratory experience either as a medical laboratory technician or laboratory assistant will qualify under a special experiential track.

NAACLS Accreditation Standards

The NAACLS accreditation standards currently consist of 19 core standards plus 3 unique standards for MLS programs. These 22 standards are listed in Table 3 (3). Standards 1-3 determine the location, sponsorship, and responsibilities of the sponsor in operating an accredited program. The clinical practicum must be overseen by the program sponsor to assure its educational value. This includes taking applications, and managing degrees and certificates awarded from the program. Standards 4-6 assess the sponsoring program's access to required resources. This assures that each operating program has the appropriate number of faculty and staff to support its students, a budget or other statement of financial support for the purchase of educational materials for the program, modern equipment, and adequate laboratory and lecture space for students. Standards 7-9 require that each education program note their accreditation and describe their program in its entirety including is rules, regulations, goals, mission, fees, essential functions, requirements of student conduct, and other documents governing the admission, matriculation, and completion of the program. Standard 10 specifically requires all programs to maintain records of grades and completion of the program so other institutions, certification bodies, and employers can verify completion of training. Standards 11-14 protect the student from harm by insuring adequate health of the student via completion of a physical and attestation of the ability to complete the essential functions. Additionally students must be protected from harm with appropriate safety protocols, emergency care, and health service for injuries during the program. These standards assure proper guidance and advising of students through the program, in completing the certification examination, and in finding employment. Each program must also have appeal procedures to protect the rights of students that may feel they received inappropriate treatment, denial of acceptance, or other concerns important to students' rights. The standard on fair practices prevents discrimination of faculty and students for admission or employment in MLS programs. Standards 15 through 18 require documentation of systematic review of program content, program objectives, learning outcomes, and statistical analysis of student performance in order to measure program effectiveness and modify areas that fall short of expectations. Each program must have a plan in place to collect and measure data on its program objectives, student outcomes such as exam scores and placement rates to ultimately create a continuous improvement plan. Additionally programs must submit data on graduation rates, certification exam results, and placement rates. Standards 20-22 are designed to evaluate the qualifications of the faculty and make sure that a qualified program director is appointed. Additionally each faculty member must maintain certification and appropriate professional development to remain current in the field of medical laboratory science. Even though faculty are evaluated for qualifications, the program must be advised by an advisory committee made up of professionals and community members that oversee the program and provide feedback to the program director and faculty regarding instruction and other issues impacting the program and students.

Table 3
NAACLS Standards for MLS Program Accreditation

Standard 1: Institutional Affiliation
Standard 2: Sponsorship
Standard 3: Responsibilities of the Sponsor
Standard 4: General Resources
Standard 5: Financial Resources
Standard 6: Physical Resources
Standard 7: Program Description/Publications
Standard 8: Admissions
Standard 9: Acceptable Conduct
Standard 10: Student Records
Standard 11: Health and Safety
Standard 12: Guidance
Standard 13: Appeal Procedures
Standard 14: Fair Practices
Standard 15: Systematic Review
Standard 16: Outcome Measures
Standard 17: Graduation and Placement Rates
Standard 18: Program Evaluation and Modification
Standard 19: Program Sponsor Responsibilities
Standard 20: Program Administration
Standard 21: Faculty
Standard 22: Curricular Requirements

In summary, NAACLS has established strong criteria for accreditation that ensures each program is evaluated in an extensive and exhaustive process to assure that programs maintain the highest standards of competency, student advocacy, fairness, and student preparedness in MLS education. The accreditation process is the cornerstone for providing quality MLS education.

Conclusion

Medical Laboratory Science Programs in the United States have specific educational requirements to meet entry level competency. The culmination of training for the medical laboratory science professional is the baccalaureate degree from a NAACLS-accredited program. Accredited programs assure the quality of the program and help students choose a reputable program that meets their career goals. There is a tremendous amount of knowledge that goes into preparing students for a career as a medical laboratory scientist. This is a diverse and detailed curriculum in anatomy and physiology, microbiology, hematology, chemistry, immunology, and management with a strong emphasis on quality control processes. After all, our work directly affects patient care and decision making. Even though we are scientists first, it is important that our professionals are well rounded in their education so that they can communicate with other highly educated professionals such as physicians, pharmacists, nurses, and other professionals in their work environment.

Since educational preparation does not always lead to competency, our certification examination remains a key part of competency. All professionals, regardless of their training program, should pass a national examination to establish competency so that each professional has met minimum standards to practice in their field. Thus, with proper education and independent competency testing, each professional possesses the necessary entry level competencies to begin work as medical laboratory scientists.

References

1. Kotlarz, VR. Tracing our roots: the rocky road toward recognition of clinical laboratory science's professional status (1962-1977). Clin Lab Sci. 2000 Summer; 13(2):166-71.
2. American Society for Clinical Laboratory Science, Practice levels and Educational Needs for Clinical Laboratory Personnel, Position Paper, July 25, 2009 found at http://www.ascls.org/about-us/voice-your-opinion/position-papers/173-levels-of-practice, last accessed 1 March 2013.
3. NAACLS Guide to Accreditation, found at http://www.naacls.org/accreditation/newguide_accreditation.asp, last accessed 1 March 2013.
4. American Society for Clinical Laboratory Science, Scope of Practice, Position Paper. Aug. 2, 2001, found at http://www.ascls.org/about-us/voice-your-opinion/position-papers/186-scope-of-practice, last accessed 1 March 2013.
5. American Society for Clinical Laboratory Science, Model Career Ladder, Position Paper, July 2004, found at http://www.ascls.org/about-us/voice-your-opinion/position-papers/179-model-career-ladder, last accessed 1 March 2013.
6. Anderson-Young, S. (Ed.). (2004). Body of Knowledge. The American Society for Clinical Laboratory Science, McLean, VA: CD publication.