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Meeting the Curriculum Needs for Different Career Paths in Laboratory Medicine

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Abstract

There are a number of career paths in Laboratory Medicine and several clinical practice models for the discipline. This article summarizes the state of current training at the medical student and residency/post-graduate levels, emphasizing practice in the U.S., and the challenges of education in the discipline to meet the needs of diverse career paths. Data regarding effectiveness of current pedagogical Approaches are discussed along with a brief review of evolving didactic methodologies. The recently published curriculum in Laboratory Medicine (Clinical Pathology) by the Academy of Clinical Laboratory Physicians and Scientists is reviewed, including its major emphases and the importance of competency assessment. Finally, the future of Laboratory Medicine and Pathology and the need to train for that future is expanded upon.

Keywords

Laboratory Medicine; Clinical Pathology; Curriculum; Education; Medical School; Residency

1. Current State of Post-Graduate Training in Laboratory Medicine

The discipline of laboratory medicine (clinical pathology) is practiced in diverse ways throughout the world. In the U.S., for M.D. trainees, the discipline, and training in the discipline, is generally carried out as a comprehensive whole including clinical chemistry, hematology, microbiology, immunology, laboratory management, molecular pathology, informatics, and transfusion medicine (including apheresis) [1]. Residency programs in clinical pathology (C.P.) training that include all these areas are certified by the nationally recognized Accreditation Council for Graduate Medical Education (ACGME). Physicians who have completed an ACGME accredited program are then individually certified to practice, following additional testing and review of qualifications, by the American Board of Pathology (ABP).

Anatomic Pathology (A.P.) training in the U.S. encompasses surgical pathology, autopsy, cytopathology, forensics, molecular pathology, dermatopathology, hematopathology, laboratory management, and informatics [2]. Certification in A.P. follows a similar paradigm. Individuals desiring certification in just C.P. or just A.P. are expected to train for three residency years following graduation from medical school. Unlike training in some other medical disciplines, a preparatory, separate broad-based internship year is not required, that is, post-

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graduate training begins directly in pathology itself. Training programs must have formal curricula and must have defined and measurable outcomes for the trainees.

Those who wish to be certified in both A.P. and C.P. must train for a minimum of 4 y after medical school. This represents a somewhat recent change in requirements; prior to 2002 a total of 5 y training was required. It should be noted that the majority (80–85%) of current pathologist trainees in the U.S. choose to learn both C.P. and A.P. and to become certified to practice both.

Once trained in C.P., further fellowship training and certification is available in the subspecialties of Chemical Pathology (Clinical Chemistry), Hematology (Hematopathology), Medical Microbiology, Transfusion Medicine (Blood Bank), and Molecular Genetic Pathology. All of these fellowships involve one year of training for those previously trained in C.P.. All newly certified pathologists must participate in “maintenance of certification”, otherwise their certification expires over the course of 8–10 y.

For Ph.D. Laboratorians in the U.S., the route to certification and practice is potentially more diverse [3]. National regulations generally require a doctoral degree in a chemical, physical, biological, or clinical laboratory science accompanied by certification by a board approved by the U.S. Health and Human Services administration. Two of the more common board certifications are through either the American Board of Clinical Chemistry (ABCC) for those destined to direct chemistry, toxicology or molecular diagnostic laboratories or through the American Board of Medical Microbiology (ABMM) for those directing microbiology, virology and public health laboratories. Certification requirements of these Boards generally involve either 3–5 y postgraduate experience, or training in a post-doctoral program approved by the Commission for Accreditation in Clinical Chemistry (COMACC) or the Commission for Postdoctoral Education Programs (CPEP) of the American College of Microbiology. The other Boards all have varying requirements for certification. Because of this variability, and because there is no required defined curriculum for Ph.D. laboratory directors, these laboratorians can represent a more heterogeneous group.

In other areas of the world, there is also a heterogeneous set of criteria for training and certification for the practice of Laboratory Medicine, both for M.D.s and for Ph.D.s. Nevertheless, efforts such as those of the European EC4 group and its successor EFCC (European Federation of Clinical Chemistry and Laboratory Medicine) are beginning to bring much greater uniformity to the discipline, much to the benefit of medical practice [4–6]. The hope remains for a truly international consensus on the best approaches to post-graduate training and certification in Laboratory Medicine.

2. Current State of Graduate Training in Laboratory Medicine

Part of the challenge in creating an appropriate curriculum for post-graduate Laboratory Medicine training lies in the knowledge base that individuals have from their graduate medical (M.D.) and/or scientific (Ph.D.) years. Among U.S. medical schools, 95% report including some laboratory medicine training but this often occurs in didactic venues predominantly oriented toward therapy rather than diagnosis and the teaching staff for these encounters are often non-laboratorians [7,8]. Consensus curricula for medical students in clinical pathology are almost non-existent, with the exception of a published Transfusion Medicine curriculum [9]. Recently, some basic principles that should be included in medical graduate education for all students have been discussed [10]. Nevertheless, a number of studies have shown poor performance of both medical students and non-C.P. residents in even basic interpretation of laboratory data [11]. Overall, then, the fund of Laboratory Medicine knowledge of medical students entering their residency in clinical pathology is quite limited and hence post-graduate

training must begin at a very basic level and move trainees rapidly to the higher levels needed for good clinical practice.

There is similarly relatively little available to guide the education of a Ph.D. graduate student aiming for an eventual career at the doctoral level in the clinical laboratory sciences [3]. While there has been some work done to utilize optimized 'evidence based' approaches to the teaching of undergraduate biomedical sciences that have occasionally considered the clinical laboratory career path as well as research and industrial laboratory pathways [12], there is a paucity of work done to specifically target Ph.D. level training in Laboratory Medicine. Of note, there is now an ongoing effort by the Academy of Clinical Laboratory Physicians and Scientists (ACLPS) to develop a realistic "essential" curriculum in Laboratory Medicine that would be of utility to all future medical practitioners. The Academy, founded in 1966 and composed of over 600 members from greater than 100 academic institutions, includes both M.D. clinical pathologists and Ph.D. laboratory scientists and seems well-poised to advance the cause of graduate level education in the field in addition to its efforts at the post-graduate level [1].

3. How well are we currently training Laboratory Medicine practitioners?

As noted earlier, career paths in Laboratory Medicine are several and those who come to post-graduate training have not necessarily been given a firm basis on which to build their clinical skills. These career paths include (in the U.S.), simultaneous community practice of both anatomic and clinical pathology, academic practice (often of just A.P. or C.P. alone or even a subspecialty of A.P. or C.P.), commercial laboratory practice (usually C.P. alone), and industry-based practice in a pharmaceutical, biotechnology, or diagnostic company setting [13]. Within the academic and industry-based options, C.P. career paths can include predominantly clinical service work, predominantly bench research work, or a combination of both. Interestingly, as community pathology practices grow in size, driven in part by the increasing complexity and breadth of both A.P. and C.P., specialization (into A.P. or C.P.) and subspecialization is becoming a more frequent approach, similar to what has been true in only academic and very large medical centers in the past.

Are there data to elucidate how well our current post-graduate residency educational approaches meet the needs of these different career paths? One way to address the question is to look at standardized testing and assess how well trainees perform. Barbara McKenna has examined the results of the Resident In-Service Examination (RISE) [14]. The RISE is produced by the American Society for Clinical Pathology (ASCP) in collaboration with ACLPS and the Association of Directors of Anatomic and Surgical Pathology (ADASP). The examination is taken by virtually all pathology residents (A.P. and/or C.P.) in the U.S. and increasing numbers of residents in Canada, Ireland, Lebanon and Australia. Dr. McKenna analyzed the increase in mean scores for various subsections of the examination over the 4–5 y of residency training. Although scores increased in all topics, there was a statistically significant difference in improvement between topics. Scores in clinical chemistry, microbiology, forensic pathology and laboratory administration increased significantly less than those in transfusion medicine, hematopathology/hematology, surgical pathology, and cytopathology. While there are many possible explanations, one interpretation would be that education in some core C.P. disciplines (e.g., chemistry, microbiology and administration) was less successful than in most of the A.P. disciplines and less successful than for transfusion medicine and hematology.

Another way of attempting to address the question of successful training is to survey both graduating trainees as they enter their first pathology job as well as surveying their employers. The Future of Pathology Task Group has conducted such a survey [15]. Of note, the areas that trainees themselves rated as being least prepared in and the areas that employers rated them

least prepared in were the same. These areas of less optimal preparation again included chemistry, microbiology and laboratory management. Although not definitive, these data all suggest a need for improved pathology residency training in clinical pathology, especially with respect to chemistry and microbiology as well as in managerial skills.

4. The ACLPS Laboratory Medicine Curriculum

Recognizing the challenges elucidated above, ACLPS elected to develop a Laboratory Medicine Curriculum that was competency-based. The development process included the review of six published curricula in subspecialty areas and unpublished curricula from eleven U.S. residency programs by an ad hoc steering committee of 15 M.D. and Ph.D. Laboratorians from 11 institutions. The curriculum was reviewed by a separate group of 20 experts drawn from community practice, academia and industry and then further reviewed by the entire membership as well as pathology residency program directors. The curriculum was simultaneously published in 3 journals [1] and was discussed in several additional editorials and commentaries [16–19]. Essential features included: (1) 3 levels of graduated responsibility in the training, the first 2 for both C.P.-only and A.P./C.P. trainees, and the third for C.P.-only trainees (or for those who expect to devote a high proportion of their future clinical duties to C.P.); (2) an emphasis on subdiscipline-based intensive initial training, at least at level I, rather than carrying out initial training in a “generalist” mode of attempting to learn many aspects of A.P. and C.P. at once; (3) a need to train for the future of laboratory medicine and not just the past, that is, inclusion of areas likely to become mainstream within five to ten years; (4) delineation of specific defined competencies that need to be demonstrated by trainees as they progress. The third rung on the three level training ladder, designed for those with anticipated intense clinical activities in C.P., was envisioned as including several possible tracks: (1) investigative laboratory medicine, especially designed for clinician-scientists [20]; (2) clinical subspecialization via extensive apprenticeship activities; (3) management intensive training, possibly combined with an MBA or similar degree program [21]

The overall goals of the curriculum were elucidated as the development of a clinical pathologist with the following characteristics: (1) A pathologist capable of communicating as a medical consultant to other clinicians and to patients, as well as being capable of optimally directing the management of the clinical laboratory enterprise; the clinical pathologist understands the science and technology of the clinical laboratory and assures the quality, clinical appropriateness, and usefulness of the data produced by that laboratory; the pathologist is a clinician first and foremost; (2) A pathologist who understands and consults on methods of diagnostic test development, test utilization in the context of both generally applicable as well as patient-specific clinical settings, and assay interpretation in the acute and chronic clinical management of patients; these activities include the pathologist’s role in the development and implementation of integrated medical informatics that optimize patient care; the specific level of technical expertise attained in training will vary with career goals/roles and with the emphasis of the training program itself; (3) A pathologist who understands methods and implementation of clinical laboratory-based therapeutics, including minimally manipulated and engineered cellular therapy; the specific level of technical expertise attained in training will again vary with career goals/roles of the trainee and with the emphasis of the training program; (4) A pathologist who has the skills to consult in these areas at the broader systems level, and in the various extant healthcare delivery models; (5) A pathologist who understands the role of research, in its broadest definition, in clinical decision-making, test development, knowledge generation, and continuing education.

Although aimed primarily at M.D. clinical pathologists, the curriculum can also be used as a basis for training subdiscipline Ph.D. specialists. At least in the U.S., many Ph.D. postgraduate training programs utilize a co-training paradigm with M.D.s and Ph.D. laboratorians sharing

many of the same experiences [3]. It is also true that many individuals who pursue clinical pathology as a career come from an M.D./Ph.D. background, which seems especially suited to a discipline that is quite friendly to a physician-scientist career [22].

5. Didactic Methodologies in Laboratory Medicine Training

In the ACLPS Laboratory Medicine curriculum document, a variety of didactic methodologies were discussed, including knowledge-based and skills-based activities, graduated responsibility, the value of case-oriented formats, the critical aspects of consultation, "apprenticeship" activities, and some "hands-on" activities as appropriate to the specific program and career of the trainee. An on-call schedule for trainees, operating *in toto* 24/7 and with appropriate attending backup, was considered essential to attaining competency in the field. It was also felt that a meaningful and substantive research and development project was similarly essentially and that a single (or relatively few) in-depth such experiences would be preferable to a series of multiple smaller projects.

Subsequent to the publication of the curriculum, work was done to begin to explore the popularity and effectiveness of different didactic activities. Interestingly, trainees rated "apprenticeship activities" as the most useful of their experiences, followed by "morning report" and didactic lectures, with journal club felt to be the least valuable overall [23].

As noted earlier, some data suggest that chemistry, microbiology, and laboratory management may be the least well-assimilated areas of practice for the broad spectrum of M.D. pathology resident trainees in the U.S. Some recent work has been done to survey program directors responsible for chemistry education to help delineate what their perception of the difficulties may be [24]. Among the challenges identified by these educators, >50% noted "lack of interest" by the trainees as relevant with some comments suggesting that the "non-visual" nature of the discipline (as opposed, for example, to hematology) led to this attitude by some trainees. Approximately 27% noted problems when training in chemistry was carried out with simultaneous responsibilities of the trainees in other disciplines (for example, A.P. specialties). Thirty-five percent noted the challenge of "new technologies" and 22% the breadth of the discipline as facts that made it difficult to adequately train future practitioners. Thirty-nine percent felt that the 2002 change from a five year minimum for training in both A.P. and C.P. to a 4 minimum had had an adverse effect on attaining competency in clinical chemistry.

6. The Future of Training in Laboratory Medicine

There remain great challenges in providing a combination of educational programs at the undergraduate, graduate and postgraduate levels that will continue to produce excellence in Laboratory Medicine practitioners. In the U.S. system for M.D. trainees, questions have been raised as to whether four years will remain truly adequate to obtain substantial and long-lasting competency in all aspects of both anatomic and clinical pathology, both of which are burgeoning in complexity [2,13]. The answer to this question is not yet definitive, but the early data suggest no difference between four and five year trainees, at least in terms of performance on the American Board of Pathology examination [25]. While this is very encouraging, further assessment remains a priority of credentialing organizations.

One critical aspect of assuring lifelong learning and lifelong re-assessment of competency has been initiated in the U.S.. Specifically, this involves more formalized "maintenance of certification" (MOC) [26]; that is, certification by the American Board of Pathology is no longer lifelong but rather practitioners must be recertified on an ongoing basis. Whether these new requirements will alter the nature of practice, for example, encouraging further subspecialization after post-graduate training so that one might choose to retain certification in only A.P. or C.P. or in a subdiscipline of A.P. or C.P., remains to be seen. There are

indications that there is a trend toward larger community pathology practices that would more easily accommodate such a paradigm, which may be driven not by MOC needs *per se* but rather by what these requirements reflect: a rapid growth in breadth and complexity of the discipline of pathology as a whole (A.P. and C.P.) and the possible need to move toward greater specialization in order to optimize clinical practice.

The final critical issue hovering over any discussion of training is the one alluded to earlier: what will Laboratory Medicine and Pathology "look like" in the next decade? Clearly the "omics" will expand (proteomics, genomics, metabolomics) and there is a suggestion that diagnostic imaging and anatomic pathology will move closer together. Improved informatics will be a crucial core of all medical practice, including our disciplines. Two other aspects of Laboratory Medicine must also be kept in mind, however. First, the need for individualized patient consultation by Laboratory Medicine practitioners will continue to expand as diagnostic testing becomes increasingly complex. In our own institution, while we continue to practice "systems" medicine, that is, all the aspects of the laboratory that are directed toward improving and maintaining excellent care across a large group of patients, we also note a progressively increasing demand for individualized patient consultation, in toxicology, therapeutic drug monitoring, genetic diagnostics, and indeed all areas of Laboratory Medicine. As practitioners, we are used to doing many of these consults as "sidewalk consultations", i.e., restricting the communication to verbal encounters with other physicians and health care providers. However, as the number of providers caring for an individual patient continues to grow dramatically in our complex, subspecialized world, there is increasing need for these previous less-formal consultations to find their way into the medical record so that critical knowledge about a patient is not lost [27]. We must be training the next generation of Laboratory Medicine practitioners to take up this challenge.

Finally, it may be worth noting that we have traditionally emphasized "diagnosis" in most areas of pathology practice. However, laboratory-based medicine is increasingly important for monitoring (and choosing) therapy. Much of the growth in Laboratory Medicine is therapeutically oriented: disease management guidelines, pharmacogenetics, tetramer analysis in immunotherapy, and so forth. In Transfusion Medicine, individualized cellular therapy has a bright future alongside stem cell treatments and cellular engineering. Thus, it is necessary to suggest that we take a cue from our radiology colleagues and begin to consider ourselves as practitioners of "Therapeutic Laboratory Medicine" and "Therapeutic Pathology", and not limit ourselves to considering our discipline as solely the "diagnostic" specialty.

Our trainees, regardless of the details of their chosen career path, have a very bright future to look forward to. The discipline is expanding dramatically. It is the duty of Laboratory Medicine educators to meet these challenges and create a next generation prepared to further advance medical practice.

References

1. Smith BR, Wells A, Alexander CB, Bovill E, Campbell S, Dasgupta A, Fung M, Haller B, Howe JG, Parvin C, Peerschke E, Rinder H, Spitalnik S, Weiss R, Wener M. for the Academy of Clinical Laboratory Physicians and Scientists. Curriculum Content and Evaluation of Resident Competency in Clinical Pathology (Laboratory Medicine): A Proposal. *Human Pathol* 2006;37:934–68. [PubMed: 16867855] *Amer J Clin Pathol* 2006;125(Suppl 1):S3–S37. [PubMed: 16830955] *Clin Chem* 2006;52:917–949. [PubMed: 16569705]
2. Association of Directors of Anatomic and Surgical Pathology. Curriculum content and evaluation of resident competency in anatomic pathology: a proposal. *Am J Clin Pathol* 2003;120:652–660. [PubMed: 14608889] *Hum Pathol* 2003;4:1083–1090.
3. Scott MG, Dunne WM, Gronowski AM. Education of the Ph.D. in Laboratory Medicine. *Clin Lab Med* 2007;27:435–46. [PubMed: 17556095]

4. Zerah S, McMurray J, Bousquet B, Baum H, Beastall GH, Blaton V, Cals MJ, Duchassaing D, Gaudeau-Toussaint MF, Harmoinen A, Hoffmann H, Jansen RT, Kenny D, Kohse KP, Koller U, Gobert JG, Linget C, Lund E, Nubile G, Opp M, Pazzagli M, Pinon G, Queralto JM, Reguengo H, Rizos D, Szekeres T, Vidaud M, Wallinder H. European Communities of Clinical Chemistry, EC4 Register Commission. EC4 European Syllabus for Post-Graduate Training in Clinical Chemistry and Laboratory Medicine: version 3 - 2005. *Clin Chem Lab Med* 2006;44:110–20. [PubMed: 16375596]
5. Lippi G, Guidi GC, Plebani M. One hundred years of laboratory testing and patient safety. *Clin Chem Lab Med* 2007;45:797–8. [PubMed: 17579534]
6. Sanders GT, Beastall GH, Kohse KP, Zerah S, Jansen R, Koller U, Blaton V, Lund E, Parviainen M, Charret J, Gurr E, Nicholou H, Kenny D, Pazzagli M, Opp M, Willems H, Martins M, Do C, Queralto JM, Landin B, Yu A, McMurray J. The practice of clinical chemistry in the European Union. *Clin Chem Lab Med* 2002;40:196–204. [PubMed: 11939495]
7. Kumar K, Indurkha A, Nguyen H. Curricular trends in instruction of pathology: a nationwide longitudinal study from 1993 to present. *Hum Pathol* 2001;32:1147–53. [PubMed: 11727251]
8. Clejan S, Crawford B. Modalities of teaching Laboratory Medicine in the 21st century. *Pathology Education* 2001;25:70–81.
9. Cable RG, Thal SE, Fink A, Calhoun L, Petz LD. A comprehensive transfusion medicine curriculum for medical students. *Transfusion Medicine Academic Award Group Transfusion* 1999;35:465–9.
10. Park YA, Marques MB. Teaching Medical Students Basic Principles of Laboratory Medicine. *Clin Lab Med* 2007;27:411–24. [PubMed: 17556093]
11. Bergus G, Vogelgesang S, Tansey J, Franklin E, Feld R. Appraising and applying evidence about a diagnostic test during a performance-based assessment. *BMC Medical Education* 2004;4:20. [PubMed: 15482600]
12. Edgren G. Developing a competence-based core curriculum in biomedical laboratory science: a Delphi study. *Medical Teacher* 2006;28:409–17. [PubMed: 16973452]
13. Wells A, Smith BR. The Goals of Resident Training in Laboratory Medicine in Combined Anatomic Pathology/Clinical Pathology Programs: An Overview. *Clin Lab Med* 2007;27:229–40. [PubMed: 17556082]
14. McKenna B. The American Society for Clinical Pathology Resident In-Service Examination: Does Resident Performance Provide Insight into the Effectiveness of Clinical Pathology Education? *Clin Lab Med* 2007;27:283–292. [PubMed: 17556086]
15. Kass ME, Crawford JM, Bennett B, Cox TM, Grimes MM, LiVolsi V, Fletcher CDM, Wilkinson DS. Adequacy of Pathology Resident Training for Employment: A Survey Report From the Future of Pathology Task Group. *Arch Pathol Lab Med* 2007;131:545–555. [PubMed: 17425382]
16. Scott MG, Bruns DE. Improving training in laboratory medicine. *Clin Chem* 2006;52:915–6. [PubMed: 16723680]
17. Wells A, Smith BR, Sacks DB. The Challenge of Training Pathologists in the 21st Century. *Hum Pathol* 2006;37:932–33. [PubMed: 16867854]
18. Prak ET, Park J, Yu G, Nachamkin I. Point: developing a curriculum in clinical pathology. *Clin Chem* 2006;52:969–71. [PubMed: 16614001]
19. Wells A, Smith BR. Counterpoint: Developing a Clinical Pathology Curriculum to meet Current and Future Needs. *Clin Chem* 2006;52:971–972. [PubMed: 16617156]
20. Peerschke EIB, Agrawal Y, Alexander CB, Bovill E, Laposata M. Proposed Research Training Guidelines for Residents in Laboratory Medicine. *Clin Lab Med* 2007;27:241–53. [PubMed: 17556083]
21. Weiss RL. Training in Laboratory Management and the MBA/M.D. in Laboratory Medicine. *Clin Lab Med* 2007;27:381–95. [PubMed: 17556091]
22. Santoro SA, Mosse CA, Young PP. The M.D./Ph.D. Pathway to a Career in Laboratory Medicine. *Clin Lab Med* 2007;27:425–34. [PubMed: 17556094]
23. Rinder HM, Smith BR. Innovative Methods in Laboratory Medicine Resident Teaching. *Clin Lab Med* 2007;27:255–67. [PubMed: 17556084]
24. Genzen JR, Krasowski MD. Resident Training in Clinical Chemistry. *Clin Lab Med* 2007;27:343–58. [PubMed: 17556088]

25. Bennett BD. Certification from the American Board of Pathology: getting it and keeping it. *Hum Pathol* 2006;37:978–81. [PubMed: 16867858]
26. Davey DD, Bennett BD. Maintenance of certification: how will it affect pathology practice? *Arch Pathol Lab Med* 2007;131:1334–6. [PubMed: 17824786]
27. Rinder HM, Smith BR. Evolving Paradigms of Laboratory Medicine Resident Education and Consultation. *Clin Chem* 2007;53:1–2. [PubMed: 17202494]