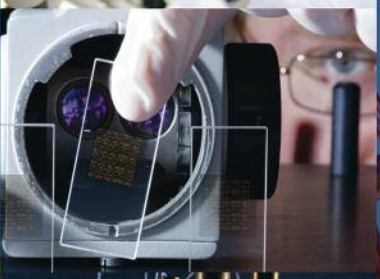

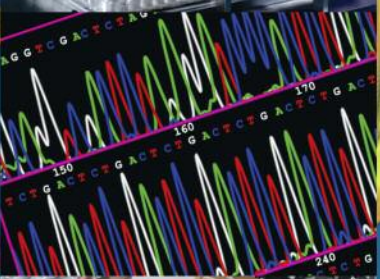

PATHOLOGY

A Career in Medicine

The Intersociety Council for Pathology Information (ICPI)
www.pathologytraining.org

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2014

Pathology: A Career in Medicine

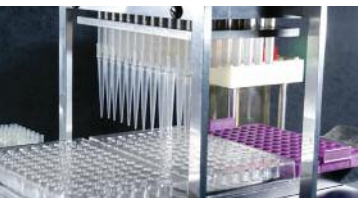
The study of the nature of disease, its causes, processes, development, and consequences.

Pathology is the medical specialty that provides a scientific foundation for medical practice

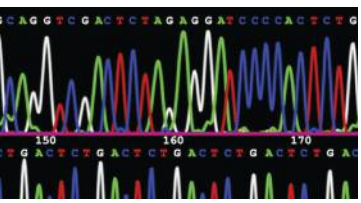
The pathologist is a physician who specializes in the diagnosis and management of human disease by laboratory methods. Pathologists function in three broad areas; as diagnosticians, as teachers, and as investigators. Fundamental to the discipline of pathology is the need to integrate clinical information with physiological, biochemical and molecular laboratory studies, together with observations of tissue alterations. Pathologists in hospital and clinical laboratories practice as consultant physicians, developing and applying knowledge of tissue and laboratory analyses to assist in the diagnosis and treatment of individual patients. As teachers, they impart this knowledge of disease to their medical colleagues, to medical students, and to trainees at all levels. As scientists, they use the tools of laboratory science in clinical studies, disease models, and other experimental systems, to advance the understanding and treatment of disease.

Pathology has a special appeal to those who enjoy solving disease-related problems, using technologies based upon fundamental sciences ranging from biophysics to molecular genetics, as well as tools from the more traditional disciplines of anatomy, biochemistry, pharmacology, physiology and microbiology.

The Pathologist in Patient Care



A biosample robot prepares specimens for testing



Genome DNA Data

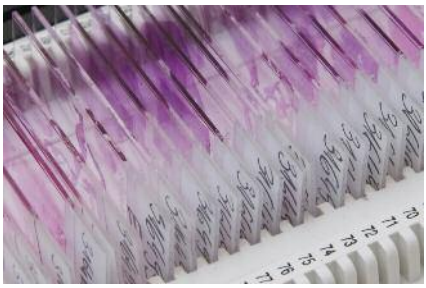
Genomic mapping of the patient's tissue sample indicates PARK9, a marker for Parkinson's Disease.

The pathologist uses diagnostic and screening tests to identify and interpret the changes that characterize different diseases in the cells, tissues, and fluids of the body. Anatomic pathologists analyze the gross and microscopic structural changes caused by disease in tissues and cells removed during surgery or at autopsy. Cytopathology, the examination of individual cells to aid in disease detection, is an important component of modern patient care. Clinical pathology encompasses chemistry, microbiology, immunology, hematology, coagulation, and blood banking, among other types of laboratory testing. Molecular pathology utilizes newly developed strategies for DNA and RNA hybridization and amplification to aid in many aspects of both clinical and anatomic diagnoses. Collectively, all the pathology specialties contribute to understanding disease and treatment of the patient.

Pathologists participate in day-to-day care of patients by providing and interpreting laboratory information to help solve diagnostic problems and to monitor the effects of therapy. New tools are used to increase the precision of diagnoses, e.g., those utilizing monoclonal antibodies, molecular biology, image analysis, and flow cytometry. Because of the expanding volume of new and highly complex tests, clinicians rely on the pathologist for guidance and direction in use of the clinical laboratory and interpretation of test results. The new field of molecular diagnostics is particularly rewarding, with techniques that permit identification of carriers of genetic disease, diagnosis of viral and bacterial infections, monitoring of cancer therapy, DNA fingerprinting for forensic (medico-legal) analysis, and detection of cancer markers that assist in prognosis. For all pathologists, clinical, anatomic, molecular, investigator or researcher, better patient care is the ultimate goal. When unusual or unexpected abnormal results are identified, and particularly when critical or life-threatening alterations are found, the pathologist communicates directly with the patient's physician.

Many pathologists have direct patient contact on a frequent, and even daily, basis. It is common for the pathologist to perform a fine-needle aspiration of suspicious masses (see "Case Study: Thyroid Cancer" in this brochure) or a bone marrow aspiration or biopsy to diagnose

hematologic disease. In Transfusion Medicine, the pathologist plays a pivotal role in the selection of appropriate blood product therapy and the management of transfusion reactions. One of the most direct patient management and practice roles that some pathologists perform is apheresis therapy, a process that removes pathologic substances from the blood stream. Apheresis is performed for a variety of disorders and can be immediately life-saving or used for long-term care. As a result, pathologists not only provide acute care, but also form long-term relationships with patients and their families.



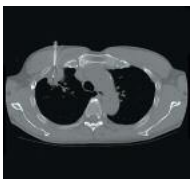
After the pathologist fixes the patient's tissue samples the specimens will be thinly sliced, mounted on slides, and examined under a microscope.

Anatomic Pathology

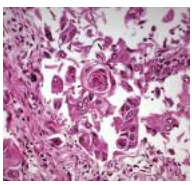
Whenever tissue is removed from the body, it must be examined to determine the precise cause of the illness that prompted its removal. Microscopic analysis of tissue changes is the focus of anatomic pathology. The pathologist plays a central role in the diagnosis of surgically removed tissues, particularly when tumor is suspected, and works closely with surgeons and other physicians in such cases.

Often during surgery for suspected cancer, a pathologist is asked to prepare a frozen section. A piece of tissue is removed during the operation, frozen, thinly sliced, and prepared for rapid microscopic examination by the pathologist while the patient is still on the operating table. The preliminary diagnosis based on the frozen section guides the surgeon as to the next steps to take during surgery.

A Case Study: Lung Cancer



CT scan



Squamous Cell Carcinoma

A 46-year-old man who has been a heavy smoker since the age of 16 complained of fatigue and a chronic cough. His serum calcium level was elevated. Computed axial tomography (CT scan) demonstrated a large mass in the right lung and hilar adenopathy. An interventional radiologist performed a fine-needle aspiration (FNA) of the lung mass under CT guidance for diagnosis by the pathologist. The pathologic diagnosis will determine management decisions, including whether surgery is required. For example, if the tumor were a squamous cell carcinoma, complete removal might be attempted; if the tumor was a small cell carcinoma, then radio- and chemo-therapy might be the preferred treatment. Pathologic analysis of a tumor can also provide predictive information; tissue can be sent for molecular testing to determine whether the patient was a candidate for molecularly targeted therapy. Sometimes, additional special stains, typically using immunohistochemistry, assist in defining the origin of a tumor, confirming the histologic classification, and helping to explain patient symptoms. In addition, clinically unsuspected problems may be revealed by the pathologist's studies.

Viewing FNA-extracted cells under the microscope.

As demonstrated in this case, cells can be obtained for microscopic examination without recourse to surgery. Originally introduced for detection of female genital cancer, the "Pap smear," cytopathology principles are now applied to most organ systems and their diseases using FNA and other methods for cell retrieval. For certain types of tissue, examination of cell aspirates can be just as rapidly diagnostic as, and can replace, frozen section examination.

Role of the Autopsy

Forensic pathologist examines a kidney during an autopsy.

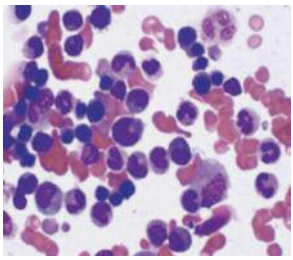
"This is the place where the dead shall teach the living." The autopsy provides unique insights into the natural history of disease and the influence of therapy on disease processes. Although autopsy information is important for general medical purposes, occasionally the patient's family is benefited directly. For example, when an unsuspected genetic disorder is found, the diagnosis and intervention can help living members of that family. The autopsy provides feedback to the physicians involved in patient care about the accuracy of their evaluations and the effectiveness of their treatments. Together, the clinicians and pathologists assess the findings in each case so that future patients can benefit from this information. The importance of autopsy data as a measure of quality-control should not be undervalued. Recent studies have shown approximately 30 percent discrepancy rates between clinical diagnoses and actual findings at autopsy.

The autopsy's value is often dramatically demonstrated to the public when a pathologist is called to determine the exact cause and manner of death in medical legal cases, and to present the findings as an officer of the court. Special training and certification in Forensic Pathology is needed for a pathologist to serve as Medical Examiner for a city or state agency, and to conduct laboratory or postmortem studies of suspected criminal activities on suspicious deaths or those of concern to the public health and safety.

Clinical Pathology

The clinical pathology specialty laboratories include hematology, microbiology, immunology, clinical chemistry (and toxicology), the blood bank (transfusion medicine), and laboratory data management. In these areas, the pathologist acts as a consultant to the clinician, defining appropriate tests and interpreting their results. Many of these tests solidify a clinical diagnosis. After diagnosis, many tests are performed repeatedly to assess progress of the disease and response to treatment.

The hospital immunohematologist prepares a patient's blood sample for testing.



*Wright stain of a post-transplant bone marrow.**

Diagnostic tests on the patient's blood specimen will be run on automated machines.

In clinical hematology, for example, pathologists review all abnormal blood smears. They may also obtain bone marrow samples from patients. In examining the smears and microscopic sections from these sources, the pathologist may encounter problems as diverse as the identification of malarial parasites or other blood-borne organisms, investigation of causes of anemia, detection of disorders of coagulation, and definitive diagnosis of malignant diseases such as leukemia.

In most hospital settings the pathologist is in charge of the blood bank, and functions as an immunohematologist, who is in charge of procurement and processing of blood and blood products. The responsibilities include monitoring the use of blood within the hospital, tracing the causes of transfusion reactions, testing for determinants of tissue compatibility that permit bone marrow and other transplants, and serving as a consultant to plan appropriate therapy for a wide variety of conditions.

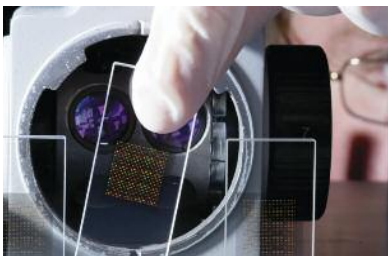
In clinical chemistry, the pathologist supervises the technical staff in performance of tests to determine the concentration of organic and inorganic substances and medications in body fluids. For example, the level of glucose (sugar) in blood or urine is needed to diagnose diabetes and to monitor the daily insulin dosage. Supervision of the use of instruments and maintenance of a strict system of quality control are essential to assure accurate laboratory determinations. Toxicology is often part of the clinical chemistry service, involving the pathologist in therapeutic drug monitoring and detection of illicit drugs and poisons. In cases of infection, the microbiology laboratory identifies the offending organism and tests to discover which antimicrobials are capable of killing or arresting the growth of that particular agent (bacteria, viruses, parasites).

Testing for immune reactions and allergies is a growing area of laboratory activity. Allergic and toxic reactions to foreign materials have long been recognized, but many recently identified diseases reflect immune responses to normal body proteins, that are either altered or present in abnormal locations. Immune functions are also critical in toleration of transplanted tissues or organs.

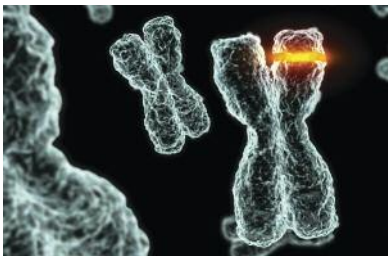
Other areas of responsibility of the clinical pathologist are the development of comprehensive information systems and the maintenance of quality control and quality assurance procedures. Both are needed to ensure economical use of the clinical laboratory, to enable the development of new testing and appropriate utilization of existing services, while maintaining a high quality of medical care. Pathologists constantly seek ways to achieve greater accuracy, precision, specificity and sensitivity of laboratory tests. Information systems are needed to handle the enormous volume of test information correctly attributed to each individual patient, and provide the correct ranges of normal values for each test in that laboratory, while maintaining patient confidentiality. Quality control checks on the accuracy of test results, whereas quality assurance aims to provide prompt, efficient collection and rapid availability of test results to the treating physician.

Molecular Pathology

The tools of molecular biology are contributing to the recent rapid growth of new tests with both greater accuracy and precision in many of the above areas of laboratory medicine. Infectious agents can be identified by virtue of unique DNA sequences. Molecular identification of chromosomal rearrangements is used not only in diagnosis, but also in monitoring for the effectiveness of therapy and detection of residual disease. Genetic alterations underlying heart diseases, iron metabolism defects, and congenital abnormalities, to name a few, are appreciated to be far more common than was previously recognized. Prenatal screening is now available to detect hemoglobin disorders and many metabolic diseases, such as cystic fibrosis. Genetic susceptibility to inherited cancer is another dynamic new testing area. For example, the advent of new treatments for certain breast cancers depends on identification of a gene that is amplified and over-expressed in those cancers; the gene amplification can be identified by molecular testing. The metabolism of many important medications can also be predicted by molecular techniques.



A DNA sequence (chip) ready for viewing.



3D computer generated and enhanced image of chromosomes through an electron microscope.

The Pathologist as a Consultant

The pathologist has long been considered the "doctor's doctor," consulted for interpretation of laboratory results, selection of diagnostic tests, monitoring the accuracy of surgical judgments, and introduction of new diagnostic modalities. They serve on many committees important in hospital and medical management, continuing medical education, and quality assessment. More recently, because of the range and complexity of diagnostic services, a role for the pathologist in explaining tests and their results directly to the patient has evolved. In addition, a very different new role has emerged for pathologists in this era of Managed Care. Pathologists have considerable experience with laboratory and hospital management. They are accustomed to thinking diagnostically across a broad spectrum of human disease. Their familiarity with issues of quality control and quality assurance also provides expertise in assessment of appropriate utilization of testing for the individual patient. These attributes are important in the evaluation and auditing of health care services for insurers and government agencies.

The Pathologist as a Teacher

Teaching in pathology is often conducted one-on-one with an experienced pathologist serving as mentor to a younger colleague. Here, a neuropathologist provides instruction on the gross anatomy of the brain and how to process the sample to diagnose the cause of death.

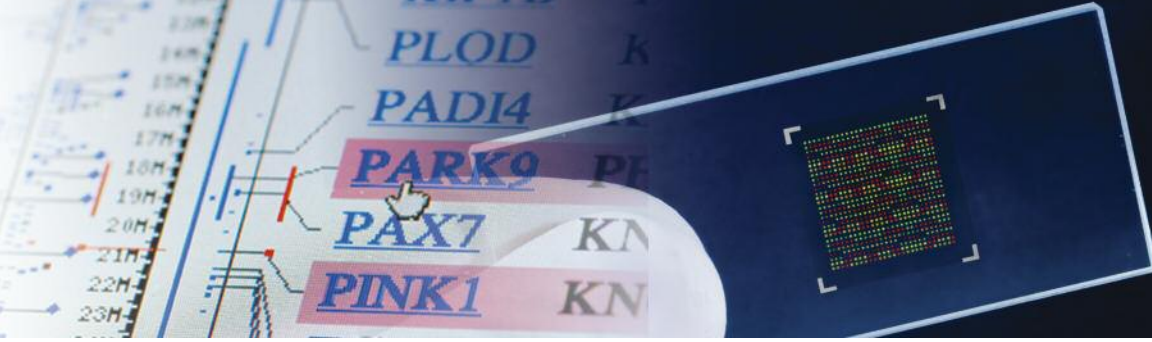
Pathologists teach at the bedside, in the laboratory, over the microscope, in the lecture hall, in the classroom, in workshops, and in seminars. They instruct medical students, residents in pathology and other clinical training programs, graduate students in basic science departments, and students in related medical disciplines. They are also important in the continuing medical education of practicing physicians in both academic and community settings. The community-based pathologist has a unique perspective on patients from the viewpoint of each individual's cumulative laboratory data. This perspective is necessary for consultation on individual patients as well as for guidance on the applicability, interpretation, and usefulness of both standard and specialized, often newly available tests. In the academic setting, the pathologist may be the developer of new testing approaches, responding to perceived patient diagnostic or therapeutic problems. In all these environments, pathologists contribute substantially to teaching on the clinical services.

Pathology is a required component of the medical school curriculum, and is often the first introduction to human disease processes. Additional training electives, tutorials, and guided research programs are available to the talented medical student in many schools. Exceptional students may be recognized by the Pathology Honor Society, sponsored by the Association of Pathology Chairs.

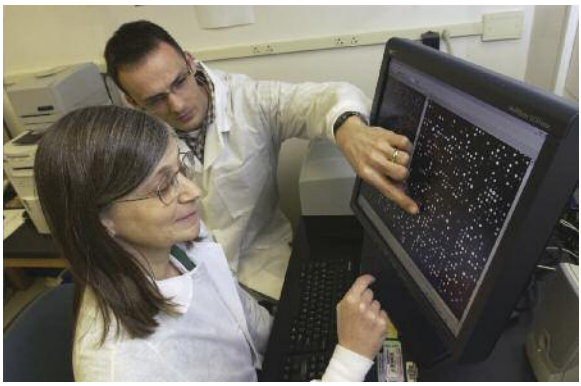
To teach well, one must continue to learn. Pathologists are committed to their own educational growth and regularly attend and contribute to programs at local, regional, national, and international meetings, where new basic science findings, diagnostic applications, and technology are presented.

One of the great appeals of a career in pathology is that it offers the opportunity to teach at many levels. No other medical specialty offers as many different opportunities in education.

Pathology has a special appeal to those who enjoy solving disease-related problems, using technologies based upon fundamental sciences ranging from biophysics to molecular genetics, and including tools from the more traditional disciplines of anatomy, biochemistry, physiology, and microbiology.



The Pathologist in Research



Chief Pathologist Dr. Elizabeth Unger, CDC, reviews a microarray image of gene expression data with postdoctoral fellow Martin Steinau, PhD.

The pathologist-investigator seeks new understanding of the basic nature of disease as a first step toward devising better ways to identify, control and prevent it. In many cases, the normal must be understood in order to define the abnormal. Pathologists have a unique advantage in biomedical research because of their close ties to clinical medicine, their familiarity with laboratory technology, and their recognition of and insight into the significance of diseased tissue changes. Pathologists engaged in research use the sophisticated technologies of modern molecular biology, biochemistry, immunology, cell biology, and tissue pathology. These tools and methods include cell culture, biochemical analysis, electron microscopy, immunological and molecular genetic techniques, computer modeling, and use of animal models. Understanding at the molecular level is particularly critical in defining normal biological mechanisms, so that the defects that lead to disease can be recognized.

Pathologists are uniquely prepared to investigate the causes and mechanisms of disease because of their experience in recognition of disease manifestations. Some examples of the range of problems under study have included tracing a newly recognized disease to its origin, or improving diagnostic approaches to well-known diseases, or identifying the genetic basis for response (or failure of response) to treatment.

Pathologists figured prominently in recognition of pulmonary disease among smokers, miners, asbestos and textile workers; of liver cancer from prolonged contact with vinyl chloride and aflatoxin; of nerve disorders and sterility from exposure to certain pesticides and toxic wastes.

The pathologist plays a key role in improving diagnoses through identifying new pathogenic bacteria, discovery of new infectious agents such as Hanta virus, and better application of modern methods of diagnosis; some recent examples include the unraveling of the role of retroviruses in AIDS, the application of DNA hybridization for rapid and precise identification of atypical forms of mycobacteria that cause infections closely related to tuberculosis, and the identification of the virus that causes SARS. Pathologists have recognized new diseases produced by medications used to treat various illnesses.

They have identified genes that are amplified in certain kinds of cancer and devised methods to test for gene amplification. Using such methods, it has been demonstrated that amplification of an oncogene in the childhood tumor, neuroblastoma, is an indicator of poor prognosis. Other amplified genes seem to confer drug resistance.

Other important pathology research led to the recognition that smoking and obesity are associated with the early onset of atherosclerosis in young Americans as well as the relationship between elevated levels of homocysteine and heart disease.

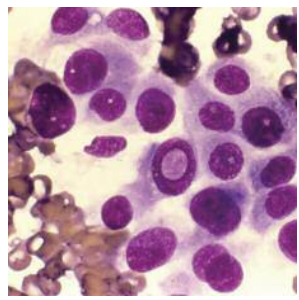
Pathologists who used their understanding of pathologic processes to make significant contributions to medicine have garnered Nobel Prizes. For example, Nobel Laureate pathologists include **Alexis Carrel,** (1912) who pioneered vascular suturing techniques , **Karl Landsteiner**, (1930) the discoverer of the A, B, O blood groups, **George Whipple**, (1934) who, with **Minot** and **Murphy**, recognized that liver contained a substance necessary to prevent pernicious anemia, **Edward C. Kendall**, (1950) who, with **Reichstein** and **Hench**, studied the hormones of the adrenal cortex, their structure and biological effects which helped develop cortisone as a therapeutic agent, **Thomas Weller,** (1954) who developed methods for the growth of polio virus in tissue culture, **Peyton Rous**, (1966) the discoverer of tumor-inducing viruses, **Baruj Benacerraf**, (1980) who identified genetically determined structures on the cell surface that regulate immunological reactions, **Peter C. Doherty** and **Rolf M. Zinkernagel**, (1996), who discovered cell mediated immune defense, **J. Robin Warren,** (2005) who with **Barry J. Marshall**, recognized that gastritis and gastric cancer are caused by infections with *Helicobacter pylori*, and **Harald zur Hausen** (2008) for his discovery that human papilloma viruses cause cervical cancer.

Case Study: Thyroid Cancer

A 35-year-old woman felt a lump in her neck. Her surgeon found the lump to be located in her thyroid gland. When she was given a tracer dose of radioactive iodine, none of it appeared in the lump - called a "cold" nodule. The referring physician asked the pathologist to do a fine-needle aspiration (FNA) to determine whether the lump was malignant. They demonstrate the diagnosis at the tumor board meeting and discuss prognosis and cancer management with the surgeons, oncologists, social workers, nurses, and radiation oncologists present. At surgery, the mass was removed and no spread of the tumor was found. The early diagnosis afforded by FNA helps achieve an excellent prognosis in thyroid cancers.

The attending pathologist and resident examine the patient and, under the pathologist's guidance, a resident obtains the specimen.

A pathologist and resident immediately analyze the cells microscopically while the patient is still in the examining room.



The fine needle aspirate reveals a papillary carcinoma of the thyroid which often affects young women

Graduate Medical Education in Pathology

Medical school graduates in the United States and Canada need three to four years of accredited residency training to prepare for a career in pathology. There are accredited training programs in many hospitals throughout the United States and Canada, and many varied opportunities for subspecialty study after residency. During training, the resident becomes familiar with all activities of a pathology department.

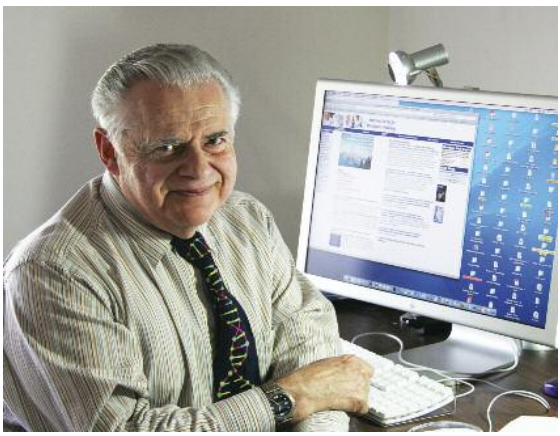
Most pathology residents receive training in both anatomic pathology (AP) and clinical pathology (CP), although it is possible to train in only one. Specialty certification for the medical practice of pathology is the responsibility of the American Board of Pathology (ABP) in the United States, which offers primary specialty (AP and CP) and subspecialty examinations for certification. Four full years of approved training are required for AP/CP, and three years for AP or CP alone. Residency training in Canada is the responsibility of the Royal College of Physicians and Surgeons.

Following residency training, candidates requesting certification must pass an objective written and practical examination. As in other medical disciplines, Board certification is not required for practice, but it is highly prized as evidence of professional competence. In both the United States and Canada, pathologists who have been board certified must continue to demonstrate competency throughout their careers and (except for those in the United States who were certified before 2006) must be recertified periodically.

Pathologists can be certified to practice in the following subspecialties in the United States:

- Blood banking/transfusion medicine
- Chemical pathology
- Cytopathology
- Dermatopathology *(with the American Board of Dermatology)*
- Forensic pathology
- Hematology
- Medical microbiology
- Molecular genetic pathology *(with the American Board of Medical Genetics)*
- Neuropathology
- Pediatric pathology

Dr. Meera Hameed is an Attending in the Department of Pathology at Memorial Sloan-Kettering Cancer Center and specializes in the fields of bone and soft tissue pathology and molecular pathology, in the areas of clinical service, research, and teaching.



Dr. Stanley Cohen, Professor & Chair of the Department of Pathology & Laboratory Medicine at the University of Medicine and Dentistry of New Jersey (UMDNJ) is a world renowned researcher in immunology and teacher.

Career Options

The largest numbers of pathologists are found in community hospital practices, where they play important roles in clinical decision making and continuing medical education of physicians throughout the hospital staff. As laboratory director, the pathologist also has responsibilities for quality improvement, risk management, and development of comprehensive information systems. In addition, hospital pathologists often operate laboratories that serve the office practices of their community's physicians. With the continuing growth of ambulatory care, pathologists may also practice in non-hospital settings such as private or group practice, clinics, and other health care facilities. Independent laboratories have assumed an increasing role as practice sites for pathologists. Many of these laboratories are part of major national medical networks; others are regional or local.

Although 75 percent of pathologists practice in the community hospital setting, many other options exist. Medical schools attract the second largest group of pathologists - currently over 3,000 individuals, interested in basic or applied research, which is often combined with extensive teaching opportunities, and diagnostic responsibilities in university hospitals. Because of their broad medical perspective, pathologists often fill leadership roles within medical schools, national professional societies, and research organizations.

Yet other positions for pathologists are available in the military and in government agencies such as the National Institutes of Health, and Food and Drug Administration. Forensic pathologists typically work in municipal, state, and federal agencies, where they investigate unexplained and unnatural deaths. In addition, pathologists often provide medical direction in research institutes and with pharmaceutical and biotechnology companies. The best available data suggest a strong continuing need for pathologists in all sectors for the future.

Sources of Information

Contact with individual pathologists in hospitals, laboratories and medical schools is the best way to learn about the profession and its personal rewards. For additional information about pathology as a career, contact local, state or national pathology organizations, including:

American Society for Clinical Pathology (ASCP)
www.ascp.org

American Society for Investigative Pathology (ASIP)
www.asip.org

Association of Pathology Chairs (APC)
www.apcprods.org

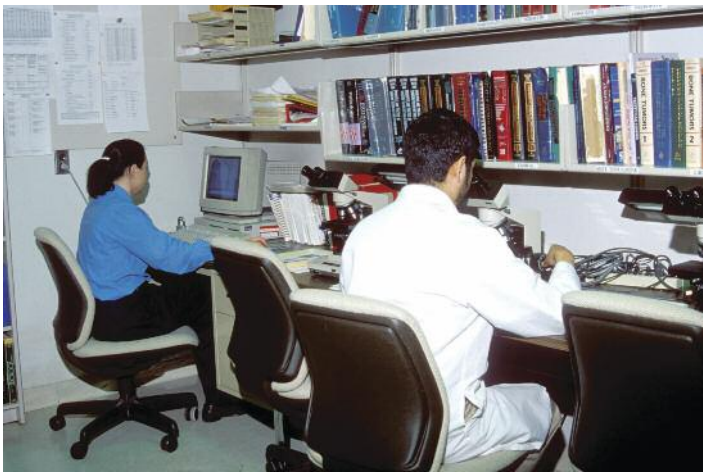
College of American Pathologists (CAP)
www.cap.org

United States and Canadian Academy of Pathology (USCAP)
www.uscap.org

ICPI is a consortium of five pathology societies (APC, ASCP, ASIP, CAP, and USCAP) created specifically to promote pathology as a career through its publications and information activities. Their website is *www.pathologytraining.org*.

Undergraduate Study in Pathology

Medical schools offer elective courses in pathology in addition to the required basic science course. Some medical schools offer year-long fellowships in pathology, usually following the second year of medical school, by which time the general pathology course has been completed.



Medical students in pathology courses often study with pathology residents and fellows.

This brochure has been published by the Intersociety Council for Pathology Information, (ICPI), whose mission is:

- to publish the annual *Directory of Pathology Training Programs* for medical students and graduate physicians;
- to provide information about pathology as a career in medicine; and
- to respond to general inquiries about pathology from the media, professional organizations, and the public.

Mark E. Sobel, MD, PhD
Editor

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ICPI
9650 Rockville Pike
Bethesda, MD 20814 (USA)
Email: icpi@asip.org

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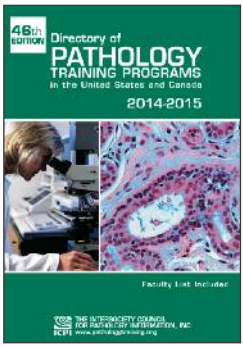
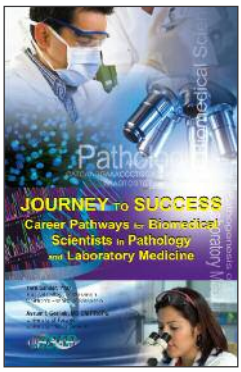


The Directory of Pathology Training Programs

Listing of Residency Training Programs, Fellowships, and Post-Sophomore Fellowships

Order the print on-demand version online at
www.pathologytraining.org

The Directory is also available online and is fully searchable by institution, region/state, and specialization.
www.pathologytraining.org



Journey to Success: Career Pathways for Biomedical Scientists in Pathology and Laboratory Medicine

Tara Sander, PhD and Avrum I. Gotlieb, MD CM FRCPC

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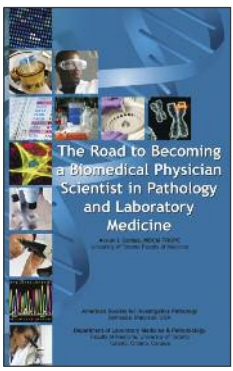
This career booklet was inspired by the American Society for Investigative Pathology (ASIP) Committee for Career Development, Women and Minorities, and the Long Range Planning Committee to provide a guide for PhD candidates in the life sciences considering a career in experimental pathology. The purpose is to present opportunities in experimental pathology for PhDs that exist in many sectors including academia, molecular diagnostics labs, public and private laboratories, industry, and consulting for-profit and non-profit institutions. This booklet should be helpful to biomedical scientists to understand how to train and then develop their early career to carry out either basic, translational, and/or clinical investigations in academic Departments of Pathology and Laboratory Medicine or in numerous non-academic environments. *Order your free copy today by emailing: asip@asip.org.*



The Road to Becoming a Biomedical Physician Scientist in Pathology and Laboratory Medicine

Avrum I. Gotlieb, MDCM, FRCPC

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Intersociety Council for Pathology Information (ICPI)
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