JOURNEY TO SUCCESS
Career Pathways for Biomedical Scientists in Pathology and Laboratory Medicine

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Journey to Success: Career Pathways for Biomedical Scientists in Pathology and Laboratory Medicine
ASIP is a member of the Intersociety Council for Pathology Information (ICPI) and gratefully acknowledges ICPI’s partial support for the production of this brochure.
Prologue

This career booklet was inspired by the American Society for Investigative Pathology (ASIP) Committee for Career Development, Women and Minorities and the ASIP Long Range Planning Committee to provide a guide for PhD candidates in the life sciences who are considering a career in pathology. The purpose is to present opportunities for PhDs in the discipline of pathology that exist in many sectors including academia, molecular diagnostics labs, public and private laboratories, industry, and for-profit and non-profit institutions. This booklet should help biomedical scientists 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.

ASIP is a professional society of biomedical scientists who investigate mechanisms of disease. ASIP thus fosters the professional career development and education of those interested in the study of pathogenesis. ASIP is committed to advocate for high quality training of biomedical scientists in departments of pathology (and other disciplines) as well as to support career paths for junior academic faculty and/or for those selecting traditional and non-traditional non-academic careers.

We thank our family, friends, mentors and colleagues for generously giving their time, guidance, patience and support for our own career development as biomedical scientists. The assistance and contributions of the ASIP staff and members of the ASIP Committee for Career Development, Women and Minorities are also greatly appreciated. ASIP gratefully acknowledges the Intersociety Council for Pathology Information (ICPI), which provided partial support for production of this brochure.

We appreciate discussions with many trainees and colleagues on the subject of career paths for PhDs in pathology and laboratory medicine. We thank Audra E. Cox, Managing Editor, *The American Journal of Pathology* and *The Journal of Molecular Diagnostics*; Sunny Kumar, Investment Manager, Investment Accelerator Fund, Ontario Centres of Excellence; and Jennifer A. Hobin, Science Policy Analyst, Federation of American Societies for Experimental Biology.

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Sincerely,
Tara Sander and Avrum Gotlieb

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About the Authors

Tara Sander is an Assistant Professor of Pathology at the Medical College of Wisconsin and Scientific Director of Molecular Diagnostics in Pathology and Laboratory Medicine at Children's Hospital of Wisconsin. She received her Bachelor's Degree in Biochemistry from Beloit College in 1994, obtained a Ph.D. in Biochemistry from the Medical College of Wisconsin in 2000, and completed postdoctoral training in Molecular and Cell Biology in the Departments of Surgery and Pathology at Harvard Medical School and Children's Hospital Boston. Dr. Sander joined the faculty at the Medical College of Wisconsin in 2003, where she directed a vascular research laboratory in the Department of Surgery (Pediatric Surgery) for five years before assuming her current position as director of a clinical laboratory.

Dr. Sander is involved in the clinical and research aspects of molecular pathology and laboratory medicine. As Scientific Director, Dr. Sander directs the development, operation, and expansion of the new Molecular Diagnostics Laboratory at Children's Hospital of Wisconsin. This clinical laboratory provides state-of-the-art molecular tests for the diagnosis and treatment of children with disease. Currently, the clinical laboratory offers pharmacogenetic testing for patients evaluated in the Neurology Clinic as a way to better guide anticonvulsant medication therapy. The laboratory is in the process of developing additional genetic tests for other diseases and conditions including mitochondrial disorders, Cystic Fibrosis, Fragile X, and vascular anomalies.

Dr. Sander's research interests include studying molecular mechanisms that regulate vascular endothelial cell function. Her goal is to understand how disruptions in these mechanisms contribute to the pathogenesis of congenital and acquired vascular diseases including valvular heart disease, acute lung injury, and cancer. She also participates in translational research activities, bridging the areas of vascular biology and clinical molecular diagnostics. Her aim is to work with investigators to identify genetic variations that cause congenital disorders and translate these discoveries to the clinic for the development of diagnostic tests for the pediatric population.

Dr. Sander has held several ASIP leadership positions including member of the ASIP Long Range Planning committee, member of the ASIP Program Planning committee, and Chair of the ASIP Committee for Career Development, Women and Minorities, and member of the ASIP Council. She has organized various career development programs at the Experimental Biology annual meetings that promote the advancement of trainees, women, and minorities in science. She is also the current Chair of the Women's Faculty Council at the Medical College of Wisconsin.
Professor Avrum I Gotlieb obtained his BSc in Psychology and Physiology, with first class honours (1967), and his MDCM (1971) from McGill University. He continued his training in medicine and anatomic pathology at the teaching hospitals of McGill University and obtained his Fellowship from the Royal College of Physicians and Surgeons of Canada in Anatomic Pathology (1975) and Certification from the American Board of Pathology (1976). He pursued research training in the Department of Biology, University of California San Diego with Professor SJ Singer, supported by a Medical Research Council Fellowship.

Professor Gotlieb is the founding Chair of the Department of Laboratory Medicine and Pathobiology, University of Toronto and previously held administrative appointments in two educational areas in the Department of Pathology, as Coordinator of Graduate Studies and as Course Director, Pathobiology of Disease, undergraduate medicine. In 2000, Professor Gotlieb, initiated an innovative and unique undergraduate arts and science Specialist Program in Pathobiology. As Chair, his graduate department grew to 160 trainees, most in the non-medical PhD track. Graduates of the program go on to postdoctoral positions, professional schools, the industrial job market and other positions. Professor Gotlieb has also been championing the role of clinician-scientists in academic laboratory medicine. He is a staff pathologist at University Health Network, Toronto.

Professor Gotlieb's research interests include atherosclerosis and valvular heart disease. He has published on blood vessel repair, especially on the role of the cytoskeleton in endothelial repair. His group has published pioneering work on how heart valve cells repair valves after they have been injured. He has published over 100 peer reviewed papers, and 35 reviews and book chapters. He edited three books, including the comprehensive textbook Cardiovascular Pathology, edited with colleagues MD Silver, University of Toronto, and F Schoen, Harvard Medical School. He has received peer reviewed funding from the Heart and Stroke Foundation of Ontario and the Canadian Institutes of Health Research (CIHR). Dr. Gotlieb has organized international scientific meetings, chaired program committees and scientific research committees and has been an external reviewer of several academic departments.

Professor Gotlieb is currently the co-Editor of Cardiovascular Pathology, a journal dedicated to basic, clinical, and applied cardiovascular science published by Elsevier. He serves on the Editorial Boards of The American Journal of Pathology (AJP) and Laboratory Investigation.

Professor Gotlieb has had extensive administrative experience as Chair, Planning and Budget Committee, Academic Board, University of Toronto. Professor Gotlieb is a former President of the American Society for Investigative Pathology (ASIP), Canadian Society of Atherosclerosis, Thrombosis and Vascular Biology (CSATVB) and the Society for Cardiovascular Pathology (SCVP). He is currently Vice-President, Science Policy, and a member of the Federation of American Societies of Experimental Biology (FASEB) Board. He is an elected Fellow of the Canadian Academy of Health Sciences.
What is a Biomedical Scientist in Pathology and Laboratory Medicine?

A PhD biomedical scientist in Pathology and/or Laboratory Medicine is a person who is scientifically trained in the life sciences to investigate the pathogenesis of human disease.

Scientific training entails acquiring a doctoral degree in one of the basic sciences or in a Department of Pathology and Laboratory Medicine, followed by postdoctoral training in a field of interest. Postdoctoral training can be acquired in any one of a number of departments, including Pathology and Laboratory Medicine. Once fundamental basic scientific knowledge on mechanisms of disease is obtained, the biomedical scientist can tailor a career in an academic research setting, a hospital research institute, or in industry to investigate the pathogenesis, prevention, diagnosis, prognosis and treatment of disease. Biomedical scientists form a broad group of individuals with various levels of scientific expertise who can drive academic laboratory medicine in various areas of healthcare. In addition, biomedical scientists are able to provide leadership to physicians and medical teams on the basic mechanisms of disease and facilitate translational research studies with clinical applications.

Pathology and laboratory medicine have led the way in the past several years to chart the new frontiers of academic medicine - in teaching, research, and clinical care. In the clinical sphere, advanced laboratory technologies are being developed and adapted to diagnose disease earlier, more accurately, and with a greater ability to predict outcomes. Furthermore, advancements in pharmacogenetics are leading to the implementation of personalized medicine, which is directly influencing the way physicians treat disease.

These new approaches and technologies provide biomedical scientists with many career opportunities geared toward understanding the mechanism of disease, so that improvements can be made to diagnose disease early and to direct therapy in ways that surpass anything that has been available until now. Working with pathologists and laboratory physicians also provides the biomedical scientist with unique access to clinical tissue specimens and human biologic materials, which can lead to an increased understanding of human disease and opportunities for applied clinical research.
By being trained at the crossroads of basic science and clinical medicine, biomedical scientists are in the enviable position of understanding how to develop clinically relevant studies. Furthermore, such training puts one in the position to collaborate and provide expertise to physicians to develop appropriate in vitro and in vivo models to investigate complex mechanisms of human disease. For example, the phenotypes arising from genetic manipulation are being thoroughly studied, including using imaging methods that effectively combine morphology and molecular biology, a powerful combination to understand genomic and proteomic function. Thus, biomedical scientists are in an excellent position to generate and effectively communicate new discoveries and state-of-the-art knowledge to the clinical arena. In fact, it is through high quality research carried out in the laboratories of biomedical scientists that health care costs will be controlled by reducing the burden of disease in the population.

The biomedical scientist fits very well into new paradigms, in which health care is undergoing dramatic changes as biomedical research and technology allow us to critically explore prevailing concepts and to discover new knowledge. As a result, there is a functional shift, in which advancements in science and patient care are less likely to be made by ‘silos’ or independent labs. Instead, there is a greater need for biomedical scientists to integrate into both the clinical and research aspects of healthcare and perform translational research that moves from the bench to the bedside.

Biomedical scientists have an opportunity to promote social responsibility and to interact with the lay public. Much more consideration is being given to the ethical and social implications of scientific discovery, such as stem cell research and genetic testing. As a result, there is a greater need for biomedical scientists, especially those in the healthcare community, to better educate the public regarding scientific advances and their impact on society.

The trained biomedical scientist may also consider training in additional fields such as business administration, science policy, editing and publishing, scientific writing, high school or college teaching and administration, or regulatory and information technology areas.

Some PhD biomedical scientists are drawn to the clinical area of laboratory medicine and do postgraduate training in clinical chemistry, clinical microbiology, clinical genetics and cytogenetics. These individuals will work in and/or direct clinical diagnostic laboratories and may also carry out investigator-initiated independent peer reviewed research.
Why Pursue Pathology as a Career in Biomedical Science?

Graduate students and postdocs experience numerous disciplines during their training and often do not formally choose a specialty. As a result, the biomedical scientist has the freedom to change fields, departments, academic and non-academic environments, and to continue to develop expertise in areas of interest. For example, a biomedical scientist is not required to be in a Pathology department to investigate the pathogenesis of disease. However, Departments of Pathology and Laboratory Medicine provide an important educational and research infrastructure to study mechanisms of disease. In these departments, trainees have opportunities to learn basic, translational and clinical investigations in laboratory medicine and pathology. As mentioned earlier, Pathology departments also have access to patient samples through tissue banks that can be beneficial for establishing translational research studies with clinical applications.

The discipline of pathology and/or laboratory medicine has distinct advantages in fashioning a successful PhD and postdoctoral training period and then a career as a biomedical scientist that embraces research centered on the pathogenesis of disease.

- The core values of the specialty of pathology are research and education. Pathology is at the interface of basic science, translational research, and clinical care.
- Pathologists and laboratory physicians are the custodians of human biologic materials and thus have an understanding of how to use this material to generate new knowledge in the pathogenesis of disease.
- Clinical subspecialty training programs link clinical laboratory medicine to research training.
- Pathologists and laboratory physicians have the training to teach PhD trainees and postdoctoral students anatomical, biomedical and molecular analyses of animal model systems, an essential tool to study human disease.
- There are many interfaces between pathology/laboratory medicine and industry, especially in the pursuit of prevention, diagnosis, prognosis, treatment, and understanding of disease. Links with biotechnology and pharmaceutical enterprises are common in pathology.
- The clinical practice of pathology and laboratory medicine requires numerous skills that are identical to those required in basic, translational, and clinical research. Thus biomedical scientists fit well into these departments.
- Pathology and laboratory medicine is a high-intensity, knowledge-based specialty that requires constant self-learning to provide high quality patient care, similar to the requirements of a PhD research investigator promoting productive interactions between scientist and clinician.
Is a Biomedical Career in Pathology for Me?

You have to carefully consider whether you have the interest and motivation to fashion a career in biomedical science that will fit your own intellectual, biomedical, social, cultural, and research goals. The successful biomedical scientist is generally an individual who is intelligent, very highly motivated, hard working, efficient, and an excellent problem solver, who likes to be challenged by difficult problems.

Like any career, there are disadvantages and advantages to a biomedical career. The training to become a biomedical scientist can be long, challenging, and financially frustrating, but the outcome is rewarding and full of many opportunities. Often, numerous failures will precede the experiments that ultimately provide data that satisfy your curiosity and lead to a high-impact well-cited journal article. Thus instant gratification is not on the menu, but a high tolerance for frustration and failure are. In academic medicine, writing grants and obtaining funds for research can also be difficult and stressful when meeting deadlines. Once you accept and overcome these challenges, the rewards are numerous. You are at the forefront of your field and at the cutting edge of discovery. You create the literature and are a consultant with unique knowledge. You collaborate with other investigators and explore new avenues of research and advancing healthcare. You are invited to share your expertise and knowledge with colleagues at scientific meetings, and to lecture at universities, and hospitals. In addition, a biomedical career may offer autonomy, flexibility for work-life balance, and many career opportunities.

You are in the dynamic world of academic medicine where inquiring minds are constantly searching for scientific truths. Your work has impact on clinical care, either directly or indirectly. You yourself have an interesting and comfortable lifestyle.

To make informed decisions about career choices, it is important to have exposure to successful biomedical scientists in your field of interest. A good way to do this is to spend time in the laboratory of a biomedical scientist and participate actively in a project course, a summer student program, or a work placement. Immerse yourself in the program so you get full value. If you work in a large laboratory, you may not spend a lot of time with the principle investigator. More junior biomedical scientists with smaller laboratories will have more time to mentor and may be able to offer a better first look at a biomedical scientist career. Discussing career choices with knowledgeable career counselors, current trainees, and junior and senior faculty is very helpful. Remember that this is your career and you must follow where your passion lies. Also, no choice is irrevocable. So, if you start down a particular career path and it is not working for you, reassess your choice and consider other options that are available. But remember to give yourself plenty of time to make an informed decision and do not give up too quickly. Embarking on a new adventure is both exciting and stressful. It will take time to adjust to your new environment, challenges, responsibilities, and colleagues. Do not be concerned about expressing frustration and doubts. We all have them. Try to
stay positive and solve issues as they arise, seeking mentorship and advice from senior colleagues and trusted friends whenever possible. Don't focus on the failures, but identify your strengths and use them to build upon your career as a biomedical scientist.

The Steps to Becoming a Biomedical Scientist

The objective is to complete your graduate training at one institution, followed by postdoctoral training at one or more institutions, and then move into your first independent position. For information on how to pursue dual training as a biomedical physician scientist (MD or MD/PhD), please refer to "The Road to Becoming a Biomedical Physician Scientist in Pathology and Laboratory Medicine" by Avrum I. Gotlieb (booklets available from the American Society for Investigative Pathology and online at www.asip.org).

How you accomplish your training may be the result of a carefully crafted career plan or by simply taking advantage of opportunities that appear as you follow your training. Usually it is a combination of planning and serendipity. Never lose sight of your ultimate goal and realize that there are several different pathways that will get you there. Your own personal circumstances are important in determining the steps you take along the way. Remember that although the end is important, the journey must be pleasant, fun, and as direct as possible so that you continue to advance in your career and do not become stuck in any one position. The traditional steps to becoming a biomedical scientist are described in more detail below.

Undergraduate Education

Obtaining an undergraduate education is in many ways the first step to becoming a biomedical scientist. This is the time to explore your science interests and gain a well-rounded education. A science major is preferred, but not necessary. In preparation for graduate school, you want to use this time to acquire laboratory experience, as well as communication, writing, computer, and public speaking skills. It is also helpful to gain teaching experience, such as serving as a laboratory assistant for a science course. In addition, any research experience gained during this time period is highly beneficial and advantageous for your application to graduate school. Explore summer undergraduate research opportunities offered through various universities, medical colleges, and national agencies, such as the Summer Research Opportunities Program (SROP) through the MARC Program of the Federation of American Societies for Experimental Biology (FASEB). ASIP currently offers a special Summer Research Opportunities Program in Pathology (SROPP), which is linked to the FASEB MARC Program and provides mentorship from established ASIP principal investigators. Many of these programs, such as ASIP’s SROPP, offer a stipend so they can be competitive. Visiting a laboratory and shadowing a biomedical scientist is also a great way to gain exposure to the research environment and to network with other scientists. As you approach the end of your undergraduate education, start to look at graduate schools and
identify programs of interest. Determine which undergraduate courses are required so that you have time to fulfill all requirements for application. Take the GRE, prepare your curriculum vitae, obtain letters of recommendation, and prepare for your interview. Meet regularly with your mentor to discuss your interests and what opportunities are available, and know the deadlines for applications. If you need time and are not ready to jump into a graduate program, consider applying for a technician position in a lab. This will give you time to think about your next step, and in the process valuable research experience and skills will be gained.

Choosing a PhD Graduate Program

A PhD Graduate Education program will take you anywhere from four to seven years to complete, depending on the institution and the research you carry out. The curriculum of each program will be unique, but a typical program will entail two-plus years of coursework and an in-depth research project that culminates in the writing and defense of a thesis. Most labs will require that you publish manuscripts in addition to your thesis. A PhD in the biomedical and related sciences should provide you with a strong background in science and both sound general knowledge and an in-depth focus in one specific area. Exposure to science that relates directly or indirectly to understanding the pathogenesis of human disease is most helpful and is best obtained in a department of pathology.

The PhD degree provides you with a unique perspective as you carry out your training. It enhances your ability to problem solve and provides you with the tools and skills to perform hypothesis-driven research and investigate mechanisms of disease. While the project of your PhD is important and should be of interest to you, the main goal is to gain an in-depth knowledge and thorough understanding of experimental design and effective critical analysis. Your graduate courses and thesis work provide excellent training to carry out critical analysis of the medical literature, carry out well-designed experiments, and develop your skills as a biomedical scientist. Your graduate training should also provide the skills to be an excellent communicator - both oral and written. Graduate school is also an excellent time to gain a well-diversified knowledge in many areas of science. This can be achieved through coursework and/or through attending lectures and symposia at your institution. Journal clubs and laboratory meetings are very important opportunities to develop these skills. There should be opportunities for you to attend local, national and international meetings to present your work as a poster or oral presentation. While many educational activities might not be directly related to your thesis project, the chances are high that you will stumble across them again during your career. Your research program should be productive with an important goal being the publication of high-quality first-authored peer-reviewed original research. You should strive to publish in high impact general and subspecialty journals.
When choosing a PhD program, there are various professional and personal issues to consider. From a professional perspective, you will want to consider the quality and type of institution (medical school, teaching hospital, state university). The quality of the professors and resources available will also directly impact your success in the program. It is also important to examine whether there are teaching opportunities and the availability of a student body association, which can be a great support system during your training. On the personal side, it is important that you consider such things as location, living expenses, child-care and school options (if applicable), public transportation, and safety. Graduate school can be stressful at times, so you ideally want to choose a PhD program at an institution that meets both your professional and personal needs.

**Choosing a Post-Graduate Training Program**

Once you have completed your PhD, you have many options for the next step in your career. You may have already decided that you want to stay in academics and conduct basic science research. In the following pages, we first address choosing a postdoc training program that will prepare you for an academic career as a biomedical scientist in pathology. Most of these are offered in academic institutions; however industry also offers postdoctoral life sciences training. We will then describe those paths that can help you navigate through other career options.

The objective of postdoctoral training is to give you the opportunity to carry out innovative science in an independent fashion with limited guidance. It is a bridge between the PhD and your first position, either academic or non-academic. Your research productivity is a very important benchmark for your success as a postdoctoral trainee.
The Academic Path
When choosing your postdoc, there are many things to consider:

The Laboratory

What are your research interests? If you are considering a career in academics as an independent lab investigator, your research career will likely build upon your postdoc experience. So, choosing a postdoctoral lab that investigates the same gene, signaling pathway, disease, or specialized technique from your graduate work can be a very efficient way to move forward, because it allows you to develop a reputation and publication record in your field. However, if you are ready for a change from your graduate work, this is also an excellent opportunity to shift your research focus and choose a postdoc laboratory that better fits your future research interests and career goals.

Another important question to ask yourself is whether you want to work in a small or large laboratory. As previously mentioned, smaller laboratories are often run by more junior faculty, who often have more time to mentor, while the larger labs are more established and directed by senior faculty. Consider several labs before selecting the best one for you. The fit must be right. Know what you want to get out of your postdoc experience and discuss these expectations with the head of the lab before starting a position. Speak to as many students and postdocs as possible so that you can obtain several opinions about the lab. You will find some trainees who are satisfied with everything and some who can see no good in the lab. You need to find a balanced view and to get this you need to ask probing questions and try to get specific answers, not general impressions and feelings.

The Institution

In addition to the lab environment, it is also important to assess the quality of the institution. What is the quality of the institution as a whole? What is the quality of the medical school, graduate school, teaching hospitals, the research, clinical care and educational programs? Research the institution on the web and speak to as many trainees as possible. Try to get a sense for the environment, as well as the level of commitment and satisfaction of the faculty. While no institution is perfect, contented faculty tend to be more inclined to creating a healthy and exciting environment for training and research.

The infrastructure is also an important factor to consider. You should understand the financial situation and the research infrastructure at the institution as a whole and in the department in which you plan to train. Is major equipment readily available? Are there adequate resources and/or core facilities to ensure a successful postdoc experience? Does your potential supervisor have the infrastructure he/she needs to carry out first class research for the duration of your training?
**Academic Program**
- Is there a clear description of the program available to trainees?
- How well do research and clinical exposures for scientists blend?
- What seminar series and visiting lecturers are organized for trainees and faculty?
- How good is the library?
- Is the information technology program adequate?
- Is there a critical mass of trainees in the program and in the institution as a whole?
- Does the program provide opportunities for formal presentations of research?
- Is there a strong policy with respect to postdoctoral affairs at the institution?
- Does the program have well-defined policies on training and postgraduate education, e.g. ethical conduct in research, intellectual property guidelines, publication policy, authorship policy, invention policy, safety policy, code of behavior on academic matters, postgraduate supervision policy and guidelines, etc?

**Personal Issues**
Do not be concerned about discussing salary, benefits, book and travel allowances with potential supervisors and program directors. Discuss holiday time, meeting time, sick time, maternity/paternity leave, benefits and health insurance. Discussing expectations for working hours and weekends are also acceptable. These are all important issues.

- How is funding arranged?
- Are you expected to apply for competitive internal and/or external funding?
- Does the program have an effective mentorship program and career counseling?
- Are there institutional housing arrangements?
- Does the location allow you and your family to have the quality of life you desire?

Living in an attractive environment makes life pleasant for the trainee and the family. Explore housing and living expense issues. Involve your family in the decision making. If you have a spouse (partner) and a family, make sure their needs are well met. If the family is not happy, the trainee will have an added burden. A community for the family is important,
even if you stay in a location for only a few years. Do you need day care or schools? What type of public transportation is available? What university programs are available for partners? Institutions should have dedicated individuals to help with information on available services and relocation issues. If you need to consider the training requirements of your spouse/partner, make sure the institution is able and willing to provide for the academic needs of the couple. Institutions are becoming much more aware of this need and should be willing and able to discuss this with you. It is very important to make the training journey fun, so keep this in mind when making your choices.

Choosing a Supervisor

In general, each postdoc experience will be different and contingent upon the specific laboratory in which you choose to work. Choosing a research supervisor is a very critical task and is just as important, if not more so, than the science of the lab. When choosing a research supervisor, visit the lab and talk to the current trainees. Review the supervisor’s curriculum vitae, especially publications and grants. Personalities are important, so learn about your potential supervisor's personality and make sure it will mesh with yours. The working relationship you have with your supervisor is very important.

- How does the supervisor run the laboratory?
- How much contact time do you want with your supervisor as you train?
- How often are formal meetings held with supervisors?
- What peer support is there?
- Is there sufficient space and equipment?
- Are journal clubs part of the laboratory activity?
- Are there visiting scientists presenting seminars and interacting with students?
- How does your supervisor regard postdocs?
- What is the track record of the potential supervisor?
- How long do postdocs generally stay in the lab?
- Where are previous postdocs currently employed and what are their positions?
- Does the supervisor expect postdocs to apply for funding?
- Will you be required to teach or will you be restricted from teaching?
- Does the supervisor provide feedback in a timely manner?
- Do postdocs publish first-authored high quality work?

It is indeed important to have a frank open discussion with a potential supervisor so that your questions are answered and you have the information you need to make a choice. Early in your training, it is important that you establish and discuss your
Individual Development Plan with your supervisor (for more information, see http://opa.faseb.org/pdf/idp.pdf). Meet regularly with your mentor and discuss any concerns that come up. Since the training is arduous, a nurturing, stimulating and supportive environment is essential. Role models and mentors are required to advise and guide, not only during your training but also when you reach the junior faculty (or equivalent) level. Despite the strenuous training commitment, the rewards are indeed wonderful. You do interesting and important work. You interact with exceptional individuals and you are at the forefront of medicine and science as you shape the foundations and directions of health care.

For how long should a postdoctoral position last? Many institutions now consider a three to four year postdoc as optimum. It allows you to carry out high quality innovative research that is published or accepted for publication before you leave the institution. The quality of your publications is an important currency that will help you to get an interview for a faculty position.

Non-Traditional Career Paths in Biomedical Science

In addition to an academic career path, you may want to explore other science career opportunities in the pharmaceutical industry, biotechnology, or clinical diagnostics. Or perhaps you want to leave the bench altogether and are considering scientific writing, teaching, public policy or patent law. You may be able to move into an entry level job in some of these areas, however, for most of these paths, you will have to complete a period of further training, with or without special certification, or acquire an additional degree before stepping directly into your first independent position.

Lifestyles vary for different career paths. The world of academics is focused primarily on hypothesis-driven research, which involves grant writing and manuscript publications. Once you obtain an academic position, a career in academics tends to be quite stable and offers flexible work hours, but the salary is not as competitive as in industry. On the contrary, a career in biotechnology or the pharmaceutical industry will offer more competitive salaries, but the focus may be more geared to product development. So, the environment is much more structured and can be quite unstable as companies change the focus of their biomedical activities, often very rapidly. In our economic climate, mergers have often occurred between pharmaceutical and biotechnology companies that may disrupt research programs and personnel. Therefore, it will be important for you to carefully examine your own interests and lifestyle and choose the career that works best for you.
Choosing to be a science writer

Science writing is a great way to use the skills that you already possess, but in a different medium. Staying involved in science means that you are still using your formal education. Oftentimes, somewhere during your graduate training or your postdoc, you realize what you enjoy most is not the lab bench but instead writing about your science and that of others. At this point, you would begin to explore the field of science writing and editing/publishing to see if this is indeed how you want to proceed.

Get involved in professional organizations related to science writing/editing and find a mentor. The advice of an individual who has already made the transition from the laboratory bench can be extremely useful. The more information you gain the better. Take courses and do self study to improve your skills. Many of the professional organizations offer classes or certifications that can boost your resume and improve your knowledge base as well as your confidence. It is important to seek out opportunities or make your own. If you cannot find a freelance opportunity, determine if you can volunteer your services to members of your own department: editing grants and manuscripts, writing for your departmental or society newsletter.

There are several professional societies in the United States that provide helpful information on career opportunities and educational programs in science writing, editing and publishing.

- The American Medical Writers Association (AMWA; www.amwa.org) hosts seminars through active regional chapters. The AMWA annual meeting includes courses and seminars that offer course certificates.
- The Board of Editors in the Life Sciences (www.bels.org) offers a certification examination that is recognized in the editing community as denoting a high standard in biological editing abilities.
- The Council of Science Editors (CSE; www.councilscienceeditors.org, formerly known as the Council of Biology Editors) annual meeting covers topics in editing, publishing, and policy issues. CSE also publishes "Scientific Style and Format," an excellent style guide.
- The Society for Scholarly Publishing (SSP; www.pspcentral.org), a division of the American Association of Publishers, sponsors educational workshops and an annual conference.

AMWA and CSE post freelance opportunities, and AMWA has active listservs.
Job opportunities are available in media, professional and scientific societies, textbook publishers, scientific journals, government, not-for-profit organizations, and industry. When applying for positions, it is important to submit samples of your writing, even work produced as a volunteer.

**Choosing a career in biotechnology/pharmaceutics**

You may continue to be a bench scientist in the biotechnology/pharmaceutical industry. The research may not be different, however, usually the topic of your research will depend on the interest of your company. This may change from time to time, often abruptly, depending on outside financial and industrial considerations. Choosing this pathway does not close the door on returning to academia. There are also opportunities to meld the academic with the non-academic. The biotechnology and pharmaceutical industries offer unique career opportunities. Biotech companies develop and market products for commercial sectors, including medicine, human diagnostics, human therapeutics, research instruments and reagents, biomedical devices, food industry, contract manufacturing, and agriculture. Pharmaceutical companies specialize in the production of pharmaceutical drugs for the prevention or treatment of illness and disease. In both industries, there are different stages of the process that are equally important for delivering high-quality products to the market. These divisions include Research and Development (R&D), Quality Control and Assurance, Manufacturing and Production, Sales, and Marketing. For example, scientists within the R&D division will conduct research with state-of-the-art technology to discover innovative products and services that meet the needs of their consumers. If the product is successful and makes it into the market, the Sales division is responsible for going into the field and selling the product to the consumer. As mentioned above, this field is often at the cutting edge of science and can offer many perks with regard to salary and lifestyle. However, this industry is in the market to make a profit, so changes may occur within the company as the focus shifts to the most productive projects at any given time.

**Choosing Science Policy, Science Administration**

A career in science policy is most rewarding for someone who wants to leave the lab bench but wants to continue to be part of the scientific enterprise. Internships are a common pathway to help you transition from lab bench to office/committee room. There are a myriad of possible careers in science policy; the nature of those jobs varies tremendously. Opportunities span the government, academic, not-for-profit, and for-profit sectors and include a range of activities.
from legislative relations to communications to policy analysis and development. Within each of those domains, science policy may be viewed as falling into two main categories. Science for policy refers to the application of scientific information to policy questions (e.g., using scientific data to set a maximum level for the concentration of a particular toxin in drinking water). Policy for science refers to the development and implementation of policies related to supporting and regulating science (e.g., determining appropriate science funding levels). Scientists are highly valued in both of these areas.

Within the United States federal government, scientists with a background in policy may serve as Congressional staffers, providing expert scientific advice on legislative issues. They could also work in one of the many science agencies, such as helping to set grant policies or facilitate scientific review at the National Institutes of Health, consider applications for new drugs and devices at the Food and Drug Administration, or develop air quality standards for the Environmental Protection Agency. Not-for-profit scientific and professional societies also employ scientists in policy positions where they may track and analyze science-related legislation, develop policy recommendations, or craft strategies for communicating scientific information to the lay public. Foundations with scientific and health-related missions also hire scientists to help identify emerging areas of research and enable the foundations to make strategic investments.

Scientists with an interest in policy are also valuable in the industrial sector. For example, those with knowledge of government and regulatory affairs can be an asset to pharmaceutical companies and biotechnology firms. Scientific training often enables scientists to develop a number of policy-relevant skills, making it possible to secure an entry-level position without formal policy training. However, many may find it helpful to acquire additional skills that will be useful in policy careers, such as non-technical writing or leadership and management. Those with a strong interest in policy may want to consider internship and fellowship opportunities aimed at helping scientists transition into science policy careers.

**Choosing a Career in Clinical Diagnostics**

A career in clinical diagnostics is ideal for biomedical scientists who want to use their basic scientific skills to diagnose the pathogenesis of disease. Clinical labs focus on performing and developing clinical tests that will directly impact the health and treatment of the patient. This involves using various methods in molecular biology, genetics, chemistry, microbiology, histology, and cytology to identify inherited or acquired diseases, conditions, or a patient’s predisposition for a disease. Clinical diagnostics can be performed within a hospital setting, academic center, government institution, private industry, or a company. The focus of the clinical laboratory will be dependent upon the institution in which it resides. Many company-based
laboratories offer a large menu of diagnostic services that are utilized by numerous hospitals. Hospital-based clinical laboratories are often located within pathology departments and offer a variety of tests, dependent on the needs of the institution. Within academic institutions, there are also opportunities to perform translational research and to bring projects from the bench to the bedside. This is often done by working with research scientists to identify a novel biomarker of disease and develop a diagnostic test for use in the clinical laboratory. A career in science that directly impacts the clinical treatment and care of patients is very rewarding. As such, the science is held to a very high standard and requires strict adherence to regulatory policies and procedures. A biomedical scientist may be required by some laboratories to obtain special training and certification.

Choosing Teaching as a Career
After completing a postdoctoral period or even graduate school, you may wish to devote your career to teaching, usually at the college, university, or high school level. You may need teaching certification in various jurisdictions to join the teaching fraternity. Being well informed is very important, as is searching out a mentor who has made the transition from bench research to full time teaching. Formal and volunteer teaching may provide you with a useful experience during your graduate school or postdoctoral training.

Choosing a Career in the Financial Side of Biomedical Science
You may wish to transition from the lab bench to the financial board room. You may be attracted to the venture capital enterprise, investment banking, or to management consultation. This transition will require that you learn the language of business. There are many transferable traits from the lab that provide you with important tools in the business world. These include problem solving, critical analysis of texts and data, ability to manage time and people, and presenting reports. Thus you are not without business skills after training in the lab; however, to gain credibility, formal business training may be useful. An executive MBA, especially a program designed for scientists, is one path to choose. There are also many courses and programs that are designed around industry standards and that provide professional designations. You need to explore these thoroughly. Once you make a decision to explore finance, become well informed. Career symposia on alternate or non-traditional careers are very useful. Network with friends and colleagues who have made this transition. Universities have informal "biotechnology clubs" that discuss the financial side of the
biomedical enterprise. This is a good way to identify mentors and to hear from people in the field.

**Searching for Your First Job**

This narrative on obtaining your first independent position applies to both academic and non-academic positions. Once you are finished with your graduate education and postdoctoral or other specialized training, you search for your first position. You should have been exploring job prospects well in advance of completing your training. The standard job listings should be carefully scrutinized. Initial contacts can be made at scientific meetings, with visiting lecturers, and through other informal means. Your supervisor, other department members, and your peers can be very helpful as well. Even if you are applying for a position at your current institution or at one you know well, treat it like an unknown entity. You now have to look at it from a faculty point of view and not from that of a trainee, which is a very different perspective. It is beneficial to interview at several institutions or companies so that you learn about the interview process and find out what each institution is offering. This is helpful in understanding how to rate an offer and how to frame your negotiations for salary, benefits, and research support. Understand the market pressures in the life sciences, academic medicine, and in the business and not-for-profit worlds so you can pursue appropriate negotiations.

**Curriculum Vitae (CV) and References**

In answering advertisements, provide a well presented CV that is clear and unambiguous. Identify your role in publications, especially multi-authored ones. Do not mix abstracts with publications. List chapters, books, and other non-peer reviewed articles separately.

Prepare a well-thought-out research plan that is not too long but is innovative in nature and feasible at the institute to which you are applying. Remember the search committee will be receiving many applications to review.

If you have teaching experience (formal lectures or one-on-one training in the lab), this is a plus, but in many cases teaching experience is limited during your training period. If you have a philosophy of teaching based on your experience, provide a few paragraphs so that potential employers can better assess your aptitude and suitability for teaching.

List any grants (internal or extramural) that you received as a Principal Investigator (PI) or participated in as a co-PI or collaborator. When applying for a faculty position, you will be much more marketable if you have already submitted or received a grant for extramural funding. Therefore, you have to carefully look at your CV and consider when to apply for a faculty position. In some cases, in might be to your advantage to complete another year of postdoctoral training and submit a grant application before applying for faculty positions.
You should let your referees know beforehand that they may be contacted and send them your CV and research plan so they understand your current situation and future plans. Referees should know you well and should be able to provide critical analysis of your work and how you work in a group. Collegiality is an important feature in choosing both faculty for departments and investigators for industry. If an individual hesitates when you ask for a reference, do not use them as a referee. Search committees do expect to see letters from those who know you best, e.g., supervisors, former employers. If these are absent you need to explain why.

The Interview

A useful strategy in preparing for interviews is to have a mentor or faculty member provide a mock interview for you. This is important, at least prior to your first few interviews.

At all times, be professional, collegial, confident, but not arrogant, to everyone. You will present a seminar so search committees and interested faculty can evaluate your research and presentation skills firsthand and see how you handle questions and discussions of your work. Prepare the seminar well beforehand and have peers and faculty listen to your presentation and ask questions. Make sure you bring the appropriate format to present your talk, along with a backup plan, so as to avoid a technical problem arising during the presentation. Offer to set up your talk and check the AV equipment beforehand. An essential feature of your interviews is to clearly understand and be able to articulate what you want your job description to be. Prior to the interview, decide where you can be flexible and where you should remain firm, and include this in your notes. Do not modify your job description during the interview to suit the needs of the institution. This tactic questions your motivation and should be avoided. An attitude that conveys the notion that "I will do anything to get a job at your institution" is not a strong selling point at all.

Know as much as you can about the department you visit and the overall institution as well. The same applies when interviewing at companies, scientific agencies, or organizations. Review web sites. If you receive an itinerary before your interview, review the research programs and publications of the faculty with whom you will be meeting. Be familiar with the research that is ongoing and know who is doing what. Know which programs are the priority of the department and the institution. Identify potential collaborators before your visit by reviewing information on websites. Develop a set of questions that you need answered in this first visit. Remember this is a first visit so not everything needs to be covered and specifics are not always necessary.
Your main objective is to determine whether the institution is potentially a good fit for your career and quality of life. The search committee wants to know if you have what it takes to set up an independent productive research program, if your program fits well with the department’s research, teaching, and, if appropriate, clinical care goals and objectives, and if you yourself will fit well into the collegial group of faculty in the department. Show enthusiasm for the position and convey a sense that you are very interested in the position, even if you have moments of uncertainty during the interview process. This is best conveyed by demonstrating that you are well prepared for your visit.

**Negotiating**

Do not be shy to discuss salary, start-up funds, and space, but that can be done in general terms. Be sure to see the physical office and lab space offered. The real negotiating usually occurs on your second visit when details are very important. Discuss what percentages of your time will be dedicated to areas of research, teaching, administrative, etc. Investigate granting opportunities from relevant agencies. Inquire about internal grant competitions. Is there support and mentorship for junior faculty when they apply for initial grant funding? If funding is not obtained, what type of departmental support will be provided and for what period of time? You will be asked to provide the Chair or Director with a list of equipment that you need to start up your lab - either as your own or as communal infrastructure equipment to which you need unrestricted access. Indicate how frequent this access will be needed and ask what the user cost will be. Your start-up plan need not reflect a specific dollar value. It is more important to make sure you have the equipment, supplies, resources, technical staff, and administrative support that you need to start your program and to work for at least three years without external funding. This may increase to five years depending on the funding environment at the time. The total dollar value then depends on what you need and should reflect the true costs at the specific institution. For example, salaries for support staff vary in different locations. You should have as much of what you need as possible when you arrive. Waiting for labs to be built (or renovated) and equipment to arrive may delay you considerably. Setting up a functional laboratory usually takes longer than originally expected. Thus, finish as much work as you can in your postdoctoral laboratory so that publications will come out as you set up your own laboratory in the new facility. There may be some overlap as you wind down your postdoctoral position and begin your faculty position and you may find yourself commuting for a short period of time.

**Launching Your Biomedical Scientist Career**

Once you arrive in your new position, be prepared for some frustration. However, by being well informed, you can successfully navigate through the pitfalls of setting up a new office and research laboratory. Be very familiar with regulations - department, university, government, and funding agencies. Spending time reading guidelines is probably not how you want to spend your valuable time; however, it will save you much grief and will speed up your set up. If relevant, be familiar with the regulatory guidelines for animal use, human subjects, radiation, hazardous materials, etc., and
when in doubt seek information. Ask for advice. Identify administrators and faculty who can be most helpful to you during your start up period. Faculty members who have just set up their laboratory are very useful advisors. We can all learn from someone else's experiences. Good luck!

**Tenure, Promotions and the First Ten Years**

It is essential for you to be very familiar with the milestones you need to reach as your career evolves and as you progress through the ranks at your institution or company. Many institutions have alternate career tracks, and not all of them lead to tenure. There can be research, teaching, and/or clinical tracks. You should have a very clear understanding of which promotion track you are on and how both the tenure process and the promotion process operate at your academic institution. It is critical that you meet regularly with at least one mentor who has excelled within your same career promotion track to advise you on your career development. The current realities of the first 5 to 7 years, depending on your institutional requirements, are to establish your biomedical research program. Competing pressures may exist between your research interests and your teaching responsibilities. Ensuring that you have protected time devoted to your own research enterprise is critical. Seventy-five to eighty percent of your time is needed to become a successful independent well funded, productive biomedical investigator. Usually the highest priority must be given to your research activities; however the satisfaction of being an effective teacher should not be overlooked. Faculty who have a reputation as an excellent teacher do attract highly qualified trainees to their laboratories.

While each institution has its own requirements, there are several general principles to consider. As you approach tenure/promotion, you should have done some teaching and attracted high-quality graduate students and postdoctoral fellows. Teaching dossiers require student evaluations, so make sure to collect these after each course you teach. You should have been awarded peer reviewed funding as a Principal Investigator from at least two funding sources and had renewals by the time you are considered for tenure. Grantsmanship is very important. Local seminars and/or those put on by granting agencies and professional or scientific societies are very useful to improve grant writing skills. Make sure to have serious reviews of your proposal prior to preparing your final submission, both by content experts and by mentors. You should have a consistent publication record in well respected peer-reviewed journals. Quality is more important than quantity and papers first authored by your trainees are a plus. When you go up for tenure and/or promotion to Associate Professor, you should be known for your research contributions. Often this is reflected in a high profile paper or series of papers that are innovative and may transform your area of research. This is best achieved by staying focused in the early stages of your career. Even when participating in multi-investigator programs you should be identifiable for the expertise you bring to the project.
You may now be involved with research review as an external reviewer of manuscripts and/or grant proposals. You may, although this is much less likely, be asked to serve on a grant review panel. While such experience can be valuable to you in learning how to develop a successful grant, these review activities are time consuming, so you must budget your time very carefully. Not obtaining your own grant funding because you are too busy reviewing others is not a useful way to advance your career. Some amount of committee activity is useful since everyone must pitch in to help administer the system in which they work. But once again, budget your time very carefully. If you are doing your share of administrative work in your department as a junior faculty member, do not hesitate to decline a request to serve on yet another committee. Indicate that once your time commitments change, you would be more than willing to take on new responsibilities. In the early years, focus your administrative roles both at your institution and externally to activities close to your research activity, e.g. graduate committees, scientific meeting program committees.

You are not working in a vacuum, so know the investigators in your field. One way to do this is to become active in your discipline’s professional and scientific societies. Once again do not over commit yourself, especially in the early stages of your career. Attend scientific meetings, especially small meetings where it is much easier to meet your colleagues and discuss science. Social settings during a meeting are a very good venue to interact with colleagues. Promote the attendance of your own trainee(s) at scientific meetings with you. It is a very good investment of your funds.

It is very useful to apply for and to receive personnel awards. It is confirmation of the high regard your peers have for you and your work. Applications are usually a time consuming process, so focus applications on those awards for which you have a very good chance of receiving. Seek much information about the application process so you understand how best to fill out the forms and what the agency or foundation is looking for in its awardees.

The Institutional Challenge to Train and Maintain Biomedical Scientists

Leaders in universities, scientific institutions, and industry need to be well trained in leadership to create high quality environments to support research and learning. It is at the academic institutions that the scientists-in-training require high quality programs that equip them to face their own future in both academic and non-academic life sciences. To achieve this, academic leaders must be able to secure resources to create stable environments for trainees and faculty. The very best biomedical scientists are required to generate and transmit new knowledge to fellow scientists, trainees and clinicians. Biomedical scientists require an environment that rewards their motivation, their ability to unravel the mysteries of pathobiology, and that fosters innovative and transformative research. High quality programs are required to provide the unique training that Pathology and Laboratory Medicine offers to study, understand, diagnose,
treat and prevent human disease. A stimulating intellectual environment with state-of-the-art resources and time dedicated to research are needed to launch biomedical scientist careers and to support their productive growth, especially in the early stages of their careers. Universities, teaching hospitals, affiliated research institutes, granting agencies, (both private and government) and industrial partners need to actively support these academic initiatives and create capacity to train biomedical scientists and to support their mentors. All will benefit from having a strong core of biomedical scientists in the biomedical research and clinical community.

Research - Excellent productive investigators need to be trained to acquire a knowledge base and the technical expertise to explore mechanisms of disease and translate basic knowledge to clinically useful information to diagnose, treat, predict prognosis, and prevent disease.

Teaching - Innovative teachers require the training to be able to link teaching to research and to state-of-the-art knowledge and technology, and to be able to carry out research in education. Faculty development opportunities in teaching are very important. High quality information technology (IT) is essential to carry out first class teaching to undergraduate, graduate and postgraduate trainees.

Academic leaders must have the vision to initiate training programs that promote innovation and encourage transformative research. Thus training programs need to be adjusted to provide the very best opportunities to train future faculty. Departments would do well to adjust their academic resources to provide their academic faculty with career development and advancement, which demands that innovation, new knowledge, and international recognition be the hallmark of excellence in research and teaching in academic laboratory medicine.
Links and Resources

Societies & Associations
American Association for Cancer Research (AACR)
www.aacr.org
American Heart Association (AHA)
www.americanheart.org
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
Canadian Institutes of Health Research (CIHR)
www.cihr-irsc.gc.ca
College of American Pathologists (CAP)
www.cap.org
Federation of American Societies for Experimental Biology (FASEB)
www.faseb.org
Heart and Stroke Foundation of Canada (HSF)
www.hsf.ca/research
Individual Development Plan
The Intersociety Council for Pathology Information, Inc. (ICPI)
www.pathologytraining.org
Laboratory Medicine and Pathobiology, University of Toronto
www.lmp.facmed.utoronto.ca

Medical Scientist Training Program (MSTP) Institutions
National Cancer Institute (NCI)
www.nci.nih.gov
National Cancer Institute of Canada
www.ctg.queensu.ca
National Institutes of Health (NIH)
www.nih.gov
National Postdoctoral Association
www.nationalpostdoc.org
Postdoc Scholars Network
http://postdocscholars.net
United States and Canadian Academy of Pathology (USCAP)
www.uscap.org

Publications

Online Jobs Board
PathologyJobsToday
www.pathologytraining.org

Residency and Fellowship Training Programs
Online Directory of Pathology Training Programs in the USA and Canada
www.pathologytraining.org
www.PathologyTraining.org

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