Blending the Disciplines–
Medicine and Engineering

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CAREER CHOICES – AN EARLY STRATEGY

Tau Beta Pi members have many paths to choose when they show a major interest in medical puzzles of the day. The decision to pursue the M.D. or other specialized clinical training degree as part of an underpinning for a career in biomedical engineering or related disciplines can be an important factor in one's career. The general flow of education is such that one feels compelled to incorporate such dual-track training early, if one is to maximize the presumed benefits of such a pathway. Conversely, the typical graduate may often be uncertain about what will be blocked if he or she does not choose these top medical credentials. Even as one becomes quite conversant with the biomedical engineering literature in one's field of interest, uncertainties remain about what one is missing or restricting if one does not bring his or her own clinical or medical skills to the work-site.

Often the only place to start is by joining a local research team in some sort of work-study affiliation, and through this process learn the backgrounds and work patterns of the participants. This will be insightful, but it is not efficient, since there will be many types of research groups that you will not be able to experience personally.

TIPS — CHOOSING COMPONENTS IN A CAREER PATH

To balance this void of information, we want to provide more systematic insight about the personal skills and inclinations of the medical members of these mixed discipline research teams. The intent is to let you more globally decide if you wish to advance up the ranks firmly on the engineering side or on the medical side of the equation or in some hybrid dual pathway. Some insight will also be shared about clinical research teams that the author has observed during his lifetime of aeromedical and occupational medical research. We will try to describe the situations realistically, so that the reader can decide which situations to attain formally and which situations best remain for serendipitous access later in one's career.

RESEARCH IN TRADITIONAL CLINICAL SETTINGS

First, the most basic of clinical and biomedical research occurs in hospital, medical school, industrial, and related settings wherein specific diseases and injury patterns are receiving not only state-of-the art care, but the participants are continuously exploring new options for addressing these diseases and injuries. In such settings one observes that access to clinical research generally requires the same types of diplomas and certificates that are checked when approving traditional practices of medicine within those institutions.

There is much on-the-job training. Teams might include imports of people who have conducted similar research at other institutions, and team building follows the patterns of what the senior researcher has brought from his or her previous institution(s). It is not uncommon for the team to initially be assembled by the senior clinical staff member who is assigned a new research initiative. In this process as many existent staff as possible are used. The senior research lead also tries to match any guidelines issued by overseeing human-research or animal-research review teams. These ancillary teams are interested mostly in safety and as part of this process review the credentials of the participants. Typically there is no standardized norm for certification of clinical or animal-research participants.

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Since these *de novo* teams are built with the aid of some senior lead clinician or researcher, there is much diversity and flexibility within such teams. Again, if you are looking at a limited number of sites where you might want to blend in your engineering expertise, you might get the best information by a series of formal interviews of team participants. But the rules for appending the correct engineering or biomedical engineering talent to such teams are open or indistinct.

MEDICAL CERTIFICATION— PRACTITIONERS' POINT OF VIEW

So what step to try next? You still are interested in knowing if you should go to the trouble of getting your personal medical training and certifications. You may accept that clinical research teams do not require any type of specific certification, but you want to understand just how the clinicians use these certifications to enhance their own options, be it within regular practice of medicine or within research.

Clinical training pathways and certifications can prove perplexing even if the topic of research is not broached. Within the medical profession, there is ongoing debate about the scope of duties of the physician, physician associate, physician assistant, nurse, nurse practitioner, nurse's aide, and many other functional subdivisions. There is an attempt to maintain an order of increasing responsibility and corresponding level of payment for services within these medical alphabet-soup members. However, the boundaries blur intensely when groups of such people find themselves in a busy medical center or academic institution, and all are sharing very closely in the execution of the same clinical mission or same research project.

Clinical certifications permit unencumbered access to specific categories of patients. However, these certifications have been structured to subdivide work among the patient population without regard to research on this patient population. You will find research teams in which all the medical personnel possess the highest medical certifications for the disciplines of interest. You will find the more typical teams wherein only the lead member (or perhaps an additional one or two members) will have the traditional medical certifications that permit full and unencumbered access to the patient populations in the studies of interest.

Though not a standardized feature of research team building, projects heavily dependent on the use of human and animal test subjects can obtain oversight board clearance more readily when both clinical and engineering talent is strongly represented on the team. All the more power to the holder if the same person has dual clinical and engineering credentials, but this is a luxury. Another time when dual clinical and engineering credentials prove of immense usefulness includes the occurrence of untoward medical events during the execution of a study. These untoward findings can perhaps more cogently be presented to oversight boards, with resultant reopening of the clinical research study in more timely fashion.

IF CLINICAL CERTIFICATION ISN'T NEEDED, WHY GET IT?

So there you stand, still seeing no absolute need for personal dual clinical and engineering training! But if you observe typical research team functioning, the person who typically diagnoses the problem, establishes the hypotheses for testing, designs the solution, and even fights for necessary funding is the clinician with maximum clinical certification. At first it may seem you really must target your training toward these lead medical roles. But do not let yourself search for these leadership roles unless you are sure that you have the time, patience, and, most importantly, the inclination to be an actual clinician. The training programs for clinical certification provide far more medical material than will truly be necessary to contribute to progress on the engineering side of the team. The clinical training will put much emphasis on patient interaction and bedside manner. You will have to feel comfortable with extremely empirical and almost "unscientific" data. You will have to become comfortable with the immense lack of quantitative data about many facets of medical diseases that confront mankind. You will truly have to understand why they call medicine an art.

DON'T CERTIFY CLINICALLY FOR THE WRONG REASONS

Just because one wants the freedom and control in future research, no one seeking certification should bring coldness and aloofness to the patient. Don't make this error even if many doctors enter practice with highly structured and impersonal methods of dealing with their current and future patients and do not even realize their behavior.

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Another major dividing line is quite practical. Although many medical disciplines allow you to skirt around the issue of blood, guts, and other intrinsically human materials, the progress in mixed discipline research must come from close work with these very natural building stones of the human. Thus seek not the path of a research physician if you are squeamish about the body and its many parts and fluids. It just does not work like a car or airplane!

If you still decide that you can carry out these technically and spiritually diverse professions concurrently, all the power to you, since seeing both professions from "up close" probably does allow better insight with problem identification and solving. But remember, you should be willing to accept a major responsibility in helping your engineering colleagues understand the details of the medical problem.

IF YOU DON'T DUAL CLINICAL-ENGINEERING CERTIFIY?

First, rest assured there are no shortages of problem-solving situations that will profit from your engineering skills.

You can be the productive engineering participant in a clinical engineering team working with human subjects (both actual patients and officially healthy people) or with non-human subjects. You will be able to work in traditional clinical settings or within complex laboratory environment settings and not bother becoming the physician with all requisite clinical certifications.

By taking courses in physiology and comparative anatomy and excelling in dissection and analyses of biological materials, you could contribute greatly in research with human and non-human animal species. Be aware that animal-based research scenarios can draw opposition groups. In the extreme, entire laboratories have ben destroyed by those wishing to make certain counterpoints.

Certainly, for some engineering specialties, you can contribute major input to medical solutions without setting one foot inside either the direct arena of the human body or of ersatz other-animal research models. Engineers contributing to sophisticated measurement techniques can frequently add valuable contributions working almost entirely from the outside of the *workspace* of the *hands-on research* team. Of course, you had better complete the appropriate *book learning* about the body environment or your *simple solutions* will elicit smiles related to the inapplicability of the proposed solutions.

WHAT IS A TYPICAL CLINICAL HIERARCHY?

You still want to make up your own mind. A brief review of clinical training and certifications may permit you the greatest amount of choice.

To minimize the medical jargon, we will focus on physician pathways and not introduce the clinical certifications available within nursing, physician associate, or other medical-support-personnel pathways. Most clinical projects still put a physician as the titular, and usually functional, head of the clinical research team. But any current research practitioner observes how nurses, physician associates, and related specialists actually conduct the day-to-day research. One can envision turf and medico-legal issues, but these will not be emphasized here.

PRE-MEDICINE; MEDICAL CERTIFICATION; SPECIALIZATION

If you travel up the physician pathway, you discover that you put in between six-to-eight years to obtain an M.D. degree. Similar time requirements exist for the alternate pathway toward a doctor of osteopathy (D.O.) degree.

Pre-medicine choices can be varied, and you must ensure that you take the requisites for the medical schools to which you plan to apply. Thus you can finish pre-medicine without any degree designation and be accepted for medical school. The medical-school curriculum is traditionally another four years of education leading to the M.D. degree. Academicians have established concentrated M.D. programs that combine master's and doctoral-level designations within the same training pathway that leads to the M.D. degree—and with some overall reduction of curriculum length achieved by letting courses count toward both degrees. These should be investigated closely by interested parties because these programs are intensive and have unique training goals.

Once you have your M.D. degree you can follow many different academic pathways, but if you are searching for clinical flexibility in your career, you should get a state license. The state license determines a base of clinical activity that the physician can provide the community. This process of state licensing is directly related to protective mechanisms undertaken in the 1800s to protect the citizenry from uncontrolled providers of medical advice and service. These state mechanisms do not attempt to rate your ability to provide specialized clinical care or to conduct clinical research. Instead the states define a floor of minimal expertise before you open the door to your clinical office.

What are the requirements for your first state license? The Oklahoma State Board of Medical Licensure and Supervision reported that initial license costs range from $1,100 in Florida to $20 in Pennsylvania. You supply proof of your medical degree, and you must show evidence of postgraduate training. This is typically one year (in 42 states). If your medical degree is from overseas, the norm for required postgraduate medical training is higher, with 24 states requiring three years. Keep in mind that postgraduate training, as used in this paragraph, is typically that which is a component of training pathways toward medical specialization, as described later.

The medical practitioner needs a state license to practice medicine in any given state of employment. But join a federal institution, and you may find that federal rules allow you to practice medicine on federal territory even if you have a license in a geographically separate state of the union.

Though each state maintains its own system of granting a license, it is possible to use the equally varied approaches to obtaining licensure in a new state by reciprocity. These rules may simplify the accessing of other state licenses after you have gone to the typically more exhaustive process of getting the first state license. As part of the process for medical licensure, expect to be investigated for medical malpractice as recorded within any of several databases available to licensing agencies. Do keep in mind that these types of functional checks vary in intensity among the various state boards, and many boards justify their fees to be able to conduct such applicant checks prior to licensing.

After you have a state license, you must also decide on paths for various medical specialty designations. These are earned by participating in formal medical-training programs and then executing a certain number of years of practice under official observation. You pass through a stage from *board-eligibility* (i.e., your requisite training is complete but you have not completed all testing) to *board-certified* status. Various specialty boards, typically national in nature, certify that you have completed requisite training, requisite periods of supervised practice, and actual examinations and reviews. These sophisticated designations reflect functional medical capabilities rather than jurisdictional or political certifications. However, many employers use these certifications as basic entry criteria when recruiting specialists.

The variety of specialization options can be demonstrated by listing the specialties the licensee may desig nate during an application for a medical license. For instance, Texas can be viewed as representative: 79 choices are tabulated, ranging from specialization in allergy to vascular medicine. The respondent is also asked to designate if the specialization is acknowledged by one of the nationally recognized groups or whether this is a self-designated specialty. Self-designation can arise when no overseeing board exists for a uniquely defined subspecialty, but these often lead to much confusion and strife, even among medical practitioners. It is of interest to note that none of the above choices has *research* in its title, that this type of specialization in research must remain *hidden* within the traditional titles, and that one may choose a title like *other specialty* or *unspecified specialty*.

FINAL DECISION IS YOURS, BUT MAKE IT FOR THE BETTER

We've tried to paint two options for you. One states that tremendous contributions to engineering components of medical unknowns can be made without taking on the separate path of medical training and specialization. The other states that you will have more freedom of choice in your work, but you must be sure you are suited to the demands of *the art of medicine*.

We leave you with the strong admonition to choose your training and career fields on the basis of enjoying and mastering the technical material, and not some future elusive administrative or tactical advantage. In the end, if you have studied and mastered your discipline or disciplines of choice, people will come to you for help!

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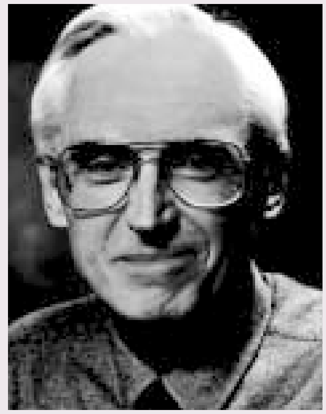
A career in occupational and aerospace medicine was abruptly ended by a diagnosis of cancer when the author had to retire medically from the FAA in 1999. Because of the special support of his wife, Martha R. Hordinsky, the author was able to offer professional contributions to the community until he died last October 20. This article is possible because of her devotion and cooperation.



Jerry R. Hordinsky worked as a flight surgeon with NASA in 1972-81 after a tour of duty as an Army flight surgeon. From 1982 until he took medical retirement in1999, he was manager of aeromedical research within the FAA and adjunct associate professor in the department of environmental health at the University of Oklahoma. Although his career path emphasized aerospace medicine, he has been active in the broader field of occupational medicine and has had a long-term commitment to practice applications that integrate medical care around the occupational health team.

Graduating from the University of Minnesota from a pre-medicine and engineering curriculum with a B.S. in applied mathematics, he attended Northwestern University in Chicago and earned a doctor of medicine in 1967. He continued his studies in occupational medicine and earned a master's degree in industrial health from Harvard University in 1972.

Board certified in both occupational and aerospace medicine, Dr. Hordinsky has published more then 50 papers, ranging in topics from space flight to formal assessments of FAA issues such as toxicological findings in general aviation fatalities, neuropsychological screening of fliers after head injury or disease, emergency medical kits within the civil aviation sector, and optimization of aircraft cabin environmental and work conditions.

Bequest Booklet

Several members of Tau Beta Pi have informed the Executive Council that they have written the Association into their wills. Others have asked about the proper wording of such statements. Tau Beta Pi is classified as an educational non-profit corporation under Section 501(c) (3) (not private) of the U.S. Internal Revenue Code.

The proper form of a bequest is:

"I give, devise, and bequeath to The Tau Beta Pi Association, Inc., a corporation existing under and by virtue of a charter granted by the State of Tennessee and with its headquarters in the City of Knoxville, in said state $. . . (or, the following described property, or securities)."

An informative booklet on deferred giving entitled ". . . on gifts of lasting value" is available from Tau Beta Pi headquarters: P.O. Box 2697, Knoxville, TN 37901-2697. The third edition was updated to include changes in the 1986 Internal Revenue Code.