Clinics in Dermatology (2019) **37**, 4–11

ELSEVIER

Clinics in Dermatology

The inevitability of change

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Abstract Change is an absolute so long as time does not stand still. We should expect it, embrace it, and try to predict its direction. Dermatology, as a specialty practice, has been changing rapidly over the past 30 years concurrent with the changes in medicine. What are these changes, how did they come about, and what may be the consequences? The goal of this review is to follow the march of time, as we move from one era to the other in step with what is happening in the world as a whole and the United States in particular. The growth of our specialty, Dermatology, is divided into 3 eras which are quite different in generational cultures. The first era spanning the 1980s and 1990s is dubbed as "old school." The second era begins with the new century, 2000 until today. This era will forever be remembered as the business era, the rise of elite cultures, and the losses and threats to academia. The third era begins now; it is that of technology which is fast progressing into the future. One can theoretically project what may occur during this technologic revolution and the directions in medicine as a whole. Dermatology can be at the forefront of this era or it could be lost as a whole if we do nothing to keep up. These eras are based on my personal experience as a dermatologist in a large academic institution in the United States and may not apply to other communities or societies elsewhere. The United States serves as a good example of a western technologically oriented society that is often emulated by others.

Era of "old school"

Although used often in conversation with colleagues and patients, the expression old school has a fluid definition depending on context and subject under discussion. As per the *Merriam-Webster Dictionary,* the definition of old school is: "Adhering to traditional policies or practices with characteristics evocative of an earlier or original style, manner, or form." Other names applied include "antique," "old-fashioned," "old time," and "obsolete," to name a few. The expression old school likely is eternal, as every mature generation tends to use expressive terms to separate itself from the upcoming younger generation, when they do not conform either in thought, ethics, or the standard way of doing things.

Currently, I believe old school has a different connotation. When I first started as a dermatology resident at the Mayo Clinic in the early 1990s, there was an aura within the department that I can describe as serious, disciplined with a strong culture of professionalism, and respect. The staff was renowned in the world of dermatology, and we all were very conscious of that. The experienced generation was revered and respected. We had a dress code, a method to greet patients, and most of all a drill in our heads of the Mayo brothers' aphorism: "the needs of the patient come first." Each morning at 7 AM sharp, we had conferences, one for dermatopathology, one for hospital cases, and three for daily patient viewing and differential diagnosis. Residents had to attend and be prepared to answer questions when called on. This was a daily routine for 3 years of residency without any didactic lectures. We were expected to learn from every case,

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https://doi.org/10.1016/j.clindermatol.2018.09.003
0738-081X/

read all of the available dermatology books on our own time, review the most recent publications, and be ready to cite them, particularly during hospital conference. Hospital dermatology was at its peak, with at least 40 inpatients. We spent most of the first year taking care of inpatients, with every other night call and preparation for the weekly hospital conference. Research and writing papers were an expectation not only for the staff but also residents. Traveling to meetings and presentations were very much supported. Although, as residents we were always anxious, we learned a lot and now look back on these days fondly reminiscing various incidences with the current staff. This experience was not unique to Mayo. I believe most dermatology programs were very similar. During our training, we focused on mastery of the art and practice of dermatology. We rarely discussed billing, reimbursement, insurance coverage, or the cost of medications prescribed.

Old school proponents deem themselves to be physicians and professionals.[1] Most consider themselves as dutiful, hard-working, and placing the needs of the patient first. The framework accepted by this group was the doctor/physician as the chief of the practice even by those who worked in larger clinics. Apart from a rare few who sat on the Board of Governors, there was no hierarchy beyond academic rank, and all physicians were considered equal, especially in nonprofit institutions.

Era of the business elites

With the turn of the twenty-first century, dermatology continued to be a growing field for private practices as well as for large multispecialty groups and academic institutions. These were exciting times, as dermatology was attracting many young physicians to a specialty that now encompassed subspecialties of clinical and hospital dermatology, research, pathology, and dermatologic surgery with a very attractive future for the new subspecialty of cosmetic dermatology. This was an opportunity for the growth of dermatology as a whole.

What occurred was unexpected; instead of growth in all facets of dermatology, procedural subspecialties expanded at a faster rate, although at the same time there was a relative decline in hospital, clinical, research, and pathology subspecialties.[2,3] For inpatient dermatology, census continued to decline to the point where many academic institutions no longer could run inpatient services. Dermatopathology had evolved over many decades through the early and mid-1900s and by the 1980s had its own subspecialty board and accredited fellowship training, spearheaded by dermatology-trained dermatopathologists. By the new century, the number of dermatologists entering dermatopathology was surpassed by those coming from a straight pathology background.

The business of medicine

Health care dollars were consuming a larger portion of the gross national product than ever; hence, government intervention grew. Instead of physicians or physician-led organizations seeking their own solutions to upcoming interventions, they instead hired consultants who were often less concerned about patient care to advise them. Physicians were trained to bill correctly and to understand invented health care codes, rather than focusing their primary attention on their patients' skin health and to clinical and basic research. Until today, physicians are consumed by educational lectures on how to bill. Within that context, it is no surprise that electronic medical records were tailored first and foremost toward fast billing. Not a single area in any medical record has been directed toward easing the clerical burden of the physician. In other words, instead of "patient comes first," it is the bottom line that is more important. Ironically, the promoted push by various entities for adoption of the electronic medical record ignored the exorbitant prices of new and even old school medications and consequently the vast price increase of all medications including generics.

A variety of clinics and health care systems and insurances, ranging from Preferred Provider Organizations to Health Maintenance Organizations popped up everywhere.[4,5] Eventually, some of these systems and practices were taken over by venture capitalists,[6] some of which were traded on Wall Street. The idea was to lower health care expenditures by decreasing unnecessary tests that doctors ordered for fear of malpractice. A veritable cobweb of complicated algorithms in a system of denial or acceptance of treatment and approved procedures was created for the patient by their insurer. Prior authorizations and models that challenge physicians in their core work of prescribing are now the norm. In the new paradigm, these new clinics and systems became more answerable to their investors rather than to the patients they are meant to serve. The more they deny expensive treatments or tests the better they performed. This is an amazing concept, because everyone will be sick at some point; one would think that good health care would not be traded on the market as a "for profit" commodity.

Business models were adopted that ended up separating the pool of physicians into elite executives and physician workers. As the business culture spread over the country, many health care institutions became similar to corporations with the development of a sophisticated management hierarchy that adopted such titles as chief executive officer instead of president, and chief financial officer. Preventative medicine which was intended to keep people healthy and avoid costly hospitalizations morphed into "wellness" putting the ownership of one's health primarily as a responsibility of the patient. At least in our specialty, it is hard to see how these concepts other than sun protection can prevent many of the inflammatory, autoimmune, and genetic diseases that we diagnose and treat on a daily basis.

The dermatology hospitalist

With the advent of managed reimbursement and government interventions in the late 1990s,[4,5] the hospital presence

of dermatologists as well as phototherapy[2] decreased considerably to where we have very few dermatologists caring for our most sick hospitalized dermatology patients. Diseases such as lymphomas, as well as immunobullous and autoimmune diseases are much more difficult to teach in residency programs given the minimal involvement with hospitals.[7,8] Newer dermatologic diseases, such as graft versus host disease, toxic erythema of chemotherapy, or cutaneous side effects of new oncologic treatments and biologics, will likely be missed by dermatologists except the few who still are working in hospitals. Consulting services for severe adverse drug reactions, including toxic epidermal necrolysis, Stevens-Johnson syndrome, and drug rash with eosinophilia and systemic symptoms are for the most part treated by the medical services leading to further demise of our knowledge base, as well as lack of teaching for the future generations.[7,8] If our staff does not obtain experience in treating these sick patients, who will be teaching our residents and students of tomorrow?

This was the state in the early part of this century; however, counter to these trends, there is a small but significant revival in hospital dermatology started by several medical centers. In 2004, our group created a "dermatology hospitalist" core group that consisted of six dermatologists each taking at least 8 weeks of hospital service per year divided into 2-week rotations[9] and comprising 24/7 coverage of two large teaching hospitals. We admitted patients to the dermatology service, responded, and rounded on consults from other services, went to the emergency room, and saw stat consults when called, in addition to monitoring the phototherapy unit. We gave conferences and focus sessions at several meetings including the American Academy of Dermatology which sparked interest in this aspect of dermatology. Dermatologists in other institutions took it further. They not only became more involved in hospitals but also formed a hospital society that meets regularly at the American Academy of Dermatology, promoting interest in publications and conferences.[7,9–13] There is still hope that dermatologists will not abandon our sickest patients in hospitals and that the hospitalist concept will survive.

Procedural dermatology

Dermatologic surgery and cosmetics grew rapidly over the past 3 decades and is continuing to grow until today. The reasons for the expansion were multifactorial but may be related to the rising numbers of skin cancers and a growing interest in surgery and cosmetics. It also was more appealing to a new generation that preferred avoidance of "on call" specialties, quality of life, time spent with family, and perhaps a much higher financial reward.

Most in dermatology have supported this growth and rightfully so, as both subspecialties are best performed by dermatologists; however, given the expansion of surgery, lasers, and cosmetics, there has also been a slow but real decline in access to outpatient clinical dermatology and research.[14–18] Clinical dermatology is now heavily dedicated to skin checks searching for skin cancers and atypical nevi for surgical intervention, which is more rewarding in many ways than clinical interventions for chronic skin diseases without cure. The sicker dermatology patients, who may need immunosuppression and regular continuous follow-up, are generally not as desired by dermatology practices. An appointment of 2 to 3 months out may be given for an inflammatory disorder, whereas a Botox injection or excision may be an immediate, if not same week, appointment.[8,14–16,19] Due to this relatively common practice, our specialty has begun to receive a slap with some of the public media commenting on such behaviors.[17]

Shortage of dermatologists

One of the unintended consequences of this shift of dermatologists' work to cosmetics and surgery, in addition to many working part-time, is a relative shortage of dermatologists nationwide.[20–28] As a result, there has been a large infusion of midlevel providers to fill this gap and the gradual but predictable takeover of dermatologic subspecialties by other medical specialties, similar to the loss of sexually transmitted diseases to infectious diseases in the past. Similarly, leprosy, a well-known biblical disease that has always been under the purview of dermatologists, is now being taken over by infectious disease in the United States. The infusion of midlevel providers into our systems was welcomed for a role in assisting the dermatologist; but in practice it has turned out that they were caring for and treating new medical patients, including patients with inflammatory diseases who may require immunosuppressive agents. The current and real issue lies with defining the responsibilities and practice of midlevel providers and how they should be integrated with dermatologists in caring for patients with various skin diseases, but not over burdening them with patients beyond their scope of practice.[29–31]

Dermatology is not the only specialty experiencing this change. There is a shortage of physicians in the United States.[32] Instead of increasing the number of medical schools or the size of the classes, the approach was to fill the gaps with midlevel providers. The purpose was to have providers who are paid less to assist physicians with their patients who in turn could become more efficient. Unfortunately, in practice, the midlevel provider is often the caring face that the patient sees and therefore viewed as their physician. No longer are the old school words *doctor*, *physician*, or *surgeon* used to refer to dermatologists and MDs, in general. We are now simply *providers*. This label has been pushed by many administrators of health care to the point where there is a general acceptance and perhaps even lack of knowledge by the patient who is seeing a provider whether or not their caregiver is a physician or a nurse. Now, we are all the same doing the same job.

In short, the old school understanding of the word *professional* with all that it entails[1] is now obsolete. This entire era is all but gone, and we are now all health care providers.

Era of optimism: The future of science and technology

It would seem that the changes previously described will never revert; but they will change, as they always do. There could be many drivers for this change, but one major driver is technology. Technology is moving at such a fast pace that it is difficult to get a handle on it. Going beyond targeted drugs, which have changed our treatment protocols for many diseases especially in oncology, there are many different avenues arising that behold a very optimistic view for medicine as a whole. Given the speed of laboratory to bedside scientific achievements, I warn the reader that this contribution may be obsolete by the time the manuscript is published.

Telemedicine

Due to the manpower challenges discussed previously, remotely offering care has become a popular idea. The art and science of taking care of patients, when there is a large distance between provider and the patient, is now a specialty referred to as telemedicine. Currently, we have teleconsults, telepathology (Figure 1), and teleradiology, the latter of which is more mature and now widely used, e-consults over the Internet and even telerobotic surgery which will probably be widely available in the near future. Telemedicine will likely expand and become more robust and sophisticated as it already has a role in dermatology.[33,34] Teledermatology opens up new avenues of practice for those with advanced training or skills.

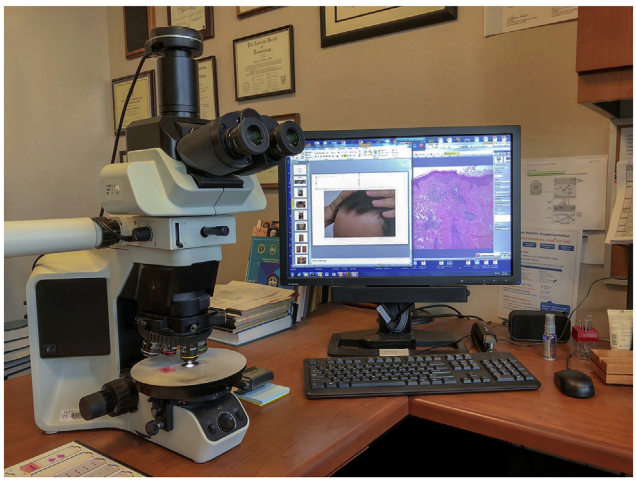

Fig. 1 Teledermatology is becoming more widely used for several purposes including diagnosis and therapy and can be accomplished utilizing several types of devices including microscopes, smart phones, and tablets either as store and forward or in real time.

Regenerative medicine

Transplant surgery has grown so much of late to include almost every organ, including limbs, face, and internal organs. The main drawback has been the required use of immunosuppressive agents for life. Is there a way to avoid it? By using one's own stem cells, can we regenerate our dying organs? The field of regenerative medicine and 3-dimensional (3D) printing will be the future of transplants. Using stem cells growing in cell culture, it has been shown that these cells can become pluripotent and can proliferate under the influence of specific cytokines and growth factors to differentiate into organs and tissue such as cartilage or bones.[35–39] Dermatologists will be able to utilize this technology for the skin. It is already available and recently has been used to regenerate the skin of a patient with junctional epidermolysis bullosa.[40]

For internal organs like the liver and kidney that have specific shapes and architecture, cell regeneration is not sufficient. With a technology known as 3D printing (Figure 2), this may be a possibility. Three-dimensional printing is similar to a word document printed by a 2-dimensional printer, the only difference being the creation of a hologram model of the organ, scanning it digitally and then printing it out. The printer copies the digital 3D image layer by layer to give an exact copy of the 3D organ model. This technique is already being used for a variety of prosthetic devices and it has had a signif-

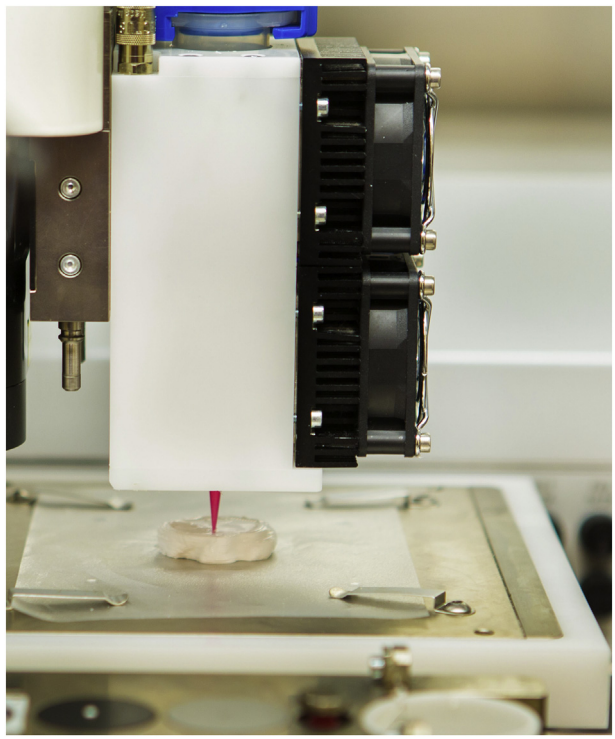

Fig. 2 Printing a digital hologram model layer by layer by a 3D printer. (Reproduced with permission from Mayo Clinic Regenerative Medicine.)

icant effect on many who have lost a limb. In the future, this type of regenerative medicine in combination with 3D printing may produce transplantable organs that would not require immunosuppression for life.[41–43]

Nanotechnology

Dermatologists know nanotechnology, as it has allowed us to make excellent sunscreens.[44] The transformation of titanium to tiny, less than 100 nm in size molecules, can change its properties from opaque to transparent yet maintain the sun-screening ability. This has led to an inert, nonallergenic sunscreen. Nanotechnology is now used in many fields of engineering and medicine. For example, the gadolinium that is used as a dye in MRI and the chemotherapeutic agent doxorubicin are both nanotechnology products. This technology is now being tried for drug delivery to targeted cells either for diagnosis or for treating hard to reach cancers in different organs.[45–51] One can imagine this technology as a targeted treatment of metastatic melanoma.

Nanotechnology is currently considered for blood filtration and detoxification, clearing of pollution smog particles and new medical devices that may eventually simulate science-fiction gadgets. Nanosheeting is used for burn victims and our clothing may soon have blood pressure and heart rate monitors embedded in them, all via nanotechnology. Safety and toxicological evaluations are ongoing for biological and medical nanotechnology products.[52] For more information, the center of responsible nanotechnology would be a good place to start learning about this amazing technology (http://www.crnano.org/whatis.htm).

Genetics

One of the emerging fields where dermatologists should be active is genetics. New targeted medications are being directed to edit the DNA or to halt a stop codon. A great development is gene editing technology known as CRISPR (clustered regularly interspaced short palindromic repeats). Also known as CRISPR-Cas, this technology utilizes a part of the bacterial immune system known as the *defense genes* (Figure 3). With this as a source of the synthetic guide, RNA and the enzyme Cas that can split or knock out specific locations in the DNA, gene editing was born.[53–55] Many ramifications of this genetic technology are currently in laboratories worldwide. It is perhaps the most promising as well as the most facile of the genetic technologies. It is expected to help patients with genetic diseases as well as for targeted drug discoveries; however, it will take time until this technology is ready for human gene manipulation, as safety is more important than the potential results themselves.[55]

Artificial intelligence (AI)

Everyone knows about AI, but we do not know how it would fit in our lives. For example, there is a hotel in Japan run totally by AI, from manager to cook to cleaning and room services. The only humans are the guests! Does this mean in the future there will be no jobs for hotel personnel? How will AI change dermatology? Generally, in order for an AI to be a provider of health care it first needs to be educated. This is the most important step where dermatologists should be involved, assuming we want to keep our jobs. For an AI to be functional,

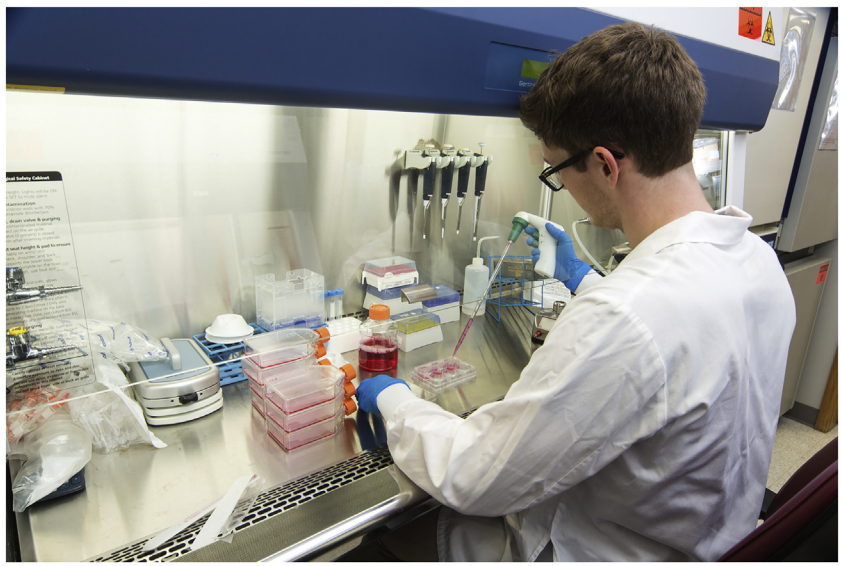

Fig. 3 Adding the CAS9 lentiviral construct as a first step for gene editing. (Reproduced with permission from Dr. Alexander Meves, Mayo Clinic, MN.)

several steps are needed in addition to education such as repetitive viewing of typical and atypical forms and colors of various diseases. Some of the technologies it will also need include medical algorithms, big data, and possibly blockchain technology.

For the past several years, medical communities have all been working on their own algorithms for a variety of diseases to better diagnose and treat them. The algorithms were created to standardize care and to assist midlevel providers to diagnose and care for patients, but the real power of an algorithm is to feed the AI who is being groomed to eventually take over a provider role. Fortunately or unfortunately, dermatology has few algorithms but eventually there will be more.

For any AI to learn a specific topic, let's say dermatopathology, it will need to be fed thousands or even millions of slides to recognize patterns. Although that seems like a lot of slides to view, the AI actually does it very fast. They may end up recognizing malignancy better than a human as shown in this melanoma AI trial.[56,57] Similarly, to recognize skin diseases they will need to see thousands of photographs with various colors and patterns to recognize a specific disease. The same concepts are applied to almost all areas of medicine. The question, of course, is how to get these numerous pathology slides and photographs of patients and diseases? That is where "big data," commonly used words nowadays, come into play.[58–60] Can the big data for dermatology training be found? Are there enough slides and photographs of a large enough and diverse number of diseases to accomplish this training? Do patients need to give approval to be a part of this training (Figure 4)?

Finally, one has to ask, if we have the big data, how will it be stored given the possibilities of hacking and difficulty with cloud storage and security? Currently, institutions are looking for different and more secure technology to store their data, as well as their financial or other transactions. Blockchain is the technology that has been used for cryptocurrency and Bitcoin. It is now being applied to many areas including medicine, being referred to as a digital ledger that can store digital transactions, financial data, accounting and record keeping, and other entities. The advantage of blockchain is the security and privacy, as it is almost tamper proof.[61–67] This is why this technology is sought after by health care institutions not only for the privacy of medical records or financial transactions but potentially for the storage of the big data.

Given the algorithms and big data for learning, coupled with security and verification, we should anticipate that AI may take over certain areas of the "provider" role. The push for making medical algorithms for every disease and its management is the first step in teaching the AI provider. By the next decade, patients may be evaluated and triaged by an AI, and may also be treated. AI can literally do almost everything. They can have all the dermatology books and journals in their memories. They can most likely even perform superficial skin laser treatments. They may also use advanced confocal microscopy techniques to reveal the depth and width of a skin cancer and proceed to excise it. Using confocal microscopy in conjunction with nanotechnology, I can imagine that the AI may be able to detect metastasis in the lymphatics or the sentinel lymph node. In addition, they probably will bill more appropriately than we do as they will have the ICD-10 and other complicated code algorithms in their memories. One dermatology AI will probably be capable of doing all those or some may be specialized for specific duties. There may be medical schools specifically for the AI or we may be their teachers. At this juncture there are many questions related to the AI provider. Medical schools and academicians should be already involved with this technology.

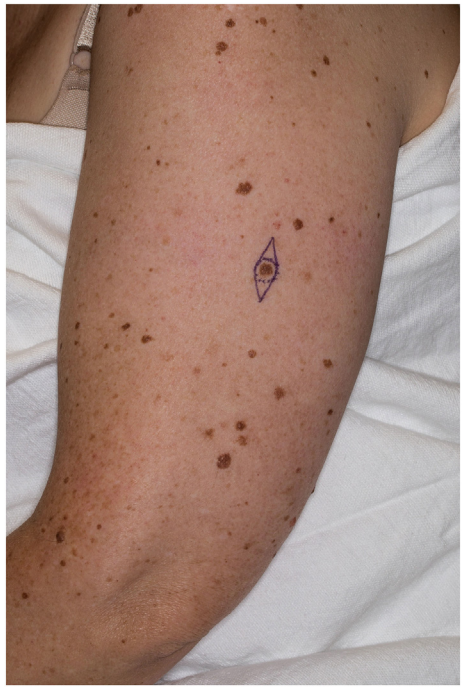

Fig. 4 Training of the AI through input of large numbers of images, even those generated by digital cameras, may be able to assist in the separation of atypical nevi from melanoma in patients who have many clinically atypical nevi with an accuracy rate above that of experienced clinicians.[58,59]

Conclusions

Do we need to be nervous about all this rapidly evolving technology? I think yes, we should be nervous! Our residents who are the smartest in their classes graduating with honors need to be engaged and mentored in basic science or technological research. We need academics and researchers who can work with everything from telemedicine to AI to genetic editing. If we do not do this for dermatology and our patients, who will? Our academic centers must be teaching these technologies and learning the appropriate uses for them. Now more than ever we must support basic science research and translational research by dermatologists. As clinical dermatologists, we can then work together with AI and have a good relationship. Perhaps, they can even increase our efficiencies in

practice and make our specialty ever more interesting and rewarding. Personally, I should be delighted to have an AI with expertise in coding and billing.

Medicine is being reshaped. We may not be called providers in the near future, but rather *diagnosticians*, *immunologists*, or even another name that better reflects our deep understanding of our specialty and our commitment to training. Perhaps, with our AI and telemedicine tools at our side, we will be even known as *physicians*, once again. If we were to recall the Middle Ages, we were sometimes called *healers*, *sorcerers*, or *witches*. It took centuries to arrive at the level where we are today, but from here on, it will take only decades to transform our specialty profoundly. Perhaps, we are currently in a brief "dark age" of dermatology and on the brink of a new renaissance where some old school principles will be put into play with new world technologic progress. Prepare to embrace it. I imagine it will be a great show and likely very rewarding! I only wish I can be here in 2050 to experience some of it.

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