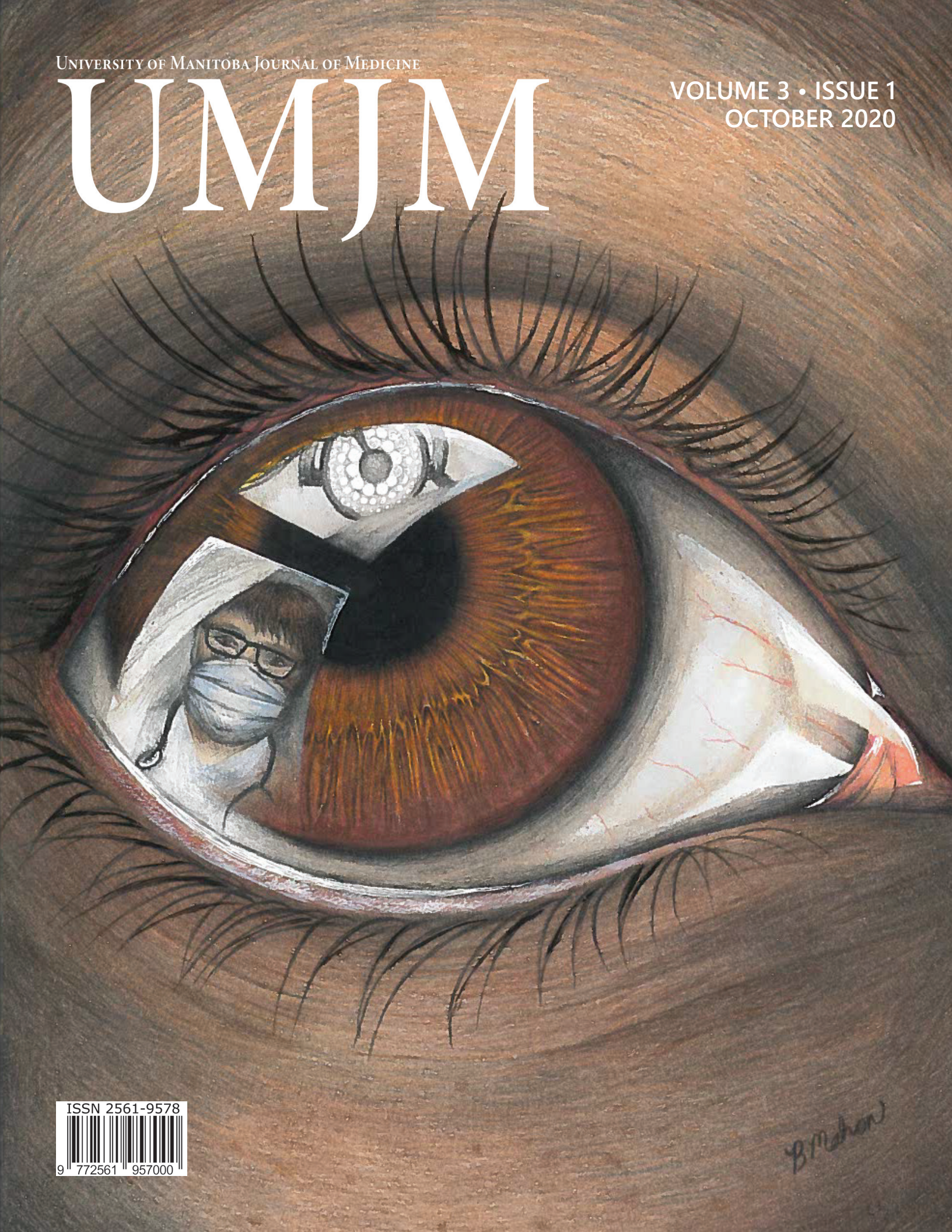


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Letter from the Editors

Dear reader,

We are pleased to welcome you to the third volume of the *University of Manitoba Journal of Medicine (UMJM)*.

The *UMJM* is a student-run journal both written and edited by medical students that resurfaced at the University of Manitoba in 2017. Founders, Dr. Emma Avery and Dr. Graham McLeod, had a goal to provide medical students, particularly within Manitoba, an outlet to share scholarly writing related to current topics in medicine. Over the past 3 years of publishing we have been fortunate enough to watch the journal grow and evolve. Along with Anirudh Agarwal, our talented Chief Editor of Design and IT, we are the last three remaining members of the original team formed in 2017. Since then, our editorial team has continued to expand into a diverse group of students in their first three years of medical school. We owe an immense gratitude to the students, faculty and staff who have made valuable contributions to editing, formatting, designing and promoting the journal. Furthermore we would like to extend our thanks to all the contributing authors and students who submitted their work this past year to UMJM and allowed us to continue to publish strong pieces about a variety of topics relevant to medicine in 2020.

2020 has been a challenging year for everyone, including the UMJM. We unfortunately were not able to meet in person as an editorial team and turned to online communication. Due to an uncertainty about the workload and stressors affecting physicians we made the difficult decision to publish without expert/faculty reviewers this year as we have had in the past. A special thank you again to the student editorial team for the extra work they put into Volume 3 given these circumstances.

Volume 3 includes incredible artistic works, and tackles important topics in medical education, medical technology, and the interaction between the humanities and medicine. Current issues in Canadian health care are explored, including incorporating the Truth and Reconciliation Commission's Calls to Action into Indigenous health care and how to challenge the heteropatriarchal ideologies that are present in health care today. Other pieces explore new technologies in medicine and draw a connection between Leonardo da Vinci and the modern physician.

We are excited to see what the future holds for the UMJM moving forward through the next school year and current pandemic. A lot has changed during 2020, but the importance of exploring and sharing ideas in medicine continues to be vitally important. We hope that by engaging with the UMJM you are exposed to new ideas, opinions and topics in medicine that you may not otherwise have come across.

On behalf of the entire team at UMJM, we hope you truly enjoy our third volume.

Happy reading! Keep well!

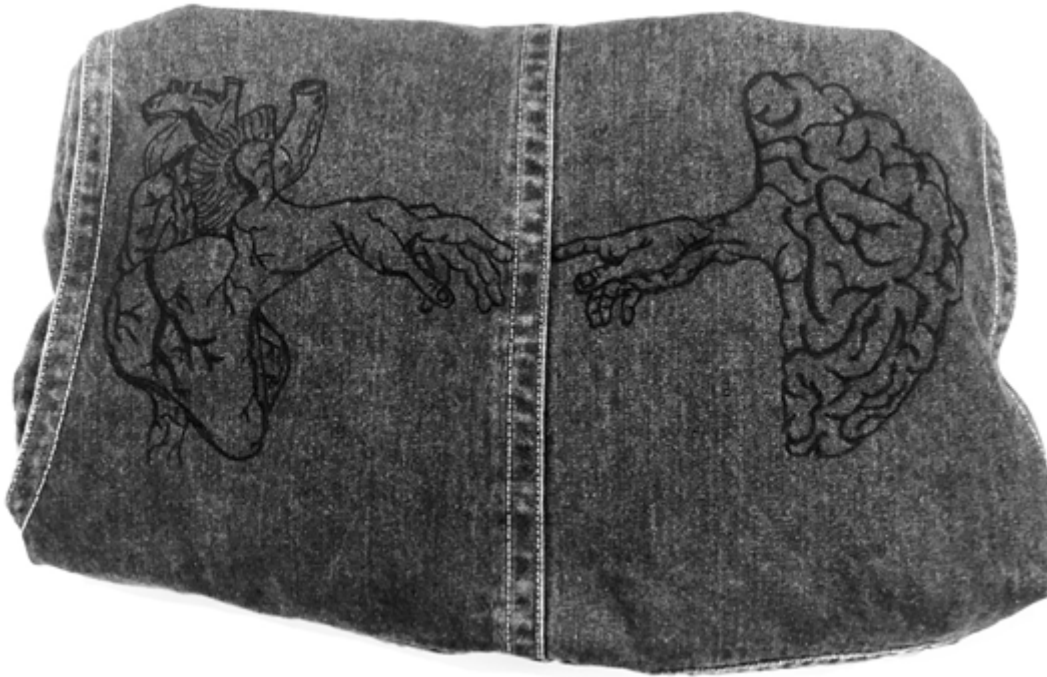


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The Art of Medicine

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The Creation of Empathy and Intelligence

This piece represents the relationship between empathy and intelligence. It was inspired by my friend and colleague Philip Kawalec after suggesting making an art piece to represent empathy versus intelligence. To expand, throughout history, medicine has been deemed one of the most prestigious professions as physicians have been regarded as the healers of society. In the past, however, medicine stemmed from paternalistic foundations where physicians told patients what was best for them and patients primarily obeyed because of the status quo held by physicians. Yet, in today's medical world, empathy (as represented by the heart) has met intelligence (as represented by the brain). Hence, the proficient physician is not only intelligent, but is more importantly empathetic. Accordingly, empathy has transformed medicine into a patient-centered care profession by allowing physicians to truly consider and reflect upon patient situations, values, and overall beliefs. With that being said, I'll leave you with a quote to reflect upon:

“No one cares how much you know until they know how much you care”
– Theodore Roosevelt.

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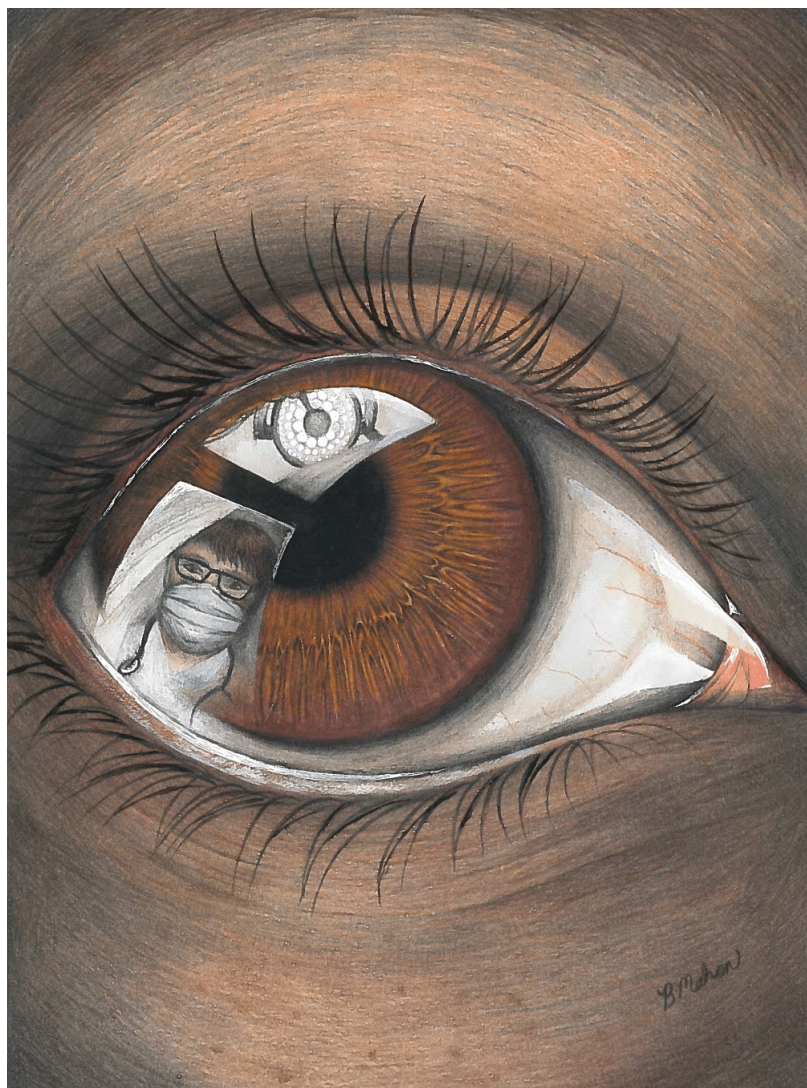
Walk the walk

This piece represents humans' perceptions of self, circumstances, and others as such perspectives influence how an individual's heart grows. A narrow perspective may hinder understanding, whereas that of a wide lens may encourage growth. The proficient practitioner is one that exemplifies compassion, intelligence, and a desire to connect with the individual patient. As future physicians, we will likely be overworked and constantly busy. Yet, we must remind ourselves that patients embody more than their ailments. They hold desires, passions, and connections, much like us, that make them human past their hindering medical conditions. Such factors, much like the eye incorporated into the heart and the skull separated from the body, will serve as a reminder to be cognisant of what we allow to influence our perspectives. Ultimately, the truly proficient physician must treat the patient, rather than just the disease.

The Patient's Perspective

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I have always been intrigued as an artist by the depth and emotion captured within drawings of eyes. For as long as I can remember, my mom's fridge has been covered in my artwork - always images of eyes, typically with the focus of the image being in the iris or the reflection of the iris.

This piece is meant to portray the vulnerability felt by the patient in a healthcare setting, inspired by my own personal experiences as a patient. As a young teen, I was struck with illness and spent a year bouncing around between various healthcare professionals - often in Winnipeg, as I was from the small town of Kenora, Ontario. Coming from a rural setting, access to specialists was often unavailable locally. I remember the uncertainty and vulnerability I felt at the time. With a drive to better the delivery of healthcare in rural settings, and an interest in life sciences I started my own journey into a career in medicine.

I hope that the viewer is reminded of the dynamics in a patient-physician relationship, and is softened by this reminder. Both healthcare providers and patients are only human, and it essential that we act in an empathetic manner with each other.

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More than the Mona Lisa: what Leonardo da Vinci can teach physicians

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Abstract

Leonardo da Vinci (1452 -1519) is renowned as the artist of celebrated paintings, such as the Mona Lisa and The Last Supper. He is not as well known for his contributions to science, but it is here that his ingenuity is highlighted. Many of Da Vinci's attributes made him an innovative scientist whose work continues to be relevant to physicians today.

Keywords: leonardo da vinci, desirable physician traits, art and medicine

Introduction

Da Vinci was one of the greatest minds of the Renaissance period¹; he was a master observer, had an inquisitive mind, and merged the boundaries between art and science. Here I will discuss the importance of these traits which da Vinci embodied and how they are relevant to the practice of medicine.

The Master Observer

Da Vinci refined his observational skills in order to improve his art. Although only 15 of da Vinci's paintings exist today, he left thousands of pages of notebooks filled with observations of the world.² In one entry, he instructed, "As you go about town, constantly observe, note, and consider the circumstances and behaviour of men as they talk and quarrel, laugh, or come to blows."¹ He recorded human expression and interaction as a reference for his artwork.² In another notebook, he wrote, "Which nerve causes the eye to move so that the motion of one eye moves the other?"¹ Characterizing the mechanism of eye movement is not necessary for painting the eye itself, yet da Vinci had a deep curiosity for the human body and how it functions. One of da Vinci's most impressive feats of observation was his ability to describe that a dragonfly had four wings, and that when the front wings were raised, the bottom pair were lowered.¹ The patience required to describe such detailed movement, from solely visual observation, is what set him apart from other artists of his time. Leonardo da Vinci honed his observational skills not only to further his painting, but because he found joy in noting the intricacies of the world around him.

Just as observation was important to an artist like da Vinci, observation comprises a large part of the physician's work.³ When meeting a patient, the physi-

cian must evaluate the patient's physical characteristics, often beginning by inspecting the patient's general health. Subtle qualities such as the colour of the skin or swelling may indicate underlying pathology. Physicians also note the emotional disposition of their patients as this often can be vital to providing appropriate care for them. For example, if their patient appears anxious or confused about a diagnosis, prognosis, etc., this changes how the physician should address the patient.³ Effective observation also requires actively listening to patients, which is crucial to providing them with good care. A physician who is passionate about observation will likely be able to provide more for patients and perhaps have increased fulfillment in their work, similarly to da Vinci with his art.

Inquisitive Mind and Experimental Methods

Leonardo da Vinci amassed knowledge from many sources and disciplines, and tested theories with early experimental methods. By 1504 he had collected 40 books on works of science, 50 books on poetry and literature, ten on art and architecture, eight on religion, and three on math, showing that his quest for knowledge spanned outside of the anatomical and artistic realms.¹ Da Vinci realized that knowledge came from a relationship between experiment and theory, stating, "My intention is to consult experience first, and then with reasoning show why such experience is bound to operate in such a way."¹ In his notebooks, da Vinci also advised, "Before you make a general rule of this case, test it two or three times and observe whether the tests produce the same effects," foreshadowing principles of experimental method that would later be revisited by Francis Bacon and Isaac Newton.^{1,4}

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Da Vinci's optic studies demonstrated his use of experimental methods to explain the world. He wondered why images turn right side up after passing through the eye. He dissected bovine and human eyes, and mapped the neural pathways of vision, showing the optic chiasma.⁵ He then placed an eye "in the white of an egg", and boiled it to preserve the humour.⁵ From these studies, he accurately described the position of the uvea, cornea, and lens, and correctly concluded that the eye receives light, thus facilitating vision.^{5,6} This contradicted the prevailing theories of Plato and Galen, who characterized vision as "emanat[ing] from the eye outward..."⁶ This was not information a painter needed to know, but da Vinci was motivated by voracious curiosity, and used scientific inquiry to investigate areas of interest. Da Vinci's relentless curiosity should be inspiring to physician. He amassed knowledge not because he was obliged to, but because it fulfilled his innate drive to know the world around him and how he fit into it.

Curiosity is a driving force for scientific endeavours, including medicine, and it is integral to physician success. A survey of patients, medical school preceptors, and students found "intellectual curiosity" to be seventh on the list of desirable physician traits.⁷ Lifelong learning, driven by inquisitiveness, is emphasised in medical school as a commitment that doctors must uphold to best serve their patients.⁸ Curiosity is thought to be driven by "an undesirable state of "uncertainty" that must be relieved", with the goal to return the situation to normality.⁸ Every day, physicians interact with uncertainty in the form of complex, unique patients. Inquisitiveness helps them to ask the right questions to better patients' lives. Moreover, to treat a disease, one must know its cause. Physicians must investigate gaps in scientific knowledge with experimental reasoning, using observation to test hypotheses, as da Vinci did.

Curiosity does not only benefit physicians in academic settings, however. A good physician cares for and empathizes with patients. The action of putting oneself in another's position is an act of curiosity itself.⁹ A physician is "... curious enough to know the patients: their characters, cultures, spiritual and physical responses, hopes, past, and social surrounds."⁹ Medical students and physicians should embody da Vinci's curiosity and continue to foster curiosity throughout their practice.

Art and Science

Leonardo da Vinci merged the boundaries between art and science. This is displayed in his anatomical studies from 1508-1513.¹ An example of this intertwined relationship is his study of the heart, specifically of the aortic valve. Da Vinci was fascinated with the movement of water and studied eddies and vortices extensively.¹ There are numerous sketches of water in his notebooks, and he painted rivers and lakes in the background of works, including the Mona Lisa.¹ He also famously painted subjects with whirlpool-like ringlets.¹ When he studied the heart, da Vinci used the knowledge of eddies he had collected for painting, and hypothesized that "the blood which turns back when the

heart reopens is not that which closes the valves of the heart. This would be impossible, because ... the blood that presses from above would press down and crumple the membrane."¹ To test this, da Vinci made a glass model of the heart with the aortic root, which he filled with water.¹ He then placed seeds and paper into the water to visualize its flow.¹ His final hypothesis was this: "Vortices, effecting partial reverse flow in the proximal aorta, would aid closure of the aortic valve in diastole."¹⁰ Amazingly, these observations were not confirmed until 450 years later.¹ Before then, the common belief was that the pressure from above the aortic valve alone caused it to snap closed.¹ In the 1960s, research led by Brian Bellhouse at Oxford performed an experiment strikingly similar to da Vinci's glass heart model, mapping the movement of blood with dyes and radiography. They showed that "Leonardo da Vinci correctly predicted the formation of vortices between the cusp and its sinus and appreciated that these would help close the valve."¹ In 2014, an Oxford research team used time-resolved magnetic resonance imaging (MRI) techniques to map aortic root blood flow in vivo, and determined that da Vinci's "prediction of systolic flow vortices was accurate and that he provided a strikingly precise depiction of these vortices in proportion to the aortic root."¹⁰ The comparison revealed remarkable similarities between da Vinci's artistic renderings of the vortices and the 4D MRI images.¹⁰ If da Vinci had published his anatomical works, he would have had lasting impacts on the scientific world. Unfortunately, they were never published, and much of his work would be re-discovered centuries later.¹

Da Vinci's skills and interests did not exist in isolation. His curiosity led him to observe carefully, which developed his artistic skills. His artistic talent allowed him to uniquely explore ideas, such as parallels between eddies in a stream and blood moving through a human heart. He took information from different areas of study, such as the movement of water or human anatomy, and merged them together masterfully in his paintings. Similarly, doctors are tasked with merging science with art. Physicians must have a solid foundation of knowledge and keep up to date with new information and technologies.¹¹ But medicine is also an interpersonal profession in which physicians must master the art of working with complex patients and ailments. The art and science of medicine are intertwined; "Taking the patient's history is as much art as science; treatment is pastoral care as well as pharmacological rationality."¹² Doctors must be familiar with the art of maximizing patient welfare, being compassionate, trustworthy, and advocating for patients.¹¹

Conclusion

Da Vinci modeled the relationship between art and science. He used his knowledge of water eddies from painting and applied it to his aortic valve studies. Physicians similarly must use their medical knowledge and apply it to individual patients, while providing compassionate care.¹² Da Vinci also demonstrated traits desirable in a physician: Firstly, he was a master observer, and

challenged himself to observe in order to advance his art. Similarly, physicians must observe the physical and emotional state of the patient in order to provide patient-centered care. Secondly, da Vinci had insatiable curiosity, and developed rudimentary scientific methods to investigate his questions. Physicians must be curious how to provide the best care for their patients and use scientific methods to prove their hypotheses. By being curious about the patients themselves, physicians can foster a genuine relationship between physician and patient.⁹ A physician, driven by curiosity, will listen carefully, observe, and utilize scientific knowledge to fortify the art of healing. Leonardo da Vinci demonstrated these qualities throughout his life, making him an appropriate role model for physicians today.

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The importance of critical literacy and lifelong learning in medicine: an interview with Dr. Allan Garland

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Abstract

I met Dr. Garland in my first year of medical school where he was the regular preceptor for my Population Health tutorials. Since then, he has also been my tutorial leader for a series of sessions on critical evaluation of literature in different fields of medicine. From him, I have learned about the importance of actively engaging with the methodology and design of medical research as opposed to simply glancing at the results and discussion. He also taught me about the fundamental weakness of our frequentist approach to research and the extension of that weakness to clinical practice. These ideas, among many others he taught us, have been crucial to my developing understanding of evidence-based best practices. However, not everyone gets the opportunity to spend every other week discussing these things with him. I sat down with Dr. Garland for an interview about critical literacy in medicine to introduce the topic to readers who might not otherwise get the same opportunity as I have. This interview examines the pitfalls of study design and statistical analysis, the importance of being able to critically evaluate literature as a future physician, and how to develop these skills over one's career.

(This interview has been lightly edited and condensed for clarity). References were cited retrospectively for context by EP after the sentence ending and condensed for clarity.

Keywords: evidence-based medicine, medical education, research methodology

Where do you begin when talking about critical literacy in medicine?

The biggest problem in modern medicine is the failure to adhere to evidence-based best practices. This takes two forms: 1) doing things that are not indicated, and 2) failing to do things that are indicated. This has everything to do with critical literacy in medicine. When we read a journal article, we are forced to believe everything we read, especially if we do not know how to critically evaluate the article, distinguish good from bad and right from wrong, and understand the limitations of the way we decide what is likely to be true.

This is a problem because most of what is in the literature turns out to be wrong. This may have to do with poor study design or poor data analysis. This may have to do with the fact that the way we determine what is likely to be true is through the use of p-values and the null hypothesis. (And notice that I say "likely to be true", not "what is true"). This approach, known as the frequentist approach to statistical inference, is intrinsically weak.^{1,2} As a result, it is not surprising that a substantial fraction of studies that have no obvious flaws in their design or analysis cannot be reproduced. Or, at least when they are, they find a much smaller effect size than the first study. This

is pretty common. In fact, the journals that have the largest fraction of papers subsequently found to not be right are the NEJM, JAMA, and The Lancet.³ Why? Because those are journals that like to publish the very first study on something. However, it is not uncommon that the very first study on something turns out to be wrong because of the intrinsically weak way we look at what is likely to be true in medicine.^{4,3}

What is critical literacy in medicine?

First, it means understanding the nature of study design, including its pitfalls. This is so that you can identify limitations in a journal article. For instance, randomized trials, which are pretty straightforward at first glance, have many potential problems. In these trials there are inclusion and exclusion criteria. You can read papers on these trials that show how many participants they started out with and how many participants they ended up with that they analyzed based on these criteria. You realize that the number of participants they analyzed after applying the inclusion/exclusion criteria may be 5% of what they started out with. This means that even if these results are completely true in the universe for that 5% of people, we still do not know if it applies for the other 95% of people. This illustrates one of the problems with randomized trials: they often

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have restrictive inclusion/exclusion criteria that require extrapolation to figure out if the results apply to your patients. There are weaknesses in every study design of course, not just RCTs. You could point out things in observational cohort studies too. For example, if there is a cohort study where they fail to adjust for a potentially important confounder, then you do not know if the answer is right or wrong.

Second, it means understanding statistical analysis. We think that statistical analysis that passes peer review means that it is okay. However, with very few exceptions, I only know of three journals (NEJM, JAMA, and The Lancet) that have in-house biostatisticians who review every paper that is accepted. Otherwise, it is dependent entirely on the knowledge of reviewers. Unfortunately, most journal reviewers are not methodologists. They are content experts. So, they may be no better than the average person at understanding whether an analysis is appropriate. As a result, there is a great deal of bad analysis in the literature. For example, the single biggest statistical analysis problem in my experience is the failure to account for multiple comparisons.⁵ So, the meaning of a p-value as weak as it is, is weakened further if there is more than one comparison done (i.e. more than one p-value reported). This dramatically increases the Type 1 error rate. Unfortunately, the problem is not recognized by many reviewers.

Why is critical literacy in medicine important? Many physicians are not academics. Why should it matter to them whether they can appraise evidence when they may simply follow clinical practice guidelines anyways?

Because we want to do the right things for people clinically. How do you know what the right things to do are? How do you know what you should do? Where should we get our evidence-based best practices? The literature. How do we decide what we should do? The literature, but a critical evaluation of the literature. If you cannot distinguish between something that is likely to be true from “can’t tell”, that is a problem. (“Can’t tell” here referring to the fatal design or analysis flaws that prevent you from claiming something as likely to be true).

Clinical practice guidelines are written when a professional society brings a group of experts together to talk about the best available evidence. So, those groups usually do have some methodologists in them. But, usually, it is the weight of the evidence that rules. How many RCTs do we have? Whether those RCTs are well-designed or contain problems is given less consideration. Nonetheless, groups of experts who come together to parse the literature and help the individual practitioner avoid reading 72 papers on a topic is helpful.

However, everybody has to learn to read research papers, even if they are not researchers. To be an informed physician you have to read the literature. You could wait until a professional group puts together a set of practice guidelines. But that is not always done

quickly. And, if you want to stay current, you have to read the literature. Specifically, read literature about the kinds of patients you have. I have not taken care of general internal medicine patients for decades, so I stopped reading that literature long ago. But, I read the literature on COPD and asthma and critical care cases. You have to figure out what to read, which journals or sources are most germane to the patients you are going to take care of. That is what you spend your time on. You need to know how to read them meaningfully and critically even if you are not a researcher.

How can medical students, residents, and early-career physicians learn to be more critically literate?

Historically, this is a topic that medical schools hardly teach. However, through the University of Manitoba’s recent curriculum redesign, critical evaluation has been incorporated as one of the longitudinal themes in the curriculum. I am responsible for a small module on critical evaluation of the literature in the PH2 course. Is it worth something? Yes. Is it enough? Well, if I had my druthers, it would be more prominent because I think that learning how to meaningfully read and critically evaluate the literature is just as important as knowing which anti-hypertensive to use first. Nevertheless, we are doing better.

It remains difficult to teach in residency.⁶ Even to the extent that we do teach it, what you don’t see is it generally modelled on the wards. So, when you’re on clinical rotations, whether you’re a medical student or a resident, there is very little discussion about these things. Instead, we mention how the results of a paper showed something important. But did it really? We should talk about how the paper showed something important. That is the purpose of journals clubs. In our internal medicine residency program, we changed journal clubs this year. Whereas, it used to be a free-for-all discussion of results, the papers presented are now meant to be a practicum in critical evaluation. So, each paper is chosen to highlight some methodological issues which are then discussed. Will our 18 journal club presentations every year for three years teach you everything you need to know? No. But, but you can learn about 54 important topics, and that will certainly help.

Unfortunately, evidence shows that most practicing physicians do not possess the learned knowledge to be able to critically evaluate the literature.^{7,8} Again, we have done a terrible job in medical schools across the world at teaching critical evaluation skills. There is Continuing Medical Education (CME) for reading journal articles, but there is no critical evaluation portion. It is hard. There is no one-stop shopping. There are some attempts to address this though. For example, there is the JAMA Users’ Guide to Medical Literature.⁹ This is a compilation of papers published in JAMA in the 1990s about how to read this kind of paper, that kind of paper, and the other kinds of papers. While it addresses study designs very well, it does not address statistical analysis to the same extent. This is a good

resource, but it is still not enough.

Overall, I think we need to do a much better job at teaching this and it needs to start in medical school. It should continue in residency and should continue in CME. We have a long way to go, but we are better than we were in my day where I learned nothing about this.

Although we try to teach about this starting right in medical school, the truth is that if you do not learn how to critically evaluate the literature on your own, by the time you are done with your training it is hopeless. This is because when you are done with your training, nobody will ever teach you anything ever again. Going to a national conference a few times a year is not going to keep you current in your area. The only way to keep current is to read, read, read and to critically read, read, read. This is so that when you read a study where the design is poor, you can say “I don’t know if this is true or not, so I’m not going to practice based on this until I see more.” If you read a study where the study design is fine, but the analysis is problematic, you can say “I don’t know if this is right or not, so I’m going to have to wait for more evidence before I make a determination.” You need to be able to critically read the literature and make that critical evaluation yourself.

What is the most common mistake medical students, residents, and early-career physicians make when learning how to critically evaluate medical literature?

I don’t think there is a most common. I think that there is a general lack of understanding of the big questions. One of the biggest things that people do not understand is the nature of evidence. Understanding the nature and limitations of the way we decide what is likely to be true is fundamental. But, there are no shortage of issues. Choose any kind of paper. There are basic things like what a p-value means and does not mean. But, depending on the papers you read, there are also a myriad of subtle pitfalls that you will never know about if you do not hear about them. Students are not taught about them. A strong example of this is the immortal time bias.^{10,11} So, there are lots of things to learn. And the truth is, to really be sophisticated enough to be able to read all kinds of papers, you almost need to be a biostatistician. However, the truth is also that the majority of papers are of just a few types. And you can learn those issues if you’re taught them. But, again, we have not done a very good job of systematically teaching them in the past. And there are still really no expectations across the country that we should to teach them.

Another thing is that, just because we are limited to the best available data we have now, does not mean we should become nihilists about data. Yes, the frequentist approach has serious limitations among the many other problems in interpreting the literature. However, we are always going to be limited by that. New evidence showing that older evidence was likely wrong does not mean that anecdotal evidence trumps best available evidence. And none of these problems gives us the freedom to ignore evidence we do not like (or what is contrary

to what we already practice). We should instead always practice on the best available data. The findings we should believe are those which are reproducible and durable over time.

For instance, one of our faculty members at a journal club debate a few years ago said, “What have we learned from all the randomized trials done on critical care in the last 20 years? Nothing, because most of them have just shown that we don’t know what we’re doing.” And it is true that most of the major themes of critical care literature in my lifetime have been to debunk things that we thought were beneficial but now we know are not beneficial. Let’s call these scientific “reversals”. Well, these reversals are actually useful. Some believe that slow, incremental improvements in outcomes are not a result of any new magic bullets, but because we have progressively stopped doing things that are harmful that we used to think were beneficial. I think that is the reason that critical care outcomes have improved in the last 25 years. But, when people say, “Well, I can’t believe anything in the literature because there are reversals,” it is because they do not understand the limitations of what they read. They do not understand the nature of how we try to get at truth. And again, reproducibility is the only way we can really approach truth.

If you could impart one idea to physicians in order to improve their ability to critically appraise the literature, what would it be?

I will say two things. First, you need to read in your area of clinical practice. Second, you need to learn the knowledge and skills to be able to critically evaluate the literature. That is not easy. There is a lot to it. We have talked about the big two: study design and statistical analysis. From here, continued learning is hard, but it is possible and it is very important because otherwise we are forced to believe everything we read. The day you finish your training will be the last day anyone ever really tries to teach you anything. You must critically read!

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The HSC Women's Hospital: Design and Patient Care

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Abstract

The recently built HSC Women's Hospital was designed with patient-centered care in mind. Many of the design elements used in the hospital are rooted in current evidence on how the physical environment impacts patient health outcomes and satisfaction. Some notable changes include improved air quality through using 100% circulating fresh air, inclusion of nature and wildlife elements in interior design, and adoption of single patient rooms throughout the hospital.

Keywords: hospital design, patient-centered care, single patient rooms, HSC Women's Hospital

When you walk into the new Health Sciences Centre (HSC) Women's Hospital on the corner of Sherbrook Street and Elgin Avenue, you are greeted by a beautiful two-story main level with large sunny glass windows, high and open ceilings, and the smell of freshly-baked muffins and croissants emanating from the local cafeteria. Above all, the most striking aspect is the sense of peacefulness and serenity that envelops the hospital.

The HSC Women's Hospital was originally scheduled to open in 2014. After a 5-year delay, due to a fire and other setbacks,¹ the hospital finally opened in November of 2019. EllisDon Corporation, a Canadian employee-owned company based in Mississauga, was commissioned to design and build the hospital.² Additionally, community consultation and input were welcome and incorporated at multiple stages of design.^{3,4} The hospital is on a spacious 250,000 square foot lot, bigger than the BellMTS Place. The first floor features 3 stretcher bays, 8 private obstetrical patient rooms with bathrooms, a fetal assessment unit, and retail services. The second to fourth floors house the Neonatal Intensive Care Unit (NICU), a 16-bed Labour and Delivery Unit, 3 operating rooms for Caesarean sections, and another 4 operating rooms for gynecological surgeries. Throughout the hospital, there are inclusive spiritual spaces, such as a Sanctuary and Ceremonial Room for smudging and other cultural practices.^{4,5}

The integration of nature and wildlife is also evident in the hospital design. The exterior glass panelling features a digitally superimposed elm forest, a tribute to Winnipeg's elm tree canopies.⁵ Wildflower themes are also incorporated into each floor of the hospital, with scenic wall art in reception areas and color-coordinated furniture.^{2,3} The rooftop gardens, open in the summer months, will feature plants native to Manitoba and lo-

cal Indigenous communities.

With the patient's privacy and comfort in mind, the designers opted for single patient rooms in the wards and triage. Each room features a window and an ensuite bathroom with a shower. The patient rooms are spacious with room for personal belongings and a sleeping area for one support person.^{4,5} The rooms are also equipped with privacy curtains behind the doors, which make them accessible while maintaining patient dignity.

There have been numerous studies examining the effect of the physical environment on patients' wellbeing and satisfaction. Many of the design elements used in the hospital are rooted in evidence-based medicine.⁶⁻¹¹

Air Quality

Air quality in enclosed spaces has a significant impact on staff and patients' health. The use of recirculated air ventilation systems, such as the traditional HVAC systems, results in increased carbon dioxide levels, negatively impacting cognitive performance and delaying recovery for patients.⁹ Recirculated air has also been associated with Sick Building Syndrome, a set of non-specific symptoms and discomfort following extended time in closed buildings.⁹ The Women's Hospital's ventilation system is designed to provide 100% fresh air as opposed to recirculated air.² Low volatile organic compound-emitting construction materials were used, and the abundance of natural lighting in the hospital also improves air quality.^{2,4,9}

Nature and Wildlife

Natural or artificial sunlight, as in light therapy lamps, have well-documented positive effects on depression, including perinatal depression.^{6,11-13} Florence Nightingale, the founder of modern nursing, was the first to

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note the positive effects of nature and sunlight on patients.^{7,14} More recently, one study conducted in a psychiatric ward noted that patients housed in sun-lit rooms had an average of 2.6 days shorter stay compared to patients without sunlight.¹³ The presence of gardens also serves as a positive distraction for patients. It allows them a space to rejuvenate, connect with fellow patients, and engage in leisurely activities.^{8,10,15} One survey conducted in the UK found that 100% of their participants reported that the gardens improved their sense of wellbeing.¹⁵ Another study conducted in a women's hospital found that both the patients and their families used the gardens as a coping tool during difficult times.¹⁰ Exposure to nature and natural light has also been shown to be effective in alleviating depression symptoms, a common struggle for new mothers who may experience baby-blues, or more severely, postpartum depression.⁶ The new HSC Women's Hospital with solariums of living green wall plants, rooftop gardens, and large windows allow patients to feel connected to nature, and enhance their recovery and satisfaction with their care.²⁻⁴

Centralization of Care

The new Women's Hospital also centralizes services for patients. Previously, there were three different Neonatal Intensive Care Units (NICU) throughout HSC. All of the units have been amalgamated on the second level of the hospital, allowing easy transfer from the Labour and Delivery Unit. Furthermore, new mothers can now easily visit their babies in the NICU while in hospital. This facilitates more bonding time and skin-to-skin contact during a critical period in the baby's development.¹⁶ Additionally, the hospital features a 24-hour video link between Thompson and the NICU in Winnipeg, improving care for preterm infants until they are transferred to Winnipeg for subsequent care.²

Single Patient Rooms

The single patient rooms adopted by the HSC Women's Hospital will have a large impact on patient care. While walking through the hospital wards, it is almost impossible to ignore how quiet and peaceful the hallways are. A reduction in perceived noise by patients has been shown to decrease stress and physiological arousal.^{2,7,8,17} It also leads to improved sleep quality, decreased hospital stays, and decreased use of pain medications.¹⁷

Moreover, single patient rooms give patients a greater sense of control over their environment, as they can change furniture layout and limit foot traffic in and out of the room. As well, they have more freedom with visitors and accommodating family members. One study found that patients who were able to freely control their room temperature were more satisfied with their care.⁹

In addition, the single patient rooms allow patients more privacy and dignity, which is especially important in the Women's Hospital as patients are undergoing sensitive procedures where they may feel vulnerable

and/or embarrassed. For neonates, single rooms have been shown to reduce ventilator days, reduce medication use, and result in fewer episodes of apnea. Furthermore, they are associated with increased milk production in lactating mothers.¹⁶ These rooms also allow mothers to feel more freedom to engage in skin-to-skin care with their babies.¹⁸

Single patient rooms benefit hospital staff as well. The additional space allows for more personalized contact with patients, fewer interruptions during care delivery, and fewer medical errors.¹⁸ Single rooms have also been shown to reduce the incidence of hospital-acquired infections and infection transmission rates.^{7,18} The improved quality of care leads to higher patient satisfaction, thus decreasing the stressors on nursing staff and conflict with patients. The reduced hospital length of stay can also lead to cost-savings.¹⁸

Unfortunately, single patient rooms present some challenges. The distance between patients increases transition time between rooms and wards, as well as the workload for existing staff, and necessitates more hiring.^{7,18} Studies also showed that single rooms induce a degree of complacency when following basic infection control precautions such as hand-washing.^{7,18} Additionally, one study showed that staff might feel isolated and lose connection with their colleagues. The study also showed physician stress levels after transitioning from shared accommodation to single room hospitals were elevated even 15 months post-transition.¹⁸

Single rooms present a different set of challenges for patients. They may feel more secure in shared accommodations as they are visible to staff at all times.¹⁸ Shared accommodations also result in good patient camaraderie. One study found that a primary disadvantage to single patient rooms was the patients' experience of loneliness and feelings of isolation.⁷

Conclusions

The new HSC Women's Hospital is a much-needed upgrade. The design's focus on patient-centered care and improving outcomes is evident throughout. By using fresh air, natural lighting, gardens, wildlife, and single patient rooms, the designers have given patients a sense of control, increased positive distractions, and eliminated many of the negative aspects of hospital stays. It will be remarkable to see how the hospital's physical environment will affect patients and staff, and how architecture and design will be part of patient care.

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Challenging Normative, Heteropatriarchal Ideologies in today's Healthcare

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Abstract

Patriarchy has not been removed from our society, it has merely adapted to ensure subtle, dominating power over the women of today. Many women pursuing a career in medicine, including myself, exist in environments that oppose a world where women are expected to live in the shadows of, or at least inferior to, men. Women in medicine who highlight social injustices and challenge heteronormative gender roles are, in turn, perceived as the problem for simply exposing the problems. The multiple internalized and externalized power inequalities between men and women have contributed to the construction of the way healthcare perceives the strength and ability of women. The oppression of patriarchy exists within healthcare and will be explored through the lens of Sara Ahmed's theory of 'Feminist Killjoys'.

Keywords: feminist killjoys, patriarchy, healthcare

I believe feminism is about recognizing and appreciating the diversity of men and women yet providing all with equal opportunities in learning spaces, workplaces, politics, and healthcare.

Gender roles and binaries have become the foundation of how most cultures organize their thoughts and have permeated into our institutions, such as our healthcare systems. Societies are constantly reminded and judged according to the stereotypical and gender-specific responsibilities that such institutions have promoted. I argue that developing equity and equality, both locally and globally, is an imperative attribute in growing and investing into a successful healthcare system. Despite the changes made by feminist movements and the accomplishments of feminist scholars, traditional gender attitudes, which are demeaning to women, are alive and thriving today. Gender roles and the multiple internalized and externalized power inequalities between men and women have contributed to the construction of the way healthcare perceives the strength and ability of women. The oppression of patriarchy exists within healthcare and will be explored through the lens of Sara Ahmed's (2010) theory of 'Feminist Killjoys'.¹

The power imbalance between men and women exists in a variety of different settings, including our communities, schools, homes, workplaces, politics and healthcare². We as a society must fight the assumption that patriarchy is universal and eternal. Marsha Robinson (2013), feminist scholar and author, classi-

fies institutionalized sexism as a "powerless incubator" for women and claims that inverting patriarchal hegemony will help construct a view of women as equal and empowered proprietors of their own lives³. Patriarchal societies are not only male-dominated, but they are male-identified, male-centered, and oppressive of women by devaluing the work they do or treating them as though they are not worthy of notice and reward⁴. These oppressive attitudes present a continuous challenge to women in science, a classic historical example of these oppressive attitudes being when Rosalind Franklin's work on DNA structural modelling being credited to her male counterparts. Patriarchy has not been eliminated from science and healthcare, it has merely adapted to ensure subtle, dominating power over the women of today.

A deeply rooted problem of patriarchal systems is that such traditional mindsets are passed from generation to generation. Children's minds are vulnerable, dynamic and highly responsive to the examples set to them by adults⁵. From a scientific perspective, it is safe to assume that all children are impressionable and sensitive to their environment. This begs the need for our generation to realize that our choices and decisions can have lasting impacts on our children and future generations to come. Past generations' inclination to enforce ideas of traditional, power divided relationships between genders onto their children are the true preservers of patriarchy and hostility towards women in today's social structure. Institutionalized sexism is not

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something we know at birth; it is learnt. Women in professional fields, such as healthcare, being painted as demanding, bossy and 'scatter-brained' builds a culture that accepts sexist attitudes and promotes spaces where sexual harassment in the workplace is tolerated.

Change is inevitable, yet people (namely those whom are privileged in the current time) allocate copious amounts of energy resisting it. In "Feminist Killjoys," Sara Ahmed highlights that those who work towards improving and challenging present day issues, such as patriarchal gender roles, are perceived as "killing the joy". Feminist Killjoys upset people's ability to enjoy what they have been taught by societal norms to be 'happy objects', such as women being socially, physically, and financially inferior to men¹. A number of us are identified by society as feminist killjoys by making non-normative choices that challenges the patriarchal order and disrupts the happiness of others by exposing patriarchal and sexist cultural norms¹ as unacceptable and vulgar.

Sara Ahmed's definition of the feminist killjoy is someone who challenges traditional gender roles. A woman who is not married with kids by the time she is forty is ultimately viewed as a failure to our hetero-patriarchal society and her value and worth is diminished as she is reminded of what and who she is supposed to be: "the happy housewife"¹. Normative society condemns individuals who step outside the boundaries of of normative expectations; female physicians being a key example. Women are told that they must choose between the personal and professional, but as a woman who is pursuing a career in medicine, I do not find happiness in being the "happy housewife". Many women pursuing a career in medicine, including myself, exist in environments that oppose a world where women are expected to live in the shadows of, or at least inferior to, men. Women in medicine who highlight social injustices and challenge heteronormative gender roles, in turn, are perceived as the problem for simply exposing the problems. Several female physicians have disclosed to me their refusal to preserve the image of the "happy housewife" and, as a result, have become alienated because of their resistance to conform to the social patriarchal order. Ahmed highlights that if one dares to comment on or correct a social injustice in certain spaces, such as harassment in healthcare settings, or political climates, they are going to be blamed for killing the joy. Happiness for such discriminatory yet traditional systems are used to excuse social injustices¹. Today's society shapes individuals to be passive and conforming to help protect the appearance of Canada's inclusive healthcare system. People adhere to normativity to avoid becoming the spectacle when in actuality, those who do not conform are highlighting the true spectacle.

Furthermore, happiness is defined as a social norm¹, especially in patriarchal societies. Consequently, if one is not happy with what may be an oppressive patriarchal social structure it is seen as their problem, and not a problem with society. A hetero-normative society

dictates how and when people should feel certain emotions. However, Ahmed states that "you cannot always close the gap between how you do feel and how you should feel"¹. By stating this, Ahmed highlights that compromising your values in order to avoid confrontation with others is not a plausible solution, which many women in the profession of healthcare are advised to do. By questioning oppressive societal systems and killing the joy you may become isolated from the majority of society who find happiness or may even benefit from such hetero-patriarchal structures.

It is a natural human instinct to look for a single source to blame for such injustices, however, this is not the result of individual perpetrators, but rather a multi-fold cultural problem. Various institutions in our society, such as healthcare, the justice system, and political structures, help to produce sexist and oppressive policies, attitudes and social environments at pandemic rates. We need not just women, but everyone to be a part of ending this stigma and changing the image of feminist movements from anti-male to gender inclusive. Changing reality requires changing perspective. If we can eliminate or at least minimize the bystander effect and start promoting a culture in which gender inequality is viewed as objectionable, we can cause a paradigm shift.

Just think about how powerful our society would be if our children were instead taught the meaning of feminism and equal opportunity as a fundamental unit in their educational curriculum⁶. Dr. Michael Kimmel, an American gender studies sociologist, stresses that it is crucial to realize that we cannot fully empower women and girls unless we engage boys and men⁷. We need to evaluate, and reshape the way society defines women based solely in relation to their male counterparts. The first step to addressing this is simply putting our feminist practices and ideologies into our everyday lives, both at work and at home.

As a young woman trying to pursue a career in a male-dominated field I am a strong advocate for the movement against institutionalized patriarchy and misogynistic attitudes. We need to call on everyone to embrace feminism and demand equality within healthcare. I shout out to all women to embrace their complexity and be unapologetically strong and present in politics, businesses, workplaces and healthcare. We need to unlock the power, strength and greatness that the female population holds and bridge the gap between our generation and gender equality; a world free of exploitation, patriarchy, domination and violence against our sisters, mothers, and daughters. A new foundation must be built, and I believe it is critical for us not to learn, as Gloria Steinem⁸ says, but to begin unlearning the inequalities that our society has placed on women of all identities, religions and cultures.

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The Benefits of Incorporating the Truth and Reconciliation Commissions Calls to Action for Indigenous Health Care

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Abstract

In 2015 the Truth and Reconciliation Commission presented 94 calls to action that would be beneficial in furthering the reconciliation efforts between Canada and Indigenous people. Of these 94 calls to action, Actions 18 through 24 touch on the topic of health. This review explores the benefits and importance of future physicians understanding and implementing the Truth and Reconciliation Commission Calls to Action in their practice. This review also discusses the importance for future physicians to understand the historical impact that continues to affect the health of Indigenous people and how these impacts can be addressed through methods that would best suit Indigenous well-being and healing.

Keywords: TRC, indigenous health, indigenous knowledge

Introduction

While Western medicine may recognize mental and spiritual wellbeing, the resources provided for these components is not equal to the resources spent on physicians and physical wellbeing (M. Cook, personal communication, June 4, 2020). Social access to health care is also limited for Indigenous people because the health care systems do not account for culture or language which can often be a barrier, as well as the social and economic determinants of Indigenous people's health¹. Culture plays a role because different groups can face additional health risks because of their socioeconomic environment that is often determined by dominant cultural values "that contribute to the perpetuation of conditions (marginalization, stigmatization, loss or devaluation of language and culture and lack of access to culturally appropriate health care and services)"². One must begin with a consideration of the historical legacy of colonization, forced removal from traditional lands that Indigenous people often had spiritual connections with, cultural genocide and, the history of the residential school system³. These variables can all play a role in the health and well-being of Indigenous people due to various stressors as well as the sense of loss and the effects that it has on the people. "It is a well-known fact that First Nations peoples in Canada suffer from a poorer quality of life, as measured by mortality and morbidity, as compared to their non-Aboriginal counterparts"⁴.

The Truth and Reconciliation Commission was created in 2008, with a mandate set to focus on six areas

as follows:

- "(a) Acknowledge the Residential School experiences, impacts, and consequences
- (b) provide a holistic, culturally appropriate and safe setting for former students, their families, and communities as they come forward to the Commission
- (c) Witness, support, promote and facilitate truth and reconciliation events at both the national and community levels
- (d) promote awareness and public education of Canadians about the IRS systems and its impacts
- (e) identify sources and create as complete an historical record as possible of the IRS system and legacy. The record shall be preserved and made accessible to the public for future study and use
- (f) produce and submit to the Parties of the Agreement a report including recommendations to the Government of Canada concerning the IRS system and experience including: the history, purpose, operation and supervision of the IRS system, the effect and consequences of IRS (including systemic harms, intergenerational consequences and the impact on human dignity) and the ongoing legacy of the residential schools
- (g) support commemoration of former Indian Residential School students and their families in ac-

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cordance with the Commemoration Policy Directive”⁵

In the process of meeting the mandate, The Truth and Reconciliation Commission released multiple calls to action that focused on child welfare, education, language and culture, health, justice, and reconciliation⁵, in an attempt to rectify the harms and damages caused by the legacy of residential schools and to further the process of reconciliation⁶.

Action 22

Action 22 calls on “those who can effect change within the Canadian health-care system to recognize the value of Aboriginal healing practices and use them in the treatment of Aboriginal patients in collaboration with Aboriginal healers and Elders”⁵. For one to be able to recognize the values of Indigenous healing practices, it is important that there is an understanding of what these practices encompass. When it comes to the overall wellbeing of Indigenous people, the Indigenous perspective places importance on not only physical wellbeing, as is common in the Western worldview, but also places equal importance on mental, emotional, and spiritual wellbeing. It is only through focus on all four aspects that one is able to be truly healthy. This teaching is seen within the Medicine Wheel, which consists of four interconnected sections (physical, mental, emotional, and spiritual), and it is when these four sections are in balance that Indigenous people are able to achieve and maintain good health as they promote overall wellbeing⁷.

A major part of the Indigenous worldview consists of the connectedness to the land which plays a central role in the development of health and resilience of Indigenous people⁸. Many of the historical policies that were put into place in an attempt to assimilate and oppress Indigenous peoples have had a detrimental impact on maintaining their cultural identity. This ultimately led to a loss of culture and cultural identity in many individuals and communities. Reconnecting with the land and participating in cultural traditions and ceremonies allows for the restoration of Indigenous cultural identity, creating a sense of belonging, and overall contributing to positive health outcomes. Within Isbister-Bear et al’s research, it is found that health promotion programs that are centered on community and Indigenous perspective are fundamental to improving the health and wellbeing of Indigenous populations⁸. Health Canada has also stated that promotion of Indigenous perspectives can improve “the skills and knowledge of individuals, families, and communities, thereby improving wellness at all levels (Health Canada, 2015, p.15)”⁸.

The Aboriginal Healing Foundation created multiple reports on the effects of residential schools as well as the type of healing that the survivors participated in to overcome the trauma that they experienced during their time in these schools. The healing that was most often utilized was Indigenous healing methods,

which were also rated the most effective (see Figure 1)⁹. When Indigenous worldviews and cultural continuity are encouraged, there is a fall in suicide rates, intentional injury, and unintentional injury⁸. As medical students and physicians within Manitoba, which has a large Indigenous population, it is important to remember that there are greater positive outcomes for Indigenous patients when they are able to utilize traditional healing practices and these are often seen as more effective in their healing.

Action 23

Action 23 calls on “all levels of government to: (I) increase the number of Aboriginal professionals working in the health-care field, (II) ensure the retention of Aboriginal health-care providers in Aboriginal communities, (III) provide cultural competency training for all health-care professionals”⁵. Within the University of Manitoba there has been an increase in Indigenous medical students. The class of 2017 graduated with nine students that self-declared as Indigenous¹⁰, while the class of 2023 has fifteen students of self-declared Indigenous ancestry. This is “the highest number of Indigenous students reported for an incoming class”¹¹. This increase in the number of self-declared Indigenous students is a major step forward and will likely help increase retention of Indigenous health-care providers within Indigenous communities as it is common for Indigenous students to want to return to and work in their home communities. It is important for Indigenous youth to see health care providers that are also Indigenous as this helps breakdown certain cultural barriers while also being a positive influence.

Action 24

Action 24 calls on “medical and nursing schools in Canada to require all students to take a course dealing with Aboriginal health issues, including the history and legacy of residential schools” and other historical policies that impact Indigenous people⁵. It is important for future physicians to have a baseline knowledge of Indigenous history as this can impact the care Indigenous patients receive. There are many significant barriers for Indigenous communities within Canada when it comes to accessing health care and as a result there are often unmet health care needs¹². Indigenous voices are often silenced within the healthcare system as “conventional biomedical ideologies and cultures have shaped healthcare policy”¹³.

When it comes to providing care for Indigenous patients it is important to address the “power relationship between service providers and patients”¹³. It is important to note that Indigenous patients will likely have different needs than those from the dominant culture, failing to recognize this difference will likely lead to Indigenous patients feeling unheard and unsatisfied with the care they are receiving¹⁴. Physicians who do not have a sense of cultural awareness, or lack consideration and respect for Indigenous perspectives and culture will not adequately meet the needs of the



Figure 1: The Aboriginal Healing Foundation conducted research on the various healing methods and asked participants to rate how effective they found the services. The services that were directly related to Indigenous healing methods were rated the highest (Aboriginal Healing Foundation, 2006). In 2005, The Aboriginal Healing Foundation researched the 1500+ communities and groups that they connected with. During this research these communities and groups were asked what had helped the community people the most in terms of healing and leading healthier lifestyles.

patients they are providing care for¹⁴. Without a baseline knowledge or understanding of Indigenous health issues, it would allow certain stereotypes of Indigenous patients to be perpetuated and as a result would be damaging to the physician/ patient relationship¹⁴. There is a significant amount of research that identifies a connection between the historical and current impacts of colonization, residential schools, and “the high rates of alcohol and substance abuse, interpersonal violence, suicide, and mental illness and disorders” that currently face Indigenous patients⁸. The policies of the past continue to have significant impacts on Indigenous patients and their health outcomes⁸. Without prior knowledge of Indigenous history, Indigenous patients could be viewed as having poor health behaviours and choices, and that they are ultimately “to blame for poor compliance levels”¹⁴. These negative stereotypes of Indigenous patients “have the potential to influence health professional attitudes, interactions, and treatment”¹⁴ which is why it is vital for the Truth and Reconciliation Commissions Calls to Action, specifically Action 24, be honoured.

Conclusion

Having Indigenous perspectives and culture as a central component of Indigenous care would result in better health outcomes and promote greater healing. The Truth and Reconciliation Commissions Calls to Action recognize the importance of this, as well as the value of traditional healing methods and the important place it has within Indigenous worldviews.

As physicians and medical students working with Indigenous patients it is important to remember the significance of Indigenous culture and the positive impact that it can have in the overall healing and wellbeing of Indigenous patients. It is also important to remember and recognize various historical policies and the negative impacts that stem from those policies. A lot of the time these policies and laws contributed to the social determinants of health that impact indigenous peoples such as their ability to have cultural continuity, educa-

tion, employment and income, and self-determination. These historical policies also had negative impacts on healthy child development, and personal health practices and coping skills. When working with Indigenous patients it is important to recognize the intergenerational trauma that residential schools and other colonial systems had and the various impacts that this had on the overall health of Indigenous people.

It is important for future physicians to understand the historical impact that continues to affect the health of Indigenous people to be able to provide them with the best care that we can and to be aware that the issues they face are often different from our non-indigenous patients.

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The Human Biomolecular Atlas Program: mapping human structure in more than 37 trillion dimensions

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Abstract

Biologists wielding transformative technologies can describe the human body in increasingly complex ways. Single-cell gene expression and metabolic profiles, and three-dimensional maps of molecular distribution in tissue, are increasingly feasible. It is hoped that such high-definition analyses could better illuminate disease states to bring new insights about pathophysiology and natural history of disease processes. New insights, in turn, could help refine clinical descriptions of disease (e.g. revise diagnostic criteria) and contribute to generating new clinical therapies. But despite advancing biotechnology and accumulating knowledge of human biology, the enhanced characterization of disease states, especially from a clinically-salient perspective that must beware multiple aspects of disease, has been limited by lack of multi-disciplinary, interoperable framework to capture, integrate, and disseminate knowledge. The Fund Human Biomolecular Atlas Program (HuBMAP) is an ambitious effort to create such a framework. HuBMAP is an NIH-funded initiative with a nine-figure budget and several-year timeline to produce a three-dimensional “atlas” that will characterize the human body at cellular and molecular levels of detail, in health and in many disease states. Here I provide an overview of the HuBMAP Consortium and describe its potential impacts on clinical medicine.

What is the precise physical nature of the human body? For centuries, science has revealed the body bit by bit, unconcealing cells that comprise tissue, molecules that form cells, and quarks composing atoms and molecules. With human biology increasingly revealed to be highly complex, distinct disciplines of analysis have emerged, each using distinct schemas and methodologies (e.g. structural biochemistry versus developmental neuroscience) such that expertise is increasingly siloed. With hypotheses generated and tested by highly specialized experts, there has been a lack of a unified, interoperable framework to integrate new knowledge, and no easy means to study transdisciplinary phenomena such as large-scale biological networks spanning multiple orders of magnitude and with effects in multiple research disciplines.^{1,2} Now an exciting new initiative seeks to address these issues by building an open-access, global framework to create an exquisitely detailed, multi-faceted “map” of the human body, answering the question “What’s going on inside the human body?” in unprecedented scope, depth, and detail.

The NIH Common Fund Human Biomolecular Atlas Program (HuBMAP) seeks to develop “a comprehensive, accessible three-dimensional molecular and cellular atlas of the human body, in health and under various disease conditions.”³ Supported by an estimated \$200 million USD over eight years,⁴ the HuBMAP Con-

sortium will assemble biologists of all kinds (molecular, cellular, developmental, computational), clinicians, software engineers, data scientists, and other experts to pursue this goal of characterizing new intricacies of physical humanity. HuBMAP is not the first effort to map the human body; other ongoing initiatives include the LifeTime initiative,⁵ the Human Protein Atlas,⁶ and the Human Cell Atlas⁷ (which already involves 1500 researchers in 65 countries).⁴ Notably, HuBMAP will collaborate with each of these contemporary mapping initiatives, and will also work alongside existent NIH-funded consortia dedicated to mapping specific organs, including LungMAP,⁸ the Kidney Precision Medicine Project (KPMP),⁹ and the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative.¹⁰ Findings from these targeted efforts will be integrated into HuBMAP’s interoperable and comprehensive framework,¹¹ alongside results of new data that HuBMAP will generate. As it progresses, HuBMAP intends to release its findings iteratively into open-source online portals, with the first outputs expected in late 2020.¹

How will HuBMAP work towards its goal? The inaugural publication in *Nature*³ outlines a simultaneous three-part approach. The first facet specifically focuses on the development and implementation of transformative new technologies, including technologies to obtain

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high-throughput single cell data and to capture three-dimensional spatial data of the distribution of important biomolecules within cells and amidst tissues. In a second and simultaneous facet, HuBMAP's "Tissue Mapping Centers" will generate single cell "omic" data (e.g. genomic, epigenomic, transcriptomic, proteomic, or metabolomic) and obtain three-dimensional spatial data of biomolecular distribution. These efforts will rely on existing technologies (see Stuart & Satija for an excellent recent review of novel single cell analytic techniques¹²) and new forthcoming technologies generated by HuBMAP contributors. In its third facet, HuBMAP will depend on its "HIVE" teams — HuBMAP integrations, visualization, and engagement (HIVE) — to organize, collate, and centralize data, and render accumulated information useable and accessible via friendly interfaces. It is intended that each of the three facets will work closely together, refining and releasing HuBMAP in improving, successive iterations.

As it is completed over the coming years, HuBMAP will bring many benefits to the biomedical community at large. One major benefit will be access to a detailed baseline framework for healthy human systems and select disease states. HuBMAP intends to resolve the human body at the single-cell level across dimensions such as genomics, epigenomics, transcriptomics, proteomics, and metabolomics.¹ In reference to this multi-omic framework, the precise molecular and cellular phenotypic deviations of pathology can be better characterized, leading to transformative progress in pre-clinical research efforts. This level of detail is crucial because there can be considerable heterogeneity between two cells nominally of the same type, even within the same tissue.¹³ Two such cells, if in different functional activation states, may play vastly different roles in the pathophysiology of disease states, and may behave entirely differently in response to endogenous homeostatic events and exogenous therapeutics. HuBMAP's multi-omic single-cell analyses will allow disease-to-health comparison at the single-cell level, leading to better understanding of disease, better characterization of specific therapeutic targets, and exquisite frameworks within which to validate putative therapeutics.

Other early benefits of HuBMAP will be towards biomedical research. In generating tissue-wide, three-dimensional molecular maps, HuBMAP will allow novel analyses of cell-cell networks, intracellular localizations, behaviour of the extracellular matrix (ECM), and characterization of cell-ECM networks. The ECM plays a significant role in tissues; for example, the brain is 10-20% ECM by weight.¹⁴ Moreover, the ECM is a crucial modulator of cell behaviour.¹⁵ However, the ECM is historically challenging to study due to its broad spatial distribution and intricate molecular networks.¹³ The tools and specific efforts of HuBMAP will help overcome this, possibly with profound contributions to expert understandings of biology. Further, HuBMAP is well-poised to characterize the role of motile effectors, such as immunologic cells, which may exert important

yet difficult-to-characterize effects in regional tissue areas.¹³ HuBMAP also aims to develop transformative new technologies that will be open for use by other researchers, such as new techniques for single-cell "omic" analyses, and spatially mapping molecular networks in three-dimensional tissue space.³

What will be the specific clinical benefits of HuBMAP? As discussed, HuBMAP may give rise to new waves of precision medicine treatments. However, it may be years before these new therapies are established. In the meantime, clinicians will have access to HuBMAP's centralized atlas framework, which may be a useful reference to consult, especially as disease states are increasingly mapped. The HuBMAP atlas may be especially useful for medical students, residents, and other learners; for established clinicians expanding the scope of their practice; for clinicians at all stages embarking on a new research interest; for clinicians facing licensure examination due to geographical relocation; or for any clinician wishing to update biological knowledge. Additionally, clinicians will also have the ability to refer patients to HuBMAP as a resource to learn more about their body in health (this may be especially of interest in primary care, or for preventive medicine) or disease (for any curious patient). It is conceivable that easy availability of biological information in HuBMAP, accessible in open-source portals,¹ may raise public consciousness of the body as a machine, directly and indirectly educate patients about the positive and negative consequences of certain modifiable risk factors, and overall encourage health-promoting behaviours in the public or some subset thereof. Altogether, as HuBMAP grows, it will be an excellent clinical resource for healthcare professionals and patients alike.

Although its benefits are noteworthy, to succeed, the HuBMAP Consortium must overcome manifold challenges. HuBMAP must integrate vast amounts of data in various modalities, collected from various donor tissues, then processed and analyzed in numerous different laboratories in various locations. This multi-dimensional variability will present significant technical challenges. Beyond this, there are further technical challenges of creating new technologies and analytic techniques. HuBMAP is intending to pioneer new single-cell analytic techniques, three-dimensional molecular mapping techniques, and integration and visualization tools, to transform raw data into a comprehensive, three-dimensional, open-access, user-friendly atlas. Achieving these ambitious aims, especially under finite budgets and within anticipated time scales (NIH funding of HuBMAP currently scheduled until 2026), will require significant ingenuity on the part of the HuBMAP contributors, who will have to work efficiently, cost-effectively, and strategically.

A putative comprehensive atlas of the human body must also contend with the challenge of innate biological variability from one person to the next. To the extent that human beings are biologically heterogeneous, even in healthy states, a single atlas is unlikely to be ad-

equate to represent the human population as a whole. This problem has already been encountered in efforts to produce a standard human reference genome. It is now known that “thousands of DNA sequences of various lengths” that are not found in extant human reference genomes are present in various populations worldwide.¹⁶ Thus, there cannot be a single “reference” human genome. Likewise, a unique single cell-resolved “reference” human atlas would likely be inadequate. Time will tell how HuBMAP plans to overcome the challenge of innate human heterogeneity.

In his famous 1910 address “Man’s Redemption of Man” at the University of Edinburgh, celebrated physician Sir William Osler rejoiced that “the leaves of the tree of science have availed for the healing of the nations” and that he considered this the “greatest glory” of humankind.¹⁷ To the extent that HuBMAP succeeds, the tree of biological sciences will grow considerably; its leaves will be more numerous and better understood, and clinicians, scientists, and patients alike may avail themselves of its fruits. It may take years for the work of HuBMAP to pay direct clinical dividends in forms of improved diagnostic categories and targeted new therapeutics, but if HuBMAP can help decipher some of the complexity of the human body, there is grounds for a specific optimism that the future of medicine can be better than the past. Moreover, humanity will be moved leaps and bounds closer towards realizing one of our longest-lived dreams: to know what’s going on inside our bodies, and understand this magnificent structure with which we live our lives.

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