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RESEARCH REPORT

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A slide into obscurity? The current state of histology education in Australian and Aotearoa New Zealand medical curricula in 2022–2023

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Abstract

Australia and Aotearoa New Zealand (AANZ) medical schools have been impacted by curricular changes and the introduction of virtual microscopy (VM). No survey has explicitly described the outcome of these events on histology education in AANZ. This study provides a cross-sectional overview of histology education in accredited medical schools across AANZ in 2022–2023. Responses were received from 83% (19/23) of Australian medical schools, and 50% (1/2) of medical schools in Aotearoa New Zealand. VM, either exclusively (42%) or combined with traditional microscopy (37%), emerged as the preferred mode for delivering histology education. Common instructional methods included face-to-face lectures (26%) and synchronous online live lectures (26%). A significant proportion (84%) of educators supplemented resources with virtual microscopy websites. Integration of histology education was prevalent (79%), primarily with pathology (32%) or gross anatomy (26%). On average, medical students in the region spent a maximum of 21 ± 17 h in face-to-face histology laboratories throughout their degree. Histology education was predominantly taught by academics with a PhD degree. This study also examined the similarities and differences in histology education between AANZ and the global landscape. Through this examination, the present study positions AANZ within the broader context of histology education worldwide discusses key factors impacting histology education, and advocates for action to mitigate a looming shortage of pathologists in AANZ. In light of these findings, AANZ medical schools should integrate histology and pathology, establish a core curriculum, and promote flexible teaching modalities.

KEYWORDS
basic sciences, curriculum, histology, medical education, medical students, teaching, university

INTRODUCTION

Histology, or microscopic anatomy, has been a fundamental component of the basic sciences of medical education for over two centuries, with its origins dating back to the 18th century when the discipline began to progress alongside advancements in microscopy.[1–3] Traditionally taught using light microscopes and prepared glass slides, histology has provided medical students with

a critical understanding of the cellular and tissue architecture of the human body in both normal and pathological states. However, histology is often perceived as a challenging subject within medical curricula.[4–7] Typically delivered bimodally, with the theoretical component delivered as lectures, and a practicum component run in laboratories with TM,[2] the introduction of integrated curricula in medical education globally has led to a significant reduction in dedicated teaching hours for the basic sciences, including histology. The reduction in dedicated curricular time has raised concerns about the depth and quality of histology instruction that students receive.[8–10]

Together with the curriculum changes, there have also been significant technological advancements that have led to the adoption of modernized and student-centered teaching methods, including virtual microscopy (VM). VM encompasses digital magnifiable versions of histological slides—also referred to as whole slide imaging (WSI) in pathology and other digital resources, which have been found to enhance flexibility and afford increased opportunities for extramural learning.[1,3,11] Developing since the early 2000s, the use of VM for histology instruction has increased dramatically. For example, there was a 129% increase in the use of VM in United States' medical schools between 2013 and 2018.[12] and in 2020, approximately half of all medical schools in China used VM.[13] Predominantly, the shift from TM to VM has been viewed as positive for student satisfaction and/or performance,[14–21] or at the very worst, benign with no significant differences between the two methods of histology delivery.[18,22–31] VM, however, became especially important during the SARS-Cov-2 pandemic, when a near-instant pivot to online learning was required.[3,13,32–37]

Medical education in Australia and Aotearoa New Zealand (AANZ) saw similar changes as those experienced worldwide with the introduction of integrated curricula and a concurrent reduction in student contact hours in the basic sciences, particularly in gross anatomy.[38,39] While there was a similar pandemic-induced rapid shift to online learning,[35] at the same time, 88% of AANZ Medical Schools also transitioned from offering a Bachelors' degree (e.g., Bachelor of Medicine, Bachelor of Surgery, MBBS) level 7 on the Australian Qualifications Framework[40] to a higher-level Masters (Level 9) or Doctorate degree (e.g., Doctor of Medicine, MD; Level 10). This transition effectively condensed 5- or 6-year undergraduate curricula of a double Bachelor's program into a 2- or 4-year postgraduate program. While the reduction in teaching of gross anatomy was reported prior to these major changes being instituted,[38,39] the current state of histology education in AANZ medical schools, including the methods of instruction, the number of teaching hours allocated, the faculty involved, and the assessment of student learning outcomes, remains largely unknown and uninvestigated.

The importance of the basic sciences in the training of effective clinicians is well established.[41–44] As medical curricula continue to evolve, ensuring that histology instruction remains robust and effective within the basic sciences curriculum is essential for maintaining the quality of medical graduates. This research aims to fill the gap by providing a comprehensive analysis of histology instruction in AANZ medical schools, offering insights that could inform future curricular decisions, and enhance the educational framework for histology. The findings could have significant implications for how histology is taught in the face of ongoing curricular changes, ensuring that this fundamental aspect of medical education is preserved and optimized.

The aims of this project therefore were (1) to identify the current method of histology instruction within these curricula, (2) to examine the average number of hours of teaching activities scheduled for histology instruction, (3) to ascertain who was performing histology instruction, and (4) to investigate how student achievements of learning outcomes were being assessed.

MATERIALS AND METHODS

Ethics was granted by The University of Western Australian Human Research Ethics Committee (2022/ET000767). A single measure collection survey consisting of 11 questions (Appendix S1) was designed (by JAC and AJM), created in Qualtrics (Qualtrics, Seattle, Washington, USA), and the survey link was emailed to histology educators at all 25 medical schools in AANZ. Five survey reminders were sent. While the survey was predominantly truly voluntary, some participants may have known JAC and AJM through their long involvement in the Australian and New Zealand Association of Clinical Anatomists (ANZACA) and perhaps felt obliged to complete the survey. No incentives were offered for educators to complete the survey. Respondents were asked to provide the Blooming Anatomy Tool taxonomic levels of assessment questions.[45,46] Responses in Qualtrics were downloaded to Microsoft Excel, and data were extracted. Text-based answers were responses to items asking for further information to clarify integration, external resources, learning activities, and teaching staff. These responses were examined using keyword analysis. The coding scheme was based on AJM's knowledge of the topic and interrogation of the data. AJM and JAC conferred and 100% agreement was achieved.

RESULTS

Demographics

There were 23 universities providing histology education in Australia and two in Aotearoa New Zealand in 2022–2023. Most of the responses came from Australian medical schools, where 19 out of 23 (83%) responded, and 1 of 2 (50%) of Aotearoa New Zealand universities replied. Twenty-one responses were received from 19 medical programs (Table 1). Two responses were received from two universities and were combined to reflect one response each. Histology was taught in the current medical curriculum at all respondents' universities.

TABLE 1 List of universities affiliated with educators who completed the histology education in medical curricula survey.

1	Bond University
2	Charles Sturt University/Western Sydney University
3	Curtin University
4	Deakin University
5	Flinders University
6	Griffith University
7	James Cook University
8	Macquarie University
9	Monash University
10	University of Melbourne
11	University of New South Wales
12	University of Newcastle/University of New England
13	University of Notre Dame Fremantle
14	University of Otago
15	University of Queensland
16	University of Sydney
17	University of Tasmania
18	University of Western Australia
19	Western Sydney University

Mode of histology education delivery

The results indicated that exclusive use of virtual microscopy 42% ($n=8$) or a mixture of traditional and virtual microscopy 37% ($n=7$) were the preferred modes to deliver histology education. Sixteen percent ($n=3$) of medical schools in AANZ still exclusively use traditional microscopy. One medical school in Australia did not deliver any laboratory-based histology education to their students.

Team-based learning (one teacher with many student teams in the same larger room) was conducted in 16% ($n=3$) of medical school curricula. Problem-based learning (many teachers, with one teacher per group in different rooms) was utilized in 11% ($n=2$) of medical school curricula in AANZ.

The most common methods of delivering histology theory to medical students were face-to-face lectures (26%) and synchronous online live lectures (26%). A combination of face-to-face and asynchronous online recorded lectures were used at three institutions (16%). Two of the medical schools (11%) employed online resources created by their own staff. The remaining three medical programs used a combination of face-to-face, synchronous, and asynchronous modes of delivery (15%).

Resources used to supplement histology education

Eighty-four percent ($n=16$) of histology educators in AANZ supplemented student learning resources with links to virtual microscopy websites such as https://histology-online.com/.[47] Other supplemental resources included course-based websites (16%, $n=3$), YouTube (16%, $n=3$), eBooks (16%, $n=3$), software applications (11%, $n=2$), and podcasts (11%, $n=2$). This demonstrates a clear preference for supplementation with virtual microscopy websites.

Histology textbooks and atlases were prescribed at 65% ($n=8$) of medical schools in AANZ. Of these, the most commonly prescribed textbook was "Wheater's Functional Histology A Text and Colour Atlas",[48] which was prescribed in 30% of the medical curricula. "Histology A Text & Atlas With Correlated Cell & Molecular Biology"[49] and "Junqueira's Basic Histology Text & Atlas"[50] were equally prescribed at a rate of 20%. Two programs prescribed the "Atlas of Histology with Functional Correlations".[51] The remaining four texts were each prescribed at one institution: "Functional Histology",[52] "Histology and Cell Biology: An Introduction to Cell Biology",[53] "Histology From a Clinical Perspective",[54] and "Histology at a Glance".[55]

Level of integration of histology education

Seventy-nine percent ($n=15$) of medical curricula in AANZ-integrated histology education, whereas 21% ($n=4$) of institutions taught histology as a stand-alone discipline. Histology was most commonly integrated with pathology (32%), gross anatomy (26%), integrated systems (21%), or in combination with another basic science (21%). It was least commonly integrated with embryology (5%).

Time dedicated to histology education

Using midpoint coding of the categorical data, the average time spent in face-to-face histology laboratories by AANZ medical students throughout their degree is 21 ± 17 (mean $\pm$ standard deviation) hours. This is less than three average working days (@7.5 h a day). The variation in the maximum total face-to-face histology laboratory instruction time offered at medical schools in AANZ is illustrated in Figure 1.

Assessment of histology education

A lack of responses to assessment questions (<30%) indicated that educators found it challenging to respond to items asking them to recall the type and percentage distribution of assessments.

In the context of face-to-face examinations, written histology theory-based questions accounted for $26.0\% \pm 24\%$ (mean $\pm$ standard deviation; $n=2$, range: 2%–50%) in stand-alone, and $8.1\% \pm 7.1\%$ ($n=4$, range: 2%–23%) in integrated curricula. Practical image-based questions accounted for $19\% \pm 22\%$ ($n=3$, range: 2%–50%) in stand-alone assessments and $13.9\% \pm 18.3\%$ ($n=5$, range: 1%–50%) in integrated face-to-face examinations. This suggests that stand-alone face-to-face examinations are likely to have three times the proportion of histology-based questions in them compared with integrated face-to-face examinations.

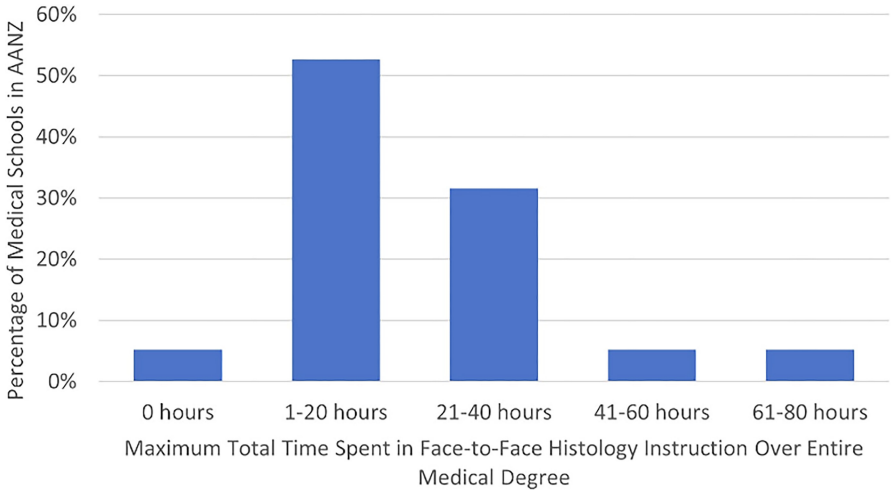

FIGURE 1 Percentage of medical schools reporting the total hours of face-to-face histology laboratory instruction per medical student in AANZ. Fifty-three percent of educators reported providing between 1 and 20 h, 32% reported 21 and 40 h, 5% reported 41 and 60 h, another 5% reported 61 and 80 h, and 5% did not provide any laboratory-based histology instruction. The graph highlights the variation in histology teaching hours across different universities.

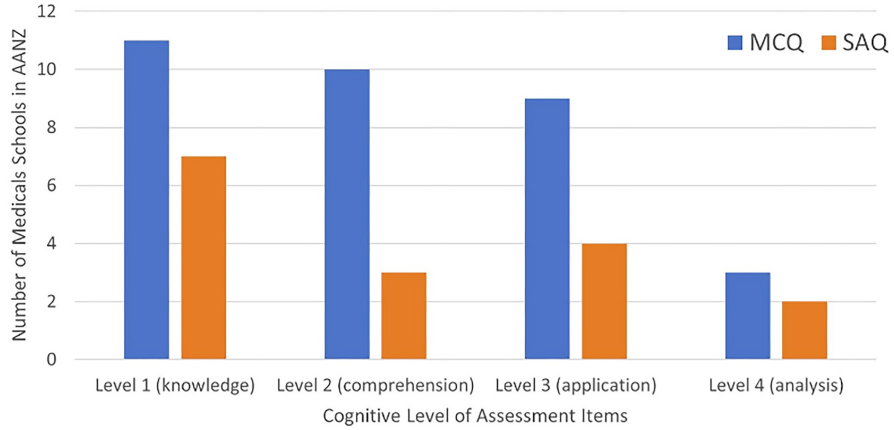

FIGURE 2 Assessment item format and Blooming Anatomy Tool level of items used. Multiple-choice questions (MCQ; blue) were used most often to evaluate histology education at medical schools in AANZ. Level 1 (knowledge) questions were used in 61% ($n=11$), Level 2 (comprehension) questions were used in 56% ($n=10$), Level 3 (application) were used in 50% ($n=9$), and Level 4 (analysis) were used in 17% ($n=3$) of medical schools. Short-answer question (SAQ; orange) formats were used less often than MCQs. Seven institutions used Level 1 (Knowledge) questions, three institutions used Level 2 (comprehension) questions, four institutions used Level 3 (application) questions, and two institutions used Level 4 (analysis) questions.

Theoretical histology questions accounted for 32.5% ± 17.5% ($n=2$, range 15%–50%) of integrated, and 5% ($n=1$) of stand-alone invigilated online (proctored) examinations.

Multiple-choice questions (MCQ) were used in examinations in most ($n=18$) medical curricula. Short-answer questions (SAQ) were used much less often (Figure 2). As illustrated in Figure 2, a small number of institutions are targeting higher cognitive levels with their questions compared to the majority.

Histology educators

Histology teaching in medical curricula in AANZ medical curricula was predominantly delivered by educators with a Doctor of Philosophy (PhD) degree (73%, $n=27$), and far less by clinicians with a Doctor of Medicine (MD)/Bachelor of Medicine and Bachelor of Surgery (MBBS)/Bachelor of Medicine and Bachelor of Chirurgy (BMChB) degree (24%, $n=9$). Only one university employed an educator with a Master's level degree.

DISCUSSION

This is the first comprehensive review of the current state of histology education within medical curricula across Australia and Aotearoa New Zealand (AANZ). It extends upon the recent chapter on global histology education, which encompassed North America, South America, Europe, Africa, South Asia, East Asia, and Australia.[3]

Previous surveys have focused on histology education in the United States and Canada,[12,56] China,[13] as well as the United Kingdom and Ireland.[57] However, within AANZ, only surveys pertaining to gross anatomy[38,39] and neuroanatomy education[58] have been conducted. This study uniquely surveyed histology educators in AANZ medical schools regarding the mode of instruction, resource supplementation, curriculum integration, time allocation, and assessment methodologies for histology.

Mode of histology education delivery

Various modes of delivery of histology education were used across AANZ. There are benefits (TM: microscopic proficiency; VM: ubiquitous accessibility) and costs (TM: infrastructure costs; VM: technology issues) to all modes of delivery which must be considered by educators and institutions.[59] Current practices among histology educators in AANZ revealed an almost fourfold likelihood of using a combination of traditional and virtual microscopy compared to counterparts in the United States and Canada in 2016/2017[12] and China in 2018.[13] Less than half of the histology educators in AANZ and China[13] exclusively opted for VM, representing two-thirds of the proportion observed in Northern America in 2016/2017.[12] In contrast, approximately 50% of Chinese medicals schools only used VM,[13] a prevalence significantly higher than the 16% reported here for AANZ, and higher than the United States of America and Canada—8% in 2005/2006[60] and 10% in 2016/2017.[12] While these findings underscore the varied landscape of histology education approaches in AANZ compared to other regions, these post-2020 results likely also incorporate responses to the SARS-CoV-2 pandemic, noting that data in other regions were captured prior to the start of the pandemic.

In the current study, lecture-based instruction predominantly took the form of face-to-face and synchronous online live lectures. This is often the case in medical education where the majority of educators view student attendance as a measure of professionalism.[61,62] Attendance is related to responsibility/reliability/accountability, respect for others, and respect for patients.[62] However, 90% of medical students supported free choice among learning opportunities,[62] which would give students more convenience for self-directed study and greater time for extracurricular pursuits.[62] Students believed that their primary task was to learn factual material and how they chose to do that was immaterial.[62,63] In contrast, educators believe that attendance provides more opportunities for learning and developing professional skills[62] and improved student outcomes and well-being.[64–66] In navigating this discourse between structured learning and autonomy, it is evident that a balance must be struck to enhance the teaching experience for educators and the learning experience for medical students.[67]

While the present study did not assess outcomes or perceptions of medical students learning histology in AANZ, the existing literature presents a complex landscape. A meta-analysis conducted in 2016, predominantly involving medical students from the United States of America between 2004 and 2014, suggested VM was favored for learning.[59] However, a more recent meta-analysis extracting data from global papers between 2019 and 2022 did not find a significant effect of virtual microscopy on histology outcomes.[68] A nuanced perspective emerged when student preferences were examined indicating a similar preference for VM and TM for studying, yet a clear preference for TM during test taking.[28,59] Notably, studies examining Australian medical students demonstrated no significant impact on student learning outcomes,[69,70] emphasizing the need for further exploration and contextualization of these findings within regional educational settings.[3]

Resources used to supplement histology education

With limited time dedicated to histology education in medical curricula in AANZ, educators must augment their traditional lecture and laboratory material with supplementary resources to ensure an optimal student learning experience. Educators without access to their own physical or virtual collection of slides can apply to Virtual Microscopy Database to gain access to a global repository.[71] Over 80% of histology educators provided links for students to access VM websites (refer to table 5.1 in Ref. [1] paper for a list of available VM websites). Almost two-thirds of histology educators prescribed textbooks, with the most popular text being "Wheater's Functional Histology" which was originally written by Australian clinicians Dr. Barbara Young and Dr. John Heath.[72] This text is now written by Dr. Geraldine O'Dowd, Dr. Sarah Bell, and Dr. Sylvia Wright who have also authored the textbook "Wheater's Pathology," reflecting the increased synergy between histology and pathology.[48,73] Although textbooks are prescribed at a high level, it does not ensure that students necessarily use them. Indeed, a study at the University of Michigan found that 78% of their medical students "never" used the prescribed histology textbook/atlas.[74] Another study found that while textbook use appeared to be low, non-native English-speaking medical students used histology textbooks three times more often compared to native English-speaking students.[75] Sixteen percent of histology educators provided links to channels on YouTube such as "Chapman Histology" (https://www.youtube.com/c/ChapmanHistology)[76] by one of the authors of this paper. Software applications (apps) such as the SecondLook™ Histology resource[77] and podcasts were the least recommended supplemental resource with histology educators with only two institutions using them, which may reflect educators' lack of knowledge of their existence, or comfort in using them. A single-institution study at Goethe University Frankfurt (Germany) found that their medical students enjoyed using the interactive e-software "Histologie für Mediziner" and felt it improved their learning of histology.[78] While histology educators in AANZ employed a range of supplementary resources, variations in student preferences and utilization underscore the ongoing challenge of optimizing these resources for effective histology education in medical curricula.

Level of integration of histology education

In an earlier paper, predicated on the preexisting literature, it was reported that histology education was integrated in almost 60% of the single-institution studies in Australia.[3] In this latest investigation, it can now be reported that integration levels are at 79% in AANZ medical schools. This is moving closer to the 98% level of integration of histology education in a multi-institutional survey of Northern American medical schools.[12] Strikingly, histology education in the present study was often integrated with pathology or gross anatomy and rarely with embryology, which is in stark contrast with Chinese medical schools where histology is ubiquitously integrated with embryology.[13] Moreover, these findings underscore a significant difference, as integration with pathology was six times more common than integration with embryology in AANZ medical curricula. Combining histology with pathology allows the typical histology to be presented prior to/or alongside the atypical pathology to emphasize the changes that have occurred during disease processes. The increased histology integration may also be a reflection of the reduced time allocated to anatomical sciences in medical curricula.[12,56,57,60]

The present study, which solicited responses from histology educators did not encompass student perceptions of the integration of histology with other subjects. However, a review of the literature indicated that a majority of students preferred histology to be integrated with pathology. Single-institution studies conducted across diverse regions consistently demonstrated this preference: 61% in Jordan,[79] 75% in Portugal,[80] 77% in Indonesia,[81] 83% in Ethiopia,[82] and 90% in Singapore,[4] whereas a multiple institution study found 98% of medical students in the United States of America had this preference.[83] North American students at the University of Michigan Medical School enrolled in an integrated curriculum, responded they were more likely to see the relevance of histology to their future careers compared to peers in stand-alone histology curricula.[84] Furthermore, medical students at the University of Cincinnati (United States of America) reported the integration forced them to revisit the histology material more frequently and integrate it with other subjects.[85] Interestingly, experiencing an integrated or stand-alone histology course did not influence American allopathic medical students to consider specializing in pathology.[86] The widespread student endorsement of integrated histology education suggests a need for AANZ medical schools to further consider this approach as a means to enhance their medical education curricula and the student learning experience.

To effectively teach histology and pathology to medical students in the AANZ region, a core curriculum must be established. An international team has already identified key histological structures that are essential or recommended for inclusion in medical education.[87,88] Furthermore, a comprehensive curriculum has been developed for Irish medical students that encompasses professionalism, clinical competencies, and skills, along with the necessary pathology knowledge.[89] It is crucial to introduce histology at the outset of the curriculum to provide students with a robust understanding of normal organ structures, which serves as a foundation before delving into pathology. This approach facilitates the integration of pathological concepts and images with existing knowledge.[90] By reviewing, combining, and adapting these curricula, they can be tailored to meet the specific needs of the AANZ context.

Time dedicated to histology education

The global landscape of histology education within medical school curricula demonstrated substantial disparities in the allocation of face-to-face instructional time in laboratories. Notably, it was uncovered that in 2022/2023, AANZ medical schools allocated the lowest reported hours worldwide, averaging a mere 21 h. This is similar to the report of 22 contact hours allocated for histology education in medical curricula in North America in the 2016/2017 academic year,[12] 24 contact hours allocated for histology in the United Kingdom and Ireland in 2019,[57] and 25 contact hours allocated to histology in Canada in the 2016/2017 academic year.[56] It appears AANZ medical schools are following the trends first laid out by the United States and Canada.[12] In stark contrast, Chinese medical schools allocated 300% more time to histology education[13] than medical schools in AANZ, North America, the United Kingdom, and Ireland. A significant outlier in the current literature, Mexican medical schools dedicated the largest amount of time to histology education with 125 h allocated to the subject—nearly six times the allocation in AANZ.[91]

The large variation in time dedicated to histology across medical school curricula could potentially impact the comprehension of histology, the perceived importance of the subject, and even the inclination to pursue a career as a pathologist. Indeed, <4% of medical graduates are choosing to specialize in pathology.[92–94] A survey of medical graduates in Australia in 2002 found that only 3% had chosen pathology as their top three specialties, and 41% reported their experience as a medical student influenced their choice.[92] This is over twice the percentage (<1.5%) of osteopathic medical graduates choosing pathology in the United States of America[93] but is one-fifth of the proportion of a multi-institutional study in Saudi Arabia choosing pathology in their top two.[95] In the United Kingdom, a survey of over 3000 medical graduates in 2015 revealed that 3.5% had chosen to specialize in pathology.[94] A recent analysis by the Royal College of Pathologists of Australasia suggests that there will be a shortage of pathologists in Australia by 2030.[96] In order to address this, the Australian Medical Council and Medical Deans Australia and New Zealand (https://medicaldeans.org.au/) should act immediately with the Royal College of Pathologists Australasia (RCPA; https://www.rcpa.edu.au/) to promote histology and pathology in basic sciences teaching within the medical curricula to ensure the continued training of pathologists. The multifaceted influences on career choices, such as educational experiences, cultural settings, and the temporal context of the studies, all contribute to the divergent patterns seen in medical graduate student pathways.

A reduction in the time dedicated to histology education may also potentially impact the development of effective clinicians.

It may lead to a poorer breadth and depth of understanding of basic sciences that underpin clinical practice, impairing the ability of clinicians to accurately diagnose and effectively treat patients. According to encapsulation theory, basic science and clinical knowledge become more integrated as time progresses and clinicians gain experience.[42] A number of studies have found that clinical problem-solving ability is mediated by the integration of basic science knowledge and clinical knowledge over time.[97-100] Without a solid foundation of basic science concepts due to reduced curricular time dedicated to the basic sciences, future clinicians may struggle to interpret complex clinical cases which may hinder the delivery of high-quality patient care.

Assessment of histology education

In this current investigation, the predominant method of assessing medical students' histological knowledge among institutions in AANZ is through invigilated face-to-face written examinations. Twice as many institutions assessed medical students' theoretical histological knowledge face-to-face rather than online, and three times as many institutions assessed practical histology face-to-face compared to online. In light of the recent finding that Chat Generative Pretrained Transformer (ChatGPT) has been found to answer over 60% of the United States Medical Licensing Examination (USMLE) Step 1 and Step 2 correctly[101] preference of invigilated and face-to-face assessments in histology education may stem from the institutions' commitment to upholding academic integrity and professionalism standards. This remains to be elucidated.

Multiple-choice questions (MCQs) are employed by the majority of histology educators worldwide.[12,56,57,102] In this current study, it was found that twice as many educators used MCQs compared to short-answer questions (SAQs), similar to 75% MCQs and 25% SAQs use in Canadian medical schools,[56] which may reflect budgetary, over pedagogical, decisions as MCQs can be automatically graded, whereas SAQs are typically graded by academics. It is also in line with 91% of AANZ medical schools using MCQs in neuroanatomy education.[58] MCQs were predominantly aimed at Level 1 (basic knowledge recall), Level 2 (identify, explain), and Level 3 (connect, apply) which is appropriate for histology as a basic science[103] and similar compared to pathology.[104]

Integration of histology education with a clinical science such as pathology will require MCQs to be adapted to higher levels of the Blooming Anatomy Tool for Histology.[45,46] Incorporation of histological images and clinical cases is a good way to elevate MCQs from Levels 1, 2, and 3 to Level 4 (analyze, classify), or Level 5 (critique, judge, predict) assessment items.[46] A study at the University of Turku (Finland) reported that medical students' performance in diagnostic pathology was predicted by their prior knowledge of histology.[103] This finding reinforces the concept that basic and clinical sciences are complementary, and emphasizes the importance of a solid foundation in "normal" histology for the accurate diagnosis of "abnormal" pathological conditions.

An inherent limitation associated with integrating histology with other subjects resides in the potential dilution of the proportion of assessment dedicated to histological knowledge. Moxham et al.[102] found worse attitudes of students at Cardiff University (UK) toward histology as only 5% of examination questions were related to histology and there was no requirement for students to pass, giving strategic learners less incentive to study the topic. Medical students at the University of Michigan (USA) reported devoting less time to histology, as the number of questions assessing histology significantly dropped, and students' average histology scores were significantly lower.[84] An unintended consequence of reduced histology assessment is that it may signal to learners that histology is less important and they may be less likely to engage comprehensively with the topic. Another is that within an integrated curriculum, students may be able to fail histology (or any other basic science subject) and still pass assessments and move forward in their degree. One way to potentially overcome this could be through the introduction of standardized medical licensing examinations to account for the large heterogeneity in teaching and assessments in AANZ medical schools.[58] The United States Medical Licensing Examination (USMLE) consists of three examinations (Step 1, Step 2, and Step 3) and is jointly administered by the National Board of Medical Examiners, the Educational Commission for Foreign Medical Graduates, and the Federation of State Medical Boards.[105] The USMLE Step 1 measures students' retention of anatomy, biochemistry, immunology, microbiology, pathology, and pharmacology knowledge.[105] The USMLE Step 2 measures clinical knowledge, and the USMLE Step 3 measures clinical skills.[105] The Australian Medical Council and Medical Deans Australia and New Zealand could work together to implement a core curriculum and standardized examinations in AANZ that foster engagement with, and competency of, the basic sciences.

Histology educators

Histology education in AANZ medical schools in 2022/2023 was predominantly delivered by academics holding a PhD degree, as opposed to clinically qualified individuals with an MD/MBBS/MBChB degree. It is noteworthy that three times as many PhD academics, compared to clinicians, were involved in teaching histology in this region. This pattern mirrors the situation in the United States of America and Canada in 2016/2017,[12] and the United Kingdom and Ireland in 2019.[106] Interestingly, in China, the distribution between PhD academics and clinicians involved in teaching histology is approximately equal, although there has been a notable 50% reduction in the number of clinicians teaching histology over the past 20 years.[13] This shared reliance on academics holding a PhD degree suggests a broader international trend in staffing of histology and other basic science educator roles.

Moxham et al.[102] expressed concern over the diminishing presence of clinicians in histology education and advocated for the importance of employing teachers who are clinically qualified. They emphasized the necessity for educators who can adeptly highlight medical evidence through the use of appropriate clinical examples. Reinforcing

this sentiment, a study at the National University of Singapore trialed collaborative histology teaching with a histologist and a pathologist.[4] Their first-year medical students responded in an overwhelmingly positive manner leading the researchers to formally propose ongoing and future collaborations of histologists and pathologists in medical school histology education.[4] In addition, 83% of Indian medical students agreed that including clinically relevant questions in practical workbooks made it easier for them to grasp the relevance of histology in the medical curriculum.[107] Given the current predominance of PhD academics teaching histology in medical schools, it is important to engage in discussions on strategies for enhancing their clinical proficiency. Alternatively, exploring avenues for fostering collaboration with clinicians is essential to ensure a more comprehensive and clinically relevant learning experience for medical students.

Student factors affecting histology performance

While the current study did not evaluate student outcomes or perceptions of the student learning experience, because of varied teaching methods and assessment practices, it is important for educators to consider student factors affecting histology performance. The mastery of histology by students is not solely determined by the time dedicated to, or the quality of teaching and resources provided, but it is also influenced by the intrinsic motivation of the individual. Intrinsic motivation, as defined by Deci and Ryan,[108] reflects an inherent drive to engage in challenging tasks that stimulate skill development and foster personal growth. Students propelled by intrinsic motivation exhibited a heightened commitment to attending classes and dedicated learning strategies compared to their less motivated peers.[109] This orientation toward goal mastery, characterized by an individuals' desire to achieve competency, significantly impacts academic performance.[109] A single-institution study at the University of Granada (Spain) found that medical students' self-efficacy and career motivation were significantly correlated with their performance on histology examinations.[110] A multiple institution study found that students' self-efficacy, intrinsic motivation, and control over their learning beliefs were significantly correlated with anatomy performance in health professions students.[111] Recognizing and harnessing self-efficacy and intrinsic motivation is imperative for students to successfully master histology.

Limitations

Despite repeated efforts to reach all accredited medical schools in AANZ, data were unable to be obtained from 17% of the Australian institutions and 50% of those in Aotearoa New Zealand. This may have introduced a bias in the results, leaning more toward the Australian context.

Additionally, the generalizability of these findings might be constrained to other affluent countries with large medical education systems, such as the United States, the United Kingdom, and Canada.

The primary aim was to offer an updated overview of histology education within medical curricula. However, this study did not delve into specific teaching methodologies, assessment practices, or the educational backgrounds of histology instructors.

Future directions

As this study did not examine student outcomes or perceptions, a future study could examine histology knowledge competencies and perceptions of histology education across all AANZ medical schools. It would be interesting to examine if delivery mode, educator background, resource availability, and/or assessment significantly impacted student outcomes or perception. In addition, it would be enlightening to interview practising doctors to examine reasons why they did, or did not, choose pathology as a career path.

CONCLUSION

This comprehensive review of histology education in medical curricula across AANZ reveals a diverse landscape with varying approaches. In light of these findings, AANZ medical schools should integrate histology and pathology, establish a core curriculum, and promote flexible teaching modalities. It is hoped that this in-depth discussion will foster reflection, contemplation, and motivation to enhance histology education in medical curricula in AANZ, and worldwide.

AUTHOR CONTRIBUTIONS

Amanda J. Meyer: Conceptualization; investigation; writing – original draft; methodology; validation; writing – review and editing; visualization; formal analysis; project administration; data curation. **Jamie A. Chapman:** Conceptualization; investigation; writing – original draft; methodology; validation; writing – review and editing; formal analysis; visualization.

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CONFLICT OF INTEREST STATEMENT

Dr. Amanda J. Meyer is not involved with Meyer's Histology and is not related to Dr. Geoffrey Meyer. Dr. Jamie A. Chapman does not receive financial gain from the Chapman Histology channel on YouTube. Dr. Jamie A. Chapman, as the sole histology teacher, completed the survey in this study for his institution.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon request from the corresponding author. The data are not publicly available due to ethical restrictions.

ETHICS STATEMENT

Ethics was granted by The University of Western Australian Human Research Ethics Committee (2022/ET000767).

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REFERENCES

1. Chapman JA, Lee LMJ, Swailes NT. From scope to screen: the evolution of histology education. Biomed Vis Adv Exp Med Biol. 2020;1320:75–107. https://doi.org/10.1007/978-3-030-47483-6_5
2. Hortsch M. Histology as a paradigm for a science-based learning experience: visits by histology education spirits of past, present, and future. Anat Sci Educ. 2023;16(3):372–83. https://doi.org/10.1002/ase.2235
3. Hortsch M, Carneiro Girão-Carmona VC, Rocha de Melo Leite AC, Nikas IP, Koney-Kwaku Koney N, Yohannan DG, et al. Teaching cellular architecture: the global status of histology education. In: Cui D, Meyer ER, Rea PM, editors. Biomedical visualisation. Cham: Springer; 2023. p. 177–212. https://doi.org/10.1007/978-3-031-36727-4_9
4. Ang ET, Liu P, Jitesh R, Chandrika M, Satish RL, Lian WQD, et al. The challenges of histology education. Clin Anat. 2023;36(2):308–14. https://doi.org/10.1002/ca.23989
5. Garcia M, Victory N, Navarro-Sempere A, Segovia Y. Students' views on difficulties in learning histology. Anat Sci Educ. 2018;12(5):541–9. https://doi.org/10.1002/ase.1838
6. Hortsch M, Mangrulkar RS. When students struggle with gross anatomy and histology: a strategy for monitoring, reviewing, and promoting student academic success in an integrated preclinical medical curriculum. Anat Sci Educ. 2015;8(5):478–83. https://doi.org/10.1002/ase.1519
7. Sherman SC, Jue CK. Pedagogical methods for teaching histology in anatomy and physiology courses. HAPS Educ. 2009;14:50–5.
8. Drake RL, McBride JM, Lachman N, Pawlina W. Medical education in the anatomical sciences: the winds of change continue to blow. Anat Sci Educ. 2009;2(6):253–9. https://doi.org/10.1002/ase.117
9. Drake RL, McBride JM, Pawlina W. An update on the status of anatomical sciences education in United States medical schools. Anat Sci Educ. 2014;7(4):321–5. https://doi.org/10.1002/ase.1468
10. McKeown PP, Heylings DJA, Stevenson M, McKelvey KJ, Nixon JR, McCluskey DR. The impact of curricular change on medical students' knowledge of anatomy. Med Educ. 2003;37(11):954–61. https://doi.org/10.1046/j.1365-2923.2003.01670.x
11. Thompson AR, Lowrie DJ Jr. An evaluation of outcomes following the replacement of traditional histology laboratories with self-study modules. Anat Sci Educ. 2017;10(3):276–85. https://doi.org/10.1002/ase.1659
12. McBride JM, Drake RL. National survey on anatomical sciences in medical education. Anat Sci Educ. 2018;11(1):7–14. https://doi.org/10.1002/ase.1760
13. Cheng X, Chan LK, Li H, Yang X. Histology and embryology education in China: the current situation and changes over the past 20 years. Anat Sci Educ. 2020;13(6):759–68. https://doi.org/10.1002/ase.1956
14. Felszeghy S, Pasonen-Seppänen S, Koskela A, Mahonen A. Student-focused virtual histology education: do new scenarios and digital technology matter? [Version 1]. MedEdPublish. 2017;6:154. https://doi.org/10.15694/mep.2017.000154
15. Ariana A, Amin M, Pakneshan S, Dolan-Evans E, Lam AK. Integration of traditional and e-learning methods to improve learning outcomes for dental students in histopathology. J Dent Educ. 2016;80(9):1140–8. https://doi.org/10.1002/j.0022-0337.2016.80.9.tb06196.x
16. Burk D, Lee LMJ, Lambert HW. Embryology and histology education in north American dental schools: the basic science survey series. J Dent Educ. 2013;77(6):744–56. https://doi.org/10.1002/j.0022-0337.2013.77.6.tb05526.x
17. Helle L, Nivala M, Kronqvist P. More technology, better learning resources, better learning? Lessons from adopting virtual microscopy in undergraduate medical education. Anat Sci Educ. 2013;6(2):73–80. https://doi.org/10.1002/ase.1302
18. Husmann PR, O'Loughlin VD, Braun MW. Quantitative and qualitative changes in teaching histology by means of virtual microscopy in an introductory course in human anatomy. Anat Sci Educ. 2009;2(5):218–26. https://doi.org/10.1002/ase.105
19. Mione S, Valcke M, Cornelissen M. Remote histology learning from static versus dynamic microscopic images. Anat Sci Educ. 2016;9(3):222–30. https://doi.org/10.1002/ase.1572
20. Weaker FJ, Herbert DC. Transition of a dental histology course from light to virtual microscopy. J Dent Educ. 2009;73(10):1213–21. https://doi.org/10.1002/j.0022-0337.2009.73.10.tb04813.x
21. dos Santos FS, Osako MK, Perdoná GSC, Alves MG, Sales KU. Virtual microscopy as a learning tool in Brazilian medical education. Anat Sci Educ. 2021;14(4):408–16. https://doi.org/10.1002/ase.2072
22. Dee FR. Virtual microscopy in pathology education. Hum Pathol. 2009;40(8):1112–21. https://doi.org/10.1016/j.humpath.2009.04.010. Epub 2009 Jun 21.
23. Blake CA, Lavoie HA, Millette CF. Teaching medical histology at the University of South Carolina School of Medicine: transition to virtual slides and virtual microscopes. Anat Rec B New Anat. 2003;275(1):196–206. https://doi.org/10.1002/ar.b.10037
24. Braun MW, Kearns KD. Improved learning efficiency and increased student collaboration through use of virtual microscopy in the teaching of human pathology. Anat Sci Educ. 2008;1(6):240–6. https://doi.org/10.1002/ase.53
25. Goldberg HR, Dintzis R. The positive impact of team-based virtual microscopy on student learning in physiology and histology. Adv Physiol Educ. 2007;31(3):261–5. https://doi.org/10.1152/advan.00125.2006
26. Krippendorf BB, Lough J. Complete and rapid switch from light microscopy to virtual microscopy for teaching medical histology. Anat Rec B New Anat. 2005;285(1):19–25. https://doi.org/10.1002/ar.b.20066
27. Pinder KE, Ford JC, Ovalle WK. A new paradigm for teaching histology laboratories in Canada's first distributed medical school. Anat Sci Educ. 2008;1(3):95–101. https://doi.org/10.1002/ase.22
28. Scoville SA, Buskirk TD. Traditional and virtual microscopy compared experimentally in a classroom setting. Clin Anat. 2007;20(5):565–70. https://doi.org/10.1002/ca.20440
29. Brown PJ, Fews D, Bell NJ. Teaching veterinary histopathology: a comparison of microscopy and digital slides. J Vet Med Educ. 2016;43(1):13–20. https://doi.org/10.3138/jvme.0315-035R1
30. Mione S, Valcke M, Cornelissen M. Evaluation of virtual microscopy in medical histology teaching. Anat Sci Educ. 2013;6(5):215–307. https://doi.org/10.1002/ase.1353

31. Paulsen FP, Eichhorn M, Bräuer L. Virtual microscopy - the future of teaching histology in the medical curriculum? Ann Anat. 2010;192(6):378–82. https://doi.org/10.1016/j.aanat.2010.09.008
32. Caruso MC. Virtual microscopy and other technologies for teaching histology during Covid-19. Anat Sci Educ. 2021;14(1):19–21. https://doi.org/10.1002/ase.2038
33. Darici D, Reissner C, Brockhaus J, Missler M. Implementation of a fully digital histology course in the anatomical teaching curriculum during COVID-19 pandemic. Ann Anat. 2021;236:151718. https://doi.org/10.1016/j.aanat.2021.151718
34. Durrani Z, Pickavance L, Duret D, Nevitt S, Noble K. Evaluation of innovative digital microscopy and interactive team-based learning approaches in histology teaching. Dev Acad Prac. 2021:1–16. https://doi.org/10.3828/dap.2021.8
35. Pather N, Blyth P, Chapman JA, Dayal MR, Flack NAMS, Fogg QA, et al. Forced disruption of anatomy education in Australia and New Zealand: an acute response to the Covid-19 pandemic. Anat Sci Educ. 2020;13(3):284–300. https://doi.org/10.1002/ase.1968
36. Saverino D, Marcenaro E, Zarcone D. Teaching histology and anatomy online during the COVID-19 pandemic. Clin Anat. 2022;35(1):129–34. https://doi.org/10.1002/ca.23806
37. Saverino D, Zarcone D. Keeping histology students under the microscope during Covid-19 lockdown: lessons learned from the University of Genoa. Anat Sci Educ. 2022;15(1):86–8. https://doi.org/10.1002/ase.2153
38. Craig S, Tait N, Boers D, McAndrew DJ. Review of anatomy education in Australian and New Zealand medical schools. ANZ J Surg. 2010;80:212–6. https://doi.org/10.1111/j.1445-2197.2010.05241.x
39. Trautman J, McAndrew D, Craig SJ. Anatomy teaching stuck in time? A 10-year follow-up of anatomy education in Australian and New Zealand medical schools. Aust J Educ. 2019;63(3):340–50. https://doi.org/10.1177/0004944119878263
40. Australian Qualifications Framework Council. Australian qualifications framework. 2nd ed.; 2013. Available from: https://www.aqf.edu.au/publication/aqf-second-edition
41. Fincher RM, Wallach PM, Richardson WS. Basic science right, not basic science lite: medical education at a crossroad. J Gen Intern Med. 2009;24(11):1255–8. https://doi.org/10.1007/s11606-009-1109-3
42. Woods NN. Science is fundamental: the role of biomedical knowledge in clinical reasoning. Med Educ. 2007;41(12):1173–7. https://doi.org/10.1111/j.1365-2923.2007.02911.x
43. Woods NN, Brooks LR, Norman GR. The value of basic science in clinical diagnosis: creating coherence among signs and symptoms. Med Educ. 2005;39(1):107–12. https://doi.org/10.1111/j.1365-2929.2004.02036.x
44. Woods NN, Neville AJ, Levinson AJ, Howey EHA, Oczkowski WJ, Norman GR. The value of basic science in clinical diagnosis. Acad Med. 2006;81(Suppl 10):S124–S127. https://doi.org/10.1097/00001888-200610001-00031
45. Thompson AR, O'Loughlin VD. The Blooming Anatomy Tool (BAT): a discipline-specific rubric for utilizing Bloom's taxonomy in the design and evaluation of assessments in the anatomical sciences. Anat Sci Educ. 2015;8(6):493–501. https://doi.org/10.1002/ase.1507
46. Zaidi NB, Hwang C, Scott S, Stallard S, Purkiss J, Hortsch M. Climbing Bloom's taxonomy pyramid: lessons from a graduate histology course. Anat Sci Educ. 2017;10(5):456–64. https://doi.org/10.1002/ase.1685
47. Meyer's Histology. 2024 [cited 2024 Feb 12]. Available from: https://histology-online.com/
48. O'Dowd G, Bell S, Wright S. Wheater's functional histology a text and colour atlas. 7th ed. Glasgow: Elsevier; 2023.
49. Pawlina W. Histology: a text and atlas with correlated cell and molecular biology. 8th ed. United States of America: Wolters Kluwer; 2019.
50. Mescher AL. Junqueira's basic Histology text and atlas. 16th ed. New York: McGrawHill; 2021.
51. Eroschenko VP. Atlas of histology with functional correlations. 13th ed. United States of America: Wolters Kluwer; 2017.
52. Kerr JB. Functional histology. 2nd ed. Sydney: Mosby; 2009.
53. Kierszenbaum AL, Tres L. Histology and cell biology: an introduction to pathology. 5th ed. Philadelphia: Elsevier; 2019.
54. Cui D, Daley WP. Histology from a clinical perspective. United States of America: Wolters Kluwer; 2022.
55. Peckham M. Histology at a glance. United Kingdom: Wiley-Blackwell; 2011.
56. Rockarts J, Brewer-Deluce D, Shali A, Mohialdin V, Wainman B. National survey on Canadian undergraduate medical programs: the decline of the anatomical sciences in Canadian medical education. Anat Sci Educ. 2020;13(3):378–86. https://doi.org/10.1002/ase.1960
57. Smith CF, Sk F, Heylings D, Finn GM, Davies DC. Anatomy education for medical students in the United Kingdom and republic or Ireland in 2019: a 20-year-follow-up. Anat Sci Educ. 2022;15(6):993–1006. https://doi.org/10.1002/ase.2126
58. Newman HJ, Meyer AJ, Carr SE. Neuroanatomy teaching in Australian and New Zealand medical schools. World Neurosurg. 2021;149:3217–24. https://doi.org/10.1016/j.wneu.2021.02.048
59. Wilson AB, Taylor MA, Klein BA, Sugrue MK, Whipple EC, Brokaw JJ. Meta-analysis and review of learner performance and preference: virtual versus optical microscopy. Med Educ. 2016;50(4):428–40. https://doi.org/10.1111/medu.12944
60. Bloodgood RA, Ogilvie RW. Trends in histology teaching in United States medical schools. Anat Rec. 2006;289B(5):169–75. https://doi.org/10.1002/ar.b.20111
61. McLachlan JC, Finn G, Macnaughton J. The conscientiousness index: a novel tool to explore students' professionalism. Acad Med. 2009;84(5):559–65. https://doi.org/10.1097/ACM.0b013e31819fb7ff
62. Zazulia AR, Goldhoff P. Faculty and medical student attitudes about preclinical classroom attendance. Teach Learn Med. 2014;26(4):327–34. https://doi.org/10.1080/10401334.2014.945028
63. Gardner G, Feldman M, Santen SA, Mui P, Biskobing K. Determinants and outcomes of in-person lecture attendance in medical school. Med Sci Educ. 2022;32:883–90. https://doi.org/10.1007/s40670-022-01581-2
64. Al Shenawi H, Yaghan R, Almarabheh A, Al Shenawi N. The relationship between attendance and academic performance of undergraduate medical students during surgical clerkship. BMC Med Educ. 2021;21(1):396. https://doi.org/10.1186/s12909-021-02833-2
65. Salzman J, Williamson M, Espina-Rey A, Kibble J, Kaufmann C. Effects of voluntary attendance patterns on first-year medical students' wellness and academic performance during COVID-19. Adv Physiol Educ. 2021;45(3):634–43. https://doi.org/10.1152/advan.00071.2021
66. Subramaniam BS, Hande S, Komattil R. Attendance and achievement in medicine: investigating the impact of attendance policies on academic performance of medical students. Ann Med Health Sci Res. 2013;3(2):202–5. https://doi.org/10.4103/2141-9248.113662
67. Nevins EJ, Moori PL, Alexander L, Richards B, Bleasdale V, Sharma VK. Could attendance at medical school be improved? A prospective study of medical education at the University of Liverpool: study of attendance at a UK medical school [version 1]. MedEdPublish. 2016;5:78. https://doi.org/10.15694/mep.2016.000078

68. Maity S, Nauhria S, Nayak N, Nauhria S, Coffin T, Wray J, et al. Virtual versus light microscopy usage among students: a systematic review and meta-analytic evidence in medical education. Diagnostics. 2023;13(3):558. https://doi.org/10.3390/diagnostics13030558
69. Kumar RK, Velan GM, Korell SO, Kandara M, Dee FR, Wakefield D. Virtual microscopy for learning and assessment in pathology. J Pathol. 2004;204(5):613–8. https://doi.org/10.1002/path.1658
70. McLean M. Flipping histology in an undergraduate problem-based learning medical curriculum: a blended learning approach. Med Sci Educ. 2018;28:429–37. https://doi.org/10.1007/s40670-018-0543-4
71. Lee LMJ, Goldman HV, Hortsch M. The virtual microscopy database- sharing digital microscope images for research and education. Anat Sci Educ. 2018;11(5):510–5. https://doi.org/10.1002/ase.1774
72. Young B, Heath JW. Wheater's functional histology: a text and colour atlas. 4th ed. Edinburgh, Scotland: Churchill Livingstone; 2000.
73. O'Dowd G, Bell S, Wright S. Wheater's pathology: a text, atlas, and review of histopathology. 6th ed. Glasgow: Elsevier; 2019.
74. Selvig D, Holaday LW, Purkiss J, Hortsch M. Correlating students' educational background, study habits, and resource usage with learning success in medical histology. Anat Sci Educ. 2015;8(1):1–11. https://doi.org/10.1002/ase.1449
75. Tauber Z, Lichnovska R, Erdosova B, Zizka R, Cizkova K. Teaching histology in the age of virtual microscopy and e-resources: is a tailored approach to domestic and international students warranted? Interdiscip J Virt Learn Med Sci. 2021;12(2):97–105. https://doi.org/10.30476/ijvlms.2021.89764.1080
76. Chapman Histology. 2024. Available from: https://www.youtube.com/c/ChapmanHistology
77. Hortsch M. Taking a SecondLook™ at a time-efficient self-review resource. Med Sci Educ. 2016;26:3–4. https://doi.org/10.1007/s40670-015-0210-y
78. Drees C, Ghebremedhin E, Hansen M. Development of an interactive e-learning software “Histologie für Mediziner” for medical histology courses and its overall impact on learning outcomes and motivation. GMS J Med Educ. 2020;37(3) Doc35. https://doi.org/10.3205/zma001328
79. Al Khader A, Obeidat FN, Abu Shahin N, Khouri NA, Kaddumi EG, Al Qa'qa S, et al. Medical students' perceptions of pathology and a proposed curricular integration with histology: a future vision of curricular change. Int J Morphol. 2020;38(1):38–42.
80. Carneiro BD, Pozza DH, Tavares I. Perceptions of medical students towards the role of histology and embryology during curricular review. BMC Med Educ. 2023;23:74. https://doi.org/10.1186/s12909-023-04019-4
81. Syaidah R, Sukmawati D, Edison RE, Jusuf AA. Medical students' perceptions toward integrated histology practical class: a quantitative and qualitative study. Int J Hum Health Sci. 2020;4(3):200–5. https://doi.org/10.31344/ijhhs.v4i3.201
82. Teshome D. Attitude and perception of medical students towards histology subject at Wollo University, Ethiopia. Adv Med Educ Part. 2022;13:337–44. https://doi.org/10.2147/amep.s359703
83. Hanley LC, Ou J, Ritter D, Chew A, Monteiro K, Dumenco L. Bridging anatomy, histology, and pathology: a novel curriculum component incorporating self-directed learning for first-year medical students. Med Sci Educ. 2023;33:1055–9. https://doi.org/10.1007/s40670-023-01870-4
84. Gribbin W, Wilson EA, McTaggart S, Hortsch M. Histology education in an integrated, time-restricted medical curriculum: academic outcomes and students' study adaptations. Anat Sci Educ. 2022;15(4):671–84. https://doi.org/10.1002/ase.2127
85. Thompson AR, Lowrie DJ Jr, Ubani M. The effect of histology examination format on medical student preparation and performance: stand-alone versus integrated examinations. Med Sci Educ. 2023;33:165–72. https://doi.org/10.1007/s40670-023-01731-0
86. McCloskey CB, Johnson K, Brissette M, Conran R, Childs J, George M, et al. Factors influencing US allopathic medical students to choose pathology as a speciality. Acad Path. 2020;7:2374289520951924. https://doi.org/10.1177/2374289520951924
87. Cui D, Moxham DC. A core syllabus for histology within the medical curriculum—the cell and basic sciences. Clin Anat. 2021;34(3):483–95. https://doi.org/10.1002/ca.23720
88. Das M, Ettarh R, Lowrie DJ Jr, Rengasamy P, Lee LMJ, Williams JM, et al. A guide to competencies, educational goals, and learning objectives for teaching medical histology in an undergraduate medical education setting. Med Sci Educ. 2019;29(2):523–34. https://doi.org/10.1007/s40670-018-00688-9
89. Humphreys H, Stevens N, Burke L, Sheehan M, Glavey S, Keogan M, et al. On behalf of the Faculty of Pathology, Royal College of Physicians in Ireland. Irish J Med Sci. 2022;191:1799–807. https://doi.org/10.1007/s11845-021-02774-1
90. Koch LK, Chang OH, Dintzis SM. Medical education in pathology: general concepts and strategies for implementation. Arch Pathol Lab Med. 2021;145(9):1081–8. https://doi.org/10.5858/arpa.2020-0463-RA
91. Salinas-Alvarez Y, Quiroga-Garza A, Martinez-Garza J-BG, Zarate-Garza PP, Rodriguez-Alanis KV, Guzman-Lopez S, et al. Mexican educators survey on anatomical sciences education and a review of world tendencies. Anat Sci Educ. 2021;14(4):471–81. https://doi.org/10.1002/ase.2017
92. Harris MG, Gavel PH, Young JE. Factors influencing the choice of specialty of Australian medical graduates. Med J Aust. 2005;183(6):295–300. https://doi.org/10.5694/j.1326-5377.2005.tb07058.x
93. Jajosky RP, Coulson HC, Rosengrant AJ, Jajosky AN, Jajosky PG. Osteopathic students and graduates matching into pathology residency, 2011–2020. J Osteo Med. 2021;121(2):149–56. https://doi.org/10.1515/jom-2020-0134
94. Lambert TW, Smith F, Goldacre MJ. Career specialty choices of UK medical graduates of 2015 compared with earlier cohorts: questionnaire surveys. Postgrad Med J. 2018;94(1110):191–7. https://doi.org/10.1136/postgradmedj-2017-135309
95. Masuadi EM, Mohamud MS, Alhassan AM, Alharbi KG, Hilabi AS, Alharbi FA, et al. Factors and determinants of choosing pathology as a future career: results from a multi-institution study. Cureus. 2021;13(6):e15790. https://doi.org/10.7759/cureus.15790
96. Cook H. ‘The cancer you didn't suspect’: medical test delays could be endangering patients. Smhcomau. 2023 Nov 12; [cited 2024 Feb 25]. Available from: https://www.smh.com.au/healthcare/the-cancer-you-didn-t-suspect-medical-test-delays-could-be-endangering-patients-20231110-p5ej6e.html
97. Danielson JA, Burzette RG, Bailey MR, Berent LM, Case H, Casey-Reed A, et al. Basic science knowledge underlies clinical science knowledge and clinical problem solving: evidence from veterinary medicine. Adv Health Sci Educ. 2024 May 16. https://doi.org/10.1007/s10459-024-10334-2
98. de Bruin AB, Schmidt HG, Rikers RM. The role of basic science knowledge and clinical knowledge in diagnostic reasoning: a structural equation modeling approach. Acad Med. 2005;80(8):765–73. https://doi.org/10.1097/00001888-200508000-00014
99. Rikers RMJP, Schmidt HG, Moulaert V. Biomedical knowledge: encapsulated or two worlds apart? Appl Cogn Psychol. 2005;19(2):223–31. https://doi.org/10.1002/acp.1107
100. Violato C, Gao H, O'Brien MC, Grier D, Shen E. How do physicians become medical experts? A test of three competing theories: distinct domains, independent influence and encapsulation models. Adv Health Sci Educ. 2018;23(2):249–63. https://doi.org/10.1007/s10459-017-9784-z
101. Gibson A, Safranek CW, Huang T, Socrates V, Chi L, Taylor RA, et al. How does ChatGPT perform on the United States medical

licensing examination? The implications of large language models for medical education and knowledge assessment. JMIR Med Educ. 2023;9:e45312. https://doi.org/10.2196/45312

102. Moxham BJ, Emmanouil-Nikoloussi E, Brenner E, Plaisant O, Brichova H, Kucera T, et al. The attitudes of medical students in Europe toward the clinical importance of histology. Clin Anat. 2017;30(5):635–43. https://doi.org/10.1002/ca.22889
103. Nivala M, Lehtinen E, Helle L, Kronqvist P, Paranko J, Saljo R. Histological knowledge as a predictor of medical students' performance in diagnostic pathology. Anat Sci Educ. 2013;6(6):361–7. https://doi.org/10.1002/ase.1352
104. Hernandez T, Magid MS, Polydorides AD. Assessment question characteristics predict medical student performance in general pathology. Arch Pathol Lab Med. 2021;145:1280–8. https://doi.org/10.5858/arpa.2020-0624-OA
105. Ozair A, Bhat V, Detchou DKE. The US residency selection process after the United States medical licensing examination step 1 pass/fail change: overview for applicants and educators. JMIR Med Educ. 2023;9:e37069. https://doi.org/10.2196/37069
106. Smith CF, Boyton L, Barassett C, Evans DJR, Munro R, Finn GM. Identities and experiences of anatomists. Eur J Anat. 2023;27(2):219–35. https://doi.org/10.52083/QLMI1353
107. Jacob TM, Jeyaseelan V, Holla SJ, Prithishkumar IJ, Isaac B, Rabi S. Structured, functional histology practical modules: an answer to medical students' histology nightmare and the way forward for relevant histology instruction in the Indian undergraduate medical curriculum? Natl Med J India. 2020;33(3):166–71. https://doi.org/10.4103/0970-258X.314019
108. Deci EL, Ryan RM. Intrinsic motivation and self-determination in human behaviour. New York: Plenum Press; 1985.
109. Han C-W, Farruggia SP, Moss TP. Effects of academic mindsets on college students' achievement and retention. J Coll Stud Dev. 2017;58(8):1119–34. https://doi.org/10.1353/csd.2017.0089
110. Campos-Sanchez A, Lopez-Nunez JA, Carriel V, Martin-Piedra M-A, Sola T, Alaminos M. Motivational component profiles in university students learning histology: a comparative study between genders and different health science curricula. BMC Med Educ. 2014;14:46. https://doi.org/10.1186/1472-6920-14-46
111. Abel Meguid E, Smith CF, Meyer AJ. Examining the motivations of health profession students to student human anatomy. Anat Sci Educ. 2020;13(3):343–52. https://doi.org/10.1002/ase.1919

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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