

## RESEARCH REPORT

# 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  $21 \pm 17$  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.<sup>1–3</sup> Traditionally taught using light microscopes and prepared glass slides, histology has provided medical students with

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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.<sup>4-7</sup> Typically delivered bimodally, with the theoretical component delivered as lectures, and a practicum component run in laboratories with TM,<sup>2</sup> 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.<sup>8-10</sup>

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.<sup>1,3,11</sup> 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,<sup>12</sup> and in 2020, approximately half of all medical schools in China used VM.<sup>13</sup> Predominantly, the shift from TM to VM has been viewed as positive for student satisfaction and/or performance,<sup>14-21</sup> or at the very worst, benign with no significant differences between the two methods of histology delivery.<sup>18,22-31</sup> VM, however, became especially important during the SARS-Cov-2 pandemic, when a near-instant pivot to online learning was required.<sup>3,13,32-37</sup>

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.<sup>38,39</sup> While there was a similar pandemic-induced rapid shift to online learning,<sup>35</sup> 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<sup>40</sup> 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,<sup>38,39</sup> 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.<sup>41-44</sup> 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.<sup>45,46</sup> 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/>.<sup>47</sup> 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",<sup>48</sup> which was prescribed in 30% of the medical curricula. "Histology A Text & Atlas With Correlated Cell & Molecular Biology"<sup>49</sup> and "Junqueira's Basic Histology Text & Atlas"<sup>50</sup> were equally prescribed at a rate of 20%. Two programs prescribed the "Atlas of Histology with Functional Correlations".<sup>51</sup> The remaining four texts were each prescribed at one institution: "Functional Histology",<sup>52</sup> "Histology and Cell Biology: An Introduction to Cell Biology",<sup>53</sup> "Histology From a Clinical Perspective",<sup>54</sup> and "Histology at a Glance".<sup>55</sup>

### 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%).

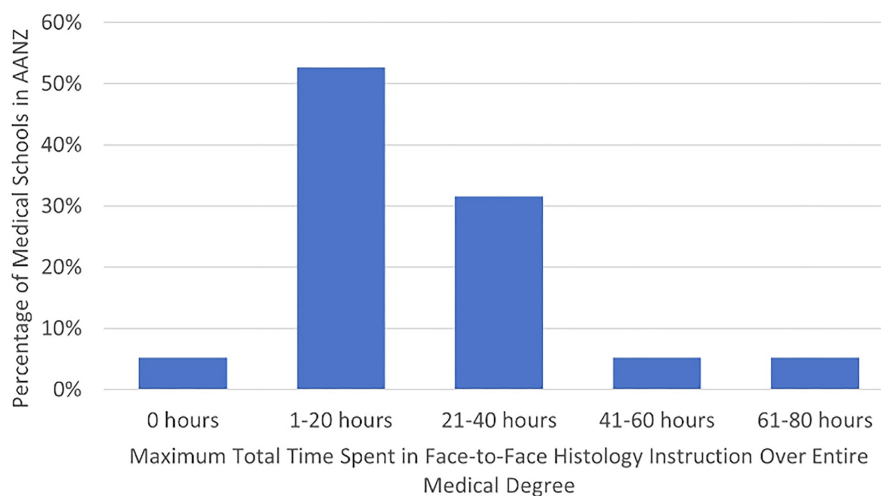
### Time dedicated to histology education

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  $21 \pm 17$  (mean  $\pm$  standard deviation) hours. This is less than three average working days (@7.5h 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.

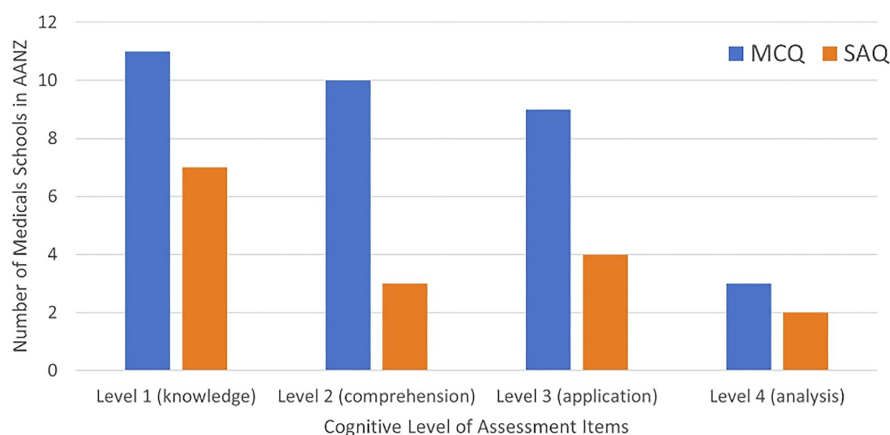
### Assessment of histology education

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 20h, 32% reported 21 and 40h, 5% reported 41 and 60h, another 5% reported 61 and 80h, 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  $32.5\% \pm 17.5\%$  ( $n=2$ , 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 Chirurgery (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.<sup>3</sup>

Previous surveys have focused on histology education in the United States and Canada,<sup>12,56</sup> China,<sup>13</sup> as well as the United Kingdom and Ireland.<sup>57</sup> However, within AANZ, only surveys pertaining to gross anatomy<sup>38,39</sup> and neuroanatomy education<sup>58</sup> 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.<sup>59</sup> 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<sup>12</sup> and China in 2018.<sup>13</sup> Less than half of the histology educators in AANZ and China<sup>13</sup> exclusively opted for VM, representing two-thirds of the proportion observed in Northern America in 2016/2017.<sup>12</sup> In contrast, approximately 50% of Chinese medical schools only used VM,<sup>13</sup> 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<sup>60</sup> and 10% in 2016/2017.<sup>12</sup> 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.<sup>61,62</sup> Attendance is related to responsibility/reliability/accountability, respect for others, and respect for patients.<sup>62</sup> However, 90% of medical students supported free choice among learning opportunities,<sup>62</sup> which would give students more convenience for self-directed study and greater time for extracurricular pursuits.<sup>62</sup> Students believed that their primary task was to learn factual material and how they chose to do that was immaterial.<sup>62,63</sup> In contrast, educators believe that attendance provides more opportunities for learning and developing professional skills<sup>62</sup> and improved student outcomes and well-being.<sup>64–66</sup> 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.<sup>67</sup>

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.<sup>59</sup> 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.<sup>68</sup> 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.<sup>28,59</sup> Notably, studies examining Australian medical students demonstrated no significant impact on student learning outcomes,<sup>69,70</sup> emphasizing the need for further exploration and contextualization of these findings within regional educational settings.<sup>3</sup>

## 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.<sup>71</sup> 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.<sup>72</sup> 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.<sup>48,73</sup> 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.<sup>74</sup> 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.<sup>75</sup> Sixteen percent of histology educators provided links to channels on YouTube such as "Chapman Histology" (<https://www.youtube.com/c/ChapmanHistology>)<sup>76</sup> by one of the authors of this paper. Software applications (apps) such as the SecondLook™ Histology resource<sup>77</sup> 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.<sup>78</sup> 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.<sup>3</sup> 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.<sup>12</sup> 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.<sup>13</sup> 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.<sup>12,56,57,60</sup>

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,<sup>79</sup> 75% in Portugal,<sup>80</sup> 77% in Indonesia,<sup>81</sup> 83% in Ethiopia,<sup>82</sup> and 90% in Singapore,<sup>4</sup> whereas a multiple institution study found 98% of medical students in the United States of America had this preference.<sup>83</sup> 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.<sup>84</sup> 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.<sup>85</sup> Interestingly, experiencing an integrated or stand-alone histology course did not influence American allopathic medical students to consider specializing in pathology.<sup>86</sup> 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.<sup>87,88</sup> Furthermore, a comprehensive curriculum has been developed for Irish medical students that encompasses professionalism, clinical competencies, and skills, along with the necessary pathology knowledge.<sup>89</sup> 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.<sup>90</sup> 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 21h. 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,<sup>12</sup> 24 contact hours allocated for histology in the United Kingdom and Ireland in 2019,<sup>57</sup> and 25 contact hours allocated to histology in Canada in the 2016/2017 academic year.<sup>56</sup> It appears AANZ medical schools are following the trends first laid out by the United States and Canada.<sup>12</sup> In stark contrast, Chinese medical schools allocated 300% more time to histology education<sup>13</sup> 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 125h allocated to the subject—nearly six times the allocation in AANZ.<sup>91</sup>

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.<sup>92–94</sup> 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.<sup>92</sup> This is over twice the percentage (<1.5%) of osteopathic medical graduates choosing pathology in the United States of America<sup>93</sup> but is one-fifth of the proportion of a multi-institutional study in Saudi Arabia choosing pathology in their top two.<sup>95</sup> In the United Kingdom, a survey of over 3000 medical graduates in 2015 revealed that 3.5% had chosen to specialize in pathology.<sup>94</sup> A recent analysis by the Royal College of Pathologists of Australasia suggests that there will be a shortage of pathologists in Australia by 2030.<sup>96</sup> 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.<sup>42</sup> 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.<sup>97-100</sup> 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<sup>101</sup> 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.<sup>12,56,57,102</sup> 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,<sup>56</sup> 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.<sup>58</sup> 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<sup>103</sup> and similar compared to pathology.<sup>104</sup>

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.<sup>45,46</sup> 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.<sup>46</sup> A study at the University of Turku (Finland) reported that medical students' performance in diagnostic pathology was predicted by their prior knowledge of histology.<sup>103</sup> 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.<sup>102</sup> 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.<sup>84</sup> 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.<sup>58</sup> 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.<sup>105</sup> The USMLE Step 1 measures students' retention of anatomy, biochemistry, immunology, microbiology, pathology, and pharmacology knowledge.<sup>105</sup> The USMLE Step 2 measures clinical knowledge, and the USMLE Step 3 measures clinical skills.<sup>105</sup> 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,<sup>12</sup> and the United Kingdom and Ireland in 2019.<sup>106</sup> 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.<sup>13</sup> 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.<sup>102</sup> 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.<sup>4</sup> 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.<sup>4</sup> 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.<sup>107</sup> 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,<sup>108</sup> 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.<sup>109</sup> This orientation toward goal mastery, characterized by an individuals' desire to achieve competency, significantly impacts academic performance.<sup>109</sup> 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.<sup>110</sup> 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.<sup>111</sup> 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.

### ACKNOWLEDGMENTS

The authors would like to thank Professor Michael Hortsch for inviting them to work on a global histology review project which led them to this study to specifically investigate current practices in AANZ. They would also like to thank the anonymous reviewers for their feedback on how to improve the manuscript. Open access publishing facilitated by The University of Western Australia, as part of the Wiley - The University of Western Australia agreement via the Council of Australian University Librarians.

### 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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## SUPPORTING INFORMATION

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

**How to cite this article:** Meyer AJ, Chapman JA. A slide into obscurity? The current state of histology education in Australian and Aotearoa New Zealand medical curricula in 2022–2023. *Anat Sci Educ.* 2024;17:1694–1705. <https://doi.org/10.1002/ase.2518>