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When Students Struggle with Gross Anatomy and Histology: A Strategy for Monitoring, Reviewing, and Promoting Student Academic Success in an Integrated Preclinical Medical Curriculum

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Gross anatomy and histology are now often taught as parts of an integrated medical or dental curriculum. Although this puts these foundational basic sciences into a wider educational context, students may not fully appreciate their importance as essential components of their medical education and may not develop a sufficient level of competency, as they are not stand-alone courses. The early identification of medical or dental students who struggle with anatomy or histology and the facilitation of adequate didactic support constitute a significant problem in an integrated curriculum. The timely intervention by an academic review board in combination with an individualized faculty-mediated counseling and remediation process may provide an effective solution to this problem. Anat Sci Educ 8: 478–483. © 2015 American Association of Anatomists.

Key words: histology education; gross anatomy education; medical education; microscopic anatomy; medical curriculum; integrated curriculum; medical students; academic failure; academic remediation

INTRODUCTION AND THE PROBLEM

The structure of medical school curricula across North America has taken a few stereotypic forms, usually comprised of two years of preclinical courses, followed by two years of immersive clinical rotations (Cooke et al., 2006). Over the past 20 years, many schools have adopted a systems-based organization to the content for each preclinical course (e.g., cardiovascular pathophysiology, endocrine-based problems) (Drake et al., 2002, 2009, 2014; Heylings, 2002). While this architecture allows students to develop a deep understanding of a single system, it also presents a challenge of how to integrate core disciplines that apply to each system but are not stand-alone courses in this approach (Muller et al., 2008; Drake et al., 2009; Abali et al., 2014). Many schools have experience with integrating a single pedagogical method or an approach that enhances the clinical relevance of the preclinical content (Donner and Bickley, 1993; Coppus et al., 2007; Scheffer et al., 2012). However, by dispersing content area such as anatomy and histology among different courses, the risk to student learning can be significant. First, learners separate their studying in time, possibly challenging their retention of facts because of prolonged time intervals. Second, students' motivation to learn an integrated discipline must compete with the motivation to engage in the organ system addressed in that course. Third, it is often difficult to assess which students may be struggling within the integrated discipline, because assessments are likewise dispersed with the content.

A few schools have used a combination of strategies to improve students' performance in medical school. These include (1) early identification of student factors that may increase academic risk, (2) monitoring of students' performance while in courses, (3) formal notification for academic deficiencies with structured remediation, and (4) recommended or mandated use of learning support resources by students who are at risk, struggling with coursework, or are experiencing academic deficiencies. More general tactics that many schools have used include addressing personal, social,

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and psychological stressors, engagement of trained longitudinal coaches or mentors, collaborative or individual development of goals and learning plans, and periodic tracking and monitoring of academic achievement (Durning et al., 2011; Audetat et al., 2013; Bearman et al., 2013; Cleland et al., 2013; McLaughlin et al., 2013; Stegers-Jager et al., 2013). These actions address some of the many reasons why students struggle in medical school, including lack of time management, limited basic science background, and inadequate study and test taking skills (Winston et al., 2010).

A review of the existing literature on this topic by Hauer et al. (2009) did not identify a single clear path toward effective remediation, but rather calls for a model involving "multiple assessment tools for identifying deficiencies, individualized instruction, deliberate practice followed by feedback and reflection, and reassessment." In addition, successful remediation at the medical school level appears to be positively correlated with teacher experience and active involvement (Winston et al., 2013). The remediation problem is further complicated as many current models only consider short-term, rather than long-term improvements of students' academic performance (Pell et al., 2012). The immediate successful completion of a failed examination or test often takes precedence over the general improvement of learning skills and approaches (Royal et al., 2014).

Specific Challenges for Students Learning Anatomy and Histology

Basic science subjects like anatomy and histology provide a foundation for clinical knowledge and are essential components of an integrated curriculum (Drake, 1998; Older, 2004; Klement et al., 2011). About half of all American schools continue to teach these subjects in separate, independent courses, but at others they are partially or fully integrated, usually within organ-based courses (Drake et al., 2014). This latter approach converts both anatomy and histology into longitudinal learning disciplines, threatening their didactic continuity by dispersing them among multiple courses. This change has been implicated in a decline in anatomical knowledge among students (McKeown et al., 2003). In addition, students might choose to spend more time studying other topics to pass an integrated course examination.

Few published studies address the problem of how to identify students at-risk of failing a preclinical course (Huff and Fang, 1999; Sadik and Rojas, 2014), specifically for anatomy or histology (Jones and Thomae-Forgues, 1984; Koenig, 1992; Lindblom-Ylänne et al., 1996; Forester et al., 2002; Selvig et al., 2015; Burns and Garrett, 2015). Relevant premedical education appears to be one important factor, as students with a biomedical science background and a related college degree and students with previous classroom experience in anatomy, histology or pathology are likely to do well in a corresponding medical school course (Koenig, 1992; Forester et al., 2002; Selvig et al., 2015). Performance in the anatomical sciences is also positively correlated with high premedical school entrance examination scores (Jones and Thomae-Forgues, 1984; Lindblom-Ylänne et al., 1996; Burns and Garrett, 2015).

Although there are some overlaps, the specific challenges students might encounter while learning anatomy or histology vary considerably. Most medical students approach anatomy primarily as a memorization task (Miller et al., 2002), a strategy that many have used successfully for college-level courses (Sternberg, 2010). In addition, spatial visualization ability is a helpful asset for learning anatomy (Guillot et al., 2007). However, its impact on overall anatomy learning success appears to be limited in today's learning environment (Sweeney et al., 2014). Students who use a variety of learning strategies that include memorization in combination with higher-level understanding and visualization usually do well in acquiring anatomical knowledge (Pandey and Zimitat, 2006; Ward and Walker, 2008).

In contrast, histology has its own and unique challenges for new learners. Burns and Garrett (2015) recently reported that grades in microscopic anatomy at the University of Arkansas Medical School correlate with preadmission academic variables such as undergraduate grade point average and Medical College Admission Test (MCAT®) scores, as well as National Board of Medical Examiners (NBME®) Step 1 Examination failures (Burns and Garrett, 2015). Considering that the visual analysis and interpretation of two-dimensional images at the microscopic scale and the reconstruction into three-dimensional structures, which reflect the functionality of specific tissues or organs, are central to any histology instruction, this should not be surprising. This approach to histology constitutes a multistep, complex learning process (Notzer and Aronson, 1979) that requires more than the memorization of molecular and cellular information or of histological images and therefore presents a new challenge for many students. In addition, for a beginning learner, visual-spatial cognitive abilities are an important asset for succeeding in a histology course (Helle et al., 2010).

Many medical anatomy and histology components only involve the first year of medical or dental school and the overall hours of anatomy and histology instructions have declined over the last decades (Drake et al., 2009, 2014). This makes the early identification of struggling students and the implementation of supportive interventions to improve the learning outcome of underperforming students a difficult and time-sensitive task.

EXPERIENCES WITH AN INTEGRATED MEDICAL CURRICULUM AT THE UNIVERSITY OF MICHIGAN MEDICAL SCHOOL

An integrated medical curriculum was first introduced at the University of Michigan Medical School (UMMS) for the 2003–2004 academic year. Since that time, anatomy and histology have been taught at the UMMS in eight organ system-based courses (heretofore called "sequences") starting in September through the middle of March during the first of a four-year long medical program. Each organ system-based sequence is between two to four weeks long (Fig. 1).

At the UMMS, an initial overview of an anatomical region is provided in lecture form at the beginning of each organ system-based sequence. This is later followed by a brief quiz to ascertain students' comprehension of the material and a small group discussion to prepare students for the laboratory assignments. Plastinated specimens and prosections are available for orientation to all students at the beginning of every anatomy laboratory session. Whole body dissections are performed under faculty supervision by small groups of students.

Histology is taught using a combination of traditional teaching methods (lectures, faculty-guided laboratory

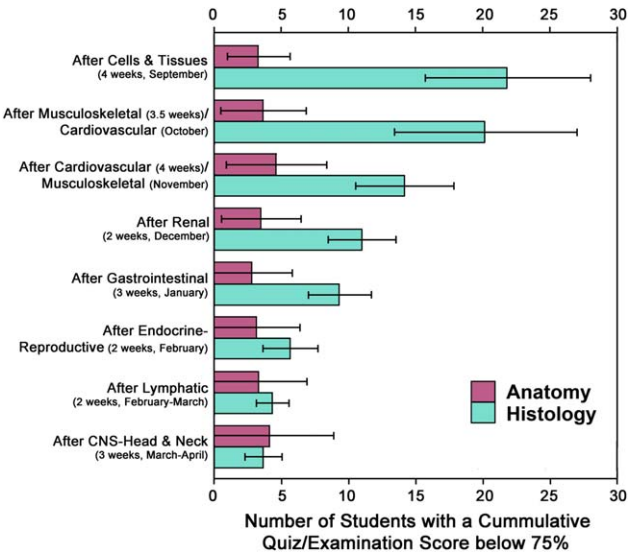

Figure 1.

Number of first year medical students at the UMMS with a failing cumulative quiz/exam score (below 75%) for anatomy and histology quiz and examination questions after each of the eight organ-system-based sequences in which these subjects were taught. Results from remediation examinations were not considered for this analysis. BSARB intervention for anatomy and histology usually starts at the beginning of the renal sequence. The columns and bars represent the average and standard deviation calculated from six different M1 classes at the UMMS (matriculating classes of 2007–2012). Each class had between 164 and 171 students. The different organ-based sequences containing an anatomy and histology component are depicted top to bottom in the temporal order in which they are taught in the UMMS first year curriculum. The length of each sequence is indicated on the left side. Only in the academic years 2007–2008 and 2008–2009 the musculoskeletal sequence was taught before the cardiovascular sequence. Starting with the academic year 2009–2010 the cardiovascular sequence preceded the musculoskeletal sequence.

sessions, demonstration light microscope stations, etc) and electronic learning tools (online lecture videos, virtual microscopy, a course website, supplemental PowerPoint files, etc). A more detailed description of the UMMS histology component was recently published by Holaday et al. (2013). Depending on the organ system-based sequence, 5–23 faculty contact hours (including 1–5 laboratory sessions) are usually scheduled for gross anatomy and 4–16 faculty contact hours (including 1–4 laboratory sessions) for histology.

Learning success is assessed by online multiple-choice weekly quizzes and sequence-ending examinations that contain both anatomy and histology questions, interspersed among other questions specific to that organ system. In addition, anatomy knowledge is also tested by eight laboratory examinations. Histology does not use separate practical examinations, but some questions in the online quizzes and final examinations require the analysis of virtual histology slides. To pass a specific organ-based sequence, a student needs to attain a strictly enforced overall cumulative minimum score of 75%. Cumulative scores below 75% require remedial work encompassing the entire content of the failed sequence. A final 75% minimum cumulative score is also expected for several longitudinal disciplines—physiology, biochemistry, pathology, anatomy, and histology. No formal remedial action is mandated if a student's score remains below this threshold for a longitudinal discipline at the end of the first year. As students meeting with the anatomy/histology component director often ask about the consequences of staying below 75% in an anatomical science subject, this policy does not appear to be widely known among UMMS students and we have no indication that it plays an important role in students' motivation to learn the anatomical sciences. The medical school has implemented several strategies that are outlined below to support students at risk of being below competency in these areas.

Figure 1 shows how University of Michigan medical students adapt to the different learning challenges posed by anatomy and histology. It depicts the number of students with a cumulative examination score for either anatomy or histology under the 75% mark after each of the eight organ system-based sequences with an anatomy and histology component. Few first-year medical students have difficulties to adjusting immediately to the demands of a medical school level anatomy course. In our experience, students who struggle with anatomy often have additional academic difficulties in other areas. In contrast, about 10–15% of students initially struggle with histology and have cumulative examination scores below the expected 75% mark (Fig. 1). This observed difference between students' adaptation to learning anatomy versus histology probably has multiple reasons. Not only have few students been exposed to histology prior to entering medical school (Selvig et al., 2015), but the microscopic scale of cells and tissues, as well as the challenge of identifying them in a complex context, poses initial problems for some students which they do not encounter learning macroscopic anatomy. In addition, UMMS histology quiz and examination questions usually involve images that were not previously available to students and often require the analytical skill of interpreting histological images and linking them to functional facts and physiological processes. With time and often with supportive didactic interventions as described in the next section, most students eventually find a successful learning strategy and develop the skills to do well in both the anatomical sciences and subsequently in the NBME® Step 1 Examination (Fig. 1 and Table 1).

Supporting Students Struggling with Anatomy or Histology Using a Combination of Academic Review Board Supervision and Individual Counseling

The experiences over the last 10 years at the UMMS of how to adapt anatomy and histology into an integrated curriculum and to support students struggling in these disciplines might be helpful for other educational programs with a similar curricular structure. At the UMMS, the responsibility of identifying students who are struggling or are at academic risk of failing mainly falls to three entities, the Basic Science Academic Review Board (BSARB), the directors for anatomy and histology disciplines, and the learning support team in the Student Services Unit. As organ-based sequences only last between two to four weeks, sequence directors often have difficulty identifying students who are struggling with a specific subject or with the material in general.

The BSARB is charged with tracking the academic performance of every student in the preclinical curricular years (approximately 170 students in each UMMS class). The BSARB consists of seven voting and 17 nonvoting members, comprised of school administration representatives, curricular

Table 1.

Quantitative Analysis of Students that were Identified by the Basic Science Academic Review Board (BSARB), Because of Deficiencies in Histology and their Subsequent Success in Passing the NBME® Step 1 Examination

	Matriculation Year			
	2010	2011	2012	2013
Number of UMMS students who completed the M1 histology component	168	167	171	167
Number of students contacted by the BSARB because of deficiencies in histology	24	18	16	13
Percent of students who met with the histology component director after being directed to do so by the BSARB	41.7%	50%	56.3%	61.5%
Percent of students contacted by the BSARB because of deficiencies in histology who finished the histology component with a cumulative examination score of >75%	83.3%	83.3%	87.5%	84.6%
Percent of students contacted by the BSARB with deficiencies in histology who since have passed the NBME® Step 1 Examination on their first attempt	95.8%	94.4%	100%[a]	N/A

[a]Student who have taken the NBME® Step 1 Examination as of November 2014.
Four students have deferrals to take the examination at a later time.

component directors, class counselors, an academic learning specialist, teaching faculty, and four nonvoting student representatives. The students and most faculty members are elected by their respective constituencies. The BSARB meets on a monthly basis during the entire academic year. If a student receives a failing overall score in one of the organ system-based sequences, the BSARB (on recommendation of the sequence director) will dictate a specific, individualized remediation process. In most cases, remediation will require the passing of a makeup examination that includes all topics and learning objectives for that organ system sequence. If a student fails the makeup examination, the BSARB will request additional remedial coursework over the following summer, or require the student to repeat the sequence the following academic year. In extreme cases, if a student fails multiple sequences, a repeat of part or the entire M1 year could be required.

An equally important contribution in helping students in academic trouble is the support received from the two class counselors, an academic learning specialist, the assistant dean for student services, and the anatomy and histology discipline directors. This team monitors student performances weekly to identify those students who might be struggling before high-stakes examinations occur in each sequence, and before they may be discussed at the BSARB meetings.

By November, after accumulating two to three months of anatomy and histology examination results, the BSARB mandates that students whose cumulative anatomy or histology scores fall below the 75% expectation line, meet with the anatomy and/or histology discipline director to discuss his/her study and learning strategy for the subject (if they have not done so already through the weekly monitoring process). Some students also approach the component director(s) prior to any BSARB action and meet with her/him to discuss improvements of their learning strategy. The board may also recommend that a student receive help from a tutor (usually an upper-level medical student) or an evaluation by the academic learning specialist. Although the reasons behind why students struggle with subjects like histology and anatomy vary considerably, there are characteristic study strategies and learning approaches that are common among students either doing well or underperforming in the anatomical sciences (Selvig et al., 2015). As shown in Figure 1, a significant number of first year UMMS students have early difficulties with finding a successful learning approach for histology. The reasons why some students initially struggle with histology often include their academic background, a lack of prior exposure to histology, and deficiencies of using the offered educational resources in their appropriate context (Selvig et al., 2015). Students' attitude to histology as an important part of their professional education is also a strong indicator for their academic success in the UMMS histology component (Selvig et al., 2015). Therefore, specific emphasis is put in the introductory lecture and the individual meetings between students and the component director on the relevance of histology as a basic science subject, its foundational importance for pathology, and as an exercise of the analytical processing of visual data.

Recommendations that are initially presented to struggling students often fall into one or more of the following strategies: (1) using the learning objectives for a more focused learning approach; (2) developing a more directed plan for using the available learning resources; (3) attending lectures in person rather than watching online streamed lecture podcasts; (4) adequately preparing for and taking part in faculty-guided laboratory sessions; and (5) subject-specific test taking skills. These suggestions are often based on learning strategies common to successful histology learners as identified by Selvig et al. (2015). In our experience, such simple advice often has a considerable impact on a student's motivation to learn and on his/her examination performance. A while ago, we started to offer early (before any BSARB action has been taken)

individual consultations with the component director(s) to students who are dissatisfied with their academic performance in anatomy and/or histology, as well as an extracurricular lecture presentation focusing on strategies how to analyze histological images and the proper use of the offered learning resources. Over the last few years an increasing number of M1 students have taken advantage of these opportunities. Although many students are able to adjust and to catch up to their peers without administrative intervention, in our experience, for some students, the guidance and mandates provided by the BSARB and the advice received from the discipline directors coincides and most likely plays an important supportive part in this process (Fig. 1 and Table 1).

Opportunities and Limitations of the Academic Review Board Approach

As each student encounters his/her own challenges during the first year of medical school and as higher education learning involves highly variable learning strategies (Newble and Entwistle, 1986), individual solutions need to be offered to students who do not perform to the expected level in a professional anatomy or histology course/component. At the UMMS, the supervisory role of an academic review board in combination with individual counseling has worked well, usually resulting in a marked improvement of a student's examination scores. All students from the matriculation years 2010 to 2012, who were contacted by the BSARB because of deficiencies in histology and have subsequently attempted to take the NBME® Step 1 Examination, have successfully passed that examination, the majority on their first attempt (Table 1).

However, the following limitations of such an approach need be considered. First, although students start participating in anatomy and histology quizzes and examinations at the beginning of the academic year, it takes about two to three months until the BSARB is able to review enough assessment data to identify underperforming students, and provide mandates to the students to meet with the respective discipline director and implement new learning strategies. If they have not done so previously, struggling students would then meet with the discipline director starting in December close to the halfway point of the M1 anatomy and histology component. This is sometimes delayed further by administrative or student-specific issues, such as hesitancy to contact and meet with the discipline directors (Table 1). Stegers-Jager et al. suggest a possible solution for the latter problem. They report that the threat of academic dismissal significantly improves students' help-seeking behavior without affecting dropout rates or study progress during the first two years of medical school (Stegers-Jager et al., 2011).

Second, while we found that offering voluntary consultation sessions with the subject component director early during the academic year is an effective way to reach many students who initially underperform in the anatomical sciences, some students remain reluctant to seek out help in a timely manner and only do so after receiving repeated letters from the BSARB. We do not have information about the individual reasons for why each student chose (or did not choose) to seek help, nor do we have information on how the student perceived the value of the described supervision and remediation strategy. While such information might be interesting, it would likely provide little additional information about the efficacy of the described procedures we implemented.

Third, an additional limitation of the academic review board strategy is its reliance on examination results in identifying underperforming students. Although passing the relevant course or sequence examinations and later doing well in the NBME® Step 1 Examination is usually considered strong evidence that a student has mastered the relevant preclinical material, higher level learning abilities such as pattern recognition, teamwork, and communication skills, as well as synthetic and logical deduction capabilities are not as easily tested in quizzes and examinations.

It needs to be pointed out that this short communication does not provide a quantitative scientific analysis of the proposed remediation procedure's or its individual components' impact on students' learning success in the anatomical sciences. Many students are able to adapt their learning approach to anatomy and histology without outside help. In addition, other types of interventions, changes in teaching strategy, and didactic resources may also be effective in supporting students with academic problems (Tekian and Hruska, 2004; Daly, 2010; Stegers-Jager et al., 2013; Prunuske and Skildum, 2014). The proposed strategy of using an academic review board in combination with individual consultations rather presents an educational case study that has been successfully used at the UMMS (Table 1). Finally, while mandated meetings and consultations can provide students with helpful information to improve their learning and study strategies, understanding the variable incorporation of those strategies by each student is a complex phenomenon, requiring more specific understanding of learners' motivation and learning preferences.

CONCLUSIONS

As longitudinal disciplines, anatomy and histology are at risk of becoming fractionated in an integrated medical or dental curriculum, loosing their didactic continuity. In addition, both anatomy and histology have specific challenges for individual learners, who might therefore be at risk of failing to achieve competence in these subjects. Continuous academic review and timely supportive intervention appear to be helpful in identifying such students and in finding individual solutions that will help them to develop their own, successful learning strategy to pass an anatomy/histology course or component, or to remediate a failing performance.

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