Curricular Response to Increase Recall and Transfer of Anatomical Knowledge into the Obstetrics/Gynecology Clerkship

Rosalyn A. Jurjus,[1]* Kirsten Brown,[1] Ellen Goldman,[2] Artin Galoosian,[1] Gisela Butera,[3] Jill M. Krapf[4]
[1]*Department of Anatomy and Regenerative Biology, School of Medicine and Health Sciences, The George Washington University, Washington, District of Columbia*
[2]*Department of Human and Organizational Learning, Graduate School of Education and Human Development, The George Washington University, Washington, District of Columbia*
[3]*Himmelfarb Health Sciences Library, School of Medicine and Health Sciences, The George Washington University, Washington, District of Columbia*
[4]*Department of Obstetrics and Gynecology, School of Medicine and Health Sciences, The George Washington University, Washington, District of Columbia*

Deficits in retention of anatomy knowledge from the preclinical years to clinical application on the wards have been well documented in the medical education literature. We developed and evaluated a web and laboratory-based curriculum to address deficits in anatomy knowledge retention and to increase anatomy knowledge recall through repetition and application of clinical concepts during the obstetrics and gynecology (Ob/Gyn) core clinical clerkship. Using principles of adult learning and instructional design, a curriculum was designed consisting of (1) interactive, case-based e-modules reviewing clinically relevant anatomical topics and (2) a hands-on laboratory session reinforcing the content of the e-modules, with the practice of clinical techniques using anatomical cadaveric dissections. The curriculum's effectiveness was evaluated by using multiple choice testing and comparing baseline and final test scores. For questions testing content directly covered in this curriculum, mean final scores increased by 14.3% ($P < 0.001$). In contrast, for questions not directly addressed in this curriculum, mean final scores did not increase significantly, only by 6.0% ($P = 0.31$). Questions related to the uterus showed the greatest gains in final scores (30.3% improvement, $P = 0.002$). A curriculum with web-based preparatory material and a hands-on gross anatomy laboratory session effectively addresses deficits in anatomy retention and improves anatomical knowledge recall for medical students on a clinical clerkship. In the future, the authors plan to conduct a multicenter study to further evaluate the ability of this curriculum to improve clinically relevant anatomical knowledge. Anat Sci Educ 9: 337–343. © 2015 American Association of Anatomists.

Key words: gross anatomy education; medical education; clinical clerkships; online modules: knowledge retention; learning and recall: obstetrics and gynecology rotations; pelvic anatomy

*Correspondence to: Dr. Rosalyn A. Jurjus, Department of Anatomy and Regenerative Biology, The George Washington University School of Medicine and Health Sciences, 461B Ross Hall 2300 I Street, NW, Washington, DC 20037, USA. E-mail: rajurjus@gwu.edu

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INTRODUCTION

Clinicians have reported that medical students have not retained anatomy knowledge from their preclinical classroom-based learning to their clinical clerkships and have argued that the anatomical education of medical students is inadequate and below the minimum level necessary for safe medical practice (Waterston and Stewart, 2005). Surgical specialists have reported a significantly lower opinion of students' knowledge compared to medical specialists (Staśkiewicz et al., 2007). Efforts to address these concerns have led to medical schools offering electives in whole body dissection (Sarkis et al., 2014) and even non-human fresh tissue dissections (Robinson et al., 2004) during the clinical years. Students have also acknowledged the retention problem; only 14% of fourth-year medical students reported confidence in their knowledge of anatomy (Bhangu et al., 2010). Students indicated difficulty transferring anatomical knowledge from the classroom to the clinic (Lazarus et al., 2012).This perception of a deficit in knowledge retention has been supported by poor pre-clinical anatomy evaluation scores. A recent study showed that students entering a clinical obstetrics and gynecology clerkship scored 52% on an anatomy retention evaluation. This represented a significant decline from the cohort's average score of 87% on matched test items from their first-year anatomy course (Jurjus et al., 2014).

The deficit is most pronounced when students are expected to transfer knowledge or skills learned in one context to another context (Ambrose et al., 2010). Generally, transfer of knowledge does not occur often or automatically. This failure of transfer may occur because of context dependence (Spencer and Weisberg, 1986), in which students associate the knowledge too closely with the context in which they learned it (e.g., gross anatomy laboratory) and therefore cannot apply it in different settings (e.g., the operating room). The inability to transfer this skill set may also be a result of not having a robust understanding of underlying principles and deep structure, for example, understanding what to do but not why (Ambrose et al., 2010). Certain instructional approaches may facilitate transfer, such as comparing and contrasting different cases (Loewenstein et al., 2003), combining learning experiences with principles that apply to different contexts (Schwartz et al., 1999), giving feedback (Menzies et al., 2015) and providing prompts to encourage transfer of knowledge(Gick and Holyoak, 1983). Formal repetition (Feigin et al., 2007) and use of mixed practices with multiple examples (Norman, 2009) also aids transfer of knowledge to new contexts.

There is widespread support among clinicians and students for vertical integration of the basic sciences throughout the medical school curriculum (Waterston and Stewart, 2005; Bhangu et al., 2010). It has been suggested that advanced courses start with a review of knowledge covered in preceding courses (Bowen, 2006; Custers, 2010). Thus, revisiting key anatomical concepts throughout the medical school curriculum may be a way to facilitate knowledge transfer (Drake, 2007; Zumwalt et al., 2010). The purpose of this study was to develop and evaluate a web and laboratory-based curriculum to (1) address deficits in anatomical knowledge retention and (2) increase anatomy knowledge recall through repetition and application of clinical concepts during the obstetrics and gynecology (Ob/Gyn) core clinical clerkship. The researchers hypothesized that such a curriculum would improve clinically relevant anatomical knowledge recall by medical students, thereby addressing deficits in anatomy knowledge retention.

METHODS

Ethical Approval

The study was reviewed by the Institutional Review Board of the George Washington University and qualified for exempt status because it involved very minimal or no risk to study participants. Participation was voluntary for students.

Curriculum

The study involved a curriculum consisting of online modules (e-modules) that link basic anatomical principles with clinical vignettes and procedures, followed by a hands-on gross anatomy laboratory session. The development of the curriculum was grounded in principles of adult learning and solid instructional design, appealing to all learning styles (Jurjus et al., 2013).

Online modules (e-modules) were developed with input from anatomy and clinical faculty, as well as medical students, using Camtasia. Camtasia is a video production and editing software that allows voice-over, animated images, and imbedded videos and quizzes in a sequential slide format. The anatomy content was based on material previously delivered and tested in the medical gross anatomy course, which was one of the first courses medical students encountered during their training (Jurjus et al., 2014). Commonly encountered clinical topics with direct anatomical correlates were selected, including perineal laceration repair (perineal muscle anatomy), cesarean section (anterior abdominal wall anatomy), intrauterine device (IUD) insertion (vulvovaginal and uterine anatomy), and hysterectomy (pelvic organ and neurovasculature).

The e-modules functioned as short online interactive review sessions, taking ∼10–15 min to complete. The format of the e-modules remained consistent for every topic, beginning with a two question prequiz, followed by a clinical case example, a review of clinically relevant anatomy with links to practical applications, and concluding with a two question postquiz to reinforce main concepts. Questions were posed to students at various intervals to facilitate active learning and improve knowledge retention (Blevins and Besaw, 2011). The students progressed through a clinical case with relevant anatomy presented through interactive-labeled images and video clips. The e-module concluded with an opportunity for students to provide feedback (Table 1).

To provide hands-on exposure and to reinforce their learning, students attended an interactive gross anatomy laboratory session after completing the preparatory e-modules. The laboratory session was conducted by an Obstetrician Gynecologist clinical faculty member and an Anatomy Faculty member. The learning space oriented to optimize learning in a group setting. A session agenda was provided with specific learning objectives, an outline of the session and key concepts to guide instruction (Berman, 2015). The laboratory session began with a short presession quiz. Students then rotated through a series of stations, reviewing clinically relevant anatomy pertaining to perineal laceration repair, IUD insertion, hysterectomy, and cesarean section. At each station, a handout outlining learning objectives, a checklist of structures to identify, and additional reference resources was provided. After rotating through all stations, students verbally summarized key learning points with their classmates. The session concluded with a postsession quiz and an opportunity for students to provide anonymous feedback.

Data Collection and Analysis

Participants were third-year medical students at The George Washington University Medical School that were enrolled in the anatomy course in the fall when they were first-year medical students. The anatomy course then consisted of topics in gross anatomy and embryology, extended over 17 weeks, and was divided into three blocks, corresponding

Table 1.

Overview of Design of Web-Based E-Modules and Hands-On Gross Laboratory Session

	Design details	
Component	**E-modules**	**Laboratory session**
Prequiz	Two multiple choice questions assessing anatomical knowledge prior to e-module	Twenty-five multiple choice and matching questions assessing anatomical knowledge covered in e-modules
Learning objectives	Outline of learning expectations for e-module content	Faculty-led outline of learning expectations for laboratory session content
Introduction to clinical case	Prompt for reflection on anatomy in clinical context	Faculty-led discussion on importance of identifying anatomy instead of memorizing surgical steps
Review of relevant anatomy	Short review on anatomy as it pertains to clinical scenario	Flipped-classroom style discussion of anatomy through clinical laboratory stations
Revisiting clinical case	Review of clinical scenario incorporating anatomical knowledge	Student-led summary to classmates of clinical scenario incorporating anatomical knowledge
Postquiz	Two multiple choice questions assessing anatomical knowledge as it pertains to case	Four multiple choice questions assessing clinical anatomy covered at stations (one question per station)
Survey	Free response assessing student perception of e-module	Free response assessing student perception of laboratory sessions

Web-based e-modules and hands-on gross laboratory session were incorporated as part of curriculum integrated into each of the Obstetrics and Gynecology clerkships from July 2013 to June 2014. Timeline for incorporation of e-modules and session is detailed in Figure 1.

to different regions of the body: (1) upper and lower limbs, thorax and abdomen, (2) head and neck, and (3) pelvis and perineum. The material relevant to the Ob/Gyn core clinical clerkship was mainly covered in the third part, at the end of the first year fall semester. The curriculum described in the previous paragraph was given to medical students in their third year of training. Students were divided into 6 groups and rotate through the various required rotations every two months at various times during that year. The obstetrics and gynecology clerkship is a required rotations for all students. This study was implemented over the entire academic year 2013–2014 for each of the six eight-week (Ob/Gyn) clerkships for a total of 177 students (48.6% women and 51.4% men). During the first week of the Ob/Gyn clinical clerkship, consenting students ($n = 143$) completed a short multiple-choice test (20 questions) to evaluate their baseline pelvic anatomy knowledge (Jurjus et al., 2014). Out of 177 medical students in the class, 143 participated in the study, with a participation rate of 81%. Demographics of participants are displayed in Table 2. The curriculum described above was nested within the clerkship. A link to the e-modules was made available to all students following the baseline assessment. During the fourth week of the clerkship, students participated in a single 2-hr gross anatomy laboratory session. For the next several weeks, the students had continual access to the e-modules as they progressed through their clerkship, which offered them the opportunity to review clinically relevant topics as necessary. At the conclusion of the clerkship, students completed a short multiple-choice final test identical to the baseline anatomy knowledge assessment (Fig. 1).

Table 2.

Description of Study Participants Rotating Through the Obstetrics and Gynecology Clerkship from July 2013 to June 2014

Demographics	***N* (%)**
Total number of students	177 (100)
Gender	
Female	86 (48.6)
Male	91 (51.4)
Age distribution	
>30	26 (14.7)
25–30	144 (81.3)
21–24	7 (4.0)

To determine the effectiveness of the curriculum for anatomical knowledge recall, the baseline and final test scores were compared. Tests were scored and percentages of correctly answered questions were tabulated by anatomic topic. Topics included the uterus, vasculature, perineum, peritoneum, fallopian tubes, muscles and ligaments, embryology, and placenta. The mean percentage of correct answers was

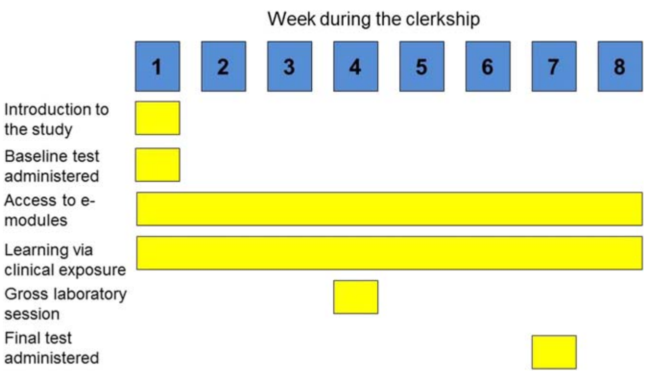

Figure 1.

Weekly timeline for the obstetrics and gynecology clerkships from July 2013 to June 2014, with curricular components indicated on the left. The bar length represents the time point at which a specific component of the study began and ended.

calculated for each anatomic topic per clerkship. Questions from the tests were then divided into two subgroups: those that were directly covered in this curriculum (curriculum questions) and those that were not directly covered in this curriculum (noncurriculum questions) and not presented in the interventional material (e-modules or laboratory session).

To compare mean differences in performance on the baseline versus final assessment, three separate analysis of variance (ANOVA) tests were performed. The dependent variable was mean percentage correct score, while the independent variable was question type: all questions, curriculum questions, and non-curriculum questions. Post hoc paired *t* tests to isolate differences in percentage correct score for anatomical topics was used. To determine whether the clerkship group affected the data, differences between clerkship groups were determined by a univariate ANOVA. All analyses were done using InStat software, version 3 (Graphpad Software, San Diego, CA).

RESULTS

Based on the difference in "mean percentage correct" between the final test and the baseline test, the curriculum had a significant effect on improving student performance (Table 3). Mean final scores (±SEM) for all questions increased by 12.2% ($P < 0.001$) from a mean of 59.48% (±2.09) to a mean of 71.20% (±1.77). For the curriculum questions, mean final scores increased by 14.3% ($P < 0.001$) from a mean of 58.86% (±2.38) to a mean of 73.20% (±1.97). In contrast, the change for noncurriculum questions was not statistically significant for the mean final scores for the noncurriculum questions increased by only 5.97% ($P = 0.31$), from a mean of 61.33% (±4.39) to a mean of 67.31% (±3.88). Importantly, mean baseline scores did not vary significantly from one clerkship to another and were comparable to the data reported the previous year (Jurjus et al., 2014).

Improvement in final scores also varied among anatomical topics. The greatest gains for final scores were found for uterus-related questions (30.3% improvement, $P = 0.002$). Improvement was also seen for final scores in curriculum questions that targeted the vasculature (15.8% improvement, $P < 0.001$) and fallopian tube anatomy (26.0% improvement, $P = 0.004$).

The same level of improvement was not seen in final scores for noncurriculum questions. With the exception of embryology (mean difference = 8.0%; $P = 0.002$), anatomical knowledge did not improve significantly for topics that were not covered in the curriculum. Final scores for noncurriculum questions that targeted the fallopian tubes and placenta exhibited nonsignificant gains with 5.0 and 8.0% changes, respectively, as detailed in Table 3. For noncurriculum questions that targeted muscles and ligaments, the opposite trend was seen: there was a nonsignificant 0.6% decrease in final scores as compared with baseline scores.

Anonymous feedback surveys collected from students showed that the majority of them completed at least one e-module prior to the laboratory session. Nearly, 100% of students thought content was well organized, covered the learning objectives, and was an efficient use of time. The only substantial comment was a request to have the laboratory sessions earlier in the rotation and this was changed to occur during the second week of the rotation for the following academic year. While student confidence levels were not directly assessed, the research team received positive verbal feedback from both students and faculty on improved confidence in anatomy knowledge.

DISCUSSION

The study tested the hypothesis that a curriculum with web-based preparatory material and a hands-on gross anatomy laboratory session would address deficits in anatomy knowledge recall and improve clinically relevant anatomical knowledge of medical students on a clinical clerkship. The results of this study supported the hypothesis, showing a statistically significant improvement in anatomy knowledge after nesting a curriculum that promotes clinical application to gross anatomy within an Ob/Gyn clerkship.

Improving recall was shown to lead to improved retention in learners (Sarkis et al., 2014; Dobson and Linderholm, 2015).The baseline anatomy knowledge measured at the start of the clerkship was low. This finding supports the perceptions of poor medical student anatomy retention expressed by clinical teaching faculty and medical students alike (Waterston and Stewart, 2005; Bhangu et al., 2010). The failure of transmission of learned material from the gross anatomy course to the clerkship likely results from a combination of factors, including context dependence and superficial understanding of the subject (Spencer and Weisberg, 1986; Ambrose et al., 2010) and the limitation of teaching to result in long-term retention (Pratt et al., 2001). The e-modules served to expand the context of the anatomical material to specific clinical correlates, which were reinforced through the hands-on laboratory session, as well as through clinical exposure on the clerkship. The anatomy images that the students encountered during their first year of training were reviewed, the content was transferred to a variety of new contexts, and this material was reinforced through many different clinical presentations. The simple act of encouraging transfer and the overlap that exists between the two sets of conditions also likely played a role in increased learning and recall (Gick and Holyoak, 1983; Grierson, 2014).

There were differences in recall based upon anatomical topics, with the greatest gains in knowledge related to uterine anatomy. The topic of uterine anatomy was addressed in

Table 3.

Performance of Third-Year Medical Students Rotating Through the Obstetrics and Gynecology Clerkship on Anatomy Baseline and Final Tests

	Curriculum questions[a]			Noncurriculum Questions[b]			All Questions		
Anatomical topic	Baseline score % (±SEM)	Final score % (±SEM)	Difference	Baseline score % (±SEM)	Final score % (±SEM)	Difference	Baseline score % (±SEM)	Final score % (±SEM)	Difference
Uterus	47.46 (±3.99)	77.80 (±2.94)	30.34[c]	–	–	–	47.46 (±3.99)	77.80 (±2.94)	30.34[c]
Vasculature	56.32 (±5.59)	72.16 (±4.15)	15.84[c]	–	–	–	56.32 (±5.59)	72.16 (±4.15)	15.84[c]
Perineum	64.32 (±4.21)	73.17 (±3.29)	9.97[c]	–	–	–	64.32 (±4.21)	73.17 (±3.29)	9.97[c]
Peritoneum	85.78 (±1.44)	94.81 (±1.40)	9.03[c]	–	–	–	85.78 (±1.44)	94.81 (±1.40)	9.03[c]
Fallopian tubes	41.52 (±3.32)	67.48 (±4.44)	25.96[c]	67.57 (±3.21)	75.07 (±1.53)	7.50	54.55 (±4.50)	71.27 (±2.49)	16.72[c]
Muscles and ligaments	54.95 (±4.91)	63.33 (±8.22)	8.38	86.51 (±2.15)	85.94 (±3.54)	−0.57	65.47 (±4.89)	70.87 (±6.09)	5.40
Embryology	–	–	–	45.33 (±6.55)	53.30 (±5.89)	7.98[c]	45.33 (±6.55)	53.30 (±5.89)	7.98[c]
Placenta	–	–	–	77.95 (±3.59)	82.93 (±3.98)	4.98	77.95 (±3.59)	82.93 (±3.98)	4.98
All topics	58.86 (±2.50)	73.59 (±2.06)	14.79[c]	61.33 (±4.38)	67.31 (±3.88)	5.97	59.46 (±2.17)	71.95 (±1.84)	12.49[c]

Mean percentage (%) of correct answers for baseline and final tests with standard error of the mean (SEM) by anatomical topic and inclusion of the topic in the curriculum review implemented for third-year medical students rotating through the obstetrics and gynecology clerkship from July 2013 to June 2014.
[a]Curriculum questions are those that assessed content specifically covered in the web and laboratory-based curriculum to review anatomical knowledge related to the clerkship.
[b]Noncurriculum questions are those that assessed content not specifically covered in the curriculum.
[c]$P < 0.05$.

multiple e-modules, as well as two of the stations in the gross anatomy laboratory session. Improvements were also seen in knowledge of vasculature and fallopian tube anatomy, which students encountered in multiple forms through the curriculum. Students knew significantly more about these topics at the end of the clerkship than at the beginning of the clerkship. Repeated exposure to similar principles through a variety of clinical presentations may have had an effect on degree of knowledge recall.

Interestingly, increased knowledge was demonstrated for topics directly covered in the curriculum, but not for the non-curricular topics. The only exception was embryology knowledge, which was not directly covered in the curriculum, but did show a statistically significant increase. This improved score may be related to emphasis on this topic during the clerkship or students' deeper understanding of the anatomy after exposure to the curriculum.

Although anatomy knowledge increased for non-curricular topics, the impact was not as pronounced as it was for the material that was covered directly. For example, students knew only minimally more about placental anatomy at the end of the clerkship than at the beginning. This finding is consistent with previous research showing that simply spending time with surgeons in the operating room combined with independent study in a clinical clerkship leads to anatomy knowledge acquisition, but not retention (Ilgenfritz et al., 1990). Therefore, simple exposure to clinical anatomy, as often occurs through the apprenticeship perspective (Pratt et al., 2001) on the clerkship, is likely not enough to significantly increase knowledge recall. Although reinforcement and repetition may increase retention (Anderson and Conley, 2000), application across contexts ensures a deeper understanding of the topic (Pandey and Zimitat, 2007). The curriculum presented provides a model to increase clinically relevant anatomy knowledge through facilitating knowledge transfer.

The relatively high participation rate in this study is believed to be due to two main factors: (1) the testing and feedback was anonymous which likely increased students comfort and participation. (2) Informal student feedback revealed that the students valued the faculty led laboratory sessions, which was a large incentive behind completing the work. As a comparison, the researchers started a similar curriculum for the general surgery rotation that included only e-modules and with no follow-up laboratory session, and the participation rate was extremely low.

Limitations

The study has a number of limitations. The anonymous nature of the recall testing did not allow for comparison of students who completed the preparatory e-modules prior to the laboratory session to those who reviewed them later or not at all. Assessing a student's knowledge is difficult. In medical education, the mainstay of formal assessment has traditionally been multiple-choice questions. This question type draws upon a combination of recall and recognition (Arzi et al., 1985). There is not a single agreed-upon measure of knowledge retention (Custers, 2010), and the length of time between knowledge acquisition and measuring recall or recognition to determine retention is fraught with ambiguity. Anatomy questions chosen for this study were limited in number and did not cover all topics presented in the curriculum. The researchers made efforts to maximize content coverage by selecting high-yield clinically relevant board-style questions from a larger validated bank. Question number was limited to meet time constraints and encourage student participation. The researchers mainly focused on recall and learning improvement as opposed to performance improvement in this study.

FUTURE DIRECTIONS

The study was completed at one institution, and test results may not be comparable across academic years or between different populations of students. Since the issue of transference of basic science knowledge to the clinical environment is not unique to our institution, the curriculum presented may be applied in training at other medical schools. To increase generalizability, the research team plans on evaluating the curriculum at other institutions in a multicenter study. In addition, the issues of knowledge retention and transfer are not isolated to undergraduate medical education. Other health science professions, like nursing, have also documented difficulties in students transferring basic science content to clinical practice (Johnston, 2010; Rizzolo et al., 2011). Tenets of this model may be applied to any training environment.

A benefit of the curriculum is the accessibility of e-modules and utilization of sessions that many medical schools already have the resources to conduct. The e-modules may be accessed anywhere in the world and reviewed countless times without additional resources. Of course, the development modules required time and expertise, but the final product is sustainable and cost-effective. The gross anatomy laboratory sessions may not be feasible at all institutions, but they could be substituted with other hands-on or simulation-based exercises that promote transfer of knowledge.

CONCLUSION

In conclusion, the curriculum presented in this study may serve as a model of vertical integration of basic science and clinical concepts. Components of this model may be adapted and incorporated into an anatomy course or during the clinical clerkship. E-modules linking anatomical material to clinical correlates can be introduced early in medical education and then revisited during the clinical experience to improve recall with the goal of increased retention. Active coordination between clinical and anatomy faculty was a strength of this curriculum and directly benefited the students. Introducing clinical faculty during the anatomy course and having basic science professors revisit the students during the clinical clerkship underscores the importance of both basic science and applicable practice, while facilitating collaboration. This collaboration is necessary as many institutions move forward with vertical integration of the medical curriculum.

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NOTES ON CONTRIBUTORS

ROSALYN A. JURJUS, M.D., Ph.D., is an assistant professor in the Department of Anatomy and Regenerative Biology at the George Washington University School of Medicine and Health Sciences, Washington, DC. She teaches the anatomical disciplines, gross anatomy, embryology, and microscopic anatomy to first and second year medical students and other graduate and undergraduate students.

KIRSTEN M. BROWN, Ph.D., is an assistant professor in the Department of Anatomy and Regenerative Biology at the George Washington University School of Medicine and Health Sciences, Washington, DC. She teaches the anatomical disciplines, gross anatomy, and neuroanatomy to first and second year medical students and other graduate and undergraduate students.

ELLEN F. GOLDMAN, Ed.D., is an associate professor in the Department of Human and Organizational Learning, Graduate School of Education and Human Development at George Washington University, Washington, DC. She is also the Director of the Master Teacher Leadership Development Program for the George Washington University School of Medicine and Health Sciences.

ARTIN GALOOSIAN, M.S., is a third-year medical student at the George Washington University School of Medicine and Health Sciences, Washington, DC.

GISELA BUTERA, M.L.I.S., is a reference instructional librarian at Himmelfarb Health Sciences Library, the George Washington University School of Medicine and Health Sciences, Washington, DC. She teaches practice of medicine, problem based-cased learning, and medical informatics to first-year medical students.

JILL M. KRAPF, M.D., is an assistant professor of obstetrics and gynecology and the Associate Clerckship Director for the Obstetrics and Gynecology Clerkship at The George Washington University School of Medicine and Health Sciences, Washington, DC. She is also a practicing obstetrician and gynecologist working regularly with medical students on clinical rotations.

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