

## THE USEFULNESS OF AUTOPSIES AS A TOOL FOR TEACHING HUMAN EMBRYOLOGY

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### ABSTRACT

Embryology is often difficult to teach because of the rapid, three-dimensional changes that occur simultaneously on a microscopic scale. A knowledge of normal and abnormal human development is important for understanding the pathophysiology, clinical treatment and surgical repair of malformations. In this study, we developed a method to enhance the comprehension of human embryology and its associated malformations. The strategy used macro- and microscopical digital documentation of embryos, fetuses and neonates undergoing autopsy in the Department of Anatomical Pathology at the State University of Campinas. The images acquired were used in the Human Morpho-Physiology course of the university's medical curriculum. The embryology lectures were divided into two parts. In the first part, the development of the body's structures was explained, while in the second, macro- and microscopic images of selected autopsies were shown to the students, who were also encouraged to find and discuss the malformations and their clinical history, diagnosis and therapeutics. At the end of the course, the teaching material and the method used were evaluated using a questionnaire, interviews, and a test of the knowledge acquired during the lectures. Most of the students approved the method, and emphasized the importance of integration between basic and clinical disciplines. Their performance in the examination was also good.

**Key words:** Autopsies, education, embryology, learning

### INTRODUCTION

Embryology, more than most other basic disciplines in medical science, has had difficulty in finding a comfortable niche within the medical curriculum [3]. One reason for this is that embryology is often difficult to teach, primarily because of the rapid, three-dimensional changes that occur simultaneously on a microscopic scale. However, knowledge of embryology is important for understanding normal and abnormal human development as well as the pathophysiology and clinical and surgical treatment of malformations.

The interest in teaching embryology in a medical course is justified by the fact that birth defects are the leading cause of infant mortality, with a prevalence of up to 15% that can account for approximately 21% of infant deaths [17]. Such data provide the justification for teaching human embryology in a more applied manner based on congenital defects. However, despite the potential for teaching embryology as a

discipline that integrates pre-clinical and clinical aspects, this subject has received little attention in the medical courses that have undergone restructuring of their curriculum [19-21,27].

Anatomists and embryologists involved in education are constantly seeking for the best way to transmit visual information on human development to students [4]. The strategies commonly used include the dissection of embryos and fetus, the projection of images, films and models, and in the use of computer programs. Different class formats have been suggested, but there have been few random studies comparing traditional classes with classes based on other resources, such as the use of clinical cases [24]. Medical education in the morphological sciences is currently undergoing major changes in many institutions. Changes in the way microscopic and gross anatomy are being taught throughout the medical curriculum reflects the increasing trend towards problem-based or systems-integrated learning and the need to provide students with more access to recent advances in educational technology [6]. Such alterations in turn reflect the fact that medicine is highly dependent on the resolution of problems since this is the process by which clinical diagnoses are

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made [13]. The use of clinical cases in medical education is fundamental, even in basic courses in medical science, because when the information is presented out of the clinical context, the students often do not establish the necessary connection between such data and their clinical relevance [8]. Learning based on clinical cases allows the appropriate organization of information that will later be necessary in situations of clinical reasoning. Clinical cases also provide the student with experiences that he would have no other way of acquiring, and also increase the student's confidence [25]. Hence, a discipline is only justified in the medical curriculum if its contents or the approaches that it demonstrates are clearly of value in the training of future physicians [3].

In 1999, the structure of the discipline of embryology offered to medical students at the State University of Campinas (UNICAMP) was reorganized around two primary goals. The first goal was to develop teaching material to enhance the comprehension of human embryology and its associated malformations. The strategy involved the macro- and microscopical digital documentation of embryos, fetuses and neonates undergoing autopsy. The second goal and major focus of reorganization was to develop an approach to make embryology more interactive with clinical disciplines. This report summarizes the major findings of a survey of first year medical students taught the new curriculum implemented in 2001. The study was done as part of an effort to establish appropriate mechanisms for evaluating the impact and effectiveness of the new educational program [6].

## MATERIAL AND METHODS

### *Course design*

The Human Morpho-Physiology discipline is a 598 h course that was implemented in 2001 as part of the new medical curriculum at UNICAMP. The lectures in embryology covered 50 h that included general embryology (24 h) and embryology of the body systems (36 h).

### *Digital capturing and processing of images for teaching human embryology*

All of the autopsies were done over two years (2000-2001) at the Clinical Hospital at UNICAMP. The autopsies were done by a specialized perinatal pathologist, always with parents' consent. The pathological study consisted of the autopsy of the embryos, fetus and neonates and histological examination of all organs, as well as the placentas and annexes. A full obstetric history was obtained for every fetus, along with the results of the antenatal screening.

The equipment used to document the autopsies consisted of a Nikon Coolpix 4500 digital camera, alone or connected to a stereomicroscope or light microscope to allow the capture of macro- and histologic images of human embryos, fetuses and neonates following autopsy. Newborn babies with birth defects were also photographed in a nursery. The images were carefully described and computer edited in Adobe PhotoShop to eliminate unwanted background, and then catalogued and organized into a digital image database.

### *Use of the images for educational purposes*

The images selected were used in the embryology classes to illustrate normal and abnormal development. The lectures were divided into two parts. In the first part (1.5 h), the development of the body's structures was explained, while in the second part (1.5 h), the clinical history and macro- and microscopic images of selected autopsies, were shown to the students, who were also encouraged to find and discuss the malformations and their diagnosis. To encourage interactivity, the students were stimulated to work together in small groups. The discipline consisted of 95 case studies explored in a dialogue display.

### *Sample and design*

Data were obtained from 218 first-year medical students enrolled in the Human Morpho-Physiology discipline in 2001 and 2002. Permission for all study procedures and data collection was obtained in advance from the university's Ethics Committee for Research in Humans. Participation in the study was completely voluntary and confidential. No names were included in the surveys, and faculty members were unable to link responses to particular students.

### *Instrument*

At the end of the discipline, the teaching material and method used were evaluated. The students were asked to complete a questionnaire based on Carmichael and Pawlina [4], Chen *et al.* [5] and Leong [16], to attend to semi-structured interview, and to answer a spontaneous test of the knowledge acquired during the lectures. The same survey was used in 2001 and 2002.

The students were asked to answer nine closed and open-ended questions regarding their perceptions of the use of autopsy images for learning human embryology. Questions 1-7 required a yes/no answer, whereas questions 8 and 9 provided an opportunity for other comments related to the material and methodology used to teach embryology. Anonymous interview transcripts were subjected to a themed content analysis. The aim of the interview was to gather criticisms and suggestions regarding the proposed educational strategy and to clarify some opinions highlighted in the questionnaires. A multiple-choice examination was used to evaluate the knowledge acquired in embryology and to make analysis of the results more objective. Each question was related to a macro- or microscopic image of an embryo or fetus. The evaluation was prepared in such a way that the questions did not require memorization of the name of the malformation, but demanded a basic knowledge of more important aspects of the malformation, such the origin of the defect or its clinical aspects.

### Data analysis

The mean values for questions 1-7 were expressed as percentage of students that answered the questionnaire. Comments on the open-ended questions were subjected to content analysis in which words, phrases and sentences were grouped into categories. The marks obtained in the test of the knowledge acquired were expressed as a frequency graph. The answers obtained in the questionnaires were reinforced by the interview in order to increase the reliability of the analysis.

## RESULTS

The database contains normal and abnormal human embryological events in various stages of development and was more illustrative than the drawings in embryology textbooks. The core instructional material was organized into 12 sessions that paralleled the embryology curriculum (Table 1). Figure 1 shows part of the material used to teach neurulation using the proposed strategy.

A total of 218 students were asked to participate in this survey. The response rate to the questionnaire, the interview and the examination was 91.7%, 27.1% and 58.7%, respectively. In the questionnaire the students were asked to answer nine questions regarding their perceptions of the use of autopsy images for learning human embryology. Questions 1-7 required a yes/no answer (Table 2) while questions 8 and 9 were open-ended questions and the students' answers were grouped into categories (Table 3). The answers indicated to these questions do not correspond to an exact transcription of the answers on the questionnaire, but to the main idea of what was written by the students. Figure 2 shows the frequency distribution for the marks of the students

**Table 1.** Contents of the digital embryology image database.

Subject	No. of teaching cases	No. of teaching images	Example of malformation
Fecundation	3	19	Mole hydatiform
Implantation	10	48	Ectopic implantation
Gastrulation	2	19	Sirenomelia
Neurulation	11	69	Anencephaly
Embryo folding	3	12	Exstrophy of bladder
Placenta	11	55	Amniotic band
Cardiovascular system	5	15	Atrial septal defect
Respiratory system	6	19	Diaphragmatic hernia
Branchial system	15	55	Facial cleft
Digestive system	14	29	Tracheo-esophageal fistula
Urinary system	14	64	Renal agenesis
Reproductive system	1	6	Chyptorchidism
TOTAL	95	410	

who participated in the test of knowledge acquired during the course.

Some pitfalls were noted in this evaluation. The most frequently mentioned negative aspects were that the lectures lasted too long and contained a lot of information that was tiring and resulted in loss of attention (20%), there were only a few three-dimensional images (2%) and the images were shocking (2%).

**Table 2.** Students' answers to the yes/no questions.

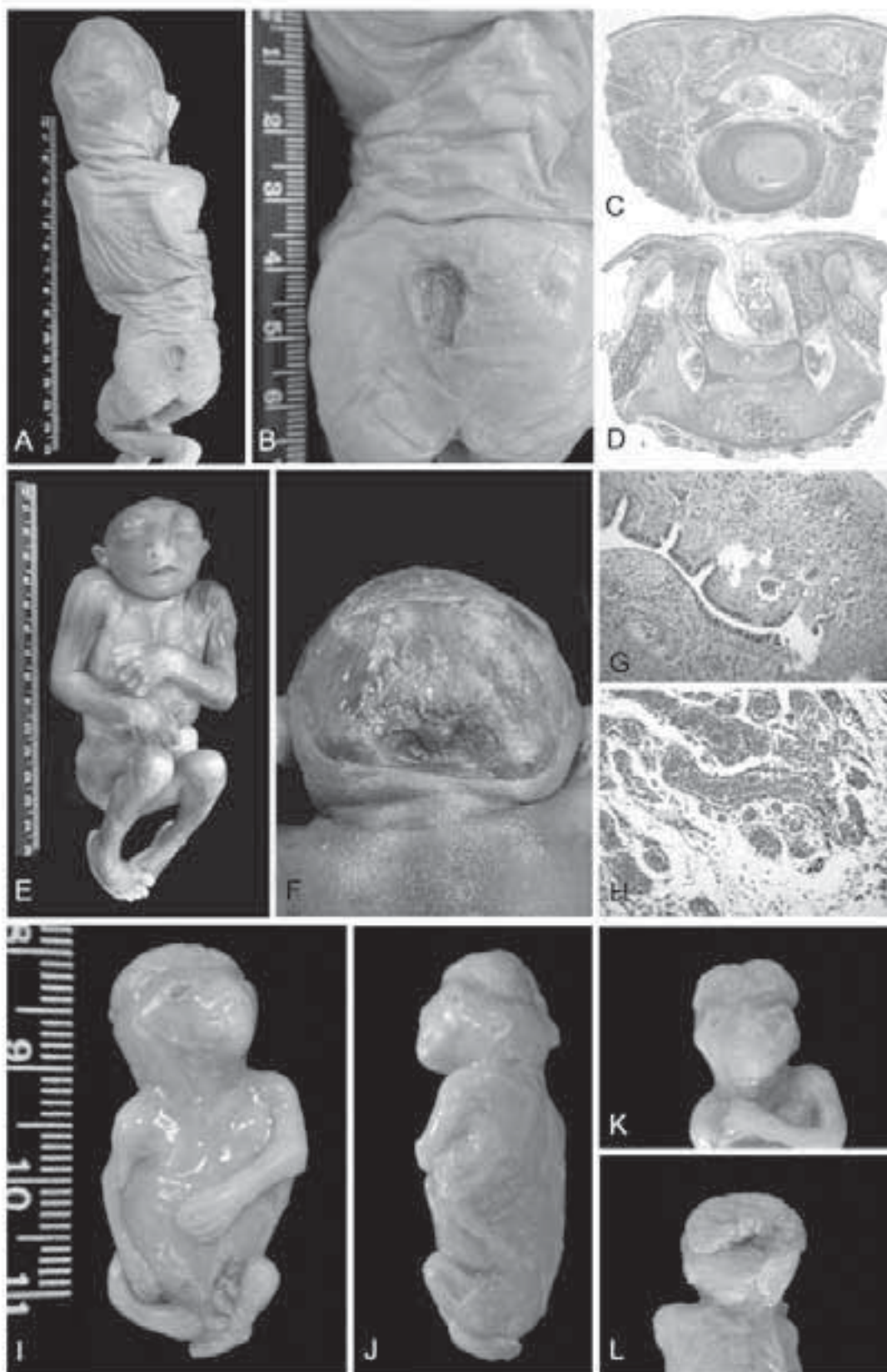
Questions	Yes (%)	No (%)
1. The images of the clinical cases helped in understanding embryology.	100	0
2. Analysis of the images of the clinical cases was better than the lectures alone.	100	0
3. The quality of the images was good.	100	0
4. The images really illustrated what was described in the lectures.	99	1
5. Teaching embryology based on images of congenital malformations is relevant for clinical practice.	98	1
6. There was integration between embryology, anatomy and physiology.	99	1
7. You would like to see similar cases in other disciplines.	98	2

**Table 3.** Positive and negative aspects of the methods mentioned by the students.

Aspect mentioned	%*
<b>Positive</b>	
1. The method provided integration between embryology and clinical medicine.	60
2. This method made the lecture less abstract and facilitated understanding a difficult discipline. The lecture was more interesting and less tiring.	56
3. The images facilitated memorization of the lecture contents.	24
4. The students were stimulated to participate and to reason.	14
5. There was integration with other disciplines in the course, in accordance with the restructured curriculum of the medical course at UNICAMP. This facilitated the comprehension of other disciplines such as anatomy, histology and physiology.	12
6. The malformations shown helped in understanding the normal development of the body.	8
<b>Negative</b>	
1. The lectures lasted too long and contained a lot of information that was tiring and resulted in a loss of attention.	20
2. There were only a few three-dimensional images.	2
3. The images were shocking.	2
4. The use of slides required that the room be dark, which made the students sleepy.	2
5. The clinical cases were presented only at the end of the lecture.	2
6. The lectures were too theoretical.	1
7. There were few images of normal structures.	1

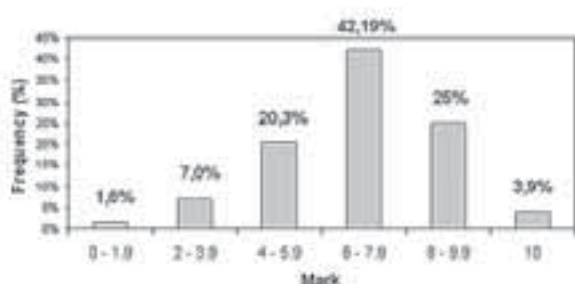
\* Percentage of students who mentioned this aspect.





**Figure 1.** Material related to neurulation obtained using the strategy proposed. (A-C), Spina bifida with meningocele. Panel **B** is a detail of the spina bifida shown in **A**. Note the normal spine with a vertebral arch and neural tissue (**C**). **D**, A photomicrograph showing the spina bifida and degenerating neural tissue. (E-H), Acrania (absence of calvaria) with meroanencephaly (absence of most of the brain). **F**, Detail of meroanencephaly. Note the disorganization of the cerebro (**G**) and vascular (**H**) tissue in the lesion. (I-L), Frontal (**I** and **K**), lateral (**J**) and dorsal (**L**) views of acrania.

Analysis of the students' comments generally indicated great enthusiasm for this approach to teaching. The most frequent suggestions in the questionnaire (and confirmed by the interview) were: 1) to make the images of the clinical cases, with explanatory texts, available on CDs, softwares or at a site on the internet, so that the students could study out of class, 2) reduce the number of class hours, while maintaining the same workload, 3) apply this method to other disciplines, and 4) present videos and/or graphic animations of the different stages of embryonic development to facilitate comprehension.



**Figure 2.** Marks obtained by the students in the examination of the course content taught using the methodology described here. The percentage of students in each score category is shown.

## DISCUSSION

To our knowledge, this is the first study to investigate the usefulness of embryonic, fetal and neonatal autopsies as an aiding for teaching human embryology. In other medical fields, autopsies continue to be a vital part of medical education and can provide an important contribution for teaching [1,2,10,18]. In this study we used a problem-oriented, autopsy-based approach to pose questions based on gross dissection and a microscopic evaluation.

The spontaneous participation of the students in the activities of the project was 91.7%; 27.1% and 58.7% in the questionnaire, interview and test of knowledge, respectively. The frequency of health area students that answer questionnaires on educational methodology varies from 43% to 98% [5,9,12,16]. Hence, the percentage of students that answered the questionnaire here (91.7%) must be considered high. This may reflect an interest of these medical students in improving our teaching methods. The use of interviews and tests to evaluate educational methodologies in health sciences is less common.

The evaluation of the strategy for teaching human embryology was very positive. The answer "yes" to questions on the questionnaire reflected positive

appreciations, with the minimum number of "yes" answers being 97% for all questions. The questions asked were related to comprehension of the discipline content with the use of the images, the quality of the images, the efficiency of the approach based on clinical cases, the correlation between embryology with other disciplines and the clinical relevance of the study of congenital malformations. The use of images to improve the understanding of basic principles has been applied in other disciplines such as anatomy and physiology [26]. The study of 200 students who answered the questionnaire, 199 agreed that human embryology was very important for the clinical training of physicians. This finding agreed with the American Association of Clinical Anatomists, which stated that an adequate understanding of human development provides a fundamental theoretical basis for the accurate diagnosis and proper treatment of congenital clinical entities, which represent a significant patient population in any medical practice [15].

The questionnaire showed that positive aspects were cited more frequently than negative aspects. The positive aspects cited most frequently were that methodology facilitated clinical reasoning that it revealed the practical applicability of the topic taught, and that it made the class less abstract, and more interesting and understandable. Another positive aspect frequently cited was that this methodology brought embryology closer to other basic disciplines and medical practice. In agreement with this, the Anatomy Society of Great Britain stated that achieving the greatest possible integration between basic and applied disciplines was an important aspect of a good education in medical anatomy [8]. Poor integration between the basic and clinical contents of medical courses is one of the main problems of basic science curricula in the medical area [6,22]. An important positive aspect cited by 18.5% of the students was that this methodology stimulated the participation and reasoning of the students, promoted greater involvement in the topics dealt with, and made the classes more dynamic and interactive. This finding agreed with the opinion that curricular reforms must emphasize active rather than learning [6,13].

The most frequent suggestion in the questionnaire, and confirmed in the interview was to make the material available on a CD-ROM or on the internet. According to Carmichael and Pawlina [4], after class access to material used in visual presentation, allows that the students to develop a better appreciation of

the topic because they are able to check notes made during class. Computer programs, CD-ROMs and sites on the internet have been widely used to facilitate the learning in various areas of health sciences, including orthodontics [11], radiology [5], surgery [14] and mainly anatomy, with the Visible Human Dataset [23]. Based on this request by the students the embryology material used in our course is being organized into an interactive software.

The interviews were done to confirm the written answers to questionnaires. The interviews result confirmed many aspects of the questionnaires, and raised additional points including criticisms and suggestions. In view of the affirmation by 5% of the students that the success of the methodology depended on the competence of the instructor or teachers, two more questions were included in the interview for explain this point. The students were asked whether the quality of the method and material was independent of the professor. Of those interviewed, 100% agreed that the method was efficient and the material was of good quality. This finding suggested that the teaching ability of the instructor can be an important factor in the success of the educational strategy used, and that this methodology and the used material are really efficient.

The negative aspect most commonly cited in the questionnaire was that the classes are long and tiring (32.5%). During the interview, when inquired on this negative aspect, 76.3% of those interviewed agreed with this point. An alternative to minimize this negative aspect would be to reduce the number of hours per period, while maintaining the same workload.

Other important aspects dealt with in the questionnaire and in the interview included the need for a better psychological preparation of the students to deal with this approach, since the images of congenital malformations were considered "shocking" by some students (Table 3). In the interview from the first phase, all of the students refuted the idea that the images were "shocking", but 48.7% of those interviewed considered that some psychological preparation was needed and that this could be provided through a brief discussion in the first class of embryology. Such a brief discussion about the "shocking" images was indeed included at the beginning of the discipline, but was perhaps insufficient for some students.

All of the students interviewed considered practical classes to be important in embryology and cited demonstrative autopsies, the use of videos and the examination of histological preparations by light microscopy (Fig. 1C,D,G,H). A study in 141 American schools showed that most of them used only classic theoretical lessons for teaching embryology, although 13% indicated that their teaching of embryology involved laboratory activities [7].

Although the interview with the students was of extreme importance in explaining several topics in this assessment, few studies of educational methodologies in the health sciences have used interviews [5,12,16].

The average score obtained by students in the test of knowledge was 6.76 with 5 being the limit of approval. Most students (87.5%) had marks above 5.0, with 44.5% above 7.0. Although this exam did not assess whether the new method was better than the old system, it did show that the students were learning the subject matter.

The questionnaires and the interviews showed that the method of teaching used here was very well evaluated by the students. This agrees with the principle that teaching must be done in a way that allows the students learn more effectively [6].

In conclusion, the method of teaching used here helped medical students to learn important concepts in embryology and stimulated them to reason about the clinical cases presented. In addition, this approach resulted in greater approximation between basic and clinical disciplines.

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#### REFERENCES

1. Bayer-Garner IB, Fink ML, Lamps LW (2002) Pathologists in a teaching institution assess the value of the autopsy. *Arch. Pathol. Lab. Med.* **126**, 442-447.
2. Burton JL (2003) The autopsy in modern undergraduate medical education: a qualitative study of uses and curriculum considerations. *Med. Educ.* **37**, 1073-1081.
3. Carlson BM (2002) Embryology in the medical curriculum. *Anat. Rec. (New Anat.)* **269**, 89-98.
4. Carmichael SW, Pawlina W (2000) Animated Power Point as a tool to teach anatomy. *Anat. Rec. (New Anat.)* **261**, 83-88.



5. Chen MY, Boehme JM, Schwarz DL, Liebkemann WD, Bartholmai BJ, Wolfman NT (1999) Radiographic anatomy: multimedia interactive instructional software on CD-ROM. *Am. J. Roentgenol.* **173**, 1181-1184.
6. Drake RL (1998) Anatomy education in a changing medical curriculum. *Anat. Rec. (New Anat.)* **253**, 28-31.
7. Drake RL, Lowrie Jr. DJ, Prewitt CM (2002) Survey of gross anatomy, microscopic anatomy, neuroscience, and embryology courses in medical school curricula in the United States. *Anat. Rec. (New Anat.)* **269**, 118-122.
8. Fitzgerald MJ (1992) Undergraduate medical anatomy teaching. *J. Anat.* **180**, 203-209.
9. Fitzpatrick JJ (2001) The role of the American Academy of Nursing in providing nursing leadership. *Nurs. Leadersh. Forum* **5**, 82-83.
10. Galloway M (1999) The role of the autopsy in medical education. *Hosp. Med.* **60**, 756-758.
11. Halazonetis DJ (2000) Advanced Power Point animation techniques: Part I. *Am. J. Orthod. Dentofacial Orthop.* **117**, 737-740.
12. Hightower JA, Boockfor FR, Blake CA, Millette CF (1999) The standard medical microscopic anatomy course: Histology Circa 1998. *Anat. Rec. (New Anat.)* **257**, 96-101.
13. Hooper RJ, O'Connor J, Cheesmar R (1998) Clinical case-based multimedia tutorials as a solution to some problems facing medical education. *Clin. Chim. Acta* **270**, 65-74.
14. Kneebone RL (2001) Skills training using multimedia and models. *Hosp. Med.* **62**, 428-430.
15. Leonard RJ, Hoos PC, Agur A, Gilroy AM, Lozanoff S, Nelson ML, Newman LM, Petterborg LJ, Rosenheimer J, Blevins CE, Dauphine C, Devon R, Gasser RF, Koester DM, Kuehn C, Lebona GT, Moore KL, Poisel S, Talbolt P, Weiglein AH, Williams VF (2000) A clinical anatomy curriculum for the medical student of the 21<sup>st</sup> century: developmental anatomy. *Clin. Anat.* **13**, 17-35.
16. Leong SK (1999) Back to basics. *Clin. Anat.* **12**, 422-426.
17. Sadler TW (2004) *Langman's Medical Embryology*. Baltimore: Lippincott Williams & Wilkins.
18. Sanchez H, Ursell P (2001) Use of autopsy cases for integrating and applying the first two years of medical education. *Acad. Med.* **76**, 530-531.
19. Skandalakis JE, Gray SW (1974) Symposium on surgical anatomy and embryology. Foreword. *Surg. Clin. North Am.* **54**, 1225-1226.
20. Skandalakis JE (1993) Surgical anatomy and embryology. Preface. *Surg. Clin. North Am.* **73**, xii-xiv.
21. Skandalakis JE, Flament JB (2000) Surgical anatomy and embryology. Preface. *Surg. Clin. North Am.* **80**, xvii-xviii.
22. Smith JJ, Koethe SM, Forster HV (1997) A new PhD training track: a proposal to improve basic science teaching. *Am. J. Physiol.* **272**, 36-46.
23. Spitzer VM, Whitlock DG (1998) The Visible Human Dataset: the anatomical platform for human simulation. *Anat. Rec. (New Anat.)* **253**, 49-57.
24. Thomas RE (1993) Methods of teaching medicine using cases. *Med. Teach.* **15**, 27-34.
25. Thomas MD, O'Connor FW, Albert ML, Boutain D, Brandt PA (2001) Case-based teaching and learning experiences. *Issues Ment. Health Nurs.* **22**, 517-531.
26. Thomson M (1998) Multimedia anatomy and physiology lectures for nursing students. *Comput. Nurs.* **16**, 101-108.
27. Travill AA, Bryans AM (1975) An embryological learning experience. *J. Med. Educ.* **50**, 401-402.

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