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Teaching embryology to undergraduates in the Faculty of Education at Dokuz Eylul University in Izmir, Turkey

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ABSTRACT This report reviews the way in which classical embryology is taught and interpreted at the Buca Faculty of Education, in Dokuz Eylul University (Turkey). This university is one of the leading teacher-education institutions in Turkey. My course is taught with appreciation of the fact that students are thinking ideologically rather than scientifically with regard to creationism and evolution in both cognitive and educational processes. However, this ideological orientation, along with lack of classroom time and material resources, hinders my goal of a student-centered education. Being flexible with regard to philosophical and metaphysical issues on which concepts of evolution and creationism are in conflict, is constructive for student development and represents the approach I endeavor to pursue.

KEY WORDS: *teaching embryology, Turkey, evolution, creationism*

Background Information

Scholarly Interests of the Author

The author is an expert on systematic zoology. His field of interest is amphibian systematics. He has written several reports exploring the herpetofauna of Turkey and discussed several classification problems in some of his articles. The author teaches animal embryology, animal anatomy and physiology along with evolution. He prefers to teach these courses from a holistic point of view.

Representative Publications

YILMAZ, I. (1994). *Evolution and Creation Discussion in Biology Education. I.* International Science Education Symposium Announcements 15-17 September, 1994. Buca Faculty of Education Buca-Izmir. Dokuz Eylul University Press, pp. 187-193. (in Turkish).

YIlMAZ, I. (1997). *Principles and Methods of Systematic Zoology.* Oran Press, Izmir, 209 pp. (in Turkish).

General Teaching Philosophy

The author's general education philosophy represents an attempt to reach agreement by discussing different views in a student-centered environment. The author allows students having conflicting views on evolution to discuss them with each other in an academic environment. On the one hand, the author is opposed to a materialistic view evolution that supports atheism. On the other hand, he is also against creationism, which is in conflict with biological change and the principles of science. The author holds the view that mutation, adaptation and natural selection are causal forces in the formation of species. He believes, however, that there also exists an intelligent design that cannot be attributed to coincidence, blind natural causes, or nonintelligent or weak-willed atoms.

Although some students claim that sophisticated biochemical and physiological events require an intelligent design, and they therefore support the idea of creationism, the author suggests to these students that materialistic and Darwinian interpretations that approximate to atheism are also possible. It should, however, be kept in mind that the subject matter of an embryology lesson can usually be taught from a point of view that is neither atheistic nor anti-science and that students can reach an understanding on their own in a democratic discussion environment. The author is of the opinion that biological phenomena should be viewed in a holistic way. Every organism from bacteria to whales has a hierarchical position in the entirety of the ecosystem. The author is of the opinion that differences in the organizational complexity of living things are created at different levels, but all levels are complex. The author believes that students can discuss different views using both evolutionist and creationist resources, and this can lead students to think more deeply and have a different perspective when looking at natural phenomena.

General Features of the Embryology Course

Student Level

The author teaches embryology to freshmen (first-year students) in a general zoology course, after teaching them about cell, tissue, and organ systems. He teaches evolution in a sophomore-

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level (second-year) course. Then, after students have taken cytology and histology courses, he teaches them embryology, physiology and comparative anatomy. The author also teaches doctoral students a course entitled Philosophy of Biology, in which he discusses different views.

Course Size

The class size varies between 30 to 40. There are presently 35 seniors taking the animal embryology course. Two teaching assistants help the author teach the laboratory section of the course. Teaching assistants prepare ready-made slides and plastic models before the lab session begins, and they help students recognize and differentiate segmentation phases and organ prototypes in embryo cross-sections.

Course Context

Students enroll in general zoology, cytology, histology, and molecular biology courses before they take my embryology course. They also enroll in an animal physiology and comparative anatomy course concurrent with my embryology course. In their last year of undergraduate education, students take genetics and evolution courses, after they have taken all of the above courses.

Course Placement

Embryology is a compulsory course in our biology education department. Students also enroll in a plant embryology course along with this animal embryology course.

Course Format

The embryology class meets 1.5 hours per week for 14 weeks. Previously, this course was taught in a more interactive way when the author was teaching at Ege University, Izmir, Turkey. That university has vast and rich resources. Because of the meager financial resources and lack of adequate teaching supplies in recently established Turkish universities (including Dokuz Eylul University), I began teaching this course in a traditional lecture format.

Despite these unfavorable conditions we are able to use recently published embryology books with their colorful illustrations, such as the 6th edition of *Developmental Biology* by Scott F. Gilbert (2000), along with the Vade Mecum CD-Rom prepared by Mary S. Tyler and Ronald N. Kozlowski. In the lab section of the course, we show videos and pictures from the Vade Mecum CD-Rom. Some important illustrations are also drawn on the chalkboard and further explained by teaching assistants (Fig. 1).

Laboratory Connection

In the lab section of the course, cross section slides of 3-, 4.5-, 6-, and 9-mm frog embryos, 12-, 18-, 24-, 36-, 48-, and 72-h chick embryos, and sea urchin embryos are studied. Students observe these slides with the help of two teaching assistants. In recent years, we started to use an interactive CD Rom (mentioned above) in the lab section of the course.

Course Concepts

Intellectual Goals

Embryology is one of the most popular courses, along with physiology, in our biology curriculum. Students appreciate the importance of embryology in the physiology course that they take at the same time with embryology. Later, in their comparative anatomy course, they also express appreciation for the learning experience provided in the embryology course. For example, the germinal layers formed by programmed cell division in an ever-changing and differentiating embryo fascinate students. As organs originate from these germinal layers in an orderly fashion, students are stimulated to think in greater depth and in a philosophical way. That developmental disorders are caused by the action of mutagenic factors acting on early embryonic phases interests students. Speculating about the nature of the (at present) obscure genetic and embryological mechanisms which cause developmental disorders increases the interest level of students. Recently, cloning discussions and the idea of an organ bank have also increased the student interest in embryology. Discussions around these subjects are always encouraged as a way to keep the students focused during classroom lectures.

Darwinism / Creationism Issues

Unintentionally, our classroom discussions also serve as a platform for Darwinism-creationism conversations of a type which are prominent in present-day Turkey. The basic issues which drive the debate are (1) whether there is a plan or program in dividing cells, and (2) whether living things are created as a result of an intelligent design or by random chance and non-intelligent natural processes. The most beneficial aspect of these discussions is that both parties are beginning to accept scientific realities and to not insist on issues in a dogmatic way. I personally recommend that we refer to philosophical explanations when scientific explanations are not satisfactory.

Because I teach vertebrate embryology, I do not review much invertebrate embryology, with the notable exception of segmentation in insect embryos. I emphasize *Amphioxus*, frog, chicken, and human embryos as models in my embryology course. Review of those vertebrate model organisms reveals a striking resemblance among egg and segmentation types in different vertebrate species. As well, the fact that the same organs and tissues originate from the same germinal layers in different species is quickly recognized by students. Those features of embryogenesis are presented as evidence in favor of evolution by some students. Conversely, some students view the same evidence as that the Creator creates similar organs from similar material. That evidence is a manifestation of the Creator's science and power for students who have this opposite view. Results which are based on scientific experiments and firm data that are outside the realm of philosophical interpretations and discussions (e.g., nucleotide sequence comparisons) are, however, generally accepted by students who favor the intelligent design theory.

Creationist students suggest that the Creator created the biological causes as a veil, stating that they, the students, are certainly not anti-science. According to this point of view, every molecular and biochemical process and phenomenon (e.g., protein synthesis, nucleotide sequence comparisons, etc.) is used as a cause by the Creator. The main difference between this view and the evolutionist view is that "random chance" is rejected. There is a perfect creation based on a holistic plan, and there is no room for unconscious and unintelligent chance events. Events which seem to happen to us as a result of chance are illusions stemming from our looking at creation in small pieces. Biological processes are set up by the Creator to veil his power. The resemblance among basic

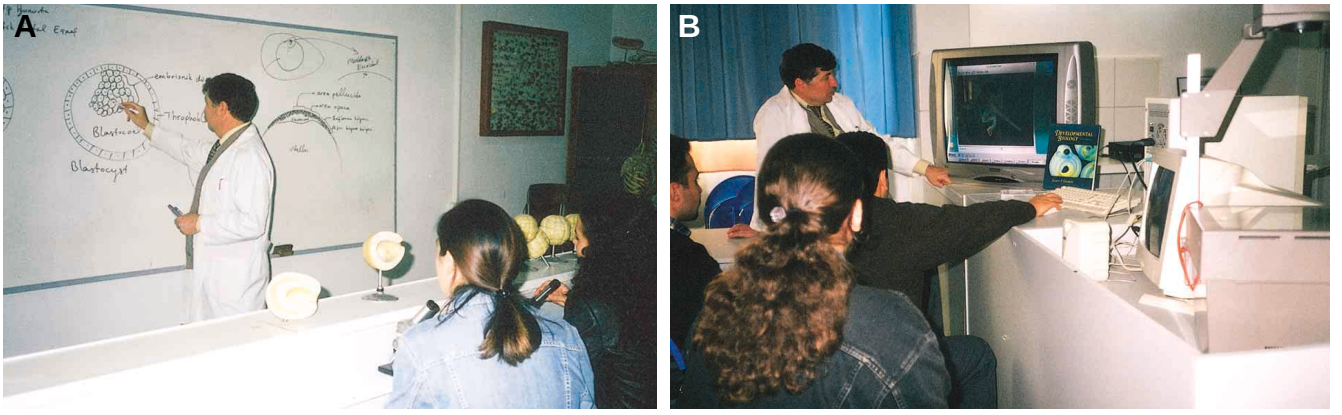

Fig. 1. A combination of (A) traditional "chalk and talk" lectures and (B) modern video demonstrations. *The author employs this combination to engage students and maintain their interest in the classroom.*

organs (neural tube, notochord, pharyngeal pouches, etc.) of vertebrate embryos indicate the unity of the Creator. Accordingly, the Creator created vertebrates based on a basic building plan. But, He designed the organs by making small changes in this basic plan according to the needs of animals which live in different environments, such as in water, underground, in forests, or in deserts) to show the infinity of his power and science.

Course Content

Topics Covered:

History of embryology
Structure of germinal cells and meiosis
Structure and types of gametes
Fertilization
Segmentation
Blastula and gastrula types
Neurulation
Germinal layers
Development of the digestive system
Development of the respiratory system
Development of the circulatory system
Development of the excretory system
Development of the nervous system
Development of the endocrine system

Human embryology is given special emphasis when teaching the above subjects, in order to maintain student interest. That level of interest increases markedly when congenital defects and developmental disorders are discussed.

Special Considerations emerge in the Creation *vs.* Evolution Debate

When embryonic induction is discussed, creationist students suggest that surface receptor molecules are synthesized at the proper time and amount when a specific time in the planned development process is reached. The balance that is achieved in the development of the whole organism is considered to be possible because of the power of a Creator. Evolutionist students, in contrast, suggest that it is futile to search for the force of an overriding intelligence in these developments. They argue that life evolved from inorganic matter as a result of random chance.

The review of derivative organs which originate from the pharyngeal arches between the pharyngeal pouches (in which the gills are situated in fishes) generates much discussion. Francis Hitching has suggested that these pharyngeal arches (pharyngeal hiatus) are not developed in humans and that the pharyngeal arches in embryo illustrations in classical embryology books were drawn by Haeckel to make fish embryos resemble human embryos. These illustrations have been, however, claimed to be forgeries (Hitching, 1982, p. 204). Yet other students deepen the discussion by claiming that the biogenetic or recapitulation law is dead (see Thomson, 1988, p. 273).

Creationist students who argue that understanding in present-day biology has developed in an evolutionary context and that atheism is propagated in the name of “secularism” suggest that alternative biological interpretations can be made. They further argue that such interpretations do not harm science. For instance, creationist students say that similar developmental processes in vertebrate classes do not mean that they evolved from each other. Rather, they argue that those similar developmental processes indicate the unity of the Creator and His Almightiness. Those students claim that the Creator set up common developmental mechanisms. He also created specific differences in development mechanisms for each species, and this indicates that He exercised free will in his creations. Those students argue that their understanding is not at all in conflict with science.

Furthermore, some students argue that the study of evolution has no practical uses and that speculations about the past do not contribute to science. Instead, it causes humans to lose their belief in the Almighty. Some of these same students also suggest that more useful studies in the field of embryology can be done outside of the current evolutionary context, studies that will certainly benefit future generations.

Examinations

Format

Two types of questions are used for lecture exams. The first type is the traditional multiple-choice variety. Here are three sample questions:

(1) Which of the following organs originate from somatic mesoderm?
a) Skin b) Cerebellum c) Liver d) Leg muscles e) Kidneys
(2) Which division type is not observed in holoblastic full division in isolecithal eggs?
a) Radial b) Spiral c) Bilateral d) Rotational e) Superficial
(3) Which of the following does not originate from the neural tube?
a) Brain
b) Lens, cornea
c) Retina
d) Spinal cord
e) Neural pituitary

The second type of question is the essay question. Students are expected to provide detailed explanations in their answers to these questions. Here is a sample question:

Draw diagrams of the pronephros, mesonephros and metanephros kidney types and discuss the transition from one type to another and the differences among these three types of kidney.

For laboratory examinations, students are asked to look through a microscope and identify the types of animal embryos to which various slides belong. In addition, they are asked to identify which organ precursor is seen in some of the cross sections. Students are also asked to draw what they see in the microscope and to name such components as the germ layers and organ precursors.

Textbooks for Assigned Readings

BELLARIZ, R. and OSMOND, M. (1998). *Atlas of Chick Development*. Academic Press, San Diego, CA, USA.

DREWS, U. (1995). *Color Atlas of Embryology*. Thieme Flexibook. George Thieme Verlag. Stuttgart, New York.

DYE, F. J. (2000). *Human Life Before Birth*. Overseas Publishers Association, Harwood Academic Publishers imprint, part of The Gordon and Breach Publishing Group, Amsterdam, Netherlands.

FRANQUINET, R., FOUCRIER, J. (1998). *Atlas Embryologie Descriptive*. Dunod, Paris.

GILBERT, F. SCOTT (2000). *Developmental Biology*. Sixth Edition. Sinauer Associates, Inc., Sunderland, MA, USA.

GILBERT, F. SCOTT and RAUNIO, ANNE M.(Eds.) (1997). *Embryology. Constructing the Organism*. Sinauer Associates, Inc. Sunderland., MA, USA.

LARSEN, W. J. (1998): *Essentials of Human Embryology*. Churchill Livingstone Inc., New York.

OPPENHEIMER, S.B.- LEFEVRE G. Jr. (1984): *Introduction to Embryonic Development*. Allyn and Bacon, Inc., Boston, MA, USA.

Visual Aids

First segmentation in an Amphioxus egg. Plastic models showing blastula and gastrula. Egg types in classical embryology. Poster showing segmentation phases

TYLER, M. S. and KOZLOWSKI, R.N. (2000). An Interactive Guide to Developmental Biology. Vade Mecum (CD). Sinauer Associates, Inc., Sunderland, MA, USA

Relevant WWW Addresses for Supplementary Information

http://www.devbio.com/34/y.med.unsw.edu.au/CBL/Embryo/

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THOMSON, K.S. (1988). Ontogeny and phylogeny recapitulated. *Am. Sci.* 76: 273-274.