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ABSTRACT

This study focused on potential pedagological uses of standardized placement exams. A sample of 250 exams of the May 1984 Biology Advanced Placement (AP) exam was obtained and student responses to the question on cell structure were analyzed. The frequency of particular responses to the question is listed and trends and patterns in the responses are discussed. Interviews were also conducted with AP biology instructors, high school science coordinators, readers of the 1985 AP Biology exam, college biology instructors, and professional research cell biologists for purposes of explaining the AP cell structure question results. Textbooks and resource materials were then examined for their impact on potential learnings of students and for the amount of information that they had on cell structures. Recommendations resulting from this study include: (1) provisions for additional uses of national standardized exam results other than the measurement of achievement; (2) development of hierarchically related science textbooks from high school to college; and (3) periodic replacement of learning resource materials to accompany test materials. (ML)

The Value of Analysis of Standardized Placement Exams: a case study of cell structure.

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Standardized placement exams serve the obvious role of determining the extent of learning by the students who take these exams. A careful review of these exams can provide extremely important additional data on what, how, and why students learn. The purpose of this paper is to draw attention to the further pedagological use of standardized placement exams.

A nationally drawn group of 20,000 high school students took the Biology Advanced Placement (AP) exam May, 1984. The author served as a reader of the Biology essay section of that Advanced Placement Exam. Of these students, 86% answered the following question:

> Describe the structure of a generalized eukaryotic plant cell. Indicate the ways in which a nonphotosynthetic prokaryotic cell would differ in structure from this generalized eukaryotic plant cell.

During the course of the reading of the essay question above, trends and patterns in the students' responses became apparent. After the June reading, the author requested a random sampling of the exams. College Board/Educational Testing Service made 250 exams available to the author for in-depth analysis. (The students' names and schools remained confidential.) Appreciation is extended to Dr. Harlan Hanson of College Board and Dr. Carl Haag of Educational Testing Service for making possible this analysis. A report of the detailed analysis of the question sample will appear elsewhere.[1]

The College Board is the organization that is responsible for the AP program; the Educational Testing Service provides the operational services. The Advanced Placement program allows high school students the opportunity to earn college credit for course work taken while in high school. The students who take the AP exam usually are enrolled in special high school second-year biology classes taught by superior teachers using college level textbooks. Although the AP exam primarily serves superior secondary school students, the program is, in effect, providing a model for a national curriculum in introductory college biology because students who do well on the standardized exam are granted college credit by numerous colleges and universities around the United States. (See reference 2 for a listing.) The national standardized Advanced Placement Exam in Biology, therefore, can yield a national data base as to the performance of students in introductory college biology.

The direction of the evaluation of the 250 exam set was suggested by the author's initial reading and scoring of nearly 1000 essays during the June 1984 reading. For example, an occasional student would state that the function of the Golgi apparatus was unknown; this was true in 1961, but not in 1984. Some students were relying on definitional phrases that have become trite: "lysosomes as 'suicide bags'." Of the 44% of the students indicating that the nucleus of the cell was limited by a barrier, only 22% indicated that the barrier was a nuclear envelope. Based upon the specific nature of their answers, it was clear that students were learning; however, the content of the responses was not always appropriate.

A sample of 250 exams was chosen to be statistically representative of the more than 17,000 students who answered the cell structure question.[3] The sample was biased so that no trivial responses (no answer at all or blantantly off-beat responses) were included. The scoring procedure was quite different from that used for the June reading. The structures and their frequency of mention by the students have been listed in Table I.

TABLE I

CELL STRUCTURE SURVEY OF THE 1984 AP EXAM IN BIOLOGY

Structure	% listed	Structure	% listed
nucleus	87.2	nuclear envelope	9.6
chloroplast	80.0	chromatin	7.6
cell wall	77.2	flagella or cilia	7.2
mitochondria	63.6	double membrane mitochondrion	7.2
cell membrane	58.8	cell plate	5.2
chloroplast function	57.9	vesicle	3.2
cytoplasm	51.2	microtubule	2.8
rough endoplasmic reticulum	48.8	double membrane choloroplast	2.8
vacuoles	48.4	peroxisome	2.4
difference prokaryote vs eukaryote	46.8	fluid mosaic membrane model	2.4
ribosomes	44.8	microfilament	2.0
membrane bounded nucleus	44.4	spindle	1.6
mitochondria function	36.8	double membrane nucleus	1.6
nuclear membrane	34.8	nuclear pore	1.6
nucleolus	32.4	mesosome	1.6
lysosome	30.8	polysome	<1.0
chromosome	23.6	plasmadesmata	<1.0
prokaryote identification	22.8	desmosomes	<1.0
phospholipid bilayer membrane model	21.6	tonoplast	<1.0
smooth endoplasmic reticulum	16.4	glyoxysome	<1.0
centriole	10.4	cytoskeleton	<1.0

The open-endedness of the essay question was a distinct advantage for this type of survey. Only two directional clues with reference to structure were in the question: 1) photosynthetic - chloroplast and 2) prokaryotic - lack of internal membranes. In any group of exams one can anticipate confusion by a few students, e.g., switching prokaryotes for eukaryotes. Over 15% of the students turned prokaryotes into animal cells. Lysosomes were placed by 31% of the students in plant cells. Ten percent of the students placed centrioles in plant cells with no qualifications. Twenty percent of the exams made no mention of plastids in a structural question that specifically introduces the term photosynthesis. Although they are serious errors, the author has found these errors often on college general biology exams.

The animal cell orientation of a plant cell ultrastructure question was more pronounced than expected. Other aspects of the students' answers were surprising. Below is a listing of cell structural concepts that did not appear with any frequency in the answers.

- virtually no mention of the cytoskeleton or microtubules
- no distinguishing between free and bound polysomes
- virtually no mention of peroxisomes or glyoxysomes
- more than two-fifths of the students did not refer to the plasmalemma

Considerable confusion existed in the students' answers referring to the following structural concepts.

- chromosomes seen in the interphase nucleus
- treatment of the nuclear envelope as a single membrane
- the relationship of the cytoplasmic waterway system and compartmentalization

Many ultrastructural concepts were found to be missing or inaccurately depicted in the exams surveyed.

Reading the exams was, in some ways, like reviewing the historical development of cell ultrastructure. A small percentage of the students accurately represented the cell as it was in the landmark issue of Scientific American, September, 1961.[4] Terms developed in the 1960s such as "powerhouse of the cell", "brain of the cell", and "suicide bag" frequently embellished the structures listed.

In an effort to explain the above results, AP biology instructors, high school science coordinators, readers of the 1985 AP Biology exam, college biology instructors, and professional research cell biologists were interviewed. High school teachers and their science coordinators consistently pointed to three problematic areas in the context of this AP study:

- remaining current in rapidly evolving fields,
- finding lab exercises that would work in their teaching environment and

- obtaining good reliable textbooks.

Several studies have shown that textbooks often represented the curriculum for many science courses.[5] A strong correlation between currentness of the content material and the textbook used was indicated. In states with state-wide textbook adoption policies, the same text edition may be in use for as long as 12 years at a time. Further, a survey of 147 secondary science teachers in the Northside Independent School District of Bexar County, Texas revealed that fewer than 20% of these science teachers were subscribing to a professional journal that would allow them to remain current in science content and pedagogy.

The teachers of Advanced Place Biology II courses had superior credentials in contrast to the whole population of high school teachers. These AP teachers were distinguished by additional hours in science after the baccalaureate, membership in organizations such as the National Science Teachers Association, participation in science education workshops and in some cases serving as biology instructors at community college night schools. They also expressed the same concerns in the three problematic areas mentioned above.

College biology instructors and research cell biologists often had little interaction with high school teachers. College instructors commented that the students they received from high school had differing degrees of science preparedness. Lack of a solid chemistry background was the most problematic issue. Medical school cell biologists were predicatably the most removed from the high school educational system. The professionals at the top of the educational ladder had little idea of how or even that the AP Biology program was providing a *de facto* national curriculum for introductory college biology courses.

The interviews provided no surprising results but they did strongly indicate the direction that should be taken to explain the AP cell structure question results. Textbooks and resource materials should be carefully examined for their impact on potential learning of the students. Guidance on textbook selection and review was provided by the biology textbook issue of Science Books and Films.[6] Reports by Cho et al. and Rosenthal provided methods for correlating learning potential from the texts.[7,8] Ten mainstream biology textbooks, five high school and five college biology texts, were selected for analysis.[9-18] Excerpts of the analysis appears in Table II. A report of the detailed analysis of the cell structure text survey will appear elsewhere.[1]

College texts averaged more than twice as many electron micrographs on their pages than the high school books. Also, the college cell structure micrographs represented were more often the transmission variety than the scanning type. Only one high school text in five used the term "nuclear envelope"; all college texts used the term "nuclear envelope". Only one in five AP responses that listed a nuclear boundary used the term "nuclear envelope". Thirty-one percent of

TABLE II

SURVEY OF SELECTED TEXTBOOKS FOR KEY CELL STRUCTURE INFORMATION

Item	*1	2	3	4	5	6	7	8	9	10
copyright year	80	86	85	83	85	82	83	83	83	85
% ratio cell/book**	4.5	2.3	2.0	2.9	2.1	2.2	2.2	2.6	3.4	2.9
total EM in book	20	57	37	58	41	49	225	119	189	161
EM per 100 pages	2.7	6.5	4.7	7.7	5.0	5.2	19.4	10.1	16.0	13.4
Nuclear membrane	+		+	+	+	+				
Nuclear envelope		~+				+	+	+	+	+
centriole not in plant	X	+	+	+	+	+	+	±	+	+
microtubules	+	+	+	+	+	+	+	+	+	+
ER - Polysome association diagram		X	X	±	±		+	+	+	X
lysosome not in plant	X	°	°	±	+	+	°	+	+	+
peroxisome						+	+		+	+
glyoxysome									+	+
plasmadesmata						+	+	+	+	

*1 = BSCS yellow edition[10]
2 = HBJ BIOLOGY[12]
3 = HEATH BIOLOGY[14]
4 = MERRILL BIOLOGY[15]
5 = OTTO AND TOWLE[16]
6 = ARMS AND CAMP BIOLOGY 2ND EDITION[9]
7 = CURTIS BIOLOGY 4TH EDITION[11]
8 = JOHNSON BIOLOGY[13]
9 = PURVES AND ORIANS LIFE: THE SCIENCE OF BIOLOGY[17]
10 = VILLEE, SOLOMON AND DAVIS BIOLOGY[18]

** cell structure chapter pages divided by the total number of book pages - expressed as a %

+ = correct
TE = teacher's edition
± = vague
X = wrong
~ = correct in places and reverts to nuclear membrane in others
° = discussed, but no distinction where found

the student responses placed lysosomes in plant cells, which reflected the more vague handling of lysosomes in high school texts. Peroxisomes, glyoxysomes and plasmadesmata were neither mentioned in the high school texts, nor in the AP exam student responses. The explanation of the lack of student listing of microtubules was difficult. All texts described microtubules, yet only 3% of the students listed microtubules on their AP essays. Animal cell bias in the presentation of microtubular subjects may account for the lack of student listing of microtubules as a plant structural characteristic. In summary, the analysis of the textbooks indicated that the students' knowledge more closely reflected the content of high school texts than it did college texts. One should be mindful that the timed essay question was rather open-ended and that the students' depth of response may have been related to this factor.

The AP biology instructors brought many teaching resources to the attention of the author. The most striking resource was the cell structure transparency set distributed by the American Cancer Society (ACS).[19] This widely used teaching set contains the term "nuclear membrane", illustrates chromosomes in an interphase nucleus, and shows no free polysomes or microtubules. The "lollipop" membrane model was used and ribosomes were depicted as randomly distributed on the endoplasmic reticulum surface. Working with the Texas Branch of the ACS, the author is updating the cell structure transparency set for ACS distribution in 1986.

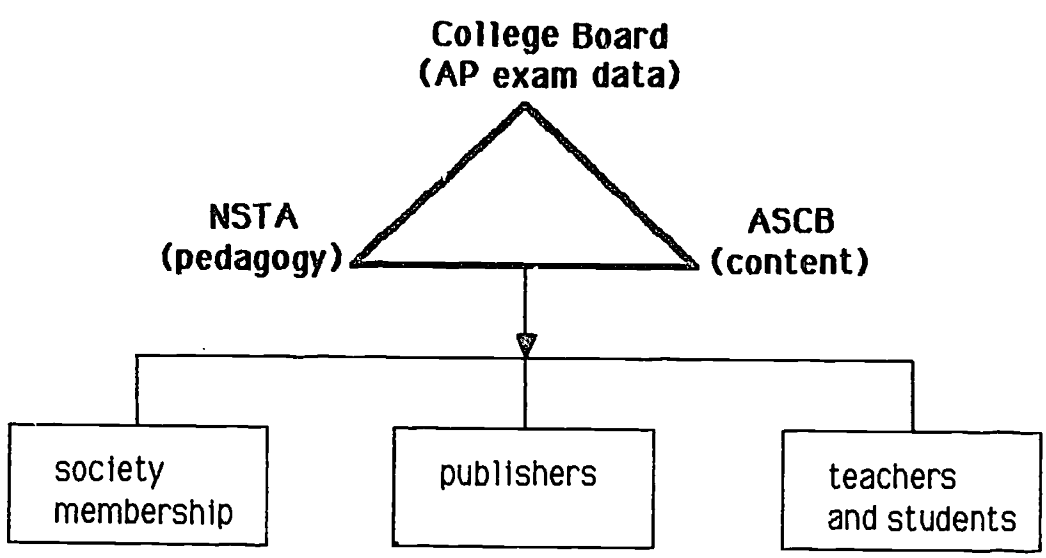
The AP cell structure survey findings have been brought to the attention of the Education Committee of the American Society for Cell Biology (ASCB). The Society has 5700 cell biologists as its members. At the Society's national annual meeting, the Education Committee organized a high school interface. The interface involved the local host committee inviting selected local high school teachers to meet with the local members of the Society and to attend portions of the annual meeting. Local liaisons were established which provided these teachers with future touchstones for cell biology resource information. Selected local high school students were brought to the annual meeting to attend a special scientific program and to visit commercial scientific exhibits. Participants at the meeting became aware of the Society's interest in high school students and teachers. The Society added a contingent of college students from primarily undergraduate schools to the meeting visitation schedule at the 1985 annual meeting. The high school/college interface will be a continuing feature of the annual meeting. Additionally, the Society published a synopsis of the AP cell structure survey in its quarterly newsletter to the membership. Thus, dissemination of the results of this standardized exam can make research cell biologists more aware of how their basic research findings are filtering down to high school and undergraduate college levels.

This report has suggested additional uses of the results of national standardized exams other than the measurement of student achievement. Analysis of the 1984 Advanced Placement Biology essay exam gave considerable insight into the cell structure knowledge of a national sampling of introductory biology college level students. Although these students used college level texts in their AP biology course, much of their terminology reflected "first impression" high school biology text descriptive wording. The study emphasized that extreme care must be expended in developing high school science texts. After reviewing biology textbooks, it was the author's impression that high school and college texts were developed independently of each another. Publishers should consider the development of hierarchically related science textbooks, from high school to college.

Learning resource material often reflected older concepts. The major reason for this was that resource material was revised less frequently than textbooks. Due to its cost-influenced longevity, resource material can be a significant contributor to the continuation of outdated material in a course. Periodic replacement of learning resource materials should accompany the acquisition of text materials.

Professional societies should develop networks with the educational community at all levels. As new directions of thought are developed through basic research, these results must be passed down the educational chain in a timely fashion. Professional societies should consider joint ventures with organizations such as the National Science Teachers Association. Through this type of communication, a science information/education network could be established.

This case study concludes with a proactive model of action.



Bibliography

1 Blystone, Robert V. 1987. Post-secondary level knowledge of plant cell fine structure. Journal of College Science Teaching. In Press.

2 The College Board. 1984. Advanced Placement Course Description: Biology. Advanced Placement Program, P.O. Box 2899, Princeton, New Jersey 08541. 36 pp.

3 Mosteller, R., S.E. Fienberg and R.E.K. Rourke. 1983. Beginning Statistics with Data Analysis. Addison-Wesley, Reading, Mass. 585 pp.

4 Scientific American. 1961. "The Cell Issue." 205(3):1-304. also as The Living Cell: Readings from Scientific American. 1965. Freeman, San Fransico, Calf.

5 Hurd, P.D., R.W. Bybee, J.B. Kahle and R.E. Yager. 1980. Biology education in secondary schools of the United States. Amer. Biol. Teach. 42:388-409.

6 Science Books and Films. 1985. "The biology textbook issue." 20(5): 245-286.

7 Cho, H-H., J.B. Kahle, and F.H. Nordland. 1985. An investigation of high school biology textbooks as sources of misconceptions and difficulties in genetics and some suggestion for teaching genetics. Science Education 69(5): 707-719.

8 Rosenthal, D.B. 1985. Evolution in high school biology textbooks: 1963-1983. Science Education 69(5): 637-648.

9 Arms, K. and P.S. Camp. 1982. Biology, 2nd edition. Saunders-CBS, New York, N. Y. 942 pp.

10 B.S.C.S. Hickman, F.M., supervisor. 1980. Biological Science: an Inquiry into Life, 4th edition. Harcourt Brace Jovanovich, New York, N.Y. 754 pp.

11 Curtis, H. 1983. Biology, 4th edition. Worth, New York, N.Y. 1159 pp.

12 Goodman, H.D., T.C. Emmel, L.E. Graham. F.M. Slowiczek and Y. Shechter. 1986. HBJ Biology. Harcourt Brace Jovanovich, Orlando, Fla. 878 pp.

13 Johnson, L.G. 1983. Biology. W.C.Brown, Dubuque, Iowa. 1177 pp.

14 McLaren, J.E. and L. Rotundo. 1985. Heath Biology. D.C. Heath, Lexington, Mass. 790 pp.

15 Oram, R.F. 1983. Biology: Living Systems. C.E. Merrill, Columbus, Ohio. 758 pp.

16 Otto, J. and A. Towle 1985. Modern Biology. Holt Rinehart Winston, New York, N.Y. 824 pp.

17 Purves, W.K. and G.H. Orians. 1983. Life: the Science of Biology. Sinauer Assoc., Sunderland, Mass. 1182 pp.

18 Villee, C.A., E.P. Solomon and P.W. Davis. 1985. Biology. Saunders-CBS, New York, N.Y. 1206 pp.

19 The American Cancer Society. date unknown. The Cell: Structure & Function. Overhead transparencies for high school biology. American Cancer Society, Texas Division, P.O. Box 9863, Austin, Texas 78766. 15 transparencies (order code 617).