

# College Students' Perceptions on Adequacy of High School Science Curriculum as Preparation for College Level Biology

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WITH the increasing number of high school graduates going on to college, there is an even greater need to insure the adequacy of the high school curriculum in preparing students for college (Uno 1988). The science education system of the United States has been criticized as providing a poor preparation for college science, lagging behind other countries such as Japan, Europe and the (former) Soviet Union (Barinaga 1990). The high school biology curriculum, in particular, has been criticized. Indeed, U.S. high school students ranked 13 out of 13 countries on knowledge of this subject in a 1988 study (Moore 1990). The strong level of concern by American educators for this issue is reflected in several national committee reports such as *Project 2061: Science for All Americans*, developed by the American Association for the Advancement of Science (AAAS 1989) and *Fulfilling the Promise: Biology Education in the Nation's Schools* (National Research Council 1990), and in surveys of professional biology educators (Leonard et al. 1991).

Much of the discussion on the adequacy of high school curricula as a preparation for college level science concerns the content of high school courses, the development of science process skills (Costenson & Lawson 1986), the relationships to technology and society and science teaching methods (Lawson 1988). While these are important concerns, less discussion has dealt with college student perceptions and attitudes towards biology and, in particular, the perceived adequacy of their own background prior to taking college biology courses. Smith (1979), for example, showed that student attitudes led to the alienation of female and black students from public school science. A negative attitude towards science is one of the main problems facing college freshmen enrolled in lower-division biology courses (Uno

1988). Such attitudes have been shown to have a negative effect on learning (Lawrenz 1976).

The goal of our investigation was to survey college students taking introductory biology courses on their attitudes and perceptions on aspects of biology that should have been covered in high school science. Since all high school students in Florida are required to take a high school biology class with a mandatory lab (Florida Department of Education 1990), one of the key indicators of the adequacy of the high school curriculum is its adequacy as a preparation for college-level introductory biology courses.

## Methods

Our sample consisted of 232 college undergraduates (96 men and 136 women) attending the University of West Florida, a southeastern educational institution with an enrollment of approximately 8000. All students were enrolled in either Introductory Biology (158 students) or General Botany (74 students) during Fall 1991.

A survey instrument was designed to address student perceptions of their high school biology curriculum as a preparation for college-level biology (Table 1). The six questions on the survey covered concepts that are not only common to the high school biology course in Florida (Florida Department of Education 1990), but are critical for an understanding of biology according to earlier reports (Thompson & Hellack 1986, Johnson & Peebles 1987, Moll & Allen 1987). Additional information was collected from each student on gender, high school attended, date of graduation from high school, number of high school and college science classes taken, present college level and major. We carried out the survey in the second week of the Fall 1991 semester.

Data were analyzed using cross-tab chi-square analysis of observed versus expected frequency distributions of responses (very familiar, somewhat familiar, not familiar) for different categories of students (e.g. males versus females). As a test of the overall confidence of freshmen students in taking college-level biology classes, a confidence index (CI)

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Table 1. Survey questions and responses (percent of 232 students surveyed) on student's perceptions of the adequacy of their preparation for college-level biology.

1. Before taking this class, how familiar were you with the <i>scientific method</i> ?			
Very familiar	Somewhat familiar	Not familiar	
40	53	7	
2. Before taking this class, how well were you able to use a <i>microscope</i> ?			
Very well	Somewhat	Not well	
56	38	6	
3. Before taking this class, how familiar were you with the principles of <i>Mendelian Genetics</i> ?			
Very familiar	Somewhat familiar	Not familiar	
13	39	48	
4. Before taking this class, how familiar were you with the <i>theory of evolution by natural selection</i> ?			
Very familiar	Somewhat familiar	Not familiar	
34	57	9	
5. Before taking this class, how familiar were you with the format used to write <i>scientific papers</i> ?			
Very familiar	Somewhat familiar	Not familiar	
15	45	40	
6. Before taking this class, how comfortable were you with the thought of taking a <i>college level science laboratory class</i> ?			
Very comfortable	Somewhat	Uncomfortable	
40	43	17	

was derived by assigning a value of 0, 1 or 2 to very familiar, somewhat familiar and not familiar responses, respectively. The mean confidence index score for all six questions, expressed as a percentage, was analyzed using analysis of variance (ANOVA) on arc sine transformed values to test for the effects of sex, number of high school science classes (0 to 3 versus 4 or more), college major (biology, nonbiology, undeclared) and high school size (less than 1500 students versus greater than 1500 students) on freshman students that had graduated from high school in 1991. Three- and four-way interactions of these four classes in the ANOVA were included in the error term since there were too few degrees of freedom for a complete analysis, and such higher order interactions would have been too ambiguous to interpret.

## Results

### Total Sample

Considering all students as a single group, the majority of students felt very or somewhat familiar with the topics covered in the survey (Table 1). A sizable majority of students were, however, only somewhat familiar with the writing of scientific papers (Question 5), and a large number of students were not familiar with the principles of Mendelian genetics (Question 3).

A difference in the frequency distribution of responses by sex was significant for Question 6; male

Table 2. Response (percent by sex) of students to Survey Question 6 by sex. Cross-tab chi-square = 6.16,  $P < 0.05$ . Difference in response between male and female students not significant for the other questions.

	Very comfortable	Somewhat	Uncomfortable
Males	50	37	13
Females	34	47	19

students were more comfortable than female students at the thought of taking a college level science laboratory class (Table 2).

The present college level of students led to a difference in the frequency distribution of responses to Question 3; a greater proportion of freshmen were not familiar with the principles of Mendelian genetics than were non-freshmen (Table 3).

The number of high school science classes taken led to a difference in the frequency distribution of responses to Questions 1, 2, 4 and 5. The pattern of

Table 3. Response (percent by college level) of students to Survey Question 3 by college level. Cross-tab chi-square = 16.69,  $P < 0.001$ . Difference in response between freshmen and non-freshmen not significant for the other questions.

	Very familiar	Somewhat	Not familiar
Freshmen	8	31	61
Non-freshmen	18	48	34

Table 4. Response (percent by number of high school science classes) of students to survey questions 1, 2, 4 and 5. Difference in response not significant for questions 3 and 6.

No. high school science classes	Very familiar	Somewhat	Not familiar
Question 1 (Chi-square = 31.6, $P < 0.001$ )			
0 or 1	31	38	31
2	32	57	11
3	25	68	7
4 or more	54	43	3
Question 2 (Chi-square = 28.7, $P < 0.001$ )			
0 or 1	23	46	31
2	57	32	11
3	49	47	4
4 or more	65	33	2
Question 4 (Chi-square = 12.86, $P = 0.045$ )			
0 or 1	23	54	23
2	21	68	11
3	27	64	9
4 or more	45	49	6
Question 5 (Chi-square = 15.9, $P = 0.014$ )			
0 or 1	8	31	61
2	18	39	43
3	6	45	49
4 or more	22	49	29

Table 5. Response (percent by number of college science classes) of students to survey questions by number of college science classes.

No. of college science classes	Very familiar	Somewhat	Not familiar
Question 1 (Chi-square = 21.2, P < 0.001)			
0	29	60	11
1 or more	57	42	1
Question 2 (Chi-square = 14.0, P < 0.001)			
0	47	47	6
1 or more	72	25	3
Question 3 (Chi-square = 42.5, P < 0.001)			
0	6	31	63
1 or more	26	52	22
Question 4 (Chi-square = 37.5, P < 0.001)			
0	20	68	12
1 or more	59	38	3
Question 5 (Chi-square = 19.8, P < 0.001)			
0	9	42	49
1 or more	26	49	25
Question 6 (Chi-square = 25.5, P < 0.001)			
0	29	46	25
1 or more	58	37	5

responses was the same for all four questions in that students having taken four or more high school science classes were more familiar with the concepts addressed by these questions (Table 4), i.e. the scientific method, use of a microscope, natural selection and writing scientific papers.

The number of college science classes taken led to a difference in the frequency distribution of responses to all six questions (Table 5). Students having taken one or more college science classes were more familiar with all the concepts addressed in the survey.

College major also led to a difference in the frequency distribution of responses to all six questions (Table 6). Students majoring in biology had a greater level of familiarity with the concepts addressed in the survey than both nonbiology majors and students that had not declared a major.

A difference in the frequency distribution of responses was significant for only Question 6 with respect to high school size. Students who had graduated from a large (>1500 students) high school were more comfortable with the thought of taking a college-level science laboratory class than those graduating from a small high school (Table 7).

### Freshmen Only

Analyzing the responses of only freshmen students who graduated in the current year (1991, n = 98) showed a significant difference in the frequency distribution of responses to three questions (Table 8). Male freshmen were more comfortable than female students, and freshmen from large high schools were more comfortable than freshmen from small high schools at the thought of taking a college level science

Table 6. Response (percent by number of college major) of students to survey questions by number of college major.

College major	Very familiar	Somewhat	Not familiar
Question 1 (Chi-square = 26.3, P < 0.001)			
Biology	59	40	1
Nonbiology	27	62	11
Undeclared	27	61	10
Question 2 (Chi-square = 26.1, P < 0.001)			
Biology	77	21	2
Nonbiology	42	51	7
Undeclared	47	45	8
Question 3 (Chi-square = 40.0, P < 0.001)			
Biology	25	51	24
Nonbiology	4	33	63
Undeclared	11	26	63
Question 4 (Chi-square = 19.4, P < 0.001)			
Biology	51	46	3
Nonbiology	23	64	13
Undeclared	26	63	11
Question 5 (Chi-square = 23.5, P < 0.001)			
Biology	23	55	22
Nonbiology	9	42	49
Undeclared	13	29	58
Question 6 (Chi-square = 23.9, P < 0.001)			
Biology	56	37	7
Nonbiology	31	49	20
Undeclared	29	37	34

class (Question 6). Freshmen students who had taken four or more high school science classes were more familiar with the scientific method than freshmen students having taken fewer classes (Question 1). In addition, freshmen students who had taken only zero to three high school science classes were a lot less familiar with the principles of Mendelian genetics than freshmen students who had taken four or more science classes in high school (Question 3, Table 8).

### Overall Confidence of Freshmen Students

Sex was the only significant factor in the ANOVA of mean overall confidence of freshmen students who had graduated in 1991 ( $F = 4.77$ ,  $P = 0.035$  at 1/65 df). The mean percentage confidence index (CI) for males was 56 percent, whereas for female students the index value was significantly lower at 49 percent. The number of high school science classes ( $F = 3.00$ ,

Table 7. Response (percent by school size) of students to Survey Question 6 by high school size (small <1500 students, large >1500 students) (n = 129). Cross-tab chi-square = 6.0, P = 0.049. Difference in response between students from small and large high schools not significant for the other questions.

	Very comfortable	Somewhat	Uncomfortable
Small	29	46	25
Large	45	44	11

Table 8. Response (percent by category) of freshman 1991 graduates ( $n = 98$ ) to survey questions. Results are presented only for categories and questions where a significant difference in the frequency distribution of responses occurred.

	<i>Very comfortable</i>	<i>Somewhat</i>	<i>Uncomfortable</i>
Sex, Question 6 (Chi-square = 6.7, $P = 0.035$ )			
Males	48	44	8
Females	24	53	22
Number of high school science classes taken			
Question 1 (Chi-square = 11.8, $p = 0.003$ )			
0-3	18	73	9
4 or more	52	43	5
Question 3 (Chi-square = 6.4, $P = 0.042$ )			
0-3	3	23	75
4 or more	11	37	52
School size, Question 6 (Chi-square = 9.87, $p = 0.007$ )			
Small	17	53	30
Large	44	50	6

$P = 0.09$ ) and the interaction between sex and high school size ( $F = 2.75$ ,  $P = 0.1$ ) were marginally significant. The former indicated that students were more confident having taken a greater number of high school science classes. The confidence values for the latter interaction indicated that females who came from smaller high schools were less confident (CI = 39 percent) than male students also from small schools (CI = 56 percent). Males and females from large high schools were equally confident (CI = 59 percent and 56 percent, respectively). Other tested factors and the two-way interactions were not significant.

## Discussion

Interpretation of the results of this survey must take into account the limitations of the methodology employed. Only a few concepts were addressed in the survey (six questions, Table 1) and the choice of responses were few (very, somewhat or not familiar), precluding a more sophisticated and sensitive statistical analysis. In addition, the number of students surveyed was low, only 232. One hundred twenty-nine had graduated from one of 20 high schools in the local area around Pensacola, Florida. However, the other 103 students graduated from one of 96 high schools outside the area ranging from California to Germany. Nevertheless, these are the limitations common to surveys of this type. The number of significant results from such a small data base, and the large number of high schools surveyed, are suggestive of general findings that a more comprehensive survey of student attitudes and perceptions might reveal.

Overall, the students were somewhat to very familiar with the concepts covered in the survey. The

principles of Mendelian genetics (Question 3) were an exception to this as 48 percent of all students and 62 percent of freshmen students who graduated from high school in 1991 were not familiar with the concept. This is somewhat surprising since concepts of genetics are specifically addressed in the Florida Curriculum Frameworks for high school biology (Florida Department of Education 1990), and NABT members devote approximately 23 percent of their class time to the topic (Leonard et al. 1991). However, students often have problems with Mendelian genetics in spite of the fact that it is cited as one of the most important topics of study in biology (Moll & Allen 1987).

Only a small percentage of the students surveyed felt very familiar with the format used to write scientific papers (15 percent of all students, 12 percent of freshmen). These percentages increased with the number of high school science classes taken (Table 4) and most likely reflect confidence borne from greater familiarity and experience in science in general.

Given the still current controversy and reluctance of some biology teachers in high schools to teach evolution (Tatina 1989), it was satisfying to see that only 10 percent of the students were not familiar with the theory of evolution through natural selection (Table 1). This figure rose to only 13 percent for nonbiology majors (Table 6).

Some of the findings from the survey were as expected; i.e. students who had taken a greater number of both high school and college level science classes were found to be more familiar with the concepts surveyed. Incoming freshmen students who had taken four or more high school science classes were more familiar with the scientific method and Mendelian genetics. It was also not surprising that biology students were more familiar with the concepts than nonbiology and undeclared students. Lord & Rauscher (1991) similarly found that biology majors had a better knowledge of life science than nonbiology students.

The perceptions of incoming college freshmen were of particular interest in this study. In addition to the general familiarity with evolution and low confidence with Mendelian genetics already discussed, the differences in familiarity and confidence of males and females, and students from large and small high schools, are a matter of concern. The lower confidence of female freshmen students compared with male students in taking a college level science laboratory class reinforces older gender-based stereotypes of science (Smith 1979, Miller 1989, although see Lord & Rauscher 1991) that recent programs are designed to reduce (e.g. Mason & Kahle 1988).

The difficulties of preparing college-bound science students are manifold and related to the fact that high

school students must be prepared for all aspects of society and not just success in taking college science courses. A minimum core curriculum with an emphasis on key concepts, science technology and society, and pedagogy should help in building student confidence to take science and biology college courses in particular (Uno 1988, Leonard et al. 1991). An understanding of student perceptions and attitudes toward biology will help not only those of us teaching introductory college biology courses but high school administrators and biology teachers as well (Goodwin et al. 1991).

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