

A Sampling of Basic Life Science Literacy in a College Population

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“What is the science of biology?” a young life science teacher asked his class the first day of school.

“It’s a subject about animals and people,” came an answer from somewhere in the room.

“And what about plants?” asked the teacher, “Aren’t they part of biology, too?”

“Nay,” answered the student in all seriousness, “they’re part of agriculture!”

This type of event occurs frequently in today’s life science classrooms. Present-day students are not learning the basics of their subjects either because they are not being taught the material or they are not retaining much of the material that is being taught. In a recent National Geographic Society survey about countries of the world, for example, American students placed last among 10 nations on their knowledge of international geography. Only three out of every 10 American participants, for example, could find Vietnam on a map. Fourteen percent of the students could not locate the U.S. on a world globe (National Geographic Society 1988).

Most of the research done over the past decade on the quality of an education in the United States, along with declining national achievement test scores, has pointed to a deteriorating academic literacy. One of the most obvious areas of national academic decline is in science education. Audrey Champagne, co-director of the Department of Education’s National Center for Improving Science Education, states that, “Many Americans, even those who are otherwise well-educated, have little understanding of science and how it affects their standards of living. Nor do they possess the intellectual skills to act effectively on scientific matters that they encounter in their personal, professional, or civic experiences” (Champagne 1989a). In addition, the number of jobs requiring basic knowledge of science is increasing and will soon reach a point where the jobs cannot be filled by our scientifically literate work force. This will lead to the export of modern technologies to countries that still value

science and are producing large numbers of science technology graduates (Hively 1988).

In a recent comparison of the 13 most industrialized nations of the world, the International Association for the Evaluation of Educational Achievement listed American high school students as eleventh in chemistry, ninth in physics and thirteenth in biology. Another report found that the majority of American students stop taking math and science courses by the end of their sophomore year in high school; only one percent study mathematics through calculus, a subject taken by more than 25 percent of secondary school students in Japan. This has affected the number of baccalaureate degrees in science and engineering awarded to American students. Bachelor degrees in these areas slipped below 20 percent this year. This compares to almost 30 percent of these degrees in Japan and more than 40 percent in England and France (National Assessment of Educational Progress 1988).

Literacy surveys taken by the U.S. citizens reflects this lack of general knowledge about science and technology. For example, in a survey by Jon Miller of Northern Illinois University, 45 percent of adults knew that the earth revolved around the sun and only 43 percent knew that electrons were smaller than atoms. Moreover, the vast majority of the sample (88 percent) also thought that astrology was based on scientific principles and 64 percent reported that lasers were based on sound waves. Sixty-three percent did not know that dinosaurs became extinct millions of years before the earliest humans roamed the earth.

How knowledgeable are people in the basic life sciences? School guidance counselors indicate that biology is the last science course taken by most students in school. One might, therefore, expect the understanding of biology to be higher than it is in the other sciences. Surely if a survey of life science knowledge was given to students that had graduated from high school and were attending college, the chance of obtaining good results would be quite high.

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The Study

Encouraged by the prospect, a survey on overall knowledge of biology was conducted at a mid-sized Eastern college. The short questionnaire was drawn from information in life science textbooks designed

1. Animals that eat other animals are called:
 - a) herbivores
 - b) carnivores
 - c) cannibals
 - d) parasites
 - e) don't know
2. Warm-blooded animals always keep the temperature inside their body the same as the outside surroundings.
 - a) true
 - b) false
 - c) it depends on the animal
 - d) it depends on the location of the animal
 - e) don't know
3. The organ that produces the sperm in male animals is the:
 - a) scrotum
 - b) prostate
 - c) penis
 - d) testes
 - e) don't know
4. In female animals the egg cells are produced by the:
 - a) ovaries
 - b) uterus
 - c) vagina
 - d) cervix
 - e) don't know
5. AIDS (Acquired Immune Deficiency Syndrome) is caused by a bacterial infection.
 - a) true
 - b) false
 - c) don't know
6. Cholesterol can be a problem for people who eat too much:
 - a) sugar
 - b) flour
 - c) saturated fats
 - d) proteins
 - e) don't know
7. Plants release oxygen from their leaves during the day.
 - a) true
 - b) false
 - c) don't know
8. A spider is an insect.
 - a) always true
 - b) always false
 - c) it depends upon the type of spider
 - d) don't know
9. Which of the following are animals?
 - a) elephant
 - b) bird
 - c) snake
 - d) fish
 - e) b and c
 - f) a, b and c
 - g) a, b, c and d
10. Which of the following are animals?
 - a) frog
 - b) grasshopper
 - c) clam
 - d) worm
 - e) a and b
 - f) a, b and c
 - g) a, b, c and d
11. Which of the following have bones inside them?
 - a) dogs
 - b) whales
 - c) turtles
 - d) crabs
 - e) a and b
 - f) a, b and c
 - g) a, b, c and d
12. Which of the following have no bones in their bodies?
 - a) worms
 - b) spiders
 - c) lobster
 - d) snakes
 - e) a and b
 - f) a, b and c
 - g) a, b, c and d

Figure 1. Survey questions on basic life science knowledge.

for upper primary and middle school grades (Figure 1). The 12-item survey was given to 300 undergraduates with both science and non-science related interests. Members of the population had graduated from a diversity of secondary schools ranging from small rural academies to large urban educational institutions. The survey contained an equal number of men and women and carried a mean age of 20 years. The results of the survey were statistically checked against grade level, academic major, age, gender and highest science class taken and significant differences were noted. Bar graphs were constructed to better visualize the differences in scores between the variables (Figure 2, 3, 4 and 5).

Results

The outcomes of the survey were interesting in several respects. Significant differences were noted between the mean group score on the questionnaire and the students' background in science and their college major (Table 1). However, when the mean score on each question was examined against the different variables, some surprising results were noted. Most of the students, for example, knew that animals that eat other animals were called carnivores. Not only did both sexes do well on this question, but the non-science related majors did nearly as well as the biology and other science majors. Older students, as a whole, had more trouble with this item than younger students, but not to a point of a significant difference.

The second question on the survey was also answered correctly by the majority of students. In most every category, three-quarters of the participants knew that warm-blooded animals do not keep the temperature inside their body the same as the outside surroundings.

Table 1. Analysis of Variance on Survey Outcome by College Major, Science Background, Age and Gender.

	mean	SD	SE	F
Bio Major*	11.07	3.42	.64	5.18*
Other Sci Major*	11.21	3.25	.57	
Non-Sci Major	8.43	2.57	.53	
High School Biology	9.04	2.34	.48	4.19*
College General Biology	9.16	2.95	.21	
Advanced Biology*	11.63	2.73	.62	
20 and under	10.1	2.57	.23	2.36
21-25	11.7	3.17	.32	
26 and over	10.9	2.65	1.08	
male	11.07	2.81	.52	1.23
female	10.37	2.55	.67	

*Significance at $p < 0.05$

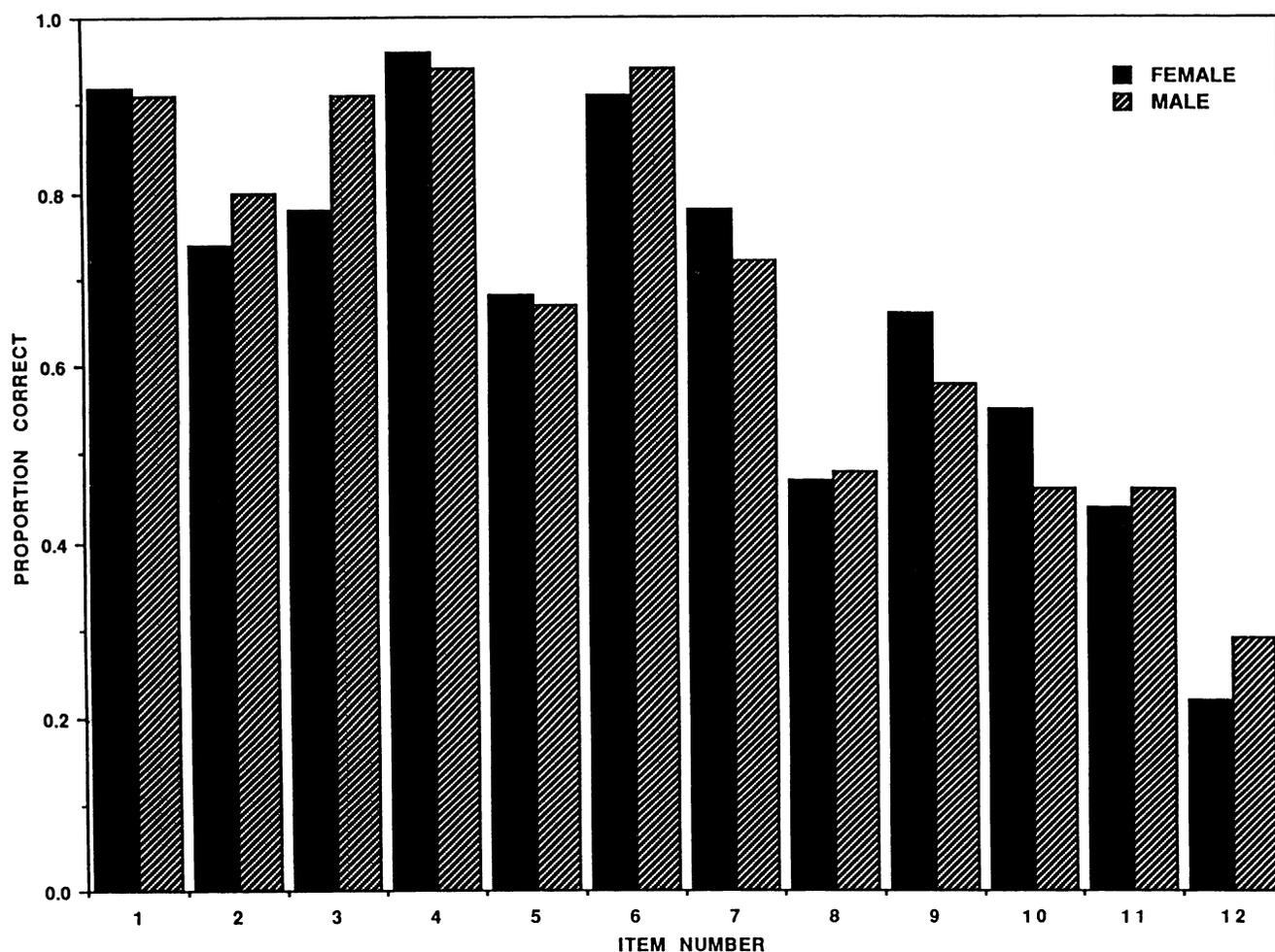


Figure 2. Proportion of correct answers on each item for males and females.

Most of the participating students also knew that sperm was produced in the testes of males. Every student category scored near or above 80 percent on the question. What is most interesting about this item, however, is that the two sexes differ significantly on the answer. While more than 90 percent of the males got this item correct, only 78 percent of the female undergraduates in the survey knew where sperm was produced.

The reverse trend was not as dramatic in the question that asked where egg cells were produced in females. Well over 90 percent of the men and women in the survey got this item correct. The students with majors outside the sciences scored the worst on this question with 88 percent of them choosing ovary as the correct answer.

Furthermore, only two-thirds of the surveyed population knew that AIDS was caused by viruses and not bacteria. Many would have predicted higher scores since there has been much coverage of this topic in the popular media. Students majoring in biology scored significantly better on this question than students majoring in other sciences or in the

non-sciences. Eighty-two percent of the students with a biology concentration got this answer correct. Students in other areas tended to score below 70 percent on this topic.

The communication media, however, have likely influenced the results on the cholesterol question. All groups scored above 90 percent on this survey item. Interestingly, the participants majoring in areas outside the sciences scored slightly higher on this question than students in a science specialty. Although certainly not a significant difference, it points to the impact the media can have on one's knowledge.

Mass communications, unfortunately, did not have as much influence on student knowledge on the next question. One out of every four students in the survey did not know that plants release oxygen during daylight hours. Sadly, the number of science majors missing this item was about the same as non-science majors. Seventy-five percent of the biology majors and 78 percent of majors in other sciences got this question right. This compares to 73 percent of the non-science majors responding correctly. Although statistical significance was not reached, older

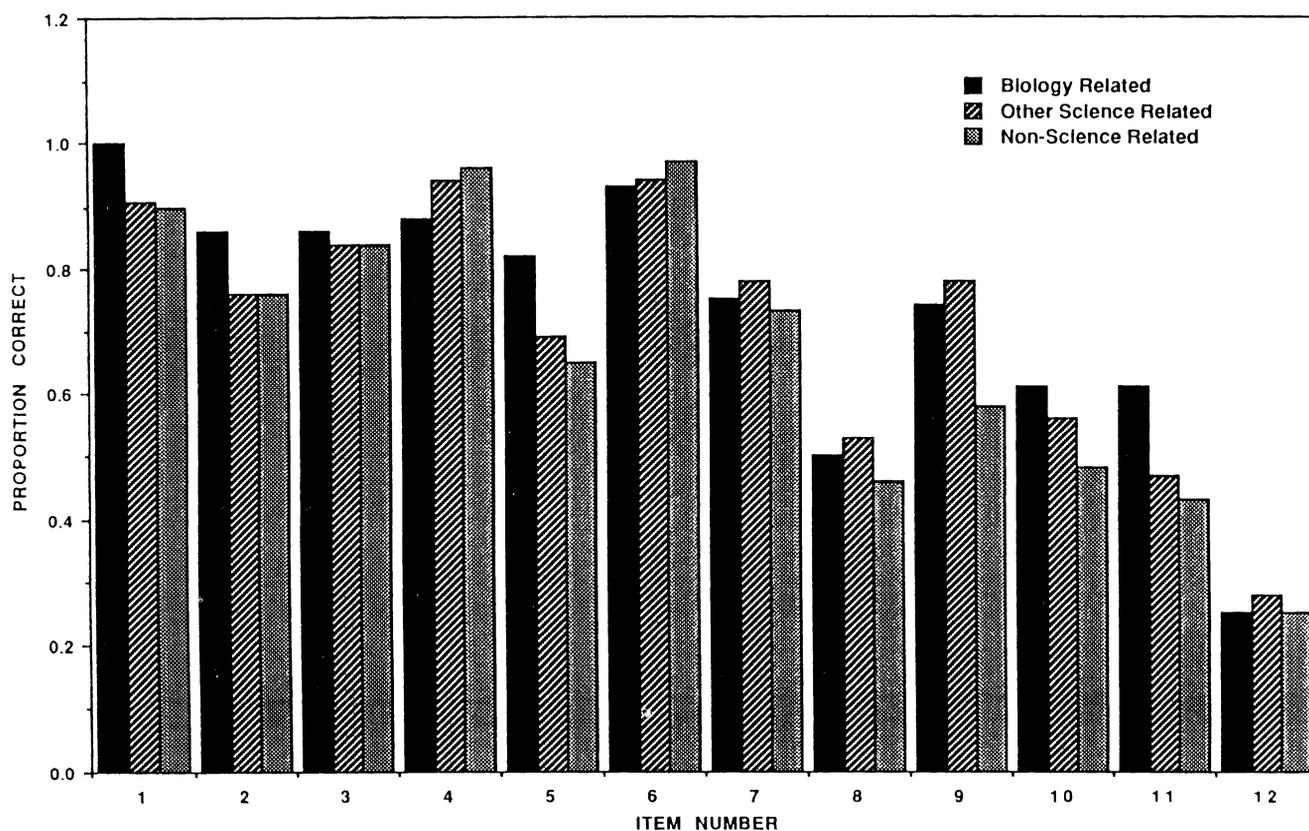


Figure 3. Proportion of correct answers for each item for biology, other science and nonscience majors.

students (those over 25) did better on this question than younger students and participants having advanced biology courses in their backgrounds scored better than those with only a general biology course.

The outcome of question 6 is indeed surprising. All the life science books perused for this survey clearly state that spiders are not insects. Readings in nature books and outdoor recreation manuals and magazines also emphasize this point. Yet fewer than 50 percent of the college men and women taking the survey got this item correct. Interestingly, students under 20 years of age score significantly better on this question than older students.

Just as disconcerting is the finding that only three-quarters of the college participants knew that elephants, birds, snakes and fish and frogs, grasshoppers, clams and worms are all animals. Science majors predictably scored significantly higher on these two questions than non-science majors, but most educators would have predicted higher scores for all participants on these items. The surprising lack of understanding of this issue may be in the way animal taxonomy is handled by our schools.

Shockingly, the majority of students questioned did not answer the question concerning vertebrate animals correctly either. Only about half the males and females taking the survey knew that dogs,

whales and turtles had bones in their bodies, but that crabs did not. Biology majors performed significantly better on this question than majors outside biology, and older students answered this question right about two-thirds of the time compared to less than half the time for younger students.

When a question was asked about invertebrates, however, the vast majority of students missed the answer. Only a quarter of the population knew that worms, spiders and lobsters did not have bones in their bodies, but that snakes did. Sadly, biology majors missed this item as often as non-biology majors, and students with advance courses in the life sciences scored no better than students with only a high school biology course in their background.

Discussion

This survey has found that many college students do not know many of the elementary facts that contemporary life science is based on. A number of students, for example, apparently do not realize that the term "animal" encompasses more than mammals and that complicated invertebrates don't have bones. Furthermore, it points out that a surprisingly large number of students that have selected biology as a specialty also do not have a complete grasp of this life

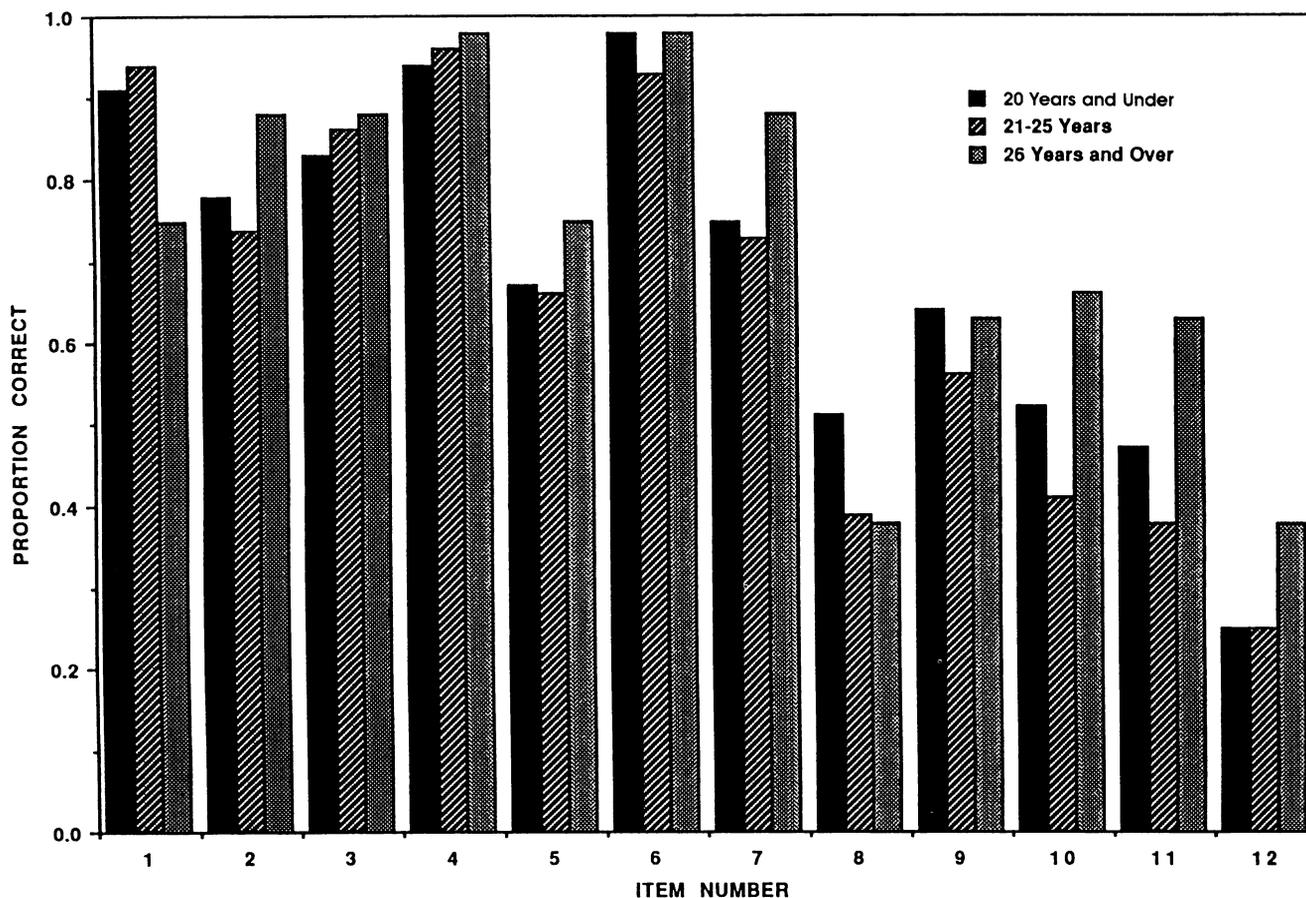


Figure 4. Proportion of correct answers for each item by age.

science knowledge. Surveyed majors in biology scored at or below the seventy-fifth percentile on a third of the questions.

The results also reveal that the more biology a student has taken, the better the score on the survey. Therefore, it is assumed that the poor showing by the biology majors resulted from a large number of first year students. A breakdown of participants by age supports this contention, for college students did poorer on the questionnaire than older college students.

The survey also found that females scored as high as males on most of the items. In fact, women outscored their male counterparts on six of the 12 questions in the survey. This does not support an earlier work by Miller (1989) that found men to be more literate about science than women. Miller's explanation of his results as "historical stereotyping of science as a male realm" is certainly not apparent in this study. Statistical analysis of the results reveals that gender differences are not significant in this study.

One might question the premise that students need to know the elementary facts of life science to understand contemporary life science issues. Why is it

important, for example, that one know that snakes are vertebrates or spiders are not insects? The answer is that it is virtually impossible to understand complicated science issues without a broad foundation of elementary science knowledge. Audrey Champagne of the AAAS contends that "The attainment of the higher order life skills presupposes the attainment of the lower order school skills" (Champagne 1989b). Without a good science foundation, one cannot solve practical problems in the workplace or react intelligently on science-related civic issues.

Unfortunately, most people do not realize they are scientifically illiterate. A National Science Board poll taken recently, for example, found that fewer than half the participants correctly answered a group of general life science questions. Yet a Harris poll taken about the same time indicated that nearly 70 percent of the U.S. population felt that their basic knowledge of science was above average. Indeed, since the majority of the nation's voters feels they adequately understand science, the next task is to change their perceptions.

"Without this change in attitude," states Morris Shamos, past president of the National Science Teachers Association and author of *Myth of Scientific*

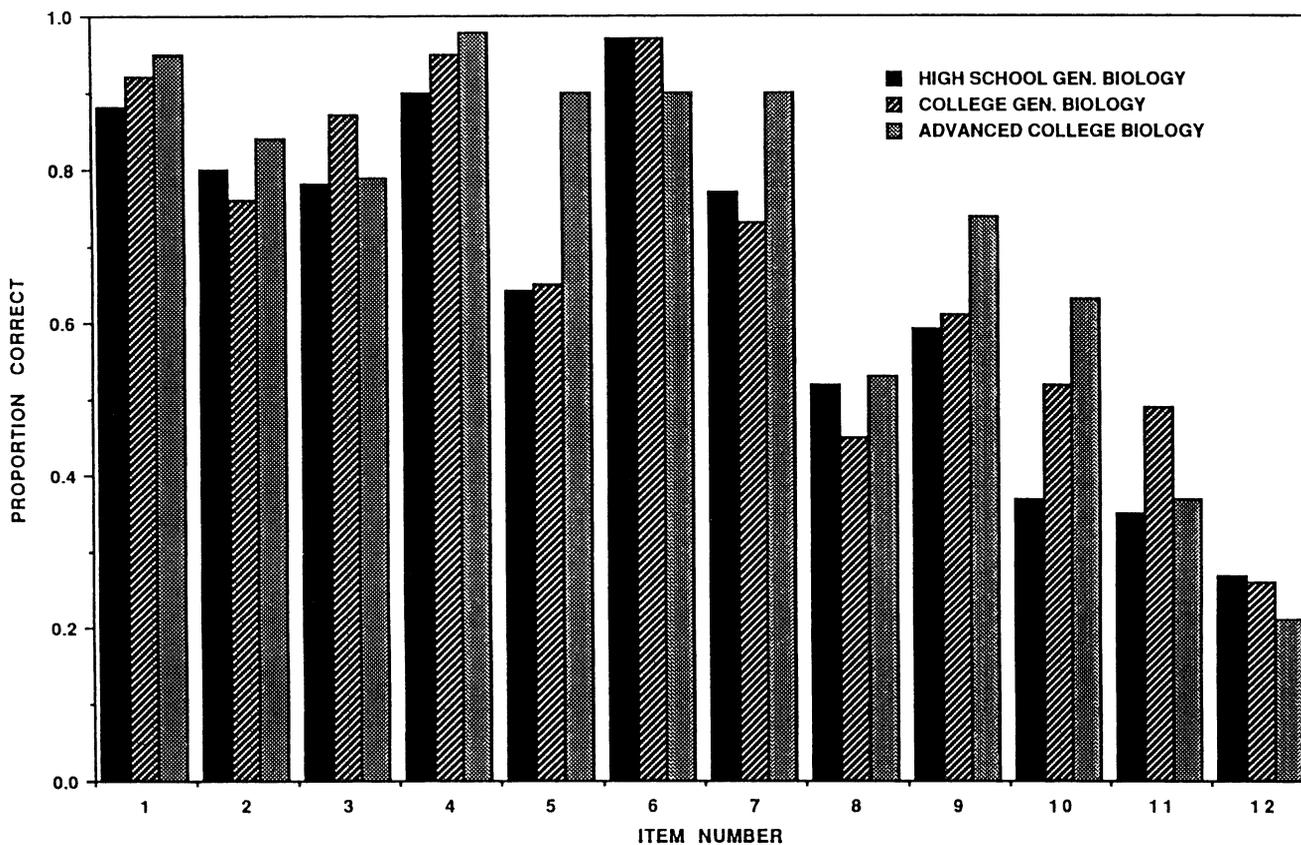


Figure 5. Proportion of correct answers on each item for highest biology course taken.

Literacy, “we will never be able to achieve universal literacy in the sciences” (Shamos 1990). The results of this survey on basic life science knowledge suggests we certainly have a long way to go.

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