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A COMPARATIVE STUDY OF TRADITIONAL AND INDIVIDUALIZED
MULTI-MEDIA TEACHING METHODS USED IN BIOLOGY
CLASSES AT GREAT FALLS HIGH SCHOOL

by

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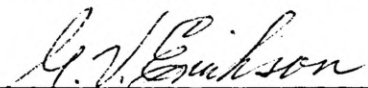
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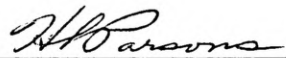
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ABSTRACT

The purpose of this study was to compare two different methods of teaching biology at Great Falls High School in 1972. Students in traditional and individualized multi-media (IMM) classes were given an objective test and a questionnaire. These instruments measured the difference in basic biological knowledge, related scientific thinking, and student interest in science in the two types of classes.

Using the analysis of covariance and the value of F, statistical data showed there was a difference at the .05 level of significance between the traditional and IMM classes in both basic biological knowledge and related scientific thinking. The adjusted mean scores showed the traditional classes achieved a higher score than the IMM classes in both areas. Statistical analysis showed no difference at the .05 level of significance in student interest in science in the two types of teaching methods.

Recommendations from this comparative study included revisions in course content and emphasis in the individualized multi-media classes. Teacher directed small group discussions were also recommended to develop student understanding, responsibility and involvement within the informal class structure.

Chapter 1

INTRODUCTION

Prior to 1970 all biology teachers at Great Falls High School used the traditional method of lecture-discussion with related laboratory investigations. Individualized multi-media classes were introduced at the beginning of the 1970-71 school year. These student-centered classes were developed from the present day student needs as outlined in the Arthur D. Little, Inc. report, Educational Needs in Montana. (7) From the findings of this report these basic goals were proposed:

1. Student involvement in biological science through laboratory investigations, reference reading, and group interaction.
2. Development of activities so the student would be a participating scientist, not a receiving center for information.
3. Individualization through teaching media, informal class structure, and student-determined achievement goals.

A team of four biology teachers initiated this individualized multi-media method of instruction. Two classrooms were used; a bank of carrels for cassette tapes, slides and individual study was placed in each room. The

laboratory tables were arranged with four to six students to a group. There was no teacher desk or lecture area; instead, there was one lab-preparation office located between the two rooms. Large windows were installed so that teachers had visual and auditory access to both rooms. Students and teachers worked in either classroom.

Instead of textbook assignments for factual learning, cassette tapes and illustrative slides were developed with multiple text references listed with each study unit. Specific laboratory investigations were written to correlate with the unit. Emphasis was placed on laboratory activities that gave students a knowledge of how scientists work and an opportunity to observe many biological processes. Factual learning was secondary to understanding the laboratory activities. Each unit was scheduled into a block of time and all work was to be completed and a test taken on the last day. The teachers were involved in student activities as resource persons, as tutors for students needing extra help, and as assistants to students in laboratory investigations.

In this chapter, the basis for comparison of the two teaching methods used in biology is presented and the questions that this study has attempted to answer are

stated. An explanation of the importance of the study is included, as is the general procedure used. The limitations and delimitations inherent in this comparative study are described in order to present the study in its proper perspective. General terms are defined to clarify their meaning with respect to this study.

STATEMENT OF THE PROBLEM

The purpose of this study was to compare two methods of teaching biology at Great Falls High School. Traditionally taught classes and the individualized multi-media classes have been compared in three areas:

1. Basic biological knowledge
2. Related scientific thinking
3. Student interest in science

IMPORTANCE OF THE STUDY

Individualized multi-media teaching methods have been used in Great Falls High School biology classes for two complete school years. Science teachers in Great Falls junior and senior high schools have followed the development of the program with interest. Typical questions they have asked include: Are students learning as much basic knowledge

in the individualized multi-media classes? Can students develop scientific thinking abilities without teacher direction? Does student interest in science increase when class emphasis is on responsibility, involvement and individualization?

Members of the administrative staff have been very cooperative and interested. They are looking for an evaluation from the point of view of these questions: Are the students in the individualized multi-media classes achieving the goals proposed? How can these classes be improved? Should this type of class be developed for other sciences or in other areas?

The teachers at Great Falls High School who are involved in the experimental program would like an evaluation to learn if their enthusiasm and hard work in preparing this type of class has accomplished the basic goals of the program. They are also interested in the student reaction to this innovation in science classes: Will students be encouraged to take additional science courses? Do students have a preference of teaching methods used in biology classes?

GENERAL QUESTIONS TO BE ANSWERED

1. Was there a difference between traditional and individual multi-media teaching methods in student learning of basic biological knowledge?
2. Was there a difference in traditional and individualized multi-media teaching methods in student learning in related scientific thinking areas?
3. Did the teaching method used increase student interest in science?

GENERAL PROCEDURES

A comparison of the two teaching methods has been made from data obtained from a test and questionnaire given in November, 1972. These two instruments were designed to answer the general questions proposed.

The test contained questions relating to basic biological knowledge and scientific thinking. Questions used were prepared by the participating teachers from the cellular biology unit studied in the traditional and individualized multi-media classes. See Appendix A, pages 48 - 50, for a sample test.

The questionnaire sampled student interest in science in the areas of additional science study, outside

scientific interests and preference for teaching procedures and methods within the classroom. See Appendix B, pages 52 - 61.

LIMITATIONS AND DELIMITATIONS

In this comparison of biology teaching methods at Great Falls High School, some limitations and delimitations should be considered.

During the 1972-73 school year, there are three classes of traditionally taught biology and twelve individualized multi-media classes. All traditional classes are taught by one teacher; there are four teachers working as a team with the experimental classes. The teachers involved in this study have a minimum of five years of classroom experience at Great Falls High School.

Traditional classes use one text as a basis for class study; additional work is programmed by the teacher to fit his interests. Individualized multi-media teachers developed basic units of study for each area. This included a basic biological reference section and laboratory investigations that coordinated with the unit. Tapes and slides were produced by the team of teachers to supplement basic information. Changes have been made with each unit when

necessary.

The test and questionnaire used in this comparative study were given in November, 1972, after completion of the first nine weeks of school. This was the only area of study with similar content in both types of classes.

Students scheduled into individualized multi-media classes were involved in a new classroom experience. Responsibility for work completed was no longer teacher-centered and programmed for them. This represented a change for students who had been conditioned to traditional methods in the junior high schools.

DEFINITIONS

For the purposes of this study, the following definitions will be applicable:

Basic biological information - factual knowledge and understanding of biological vocabulary and biological concepts and principles.

Related scientific thinking - a broad area as evidenced by student ability to recognize and solve problems, recognize hypotheses and select methods of testing them, and critically evaluate experimental procedures, data, conclusions and implications.

Traditional class - a conventional teacher-centered class using lecture and discussion with related laboratory investigations.

Individualized multi-media class (IMM) - a student-centered class using individualized instruction techniques with tapes and slides and emphasizing laboratory investigations.

SUMMARY

This study compared traditionally taught biology students with the individualized multi-media (IMM) biology students. They were tested for recall of basic knowledge and for scientific thinking abilities. Student interest in science was determined by a questionnaire.

The scope of this study was limited to the effect of teaching methods on student learning outcomes. There was no evaluation of individualization, involvement, and responsibility inherent in the IMM method of teaching.

Results from this comparative study can be used to give direction for IMM revisions and changes for the 1973-74 school year.

Chapter 2

REVIEW OF RELATED LITERATURE

This review of literature describes changes in science teaching methods and presents evaluations of learning outcomes from several comparative studies.

Important characteristics of the textbooks and teaching methods used today have their origin in the history of science textbooks. In the period from 1890-1930, high schools were comparatively small; their students were relatively homogeneous in scholastic aptitudes and social and economic backgrounds. The curriculum provided a general education for those who went on to college. Textbooks were written by working scientists or their colleagues and consisted of a "mass of disconnected facts and elementary generalizations"....(12)

With the rapid increase in high school enrollment the school population was no longer homogeneous, but represented a diversity in purpose, attitude and interest. The textbooks that were written during this period reflected this change with a major shift in content and emphasis. Knowledge in the scientific field was modified to conform to the theories of teaching and learning. As a result a distorted view of science was presented. "The line of

communication between scientific inquiry on the one hand and the textbook on the other grew thinner and thinner. The gulf between scientific knowledge and the content of our textbooks grew wider and wider" (13).

Classes were taught by lecture, recitation and discussion, with laboratory activities that restated or confirmed scientific facts already known. Emphasis was on knowledge and factual learning (5).

Discontent with the quality of education was widespread in the 1950's. Science teachers, educators from colleges and universities and practicing scientists combined their efforts toward revitalizing the science curriculum. Funding of these studies by the National Science Foundation made possible the texts, laboratory investigations and teaching guides for physics, chemistry, and biology.

Novak describes the shift in emphasis of science teaching and textbooks.

Programs in chemistry and physics did more than produce new textbooks. New kinds of laboratory activities which placed greater emphasis on the process of scientific inquiry, rather than confirmation of results reported in books, characterize these programs (8).

Inquiry and investigation as outlined above placed the student as a participating class member directly involved in problem-solving investigations. Memorization of facts was minimized, and knowledge of scientific concepts and principles was acquired by directed laboratory activities.

Anderson and Weigand point to difficulties that may develop when using this method.

Some students will find a constant diet of problem-solving a bit rigorous; but even these students will typically gain more insight into the "content" they need than students struggling along the path of rote memorization and regimentations (1).

The research studies of Ramsey and Howe (11) and Anderson (2) indicate that different teaching methods show little influence on learning outcomes when students are tested for knowledge and content learning. When other learning outcomes are desired, teaching methods are important determinants in the results.

Traditional chemistry classes were compared with lab-centered classes (CHEM Study) in a study by Rainey (10). Tests for factual information gave similar results from both kinds of classes taught. The laboratory activities in CHEM Study were directed to development of topics from laboratory evidence. Traditional classes used open-ended

labs to explore areas of interest more completely. Students like the open-ended labs better than the directed activities of the CHEM Study program.

Yager and Wick (16) compared three biology classes. One class used the traditional presentation of text and laboratory materials, another class used only references and laboratory investigations, and the third class also used references and lab investigations but was oriented toward the development of important ideas of science.

When these classes were compared, the test results of factual knowledge learning were similar. Outcomes of understanding science and critical thinking were greater with the classes that used methods other than text-presented facts and concepts.

In 1965 Bennett (3) compared seventh grade science students studying an Ecology unit. One group was taught by the traditional classroom method; the second group was taught by an experimental-field method. Testing at the conclusion of the unit showed no significant difference in factual information learned or attitude change toward science. The traditional classes scored better on the comprehension test.

Recent innovations in science teaching have concentrated on developing science classes that focus on the individual, his problems and interests.

Individualized instruction means that the student has been matched to an instructional system such that he is working at his own speed, learning style, and ability level on appropriate materials in keeping with goals, supported by adequate assistance in a suitable learning environment. Individualized instruction is not synonymous with independent study, although independent study might be a proper subset of the total methods used (15).

Dr. S. N. Postlethwait was one of the first to develop a working model for individualized instruction. He designed an audio-tutorial approach for a freshman botany course at Purdue University (9).

Studies of models of individualized instruction in high school mathematics (15), physics (6), and biology (14) used the audio-tutorial presentation of traditional material. In addition to the tapes, there was a student guide that defined the objectives and provided related problems, labs, and practice sheets. Short quizzes provided content learning evaluation for each student. Group interaction and individual tutoring were also part of the total program. Depending on the pace of learning and the ability of the student, time was available for open-ended research.

Description of the class structure was outlined but evaluation of these individualized instruction classes was incomplete.

Cole (4) presents some of the problems that are encountered in individual study programs. Independence or self-discipline must be developed gradually. Students need to have a teacher provide frequent checks or reports on their progress. This can be done by establishing minimum standards for passing, with suggestions for related activities for advanced work. The student-student and student-teacher interaction creates a "noisier" authoritarian figure found in traditional classes. Evaluation of learning is difficult except in the content areas.

SUMMARY

Traditional classrooms use the lecture-recitation method for teaching knowledge and content. Laboratory activities are additional examinations of known facts and principles. In contrast, the inquiry and investigation method uses laboratory activities as a method of determining scientific facts and concepts. Studies show that both methods are successful in teaching knowledge and concepts.

Recent science teaching methodology emphasizes individual student involvement for acquiring knowledge, for laboratory investigations and independent research in areas of interest. Knowledge and content of learning was similar to the methods used and tested.

Chapter 3

PROCEDURES

The problem of this study was a comparison between teaching methods in the biology classes at Great Falls High School. The three areas compared were: basic biological knowledge, related scientific thinking, and interest in science. A test and questionnaire were designed to measure the difference in student responses in the two types of classes.

The description of the procedures used in this study includes information of the population compared, the experimental treatments used, the methods of collecting and organizing the data, the statistical hypotheses tested, an analysis of the data collected, and a summary of the chapter.

POPULATION DESCRIPTION

There were 256 biology students who participated in this comparative study in November, 1972. The three traditional classes had 48 students; the experimental group (IMM) had 208 students in twelve classes. Test scores from the Differential Aptitude Test were obtained for each student from the permanent records at Great Falls High School.

These DAT raw scores were used to statistically equate the students in this study.

EXPERIMENTAL TREATMENTS

One teaching method used in biology is traditional. By definition, this is a teacher-centered class in which students are presented factual materials through lecture and discussion. Laboratory activities are teacher directed. There are homework assignments and study sheets to be completed and graded. The teacher discusses with the entire class the labs completed, the text materials and the study guide questions. Class routine and the schedule of daily activities are programmed by the classroom teacher.

The development of the experimental method (IMM) began in 1970. Individualized multi-media classes use a student-centered, informal class structure. Factual material relating to the unit of study is available for the student but is not a scheduled part of class procedure. There are study outlines that present the basic biological knowledge needed and suggestions for reference texts to use. Cassette tapes and slides are also available for individual student use. Small group discussion is encouraged by having lab tables that seat four to six students.

Laboratory activities have been developed by the participating team of teachers to illustrate or develop concepts pertaining to the unit of study. In addition to the required lab activities for each unit, there are advanced labs that students may complete if they want to continue their investigations. Students may work independently or in small groups.

Classes in IMM biology are scheduled into two adjoining rooms. After the students have checked into their assigned classrooms, they are free to work in either area. Students are encouraged to discuss their work with other students and with any or all of the teachers. They are encouraged to develop responsibility for an in depth study in both factual and related scientific areas.

Each unit of study is scheduled into a block of time, usually two to three weeks in length. Work must be completed and evaluation of laboratory investigations, general biological knowledge, and student participation in learning and concept understandings are made. No emphasis is given to the knowledge acquired with a long, detailed unit test.

Students who are scheduled into IMM biology classes are involved in a new classroom experience, as science in

the junior high schools is taught by traditional methods. Science is required in the seventh and eighth grades in the Great Falls Public Schools; it is an elective in the ninth grade.

There is no science prerequisite for biology. However, a comparison of the students in each type of class who have and have not taken this science will be made in the final analysis of data.

A comparison of the girls and boys in both types of classrooms will be determined in the basic biological knowledge and related scientific thinking areas.

METHODS OF COLLECTING DATA

Data for this comparative study of biology teaching methods was obtained from an objective test and a questionnaire. These were given to all biology students during a regularly scheduled class period. The classroom teacher administered the test. Testing procedures were the same as for a class test. Special answer sheets were used so the data could be machine-scored and analyzed. Directions for using this were given before the test.

The five biology teachers participating in this comparison were involved in the test construction. Most

of the questions were taken from current test files, and the remainder were developed from teacher-resource materials. The content validity of the test was determined by an item-analysis of the test questions. A two-way grid was used to classify each test item as to content covered and student behavior required. In the final analysis, there were twenty-five questions in each of the areas of basic biological knowledge and related scientific thinking.

A measure of reliability was determined from test results. The internal consistency of the test was .789 using the Kuder Richardson Correlation as the reliability coefficient.

Each student identified his answer sheet with his name and room number. All tests were scored by machine and the total score for basic biological information and related scientific thinking was tabulated.

A questionnaire concerning interest in science and classroom method preference was given to the same students. The directions preceeded the items, and answer sheets were provided. The results were recorded by machine.

After completion of the test and questionnaire, the researcher coded this additional information on the answer

sheet: DAT raw score, sex, completion of ninth grade science, and teaching method used.

STATISTICAL HYPOTHESES

Traditional and experimental methods of teaching biology have been compared in the areas of basic knowledge, related scientific thinking, and student interest in science. The hypotheses presented were tested at the .05 level of significance. There was no determination as to the direction of difference in teaching methods so this test was regarded as a two-tailed test.

1. Null--There is no significant difference between the test scores of basic biological knowledge in the traditional and IMM biology classes.

Alternative--There is a difference between the test scores of basic biological knowledge in the traditional and IMM biology classes.

2. Null--There is no significant difference between the test scores of related scientific thinking in the traditional and IMM biology classes.

Alternative--There is a difference between the test scores of related scientific thinking in the traditional and IMM biology classes.

3. Null--There is no significant difference between the male population test scores of basic biological knowledge in the traditional and IMM biology classes.

Alternative--There is a difference between the male population test scores of basic biological knowledge in the traditional and IMM biology classes.

4. Null--There is no significant difference between the male population test scores of related scientific thinking in the traditional and IMM biology classes.

Alternative--There is a difference between the male population test scores of related scientific thinking in the traditional and IMM biology classes.

5. Null--There is no significant difference between the female population test scores of basic biological knowledge in the traditional and IMM biology classes.

Alternative--There is a difference between the female population test scores of basic biological knowledge in the traditional and IMM biology classes.

6. Null--There is no significant difference between the female population test scores of related scientific thinking in the traditional and IMM biology classes.

Alternative--There is a difference between the female population test scores of related scientific thinking in the traditional and IMM biology classes.

7. Null--There is no significant difference between the test scores of basic biological knowledge in traditional and IMM biology classes after the population had completed 9th grade science.

Alternative--There is a difference between the test scores of basic biological knowledge in traditional and IMM biology classes after the population had completed 9th grade science.

8. Null--There is no significant difference between test scores of related scientific thinking in traditional and IMM biology classes after the population had completed 9th grade science.

Alternative--There is a difference between the test scores of related scientific thinking in traditional and IMM biology classes after the population had completed 9th grade science.

9. Null--There is no significant difference between test scores of basic biological knowledge in traditional and IMM biology classes if the population did not take science in the 9th grade.

Alternative--There is a difference between the test scores of basic biological knowledge in traditional and IMM biology classes if the population did not take science in the 9th grade.

10. Null--There is no significant difference between test scores of related scientific thinking in traditional and IMM biology classes if the population did not take science in the 9th grade.

Alternative--There is a difference between the test scores of related scientific thinking in the traditional and IMM biology classes if the population did not take science in the 9th grade.

11. Null--There is no significant difference in student interest in science between the traditional and IMM biology classes.

Alternative--There is a difference in student interest in science between the traditional and IMM biology classes.

COLLECTION AND ANALYSIS OF DATA

All test and questionnaire scoring was done by machine. Tabulation of results and the analysis of data

was made by the computer service at Montana State University. The raw test scores for basic biological knowledge and related scientific thinking were analyzed, using the analysis of covariance. The DAT raw score was the covariate. An F value was computed for each statistical hypothesis proposed. The adjusted mean of each group, the F statistic and the significant value of F at the .05 level of significance has been determined. This data has been tabulated and interpreted in Chapter 4.

Data from the questionnaire was recorded and analyzed, using the chi-square of independence. Results have been itemized and interpreted in the following chapter.

SUMMARY

This chapter has outlined the procedures used to compare two biology teaching methods used at Great Falls High School. There were 256 students tested for basic biological knowledge and related scientific thinking. These students also completed a questionnaire on their interest in science.

The data was analyzed, and the hypotheses were tested at the .05 level of significance. This information has been presented and interpreted in the next chapter.

Chapter 4

ANALYSIS OF THE DATA

A comparison of traditional and individualized multi-media biology classes at Great Falls High School was made November, 1972. An objective test containing questions of basic biological knowledge and related scientific thinking was used for data collection. The raw test scores were analyzed by the analysis of covariance and reported as adjusted mean scores and a value of F. A questionnaire determined student interest in science. Results were statistically analyzed using the chi-square of independence.

OBJECTIVE TEST ANALYSIS

The researcher has reported the results of the test with a restatement of the original hypothesis. A tabulation of pertinent data follows. An interpretation of the statistical data and confirmation or rejection of the hypothesis has been made at the .05 level of significance.

1. Null--There is no significant difference between the test scores of basic biological knowledge in the traditional and IMM biology classes.

Alternative--There is a difference between the test scores of basic biological knowledge in the traditional and IMM biology classes.

5.15	Table value of F for 1 and 253 D.F.	
31.1274	Computed value of F	
	N	Adjusted mean score
Traditional	48	21.8489
IMM	208	16.5749

The computed value of F greatly exceeded the table value of F so the difference could not be due to chance alone. Therefore, there was a significant difference between the traditional and IMM classes in basic biological knowledge. There was a difference in the adjusted mean scores of the two types of classes. The traditional classes mean score was greater than the IMM classes.

The null hypothesis is rejected and the alternative hypothesis of difference between the traditional and IMM classes in basic biological knowledge must be accepted.

2. Null--There is no significant difference between the test scores of related scientific thinking in the traditional and IMM biology classes.

Alternative--There is a difference between the test scores of related scientific thinking in the traditional

and IMM biology classes.

5.15 Table value of F for 1 and 253 D.F.
31.1274 Computed value of F

	N	Adjusted mean score
Traditional	48	18.9857
IMM	208	16.4264

The computed value of F exceeded the table value of F so the difference could not be due to chance alone. There was a significant difference between the traditional and IMM classes in related scientific thinking. There was a difference in the adjusted mean scores of the two types of classes. The traditional classes mean score was greater than the IMM classes.

The null hypothesis is rejected and the alternative hypothesis of difference between the traditional and IMM classes in related scientific thinking must be accepted.

3. Null--There is no significant difference between the male population test scores of basic biological knowledge in the traditional and IMM biology classes.

Alternative--There is a difference between the male population test scores of basic biological knowledge in the traditional and IMM biology classes.

5.15 Table value of F for 1 and 120 D.F.
 6.1744 Computed value of F

	N	Adjusted mean score
Traditional	20	18.4089
IMM	101	16.6616

The computed value of F exceeded the table value of F; there was a difference between the traditional and IMM classes in basic biological knowledge in the male population. The adjusted mean scores showed a difference between the traditional and IMM classes.

The alternative hypothesis of difference between the male population in the traditional and IMM classes must be accepted. The null hypothesis is rejected.

4. Null--There is no significant difference between the male population test scores of related scientific thinking in the traditional and IMM biology classes.

Alternative--There is a difference between the male population test scores of related scientific thinking in the traditional and IMM biology classes.

5.15 Table value of F with 1 and 120 D.F.
 35.1787 Computed value of F

	N	Adjusted mean score
Traditional	20	22.0832
IMM	101	16.8251

The computed value of F exceeded the table value of F; there was a difference between the traditional and IMM classes in related scientific thinking in the male population. The adjusted mean scores showed a difference between the traditional and IMM classes.

The alternative hypothesis of difference between the male population in the traditional and IMM classes must be accepted. The null hypothesis is rejected.

5. Null--There is no significant difference between the female population test scores of basic biological knowledge in the traditional and IMM biology classes.

Alternative--There is a difference between the female population test scores of basic biological knowledge in the traditional and IMM biology classes.

5.02 Table value of F with 1 and 200 D.F.
30.1013 Computed value of F

	N	Adjusted mean score
Traditional	28	19.4742
IMM	107	16.1843

The computed value of F exceeded the table value of

F; there was a difference between the traditional and IMM classes in basic biological knowledge in the female population. The adjusted mean scores showed a difference between the traditional and IMM classes.

The alternative hypothesis of difference between the female population in the traditional and IMM classes must be accepted. The null hypothesis is rejected.

6. Null--There is no significant difference between the female population test scores of related scientific thinking in the traditional and IMM biology classes.

Alternative--There is a difference between the female population test scores of related scientific thinking in the traditional and IMM biology classes.

5.02	Table value of F with 1 and 200 D.F.
70.8486	Computed value of F

	N	Adjusted mean score
Traditional	28	21.7242
IMM	107	16.3245

The computed value of F exceeded the table value of F; there was a difference between the traditional and IMM classes in related scientific thinking in the female population. The adjusted mean scores showed a difference

between the traditional and IMM classes.

The alternative hypothesis of difference between the female population in the traditional and IMM classes must be accepted. The null hypothesis is rejected.

7. Null--There is no significant difference between the test scores of basic biological knowledge in traditional and IMM biology classes after the population had completed 9th grade science.

Alternative--There is a difference between the test scores of basic biological knowledge in the traditional and IMM biology classes after the population had completed 9th grade science.

5.15	Table value of F with 1 and 120 D.F.
43.1428	Computed value of F

	N	Adjusted mean score
Traditional	24	22.0798
IMM	100	17.0108

There is a significant difference between the traditional and IMM classes in basic biological knowledge when the population had completed 9th grade science. The table value of F is exceeded and the adjusted mean scores showed a difference.

The null hypothesis is rejected and the alternative hypothesis of difference is accepted.

8. Null--There is no significant difference between test scores of related scientific thinking in the traditional and IMM biology classes after the population had completed 9th grade science.

Alternative--There is a difference between the test scores of related scientific thinking in traditional and IMM biology classes after the population had completed 9th grade science.

5.15 Table of F with 1 and 120 D.F.
16.4471 Computed value of F

	N	Adjusted mean score
Traditional	24	19.5355
IMM	100	16.8015

There is a significant difference between the traditional and IMM classes in related scientific thinking when the population had completed 9th grade science. The table value of F is exceeded and the adjusted mean scores showed a difference.

The null hypothesis is rejected and the alternative hypothesis of difference is accepted.

9. Null--There is no significant difference between test scores of basic biological knowledge in traditional and IMM biology classes if the population did not take science in the 9th grade.

Alternative--There is a difference between the test scores of basic biological knowledge in traditional and IMM biology classes if the population did not take science in the 9th grade.

5.02	Table value of F with 1 and 200 D.F.
54.7987	Computed value of F

	N	Adjusted mean score
Traditional	24	21.6291
IMM	108	16.1657

There is a significant difference between the traditional and IMM classes in basic biological knowledge when the population did not take science in the 9th grade. The table value of F is exceeded and the adjusted mean scores showed a difference.

The null hypothesis is rejected and the alternative hypothesis of difference is accepted.

10. Null--There is no significant difference between test scores of related scientific thinking in traditional

and IMM biology classes if the population did not take science in the 9th grade.

Alternative--There is a difference between the test scores of related scientific thinking in the traditional and IMM biology classes if the population did not take science in the 9th grade.

5.02 Table value of F with 1 and 200 D.F.
15.1454 Computed value of F

	N	Adjusted mean score
Traditional	24	18.4974
IMM	108	16.0654

There is a significant difference between the traditional and IMM classes in related scientific thinking when the population did not take science in the 9th grade. The table value of F is exceeded and the adjusted mean scores showed a difference.

The null hypothesis is rejected and the alternative hypothesis of difference is accepted.

QUESTIONNAIRE ANALYSIS

Does the teaching method used increase student interest in science? There were 48 traditional students and 208 IMM students who answered a questionnaire designed

to test these hypotheses.

11. Null--There is no significant difference in student interest in science between the traditional and IMM biology classes.

Alternative--There is a difference in student interest in science between the traditional and IMM biology classes.

The results of each of the sixteen items have been tabulated. The number of students who responded to each of the categories in traditional and IMM classes have been recorded and the chi-square value for each item has been reported.

The table value for 4 degrees of freedom at the .05 level of significance is 9.49. None of the chi square values are significant. The null hypothesis of no difference in teaching methods increasing student interest in science must be accepted. The alternative hypothesis is rejected.

Table 1
Responses for Both Traditional and IMM Classes

Response	1	2	3	4	5
----------	---	---	---	---	---

Item 61

Traditional	17	18	3	5	5
Experimental	73	56	3	4	5

Chi Square = 3.4380 with 4 D.F.

Item 62

Traditional	12	25	3	7	1
IMM	58	123	11	15	0

Chi Square = 7.2966 with 4 D.F.

Item 63

Traditional	8	30	2	7	1
IMM	58	117	4	26	2

Chi Square = 3.5450 with 4 D.F.

Item 64

Traditional	15	20	2	9	2
IMM	78	84	10	32	3

Chi Square = 2.2195 with 4 D.F.

Item 65

Traditional	0	16	12	14	4
IMM	4	43	50	66	43

Chi Square = 7.0712 for 4 D.F.

Table 1 continued. Responses for Both Traditional and IMM Classes

Responses	1	2	3	4	5
-----------	---	---	---	---	---

Item 66

Traditional	11	9	11	11	4
IMM	52	33	51	46	23

Chi Square = .5741 for 4 D.F.

Item 67

Traditional	13	10	6	5	13
IMM	51	62	17	37	39

Chi Square = 4.6855 for 4 D.F.

Item 68

Traditional	3	26	5	6	7
IMM	18	75	33	37	43

Chi Square = 5.7220 for 4 D.F.

Item 69

Traditional	10	15	20	2	0
IMM	39	82	74	8	2

Chi Square = 1.6467 for D.F.

Item 70

Traditional	12	20	10	2	3
IMM	88	71	26	14	6

Chi Square = 7.2336 for 4 D.F.

Table 1 continued. Responses for Both Traditional and IMM Classes

Responses	1	2	3	4	5
Item 71					
Traditional	24	17	5	2	0
IMM	75	67	47	15	3
Chi Square = 6.1479 for 4 D.F.					
Item 72					
Traditional	6	14	19	7	2
IMM	18	57	113	10	8
Chi Square = 7.8746 for 4 D.F.					
Item 73					
Traditional	8	24	3	8	3
IMM	53	90	17	33	11
Chi Square = 1.9424 for 4 D.F.					
Item 74					
Traditional	16	14	12	4	0
IMM	96	63	35	8	3
Chi Square = 5.3317 for 4 D.F.					
Item 75					
Traditional	9	28	5	6	0
IMM	33	129	19	23	1
Chi Square = .6409 for 4 D.F.					
Item 76					
Traditional	3	14	23	7	1
IMM	11	64	102	21	6
Chi Square = .8928 for 4 D.F.					

SUMMARY

The data from the objective test and the questionnaire have been statistically analyzed.

Test results were reported in this manner. Each hypothesis proposed was restated. The statistical results as a value of F and the adjusted mean score was tabulated. The rejection of the null and the acceptance of the alternative was made in all hypotheses comparing traditional and IMM classes.

Traditional classes exceeded the IMM classes when adjusted mean scores were compared in basic biological knowledge and related scientific thinking. Subdivisions in these test areas also showed a difference between the two teaching methods. Comparisons were made with total test scores, male population only, female population only, those students that had taken 9th grade science, and those students that had not taken 9th grade science as an elective.

The responses from a questionnaire in the traditional and IMM biology classes were tabulated. Statistical analysis using the chi square of independence showed no difference in student interest in science in the two types of teaching methods.

Conclusions and recommendations have been made by the researcher in the next chapter.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

This study has compared two teaching methods used in biology at Great Falls High School. There are traditional, teacher-centered classes and classes using an innovative program of individualized multi-media (IMM) instruction. A comparison of these methods was made in three areas: 1) basic biological knowledge, 2) related scientific thinking, and 3) student interest in science.

An objective test designed to measure basic biological knowledge and related scientific thinking was given November, 1972 to all students enrolled in biology. The data collected and analyzed showed that there was a difference in the two teaching methods in both areas. A questionnaire accompanied the test; the purpose was to measure student interest in science. The analysis of data showed that the teaching method used did not increase student interest in science.

CONCLUSIONS

Traditional classes used lecture, class discussion, and related laboratory and study guide activities to develop student understanding of basic biological

information. In the IMM classes, this type of learning was minimized; it was not a scheduled part of class activity. Students had the materials available for learning basic biological knowledge with cassette tapes and slides, reference reading, and student group discussions. Teachers did not direct the study and discussion in this area.

Related scientific thinking in traditional classes developed from teacher-directed activities. The basis and direction was programmed into class laboratory and study assignments. IMM classes emphasized laboratory investigations to develop scientific thinking. Involvement in these activities was student-centered.

Results of the test show differences in traditional and IMM classes.

Table 2
Differences in Traditional and IMM Classes

Test Areas	Adjusted Mean Scores	
	Traditional	IMM
Basic Information	21.8419	16.5749
Scientific Thinking	18.9857	16.4264

The difference in class structure and emphasis on learning was illustrated by the higher basic biological information test score in the traditional classes. When comparing the basic information and related scientific thinking areas within each type of class, the traditional classes show a lower mean score on the related scientific thinking test. This corresponds to the class structure and emphasis.

Individualized multi-media classes showed little change in the mean scores in the two areas tested. Classes were designed with laboratory investigations to develop scientific thinking. However, test scores did not show an increase in scientific thinking ability.

Data from this comparative study does not parallel the studies in the review of literature. Comparative teaching methods of Rainey (10), Yager and Wick (16), and Bennett (3) showed factual information learned was similar in all classes tested with an increase in scientific thinking in the innovative classes.

Questionnaire results showed no difference in interest in science with the teacher-centered, traditional classroom or the student-centered, IMM classroom. Biology students showed no preference for structured lecture,

lab-discussion classes or informal, individualized lab-oriented classes.

RECOMMENDATIONS

The difference in basic biological information test scores showed a need for review and evaluation of the minimum requirements in IMM classes. The researcher recommends restructuring the presentation of basic knowledge to stimulate scientific thinking. Comparison of individualized multi-media format with parallel innovative programs reviewed in the literature may provide direction for these revisions. Laboratory investigation revisions should be directed toward reinforcement of student understanding and development of scientific thinking.

Teacher-centered classes present well organized, programmed directions for the students. This is the type of classroom instruction they have had in previous years of science. In contrast, the IMM classes are student-centered with the teacher as a participant in learning, only if the student seeks help. This was a new experience for all students scheduled into IMM biology. They have had little training or preparation for the responsibility of self-directed learning.

The researcher recommends scheduling teacher-student discussion sessions. This would direct student learning in both basic information and related scientific thinking areas. Emphasis on understanding and interpretation of laboratory investigations in these small discussion groups should be individualized to meet the needs of the participating students. The members of the teaching team should vary the activities and presentations for each student group. Individual student-teacher discussion should develop from the small groups. These may have to be programmed by a teacher until student responsibility and involvement in science has developed.

After changes in the IMM course content have been completed and the small discussion groups directed by a teacher have been developed, the researcher recommends that another comparative study of the two teaching methods be made.

APPENDIX A

BIOLOGY QUESTIONNAIRE

Directions:

Read each statement or question carefully. Choose your answer from the rating scale immediately below the question that is most appropriate for you.

The descriptions are relative; the best rating is at the left (1) and the lowest rating is at the right (5).

Mark the number on the answer sheet that best expresses how you feel about the question, or statement.

The questionnaire begins at number 61 on the answer sheet.

61. If you had it to do over again, would you take biology?

1	2	3	4	5
definitely yes	maybe yes	don't know	probably not	absolutely not

62. How do you find your biology class?

1	2	3	4	5
very interesting	somewhat interesting	don't know	seldom interesting	never interesting

63. Your attitude toward this class has been?

1	2	3	4	5
highly favorable	somewhat favorable	don't care	not always favorable	very unfavorable

64. How interested are you in learning more about biology?

1	2	3	4	5
very interested	somewhat interested	don't care	not too interested	not at all interested

65. Does biology relate to other classes you are taking?

1	2	3	4	5
always	usually	not sure	seldom	never

66. Are you interested in taking another science class next year?

1	2	3	4	5
very interested	somewhat interested	undecided	not very interested	not at all interested

67. After high school graduation, do you plan to study science or something related to science?

1	2	3	4	5
definitely	maybe	undecided	probably not	no

68. Do you have hobbies or interests relating to science?

1	2	3	4	5
most of them	part of them	not sure	very little	none

69. Your teacher's concern for students is

1	2	3	4	5
outstanding	above average	average	below average	very poor

70. This course has encouraged you to think

1	2	3	4	5
greatly	usually	like other classes	sometimes	very little

71. Laboratory procedures have been understood

1	2	3	4	5
almost always	usually	sometimes	usually not	never

72. Your teacher's presentations of basic information was

1	2	3	4	5
novel, original	very interesting	fair	not very interesting	boring

73. The labs done in this course stimulated learning

1	2	3	4	5
always	usually	don't know	sometimes	very little

74. This course encouraged individual responsibility

1	2	3	4	5
a great deal	usually often	sometimes	once in a while	not at all

75. This course has been

1	2	3	4	5
very difficult	sometimes difficult	same as other classes	usually easy	very easy

76. Meaningful evaluation of student accomplishment (grading) was

1	2	3	4	5
outstanding	above average	average	below average	poor

APPENDIX B

BIOLOGY TEST

Directions:

Each question in this test is followed by four choices for an answer. Read each question and then decide which is the one best answer. On the separate answer sheet find the row which has the same number as the question you are answering. In that row blacken the space to the right of the number that matches the answer you choose. Make your marks heavy and black. If you make a mistake, erase completely the answer you wish to change. The answer sheet is numbered across the page.

Look at the example below:

475. Which one of the following diseases is transmitted by a mosquito?
- 1) smallpox
 - 2) tetnaus
 - 3) malaria
 - 4) pneumonia

Sample of Answer Sheet

475. 1----- 2----- 3----- 4----- 5-----

Make no marks in this booklet. Do not open this booklet until told to do so.

1. Every known cell contains--
 - 1) cellulose
 - 2) chloroplasts and centromeres
 - 3) plasma membrane and cytoplasm
 - 4) vacuoles and cell walls
 2. Which of the following is true of all cells?
 - 1) They are basically the same in structure, yet different in shape and function.
 - 2) They have a cell wall and a definite nuclear membrane.
 - 3) They have either cytoplasm or protoplasm.
 - 4) They have the ability to make their own food.
 3. Cytoplasm--
 - 1) is the portion of the cell outside the nucleus and within the cell membrane
 - 2) is a region and not a single substance or structure
 - 3) is relatively fluid in living cells
 - 4) all of the above are true
 4. The control center of all cell activity is the--
 - 1) cytoplasm
 - 2) nucleus
 - 3) nucleolus
 - 4) mitochondria
 5. A cell containing only structures found in both plant and animal cells would include--
 - 1) cell wall, cell membrane, nucleus, and cytoplasm
 - 2) chloroplasts, cytoplasm, and nucleus
 - 3) cell membrane, nucleus and cytoplasm
 - 4) cell wall, chloroplasts, a large vacuole and cytoplasm
 6. The cell nucleus may be said to control growth and reproduction because it contains--
 - 1) cytoplasm
 - 2) chondriosomes
 - 3) chromosomes
 - 4) centrosomes
-

7. Which structure carries out a similar function in both plant and animal cells?
- 1) cell wall
 - 2) chloroplast
 - 3) plasma membrane
 - 4) all of these
8. Two structures found in a plant cell but not in an animal cell are--
- 1) cell wall and chloroplasts
 - 2) centrosomes and nucleolus
 - 3) vacuole and chromosomes
 - 4) plasma membrane and Golgi bodies

Where are the following cell organelles or materials found? (Use numbered answers from the list at the right.)

- | | |
|---------------------------|---|
| 9. Nucleolus | |
| 10. Golgi apparatus | Answers: |
| 11. Cell wall | 1) Outside of the cell
(plasma) membrane |
| 12. Mitochondrion | 2) In the cytoplasm |
| 13. Endoplasmic reticulum | 3) Inside the nucleus |
| 14. Chromosome | 4) In the nucleus and in the
cytoplasm |
| 15. Ribosome | |
| 16. Lysosome | |
| 17. DNA | |
| 18. Chromatin | |
| 19. Chloroplast | |
| 20. Vacuole | |

21. Animal cells lacking nuclei would also lack--
 - 1) mitochondria
 - 2) chromosomes
 - 3) cell membranes
 - 4) vacuoles
22. The structure of a cell is most closely related to its--
 - 1) age
 - 2) number of mitochondria
 - 3) function
 - 4) size of the chloroplasts
23. A summary of the cell theory would state that--
 - 1) some plant-like and some animal-like forms exist as unicellular organisms
 - 2) all living organisms consist of cells, either as single cells or as groups of cells
 - 3) all cells are alike
 - 4) all organisms have cells, but many are essentially noncellular
24. The cell is considered to be the fundamental living unit because--
 - 1) the organism is composed of cells
 - 2) it is the smallest amount of material that exhibits growth, metabolism, self-regulation and self-reproduction
 - 3) no smaller unit of material can be experimentally tested by the biologist
 - 4) it is the smallest part of the organism that is visible through the microscope
25. Cells in multicellular organisms assume a nearly endless variety of shapes largely in relation to--
 - 1) special function they serve in the organisms as a whole
 - 2) the size of the organism in which they are found
 - 3) the number of the cells in a particular tissue
 - 4) none of these

Questions 26-30 are based on the following diagrams and descriptions of a number of specialized cells.



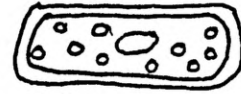
Flat cell

I



Elongated cell

II



Thick-walled
cell with starch
grains

III



Thick-walled
flat cell

IV



Thick-walled cell
with chloroplasts

V



Ameba-like cell

VI

26. Impulses are generally conducted by cells of type
- 1) I.
 - 2) II.
 - 3) V.
 - 4) VI.
27. Surfaces of animals are generally covered by cells of type
- 1) I.
 - 2) II.
 - 3) III.
 - 4) IV.
28. Manufacture of food would be expected in cell type
- 1) I.
 - 2) III.
 - 3) IV.
 - 4) V.

29. Which of these cells can move independently?

- 1) II.
- 2) III.
- 3) V.
- 4) VI.

30. Which of these cells would be best for support?

- 1) I.
- 2) II.
- 3) IV.
- 4) VI.

Early observers of the cell invented new terms or used old terms in new ways for the structures they observed. The following questions use some of these terms. You should be able to determine which structure was being referred to by the way in which the word is used. In each of the questions which follow, select the structure referred to from the key.

Each utriculus contains a single circular areola which is not in the same place in every utriculus. In some it appears near the surface; in others near the center. A jelly-like substance surrounds the areola.

31. What is the utriculus?

KEY:

32. What is the jelly-like substance?

- 1) nucleus
- 2) cell
- 3) vacuole
- 4) cytoplasm

33. What is the areola?

All cells are covered by a thin lamina, which completely surrounds the cell. In plant cells this is surrounded by a single membrane which seems to cement the cells together.

34. What is the lamina?

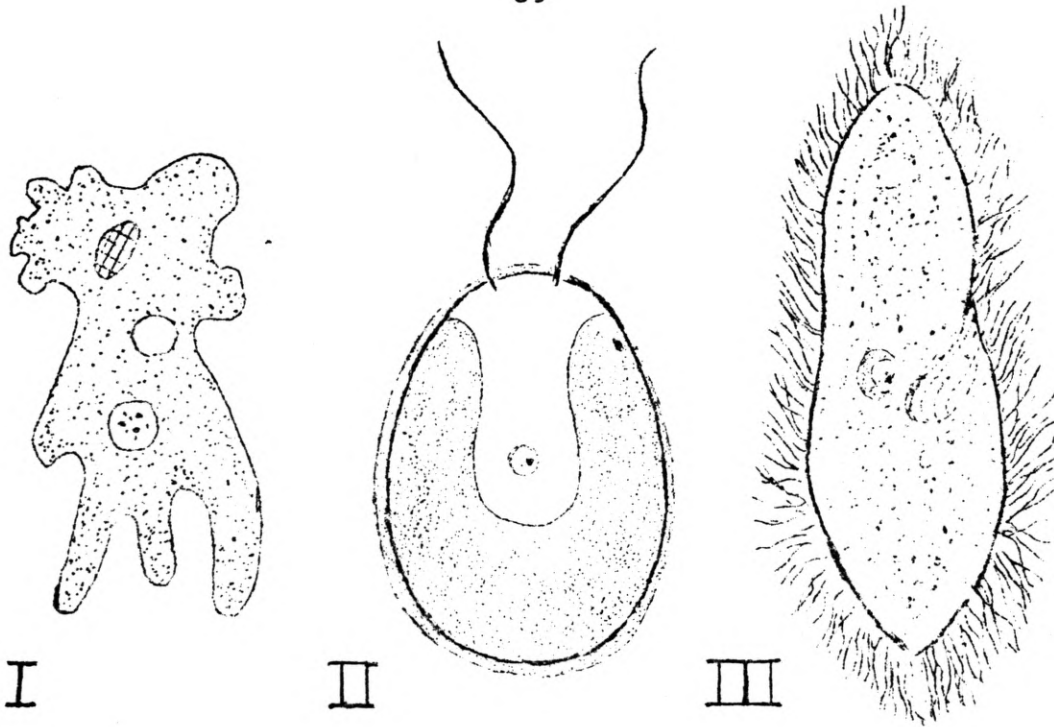
KEY:

35. What is the single membrane?

- 1) cell wall
- 2) cell membrane
- 3) nuclear membrane
- 4) cytoplasm

Choose the one that does not fit with the group. Answer by number.

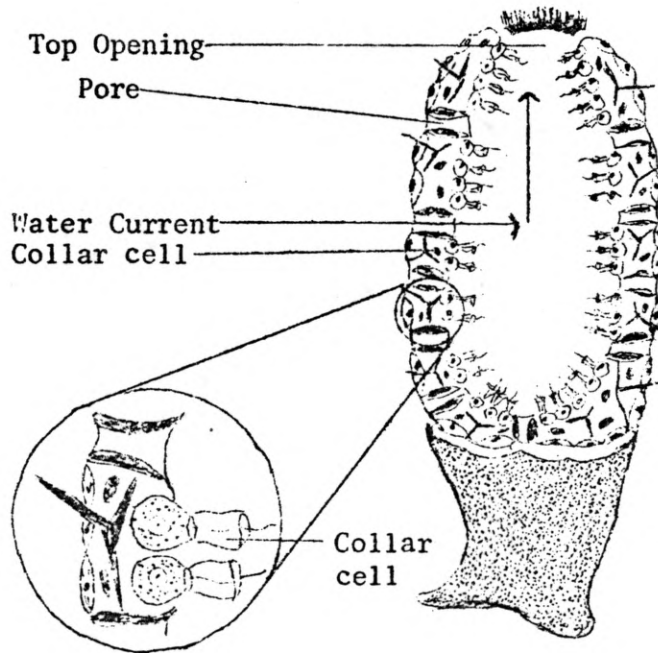
36. 1) cell, 2) crystal, 3) organ, 4) organism
37. 1) sand, 2) salt, 3) sugar, 4) snake
38. 1) proteins, 2) carbohydrates, 3) fats, 4) cytoplasm
39. 1) ionization, 2) growth, 3) reproduction, 4) excretion
40. 1) blood, 2) heart, 3) root, 4) stem
41. Both plants and animals are made of tiny units called cells. They use oxygen to release energy from their food and they store food reserves as fat. These facts--
 - 1) prove all life had a common origin
 - 2) support the idea that being alive is about the same in all living things
 - 3) indicate that plants evolved from animals
 - 4) support the idea that animals gradually evolved from plants
42. Which of the following represents the correct sequence of relative sizes (in descending order) of the materials named?
 - 1) cell, nucleus, water molecule, oxygen atom, chromosome
 - 2) nucleus, water molecule, cell, chromosome, oxygen atom
 - 3) chromosome, cell, nucleus, water molecule, oxygen atom
 - 4) cell, nucleus, chromosome, water molecule, oxygen atom



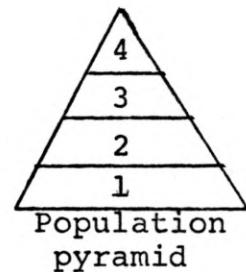
Pictured above are three organisms, each having different structures for locomotion (movement). The questions below involve these structures and what type of habitat they would permit an organism to live in.

43. Observe the locomotive structures of Organism I. Determine if it most likely lives in:
 - 1) a still pond
 - 2) a pond with slight currents
 - 3) a pond with heavy currents
 - 4) a fast moving mountain stream
44. Observe the locomotive structures of Organism II. Determine if it most likely lives in:
 - 1) a still pond
 - 2) a pond with slight currents
 - 3) a pond with heavy currents
 - 4) a fast mountain stream
45. Observe the locomotive structures of Organism III. Determine if it most likely lives in:

- 1) a still pond
 - 2) a pond with slight currents
 - 3) a pond with heavy currents
 - 4) a fast moving mountain stream
46. Why did you choose your answer for Organism I?
- 1) a plant cell that has no structures for locomotion
 - 2) a plant cell that has structures for locomotion
 - 3) an organism that can move slowly in any direction
 - 4) an organism that can move rapidly in any direction
47. Why did you choose your answer for Organism II?
- 1) a plant cell that has no structures for locomotion
 - 2) a plant cell that has structures for locomotion
 - 3) an organism that can move slowly in any direction
 - 4) an organism that can move rapidly in any direction
48. Why did you choose your answer for Organism III?
- 1) a plant cell that has no structures for locomotion
 - 2) a plant cell that has structures for locomotion
 - 3) an organism that can move slowly in any direction
 - 4) an organism that can move rapidly in any direction



49. The picture above is of a sponge, with a segment of it enlarged. The collar cell is labeled. What is its function?
- 1) they protect the sponge
 - 2) sweeps water through the cavity, so the sponge can get food
 - 3) secretes poisons to kill food
 - 4) none of the above
50. Because small organisms and cells are food for other organisms, which segment of the population pyramid would cells be located?
- 1) 1
 - 2) 2
 - 3) 3
 - 4) 4



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