This is to certify that the

thesis entitled

Modified Laboratory Activities for Cell Biology

Used as an Introduction to High School Biology

presented by

Brian A. Webster

has been accepted towards fulfillment
of the requirements for

MS degree in Biological Sciences

Major professor

Date 3/3/94

MODIFIED LABORATORY ACTIVITIES

FOR

CELL BIOLOGY

Used as an Introduction to High School Biology

By

Brian A. Webster

An Abstract of a Thesis

Submitted to:
Michigan State University
in partial fulfillment of the requirement
for the degree of

MASTER OF SCIENCE

Department of Natural Science

1993

ABSTRACT

Evaluation of Modified Activities in Cell Biology used as an introduction to High School Biology.

by

Brian A. Webster

The Modified Laboratory Activities for Cell Biology was used as a unit for a first-year biology course requirement for High School sophomores. The unit is tailored for students who have poor attendance, low test scores, and who are within a school having limited supplies and equipment. These labs twenty "hands on" cell biology laboratories pro-promote active involvement, and are geared for a wide range of student abilities and learning styles.

Each activity enables students to discover and appreciate the study of the cells as an enjoyable and integrated part of their biology curriculum. These activities are easy to do and stimulate as well as entertain students while enabling them to master basic skills.

The materials for activities were readily available and inexpensive, and the laboratory format was condensed and modfied to fit the needs and interests of the students.

The students' understanding of cell biology and its implementation was measured using a Pre-test, Post-test, along

with an Evaluation Survey.

As a result of the application of this unit, the students demonstrated progressively high scores as well as a desire to complete each task.

ACKNOWLEDGMENTS

Sincere appreciation must be expressed for assistance, support and encouragement provided by Dr. Clarence Suelter and Dr. Merle K. Heidemann. They first proposed the idea of implementing "hands-on" activities with an emphasis on cell biology. It is also necessary to mention the immeasurable benefits and varied experiences connected with the workshops in Molecular Biology and Environmental/Behavioral Biology, along with the Frontiers Program in Biological Science.

My gratitude also goes out to my students, because without their patience and cooperation there would be no Cell Biology Unit. It was their work, dedication, and discipline that made this program such a success. I believe in the philosophy that good students make good teachers.

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CHAPTER 1

INTRODUCTION

INTRODUCTION

Teaching at Redford High School, a high-risk, high-needs urban minority institution, served as an impetus for the development of this program. Problems that beset the school in general, such as poor attendance, lack of interest and inadequate supplies, are also the primary problems in the science classroom. Added to these problems is a very negative perception about studying science. To address these problems in sophomore biology classes, this program was developed to provide interactive, hands-on activities that could be understood and completed within fifty minutes with minimal equipment and supplies. The labs were developed to pique the interest of even the occasional learner whose brief forays into the classroom were usually very ambiguous for the student.

The problems attendant to lengthy laboratory activities that required an extensive pre-lab, days to complete and a comprehensive lab debriefing are avoided in this approach. Also avoided is the nearly insurmountable task of preparing for such labs, with their very expensive and extensive materials. What is not studiously avoided is finding ways for the students to become involved in "hands-on, minds-on activities" (Tobin, 1987) that appeal to their individual learning styles.

Research in science instruction provides the basis for these ideas:

> Students who engage in activity-based instruction have more positive attitudes toward science.
>
> The more direct experiences students are given with concept development, the more successful they will be in comprehending the textbook material.
>
> Hands-on activity based instruction improves communication, computational and problem-solving skills. (Yager, 1991)

The students involved in the testing of this program were sophomores at Redford High School. Each of the students has had one year of Fundamentals of Natural Science. Redford High School has a student population of over three thousand students, one hundred thirty-five teachers (thirteen science teachers) and another fifty administrators and support staff.

The ethnicity of the students is 99% African American. The remaining 1% are Caucasian, Asian, and Hispanic. The students also come from socio-economically diverse families, with students coming from traditionally middle-class families to those families classified as low-income.

The students are subjected to an anti-intellectual environment with high levels of violence evident.

The focus of this program was to create interest in science, improve attendance and enhance achievement. The qualitative issue of interest was addressed by using an attitude survey, administered before and after the unit. A significant increase in development of a positive attitude toward the study of science was evident.

A demonstrable improvement in attendance during the program had a carry-over effect into the next unit. The results on the pre- and post-tests showed the accumulation of knowledge about this unit.

What was less measurable was an increase in science process skills that influenced subsequent learning. This correlated with research that suggests guided inquiry is the most successful mode of instruction:

> Have students use as many hands-on activities as possible to help them discover biological concepts for themselves. Provide students with an introduction to a concept and enough background information so they can work out the rest of the idea. Begin with the familiar and move toward the unfamiliar. (Gordon, 1990)

CHAPTER 2

INSTRUCTION

OUTLINE OF UNIT

PRE-TEST

1. Microscope
2. Making a cell
3. Cheek cells
4. Onion cells
5. Osmotic imbalance
6. Cell division
7. Chromosome number
8. Chromosome study
9. DNA model
10. Transcription and Translation
11. Making Protein: Translation
12. Protein
13. Properties of enzymes
14. Probability and heredity
15. Sex-linked traits
16. Crossing over
17. Gene pool
18. Dihybrid cross
19. Trait survey
20. Recombinant DNA

POST-TEST

EVALUATION

ANALYSIS OF LABORATORY ACTIVITIES

The laboratory activities in cell biology are divided into five categories of study.

1. Cell structure and function
2. Cell division and reproduction
3. Chromosome and DNA study
4. Protein and enzymes
5. Genetics and heredity

The labs within this unit are based on the Scientific Method and follow this format:

I. Introduction

II. Materials

III. Procedure

IV. Observations

V. Analysis and Conclusion

I. INTRODUCTION - In the introduction students are given background information on the activity that includes the purpose and the connections to prior learning.

II. MATERIALS - The materials needed to do these activities are easily obtained: paper, rulers, glue, scissors, etc. Most are readily available household supplies. Other pieces of equipment such as microscopes, glassware, along with stains and dyes, may be obtained from a high school science lab.

III. PROCEDURE - The procedure is briefly stated in a simplified manner. The step-by-step process involves five steps or less. This helps maintain the students' interest, keeping the students on task throughout the lab activities.

IV. OBSERVATION - During the lab, the students are able to note changes that take place throughout the duration of the lab activity. Some labs require students to make drawings of what they observed, while others require a brief written explanation as to what they have witnessed. The students graph their data, if indicated, and compare their results with those of the other students in the lab.

V. ANALYSIS AND CONCLUSION - This section encourages students to answer questions and draw their conclusions based on the results of the observations obtained from their activity.

The laboratory activities are provided in Appendix A.

LAB #1 MICROSCOPE

The students in this activity were to learn the proper use of the microscope, a basic tool for the study of cell biology. The students worked in collaborative units. Each group shared the responsibilities of gathering the materials: microscope, slides, cover-slips, newspaper and other samples.

A brief pre-lab discussion consisted of a review of the parts of the microscope and its appropriate use. The proper method of preparing a wet mount was also demonstrated.

The students were instructed to start their investigation by observing the letter "e". This was to be followed with attempting to read a word or phrase from the newspaper through the microscope. Upon mastery of the necessary locating and focusing skills, the students were free to investigate items such as make-up, hair strands and skin. A variety of preserved slides were also available for investigation.

LAB #2 MAKING A CELL

The purpose of this activity is to understand the structure and function of organelles in animal cells. Since many of these components are too small to be seen with the light microscope, a model cell was created using food materials such as noodles, cereal and beans to represent the cellular organelles. The materials were readily available for under ten dollars. They were placed in containers marked with the organelle they were to represent.

Using a textbook diagram of an animal cell as a template, the students wrote their function next to the name of the organelle.

LAB # 3 CHEEK CELLS

Students were given an opportunity to observe their own cells using the microscope. Telling students that the human body consists of billions of cells is not as effective as having them examine their own cells.

The students were guided through the procedure of gently scraping their cheek cells in a preparation of a wet mount.

The students were asked to sketch the structures they observed and to label them based on the "Making a Cell" activity. They were then asked to list which structures were in the textbook and in their model but that could not be seen under the microscope.

LAB # 4 ONION CELLS

Observing a plant cell under the microscope gave the students the chance to compare the structure of a plant cell with that of an animal cell. The students prepared a wet mount of thin sections of onion. After observing and sketching what they saw under low and high power, the students stained additional onion slides, using a demonstrated staining technique.

The students again sketched and labeled what they observed. A brief written comparison of the effects of staining onion cells on visibility was also included.

LAB # 5 OSMOTIC IMBALANCE

The concept of transport through a cell membrane was presented to the students using examples from daily life. To reinforce these concepts, the students exposed plant cells to hypotonic and hypertonic environments.

While waiting for the results, the students were asked to formulate an hypothesis about the outcome of their treatments. The students recorded their hypothesis and their final observations. They then sketched diagrams of the cells before and after treatment.

The students were asked to describe the mechanisms that might be the explanation for their results. They were then debriefed to check to see that appropriate conclusions were made.

LAB # 6 CELL DIVISION

In this activity the students modeled the steps of mitosis using a variety of materials such as colored construction paper, yarn, toothpicks (donated by the school's art department). These materials were measured, cut and assembled on a long sheet of construction paper, to depict the cell parts and the role they play in the mitotic process.

The students used a diagram of mitosis as their guide. They labeled their assembled construction as to the phases and the names of the individual components. Upon completion of this activity, the students viewed prepared microscope slides depicting the stages of cell mitosis.

LAB #7 CHROMOSOME NUMBER

The species specificity of chromosome number was evaluated in animals. A worksheet supplying information about chromosome number gave the students the opportunity to compare the number of chromosomes in different species and to speculate about their differences.

The unique nature of the chromosome number in plants was explored by looking at specific plants and their hybrids using seed catalogues. Students cut out pictures to make family groupings. The economic value of hybrids was then discussed with the students. They were asked to speculate about this process if it were to be applied to human beings.

LAB #8 CHROMOSOME STUDY

The students were introduced to the clinical laboratory test of producing a human karyotype.

Students were given a sample simulating normal chromosomal distribution in the cell nucleus. They were directed to sort the forty-six chromosomes and to arrange them into homologous pairs according to their likeness in both shape and structure to produce a karyotype.

After matching chromosomes the students assembled and numbered their sequence. Pictures of human karyotypes with abnormalities were then given to the students to compare to their normal karyotype.

LAB #9 DNA MOLECULE

This lab permits students to learn how the nucleotides (phosphates, sugars and bases) are arranged in a DNA molecule. By using candies of different colors and joining them together with toothpicks the students were able to demonstrate how the base-pairing rule applies to the building of DNA.

The students fitted "pick up sticks" through the outside phosphate groups (miniature marshmallows) for support. Twisting the sticks provided a clear illustration of how the DNA is shaped into a double helix.

LAB #10 TRANSCRIPTION

To demonstrate transcription and translation, the students traced and cut out the DNA components from colored construction paper, using the same colors used in the DNA candy lab. Students constructed the RNA strand from the DNA code spelled out on the lab sheet. The tracings were assembled, labeled and glued on a sheet of paper. The students made their observations, then answered the questions pertaining to the shape of the DNA/RNA molecule.

LAB #11 MAKING PROTEIN: TRANSLATION

This lab is basically a follow-up activity worksheet showing how DNA and RNA are involved in the making of protein. The previous laboratory demonstrated how the message in DNA is transferred to m-RNA. The students in this activity fill in the missing pieces of the puzzle needed to code the specific amino acids to form protein.

The order of events in the building of protein were diagrammed and discussed prior to doing this activity.

LAB # 12 PROTEIN

This is a standard laboratory investigation in which diverse materials are tested for the presence of protein using nitric acid staining.

The students place materials in test tubes and added drops of nitric acid to the test tubes of each sample being tested. The students recorded their observations, determining whether the materials contained protein.

LAB #13 PROPERTIES OF ENZYMES

In the pre-lab, the students were briefly exposed to the concepts of enzymes, substrates and catalysts. Liver contains the enzyme peroxidase. Peroxidase breaks down hydrogen peroxide into water and oxygen gas. Based on this information, the students were asked to hypothesize what if any effect altering the liver would have on its peroxidase activity.

The students placed liver, fresh, ground and boiled, into separate test tubes filled with two milliliters of hydrogen peroxide. They then rated the results from zero (having no bubbles) to ten (having the most activity). The students recorded their results. Many students were able to explain the observed differences and draw conclusions.

LAB #14 PROBABILITY AND HEREDITY

The purpose of this activity is to give students an understanding of what is meant by probability and how it plays a role in determining the outcome of visible physical traits.

The necessary genetic terms were introduced as well as the diagraming of a Punnett's square. From this, questions were raised concerning how different traits such as eye color might be passed on from generation to generation.

The activity of flipping coins to determine probability reinforced the concept of chance.

<u>LAB</u> #15 SEX-LINKED TRAITS

The pre-lab consisted of a review of the concept of sex-linked inheritance. Having already explored the role of probability in regard to autosomal inheritance in the previous lab, the special situation of sex-linked inheritance was covered. The students marked pennies. The one penny represented the egg cell and was labeled XM on one side and Xm on the other side. The penny representing the sperm was marked Y on one side and XM on the other side. The capital "M" on the chromosome is for a normal gene and the small "m" expresses the muscular dystrophy gene carried on the X chromosome. This procedure assumes neither parent has the condition.

The students flipped the coins 48 times, then tallied their results on the chart under the observation section of the lab sheet.

The students were then given a list of linked traits (i.e. baldness, color blindness) and asked to explain why their results showed a higher incidence of these traits in males.

<u>LAB</u> #16 CROSSING OVER

The students were introduced to the concept of meiosis and the possible exchange of homologous chromosomes. The chart diagramed on the lab sheet represented the crossing over points of seven genes on the homologous chromosomes of a fruit fly. The alleles were (A-G) on the one chromosome and (a-g) on its homologue.

Students rolled the dice. This number obtained would indicate the point of crossing over. The genes that were present on one chromosome (A-G) were switched at a location point on the adjoining chromosome (a-g). For example, point three might be shown as ABCdefg.

The students rolled the dice a set number of times and then tallied their results on the data table. Questions based on the activity were completed.

<u>LAB</u> #17 GENE POOL

The purpose of this activity is to simulate a gene pool, by demonstrating how the mixing of genes affects a population.

The students were given instructions in the procedure to form two piles of fifty each, containing thirty-five B: fifteen b. These were written on small pieces of paper to represent brown and blue-eyed individuals.

One pile represented males and one represented females. Assuming each pairing resulted in one child, it was possible to determine the genotype of the children.

It was the students' responsibility to randomly select one piece of paper from each pile and to create a genotype.

The students were to complete this task 49 times, as outlined in the procedure, then divide their pair totals by 50 and multiply by 100. They were then able to calculate the percentages of the two alleles for eye color in that given population.

The students were asked to critique this procedure and to list the variables of what would keep this matched system from working i.e. death, infertility, choosing not to reproduce, etc.

LAB #18 DIHYBRID CROSSES

This activity demonstrated the F one generation in a dihybrid cross with 2 alleles at each gene site. They were to simulate a dihybrid cross by using paper as flags on toothpicks. The flags represented the 2 gene traits and their alleles. The allele combination: BC, Bc, bC, bc of the sperm and egg cell were discussed at onset of this activity.

The students were responsible for placing the sex cells, male and female, into a Punnett square. They were then asked to predict the genotype ratio of each offspring. Punnett squares with labels across the top and along the side for the paired genes BC, Bc, bC, bc were provided. Completing the Punnett square made it possible to determine the ratio of each genotype.

LAB #19 TRAIT SURVEY

Performing a survey to determine the frequency of dominant and recessive traits within a small population demonstrates a trait survey. Students were given a list of detailed physical traits, evaluated themselves for these traits and completed the worksheet provided as part of the lab sheet.

The individual data were compiled and presented to the students as a class survey. The students then graphed the results.

LAB #20 RECOMBINANT DNA

The students modeled the techniques used by scientists in the technology of forming recombinant DNA. Prior to doing this activity the students were given an opportunity to assemble a DNA molecule (Lab #9) using the base-pairing rule.

In this activity students were asked to cut out segments of new DNA and splice in the complementary segment to the blank segment on the circular plasmid model.

Performing such recombinant DNA techniques gave students an understanding of how bacteria (Escherichia coli) can be given the genetic information for proteins and used to produce hormones and other substances.

CHAPTER 3

EVALUATION

PRE-TEST AND POST-TEST

A Pre-Test and Post-Test of the same twenty questions was administered before and after exposure to this unit. This test is found in the appendix B.

The students as a whole demonstrated a considerable improvement in performance on these questions. The students apparently developed a better understanding of the material during this "hands-on" Cell Biology Unit than through a lecture based format.

The improvements ranged from 5% to 70% as shown in (Figures 1-4). The trend seen in these figures strongly supports the supposition that clearly-demonstrated increases in learning would be seen with this method of teaching.

Table 1 PRE- AND POST-TEST DATA: 2ND HOUR

PRE-TEST			POST-TEST		
STUDENT	INDIVIDUAL SCORE	%	STUDENT	INDIVIDUAL SCORE	%
1	6	30	1	20	100
2	12	60	2	8	40
3	9	45	3	12	60
4	8	49	4	8	40
5	7	35	5	15	75
6	6	30	6	8	40
7	4	20	7	17	85
8	9	45	8	14	70
9	3	15	9	14	70
10	2	10	10	16	80
11	10	50	11	15	75
12	8	40	12	14	70
13	6	30	13	14	70
14	4	20	14	9	45
15	5	25	15	16	80
16	5	25	16	15	75

MEAN =	6.5	32.5%	MEAN =	13.4	67%
MODE =	6.0	30%	MODE =	14.0	70%
MEDIAN =	6.0	30%	MEDIAN =	14.0	70%
RANGE =	2.0-12.0	10-60 %	RANGE =	8.0-20.0	40-100%

Table 2 PRE- AND POST-TEST DATA: 4TH HOUR

PRE-TEST			POST-TEST		
STUDENT	INDIVIDUAL SCORE	%	STUDENT	INDIVIDUAL SCORE	%
1	12	60	1	17	85
2	7	35	2	6	30
3	7	35	3	17	85
4	8	40	4	9	45
5	9	45	5	10	50
6	12	60	6	17	85
7	11	55	7	15	75
8	6	30	8	9	45
9	9	45	9	10	50
10	5	25	10	9	45
11	10	50	11	14	70
12	6	30	12	11	55
13	14	70	13	17	85
14	8	40	14	16	80
15	9	45	15	11	55
16	6	30	16	15	75
17	10	50	17	12	60
18	7	35	18	17	85
19	8	40	19	11	55
20	7	35	20	17	85

MEAN =	8.5	42.5%	MEAN =	14.2	71%
MODE =	7.0	35%	MODE =	17.0	85%
MEDIAN =	8.0	40%	MEDIAN =	17.0	85%
RANGE =	5.0-14.0	25-70%	RANGE =	6.0-17.0	30-85%

Table 3 PRE- AND POST-TEST DATA: 6TH HOUR

PRE-TEST			POST-TEST		
STUDENT	INDIVIDUAL SCORE	%	STUDENT	INDIVIDUAL SCORE	%
1	3	15	1	10	50
2	7	35	2	15	75
3	7	35	3	17	85
4	8	40	4	10	50
5	5	25	5	14	70
6	12	60	6	20	100
7	9	45	7	19	95
8	5	25	8	17	85
9	11	55	9	13	65
10	14	70	10	19	95
11	11	55	11	20	100
12	3	15	12	8	40
13	11	55	13	19	95
14	6	30	14	15	75

MEAN =	8.0	40%	MEAN =	15.3	76.5%
MODE =	11.0	55%	MODE =	19.0	95%
MEDIAN =	7.5	37.5%	MEDIAN =	16.0	80%
RANGE =	3.0-14.0	15-70%	RANGE =	8.0-20	40-100%

Table 4 PRE- AND POST-TEST DATA: 7TH HOUR

PRE-TEST			POST-TEST		
STUDENT	INDIVIDUAL SCORE	%	STUDENT	INDIVIDUAL SCORE	%
1	9	45	1	20	100
2	4	20	2	16	80
3	6	30	3	9	45
4	8	40	4	13	65
5	10	50	5	20	100
6	12	60	6	16	80
7	5	25	7	10	50
8	9	45	8	16	80
9	4	20	9	19	95
10	4	20	10	8	40
11	7	35	11	19	95
12	4	20	12	17	85
13	6	30	13	11	55
14	7	35	14	13	65
15	4	20	15	15	75
16	2	10	16	15	75
17	10	50	17	19	95

MEAN =	6.5	32.5%	MEAN =	15.8	79%
MODE =	4.0	20%	MODE =	20.0	100%
MEDIAN =	6.0	30%	MEDIAN =	16.0	80%
RANGE =	2.0-12.0	10-60%	RANGE =	8.0-20	40-100%

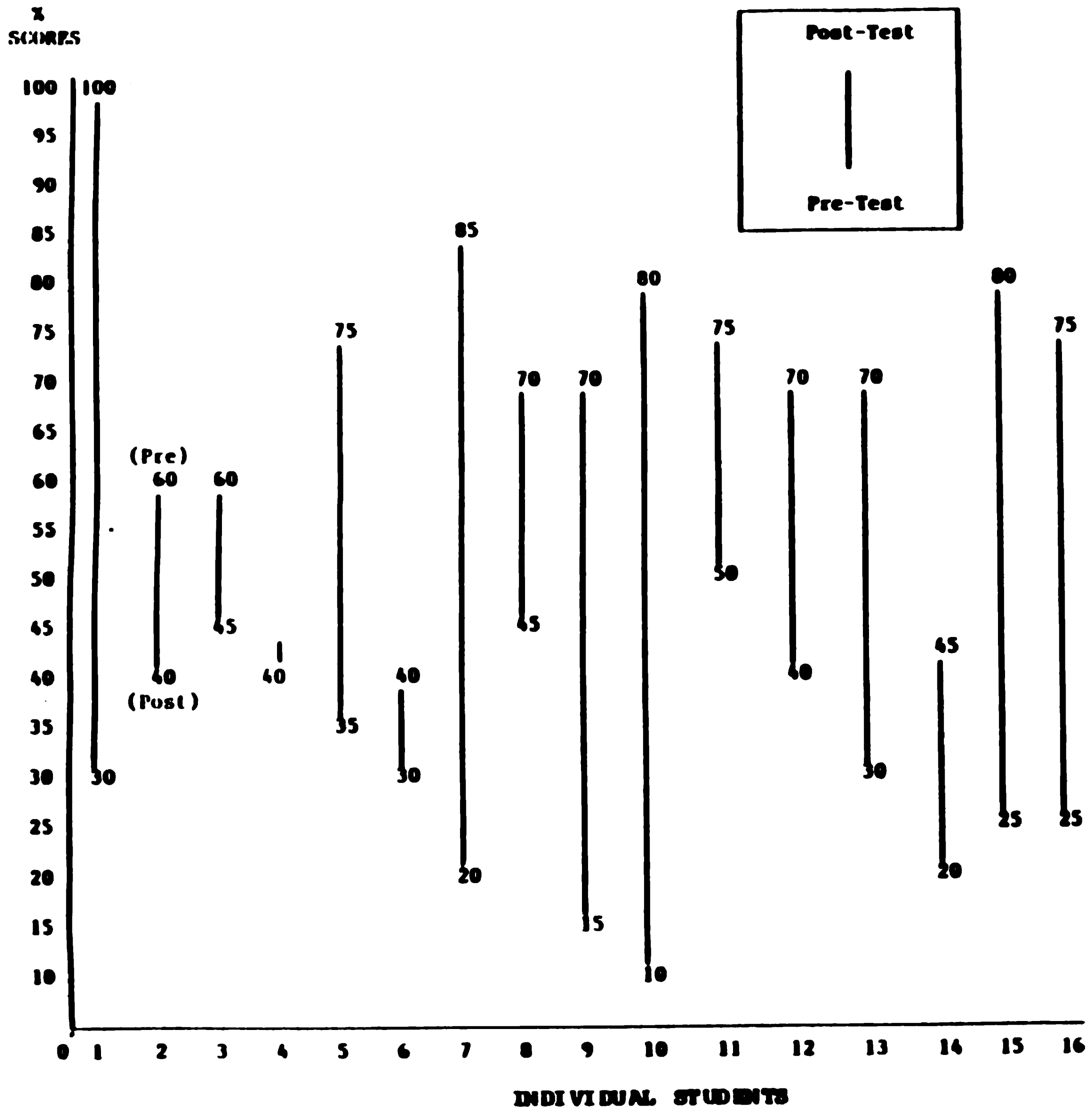


Figure 1 COMPARISON OF PRE- AND POST-TEST FOR EACH STUDENT: 2ND HOUR

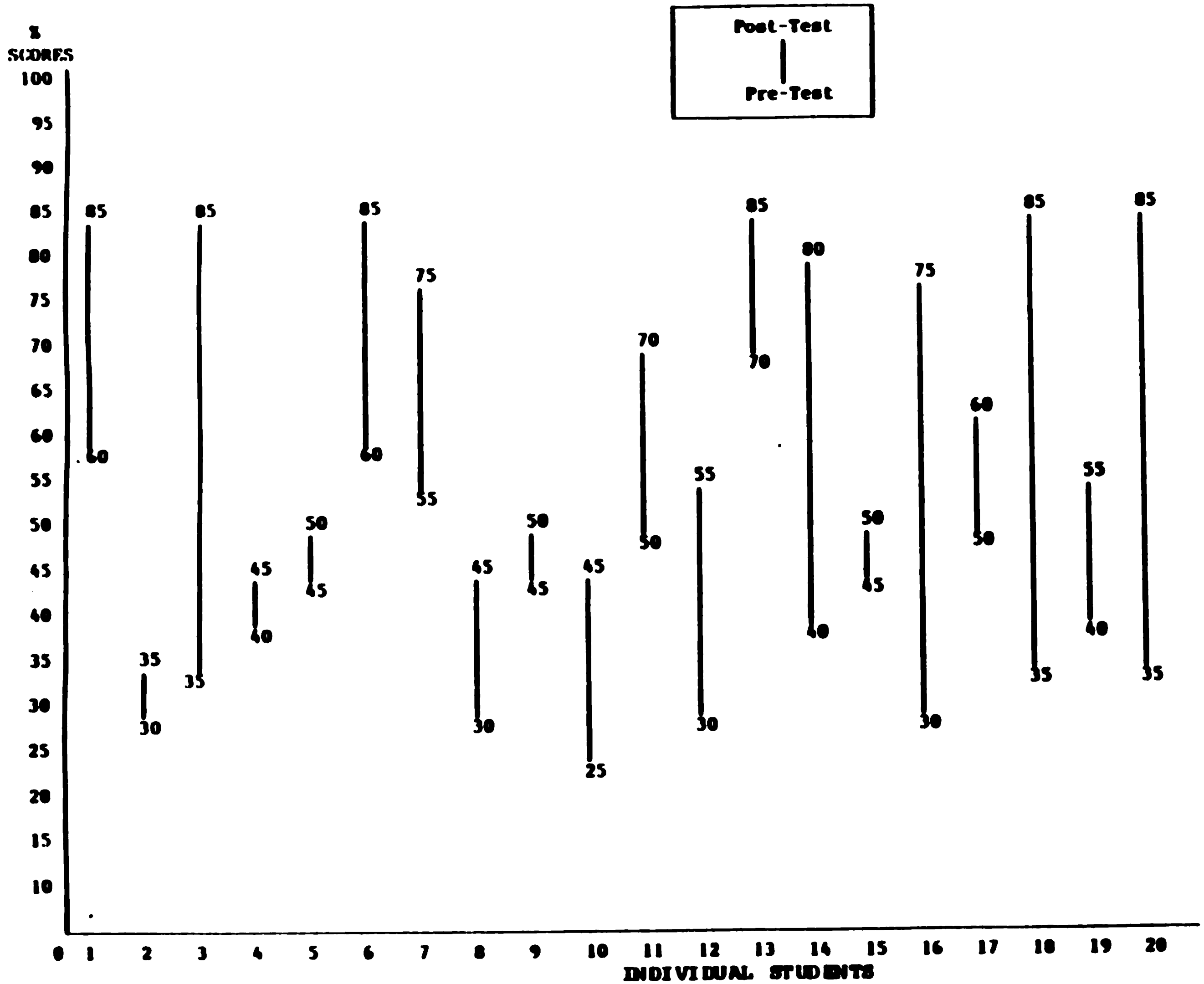


Figure 2 COMPARISON OF PRE- AND POST-TEST FOR EACH STUDENT: 4TH HOUR

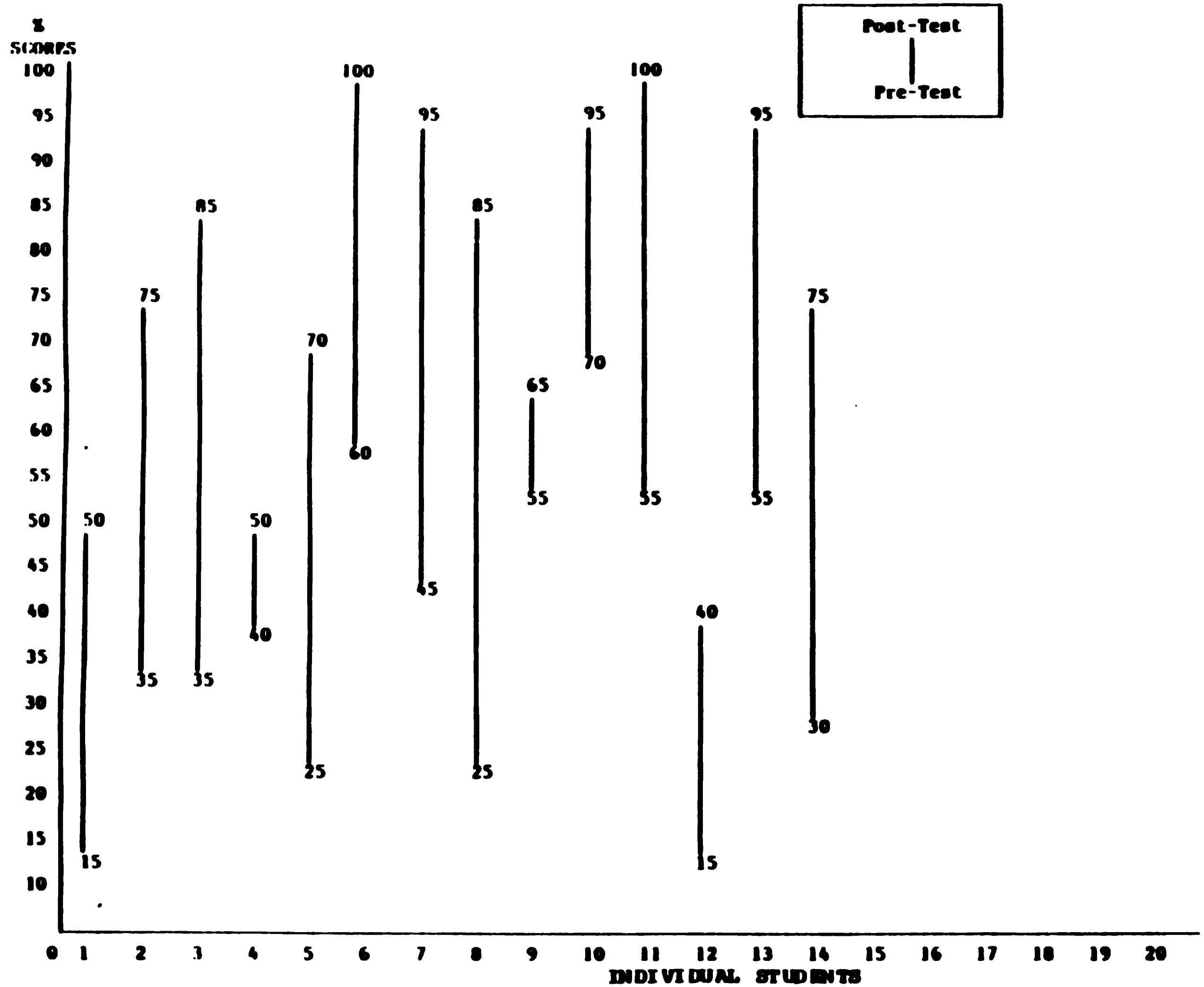


Figure 3 COMPARISON OF PRE- AND POST-TEST FOR EACH STUDENT: 6TH HOUR

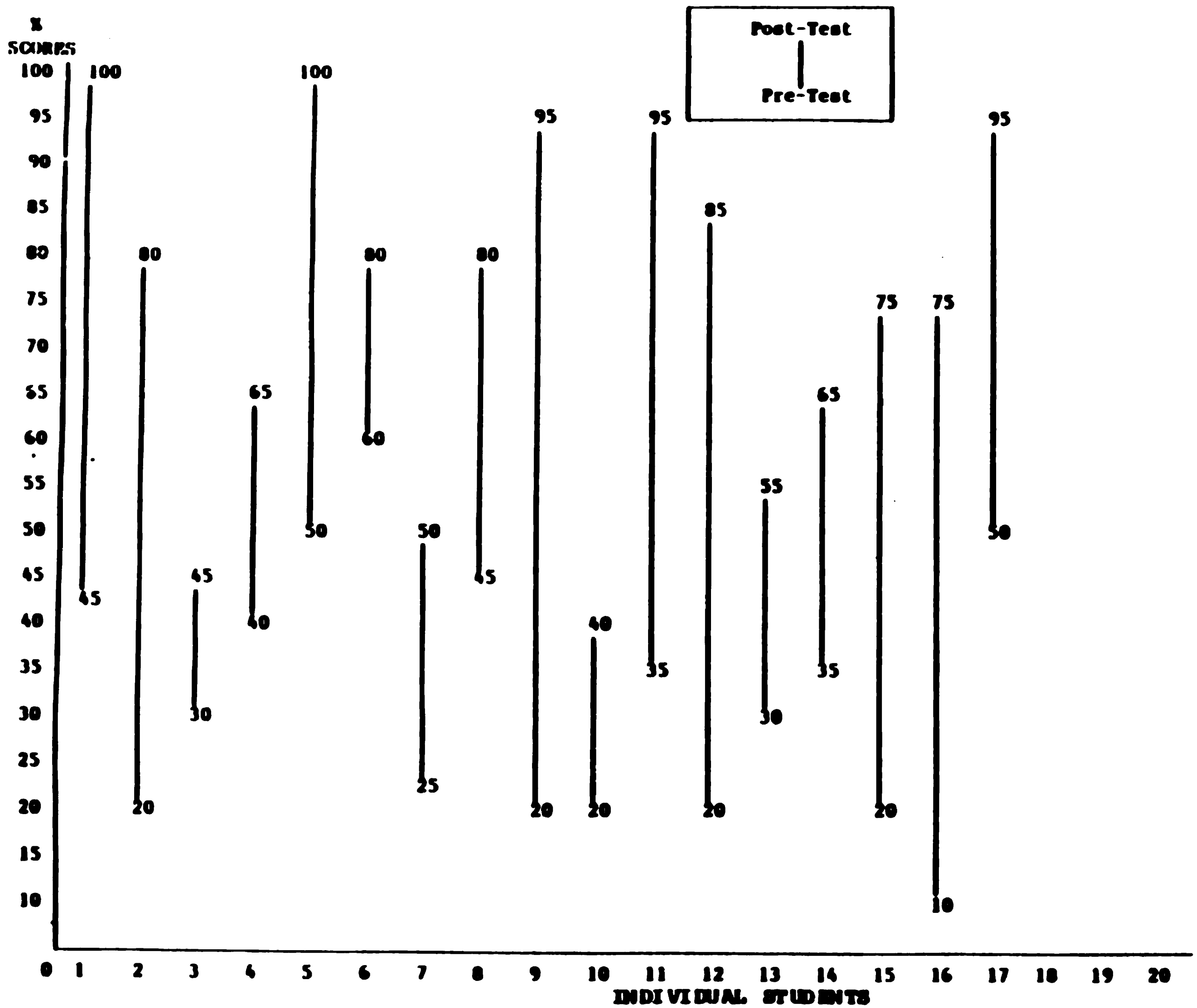


Figure 4 COMPARISON OF PRE- AND POST-TEST FOR EACH STUDENT: 7TH HOUR

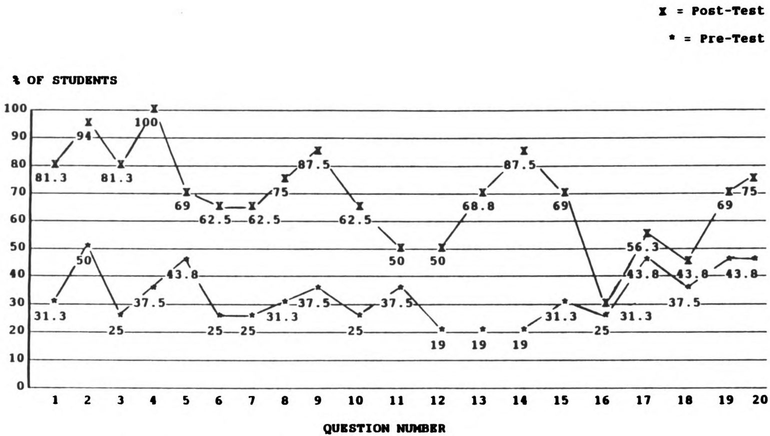


Figure 5 ITEM ANALYSIS OF PRE- AND POST-TEST: 2ND HOUR

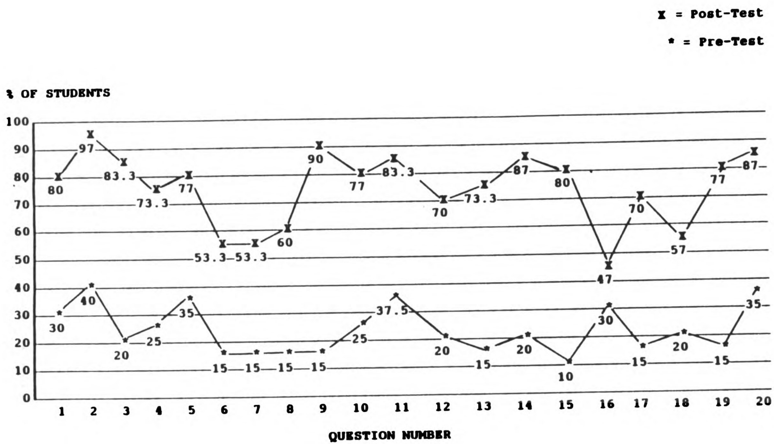


Figure 6 ITEM ANALYSIS OF PRE- AND POST-TEST: 4TH HOUR

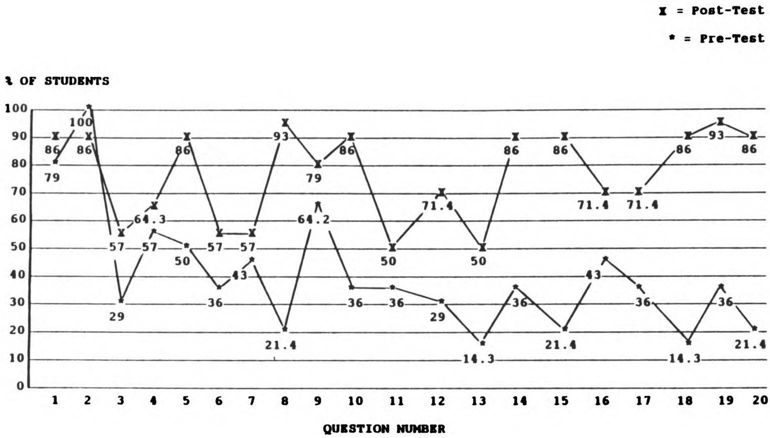


Figure 7 ITEM ANALYSIS OF PRE- AND POST-TEST: 6TH HOUR

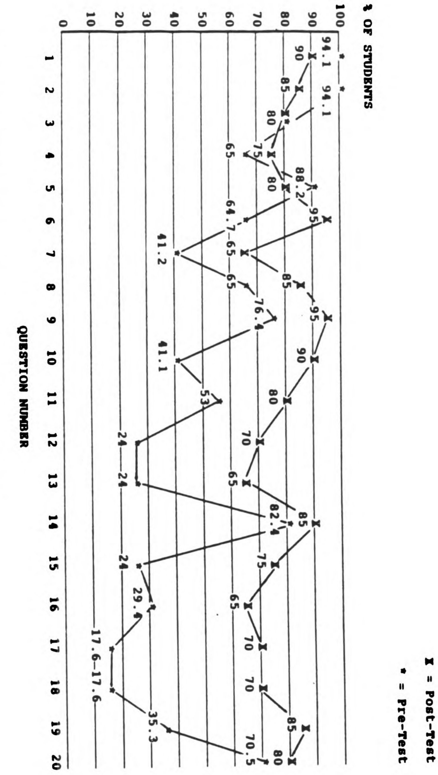


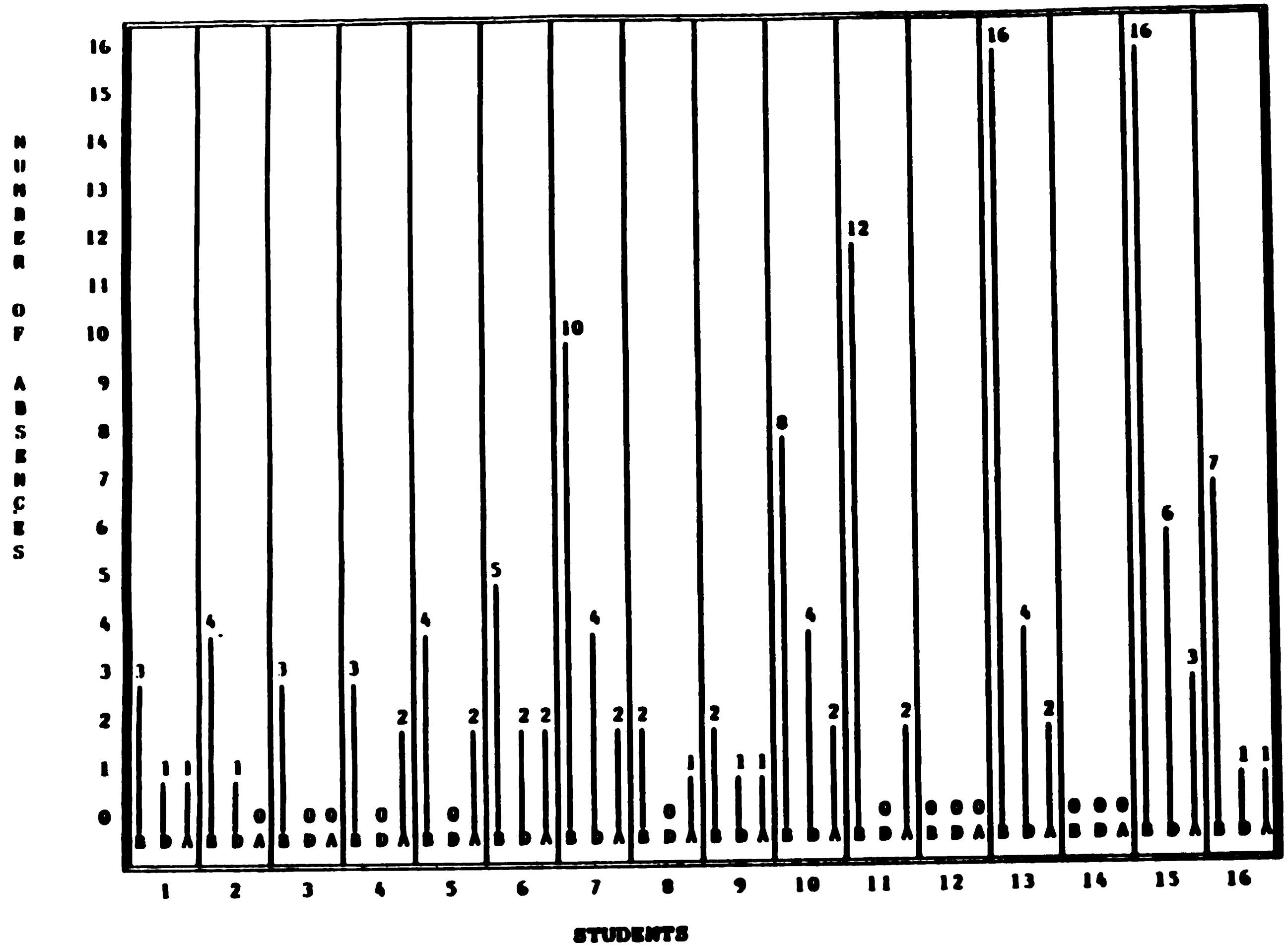
Figure 8 ITEM ANALYSIS OF PRE- AND POST-TEST: 7TH HOUR

ATTENDANCE

Attendance improved both during and directly after the Cell Biology Unit (Figures 5-8). The poor attendance generally seen was a deciding factor in the development of this unit. Rather than commit the classes to lab activities of several days duration, the labs were designed to be introduced and conducted within a fifty minute period. This approach forestalls student attempts to be exempt from labs because of absences during the Pre-Lab.

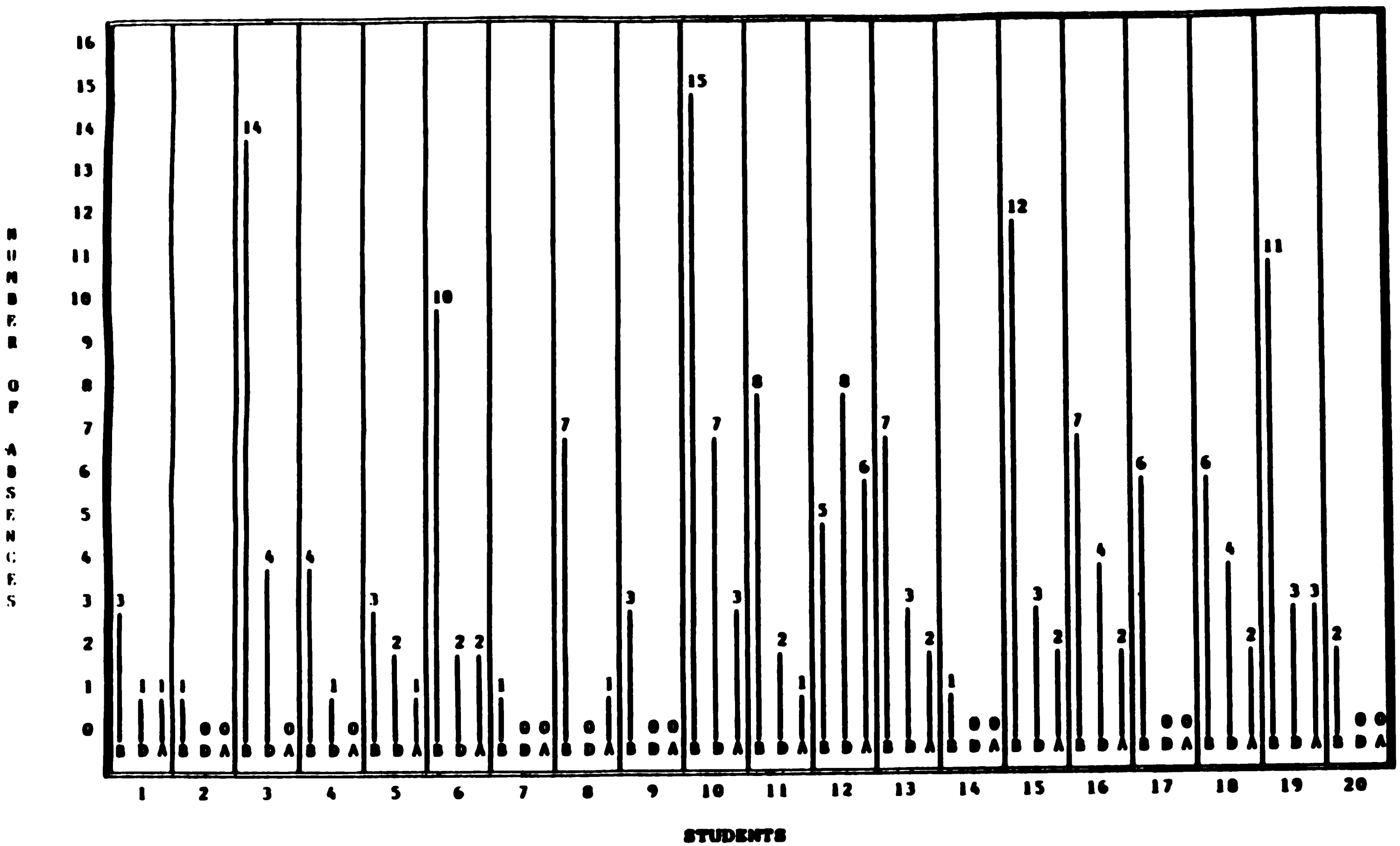
An unanticipated effect of this unit was a carry-over in improved attendance after completion of the unit.

All of this supports the basic supposition that active participation will engage even the most reluctant learner. Also, when the frustration of not knowing what is going on is eliminated, students are more likely to attend.



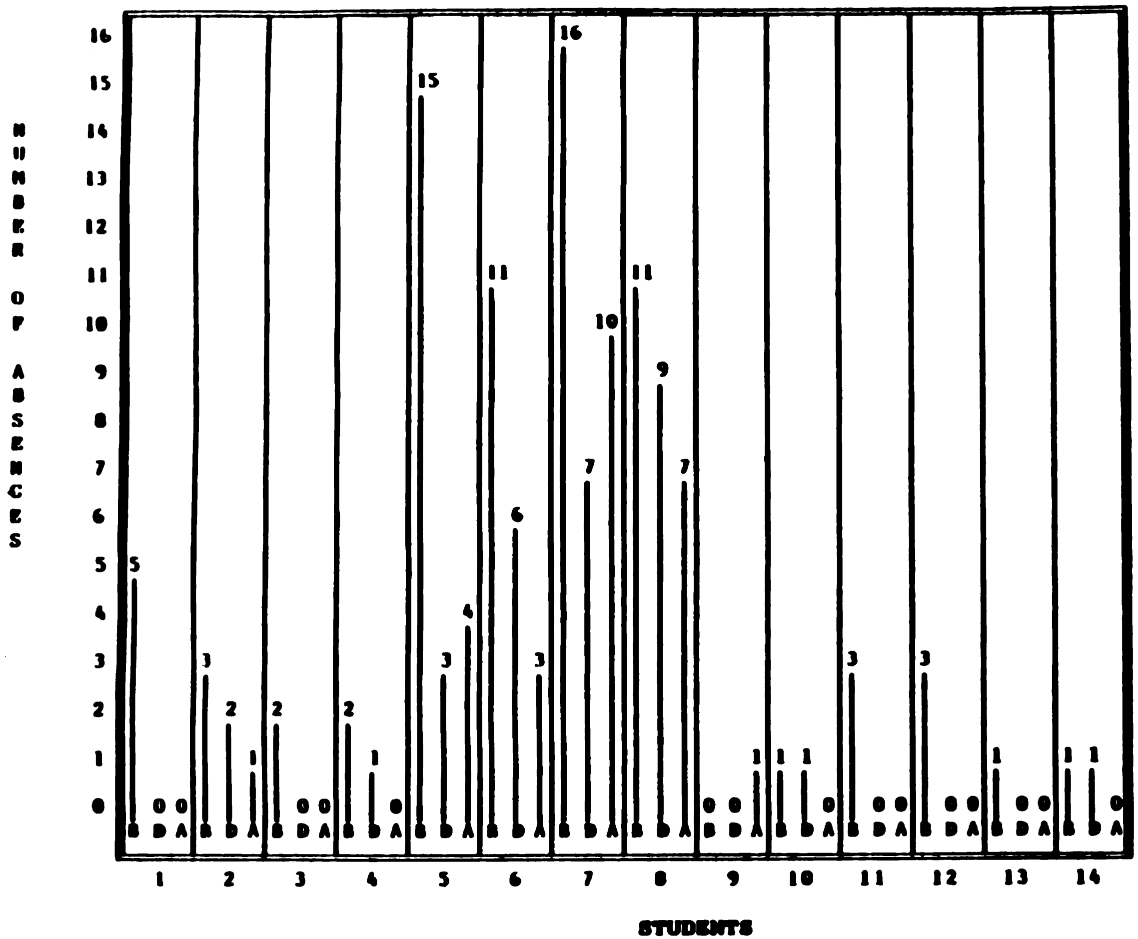
B = Before
D = During
A = After

Figure 9 ATTENDANCE: BEFORE, DURING AND AFTER UNIT: 2ND HOUR



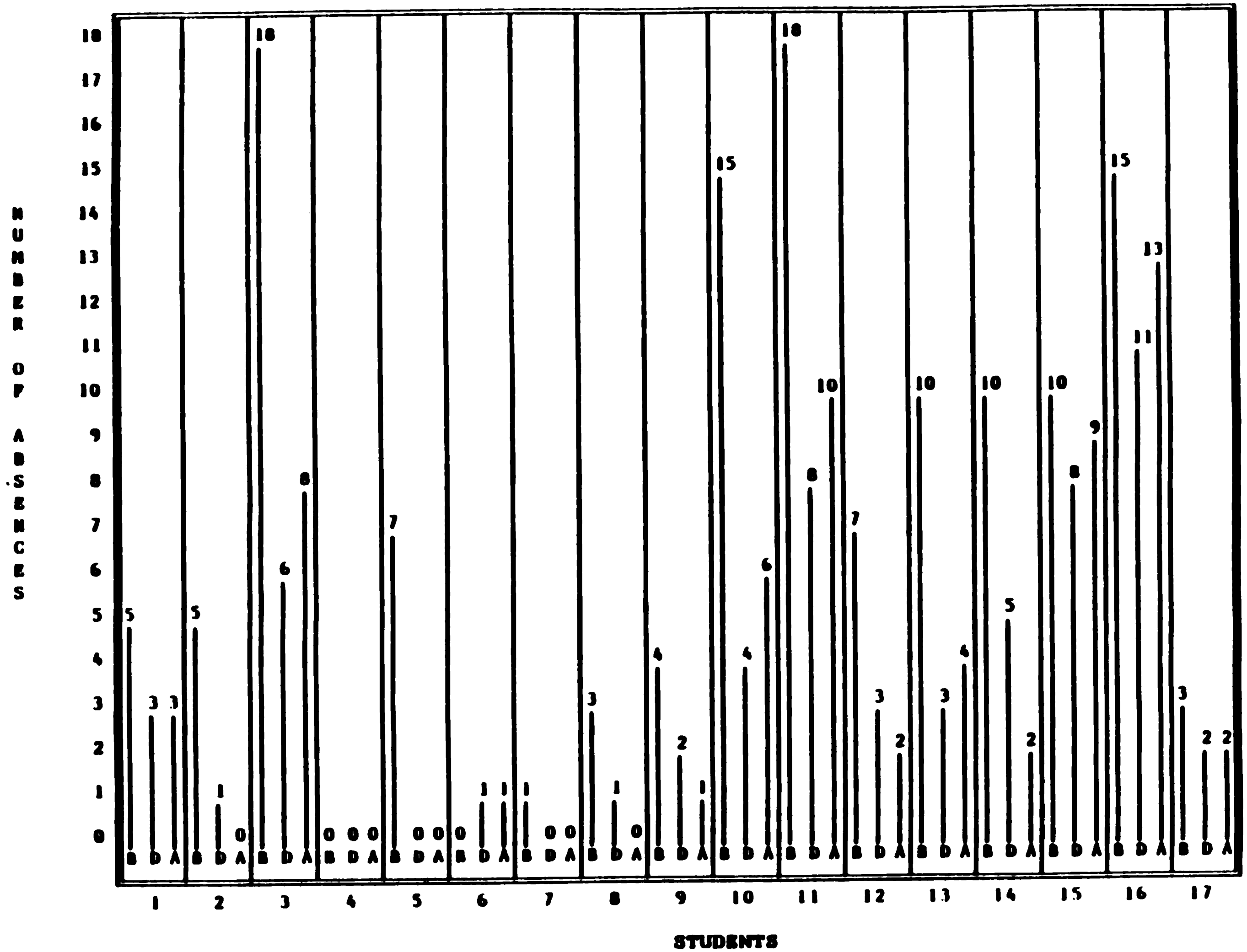
B = Before
D = During
A = After

Figure 10 ATTENDANCE: BEFORE, DURING AND AFTER UNIT: 4TH HOUR



B = Before
D = During
A = After

Figure 11 ATTENDANCE: BEFORE, DURING AND AFTER UNIT: 6TH HOUR



B = Before
D = During
A = After

Figure 12 ATTENDANCE: BEFORE, DURING AND AFTER UNIT: 7TH HOUR

ATTITUDE SURVEY

When asked to respond to a series of twenty qualitative questions about the Cell Biology Unit, the students were uniformly positive in their responses. The questionaire is found in appendix C.

The questions gave the students an opportunity to evaluate the unit. More than seventy-five percent of the responses on the survey were quite in contrast to the usual refrain of the work being too boring, too hard, and too meaningless. There is a chance that their positive responses were enhanced because they were being asked.

Table 5 ATTITUDE SURVEY

RATING SCALE: STRONGLY AGREE 5
AGREE SOMEWHAT 4
NEITHER AGREE NOR DISAGREE 3
DISAGREE SOMEWHAT 2
STRONGLY DISAGREE 1

	RATING									
STATEMENT	5	%	4	%	3	%	2	%	1	%
1	38	49	33	42	6	9	0	0	0	0
2	47	61	16	20	9	11	3	3	3	3
3	46	59	24	31	3	4	4	5	1	1.2
4	38	49	28	36	7	9	3	3	1	1.2
5	43	55	25	32	3	4	3	3	3	3
6	40	51	25	32	8	10	0	0	3	3
7	42	54	23	29	8	10	2	2.5	2	2.5
8	25	32	25	32	11	14	10	12	7	9
9	28	36	16	20	14	18	10	12	9	11
10	47	61	19	24	3	4	3	3	4	5

TEACHER OBSERVATION

The students worked in pairs to complete their activities. A majority of students made an effort towards the success of this program. The students appeared to enjoy doing "hands on" activities, opposed to that of a written busy-work assignment. It was shown also that students were able to master basic skills, illustrated in the comparison between the Pre-Test and Post-Test administered at the beginning and end of the unit. There was also a significant improvement in the students' attendance, which was taken daily.

The attitude survey that was provided at the end of the unit clearly showed a positive response, as indicated in the rating Survey Evaluation given at the end of this unit.

CHAPTER 4

CONCLUSION

SUMMARY

The cell biology program developed and tested in this study was created to realistically deal with the science classroom problems of disinterest, poor attendance and limited supplies.

The emphasis on short, hands-on activities engaged the interest of the learners. In fifty-minute classes it was possible to introduce a topic, complete an activity and debrief the activity. This packaged approach reduced the frustrations felt by both the student with consistent attenance and the occasional student whose brief forays into the classroom are frequently disruptive.

Attendance became less of a confrontational issue and more of a "do what we are doing while you are here" situation. The net result was improved attendance.

The basic, inexpensive materials needed for the activies simplify the almost insurmountable task of finding sufficient materials for the students. A lateral effect of this was the inclusion of more activities on different topics and the establishment of hands-on learning stations.

The net result of this project was a workable approach to current classroom problems and a revitalization of my biology courses.

PLANS FOR THE FUTURE

The very positive results in the three areas of interest, attendance and learning make it evident that the rest of the units must be adapted to involve "hands-on" activities using the same general approach.

Also, since these activities required minimal materials and moderate amount of instruction, this is not an insurmountable task for the teacher.

There was also the joy involved in watching classes form cohesive, cooperative learning units, interested in their tasks.

APPENDIX A

MODIFIED LABORATORY ACTIVITIES FOR CELL BIOLOGY

By

Brian A. Webster

MICROSCOPE

INTRODUCTION: With the invention of the microscope, biologists were able to see smaller and smaller objects. A light microscope can magnify an image several hundred times. A light microscope directs a beam of light through a specimen. An electron microscope uses a beam of electrons to magnify 100,000 times more than the naked eye.

MATERIALS: light microscope
microscope slides
cover slip
scissors
newspaper

PROCEDURE:

1. Prepare a wet mount of a lower case letter "e" from a piece of newspaper.

2. Place the wet mount of the letter "e" onto your microscope stage. Position the slide on the stage so the "e" faces you as it would on a newspaper.

3. Observe the letter "e" using low power on your microscope. Focus the "e" with the fine adjustment.

OBSERVATIONS:

ANALYSIS AND CONCLUSION:

1. How did the "e" appear when you put the slide on the stage?

2. How did the "e" appear through the low and high power objective? Was there a difference?

MAKING A CELL

INTRODUCTION: Your body is made up of skin, blood, bones and muscle. All these parts are made up of smaller living units that are too small to be seen with the naked eye. They are called cells. Each cell in an animal or plant lives its own life while at the same time enabling the body to go on working.

MATERIALS: food materials: kidney beans
pasta of different shapes
kid's cereal

PROCEDURE:

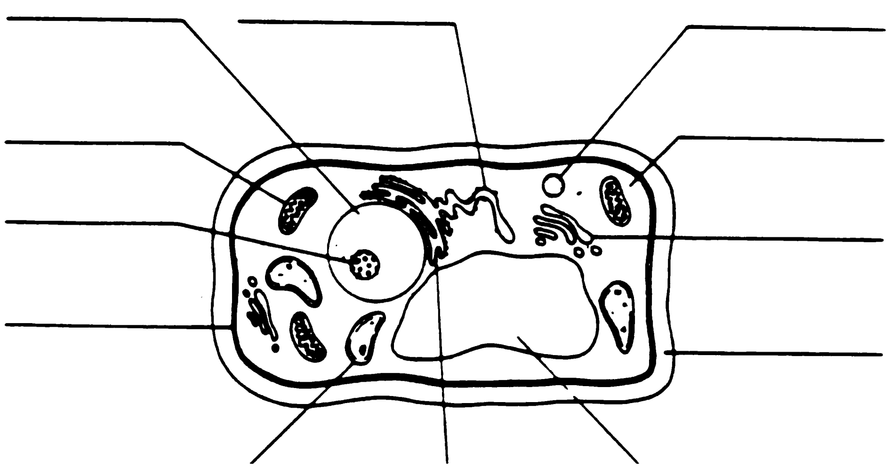
1. By using different food materials that resemble cell parts, assemble a plant cell.

OBSERVATIONS:

PLANT PART	FOOD MATERIAL	MAJOR FUNCTION
1. nucleus		
2. cytoplasm		
3. cell membrane		
4. cell wall		
5. chloroplast		
6. mitochondrion		
7. endoplasmic reticulum		
8. ribosomes		
9. lysosome		
10. vacuole		
11. microtubules		
12. centrioles		

ANAYSIS AND CONCLUSIONS:

1. Label the parts of a plant cell.



CHEEK CELLS

INTRODUCTION: Cheek cells are typical of all animal cells and have a nucleus, cytoplasm and cell membrane.

MATERIALS: microscope
coverslip
microscope slide
tooth picks
medicine dropper
iodine stain
pencil
paper

PROCEDURE:

1. Place a drop of iodine stain on a clean microscope slide.

2. Gently scrape the inside lining of your cheek with the flat end of a clean toothpick.

3. Stir the material from your cheek into the drop of stain.

4. Cover the material with a coverslip.

5. Using low power, examine it under the microscope.

OBSERVATIONS:

ANALYSIS AND CONCLUSIONS:

1. Do the cells all have similar shapes? Are they all about the same size?

2. Label and describe the observed parts of the cell.

ONION CELLS

INTRODUCTION: Plant cells contain many structures found in an animal cell. The most obvious difference between the plant cell and the animal cell is the size of the vacuoles. Vacuoles in both plants and animals act as storage areas. Plant cells also have a thick, firm, outer boundary called a cell wall. This outer boundary supports and protects the cell.

MATERIALS:

microscope	paper towel
coverslip	medicine dropper
forceps	iodine stain
onion section	pencil
microscope slide	paper

PROCEDURE:

1. Slice a raw onion and cut one of the rings into one-centimeter sections.
2. Peel the thin layer of cells from the inner curve of the onion section.
3. Place this thin layer in a drop of water on a microscope slide.
4. Add a coverslip and examine the slide under low power.
5. Place a drop of iodine stain on one edge of the coverslip.
6. Place the edge of a paper towel at the other edge.

OBSERVATIONS:

ANALYSIS AND CONCLUSIONS:

1. How are the onion cells and animal cells alike?
2. Does each cell have a nucleus? cytoplasm?
3. What do you notice in the vacuole in the onion cell?

OSMOTIC IMBALANCE

INTRODUCTION: What would happen if a cell were placed in pure water? The concentration of water outside the cell would be greater than inside a cell. More water molecules would enter the cell than would leave a cell. The cell would swell up and eventually burst if the water movement does not reach a balance. The reverse of this placement in a hypotonic solution is to place the cell in a hypertonic salt solution. The opposite is expected to occur.

MATERIALS:

- microscope
- slide
- coverslip
- eye dropper
- Elodea leaf

PROCEDURE:

1. Make a wet mount of an Elodea leaf in tap water.

2. Observe the cells under the microscope.

3. Locate a single cell along the edge of the leaf.

4. Then, make a 6% salt solution (6 g of salt dissolved in 94 ml of distilled water).

5. Use this solution to make a second wet mount of another Elodea leaf.

6. Let this wet mount stand for 5 minutes.

OBSERVATIONS: Draw a diagram of one cell from each slide. (Notice chloroplast positions)

TAP WATER (hypotonic solution)	SALT WATER (hypertonic solution)

ANALYSIS AND CONCLUSIONS:

1. Which cell do you think is in osmotic balance and which one is not?

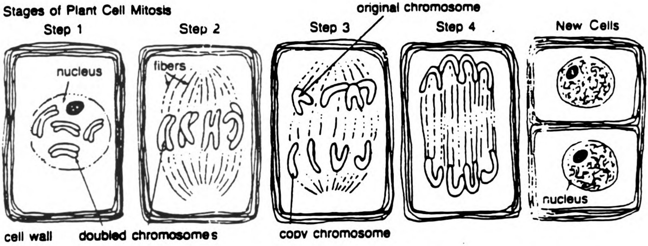
CELL DIVISION

INTRODUCTION: Cells form new cells by a process called mitosis or cell division. During mitosis, one cell divides in half to form two new cells (daughter cells). Suppose you could watch a cell divide. You could see that the cell parts called chromosomes (rod-shaped structures) move around the cell during mitosis. Because chromosomes move in a particular way, you could arrange the events of mitosis into several steps.

MATERIALS: construction paper - 4 colors
scissors
glue
black yarn
black thread
toothpicks
metric ruler

PROCEDURE:

1. Study the steps in mitosis as outlined.



Interphase   Prophase   Metaphase   Anaphase   Telophase

2. Use the materials listed below to represent the cell

2. Use the materials listed below to represent the cell parts. Cut the pieces of paper, yarn and thread to the sizes given in the table.

CELL PART	MATERIAL	SIZE	NUMBER
Cell wall and membrane	Blue paper	14 by 8 cm	5
Cytoplasm	Orange paper	13 by 7 cm	5
Nucleus	Purple paper	5 cm circle	3
Nucleolus	Green paper	1 cm circle	1
Chromosomes	Black yarn	4 cm long	20
Fibers	Toothpicks	Full size	24
Cell wall between new cells	Dark paper	1/2 by 8 cm	1
Nuclei	Thread	1/2 m	2

3. Start building the models of cell division steps by gluing each cytoplasm paper to the top of a cell wall and membrane. The cell wall and membrane should show on all sides.

4. Make each of the cell wall-membrane-cytoplasm pieces into a mitosis step.

5. Use glue to attach the proper parts to the pieces.

<u>ANALYSIS AND CONCLUSION</u>:

1. Describe what happens in each step of mitosis.

   a. Interpahse:

   b. Prophase:

   c. Metaphase:

   d. Anaphase:

   e. Telophase:

CHROMOSOME NUMBER

INTRODUCTION: Every living thing has a certain number of chromosomes in all its body cells. The number of chromosomes is different from species to species. The number of chromosomes in body cells is called chromosome number.

MATERIALS: organisms and their chromosome number
pencil

PROCEDURE:

1. Study the list of organisms and their chromosome number.

ORGANISM	CHROMOSOME NO.	ORGANISM	CHROMOSOME NO.
white ash	46	alligator	32
turkey	82	cat	32
cattle	60	tobacco	48
corn	20	rose	14
dog	78	rhesus monkey	42
grasshopper (sp.1)	24	pigeon	80
guinea pig	64	marijuana	20
hydra	32	horse	64
human	46	grasshopper (sp.2)	24

OBSERVATIONS:

ANALYSIS AND CONCLUSIONS:

1. Which organism has the most chromosomes?
2. Which organism has the fewest chromosomes?
3. Do any organisms have the same chromosome number? If so, which ones?
4. Is there any relationship between chromosome number and the size of the organism?
5. Why is it that two species may have the same chromosome number but not resemble each other?

CHROMOSOME STUDY

INTRODUCTION: The 46 chromosomes in your somatic (body) cells actually are 23 matched pairs of chromosomes. (23 multiplied by 2 = 46). Matched pairs of chromosomes are called homologous chromosomes. This collection of match chromosomes is called a karyotype. This provides a way to check for chromosomal abnormalities. A normal human karyotype is being prepared. Abnormal karyotype will be displayed for comparison.

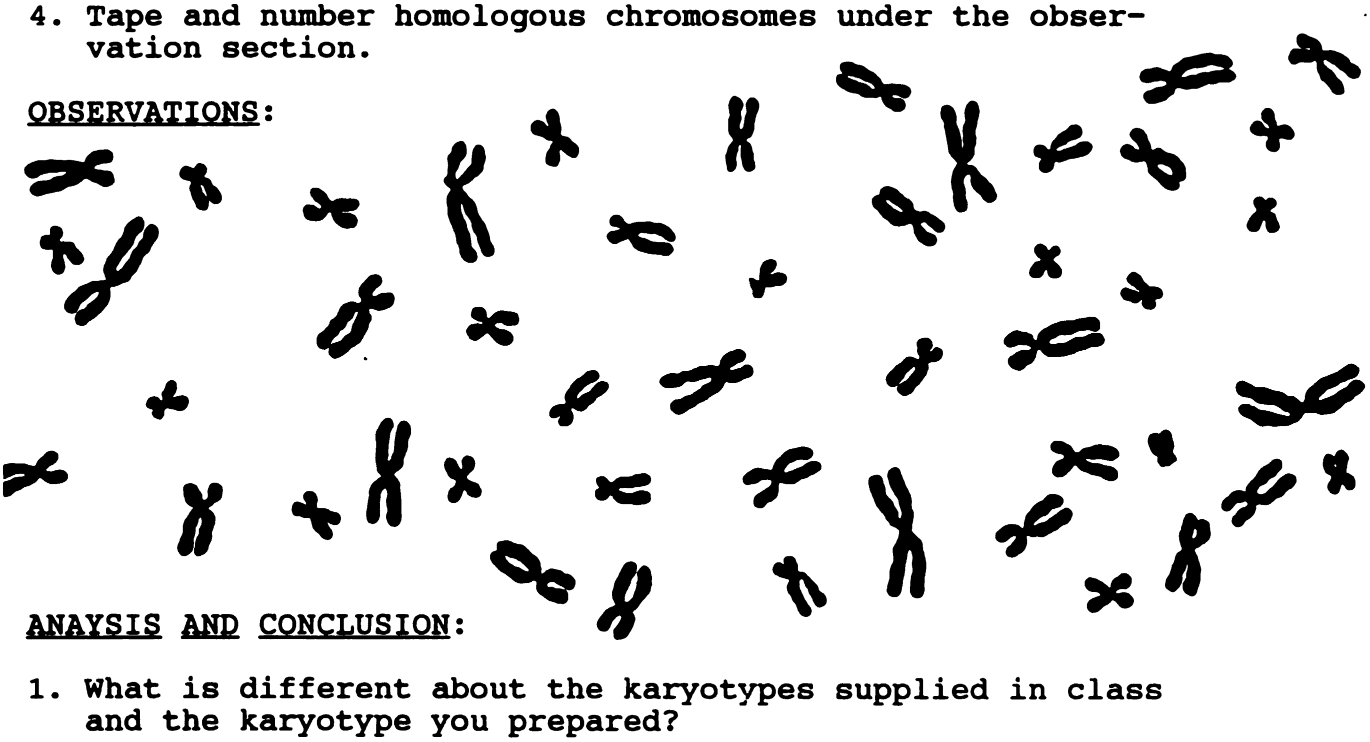
MATERIALS:

paper	pencil
scissors	tape

PROCEDURE:

1. Cut out each chromosome from sheet with scissors.
2. Match chromosome pairs by size and shape.
3. Arrange pairs of chromosomes in sequence from longest to shortest as shown below.
4. Tape and number homologous chromosomes under the observation section.

OBSERVATIONS:



ANAYSIS AND CONCLUSION:

1. What is different about the karyotypes supplied in class and the karyotype you prepared?

DNA MODEL

INTRODUCTION: A DNA molecule looks like a twisted ladder. A DNA molecule is made up of two chains of sugar groups and phosphates connected by pairs of nitrogen bases. There are four nitrogen bases; adenine A, Thymine T, Cytosine C and Guanine G. A connects to C, C connects to G.

MATERIALS: Assorted color candy pieces
Miniature Marshmallows
Toothpicks
Pick up sticks

PROCEDURE:

1. Using toothpicks, join the nitrogen bases together; 3 A's (green candies), 3 T's (orange candies), 3 G's (blue candies), 3 C's (red candies), following the base-pairing rule.

2. Arrange the sugars (black candies) and phosphates (miniature marshmallows) along the two sides of the DNA molecule.

3. Fit the pick-up sticks through the phosphates (miniature marshmallows) for support.

4. Complete by twisting the DNA molecule into a double helix.

OBSERVATIONS:

ANALYSIS AND CONCLUSIONS:

1. What chemical make up the sides of the DNA molecule?

2. What nitrogen base always pairs up with A? G?

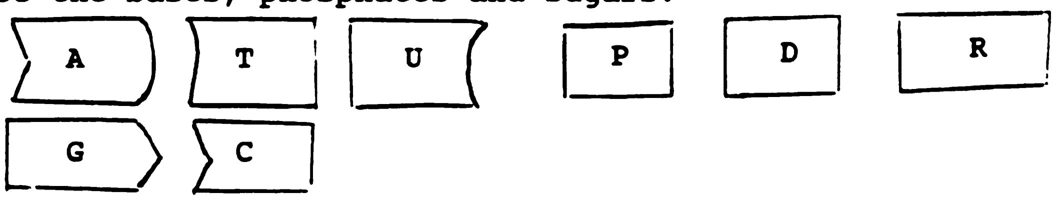
TRANSCRIPTION AND TRANSLATION

INTRODUCTION: Proteins are molecules needed by each and every cell in your body. An exact copy of the code for each protein, RNA, must be made from the DNA. The process by which the DNA code is copied onto a strand of mRNA is called transcription. The process of building a protein molecule according to the code in mRNA is called translation. Two step process: DNA yields mRNA; mRNA yields protein.

MATERIALS: construction paper glue scissors

PROCEDURE:

1. Trace the bases, phosphates and sugars.



2. Make a stencil by cutting out each shape.

3. Use the stencils to draw shapes on the construction paper. You willl need the following numbers of each unit.

2 Guanine G (blue)	2 Uracil U (purple)
2 Cytosine C (red)	6 Deoxyribose sugar D (yellow)
4 Adenine A (green)	6 Ribose sugar R (white)
2 Thymine T (orange)	12 phosphates P (black)

4. Use the appropriate pieces to construct a strand of DNA with the following base code: C, G, A, T, T, A

5. Use the remaining pieces to contruct a strand of mRNA that is complementary to the DNA strand.

6. Glue the pieces together on a brown sheet of paper.

OBSERVATIONS:

ANALYSIS AND CONCLUSION:

1. How do the shapes of bases in the strand of DNA determine the order of bases in the mRNA strand?

MAKING PROTEIN: TRANSLATION

INTRODUCTION: Proteins such as enzymes that control chemical changes in the body are made up of chains of amino acids. Each group of three bases in a molecule of DNA stands for a certain amino acid. This DNA code transcribed to mRNA (see previous exercise) and which moves from the nucleus to the cytoplasm. The code carried by the mRNA is used to arrange the amino acids in a particular order in the making of protein.

MATERIALS: pencil
table - mRNA codes for amino acids

PROCEDURE:

1. Use the information in the table to fill in the missing parts.

ORDER OF BASES - ORDER OF BASES IN mRNA - AMINO ACIDS

CAT		
GGT		
	UGU	
AAT		
		Proline

TABLE - mRNA codes for amino acids

GUA	valine	CCA	proline
UCA	serine	UGU	cysteine
CGU	arginine	UUA	leucine
ACC	threonine	CAC	histidine
UUC	phenylalaine	AUU	isoleucine

OBSERVATIONS:

ANALYSIS AND CONCLUSIONS:

1. What are proteins formed from?

2. What are the roles of mRNA and tRNA in the formation of proteins in a cell?

PROTEIN

INTRODUCTION: One of the most important compounds in living things is proteins. They are molecules needed in living things for growth and repair of body parts. A simple test can be performed to determine if a material has proteins in it. If you add nitric acid to a material, the color yellow will indicate the sample contains protein. When yellow fails to appear, very little protein is present.

MATERIALS: Samples - cotton, paper, fingernail clippings and hair
test tubes (5)
labels (5)
medicine dropper
chemical compound - nitic acid

PROCEDURE:

1. Label (5) test tubes for each material you test.

2. Place a small sample of each material in each test tube.

3. Using a medicine dropper, add (5) drops of nitric acid to each test tube. (Do not spill, due to staining)

OBSERVATIONS: Write down the results of each test.

SAMPLES	RESULTS
Test tube #1 Cotton	
Test tube #2 Paper	
Test tube #3 Fingernail	
Test tube #4 Hair	
Test tube #5 peanut	

ANALYSIS AND CONCLUSIONS:

1. What do you think would happen if you tested meat or other protein-containing foods?

PROPERTIES OF AN ENZYME

INTRODUCTION: Enzymes are protein molecules that act as catalysts to speed up biochemical reactions. The enzyme peroxidase speeds up the breakdown of hydrogen peroxide, a toxic by-product of cell metabolism, into harmless water and oxygen.

MATERIALS:

3 test tubes	400 ml beaker
test tube rack	3 % hydrogen peroxide
forceps	mortar and pestle

PROCEDURE:

1. Set up 3 clean test tubes in a test tube rack. Pour 2 ml of hydrogen peroxide into each test tube.
2. Half fill a 400 ml beaker with water and put on the hot plate to boil.
3. Add a small cube of fresh liver to the first test tube.
4. Grind another piece of liver with some fine sand in a mortar and pestle. Use a spatula to transfer the ground liver to the second test tube.
5. Using forceps, put a piece of liver into the boiling water bath. Boil the liver for about 2 minutes. Remove the liver with forceps and drop into the third test tube.

OBSERVATIONS: Describe the activities that took place within each of the 3 test tubes being tested.

ANALYSIS AND CONCLUSIONS:

1. How do you explain the differences in activities between whole liver and ground liver?
2. What is the effect of boiling the liver on peroxidase activity?

PROBABILITY AND HEREDITY

INTRODUCTION: Probability is the law of chance. A simple example of the laws of chance is tossing a coin. The coin can turn up either heads or tails. Both are equally likely. Therefore the probability of it being heads is half and the probability of it being tails is half. If you toss two coins, the situation is a little more complicated. This experiment will show that complication.

MATERIALS: (2) pennies
pencil
paper

PROCEDURE:

1. One person should flip the two coins at the same time. The other person records the outcome on the data table.
2. Repeat step (1) until you have completed (4) flips.
3. Repeat step (2) until you have completed a total of 50 flips.

OBSERVATIONS: TOSS COMBINATIONS

RESULTS	COUNT	TOTAL
BOTH HEADS HH		
ONE HEAD;ONE TAIL HT		
BOTH TAILS TT		

ANALYSIS AND CONCLUSION:

1. What is your ratio of toss combinations for HH : HT : TT ?

2. What biological processes are represented by flipping and pairing the two coins?

SEX-LINKED TRAITS

INTRODUCTION: If a trait is sex-linked, the genes are located on the X chromosome. A heterozygous female (XM,Xm) has a (50/50) chance that her egg cells will receive either an (XM) or an (Xm) during meiosis. Normal males have only one gene (XM) present. The chances of the sperm cells receiving either XM or Y during meiosis are (50/50). You can determine the offspring of the cross (XM,Xm) and (XM,Y) by coin tossing.

MATERIALS: adhesive tape pennies

PROCEDURE:

1. Put adhesive tape on two pennies.

2. Mark one penny to represent the possible egg cells. Mark one side XM and the other side Xm. Mark the second penny to represent the possible sperm cells. Mark one side XM and the other side Y.

3. Toss both pennies together 48 times. Use slashes to indicate the combinations that result after each toss. Total the results of each genotype and record them in the table.

OBSERVATIONS:

OFFSPRING PHENOTYPE	OFFSPRING GENOTYPE	RESULT OF EACH TOSS	TOTALS OBSERVED
Normal female	XM,XM or XM,Xm		
Female with muscular dystropy	Xm, Xm		
Normal male	XM,Y		
Male with muscular dystrophy	Xm, Y		

ANAYSIS AND CONCLUSIONS:

1. If a trait is sex-linked, how many genes for muscular dystrophy must a female inherit to have the disease?

CROSSING OVER

INTRODUCTION: Crossing over is the exchange of parts between two homologous chromosomes. During meiosis, two chromatids (duplicated chromosomes), one from each homologous chromosome, twist around each other. As they twist, the chromatids often break and the broken ends may switch places. This exchange of genetic material is called crossing over. Each pair will be heterozygous (different alleles) for the given trait, to supply clear and informative results.

MATERIALS: paper
pencil
dice

PROCEDURE:

1. Study the pair of chromosomes from a fruit fly. The fly is heterozygous for each of seven traits, a through g, found on each chromosome.

A	1	CROSSINGOVER POINTS	1	a
B	2		2	b
C	3		3	c
D	4		4	d
E	5		5	e
F	6		6	f
G	7		7	g

2. Numbers 1 through 6 represent points at which crossing over may occur. For example, if a crossover occurred at point 3, the alleles on chromosome 1 would be abcDEFG. The alleles on chromosome 2 would be ABCdefg.

3. Roll the dice, using the number that comes up as a cross-over point. Record this information as a tally mark in the data table.

4. Repeat step 3 another 99 times.

5. Calculate the percentage of the time each allele is found on the same chromosome as a. Record this information in the data table.

OBSERVATIONS: DATA TABLE

Number of times a on the same chromosome as	Percentage of times is a is on the same chromosome as
b	b
c	c
d	d
e	e
f	f
g	g

ANALYSIS AND CONCLUSIONS:

1. Is the location of crossing over more or less random, or does it occur more frequently in any particular location?

2. Which recessive allele most often ends up on the same chromosome as a?

3. Which recessive allele is separated most often from a?

4. Assume a crossover occurs at point 2. What would be the order of alleles on the resulting chromosomes?

GENE POOL

INTRODUCTION: Scientists have found that living things in a population may change over time because of changes in their genes. All the alleles for a trait of a certain population can be thought of as if they were together in a pool. Changes that take place in the alleles of individuals will slowly change the gene pool of the whole population.

MATERIALS: sheet of paper
pencil

PROCEDURE:

1. Cut out 100 pieces of paper.
2. Separate into two piles of 50.
3. Label dominant (B) on 35 pieces of paper and recessive (b) on the other 15. B and b are the alleles for a particular gene.
4. Pick one piece of paper from each pile.
5. Repeat step (4) 49 more times.

OBSERVATIONS: DATA TABLE

	TWO BB	ONE B, ONE b	TWO bb
PAIR TALLY			
PAIR TOTAL			

ANALYSIS AND CONCLUSIONS:

1. Determine the percentage of genotypes in the population.
2. How would this affect the population?
3. What factors affecting this process are not considered in this methodology?

DIHYBRID CROSSES

INTRODUCTION: A dihybrid cross involves two selected traits: brown eye color (B) is dominant to blue eye color (b); curly hair (C) is dominant to the recessive straight hair (c). Assume that a brown-eyed, curly-haired man and his wife, also with brown eyes and curly hair, plan to have children. They are both heterozygous for both traits and carry alleles for blue eyes and straight hair.

MATERIALS: paper
pencil
toothpicks (8)
tape

PROCEDURE:

1. Tape a flag to each of the (8) toothpicks.

2. Label the flags: sperm - BC, Bc, bC, bc

   egg - BC, Bc, bC, bc

   (Each toothpick represents a chromosome and each flag represents alleles for each of the two genes in question on the chromosomes)

3. Place flagged toothpicks in circle diagrams.

4. Arrange (4) sex cells for the male and (4) sex cells for the female into the punnet square.

5. Fill in the squares on your Punnett square with the genotype for each offspring.

OBSERVATIONS: PUNNETT SQUARE

ANALYSIS AND CONCLUSIONS:

1. What is the phenotype ratio of this dihybrid cross?

   a. Brown-eyed and curly-haired
   b. Brown-eyed and straight haired
   c. Blue-eyed and curly-haired
   d. Blue-eyed and straight haired

TRAIT SURVEY

INTRODUCTION: There are many traits in which dominant and recessive alleles are involved. For instance, the brown eyed allele is dominant over the recessive blue eyes allele for the generic trait, eye color. In hair color, black or brown genes are dominant over red and blond genes, while by itself the red gene dominates the blond gene. Curly hair or wavy hair genes are dominant over straight hair genes. Unattached earlobes and the ability to roll your tongue are also dominant traits. By making a sample survey we can learn more about the different kinds of individual traits within our population.

MATERIALS: trait tally sheet
pencil

PROCEDURE:

1. Count the number of students in your class who possess each of the traits listed.

2. Write this number in the column to the right of each particular trait.

OBSERVATIONS: CLASS SURVEY

Boy	Girl
Brown eyes	Other color
Can roll tongue	Cannot roll tongue
Unattached earlobes	Attached earlobes
Widow's peak	No widow's peak
Hitch-hikers thumb	No hitch-hikers
Bent little finger	No bent finger

ANALYSIS AND CONCLUSIONS:

1. Which trait of each pair is more common?

2. Which trait of each pair do you think is dominant? Why?

RECOMBINANT DNA

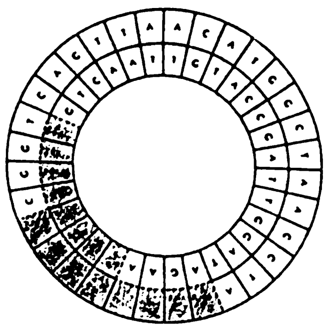
INTRODUCTION: The common bacterium, Escherichia coli, or E. coli, is used in recombinant DNA technology. Segments of DNA can be spliced into circular forms of DNA, or plasmids. These recombinant DNA organisms then can produce proteins as the organisms grow and reproduce.

MATERIALS: tape
scissors

PROCEDURE:

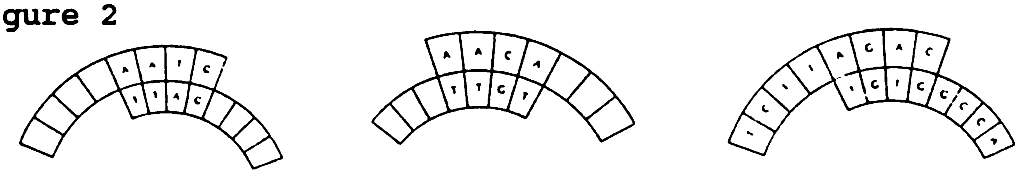
1. The plasmid shown below (fig. 1) has been chemically cut at the nucleic acids indicated by dashed lines.

Figure 1



2. The blank segment is to be replaced by one of the following new DNA segments (fig. 2 : A, B, C).

Figure 2



A B C

3. Cut out the labeled segments, then fit it into the corresponding plasmid following the base-pairing rule: A with T and G with C.

OBSERVATIONS:

ANAYLSIS AND CONCLUSIONS:

1. Explain how a mutated segment might change the intended

APPENDIX B

PRE-TEST

I. Multiple choice

___ 1. The activities of a cell are directed by the information that is carried in
   a. chloroplast
   b. ribosomes
   c. DNA
   D. mitochondria

___ 2. Which of the following structures is not present in an animal cell?
   a. cell wall
   b. cytoplasm
   c. cell membrane
   d. well-defined nucleus

___3. A membrane that is selectively permeable will allow what substances to pass through?
   a. a polar molecule
   b. a molecule that is insoluble in the phospholipid molecules
   c. a small molecule
   d. starch

___4. A double layer of phospholipid molecules with proteins embedded in the phospholipids would best describe the structure of the
   a. ribosomes
   b. mitochondria
   c. cell wall
   d. plasma membrane

___5. A DNA molecule resembles a twisted ladder with
   a. sides composed of sugar-phosphate chains
   b. rungs composed of nitrogen bases
   c. rungs held together by hydrogen bonds
   d. All of the above

___6. The coded messages in DNA
   a. produce ribosome molecules
   b. are controlled by transfer RNA
   c. are read by lysosomes
   d. determine amino-acid sequence in proteins

___7. RNA differs from DNA in all of the following ways except
a. it contains ribose instead of deoxyribose
b. it consists of a single strand
c. it has a phosphate component
d. it contains the base uracil instead of thymine

___8. Which of the following RNA molecules carries the protein blueprint out of the nucleus to a ribosome?
a. mRNA
b. tRNA
c. rRNA
d. all of the above

___9. The cell theory states that all cells come from
a. protein
b. carbohydrates
c. nucleic acid
d. other cells

___10. Mitosis always occurs ________ cytokinesis.
a. before
b. after
c. during
d. instead of

___11. The entire framework of microtublules assembled within a cell during prophase is called the
a. spindle fiber
b. mitotic spindle
c. aster
d. kinetochore

___12. For unicellular organisms, mitosis and cell division aid in
a. growth
b. replacement of body
c. reproduction
d. maintenance
e. all of the above

___13. Mendel crossed pea plants containing green pods (yy) with plants containing yellow pods (YY). The resulting offspring were
a. 100 percent green
b. 50 percent yellow
c. 100 percent yellow
d. 25 percent green

___14. Organisms with the genotypes Bb and BB have the same phenotype because
a. B is dominant over b
b. both organisms are homozygous
c. the recessive trait reappeared
d. both organisms are hybrids

___15. In pea plants, purple flowers are dominant over white flowers. If two heterozygous purple-flowered plants are crossed, the resulting ratio of phenotypes in the F one generation is
a. 1:1
b. 2:1
c. 3:1
d. 1:2:1

___16. If a heterozygous, short-haired black rabbit (BbSs) is crossed with a long-haired brown rabbit (bbss), the percent of short-haired brown rabbits in the F one generation is
a. 100 percent
b. 50 percent
c. 25 percent
d. 0 percent

___17. Crossing over
a. takes place during mitosis
b. may cause linkage groups to break apart
c. creates new genetic information
d. both a and c

___18. Which of the following human traits are not governed by multiple genes?
a. eye color
b. blood type
c. skin color
d. height

___19. Distinct groups within a species are called
a. races
b. gene pools
c. clones
d. mutations

___20. Chemical reactions in the mitochondria
a. are not important to the cell
b. are energy releasing
c. help digest food in the cell

POST-TEST

I. Multiple choice

___ 1. The activities of a cell are directed by the inform- ation that is carried in
a. ribosomes
b. mitochondria
c. chloroplasts
d. DNA

___ 2. Which of the following structures is not present in an animal cell?
a. well-defined nucleus
b. cell wall
c. cell membrane
d. cytoplasm

___3. A membrane is selectively permeable will allow what substances to pass through?
a. starch
b. a small molecule
c. a polar cell
d. a molecule that is insoluble in the phospholipid molecules

___4. A double layer of phospholipid molecules with proteins embedded in the phospholipids would best describe the structure of the
a. plasma membrane
b. mitochondria
c. ribosomes
d. cell wall

___5. A DNA resembles a twisted ladder with
a. rungs held together by hydrogen bonds
b. sides composed of sugar-phosphate chains
c. rungs composed of nitrogen bases
d. all of the above

___6. The coded messages in DNA
a. are controlled by transfer RNA
b. are read by lysosomes
c. determine amino-acid sequence in proteins
d. produce ribose molecules

___7. RNA differs from DNA in all of the following ways except
a. it has a phosphate component
b. it contains the base uracil instead of thymine
c. it consist of a single strand
d. it contains ribose instead of deoxyribose

___8. Which of the following RNA molecules carries the protein blueprint out of the nucleus to a ribosome?
a. rRNA
b. mRNA
c. tRNA
d. all of the above

___9. The cell theory states that all cells come from
a. nucleic acid
b. protein
c. other cells
d. carbohydrates

___10. Mitosis always occurs ________ cytokinesis.
a. during
b. instead of
c. before
d. after

___11. The entire framework of microtubules assembled within a cell during prophase is called the
a. aster
b. spindle fiber
c. mitotic spindle
d. kinetochore

___12. For unicellular organisms, mitosis and cell division aid in
a. replacement of body parts
b. maintenance
c. growth
d. reproduction
e. all of the above

___13. Mendel crossed pea plants containing green pods (yy) with plants containing yellow pods (YY). The resulting offspring were
a. 25 percent green
b. 100 percent green
c. 50 percent yellow
d. 100 percent yellow

___14. Organisms with the genotypes Bb and BB have the same phenotype because
a. both organisms are hybrids
b. B is dominant over b
c. the recessive trait reappeared
d. both organisms are homozygous

___15. In pea plants, purple flowers are dominant over white flowers. If two heterozygous purple-flowered plants are crossed, the resulting ratio of phenotypes in the F one generation is
a. 3:1
b. 1:2:1
c. 1:1
d. 2:1

___16. If a heterozygous, short-haired black rabbit (BbSs) is crossed with a long-haired brown rabbit (bbss), the percent of short-haired brown rabbits in the F one generation is
a. 0 percent
b. 25 percent
c. 50 percent
d. 100 percent

___17. Crossing over
a. may cause linkage groups to break apart
b. takes place during mitosis
c. creates new genetic information
d. both a and c

___18. Which of the following human traits are not governed by multiple genes?
a. skin color
b. height
c. eye color
d. blood type

___19. Distinct groups within a species are called
a. phenotypes
b. races
c. clones
d. gene pools

___20. Chemical reactions in the mitochondria
a. are energy releasing
b. help digest food in the cell
c. are not important to the cell

APPENDIX C

EVALUATION FORM

RATING SCALE:

STRONGLY AGREE	5
AGREE SOMEWHAT	4
NEITHER AGREE NOR DISAGREE	3
DISAGREE SOMEWHAT	2
STRONGLY DISAGREE	1

1. This unit improved my understanding of cell biology. 5 4 3 2 1

2. Laboratory activities were enjoyable and useful. 5 4 3 2 1

3. The directions for activities were clear and simple to follow. 5 4 3 2 1

4. The labs presented were easily comprehended. 5 4 3 2 1

5. This program challenged my interest to learn. 5 4 3 2 1

6. I would highly recommend this unit to be used by other biology students. 5 4 3 2 1

7. I prefer this method of learning to others. 5 4 3 2 1

8. There was enough time to complete each of the activities. 5 4 3 2 1

9. This program helped to improve my attendance. 5 4 3 2 1

10. I looked forward to doing the laboratory activities. 5 4 3 2 1

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