DOCUMENT RESUME

ED 273 459 SE 046 919

AUTHOR Lash, Andrea A.
TITLE Portraits of Intermediate Science Classes.
INSTITUTION Far West Lab. for Educational Research and Development, San Francisco, Calif.
SPONS AGENCY National Inst. of Education (ED), Washington, DC.
PUB DATE Nov 84
CONTRACT 400-83-0003
NOTE 245p.
PUB TYPE Reports - Descriptive (141) -- Guides - Non-Classroom Use (055)

EDRS PRICE MF01/PC10 Plus Postage.
DESCRIPTORS *Biology; Case Studies; Classroom Environment; *Classroom Techniques; Grade 7; Instructional Improvement; Junior High Schools; Science Education; *Science Instruction; *Secondary School Science; *Teacher Characteristics; Teacher Student Relationship
IDENTIFIERS Science Education Research

ABSTRACT

Designed to examine the key factors that characterize effective science instruction, this particular volume of the Intermediate Life Science Study portrays the ways in which 11 teachers taught two topics in seventh grade life science. The participating teachers were volunteers from schools in the greater San Francisco Bay area and from the greater Salt Lake City area. Information obtained in the study consisted of: (1) initial student and teacher characteristics; (2) classroom process variables which included teachers' perceptions of and practices during instruction; and (3) outcome variables as measures of student knowledge, cognitive skills, and attitudes. A summary of teacher characteristics is provided as to: gender; highest degree; degree specialization; total years teaching; class size; and subject matter for the observed classes. Profiles are presented of the teachers' approach to the selected topics; examples of instructional activities are described that were employed in the classes. (ML)

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Jeremy George
Dale Baker
David Haller
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Alexis Hitman
Ken Peterson
Mike Piburn
George St. Clair

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The authors wish to acknowledge the support of the National Institute of Education, Department of Education, under NIE Contract 400-83-0003 to the Far West Laboratory for Educational Research and Development, San Francisco, California. The opinions expressed herein do not necessarily reflect the position or policy of the Institute and no official endorsement by the National Institute of Education should be inferred.

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*This document was designated on the May 9, 1983 Revised List of Deliverables as "Updated Catalog of Junior High/Middle School Programs with emphasis on science education".

PREFACE

This report is produced by the Secondary Science and Mathematics Improvement Program at the Far West Laboratory for Educational Research and Development. It is part of an intensive study of intermediate science education conducted in California and Utah. Our overall goal in this research was to describe and understand the combination of student, teacher, and curricular factors that characterize effective science instruction.

In this volume, our goal is more limited. We portray the ways in which eleven teachers in the study taught two topics in seventh-grade life science. No evaluation is made of these teachers' instructional strategies as we seek only to give readers an idea of what intermediate life science classes are like. Later documents will analyze different combinations of teacher, student, and curricular characteristics to illuminate what makes for effective science teaching. Those interested in receiving further reports from ths study should contact the Secondary Science and Mathematics Program at Far West Laboratory.

We thank Dr. Virginia Koehler, Mr. Michael Cohen, and Dr. John Taylor, Teaching and Learning Division, National Institute of Education, for their support in this and other work. Their interest in exploring innovative ways of approaching the problems that confront educators and their encouragement of educational excellence are appreciated.

We also thank the teachers and principals who collaborated with us in the conduct of this study. Their willingness to welcome us into their classrooms and schools and to describe their programs have helped us to understand better the current state of intermediate science education.

Many individuals helped in the preparation of this report. Authors of individual portraits are identified on the title page and in the portraits. Dr. Andrea Lash edited this volume and supervised its production with the assistance of Jeremy George and Thomas Rounds. Madeline Finch and Betty Hey prepared the final copy. To all, thank you.

John R. Mergendoller
Principal Investigator

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

INTRODUCTION

Pre-college education in science is a subject of fresh concern in the forums of national self-assessment and public policy. Termed by some critics as a "crisis" (American Association for the Advancement of Science, 1982), the concern centers around data indicating that very few of the nation's students experience lengthy science curricula, that students' science achievement has declined during the 1970s (National Assessment of Educational Progress, 1978), that large portions of teachers who teach science are not qualified to do so, and that much of the available curricula do not represent the multiple goals of science education or recent advances in technology (Good & Hinkel, 1983). Science serves as a good specific example of many of the general problems that plague education today (National Commission on Excellence in Education, 1983). Furthermore, science is viewed as an especially important example because of the increasing role that science plays in shaping our society.

Most students first encounter science as an isolated subject in junior high or middle school. We suspect that their first experience of a science class may have a major role in forming their perceptions of science as a discipline, avocation or future career choice. Consequently we believe it is important to focus analysis and improvement attempts at the intermediate grades.

In the professional lives of teachers, there is also significant change at the intermediate level. For the first time, those teaching science are science teachers skilled in a particular subject matter. With subject matter specialization comes opportunities to foster professional identification and provide specialized training to help instructors become better teachers.

Because of the confluence of these trends in the lives of students and teachers, we have focused a major research effort on effective science instruction in the seventh grade (Mitman, Mergendoller, & Guthrie, 1983). We have chosen to look at life science because this subject is frequently taught at the intermediate level, and it provides a foundation for high school biology, the science course taken by the majority of high school students. By illuminating effective instructional practices, and then developing programs to help other science teachers become proficient in these practices, we hope to affect the quality of science education in the United States, and indirectly, the scientific preparation of America's citizens and scientists.

This document is a first step in the understanding of effective science instruction. In it, we portray the instructional procedures used by eleven teachers during two topics in seventh-grade life science. We hope the profiles will be interesting to those curious about students' initial experience in science classes. In our work with educators we have learned that many

people would like more opportunities to observe teachers and students in classrooms. Teachers, for example, have asked how other teachers organize and deliver instruction. Researchers who have not observed science classes have little idea of the activity and numerous materials involved in laboratories and demonstrations. In addition to satisfying curiosities, we expect these portraits to be useful to those implementing staff development programs or new curricula. Without an understanding of the status quo, intervention efforts may focus on inappropriate goals and be ineffective. Agreeing with Stake and Easley (1978) that "the teacher is the key" to curricular change, we believe that the classroom reality of this key actor must be understood before plans can be made to change it.

The Intermediate Life Science Study

The overall goal of the Intermediate Life Science Study is to describe and understand the combination of student, teacher, curricular, and task factors that characterize effective science instruction. In working toward this goal, we studied eleven classes during a school year and collected three types of information about those classes: background information, which includes initial student and teacher characteristics; classroom process variables, which include teachers perceptions of and practice during instruction; and outcome variables, which include measures of student knowldege, cognitive skills, and attitudes. The profiles in the chapters that follow are based on the background and classroom process data obtained through teacher interviews and classroom observations.

The eleven teachers in this study were volunteers who allowed us to observe one life science class. There were no stringent criteria for selection of the class; teachers simply nominated a class that was typical of the seventh-grade life science classes at their school. Four of the participating teachers were employed in three schools in the greater San Francisco Bay Area. The other seven teachers were employed in five schools in the greater Salt Lake City area. (The smaller number of teachers in California was due to the fact that a full year of seventh-grade life science was not as common there as it was in Utah.) One school was located in a rural area of Utah, while the other seven schools were in suburban areas. The socioeconomic conditions of the schools' communities were generally similar, ranging from middle to upper-middle class. Total school enrollment varied greatly, ranging from 492 to 1532 students.

Observations were made of each class during two topics of instruction, one in late Winter and one in Spring. One reason for building observations around specific topics was to enable descriptions of how different teachers handled similar subject matter. A second reason was to create opportunities to observe a variety of activites within a single classroom. Selection of the two topics for each teacher was based on four criteria: 1) that

the topics be part of the teacher's normal plan, 2) that each topic last at least 5 days, 3) that the two topics represent a contrast in level of organization (micro vs. macro), and 4) that commonality across teachers in the topics be maximized.

A summary of the classrooms and a list of the topics taught in each are provided in Table 1 to aid readers in selecting classrooms of interest to them. The table indicates that four of the eleven teachers are female. Three of the teachers have a masters degree, and all but two teachers have some specialization (major or minor) in the field of science. The general teaching experience of this group ranges widely from 1 to 24 years. The sizes of the teachers' classes at the start of the school year ranged from 24 to 32. The table indicates several topics common to three or more teachers: cell structures and genetics, protists, ecology, and human organs and systems. The profiles in the chapters that follow describe each teacher's general approach to the topics and provide examples of instructional activities as they occurred in the classrooms.

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Table 1. Characteristics of Participating Teachers and Classes

TEACHER ID	TEACHER GENDER	HIGHEST DEGREE	DEGREE SPECIALI-ZATION	TOTAL YEARS TEACHING	INITIAL CLASS SIZE	SUBJECT MATTER OF FIRST TOPIC	SUBJECT MATTER OF SECOND TOPIC
1	F	Bachelor's	Biology	5	32	Genetics	Ecology
2	F	Bachelor's	Biology	14	29	Protists	Digestive Systems
3	M	Master's	Zoology	24	29	Sponges and Coelenterates	Human Systems
4	F	Bachelor's	Physical Ed. (Botany Minor)	7	32	Protists	Human Organs and Systems
5	M	Bachelor's	Biology	15	30	Protists	Genetics
6	M	Bachelor's	Mathematics & Elem. Ed.	1	24	Bacteria and Viruses	Birds and Mammals
7	M	Bachelor's	Science	15	28	Ecology	Genetics
8	M	Master's	Physical Ed. (Life Science Minor)	17	24	Protists	Human Digestive System
9	M	Master's	Physical Ed. (Sci. Minor)	23	29	Cell Structure and Function	Human Circulatory System
10	M	Bachelor's	Biology	10	29	Cell Division and Genetics	Human Circulatory & Skeletal Systems
11	F	Bachelor's	Soc. Science	15	29	Ecology	Bacteria and Viruses

TEACHER 1: JULIE STONE

by Ken Peterson

Introduction

This is a brief description of Julie Stone's 7th-grade life science class at Brooks Junior High School. The first set of observations were conducted in early December, 1983. The topic was reproduction and inherited traits. The second set of observations occurred in April, 1984 and covered the topic of ecology.

Background and Viewpoints

Julie is an enthusiastic, energetic, and pleasant person. She has a quick pace about her and works hard at her teaching in terms of time and preparation. This is her fifth year of teaching, all at Brooks, and her work still is characterized by novel approaches and organizations. She has a strong interest in the out of doors and microbiology and does a good deal of nature study on weekends.

Julie completed a composite biology program at a western university. In addition, she accumulated several years of biology credits at another university. She has kept active in inservice courses, and plans to complete a master's degree when she can find a program that emphasizes science content more than education.

According to Julie, hands-on experiences are important in science classes. At this age, students are becoming "formal thinkers" where they "can read and then think about things they can't see, and understand them." She feels there is always the problem of providing freedom and responsibility in the classroom. Two barriers to active, learning classes are the short class periods (50 minutes) and large class size (more than 30 students).

Julie reports that about 75% of the students who begin her class know almost nothing about life science. "A few of the grade school teachers have covered several science units, but not all of them. Some [students] come in with essentially no background at all." She believes that some of the students are excited about taking science, but others are afraid. She says that "girls are generally a little more emotionally mature than boys at this age. But as far as their attitudes in science, it is about even. I have as many good girls working in science as I do boys." When asked about the goals for her science classes, Julie commented,

I would like them to be able to have a real feeling of curiosity about the world around them. I'd like them to know that if they do have a question, they'll know how they can go about answering it; how they can use resource material. And I'd like them to end up with a feeling of wanting to question the world around them to begin with. I'm working more on attitudes more than specific information. I want them to feel excited and happy and know what's going on in science. I want them to be curious about the world around them and come up with questions, and think about ways to answer them.

Julie enjoys teaching science in junior high school because of the great enthusiasm and changes in students at that age. Julie is not ". . . extremely impressed" with textbooks available for her class. She uses three different textbooks because each has passages or treatments that she prefers for specific topics. In addition, she is critical because the textbooks do not go into sufficient depth on topics covered. She thinks that students have some difficulty in comprehension, although not in basic reading (decoding) skills.

Classroom Description

Julie's classroom is windowless, tile-floored, and somewhat small in size. Students sit at 16 two-person, moveable lab tables which are arranged four across and four deep. A demonstration table (with sink and gas jet) and a teacher's desk are at the front of the room. Laboratory work counters are along the sides and back of the room. Sinks, gas jets, and electrical outlets are plentiful. The room is clean and orderly, but feels crowded with 32 students present.

The classroom contains seven aquaria-terraria with fish, kangaroo rat, spider, hamster, lizard, and tortoise. There are six living plants around the room. At the left rear is a door to a south-facing greenhouse, shared with the adjacent classroom. Around the periphery of the room are bulletin boards with teacher-made displays. Under the counterspace and in cabinets around the room is much storage space. Several sets of old science textbooks are kept above one counter. Safety equipment, fire extinguisher and fire blanket, are visible and available. The front of the room has projection screen, chalkboard, and intercom speaker. An overhead projector is a regular item in the room. The room is lit with fluoroscent lights.

The room is used once a day by another teacher. This places a limit on what materials can be left out during the day.

Course Overview and Instructional Strategies

Julie organizes the year to cover the major topics of life which she feels are important to a good understanding of how science works. She organizes the course in 2-3 week units. She uses the textbook Exploring Living Things (Smith, Frazier, & Magnoli, 1977). The course does not follow the text directly, but is planned in shorter units by Julie. She begins the year with a unit on how scientists learn and what is meant by scientific inquiry. She then moves on to physical influences and the plant and animal kingdoms. By mid-year, students learn about plant and animal structure and function. The last part of the year focuses on ecology and human-nature interactions. Science fairs and student projects play an important role in several of the units.

Units are organized around worksheets that contain knowledge objectives, usually consisting of vocabulary definitions. Julie has collected and written a large number of worksheets that require hands-on activities and brief definitions from the text. A unit begins with an inquiry activity or a movie.

Julie's instruction relies on initial presentation of vocabulary words (which in some cases represents concepts), followed by a combination of looking them up in texts, hearing them described, and seeing them in association with hands-on activities. She describes her approach as follows,

> Usually we start a new unit off with some type of an inquiry or a movie. First of all I think of an inquiry session with them or thinking about what we're going to be studying and I just do it in segments, not day by day, but by the type of activities we're going to cover. And then we'll have some reading and some hands-on experiences. And then we'll come back to help them put things in the right garages.

Her recitations usually require students to recall brief definitions or facts which she expands with further description. Recitation sessions are fast-paced and filled with considerable detail. Hands-on activities provide detailed directions and materials; it is usually clear to students what they are to do and see. Activities are designed to demonstrate a relationship or principle and do not call for pupil innovation. Use of the text is limited to brief readings followed by worksheet questions. Students have limited opportunity to practice new subject matter--worksheets are rather slow, and few students are called upon in class. Student reports are brief and perfunctory and homework is not relied upon. Films and videotapes play a key role in introduction and illustration of class topics. A class period usually contains 5 to 6 distinct segments. Tests are limited to quizzes. In the second set of observations, Julie used "concept dramatization" activities, which illustrated principles without actually involving students in first-hand biology.

Excerpts from Classroom Observations
Topic One: Reproduction and Heredity

Table 1 summarizes how Julie taught the 10 days of Topic One. During this time she relied on approximately 8-12 recitation episodes, group presentations, two hands-on lab activities, daily seatwork times, and two audiovisual presentations. She began each day with a quick presentation of vocabulary-concepts. Students reviewed materials with a vocabulary game. Illustrative examples of the instructional segments follow.

Recitation: Asexual Reproduction (Day 2)

She tells the students to take out their notebooks and says, "Now, I want everyone to be quiet." Referring to a list of objectives for the unit, she continues, "Who will read #1? Joe?" Joe responds, "Compare asexual and sexual reproduction." Julie says, "Okay. That's the first thing we're going to do today. What's the second, Tony?" Tony replies, "Describe five methods of asexual reproduction."

Julie reads four more objectives for the unit and then takes a stack of papers from her desk and distributes them to the students. Her pace is brisk as she continues, "Okay, now, there are two main ways that living things reproduce. Now, first of all, sexual reproduction requires two parents." Julie is at the overhead projector and is writing notes as she goes along. Students are quiet and listening and she instructs them to make notes on their worksheets. She continues,

> There two main kinds of reproduction, sexual reproduction and asexual reproduction. The next thing is that sexual reproduction requires special sex cells. The third thing is that offspring are different from either parent. Now, I want you to think back why that might be. Josh?

Josh replies, "Cause they have genes from both parents?"

> Good, Josh. Because when the chromosomes come together, the chromosomes from both parents, the two chromosomes are able to produce a new individual whose genes are different from both parents. Okay, under asexual reproduction, here are the things I want you to remember. First of all, it just requires one parent. Second, this involves mitosis, and now you're all experts on mitosis. I was really pleased when I looked at your quizzes yesterday. And the third thing is that the offspring look exactly like the parents. No, I don't like to call them offspring, they really are resulting organisms.

Table 1. Duration of Classroom Activities During Reproduction and Heredity Unit (Teacher 1)

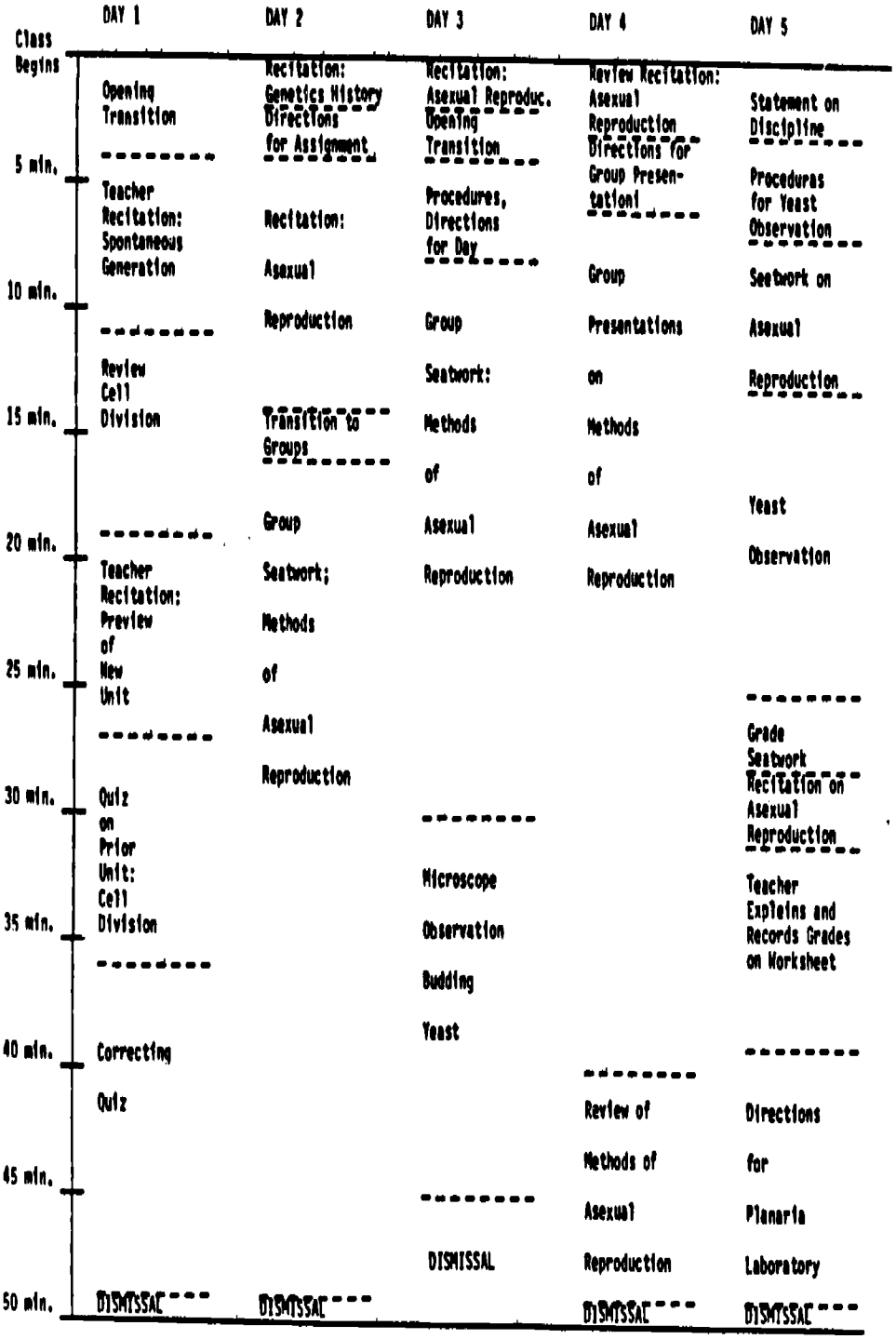


Table 1 (continued). Duration of Classroom Activities During Reproduction and Heredity Unit (Teacher 1)

Class Begins	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
5 min.	Recitation: Regeneration in Planaria	Recitation on Sexual Reproduction	Continued Planarian Lab	Vegetable Reproduction Assignment Recitation: Vegetative Reproduction Directions for Seatwork; Crossword Puzzle	Recitation: Heredity Procedures for Seatwork
10 min.	Procedures for Planaria Study				
15 min.			Directions for "Takehome Test": Reproduction: Logistics and Procedures		Film on Inherited Traits
20 min.	Planaria Regeneration Lab			Seatwork: Crossword Puzzle on Reproduction Vocabulary	
25 min.			Recitation on Cell Division		Recitation on Inherited Traits
30 min.		Seatwork	Additional Directions for "Takehome Test"		Procedures for Seatwork
35 min.	Clean-up	Continued Recitation-Discussion on Sexual Reproduction	Seatwork: "Takehome Test" on Reproduction		Seatwork-Lab: Checklists of Inherited Traits
40 min.	Review Lab Sheet			Review Game on Unit Vocabulary	
45 min.	Recitation on Grafting	Videotape on Sexual Reproduction in Sea Urchins	Review on Reproduction		
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Julie's pace is quick and energetic. She continues to write notes on the overhead sheets for students to copy. Students are attentive and enthusiastic. She continues, "Now, why would the resulting organism look just like the parents?" Sheila responds, "Because their chromosomes have been exactly duplicated?" Julie says, "That's right. They've been exactly duplicated, haven't they?" Josh interjects, "If the world started from one cell, how does everything look different?" Julie responds, "Well, that's a good question. Would you like to do an extra credit report on that?" Josh doesn't appear anxious to do a report but Julie pursues the idea with the rest of the class,

> Now, that's a really good question. I think you should be able to read about and find the answer for yourself. Now, how many of you know about this idea that all life started from one cell? How many of you would like to do an extra credit report on that? Josh, could you do that? I'd really like you to write about how life could have begun in the sea.

Doris asks, "What would you look it up under?" and Julie says,

> You could look it up under creation or origin of life. I have an article from Science Digest on the origin of life. How many of you would like a copy? Maybe all of you would like a copy. How many would? It's really an interesting article. I'll bring about 20 copies, so any of you who want to can read and then we'll discuss it. Okay, next I'd like you to look at the pictures on the notes I handed out to you. They show five different ways of asexual reproduction. Okay, look at the top picture and tell me what organism that is. Bruce?

Bruce doesn't respond, so Julie calls on Mickey, who says, "Cell division." Julie continues, "Okay. That's what's happening. Cell division is what's happening. But, what is the organism that it's happening to? Can any of you guess?" A student calls out, "Amoeba?" Julie says, "Okay. When your cells undergo mitosis, what happens to you?" Another student calls out, "You get bigger." Julie continues, "You get bigger, or your cells replace other ones. But what happens to this guy?" A few seconds pass and no one responds, so Julie continues,

> It becomes two amoebas. So when an amoeba undergoes mitosis, does it just get bigger? No, it becomes two. Okay, now there are many single-celled organisms who reproduce just this way. Now, here we have another way. It's called spore formation. Does anyone want to guess how this works?

A couple students voluntarily call out answers which are incorrect. A student finally says "fungus" and Julie responds,

> Yes, a fungus. How many of you have seen moldy bread at home? I think most of you have. If you looked at it through a microscope you would see something that looks like this. It looks like a lollipop, but it's releasing spores all over the place. Now, down here is a strawberry plant, and you can see the runners and how one plant is making another. This one micro-organism is making another through mitosis. Now, does anybody recognize what's down here? (She points to a hydra.)

When no one responds, she continues,

> It's called a hydra and it lives in the water. It's about a half an inch long and forming a bud. And then you have a starfish and it's growing a new arm. Now, turn your paper over, you're going to have to do it fast. You'll be put into groups. I want each group to investigate one method of asexual reproduction. That way, no one has to research all of them. On Monday, I want you to tell the rest of the class about that method of asexual reproduction and they will take notes.

Microscope Observation (Day 3)

Hands-on activities play an important role in Julie's instruction. This activity is guided by a handout sheet that provides instructions and asks students to answer seven questions (e.g., "What are the advantages of this type of asexual reproduction?").

The first lab directions are given as part of the procedures for the day. Students are instructed to start the lab after finishing the group seatwork assignment. Julie begins:

> Start the budding lab. This is not easy because the yeast are really small. Be careful not to make a big, fat glob of yeast culture on your slide. Make a thin smear. Then, follow the lab. At the five-minute bell, I want you to stack the books, clean the table and hand in your transparencies. Are there any questions?

When no one responds, Julie tells the students to break into groups. Students choose their partners. The activity is set up on the counter spaces around the room. At each of the work stations, there is a microscope, yeast culture, iodine stain, glass slides, and dropper.

The budding activity calls for students to take a dropper full of yeast culture, stain it with iodine, observe it under the microscope, and diagram what they see. The microscopes have only a low power objective, so viewing is quite difficult. Difficulties in the procedure include getting an optimum amount of stain, not too large a sample of culture, and focusing properly. There

is no movement or visible growth in the yeast, just many yeast cells--some of which have small attached spheres.

Julie gives procedural help to students during the lab. She says, "Now as you do the lab, be sure that you're seeing individual yeast cells. Your eyes are not like mine, so you'll have to focus for yourself." Students complete the activity by filling in their worksheets which will be included in unit notebooks, and become a small part of the grade.

Recitation: Regeneration in Planaria (Day 6)

After completing a few administrative tasks, Julie begins distributing ice cubes for use in today's lab. She begins,

> Now, this has turned out to be a fun lab today. I think you will enjoy it. To start, I want to talk to you for a bit about regeneration. Usually, regeneration, the ability to grow back parts that are lost all the way to a new organism, is limited to invertebrates. Now what are invertebrates? What is an invertebrate animal?

She first calls on Lauren who does not respond and then on Janet who says, "Animals without a backbone." Julie continues,

> That's right. Invertebrates are animals without backbones. Now, not all invertebrates can regenerate. Some that can are earthworms and planaria, they can regenerate. How come we can't regenerate? The thing is that we are highly specialized. Some of our cells are so specialized they don't even reproduce. For example, muscle, nerve, red blood cells don't even reproduce. That's the problem with a heart attack, when most cells are gone they're gone for good. The muscle can be permanently damaged. If there's scar tissue, we'd have real problems. Does anyone know why?

Steve responds, "The heart beat is not very strong." Julie says, "Well, yes. But the problem is that the muscles don't reproduce new cell. Now, what happens to other tissues when there is a cut?" Tony volunteers, "Cuts will heal." And Julie adds, "Yes. The tissues can make more cells so that cuts will heal. That's about as far as regeneration goes in humans."

During this presentation students are quiet, attentive, and rarely whisper to one another. Julie now takes a small specimen jar and holds it up for the class. She continues, "Now, these are planarians in this jar. These are not parasitic. Does anyone know what that means? What's a parasite?" When no one responds, Julie says, "Now, these flat worms are nice, they're not parasitic. Tony?" Tony responds, "They're a host organism." Julie continues,

Yes, parasites live off of the host. Now,if you want to collect some planaria of your own, you can put some liver under a rock in a stream and the next morning there'll be planaria attached to it. These planaria are really interesting. If you look at them through a magnifying glass, they look like they have eyes, but let me show you.

She now turns on the overhead projector and continues.

They're really cute little guys. They look like they have eyes, but they really have photosensitive spots, not eyes, on their anterior end. Planarians have learned to avoid light and they crawl back into the dark. Why do you suppose they want to do that? Josh?

Josh responds, "They don't want to dry up." Julie says, "No, in water they won't dry out. Tony?" He answers, "They might get eaten." Julie then continues,

You've got the right idea, they like to stay hidden. It helps them to stay in dark places, so they can stay away from animals that might like them. Now, when you turn them over on their backside, you'll see that the underside is gray. You can turn them over and look at the underside and you'll see a little tube, called a pharynx. This is where they suck in food and wastes go out. Today, when you cut your worms in the lab, you'll cut just right below the head. You may have a hard time in finding the pharynx. (She continues to use the diagram on the overhead projector.) These worms can reproduce asexually. They have both male and female organs inside them. That means they can reproduce alone, together, or they can regenerate. That's what you're going to do today. I'd like you all to take your lab sheets out from yesterday.

Students shuffle their papers, looking for their lab sheets. Julie stays at the front of the room waiting for the students to get settled. Tim asks, "Do they bleed when you cut them?" Julie responds,

They don't; not that you'd notice. Okay, class, before we go over the instructions, I want you to observe before you begin to cut. Notice how they move. They have a muscular side-to-side movement, or a gliding type movement. They're fun to watch. They have cilia on the top surface to help them glide through water. Remember, cilia are hair-like projections. You won't be able to see them even with your hand lens, but, they help the planarian to move through water.

Planaria Regeneration Lab (Day 6)

After the brief recitation on planaria regeneration Julie sets up the lab activity. She moves down the aisles, assigns students to work with each other, and gets the materials needed for the lab. She asks one group to check to make sure all materials are ready. She now talks to the entire class,

> Now, I need your attention, shhhh. I want to make sure you have the materials. You should have a safety-razor, microscope slide, an ice cube, a dropper, and you'll have to share magnifying glasses, as we don't have enough.

After several minutes of making sure students have the necessary materials, Julie continues,

> We are short of brushes, the little planaria can get stuck in the dropper. Use the brush by each bottle or you can use the edge of a paper towel as we found out earlier today. Now, read the instructions. It says to use aged water. That means leaving it out 24 hours. The chlorine gas leaves the water. It helps to dechlorinate the water, which the planaria can't tolerate. Never use tap water with the planaria. Just use the water in the bottles.

Mickey asks what he should do because they don't have a small brush. Josh asks if it should be turned over with a brush. Julie says to all, "I don't want to take time to read the instructions to you. Start with #1 and do things a stage at a time." At this point students are beginning to work intently at their tables transferring planaria, putting ice on them to slow them down, getting paper towels ready to move them. A few students are reading instructions.

A few students move around the room getting aged water; most are on the task at their tables. Julie moves up and down the aisles stopping and assisting students with their work. She moves about the room, making sure students have their materials and that they are following instructions. She reminds Mickey to use aged water and tells Marilyn to number petri dishes. Tim asks, "How many planaria do we need?" Julie says to the entire class, "You'll need one worm per team, which is two people. We have just enough for today."

Julie continues around the room, talking to various students as she does so. Her conversations focus on directions and procedures. She uses praise when she sees that students are doing the assigned activities.

After 35 minutes of class, Julie tells the students, "Most of you are ready to put your planaria away." Students begin their cleanup. After cleanup, the students review lab sheets before dismissal.

Excerpts from Classroom Observations
Topic Two: Ecology

Table 2 summarizes the activities which occurred during the second set of observations. The topic was ecology and covered nine days of instruction. Several "concept dramatization" activities, more seatwork, and a greater reliance on a study guide differentiated this presentation from Topic One. Excerpts from the observations follow.

Seatwork (Day 2)

The class begins with an opening transition and directions for completing the unit study guide. The seatwork assignment for today is to complete a worksheet consisting mainly of defining terms (which are to be looked up in the textbook) and construction of a food web.

Students are quiet and attentive while paging through their textbooks, looking for answers. The teacher is at the front of the room. After several minutes she says,

> Now, on the next assignment sheet. Note #47 is a lab and Note #48 is the activity. I'm going to come around and put a ruler on each desk. You're supposed to actually draw a diagram of your neighborhood on the backside. You should be able to do this assignment in class today. You can do the map part at home. But you should do the reading here because you can't take [the textbook] home."

Students concentrate on their worksheets and fill in answers. Most of them, but not all, start from the top of the sheet and work down. They do not read for extended periods of time, but scan two or three sentences until they find answers. Julie begins distributing the rulers.

While the students are working, Julie attends to several terraria and cleans the counter. Julie responds to every student who asks for help. In addition, she gives unsolicited comments to about 25% of the students during the segment. Students do not appear to resent intrusions. After several minutes, about a third of the students begin to look around the room and concentration begins to lag. However, students are not disruptive. Julie walks down the middle of the room, glancing at various papers. She stops and helps students along the way.

After several more minutes, Julie says to the entire class,

> Uh, as I walked around, there's one question that quite a few of you are having a problem with, and I'd like to

Table 2. Duration of Classroom Activities During Ecology Unit (Teacher 1)

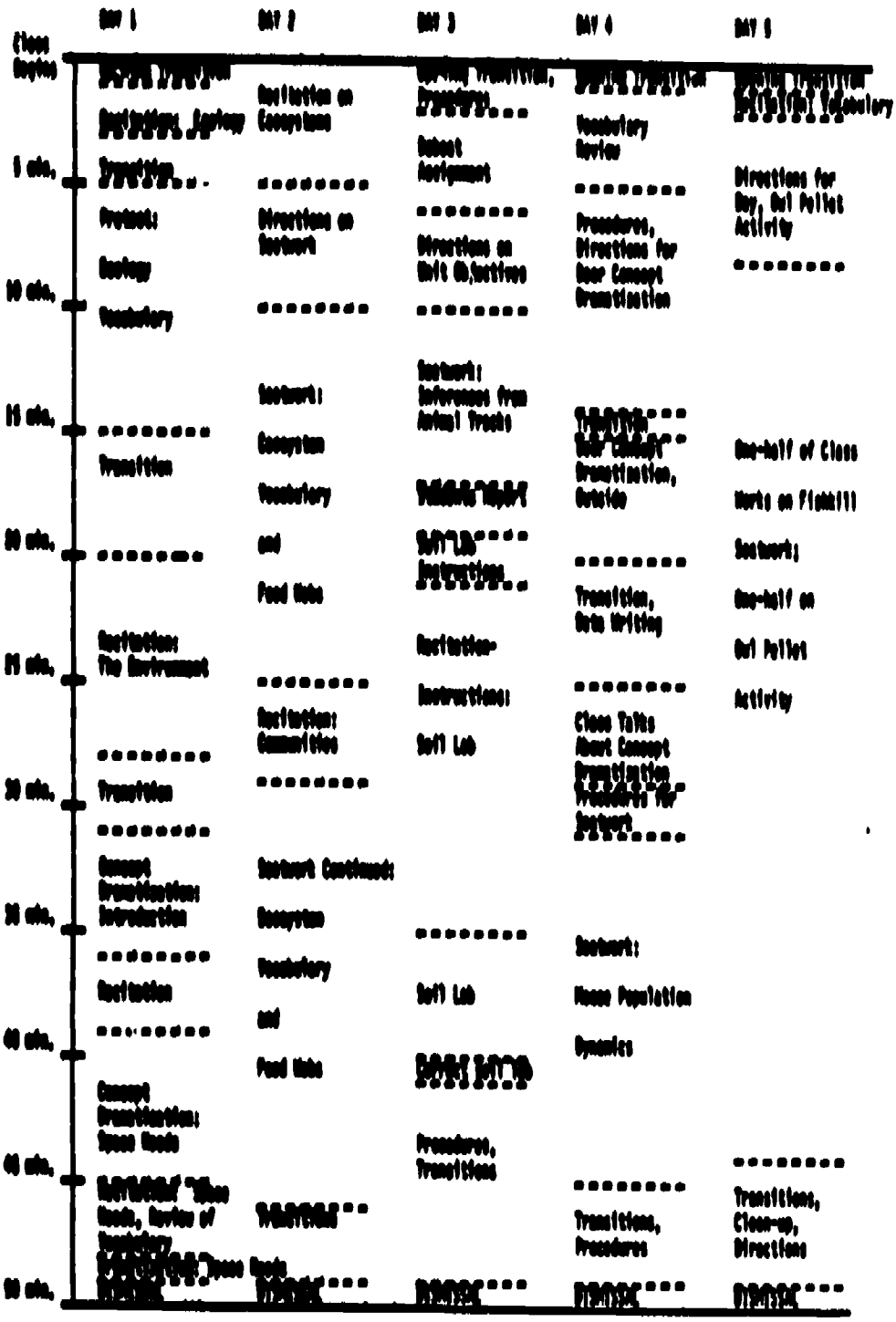
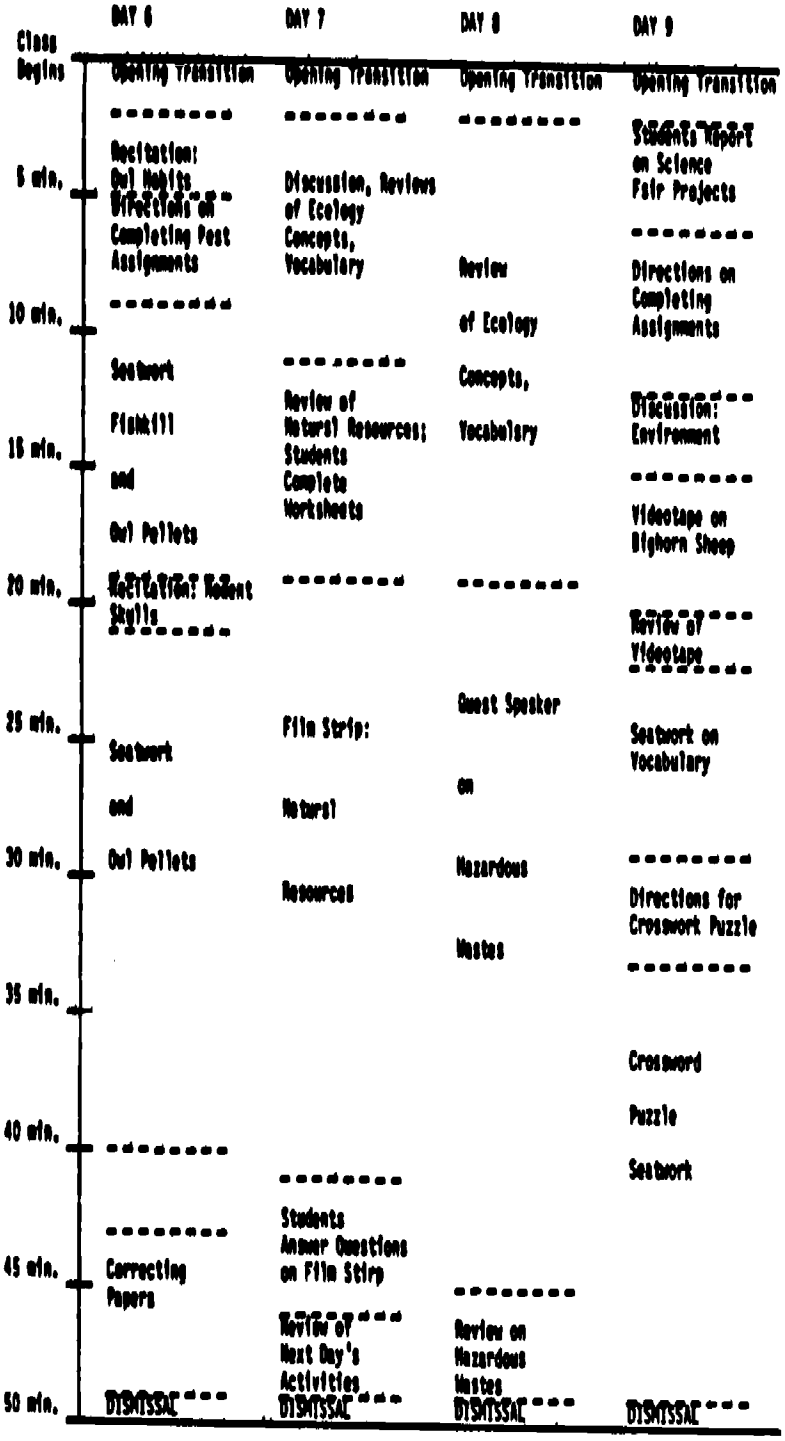


Table 2 (continued). Duration of Classroom Activities During Ecology Unit (Teacher 1)



talk to you all together about it. It's number three. It says, "Explain how populations in a community are dependent on each other." Now, I've talked to several of you about this. Visualize a mountainside where there are only deer living. And there's a brush fire. All the shrubs that they usually eat were taken. What would happen to the deer?

Josh says, "They would die." Julie continues, "Okay, on that mountainside, we're talking about a limited amount of species. How do the populations really depend on each other? If there were only wildcats on the moutainside, what would happen?" Joe says, "They'd die." Julie continues, "So that's one way populations are dependent upon each other, then. Right, for what? A student replies, "Food." Julie concludes, "That's one way; see if you can think of some other ways." The students resume work until completion of the sheets.

Discussion on Bobcat Assignment (Day 3)

The class period begins with 2 minutes of opening transitions and orientation to the day's activities. From readings in their text, students completed a worksheet on the feeding habits of bobcats. Julie begins:

Now I'd like to hear from several of you. Let's read the question one more time. You did a graph on the food habits of the bobcat and your assignment was to write a paragraph describing how the bobcat's diet changes from season to season. Okay, now I know Josh gave this some special thought because I talked to him after school. You go up to the front of the room and read your paragraph.

Josh reads,

In early winter, every category rises except for the birds. And for the rest of the winter, every category increases except the rabbits, hares, field mice, moles, squirrels, and chipmunks. In the early spring, all the categories go down, the rabbits and hares keep going down. The sheep, goats, and cattle slowly increase. And the other 4 categories rise sharply in summer. In summer, insects and birds rise; and deer, sheep, and cattle go down. The field mice go down, and then they start going up. In fall, the insects, they go up a little, then they come back down. Then the birds go down and come up a little. And that's about how most of it goes.

When Josh finishes reading his paragraph, Julie says,

Thank you Josh. Now the data table itself does not tell you what the bobcat prefers, or the availability

of those particular animals that particular season. When you look at the graph the way Josh did, and notice that for instance in the wintertime, the rabbits are eaten more than they are in the summertime and that the deer are eaten more in the fall, what are some of the generalizations you can draw? Why do they like deer? Deer was, I think, one of the third preferences as far as the amount of food found in the stomachs of these bobcats. But, why would they eat more deer in the fall? Why do you think the reason behind that is? Because they'd be more available?

Josh replies, "Probably." Julie replies, "Right. Now how many of you go hunting for deer with your dads?" (Most of the boys raise their hands.) Okay, what do all the hunters hope for in a hunting season?" A student replies, "Shoot a deer." Julie says, "Well, besides shoot a deer. But what?" Margaret answers, "Snow" and Julie continues, "Why do they like snow? It sounds like Margaret's father hunts. Okay, why does he want snow, Margaret?" She replies, "When it snows up in the mountains, it gets too cold so the deer go down." Continuing the discussion, Julie says,

> And now what elevation does it say bobcats usually like to be at? Okay, they're below 7,500 feet elevation so that they usually don't go to the tops of mountains. And that's where the deer are in the spring and summer. But, what happens in the fall? Usually when the snow falls, the deer, like Margaret says, come down looking for food. Then what happens? They're natural prey for bobcats.

Instructions: Soil Lab (Day 3)

For hands-on activities, Julie generally prepares students with fairly extensive background information and procedural sessions. The directions are repeated on lab sheets which are turned in at the end of units and become part of a unit grade. Students are not expected to take notes during these preparation sessions. Activity materials have been on the desks since the beginning of class and include paper towels, soil samples, egg carton holder, and a hand lens. Julie begins,

> Today I want you to look at five different types of soil. Four of them I collected at Ram Rock last weekend. I was really pleased to see such good examples of the four types of soils that I wanted you to look at today. So, I want you to see if you can use a key to identify the soil types. And then after we correct the lab, this lab shouldn't take more than fifteen minutes, then I'd like to choose several of you to do a class experiment. In each class, I've chosen several students who will do a class experiment with bean seeds to see which type of soil the bean seeds will grow best

> in. And we'll have just enough time between now and the end of school to see which plants do best in which type of soil. Okay. Look at the soil identification chart. Now, you've used an identification chart before when you identified invertebrates. And remember when you use a key, each time you look at a new specimen you go to Number One. So, for each soil type, you'll go to Number One. What I'd like you to do so that we don't mix up soil types, is take a pinch of soil and put it on the newspaper by the corresponding number. Then you can run it through your fingers, or look at it under the dissecting microscope if you want to. But move it out of the egg carton onto the paper. Okay, now you'll start with Number One each time you have a soil type. Number One, if the soil feels gritty, go to step two. So, you go to two. Let's say it felt gritty, go to 2A, which says "soil forms cohesive ball like loam." What does cohesive mean? Any ideas?

Seth raises his hand, and Julie calls on him. He answers, "Sticks together." Julie continues, "Yeah. It's going to hold together. Okay, now let's say it doesn't form a cohesive ball, now what am I going to do?" A student says, "Go down to 2B." Julie says, "The color. You're going to pick up some of the color on your fingers, okay? And so this is how you're going to classify the different types of soil." A student interrupts, "What do you mean by silky?" Julie answers,

> Okay. How many of you have felt silky material? How smooth and silky it is? It kinda slides between your fingers. Now, early-morning classes had a really hard time with this lab. Let' see if you guys can do any better. I still need your attention for a minute before you start. After you classify each soil according to type, I want you to think about particle size. This is really hard, really hard. So, I've decided not to make a particle size part of the lab grade. But, let's just see how well you can do, it's really difficult. You can use the microscope. If you can get a particle size, I'll give you extra credit if you get that right. That would be an extra credit point.

A student asks, "For each one?" Julie answers, "For each one that you can get correctly. Okay, go ahead and start. You're welcome to use the microscopes, but use the petri dishes to put the soil on.

TEACHER 2: CATHY MORGAN

by Vicki Lambert

Introduction

This is a portrait of Cathy Morgan's 7th-grade life science class at Southwood Junior High. The first set of observations was conducted in January, 1984, when she taught about protists. The second set of observations was conducted in May, 1984, when she taught the digestive system.

Background and Viewpoints

Cathy completed a composite biology program and received her Bachelor of Science degree and a secondary teaching certificate in 1970. Although a composite biology degree has no specialty, Cathy emphasized field zoology in her studies. Cathy's first teaching assignment was a combination of 7th-grade science classes and health classes which she taught for 10 years prior to coming to this school. Her assignments at Southwood have included physical education, English, and mathematics as well as science.

Cathy takes part in many activities. She is on a committee which writes curriculum for the district, she also helped to establish an alternative program for underachieving students. In addition, she continually takes in-service courses. When asked how many classes she had taken, she responded, "I can't even tell you the number that I've taken since I started teaching." Outside of school, she belongs to a medieval organization that studies the Middle Ages. She is the coordinator of an arts program for five states, and she studies Japanese.

Cathy feels that most students entering seventh grade have a "spotty" background in science and that their scientific knowledge varies. She stated, "Some students have had elementary teachers that are really interested in life sciences and [as a result the students] have a pretty good background. . . but I can't guarantee what they know." She added, ". . .some of the students have used microscopes, most of them haven't."

Cathy feels that at least 80 percent of the students are highly motivated toward science since it represents "an adult subject" that signals they have grown up. She sees little difference in motivation between girls and boys. By the time students leave her class, she wants them to like science, "to know what they can learn and to know that they can use their minds and come out with a liking for science." After all, she says, "I wouldn't like them to look at a plant or just the world around them and not see anything. I'd like them to really feel a part

of it. But mostly, they need to know that they really are capable of learning."

Cathy wants her students to learn basic science concepts in her class, including the relationship of cells to living things and an understanding of how plants and animals work together. She feels these are particularly important in establishing a strong scientific knowledge base. Of course, she would like students to learn as much as possible, for "the more you know, the more you see." If students leave her class more aware of the living world around them and how its component's interact, then she feels she has successfully fulfilled her primary objective.

Also, Cathy wants her students to know that they can think in her classes and that there are many ways to do this. "There are so many ways to solve any given problem. There's no one right way." More than anything else, Cathy feels that "learning is very personal." Consequently, she demands that students respect the learning of others by following classroom rules and being conscientious about their behavior. She tells the students at the beginning of the year, "I won't allow you to do anything that will keep me from teaching and other students from learning."

Cathy changes her curriculum frequently, adapting, eliminating, and adding to activities and discussions based on new information she has discovered either from reading or from classes she has taken. She is constantly on the look for new materials, and says she does "an awful lot of plagiarizing of labs and changing them to fit my activities." Her classroom activities are diverse, including reading assignments, vocabulary assignments, labs, observations, discussions, readings and reviews, demonstrations, and exams. She changes her approach frequently, keeping the students interested and looking for greater success. "If I'm getting success, then I'll use it. I'm not real proud. I change my approach alot."

Classroom Description

Cathy's classroom is average-sized but it appears quite small for a science room and has little lab space. The thirty desks in the room occupy all the space and impede quick, easy movement. The desks are set in seven rows of four or five seats each, and all face the front of the room. The front of the room is identified by the teacher's desk and lab station.

Three closets and a low-countered shelf line the north side of the classroom. The counter extends approximately half the length of the wall and has shelving units above it. In the center of the counter is a sink. Two guinea pig cages sit on the countertop towards the back of the classroom; one cage holds a pig, one is empty. On the shelves above the counter are a plastic model of the heart, a mounted butterfly display and an insect display. At the northwest corner of the room is a doorway which

leads into a greenhouse attached to this classroom and shared by the classroom next door. The greenhouse is approximately five feet by eight feet, is lined with shelves, and has numerous plants.

The back of the classroom also has a low-countered shelf which spans the entire width of the room. Two sinks are set in the counter. Above the counter are bulletin boards with pictures of glucose and glyceral molecules on them.

The back counter extends around the room on the south wall. Where the counter ends a closet begins; there are models of cursive writing displayed on the three doors to this closet. Above the counter is a bulletin board with cut-out letters reading "One thing about reaching for the sky is that we never come up with a handful of mud." In the southeast corner hangs a plastic life-sized human skeleton covered with a dust cloth.

In general, the classroom is clean, comfortable, well-lighted, and neat, though crowded. There is a sense of activity and an emphasis on life science topics.

Course Overview and Instructional Strategies

Cathy uses Exploring Living Things (Smith, Frazier, & Magnoli, 1977) as her main textbook. In addition, she uses Holt Life Science and Living Things as supplementary texts. Cathy likes this combination of texts as it allows her freedom that one text would not provide; she is not "tied down to a particular. . . a total format."

Cathy begins the year teaching about plants, animals, and seed plants, then moves into bacteria, protozoa, and viruses interspersing information on land and ecosystems. She ends the year with bones, muscles, the nervous system, genes, and heredity. This does not follow the outline of topics in the book, but Cathy feels her format makes more sense.

When presenting units, Cathy often departs from the "read, answer questions, discuss, conduct labs, take a test" format. She does not follow the sequencing of the textbook chapters or rely on the combination of texts to serve as total resource information. Generally, units take from six to twelve class days to cover. Frequently, students are divided into groups of four or five; each group then follows a programmed, self-instructing lesson. As many as eight groups may be at work on different activities. Cathy, at once, monitors during these activities, moving from group to group to assess the group's progress and answer questions. Cathy feels these group rotational activities work particularly well given the space limitation and the lack of lab area. Materials for these activities may come from the text, the teacher's workshop, other teachers' labs, outside sources, or

be written by the instructor. A traditional paper-pencil test concludes each of these units.

Cathy also uses a more traditional approach for some units. These units generally begin with students reading orally from the text or worksheets. Students take notes during the reading, or copy notes from teacher-designed handouts. Vocabulary is introduced and students must be able to spell and define the words, and then pass a test on these words approximately one week later. Cathy gives students various seatwork activities including worksheets, reading assignments, and chapter questions. Because of space limitations half the class observes demonstrations or conducts labs while half does work at their seats. The end-of-unit test is preceded by a verbal review and followed by going through the exam item by item.

In addition to science content, Cathy stresses organizational skills, writing skills and thinking skills. She often requires students to keep notebooks and has the students use them as reference books for "hunt and find" assignments. Students are encouraged through this process to organize their materials, worksheets and notes. Cathy has students take all their notes on "controlled paper," paper with wide lines. She requires students to write in cursive within the lines, to be as neat as possible and to follow the handwriting samples displayed on the closet doors.

Excerpts from Classroom Observations

Topic One: Protists

Table 1 summarizes how Cathy taught Chapter 10, entitled "Protists." During the eleven days on this topic, students worked in groups of four. The group rotated through eight self-instructional segments that lasted one class session each. Day one was spent assigning groups and taking a pre-test on protists. Days two through nine were spent in group activities. Day ten was spent reviewing for the final test, which was taken and corrected on day eleven. Table 1, Day 2 outlines the eight activities. There was no homework during this unit.

Students Take Pretest on Protists and Correct Them (Day 1)

Twenty-five minutes into the class, Cathy passes out pre-tests on the new unit, protists. She tells the students to "be sure to circle pre-test." Students get their paper and begin circling as instructed. Cathy repeats, "Circle the word pre-test on them. Now remember, this does not count on your grade. This is so I can better judge what happened in the unit. Cathy gives further instructions:

> All right. Go through and answer as many of these questions as you can. Write down as many answers as

Table 1. Duration of Classroom Activities During Protists Unit (Teacher 2)

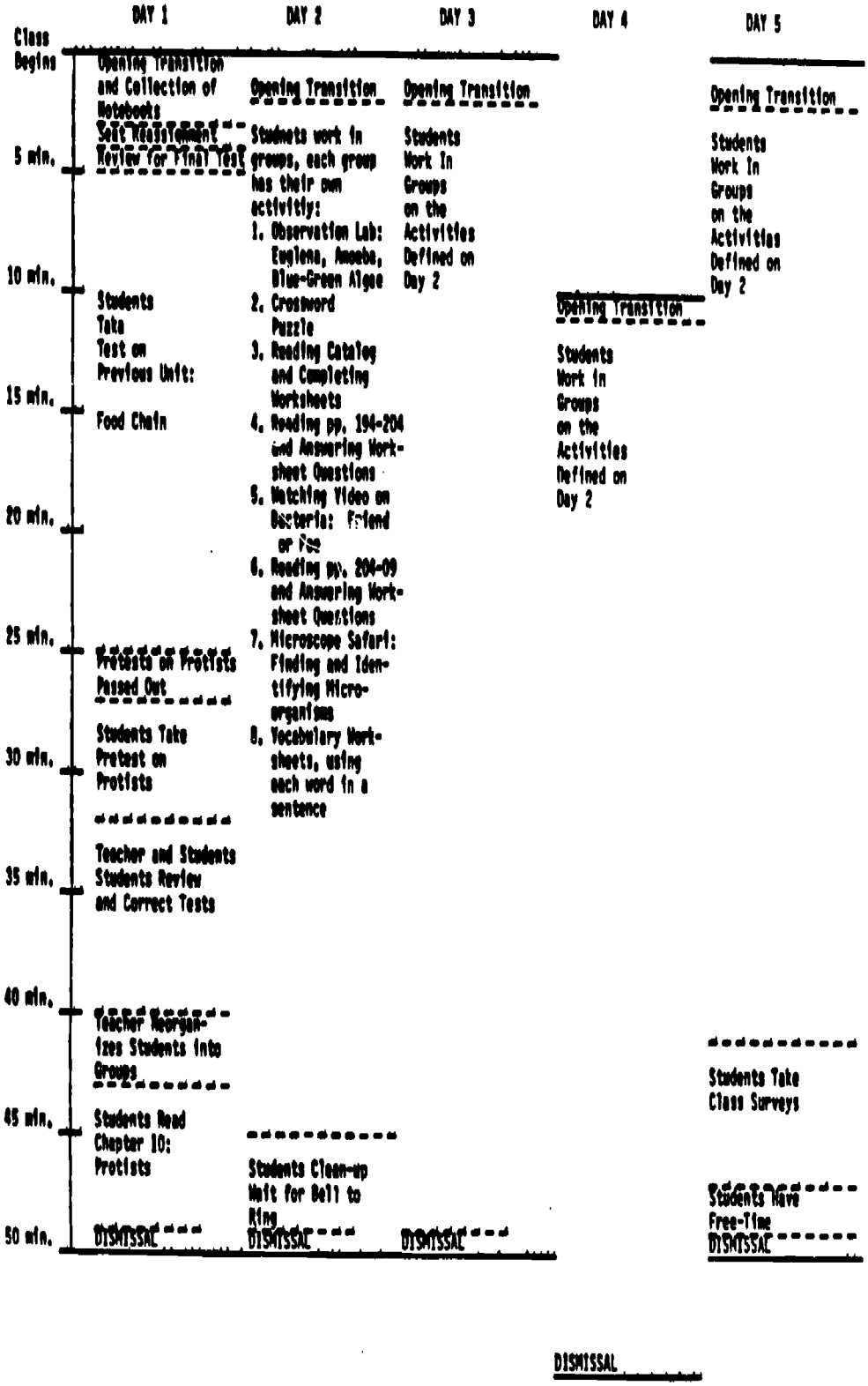
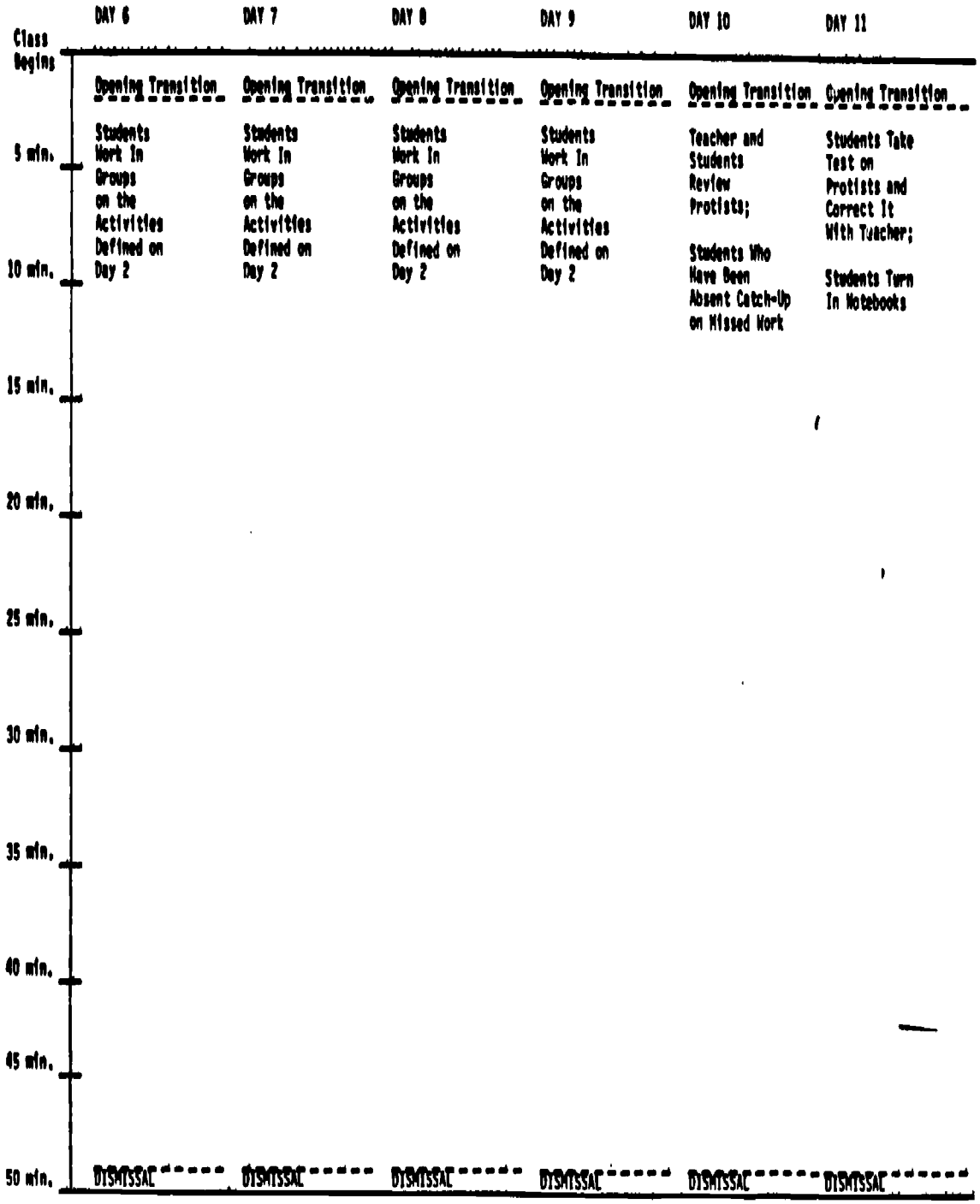


Table 1 (continued). Duration of Classroom Activities During Protists Unit (Teacher 2)



you can and then we will go through and correct them and then you can write down the answers if you want on this pre-test and use it to study.

It takes the students a second or two to settle down, and the teacher says to them, "Hey!" She focuses on one student who is turned around in her seat, saying, "Turn around and take the pre-test. You don't have to talk to your neighbor."

Cathy monitors the classroom by walking up and down the aisles, looking at students' work as she passes. Many students ask her questions as she comes to them. She says, "How many people need more time? One boy raises his hand. She gives the class additional time. After approximately 8 minutes, Cathy says,

> Let's go over these. I will read the questions and then I will read the answer. If you got it correct, raise your hand. If you didn't get it correct, and you want to write down the correct answer, you may do so. I would suggest strongly that you do, but I won't force anybody.

Cathy then says, "All right, if you have circled on your test pre-test. All right, what is the name of the round bacteria? She pauses for five seconds then says, "The cocci, c-o-c-c-i", and spells the word. She then asks the students, "How many got it correct? One? Okay, that's fine. Nobody got it correct? Okay, fine. Now what is the name of the long hair-like structure that some protists use to move around?" Again, she pauses for five seconds then says, "Flagellum, f-l-a-g-e-l-l-u-m. How many people got that right? None of you. Okay." A student asks, "Spell that again", and Cathy says, "F-l-a-g-e-l-l-u-m." She adds, "If you've got a question, raise your hand. Number four - now everybody should get this one right. If an organism is so tiny that it could only be seen through a microscope, it is called. . . microscopic." Several students call out "You've forgotten number three." Cathy's response is, "Oh, I was so excited about number four, I forgot about number three. Okay, never mind. Number three is cilia, c-i-l-i-a. Anybody get that one right?"

Cathy continues in this fashion, giving the answers and asking for those with correct answers to raise their hands.

The Teacher Monitors Rotational Group Activities (Day 2)

After approximately five minutes of initial confusion, most students have found the group they were assigned to yesterday and begin to work on their various activities. Cathy walks around the room, monitoring the students. She spends time with the lab groups who need help focusing the microscope. She moves from desk to desk, saying to several of the groups, "Be sure that you finish this today."

In the first lab, students have to look at prepared slides of live specimens under the microscope, compare them to the pictures that they have of euglena, amoeba, and paramecium and try to label the structures on the pictures on their worksheets.

Cathy pauses at the lab table and says to them, "Be sure you find each structure. You might not be able to find them all. Can you find the nucleus?" Students look questioningly at her and she gives them a brief description, then finds it in the microscope for the students. As she points it out, one of the girls says, "Flagellum?" The teacher raises her head from the microscope and says, "That's real hard to see.

Lab two is called a "microscope safari." The students in this lab prepare slides from a culture of water, hay, and living matter. Brian, as he looks at his slide, says, "Every time I look in this they stop moving." He looks up from his microscope just as the instructor stops by this lab station and she says, "What do you find in there? It's a really good infusion. It's been sitting out in the sun. Did you see anything yet? What did you find?" Art's response is, "There's something in there - some kind of little things." Cathy says, "Draw what you see." Brian's replies, "Mine ain't crawling, Mrs. Spencer." Then Jack responds, "Mrs. Morgan, mine ain't movin." The teacher responds, "Make another slide." Both boys begin to do so. Cathy leaves this lab and moves towards the back of the classroom.

At the third activity, which is an observation activity, Michelle says, "I can kinda see them." The second girl at the observation station says, "Can I see them?" and Michelle says, "Yeah, they're tiny, they're tiny." Then they look in each other's microscopes. The teacher moves over to the group and she says, "You have to look. You have to train your eyes to see details." Michelle says, "I can see the cilia." The teacher's response is, "Yeah, great." Michelle then says, "Britt saw the cilia, too." Then Michelle says, "What is that? Oooh." And the teacher looks in the microscope and responds, "Blue-green algae." Michelle asks, "We have to do all this?" The teacher responds, "It's just four questions." She leaves that group and starts moving around the room.

Brian's hand goes up at the safari station and he waits for the teacher to come and help him.

Cathy stops rotating around the room and works on a new seating chart at her desk; she also talks to the students, quietly, at Lab #4. Brian's hand is still up, and most of the people at Lab #6 appear to be fooling around.

Cathy finishes the seating chart and then moves around from table to table asking whether or not the students have picked up their notebooks and if not, telling them they should go ahead and get it from the box.

Brian's hand is still up; the teacher notices it and goes over to Brian. Brian says, "I found a Hydra." The teacher responds, "You found a Hydra? I rather doubt that you'll find a Hydra." She then moves to Lab #1 and reprimands the students who were not working.

Then Cathy moves from Lab #1 through the eight lab stations, engaging in frequent conversation with the students, and helping students find specimens under their microscopes. Five minutes before dismissal she instructs all students to begin cleaning up. As they put away their materials, Cathy moves about the room reminding students of items they have overlooked and generally overseeing the clean-up.

Escerpts from Classroom Observations

Topic Two: Digestive Systems

Table 2 summarizes how Cathy taught the unit on Digestive Systems. This unit is not found in the text, since Cathy has designed a composite unit of comparative digestive systems, working through all the phyla and culminating in the human system. She spent ten days on this topic. During this time, students worked out of teacher-prepared packets of materials including readings, questions, lab worksheets, diagrams, and charts. Lecture and discussion segments were mixed with seatwork and controlled-writing assignments. Recitation exercises were conducted on days 2 and 3, interspersed with teacher directed "hunt and find" questions. A vocabulary exercise was introduced on day 2, with a test on day 3 and again on day 8. Observation labs were conducted on days 5, 6, and 7, with a dissection lab on day 8. The final unit test was given and corrected on day 10, with a review preceding it on day 9. Illustrative examples of the instructional segments follow.

Seatwork (Day 1)

Cathy begins the activity by saying, "Get a copy of the vocabulary that says "Digestive System". You will need two pieces of paper. On one you will be alphabetizing the vocabulary and on the other you will be writing the definitions." Students come to the front of the room to pick up the assigned worksheets. They return to their seats and begin work.

As students settle into their assignment, Cathy walks around the room. She stops at various students' desks and engages in quiet conversation with them. The noise level in the room increases, and several students make razzing noises. The instructor singles out one of the students, raises her voice and says, "Hey, Mister Johnson." The students quiet down. Cathy moves to the front of the room and quickly takes roll, checking students against a seating chart.

Table 2. Duration of Classroom Activities During Digestive Systems Unit (Teacher 2)

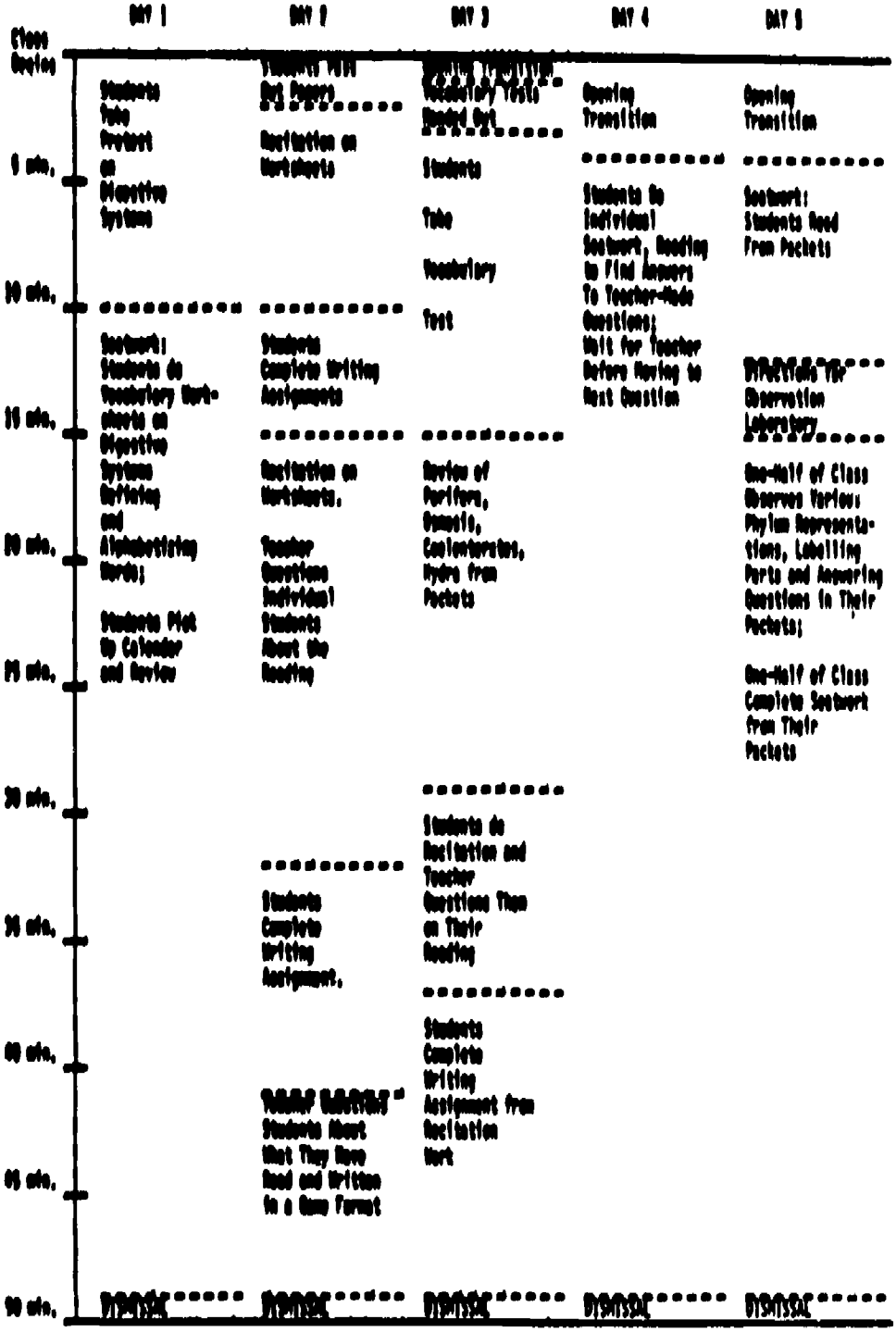
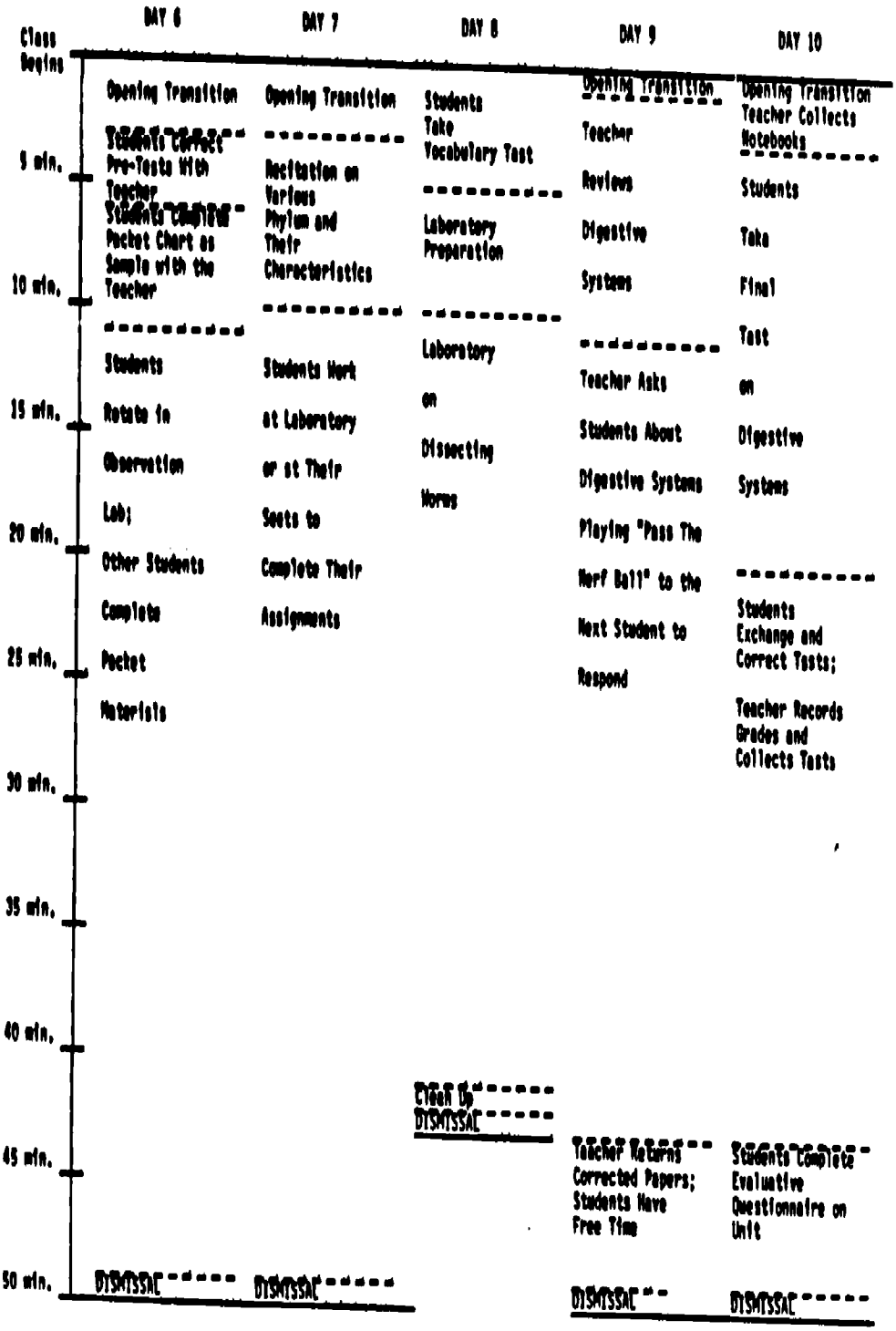


Table 2 (continued). Duration of Classroom Activities During Digestive Systems Unit (Teacher 2)



As Cathy resumes monitoring the students, she pauses at Brian's desk and tells him "Brian, work on the assignment please." Brian replies, "Oh, that!" and goes to the front of the room to pick up the worksheets.

Cathy pauses, raises her voice, and tells the students, "Do your calendars at home. Remember, the fourth is the day that you have the quiz." As she gives them this information, students look up, then resume working. Cathy adds, "It's also the day that your posters are due and the 18th is the last day that you can hand in your field trip assignments." As she walks around the room, she interrupts the students to say, "I want them in alphabetical order, and I want them in cursive."

Cathy continues to monitor the students; she goes around from student to student, has quiet conversations with some, praises or compliments others for their work and offers suggestions for alphabetizing. Then she picks up the pre-tests from the counter-top and returns to her desk where she begins to correct them. Most of the students are working quietly or talking to their neighbors. Madeline, Phillip, and Rhoda are passing notes back and forth to each other. But Cathy doesn't notice and continues to work on the pre-tests.

After correcting the pre-tests, Cathy gets up and walks around the room to monitor the students up until the bell rings.

Recitation Session (Day 2)

As class begins, Cathy instructs several students to pass out worksheets for today's exercises. She tells the class, "Please do not lose this material. Put your name on the white sheet. Put your name on the other one too."

Cathy tells the students,

> Initially, in seventh grade science what your textbook does and what we've been teaching you is going through the different phyla, taking the sponge and talking about the sponge; digestion, food, how it reproduces and everything all together. Then we go on to the coelenterates and talk about digestion, food, and how they reproduce and information about them. Then we go on to the next phylum. Since you have been through an overview of the phylum, you've gone through all the information, compared the characteristics and you know which characteristics are used to classify the animals. . . Since you've done that, I wanted to try something different. I wanted to take and compare systems with the different phyla. Now, what you have in front of you is the comparison of the digestive system. We're going to be doing this. We're going to be reviewing some information. The procedures, we're going to be

reviewing this by reading some information in a #1 voice. Remember that a #1 voice is a voice where I can hear you, standing like this I can tell what you're saying. If I'm standing like this I can't tell what you're saying.

She demonstrates by her posture where she would be able to hear and where she would not be able to hear. She asks the students, "You remember that?" The class responds, "Yeah." Cathy says,

I'm sure you do. Find the information. We're not going to go over how you find the main idea and all that because you already know that. We're going to be using that technique to make sure that everybody in the class has the information. Another reason for doing it like that is because some of you scored less than high on the listening comprehension and listening ability on the SATs. So, one of the things we're going to be addressing is to help you to remember how to listen.

Students talk quietly and Cathy reminds them to settle down. She then instructs the students to turn to the first section of their worksheet. Cathy points to her worksheet and tells the students, "Please read the first three lines as many times as you can until I tell you to stop." She pauses for ten seconds, then says, "Begin." All the students in the class read the first three lines aloud as many times as they can and in some cases as fast as they can. As they do this, the teacher looks around the room and listens as they read. She then says, "Stop! Now, what information in that first section tells you what a system is? Find that information and put your finger on it. Find where it tells what a system is and put your finger on it." The students look at their worksheets and put their fingers on the place as they find it. Cathy walks around the room and makes comments like, "Good" as she checks student's papers.

After checking several papers, she stops and tells the entire class, "You're finding information that tells you what a system is. As soon as you find it, underline it." She then returns to the front of the room and says, "All right, a system is what?" The class responds in a jumble of answers and the teacher says, "Wait, let's do it together. A system is. . . " The class responds in unison again, and again no distinguishable answer emerges. Cathy responds, "Good." She then says, "All right, read the next section as many times as you can until I tell you to stop." The students proceed to read, and the noise level rises dramatically. Cathy moves from student to student, listening and monitoring. She stops in front of Brian and says, "I shouldn't be able to hear it from here." She then says to the entire class, "Stop! All right, what are the three things that the digestive system does? Let's do it this way. What's the first thing that the digestive system does?" The class responds as a whole, "Takes in food." The teacher says, "What is the first thing?" The class repeats as a whole, "Takes in food."

The teacher then says, "What is the second thing?" This time there is no clear response, but many simultaneous answers. The intructor says, "Breaks down the nutrients into usable parts." She then asks, "What is the second thing it does." And the class responds, "Breaks down food into usable parts."

Cathy asks, "What is the third thing?" Most students reply, but their answers are varied. The instructor then tells them, "Eliminates waste." The students repeat this response, saying, "Eliminates waste."

Cathy directs the students to circle on their worksheets all three things that the digestive system does. She tells them to "Circle those things, those three things: takes in food, breaks it down, makes waste." Students quickly begin to circle these items on their sheets and Cathy walks quickly around the room looking at students' work. As students conclude this task, Cathy gives instructions for their second worksheet and the next five minutes of class time is spent doing monitored seatwork. Then the class returns to recitation exercises.

Teacher Lectures on Coelenterates and Discusses with the Students (Day 3)

As the first activity of the lesson, the students take a vocabulary test which lasts approximately fifteen minutes. After collecting the tests, Cathy talks about various phylum and their characteristics, leading into a distinction between porifera and coelenterates. She turns to the class and says,

> All right. Now, coelenterates are very similar in many respects to the sponges. OK. They're similar, but they're not identical. They are more complex. Their cell layers--the two layers that make up the body--are far better defined than those of the sponges, but they do have these things in common. OK, they also have one body opening. That's the first thing that was mentioned. OK, and that's very important. Now, the next paragraph tells you several things. I would like you to read the next paragraph. Answer the question: Tell me one way that sponges and coelenterates are different. Please read that, looking for that information. As soon as you have that information, raise your hand.

Students start to read the paragraph while the teacher walks around the class. As students come upon the answer they raise their hands. One student would like to give the answer, and Cathy says, "Don't tell me. Just raise your hand." Cathy is counting the hands as they go up: "One, two, three, four. . ." She points to students whose hands are not up, and she says, "Do you have it? Do you have it?" The students respond, "Yes" and "No." Tony again responds, but this time she says "Tentacles," and the teacher responds, "Tentacles. They have tentacles. Good. How are they different?"

The entire class responds, "Tentacles." The teacher again asks, "How are they different?" The class again responds, "Tentacles."

The teacher then proceeds. "OK. Can you tell me something about the tentacles? Tell me something about the tentacles."

A student responds that they are located around the mouth. The teacher says, "Right. They are located around the mouth, which is the one opening. OK." Another student volunteers that they can paralyze and the teacher responds, "Right. They have stinging cells which paralyze. Yes. Anything else?"

Several students respond at once and the noise level in the room becomes very loud. The instructor reminds the students to quiet down, and waits for them to do so. When the room is quiet, she continues, "The tentacles are really very important, aren't they. Now, I want you to reread that same paragraph again. This time I want you to look for information. I want you to tell me how a Hydra catches its food."

The students begin to read, and the teacher interrupts, saying, "Step by step. Tell me step by step. When you think you can explain it step by step, I want you to put your hand up." The teacher says to Carl, "You want to try it?" Carl mumbles that he would. The teacher says, "OK. Come on. Try it." Carl starts to talk but speaks so low most students cannot hear him. The instructor prompts his reply by asking, "How does it catch its food--in that same paragraph--in that second paragraph?" Carl doesn't respond, and the teacher says, "Have you been reading the wrong paragraph?"

Carl says, "Yes." She says, "Uh-oh. Let's go back, then."

Steve's hand is up, and the teacher says, "OK." Steve proceeds to give his answer, but like Carl speaks very low. As he gives his answer, every few seconds the teacher says, "Uh huh," or, "OK." When Steve is finished, the teacher says, "OK. Good."

Then the teacher stands up in the front of the room extending her arms over her head. She starts to wave them back and forth, saying, "I'm a Hydra. This is really weird. You'd never know it to look at me, but I'm a Hydra."

Brian, from his seat, waves his hands in the air and imitates the teacher. As Cathy sees him do this, she invites him up to the front of the room. He does not come, however. Cathy now says to the entire class, "All right. I've got my mouth right here," and she pats the top of her head. And she says, "I've got my tentacles. . . " and she is waving them in the air. She says to Kelly, "You want to be one, too? You want to be one, you have to come up here and do it."

Brian makes a face and she says, "Come on. It's all right." Many students giggle as Brian smiles and stands up. He walks to the front of the room and stands next to the instructor. Cathy smiles at him and says, "Good. You be the Hydra, and I'll be the food."

Brian raises his hands above his arms to make the Hydra tentacles, and the teacher picks up a rubber ball and says, "OK, here comes the food." She moves the food towards him, and the class giggles. Brian reaches for it, and the teacher says, "Now, wait a minute. You can't reach for it. You're stuck. You're not free-living. You're attached. Remember?" He nods his head in agreement, then Cathy asks, "What happens?" She brushes the food against the tentacles and says, "It brushes against the tentacles, and then what happens?"

Brian says, "It shoots a dart." The teacher says, "OK, shoot your dart." Brian shoots his dart, everybody laughs, and the teacher says, "Oh, boy! You shot me with the dart. . . " and she holds the food above his head in the simulated tentacles of his arms. She then says, "The food's going to get tangled up in the . . . " and the class responds in unison, "In the threads."

The teacher then says, "OK, here it is. Now, look at that food. Doesn't it look good? OK. Next, what happens?" Most of the students are laughing in unison as she asks this question. One of the students speaks up and volunteers, "It opens its mouth." The teacher says, "No. No. The mouth is always open. What happens? Brian says, "The food gets paralyzed."

The teacher says, "Oop, there is goes. The food is paralyzed." The ball that she had been holding above his head and moving a little bit becomes stationary. The teacher asks again, "Now what happens?" Many students start to talk simultaneously. The teacher asks again, "What happens? Tentacles don't push it into the mouth, but they just kind of close around it." She moves the food, pretending it's right in the middle of Brian's stomach, and says, "Now it's right inside. You're a wonderful Hydra." The class begins laughing again, and Cathy dismisses Brian back to his seat

Brian smiles and returns to his seat. Cathy tells him, "I really want you to know that I appreciate that. Now, once the food is in the gastrovacular cavity, now we're going to start the process of digestion. This is different from the process of digestion in the sponge. Quite different. Read the third paragraph there. Please read the third paragraph. Tell me what happens inside the gastrovascular cavity."

The students begin to read, and the teacher says, "You'd better read it in number one voices," which they do.

Half the Class Participates in an Observation Lab of Various Phylum (Day 5)

The teacher has set up numerous stations around the perimeter of the classroom, displaying various phylum, including a fetal pig, a frog, a fish, a shark, a lamprey, and cricket, a clam, a starfish, and a segmented worm. There are also eight different types of mollusks, and specimens and slides of sponges and trichina. There is also a picture of the planaria.

The teacher gives some intital instructions on doing the lab, then gives everyone a reading assignment so she can finish labelling some of the stations. Students read for seven minutes, then the instructor gives further instructions for the lab and selects students who will be participating today; half the students are selected for the lab and the other half are given a reading assignment to be done at their seats. For the benefit of the entire class, the teacher moves from lab station to lab station, pointing out some of the highlights of each and some of the things to pay particular attention to. As she stands at the mollusks she says,

> Okay, a mollusk is a bi-valve and it's a mussel so it's very very hard to see the parts. Look and see what you can. I realize it's very, very difficult. The starfish I think you'll be able to see fine, but you'll have to look carefully. Okay, the worm hasn't been injected. It doesn't have any latex in it, so everything inside is going to look kind of gray. Look carefully at the parts of that. You'll find it hard, but I think you can see everything you need to.

Cathy moves from station to station as she talks, then takes the covers off the microscopes and turns on their lights. She adds, "You will not need to move the slides around, but you can change from high to low power. And focus. But please don't be playing wih the slides, okay?"

Those students selected to participate in the lab come to the back of the room, looking for empty stations, jostling one another, and begin the lab.

The instructor moves amongst the students in the lab. A student asks for a pencil, and Cathy tells him, "You don't have a pencil? If I loan you a pencil, you're unprepared, but if you borrow a pencil from another student, you are not unprepared." He shrugs his shoulder and moves towards another student. Chris has not opened his book as yet, and the instructor tells him, "John, you've got to be working." Bill comes up to look at the lab, and Cathy sends him back to his seat. Phillip gets up and starts towards the lab, but Cathy stops him, saying "Phillip," and points to his desk. Phillip sits down and begins to read. The teacher continues to monitor the room while people are working at the lab and at their seats. She stops at Mickey's desk and has a quiet conversation with him. Adrian raises her hand;

the teacher goes to her and they have a quiet conversation. John is acting up, and the teacher goes to him and puts her hands on both of his shoulders; he quiets down. Cathy continues to monitor the lab and the seatwork.

Students participating in the lab move from station to station as they complete the assigned questions and labelling. There is little talking, other than conversing with another student to determine the best answers. The students reading at their seats are also quiet, working to complete their assignment. Cathy moves amongst both groups of students, stopping occasionally to talk with individual students. These activities continue for the remainder of the period, with the noise level increasing during the last five minutes of class.

Dissection Lab (Day 8)

Cathy begins this activity by informing the students they will participate in a lab, pointing to the board as she talks. Written on the board are numerous instructions which Cathy discusses with the students:

> You will be working in groups of two. Now, if you do not want to dissect, you do not need to. When you get your materials, and then you decide you don't want to dissect, you still don't need to. That's all right. I will give you another assignment. For two of you, there will be one for each person. Now, you will need a dissection tray with a worm on it, and a . . . this is not actually a scalpel. It's a homemade one with a blade on it. It has a blade on it from an Exacto knife. It is very sharp. It is every bit as sharp as a scalpel. Be very careful with it. You'll use this to make the cut, or incision, on the worm. I explained that here. Follow the directions carefully.

She holds up a lab sheet, pointing to the directions. She continues, "You'll need two of these and your dissection tray, and you'll need a ruler. Some of you will wonder how to tell the front of the worm from the back end of the worm." The class laughs, and Cathy continues, "Okay, this is called a clitone. It's a little band around the worm. It's closer to the head end than the back end. Also, the head is larger. All right, so, okay." Students begin talking to one another, and the noise level increases. Cathy pauses, then says, "I can't go on and talk, if you're talking." Students become quiet as she says this. She then turns to the board, pointing to the schematic drawing of the worm. She tells the students, "Okay, I need quietly one person from each uh. . . let's take one person from each of these tables. All right?" Kids begin getting up and scraping their chairs, going to the front of the room and picking up their materials. Students get the materials and return to their desks. The noise level again increases dramatically.

Cathy begins walking around the room. She tells one student, "Take everything off your desk." Phillip shoves a worm into Angie's face and Angie recoils. Jack and Sue are flirting with each other and hitting and fooling around. A lot of kids are at the front desk trying to get materials, and the teacher says to them, "One person." Several students return to their seats.

When all the students have materials for dissection, the teacher says, "All right, Jack, do you want to settle down?" At this point, the class becomes quiet. Pat chooses not to dissect and he is given an assignment. Mickey is pretending to eat a worm, holding it high in the air, and dropping it into his mouth. Many students are working in pairs. Cathy pauses from monitoring and says, "If students need help, I'll come around, but first read [the lab sheet] and find out. Work as a team on this."

Students begin working and several ask questions, raising their hands. Jeff McNeese has his hand up; Cathy goes to Jeff and they have a quiet conversation. Rebecca has her hand up, and the teacher goes over and talks to her. She continues moving around the room. She goes to Sue and Madeline and she says to them, "It's not that big a deal. You guys can do it." Both girls make a face and touch the worm gingerly. Many students now have their hands up, waving them back and forth. Cathy says, "Ill be right there, I'll be right there."

Cathy continues monitoring the students for a minute, then says to the class as a whole, "Hey, I got a question over here that everybody will be asking. Some of you. . . okay, you are to cut starting at the tail end and make a little tiny incision and using your scissors just cut the skin away from the internal structures. Be careful not to squish up the internal structures. Okay? Just do they very best you can." Students pause, then continue to work. Alexis and Mary make faces and look at one another. The teacher says to them, "Hey, Hey, none of that." She then moves to Sue and Madeline and starts the cutting for them.

As the students work they fill out their lab sheets, frequently raising their hands for Cathy's assistance. The noise level in the room remains quite high, with students talking and working together. On several occasions the teacher reminds the students about their behavior and the noise. The last five minutes of class are spent cleaning up the labs, and as the final bell rings, students leave the room.

TEACHER 3: BASIL KEISER

by Mike Piburn

Introduction

This is a portrait of Basil Kaiser's seventh-grade biology class at Horton Junior High School. The first set of observations were conducted during the last week in January, when he taught a unit on sponges and corals. The second set of observations occurred during the last week in April and the topic was the skeletal system.

Background and Viewpoints

Basil has taught at his present school since 1959. He started teaching in a math/science core, then moved into teaching eighth- and ninth-grade physical science and high school biology. He began teaching seventh-grade life science eight years ago. He has also coached a cross-country intra-mural team and is currently in charge of the school's chess team. During the second series of observations he was organizing a stamp collecting club.

Basil graduated from college with a bachelor's degree in biology and a teaching certificate. Later he returned to the same college and earned a master's degree in zoology. He has attended several National Science Foundation institutes, including one in radiobiology and another in teaching the Earth Science Curriculum Project. He has participated in numerous in-service institutes, including a workshop on teaching the Intermediate Science Curriculum Study, and another at the district level on teaching astronomy/space science. His classroom contains a wide variety of high quality science curriculum materials. These include: all versions of the BSCS high school biology course; Patterns and Processes; the PSSC reading series; Introductory Physical Science; a series of National Science Teachers Association publications, and, a variety of recent science texts. Two other books discovered in the classroom may suggest Basil's other interests. The first is titled Logical Chess Move by Move, and the other is Succeed and Grow Rich Through Persuasion.

Basil feels that the students come to him with a reasonable preparation from the elementary school, and that they have a "fairly decent knowledge of elementary life science." However, they do not have a very positive attitude toward science.

> Most come in and say they hate science. Most don't even know what science is. Evidentally the science they've had, they didn't care for. That's why I'm trying to do a lot of lab work. Things like that to see. They like microscopes, they like animals, plants.

Basil feels that much of what he does in his seventh grade

Basil feels that much of what he does in his seventh grade science class is designed to change this attitude.

> I try to show them the whole gamut of life science, that it isn't all just tests and papers, that there is observing and lab work. I would like them to know at least where to look things up and be curious about their environment and use the scientific approach in all their lives. You can use the scientific method for English or whatever you do.

Of all his students, Basil has the least confidence in those in seventh grade. He feels that they lack maturity and need considerable guidance.

> Seventh and eighth grades are quite a bit different. What's a better term for 'baby sit?' You've got to outline you material. That's better. You have to put it in order and you have to go over it many times. They aren't quite as mature as the eighth grade, yet they're more trusting and they're easier to teach. I enjoy seventh graders. I have an extremely good group. Their interest span is lacking a times. I have to take a few notes away here and there sometimes. Some of them are almost on the third and fourth grade level so I have to really work with some of them. I have one girl who didn't even know what a boa constrictor was.

Basil likes to portray himself as a strict disciplinarian, and in some senses he is. His school has adopted a program in assertive discipline, and the rules are posted next to the door in Basil's classroom. He uses the system, and is usually able to maintain a very quiet and orderly classroom. However, in the time that his class was observed, he never actually punished any student. He describes himself to the students as an ogre. The following narrative is taken from the first day of a new term, when several students from other classes have transferred into his class. He describes his system of discipline to them:

> Are there any new people? All of the new students raise their hands. To all of those who are new, I am mean, ornery. If you do anything wrong, I hit you, right? I hit you as hard as I can with my fist. (This causes some student amusement and there is a lot of talking.) All of those that agree, raise your hand. (All of the students raise their hands.) You've got to watch out for me, I'm one mean dude. (Laughter. One student repeats "one mean dude.") Just so you remember that for the first five days. Now, there will be periods of time when you aren't allowed even to move -- not move at all. There'll be other times when you'll have a lot of freedom when you'll be working together in pairs. Now, make sure that you know the discipline plan that we have.

(Teacher moves to spot near door where "assertive discipline rules" are taped to the wall.)

When interviewed, Basil expanded his ideas about classroom discipline.

> I like to discourage things that don't pertain to the classroom, notes and things like that. I don't like students talking about things that do not pertain to the classroom. And that's hard to do. When they get together they like to talk about boys, girls. It's part of their growing up. I would like to eliminate that from the classroom.

Basil has been teaching junior high school science for a long time and clearly enjoys it. His teaching has fallen into a fairly repetitive pattern, and he no longer finds it necessary to use a plan book. In fact, he seems to have lost it some years ago. He says that he changes his course some every year, and that he wishes he had time to do more.

Classroom Description

Basil's classroom is traditional. It contains thirty-eight desks, facing the front of the room. Occasionally these are rearranged so that students can sit in groups of two to four. Over the years, the legs of these desks have formed small circular depressions in the tile floor, and Basil insists that the chair legs always be in these "little holes." He may stop several times during a class and tell the students to adjust the positions of their desks. There are 36 students is his class.

At the front of the room is a laboratory bench, with sink, an oak desk, two bookcases, a filing cabinet and a fish tank. The fish tank is very large, and contains one very small fish.

On the left side of the room, facing the teacher, is a wall of windows. Under these windows, and wrapping around the back of the room, are cabinets with bench tops. These benches have four sinks. These benches are covered with a variety of materials too complex to describe quickly. The most prominent items are a group of hand-made insect collecting nets and insect collections, left over from a previous unit, and a pile of chess magazines. Chess boards and pieces are also found around the room. The right wall of the room is lined with glass-fronted cabinets.

Under the lab benches and in the cabinets are a jumble of materials: rocks, chess boards, a box full of skulls, including one of a chihuaha, microscopes, pieces of cardboard with chemical formulas written on them, a very old rolled up chart about hearing and music.

There are two bulletin boards at the front of the room and two at the back. One of the front boards has pictures of butterflies and other insects and a description of how the microscope works. The other front board has pictures of whales and other animals, including a rhinoceros, a snake, and a duck. There are no labels. One of the bulletin boards at the back of the room has a poster about the light spectrum that looks as though it has been there for a long time. The other has a variety of pictures of eagles, and the words "We care about eagles."

The materials in Basil's classroom are things he likes. He likes skulls, and he likes chess. Chess boards, boxes of skulls, boxes of chess pieces, chess playing magazines, books about science, and books about science teaching are all present in casual disarray.

Course Overview and Instructional Strategies

Basil uses Exploring Living Things, (Smith, Frazier & Magnoli, 1977). Basil teaches almost directly from the book and finishes most of it by the end of the year. The only major exception is around the Christmas holidays, when he takes nearly a month for science fair projects.

Basil follows a very regular pattern of instruction. The observations and interviews with students suggest this pattern rarely varies. Each instructional unit lasts for five to ten days and covers one chapter in the text. The unit invariably begins with a word search or some other kind of vocabulary activity. This is followed by handouts which students trace, label and color. During the first topic, students copied diagrams of a sponge. The diagrams are usually from the text or very similar to those in the text. Students complete these materials as seatwork and homework, and turn them in at the end of the unit as their "journal." Basil feels drawing creates a visual memory that will help students remember the material. In fact, he is quite concerned with visualization and often encourages students to represent things in their mind as pictures.

Laboratory activities, according to students, are relatively rare. One unit involved collecting insects, and another looking at a variety of microscope slides, but during the two units observed, there was no lab work. In the first unit, students passed around jars of preserved specimens, and in the second they recorded on a laboratory sheet information that Basil gave them. These activities represent Basil's closest approach to lab work.

Each unit ends with a test, which occupies most of a class period. Before the test the teacher devotes a full class period to an exhaustive review. He reviews the word search, diagrams and chapter-end questions and provides the correct answers. He tells the students almost exactly what will be on the test and what the answers are.

Excerpts from Classroom Observations
Topic One: Porifera and Coelenterata

Table 1 summarizes how Basil taught Chapter 15. He spent seven days on this topic. Of this time, 48 minutes, or nearly one full class period, the principal used making announcements on the intercom. Another ten minutes were lost to an assembly. The teacher allocated the majority of the remaining time, approximately 133 minutes, to seatwork, during which the students completed a word search, and copied, colored and labeled diagrams. There were five instructional episodes. During three, of less than ten minutes each, the teacher led recitations covering content in Chapter 15. The fourth the teacher described as a "hands-on" experience; he passed a series of preserved specimens down the rows for students to observe. The final instruction consisted of a 33 minute review for the test; the teacher gave the students all the test questions and their answers.

A "Hands-on" Experience (Day 5)

The teacher has just finished taking attendance and reviewing the assignments with his students. He turns to a group of specimen jars resting on the front desk.

> Now I want to show you some of these organisms. Ideally what we should have, we should be in a museum and they should have this giant tank that's like an aquarium where we could see all these animals. We could look and see everything in its natural habitat. We have to do the second best, so I'm going to pass some sponges and some coelenterates and some coral around.

Basil emphasizes order and care in handling the jars and specimens.

> Now please, and I say this again, please don't drop the jars. Okay? Now we have a few people that drop things, but we don't have many in this class, and I hope Kuhin won't drop anything.

The teacher often refers to Brian Kuhin as though he were a troublemaker. He resumes his introduction.

> Now does anyone know what we call all sponges? What do they belong under? We call them, the name given to them, is porifera. Now there are different kinds of sponges, and I want you to be very, very careful.

The teacher picks up the first specimen bottle and holds it up in front of the class.

> This one here (No. 1) is a fresh water sponge. It's very very delicate. If you take it and hold it up,

Table 1. Duration of Classroom Activities During Proifera and Coelenterata Unit (Teacher 3)

Class begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
1 min.	Intercom Announcements by Principal	Intercom Announcements by Principal	Intercom Announcements by Principal	Intercom Announcements by Principal	Intercom Announcements by Principal	Intercom Announcements by Principal	Intercom Announcements by Principal
2 min.	Teacher Takes Attendance	Teacher Passes Out Worksheets, Gives Directions	Teacher Takes Attendance	Teacher Reviews Symmetry with Students	Teacher Takes Attendance	Teacher Leads Review for Test	Students Study while Teacher Finishes Test
3 min.	Teacher Reviews Assertive Discipline	Seatwork: Students Work on Word Search, Color and Label Diagram of Sponge and Hydra	Teacher Reviews Chapter 13 with Students	Seatwork: Copy Coral Diagram; Complete Other Diagrams	Teacher Introduces Preserved Specimens, and Passes them Down the Rows	Test	Teacher Distributes Test, Gives Directions
4 min.	Introduction to New Unit (Chapter 15)				Directions for Finishing Assignments		
5 min.	Seatwork: Word Search		Seatwork: Students Color Sponge and Hydra, Copy Animal Kingdom Diagram		Seatwork: Complete Diagrams, Answer Chapter-end Questions		Students Take Test
6 min.	Teacher Takes Attendance, Grade Conferences					Students Complete Survey, Science Fair	DISMISSAL
7 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	

you'll see little bits of sponge all through the area, because if you shake it in any way, shape or form, these little tiny parts of the sponge will break up, so be very, very careful. Now do I dare pass it around?

The students are anxious for the teacher to pass the specimen around, and several say "Yes."

Now I think I'd like to pass it around and have you look at it. If I have to I'll have somebody come and hold it like this and walk around so you can see it. But I'd like you to have a hands-on experience and look at it carefully.

The teacher moves to the front of the room and passes the sponge down the first row next to the window.

So we'll pass this down here, then we'll pass over there, up, and we'll kind of snake around the room. Now this particular sponge is a fresh water sponge. It belongs to the particular group called spongella. Now it's a hard shelled sponge, and this is the kind of sponge you see here.

The students move the sponge rapidly around the class and it reaches the fifth student in the first row by the time the teacher holds up another specimen.

Now this next sponge that I have is a regular bath sponge. When I was a kid, this was the only kind of sponge we had, and they didn't cost too much. You've seen the movies where they dive way down and they have to pick up these sponges, and they're growing on the bottom, and they put them in a net and they drag the net up to the top and then they slip the sponge out. So actually the only thing that's left is the skeleton. What you clean with, clean cars with, is actually the skeleton, and the little holes in the sponge are where the little animals lived. Does that make sense? Now if you'll look at this sponge very carefully, you'll see that there are little holes in it, and after these have rotted out in the animal, rotted out to leave these little pores, and the pores in the sponge are where the little animals lived. Now this belongs to the group called eusponga. I don't expect you to remember those names, but I tell them to you so that you'll be at least able to recognize them when you see them again.

The teacher takes this specimen to the row nearest the door, and starts it on its way back. The students show little interest in the specimens. They glance at them and pass them on. Most are sitting quietly, leaning back in their seats, with their books closed. They seem to be paying attention to the teacher.

Now the next animal we'd like to deal with is the coelenterata. Now, can anyone tell me what the five-centimeter length coelenterata is?

This is the first time the teacher has asked a question, and seven hands go up. He recognizes Jenn, who says, "Hydra." The teacher responds:

It's kind of like a coral and it has tentacles on its top, and it somersaults. Yes, it's a hydra. Now if you put a hydra in a bottle like this, you'll lose it on the bottom. So they have actually mounted the hydra on a glass plate. You will have to hold it up to the light.

The teacher passes the jar containing the hydra down row five following the second specimen.

The teacher holds up a jar containing a jelly fish. He stresses features and aspects of the specimen.

Well, when I was on the coast, they used to have jelly fish and they lived in the shallow water and you could bring your hands underneath and you'd have a big mass of jelly in your hands, but it isn't wet like. There's a membrane that holds the jelly in there. And you look right through it and you could see the internal organs. There's four circles inside it. It looks almost like a grape, and if you very gently move it up and down, you'll see how it moves, and that's how they move in the water. Now be very, very careful with this one. You can hold it up to the light and see those circles I told you about. They're internal organs and it's a very interesting organism. Be very, very careful with these as you pass them around.

The teacher passes this specimen down the third row from the window, and picks up another.

Now this is another type of jellyfish. It's a different group. It's a small one and it has tentacles down at the bottom. They're more like streamers. They're not a true tentacle. Now this is a very small, pretty jellyfish. It belongs to another special group called the cone jellyfish. To preserve this one they've actually put a bottle in a bottle because it's such a small organism and I think it probably get lost in the big bottle. So it looks like a little berry, but this is a jellyfish.

He passes this one down the row next to the door.

Now the next one that we're going to show you will be the sea anenome. We have two different ones and we're

> going to pass them together. One's a smaller one and the other's a larger one. They're both the same organism. One's smaller than the other. Now these are tentacles like, they're like tentacles and they actually catch the prey and pass it into the mouth.

There are now seven jars being passed relatively quickly, and most students just glance at them. In fact, the teacher just said that they should spend "a couple of seconds" on each, and he does not encourage students to examine the animals closely or share their observations. Some students do become interested in the specimens and they talk among themselves about them, while ignoring the teacher. Rob, Matt, Dan and Evan have managed to accumulate three jars, and they study the specimens together.

> Now the next we will be passing out will be the coral. Now a coral is almost like glass. It's very brittle and the animal is gone. You will see little pin-like holes and that's where the organism went.

Perhaps all the students know that coral is the animal's skeleton. The teacher passes this specimen down the row nearest the door. He has not said much, and appears to be hurrying through the presentation, as though he wishes to get on to something else. The teacher passes this specimen down the third row from the window and ends his presentation with these words:

> Okay, are there any questions about the things that we're passing around? Okay, now pass these around very, very carefully.

Reviewing for the Test (Day 6)

The teacher has just finished taking roll, and has been going over the word search with the class, making sure that the students have spelled the answers correctly. He begins a serious review for the text.

> Okay, now what I'm trying to do is to get you people to realize that there are other ways to learn than just to memorize and it makes things more exciting. Now, how many understood what I meant when I said try to paint a picture in your mind of the different things? How many tried it? Now it'd be a good thing to do whenever you're studying, try to picture it in your mind. Now I want you to take all of your pictures out and put them on the desk, all of them.

The class is relatively quiet, all are in their seats except Brenda, who gets up, starts toward the front of the room, then turns around and sits back in her seat. Students get out the diagrams that they have been working on all week.

I'm going to go over those in a minute. Now everyone should have done the questions at the end of the chapter. Again, I'm going to go over each one of these questions and be sure you have the right answer. If I'm going too fast, raise your hand in the air, and I'll stop and we'll go over the answer. Now if you haven't done these, I'm not going to wait for each of you to write them down. I'm just going to help you fill those in, and you know you've had an assignment, a homework assignment that was to take the book and answer these questions at the end of the chapter. You should have those done now. Now these questions are necessary for the test tomorrow, and I'm going to go over them them and make sure you have them right.

The students get out the answers to the chapter-end questions, and put them on their desks along with the diagrams. The teacher forgets he told the students to take out the pictures they were coloring as he was going to review those, because he moves directly to the chapter questions and does not refer to the pictures at all. He begins, "The first one sounds like a horror movie, a worm that sucks blood through the holes after cutting the skin with its teeth." There is a long silence, and then Heather says, "A what?" Basil responds, "A worm." It goes up on your leg and sucks blood."

Heather answers, "A leech." The class goes wild. There is a general uproar as students wave their hands and yell at the teacher for the question was not from this unit's chapter, but from the one they studied last week.

Brenda leaves her seat and approaches the teacher. She has not brought a pencil with her to class today and asks the teacher for one. He denies her request for a loan and she returns to her seat. Basil continues with the relevant questions, "Okay, what is a rock-like object produced by animals in the sea?" The teacher points to a student who answers, "Coral reef." "Okay, coral reef."

The teacher moves very fast leaving very little time for answers or discussion. The students are quiet and attentive and do not seem confused. As he goes through the review, he points to students to answer the question. Sometimes they have volunteered, and sometimes they have not. "What do you call the cells that let water get into the sponge?" Arlene answers, "Pore cells." Basil replies, "Yes, they're called the pore cells. Number 3, what are the armlike parts around the mouth of a coelenterate? Jan answers, "Tentacles."

Tentacles. Now if I were going too fast, I figure the hands would be going up in the air. Now there's one girl who's sitting down like this (Teacher puts head in his hands) doing nothing. Now what I'm wondering is do you have a pencil?

The teacher is talking directly to Brenda. She has not been working since the teacher refused to give her a pencil. He asks the students if they can help her. He reminds the students that they are responsible for bringing pencils and other equipment, and that it is not his business to help them if they forget.

> And what we're doing now is. . . I expect everyone to have them done, but now I just want to make sure that you don't have any questions. Next, what is the male sex cell?

Tricia answers, "Sperm." Basil says, "Sperm, that's right. Next, main function of any living organisms." Christine answers, "Reproduction."

The review continues in this manner: the teacher reads a question and students provide one word answers. Everybody sits in their seats, and most write down the answers as the teacher goes over the questions. As the lesson progresses, the teacher quickens his pace and does not finsh reading the questions. He asks a question, looks at a student and says, "Do you know?", then asks other students. Sometimes he answers his own questions.

Basil continues, "Okay, now next. For sexual reproduction, in the case in the sponge, what happens?" Leanne says, "Sperm cells must combine with an egg."

> Right, sperm cells must combine with an egg. Yes that is correct. Now the next two are real short essays we have to take care of. I'll answer these as carefully as I can. I figure you'll be able to handle them yourself.

A number of students are copying down the answers to these questions on a separate piece of paper. Basil says:

> Let me read it for you, and then I'll go over it. "In what way are coelenterates more complex than sponges?" Now the primary ways are the following: Now the corals are more complex than the sponges in that the cells in the coelenterates work together, where each cell in the sponge acts like one cell at a time. Now let me paraphrase that a bit. Remember the sponges? Each cell in the sponge is like it was an amoeba, another one-celled organism. But in the coelenterates, they work together, much like the cells in our body work together to take care of our whole body. Now, what is another thing that coelenterates have that sponges don't?

The teacher conducts a discussion of this question, but speaks very quietly and only to the students in the front of the room. I am at the back, and can hear almost nothing, so I assume the students around me cannot hear either. However, they remain quiet. Michelle says that coelenterates have tentacles. Jennifer makes a comment, and another student mentions digestion. The

teacher discusses these characteristics as students bring them up. He continues:

> Digestion in a coelenterate takes place in the center of the cavity, okay? Now, it doesn't take place in the central cavity in a sponge.

The teacher finishes the discussion of this question, talking for the most part to the students on his right in the classroom, and to the girls at the back of the room on his right. In this manner Basil finishes his review for the test.

Excerpts from Classroom Observations
Topic Two: Protection, Support, and Movement

Table 2 summarizes how Basil taught Chapter 20. He spent ten class days on the topic, although one day (Day 6) was almost entirely devoted to giving students their mid-term progress reports. During the remaining nine days, about 45 minutes (almost a whole period) were lost to the principal's intercom announcements and to early release for an assembly.

Basil began this topic with a full class period of recitation, during which he went over the topic in some detail. He followed this with a full class period of seatwork, during which students received a large number of diagrams and puzzles to complete for their journal. About half of the next two class periods were devoted to completion of a laboratory concerning the composition and structure of bones. One the seventh day, the teacher reviewed the bones of the skeleton, and on the ninth he shared his collection of skulls with the class. There were two quizzes, at the end of the seventh and the eighth days. The tenth day was completely devoted to a final test for the unit.

A Laboratory (Day 3)

At the start of class Basil announced that the students will work at a laboratory activity. He has handed out a laboratory sheet titled Them Bones, Them Bones, which came from another teacher, and has read through most of it with the students. The laboratory will be concerned with the composition and structure of bones.

The teacher brought two kinds of bones to class. The first is a very large beef bone, and the other is a bag of five chicken bones. All of the bones are more or less cleaned, although they still have a little meat clinging to them.

The first part of the laboratory handout involved weighing the beef bone, frying it in an oven, and weighing it again. The teacher reviews this part with the entire class. Then he goes on to the second part of the handout and points out some jars in the

Table 2. Duration of Classroom Activities During Protection, Support, and Movement Unit (Teacher 3)

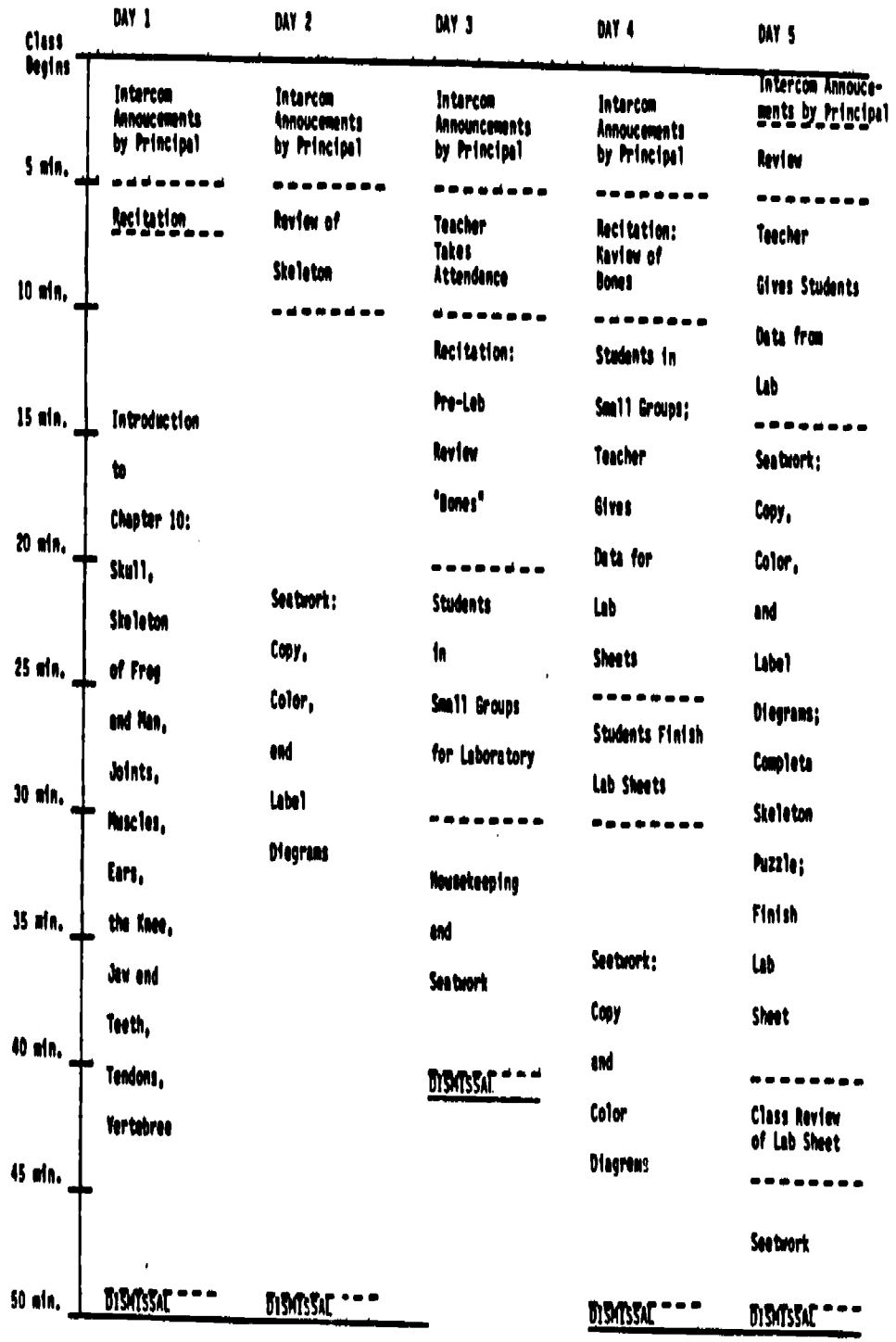


Table 2 (continued). Duration of Classroom Activities During Protection, Support, and Movement Unit (Teacher 3)

	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
Class Begins	Intercom Annoucements by Principal; Students in Advisory Groups Receive Instructions for the Day	Intercom Annoucements by Principal	Intercom Annoucements by Principal	Intercom Annoucements by Principal	Intercom Annoucements by Principal
5 min.	Class Begins; Teacher Takes Attendance; Gives Directions for the Day	Review of Skeleton	Teacher Takes Attendance; Review of Homework Assignments	Teacher Passes Skulls Down the Rows	Teacher Takes Attandance; Hands out Tests
10 min.	Seatwork While Teacher Completes and Hands out Grade Reports		Seatwork: Students Work in Pairs; Finish Homework and Quiz Each Other		Students Take Test
15 min.		Review of Seatwork Assignment		Review for Test: Chapter-end Questions, Bones Puzzle, Diagrams, Laboratory	
20 min.			Teacher Passes out Paper		
25 min.					
30 min.					
35 min.					
40 min.	Grade Conferences	Students Take Quiz	Students Take Quiz		
45 min.					
50 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

back of the room that will be used with the chicken bones. The students are sitting quietly, listening to the teacher as he gives a short discussion on lab safety before letting them begin.

> Now, I have prepared in the back of the room some bottles and we're going to take some of these bottles and put them in jars when we're ready for them. We'll have five different liquids. You'll have hydrochloric acid. Now, if I ever require you to handle any of these liquids I want you to be very, very careful.

Basil continues, relating disasters which he has witnessed involving students and chemicals. The students are very attentive and sit quietly in their seats.

The teacher opens a small sandwich bag that contains five or six partially cleaned chicken thigh bones. He tells the students, "Now, we're going to pass out chicken bones."

At the teacher's request, the students get up and move their chairs into groups of four to six, joining them to make large work areas. They perform this with relative ease, and it must be something they have done before. Although it is quite noisy, it only takes the students a minute or two to form their groups.

The students initially arrange themselves into eight groups. Four groups contain only boys, and four only girls. As the students move into their groups, the teacher assigns two girls the task of passing out the chicken bones and the pieces of paper to put them on. As the girls distribute the bones, they discover there are not enough bones for each group to have a bone. The teacher merges the groups so that there are just five groups.

The students are noisy, confused, and appear not to understand what they are to do. The teacher is reducing the number of the groups and he moves around the room shifting people. Basil says,

> Now, you have a chairman in your group. You have one person that'll be handling the bone and the other people will be watching them. Read your handout and do what it says. Number one, check the hardness of the chicken bone by trying to bend it or twist the ends.

It's getting noisy enough again that it is hard to hear the teacher, and all of a sudden there is a round of "Shhh's" from the class.

The students are trying to get themselves organized in their groups. Every group has begun the task of cleaning the chicken bone. In some cases, one person has taken charge, and in others the bone is on the paper in the middle and everyone is very delicately picking off tiny little pieces of meat left on the bones. Basil says,

Now, we're going to place a bone into each jar. We're going to cover it and place it in an area in the room where nobody will be able to get it. Now, after we've soaked it, we're going to retest it for hardness, like twisting and bending. Now, we're going to have to record all of this material on this particular sheet that we have here.

The teacher makes several comments in a very low voice. He appears to be listing the goals of the exercise. He says, "Okay, we're going to check the percentage of water in the bone. . ." Some girls say, "What is he saying?"

. . . and then we're going to tell the difference between a hard and soft bone. We're going to be able to tell which liquids soften bones and we're going to see the importanace of doing an experiment and seeing the results, rather than just guessing at the results. Now, there'll be a series of questions that you'll answer.

The teacher goes through the assignment sheet quickly and says:

There really isn't too much that we can do with this lab now. It's just a matter of placing these bones into the jars and they'll be finished by Monday.

When the teacher decides that the activity portion of the class is over, he directs the students back to their regular places.

Now, will the same person that passed out the bones please gather the bones and then the person that passed out the paper please gather the paper. Then we'll go to the the next part. After we've gathered the bones, I want you to go back into your regular seats.

The students put their chairs back in their regular places and put materials away. Most of the girls, but none of the boys, go to the sink to wash their hands. Some of the boys comment, "That was no fun. We had to get into our groups for nothing."

After the students left the classroom, the teacher put the chicken bones into jars with different liquids.

Seatwork (Day 4)

Just before this seatwork activity the students were working in groups of two to four, completing their laboratory sheets. Now the teacher gives them a new assignment for seatwork and homework to be turned in at the end of the unit as part of their "journal."

Now, we're going to have two more drawings, but I want you to only do one now. Do not write on this. Make sure that I get it back. As you make the drawing, put the number at the top. The number that you have at the top of this, put that on your sheet of paper.

The teacher has taken out some sheets with drawings of the bones of the head and neck, and given them to Alta. He asks her to number them. This is done so that the original diagram can be returned to the teacher for use again next year.

Basil asks, "Who wants to pass these out?" Todd volunteers, and the teacher tells Alta to give them to Todd as soon as they are numbered. During this time, the students are talking with one another and working on their lab sheets.

A student has asked the teacher for something, and now he turns to the class, "Does anyone have any pencils to loan?" Todd throws a pencil across the room to the student who needed it.

Remember, put the number at the top. You have plenty of time to do this, but you just barely have it. So. . . copy it on your paper. You were passed out a piece of paper, right? I want this to go, copied on that paper.

The teacher is talking loudly over a fairly noisy classroom. The students pay little attention to him, for this is a familiar task. They are to copy, not trace, the diagram, color it and label it. They are working in groups and talking. Some still have not finished their laboratory sheet or other work, but most are turning to the drawing of the skull. Pat and another student get up and walk to the pencil sharpener, but most remain in their seats.

The students are quiet, in groups tracing the diagram of the skull. The teacher wanders up and down the side of the room by the window, mainly in the front, and then down the side and leans against the lab bench and walks back up to the front of the room. He speaks to no one. Most of the students are hunched over their desks, tracing the drawing of the skull.

Basil says to the class, "Now, learn the parts of the head by. . . uh, by tomorrow. Okay?" This gets a lot of comment from the students, who think that maybe nobody could ever learn all of this: the ethoid or the lacrimal. "There are just a handful" of bones, says Basil. "A handful. . !" Even more complaints from the students. "Probably you could count all of them on your fingers and toes," Basil replies. Now there is general abuse, friendly of course, from the students. As they begin to finish their diagrams, the students leave their seats and move around the room. Soon everyone has finished.

Review of the Skeleton (Day 7)

On Day 7, Basil began with an instructional recitation concerning the bones of the body. He used a plaster replica of a skeleton as a prop. He takes the plastic cover off the skeleton, and begins,

> Now, I just want to review the skeleton. You've had plenty of time to learn everything and I expect you to know it. If you did not utilize the time, then of course, that isn't my fault. You were given handouts that should have helped you on each and everything, and you should be very familiar with it. And, anything that I go over, might be on the test. So, I just think you should be familiar with it. I may ask any questions at all.

The teacher now has things well enough organized that he no longer takes attendance. This has become Wendy's daily task, and she is sitting at his desk with the attendance cards. Basil says,

> Now, let's get started. Let's start with the different bones of the head and see how you remember them. We'll call on different people. Okay, what is this front bone here called? Jeff?

Jeff answers, "That's the frontal." Basil replies, "Frontal. What is the bone back here? Wayne?" Wayne says, "Pariatal." Basil continues,

> Okay, pariatal. Now, you get anywhere from four to five different pronunciations. You go up to the university and the professor will pronounce many of the words differently. So, the main thing is that you know the word and know how to spell it and know where it belongs. Okay, are you with me now? Now, what is this bone right here? Yes?

"Nasal," says a student.

> This is your nasal bone. Okay, now, you have a superior and an inferior. Anyone know what that is? Yes?

Chelsie has raised her hand, and the teacher recognizes her. She says, "Maxillary." Basil responds, "Maxillary. Now, do you know where the malor is?" This question is to Chelsie also, and she answers "Below the eye." The teacher continues,

> Now, some time during the period, I'm going to give you a quicky quiz on the skull to see if you know the bones. So, what I'm going to do is I'll point to it and you have to write it down. That's why I'm doing it now, to make sure you get this down. In some profes-

> sions, you have to know every part of the skull, every part of the skeleton, especially doctors and nurses. And they have to know where all the muscles are included. And they have to know what each one of these swellings on the bones are. And they have to know it in detail.

After providing this rationale for the assignment, Basil continues, "Now, what is this bone here? It's hard. Yeah, it's the arch." The teacher asks Wendy first, but she doesn't know. Then he asks Christy, and she knows it is the arch, but can't pronounce it. Finally, Pat says, "Zygomatic." Basil repeats "Zygo-matic arch. What is the bone right inside the zygomatic arch? Yes?" The teacher asks Dianne, but she doesn't know. There is a lot of low conversation between the teacher and the students at the front of the room about this question, but it is very hard to hear. Finally, Tom says "Sphenoid." Basil agrees, "Okay, how do you spell that?" Tom says "S-p-h-e-n-o-i-d." Basil asks, "Now, what is the one at the back?" A lot of hands go up, and the teacher calls on Todd, who says "Occipital."

Basil continues in this fashion, pointing to bones on the skeleton and asking students to identify them. He tells the students "Now, I want you to learn these well. I want every part known so you can understand it." He now points to the two bones in the forearm. Wendy says, "The radius goes to the thumb and the other goes to the fingers." Basil replies, "How many agree? Take a look at your drawing and make sure." Most of the other students are attentive. Basil explains the workings of the wrist, "Now, there are many bones in the wrist. As you move your wrist back and forth, they slide. These are your sliding bones." This is one of few times he goes beyond the bone's name to explain its function. He continues, "I could have you learn each one, but all of the groups together are called the. . . yes?" Wendy answers, "The carpals." Basil agrees, "The carpals. Now, these are the carpals. So, what are these here called? Yes?" Christy says "Metacarpals." The teacher moves on to the vertebrae which he treats in detail.

> Now, in between each one of these vertebrae, we have a kind of cartilagenous material. Now, take your fingers and place them on the back.

The teacher reaches back and feels his spine with his left hand.

> And see if you can isolate them in between, where these are. Now, first of all, you're going to come to a what? A bone. Kind of a ridge. Now, try to circumvent around that ridge and you'll come fairly close. It's the only way you can really come close enough, is to go right through the stomach. Now, why do you think we have these bones sticking out in the back?

There is no answer at all from the students. Then one tries, but the teacher is not satisfied.

> Okay, if somebody takes a baseball bat and hits you on the back, these bones here are in such a way that they will splinter and soften the blow, to help protect your back. If you had it open, like this, you would have a lot of problems, wouldn't you? Your back would be injured a lot more. Now, a lot of women, when they're preganant, the bones kind of soften in this area right here and it allows these here to slip out. So, then bone is grinding on bone. Does anyone know what that's called?

It is quiet, and there is no answer from anyone.

> Does anyone know what these are called here, these little disc-like things? Have you had anyone in your family with a slipped disc?

Six hands go up now, but the teacher doesn't call on anybody.

> How many ever heard of a slipped disc? Now, that's what happens. When these slip out, then the bone grinds on bone and you could say the person has a broken back because this disc slipped out here and these wobble and cause all kinds of pain. And, in some cases, they break right up and rupture, and it's what we could call a broken back.

The entire class is quiet and attentive. This seems to be a subject they are interested in.

> So, what the doctors try to do is to lift up and get this disc back, or in some cases, they'll operate on the person, take the disc right out. Years ago they used to put pieces of bone in there and then it grew to solid bone. And some people would have this whole area fused, so that there'd be no movement at all. But, now what they do is they just take this out. The person is able to get up after three or four days. Then, over a period of time, the body makes another one of these. Not quite as good as it was before, but it's good enough so a person can go back to normal activity. Are there any questions about the backbone, about the discs? So, a ruptured disc would be one that's broken up. A slipped disc is one that's just slipped out. Does that make sense?

There is no response at all from students. They don't say anything, nor do they nod or frown.

Basil continues on with bones of the lower back and legs; "Now, what is this bone right here? Yes?" The teacher recognizes Wendy, who says, "The pelvis." The lesson continues

in this fashion until he reaches the feet, and Basil says, "I think you should be familiar enough with the skeleton, and I'm going to give you a little quiz a bit later." The teacher puts the platsic cover on the skeleton and wheels it back into the corner.

TEACHER 4: DIANE STAHL

by Vicki Lambert

Introduction

This is a portrait of Diane Stahl's 7th-grade life science class at Horton Junior High School. Observations were conducted in January, 1984 when she taught protozoans, and in May, 1984 when she taught genetics.

Background and Viewpoints

Diane began her college education at a small western agricultural university, majoring in horticulture. After transferring to another univerity, she completed her degree with a major in phycial education and a minor in botany. Diane began her teaching career at Horton several years ago with a diverse teaching assignment (PE, civics, life and physical science). Her assignments have remained diverse; this year she is teaching four periods of life science, one of student government, and one of biology for gifted students. The only continuity in her scheduling has been life science assignments, teaching at least two classes each year.

Diane is extremely active in and out of school. As sponsor of the student officers, she is responsible for all activity scheduling, many assemblies, dances, fund raising, and any other non-athletic activities of the school. She plays soccer on an outside team, often organizing teachers in the school to play against the students. She runs three to five miles per day, and often participates in the aerobics classes offered at the school for students. Her philosophy is that participating with students helps build morale. As she says, "If you get the kids on your side, you've got them wrapped around your finger. . . when they see an 'old teacher' out there playing, they think, 'I guess they can't be all that bad'." She often participates in workshops to enhance her teaching skills.

Diane describes life science as a real "hands-on" opportunity for the students. She wants them "to see for themselves" how nature looks, works, and interacts with the rest of the environment. She feels many students come to her classes with some knowledge of science. However, Diane distinguishes between students' knowledge and their ability to apply that knowledge. As she states, "They've learned the words, but they can't give you any ideas and they have a real hard time distinguishing between . . . 'give me a definition for something' and 'tell me what it means'."

Diane feels that seventh graders are generally quite enthusiastic about science when they come into her class. She describes them as being "just wonderful and. . .excited. I could ask

them to do anything and they would. Anything!" By the time they leave her class, she expects them to increase their knowledge dramatically, and to be able to relate concepts to reality. And "generally they do." However, they don't retain it. Many of the students return to her ninth grade biology class, and "They can't remember a thing. So then I spend my time having to go back and reteach. I don't think the kids learn the material to actually learn it and remember it now. I really don't."

Diane wants her students to think about what they are learning, rather than simply finding answers in the textbook. As a result, she will often design her own tests and worksheets, or change textbook exercises so the answer requires some thought. When students ask questions in class, Diane will often ask a question in return, aiding students in discovering the answer on their own. She also prompts students to expand their answers to her in-class questions by asking them to "tell me more," or "keep talking, I need just a little more information." Diane also wants her students to experience being able to complete assignments and lab activities. As she says, "I would say 'complete', is the ultimate thing that I would like, but there are some kids who can't. If they will just make an attempt and show me that they are doing the best they can do, I am satisfied."

Diane particularly wants to develop positive attitudes toward science in her students. She wants students to "not hate science, but like it. But you don't have to like it all." She strives to encourage her students to continue their interest in science beyond her class:

> I would hope that through the class they ... stimulated enough that they would pursue possibly another class and maybe take another field. So that they would take maybe ninth grade biology and then that would give them an opening so that when they get to high school they can take possibly zoology or botany, chemistry or physics.

Classroom Description

Diane's classroom is average-size, containing twelve tables which seat three students each. These tables are arranged in two rows of six, with students facing the front of the room which is identified by a four-sectioned chalkboard, a flag, a pencil sharpener, a movie screen, a loud-speaker, and a "Horton" calendar with school activities penned in. Next to the calendar is a discipline plan sheet (from the Assertive Discipline workbook). There is also a doorway (directly south of the chalkboard) leading into the supply room. The teacher's lab table is centered between the student tables and the chalkboard, with a student-aide desk directly adjacent to it.

Windows and low-countered shelves line the south side of the room. The shelves are filled with odds and ends of science

paraphernalia, rubber gloves, a podium, some steel wool, a slide carousel, a hot plate, a tape recorder, and numerous lab workbooks. Several plants sit on top of the counter as does a stack of wire baskets labelled with each period's number, containing student papers. There are three posters and a fire blanket attached to the wall.

The back of the classroom has low-countered shelves which span the entire width of the room. Above the shelves are a chalkboard, two bulletin boards filled with various colorful arrangements, cupboards, and a clock. The cupboards are filled with magazines (including Popular Science, Building Ideas, and Science '83), pink and white crepe paper, a bucket, a hose, a long roll of newsprint paper, and two large butterfly nets. On top of the counter sit several boxes containing bottles, cloth, cotton balls, and rocks, and an aquarium filled with fish.

The north wall of the classroom is identified by numerous full-length glass-doored cupboards filled with science equipment (glass beakers, jars, tubes, funnels, microscopes), textbooks, academic supplies (colored marker pens, tempera paints, colored construction paper), science games (Energy Quest, Science Bingo, Gomston) and O'Haus scales. Above these cupboards are three pictures of owls in varying poses. There are two additional wooden cupboards with locking doors on this wall. Taped to one of the doors is an outline of the teacher's grading scale (broken down by percentages). Above one of the cupboards is a poster. Towards the front of the classroom is the doorway to the classroom and directly adjacent to the doorway is a filing cabinet.

In general, the classroom is clean, comfortable, well-lighted, and neat. Live fish and plants are present, but there is no display of ongoing science demonstrations. The general tenor of the class environment is one of welcome, warmth, and a casual orderliness.

Course Overview and Instructional Strategies

Diane uses Exploring Living Things (Smith, Frazier, & Magnoli, 1977), as her main textbook. In addition, she uses what she refers to as "The Cat Book" (because of the picture of a large cat on the cover), Challenges to Science: Life Science (Smallwood, 1978) as a supplementary text, although students only have access to it in class. She does not follow the organization of the textbook to present topics because they do not fit her needs and are not organized for the weather. Consequently, she begins with cells then moves to plant life prior to November, when the snow begins to fall. She then does protists, the animal kingdom, classification, and ends with the human body (including bones, various systems, heredity, and evolution).

Diane changes parts of her curriculum from year to year, adapting, eliminating, and adding to activities and discussions

to have them "work better." She also maintains a wide array of resource books in the classroom, borrowing information from each as various units progress, and directing students to them for additional information. She likes to vary activities frequently, "doing at least two experiments a week," using magazine articles, guest speakers, films, and the textbook for reading assignments and vocabulary assignments. "I feel that anything you can bring in from out ide the book will only enhance it, because I think the book is boring by itself."

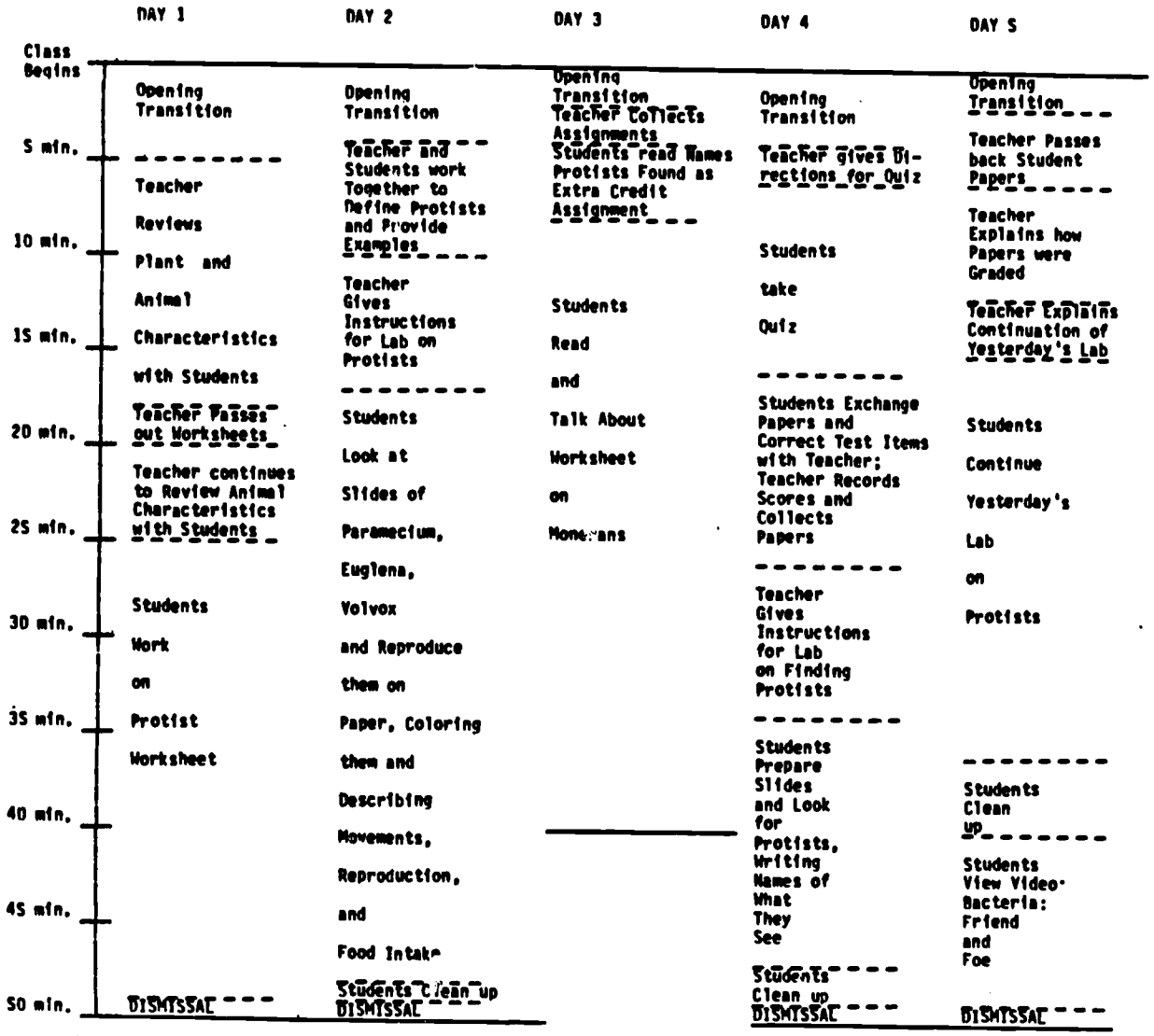
Although Diane does not follow the sequencing of the textbook chapters, she does build her lessons around the units in the text. Typically, it takes from five to fifteen days to cover one chapter (or unit). Generally, she begins with a reading assignment and a list of vocabulary words. Sometimes the students read the assignment in class, but more often Diane begins with an introductory activity such as a film or demonstration. After the students have read the material, she discusses it with them, asking questions, calling students to the board, or having them make presentations. Interspersed with the discussions are lab activities which require the students to look for specific things, fill out worksheets, draw and color what they have seen, and/or analyze their results. These activities often take the students out of the classroom, and sometimes outdoors. Students are generally required to answer the review questions at the end of the chapter as homework, and a quiz may or may not be given during the unit. A test is always given at the end of the unit, preceded by a verbal review in class, and followed by going through the exam item by item. Diane frequently designs her own worksheets and exams, but will also use those supplied with the textbook, adapting items and adding several of her own.

To ensure that students understand the science content of the unit, Diane usually begins discussions by asking questions which review material previously covered. She then builds on this information, relating it to the new material. She will frequently give the students a lot of information which expands on the material in the chapter, or which shows it in a differing manner, asking questions which cause the students to integrate previous information or expand it. She also asks a lot of "What do you think would happen if. . ." questions. She uses other students in the classroom to add additional information to student comments, or allows them to challenge ideas presented. She encourages students to discover information on their own by asking them to elaborate on a question they have just asked or an idea they have suggested. The pace of these sessions is fast and dynamic, and always under tight control.

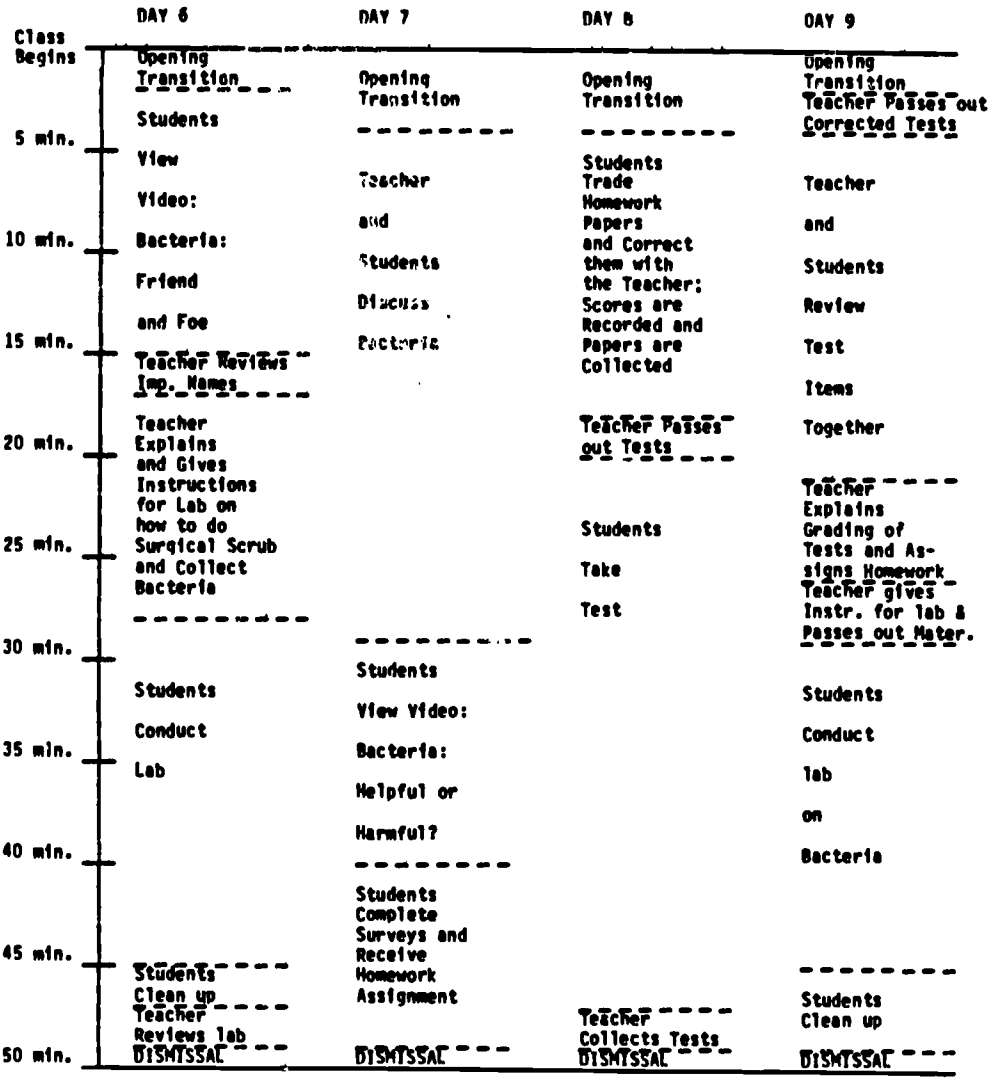
Excerpts from Classroom Observations
Topic One: Protists

Table 1, summarizes how Diane taught Chapter 10, entitled "Protists." She spent nine days on this topic, mixing lecture

Table 1. Duration of Classroom Activities During Protists Unit (Teacher 4)



able 1 (continued). Duration of Classroom Activities During Protists Unit (Teacher 4)



and discussion segments with seatwork and home work assignments. Two videos on bacteria were shown and discussed, and note-taking was required. Illustrative examples of the instructional segments follow.

Review of Plant Characteristics (Day 1)

After six minutes of administrative tasks, Diane says, "What I want to know is (turning to the chalkboard and writing the word PLANTS) what type of characteristics would you consider plants to have, or let me repharase that. What type of characteristics would you say that organisms have that make them a plant?" Sol raises his hand. Diane nods at him and he says, "Cell wall." The teacher responds saying, "O-o-o-o, I like that; they have a cell wall. You're right." She then writes on the board 'cell wall'. She turns to the class saying, "What else?" Several students raise their hands and she calls on Tim. He replies, "Chlorophyll." Diane repeats his answer and writes it on the board. She then asks, "What is chlorophyll?" Several students reply and she repeats their answers, saying, "Green stuff. It's the stuff in a plant." Several students continue shouting and Diane finally calls on Lucy.

Lucy replies, "It's the green pigment in the plant that makes the oxygen." Diane says, "Good, good definition. You remember well." She calls on Janet and she says that plants make their own food. Diane responds, "Excellent! They make their own food." She writes this on the board. As she turns around to face the class, she again asks, "Anybody else?" One student contributes, "They grow in the ground." Diane writes on the board, "grow in ground." She calls on Kathy, who adds "They have vascular tissue." Diane responds, "Good." Hey, I'm impressed. You guys are remembering this." Ken contributes, "They are the first in the food chain." Diane repeats the response and writes "first in food chain" on the board. Another student then contributes, "They have leaves." Diane repeats this response with a question mark after it, and a student says, "What about cactuses? They don't have leaves." Another student contributes, "They're all green. Plants are all green." Again the teacher repeats this with a question mark after it.

Diane says, "Okay, let's write these down and we can come back in a minute." She puts the responses "leaves" and "all green" on the board. She calls on Joe who has his hand up and he contributes, "They breathe carbon dioxide." Diane says, "Okay, I'm going to write it down just the way you said it. Is that all right?" And she puts on the board, "breathe CO_2." Another student contributes, "They let off oxygen." And she writes on the board, "off O_2". Another student contributes, "They have the most energy in the food chain." Diane raises her eyebrows at this response and goes, "Oh, oh." (She is very impressed at this response; her facial and vocal expressions convey this message to the students.) She writes in parentheses under "first in food

chain" the word "energy." She then says to the class, "Anybody else, or are we about through with what plants are?"

Approximately five seconds pass, then she continues "I'm impressed! I thought that most of you with some kind of an explanation would say that 'they're all green'. And we did end up with that, although there's some disagreement. What sort of disagreement do you see in that pl[illegible]s are all green?" Kathy says "We have a lot of shrubs that are [illegible] red." Diane says, "Yes." Mike indicates that spider plants are red and white. Diane replies, "Yes, spider plants are variegated. They have the red and the white leaves." William says, "What about geraniums?" Diane replies, "What about them? Keep talking." William continues indicating that there is red, white, and green on the leaves. Several students interrupt him, and point out that, "Yeah, but they're still green." Diane stops the interruptions and says "In a geranium leaf . . . there is a bit of color pigmentation in the leaf that is reddish. Is that what you're talking about?" She looks at William and he nods yes. She continues, "The leaves are basically green, but there is a little red pigment in the leaf itself. We're not talking about the red flower. Okay?"

She then moves to the chalkboard saying, "What about this particular thing . . ." and draws a mushroom. As she completes the drawing several students snout out, "It's a mushroom." One student calls out, "It's a protist." And another calls out, "It's a fungi." She then asks, "Is that a plant?" And puts a question mark on the head of the mushroom, and writes directly beneath it the word "plant" with a question mark. A number of the students respond very loudly, "No." There appears to be a bit of disagreement among the students and some start saying, "It's a plant." Another student says, "It's a fungi." Other students say, "No, it's not a plant." Diane then says, ". . . if you are saying, 'no, it is not', the question is if it's not a plant, then what is it?" Several students shout out, "It's a fungi." Diane replies, "Back to Kingdoms. Back to Kingdoms. Chapter Four." One student shouts out, "It's a protist." Diane replies, "Now there's a new word. Protist. We'll come to that in just a moment." Diane continues,

> Scientists' questioned . . . whether or not mushrooms, and your different type of fungus, should be considered as plants, or whether there should be an entirely different kingdom for them. Because they don't have chlorophyll then, that is where the question comes up. If they don't fit into the plant kingdom, then what are they? Scientists have decided, 'Yes, we will put them in the plant kingdom for now'. However, you will have other scientists who will disagree with you, and will say, 'Well, we can't say they are in the plant kingdom or they are in this other kingdom'. What is this other kingdom?

Two students reply, "Protists." Diane says, "No, you're bringing up something we haven't studied yet." Several students respond, "Plants or animals." Diane replies, "If it is not a plant then we have to say that it is an animal. Scientists are saying, 'Well. . . it doesn't really fit.' Some of them think that it's a plant and so I have to tell you at this point then, we have decided that there are only two kingdoms. . . plant or animal kingdoms. What type of characteristic would you say that an animal has?"

Diane now turns the discussions to the animal kingdom. She continues in much the same way as before but with less writing at the chalkboard and more moving about the classroom.

After concluding the discussion regarding the differences between the plant and animal kingdoms, Diane distributes worksheets to be used in conjunction with a reading assignment on protists.

Reading and Review of Monerans (Day 3)

After a brief transition Diane distributes worksheets on monerans. As she does so she says to the students,

> What I found yesterday in reading through the book is what we call, or what they call, a fourth kingdom. . . So what I want to do is go over this fourth kingdom with you. Everyone focus your attention to the page.

Diane calls on Ethel to read the first paragraph. When Ethel concludes reading Diane asks, "So now what is the name of our fourth kingdom?" Joe raises his hand and replies, "Moneran." Diane asks "What is a moneran? Just give me a simple definition like what you read." She calls on Carl who says, "How about bacteria?"

Diane does not accept this answer, and says, "We haven't gotten that far yet, but that is an example." Several students point out that it is on their worksheets and in the paragraph just read. Diane replies, "Oh, I'm sorry. It's my fault. What I'm looking for is a definition of what is a moneran other than an animal, or a kind of organism, that is inside that."

Diane calls on Joe, who says, "They don't have a distinct nucleus." Diane agrees with this response and says, "Backing up, do you remember in Chapter Three when we were talking about cells, and how the cells were organized? One of your questions the other day asked 'What was the structure of bacteria?'" She now goes to the chalkboard and draws a large circle. She continues, "Let's say that this is our basic cell. What is the part of the cell that holds the cell together." A student calls out, "The cell membrane." Diane now draws a line around the outer rim of the circle and labels it the cell membrane. She then asks about the substance inside the cell, and a student replies that

it is the cytoplasm. Diane labels this and draws a lot of wiggly lines to indicate the "substance." She then refers to the structure inside saying, . . ."usually only one, which is called the 'head honcho'." She wants to know what this is called. Amy says, "Nucleus." The teacher agrees and labels this on the drawing. Diane continues:

> Now, in talking about this fourth kingdom, the monerans, it said that the monerans don't have a nucleus, at least that is made up of a main distinct nucleus. What does that mean then. I want to see if you're with me?

She calls on Ken who indicates that it does not have a "controlled center." The teacher says, "But, if it isn't a controlled center, what is missing?" One student calls out, "DNA." Diane indicates that they have not yet studied about DNA. She says, however,

> The DNA is the substance that is inside the nucleus that controls what the next cell is going to look like. Remember? As in mitosis. But, we'll talk about DNA later on. What I want to know is what's going to happen when we don't have a distinct nucleus?

She then calls on Steven, who says, "The whole cell has got the DNA scattered all through it." The teacher asks, "But how come? What is missing? What is the container of the nucleus?" At this, several students reply, "The nuclear membrane." "Thank you," responds the teacher and she turns to the chalkboard and fills in and labels "nuclear membrane." She continues, "The nuclear membrane is not there. And you're probably saying 'Is that possible?' Well, scientists are saying, 'Yes, at this point it is'. The DNA material is scattered all throughout the cell."

She then calls on June to read the next paragraph. As June concludes reading, Diane says, "Okay, Susan, we haven't heard from you yet. What would you say is blue-green algae?" Susan stammers and starts a sentence several times, finally saying, "I don't know." The teacher says, "You're not sure?" We'll have Gary help you out." Gary says that it is "a kind of bacteria." Another student interrupts and says, "It has characteristics of both plants and animals like a protist." Diane agrees and calls on June who says, "It has sort of like the qualities of a protist, but it doesn't really because it doesn't have a distinct nucleus, because it doesn't have the membrane." Diane smiles, nods agreement, and says, "Excellent! Did all of you hear what she said?" Most students respond that they did not and the teacher repeats what was said.

The remainder of class is spent in the same manner, with Diane calling on students to read each paragraph, then asking numerous questions about the paragraph just completed. Students contribute to the discussion and ask questions. When the worksheet is completed, Diane instructs the the students to turn it

over, saying, "There are three questions, my friends, that I need you to answer. Now that we have discussed and talked and have read a little bit about it, you might be prepared tomorrow also for a slight quiz."

Students Take Quiz and Correct Their Papers (Day 4)

After five minutes of opening transition and two minutes of instructions for taking the quiz, Diane directs the students to "Take out a piece of paper and number it from one to ten." All students comply, then wait for Diane to verbally deliver the test.

When the room is quiet and all eyes are forward, Diane begins, "Number One: I'll draw a picture on the board. Your goal is to tell me what the organism is." She turns and moves to the chalkboard, writes #1 and then draws a picture. Facing the students, she says, "Real tough, huh? Number one, what organism is that?" She is now walking down the center aisle and Carl asks, "What if we don't know how to spell it?" Diane responds by saying, "Spelling counts." Several students begin to remark at this comment about spelling, and the teacher reminds them, "Shhhh, you're taking a quiz." The students immediately become quiet and settle down. Carl says, "You mean if it's spelled wrong, that we get it wrong?" And the teacher responds, "Yeah!"

Diane continues, "Number Two: This particular organism has this gizmo. What is this gizmo called?" Again, the students are a bit noisy and the teacher reminds them "Shhhh. Remember, this is what you know, not your neighbor." Again the classroom gets very quiet.

She now writes a #3 on the board and draws an arrow from the tail-like apparatus down to #3, saying, "Tell me what that gizmo does." A student asks for clarification, and the teacher repeats the question, saying, "This thing, tell me what it does," and points to the tail. Diane writes #4 on the board, turns to the class and says, "Particular organisms have hair-like structures around their bodies. What are those little hair structures called?" She writes "hair-structures" by Item 4.

Diane continues the quiz in this manner through #10, the last item. She then moves to the front of her lab table saying, "Okay, now, if you need a question repeated, raise your hand and I'll respond to your question only with your raised hand. And, I'll only repeat the question once."

Several students ask that various questions be repeated which Diane does, providing further clarification on some. When no additional hands are up she says, "Anybody else?" When she receives no response, she says, "Swap papers. Don't grade your own. I'm going to quickly go through this."

The noise level rises as students trade papers at their own

table. Diane interrupts saying, "Okay, number one . . .Raymond, what is the answer to number one?" Raymond replies, "Amoeba," and the teacher asks him to spell it, which he does correctly. The teacher continues by asking Joe what kind of an animal we're looking at in Figure #2, pointing to the chalkboard. Joe indicates that it is an "euglena" and the teacher agrees, asking, "What is the little thing of the euglena?" She calls on Joe, who responds, "Flagellum."

Diane asks Tim to spell the word, saying, "We better spell this one too, since it was a vocabulary word." Tim is unable to spell it correctly, but the teacher takes the root portion as being correct and writes on the board f-l-a-g. She then calls on Janet, who spells the word "flagella". Diane indicates that any students who put "flagella" on their paper may be given credit for that response. Diane then explains the difference between the two words.

She then calls on Gary to answer Question #4, "What are the little hair-like structures around the paramecium?" Gary responds, "Cilia."

Diane gives the students additional information about the cilia and how it is found in the human throat by saying, "When you swallow and things go down your throat in your esophagus, which is the tube that connects your mouth down to your stomach right here, you've got little hairs that are waving back and forth that help to push the food down. Now, that doesn't mean when you get a tickle in your throat that the hairs are tickling you."

After this explanation, Diane continues correcting the test, calling on Sam to explain the fourth kingdom. He replies, "Monera." The teacher agrees with this answer, but says she will not count off for spelling because she had not specified that they needed the correct spelling on this particular item. Diane calls on Mark to answer Question #6, "Name one organism that is found in the fourth kingdom? Only one." Mark replies, "Bacteria." The teacher accepts this as one example, then asks for another. June contributes, "Blue-green algae." The teacher then asks if anyone has anything different, saying "We might have to look it up." One student indicates that he has the word "algae" written on his paper, and the teacher tells him, "No. That is not a correct answer. It must be blue-green algae to be a moneran."

The students continue correcting each others papers in this manner. Diane continually prompts students to obtain the correct answers, and provides additional information to questions when students appear confused.

After all the questions have been answered, Diane explains how the papers are to be graded. She puts a grading scale on the board and the students grade the papers and return them to their respective owners. She then calls each student by name and they

call out their grade. She compliments the students as she goes along.

Students Conduct Lab on Bacteria (Day 9)

The first half of today's class is spent reviewing corrected test papers. Then Diane gives the students instructions regarding their petri dishes filled with bacteria, which they prepared on Day Six. She moves to a large cardboard box sitting on the floor by the teaching assistant's desk. As she picks up the box and brings it to the front of the room, she says, "Oh, Lordy-be, you won't believe what we've got growing in here." Most of the students are quiet as she begins taking the petri dishes out of the box. She says to the class, "I'll give you your petri dish . . . your easiest bet to see if something is growing . . .hold it up to the light and look for the little white spots. Some of you will have little white spots. What does one spot signify?" Diane holds the petri dish up to the light, demonstrating how to look into it. Several students shout out, "A colony." The teacher replies, "A colony of bacteria. How many different kinds of bacteria are there in that one colony?" And again, numerous students shout out, "One." The teacher repeats this, saying, "They all came from one kind of bacteria, right?" Joe says, "What if you look at the colony and they're different?" The teacher replies, "They shouldn't be." And then continues with her discussion,

> Your goal then is to take your probe and in the little colony, just barely touch it with your probe, put it on your slide. . . or wait. . . put a drop of water on the slide first. Catch your colony and then put it into the water. And then your cover slip. . . don't forget your cover slip. Sometimes the bacteria will be a little difficult to see. Focus with. . . begin with low power and then slowly go to a little bit higher power. Some of you will have mold growing on them. If you'd like to look at mold, feel free, that will be fine. If you want to save your petri dish to take home, do so. If you don't, when you are finished with it, make sure the lid is on it and we're going to throw them away. Some of them are real fuzzy.

The students are all attending to the teacher's instructions and demonstration. Diane removes one of the colonies with her probe and puts it on the glass slide, covering it with a cover slip, and demonstrating how the students are to do this. As she mentions that several of the dishes are fuzzy, there are a few mumbled "Ughs" from various students.

Diane calls the students by name as she takes the dishes out of the box. As she does so, the students come to the front of the room to get their petri dish. Students who have received their petri dishes head to the microscopes, and those who have not cluster around the teacher, waiting for her to call their name. Students appear anxious and enthusiastic. Lucy, who is at the back microscope, makes the comment, "O-o-h, they stink like heck!" as

she opens her petri dish. Joe comes back down the center aisle after receiving his dish and says, "This is s-o-o-o gross."

A couple of students indicate that they have no growth on theirs and the teacher offers some of the left-overs from 7th period. She takes these out and moves back to the front of Table #7, where she hands the students who do not have any growth these additional dishes.

Steven and Raymond are working already, but they have not put their culture onto a glass slide. Instead they slide their entire petri dish under the microscope and are attempting to get some sort of focus on it. Six students are at the front lab table getting their probes, slides, and other materials. As they take the bacteria colony and put it onto the glass slide, they put their remaining culture and the petri dish into the trash.

Throughout the lab session Diane circulates throughout the room. She occasionally stops and talks with the students. She helps some students by adjusting microscopes, answering questions, and reminding them of previous class discussions. Some students are moving around the room looking at each others' slides. The lab continues in much the same manner until the teacher announces that it is time to clean up. This is done quickly and all students are ready to leave when the bell sounds.

Excerpts from Classroom Observations
Topic Two: Heredity and Change

Table 2 summarizes how Diane taught Chapter 26, entitled "Heredity and Change." She spent eight days on this topic and mixed lecture and discussion segments with note-taking on specified worksheets. Illustrative examples of the instructional segments follow.

Review of Characteristics of Living Things (Day 1)

The teacher has concluded beginning activities of taking roll, distributing worksheets, collecting papers, and answering questions. When students fail to quiet down as she begins speaking, she puts a large "6" on the chalkboard (part of the assertive discipline program) and students immediately become silent. She says, in a subdued voice:

> The paper I just passed on to you is a paper for you to use to take notes on. You'll notice one side is blank on the back. The front side is a list of vocabulary words that we will be discussing for the next. . . well, actually. . . week and a half. As we're getting real close to the end of school, we're gong to cover genetics. Yes, there will be a test on it. It will be at the very end of the next week, and yes, you are still accountable for school. Okay, now, what we have

Table 2. Duration of Classroom Activities During Heredity and Change Unit (Teacher 4)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5*
	Opening	Opening Transition	Opening Transition	Teacher Outlines Student Activity	Opening Transition
	Transition	Teacher	Students Assigned to Board	Teacher Passes Out	Student-Teacher
5 min.	Review: Living Things (Mitosis, Cells, Nucleus)	Reviews	Assigned Students put Homework	PTC Paper; Students	Reviews Mendel, Generation Traits, F_1, F_2, Alleles,
		Genetics	on Board (Punnet Square	Conduct Activity	Chromosomes, and
10 min.		Information	Problems)	to Check for:	Mitosis
	Teacher	with Students,		Taster of PTC	Student-Teacher
	Gives	Practices	Students	Attached Earlobes Widow's Peak Tongue Roller	Lectures on
15 min.	Introductory	Punnet Squares,	Review		Meiosis.
	Lecture on	Introducesd	Problems	Teacher Assigns Homework	Students
20 min.	Genetics:	Co-dominance	on Board	Dismissal	Fill in
	Mendel	(Incomplete	with		Meiosis
	Alleles	Dominance),	Teacher		Worksheets
25 min.	Genes,	Phenotype,	and		During
	Homozygous	and Genotype,	Correct		Lecture,
30 min.	Heterozygous	F_1 and F_2	Worksheets		Copying
	Punnet Squares,	Students Practice Making Cross on Punnet Square, Tchr Passes out Homework			Information
	Dominant,				From Board.
35 min.	Recessive	Tchr Reviews Above by Putting on Board			Topic
		Tchr Works Through a Problem and Assigns Homework			Concludes
40 min.		Dismissal	Teacher Reviews Phenotype and Genotype		with
			Students Work Prob. From Board		Introduction of
45 min.			Teacher Talks About Incomplete Dominance		Down's Syndrome
	Students Copy Homework Problems From Board				Students Finish Drawing on Work-sheets and are Given Assignment
	Work on Problems				
50 min.	Dismissal		Dismissal		Dismissal

*A student-teacher instructs the class today while the regular teacher supervises a school activity.

ble 2 (continued). Duration of Classroom Activities During Heredity and Change Unit (Teacher

	DAY 6	DAY 7	DAY 8
Class Begins	Opening Transition	Opening Transition	Opening Transition
5 min.	---------	Teacher Reviews Determination of Sex, Punnet Squares	---------
10 min.	Teacher Reviews and	Teacher Passes Back Student Activity Paper Teacher Reviews Punnet Squares	Teacher Reviews Test
15 min.	Expands on Genetic	Transition to Prepare to Take Test ---------	Items With
20 min.	Replication and DNA,	Students	Students
25 min.	Chromatids, Centromere,	Take Genetics	---------
30 min.	Spindle Fibers, Centriole	Test; Hand in Papers	Teacher Collects Test Booklets --------- Students Sign Yearbooks and
35 min.	Discussion of	as They Finish,	Socialize
40 min.	Mutations, Twins, Siamese Twins,	Sit at Desks	Students Clean Up and Prepare to Leave DISMISSAL
45 min.	Mongolism, and Effects of Drugs		
50 min.	Student Surveys Administered DISMISSAL	Students hand in Misc. Papers DISMISSAL	

to review. . . some of you were in a different class first semester. Some of the information that is important here I'm not sure if all of you still remember it. I don't know how much you've already learned, so we need to review.

After reminding the students to take notes, Diane continues, saying "Okay now. Every living thing we have said in the past, has to do certain things. . . every living thing. Let's go back to Chapter Two. What does every living thing have to do?" Kathy raises her hand, and the teacher calls on her. Kathy says, "They have to reproduce." Diane replies, "Okay. . . It reproduces. Good point." She then calls on Susan, who has her hand up, and Susan says, "They, um. . . breathe, or whatever. . ." Diane says, "Okay, they breathe or take in oxygen to combine with what?"

Several students raise their hand and the teacher calls on Joe who says, "To combine with food." The teacher repeats this response and adds, "By combining with food, what do they get?" She calls on Linda, who has her hand up and replies, "Energy." The teacher then asks, "What else do they do?" She calls on Joe, who says, "Grow." The teacher says, "All right, they all grow. And, what's the last one?" She looks around the room there are only one or two hands that are raised. One student shouts out, "They eat." And the teacher says, "Well, yeah, but we've already said that one. They take in food. Uh. . . something else. This is always the stickler that people don't remember. And this is something that we've said in the past. . ." She then calls on Amy, who says, "Reproduce." Diane repeats this reply with finality and continues saying, "Basically, what we're going to be talking about is reproduction, and what happens during the reproductive process. Okay. . . every living thing, Claudia. . . is make up of what?" Claudia ponders for a moment, then replies, "Uh. . . cells." The teacher replies, "Okay. Let's say that this is a cell" and she draws a large circle on the chalkboard.

Diane continues, saying "This is a cell magnified many, many, many times. And the structure in the cell. . . what we have called the brain of the cell, controls all the activity. It is known as what, Henry?" Twelve students immediately raise their hands. As Henry sits thinking about a response to the question, several seconds pass and the teacher says, "The part of the cell that is like the brain, that controls all of the activities that happens." Again, there are several seconds of silence and Henry is unable to answer the question. The teacher then says, "We'll just draw it right there." She draws a small circle inside the larger circle and then says, "It is usually the largest one. You can see it as you are looking through the microscope kind of as a dark spot." Again, several seconds pass and Henry shakes his head, indicating that he does not know the answer.

Diane calls on Jack, who says, "The nucleus." The teacher says, as she points to the small circle inside the large circle,

"Okay, that is the nucleus of the cell." And she writes the word 'nucleus' out to the side of this small circle. Diane continues, "In this nucleus, do you remember a process called mitosis?" Several of the students shake their heads yes and some verbally state, "Yes." The teacher now writes the word "mitosis" underneath "nucleus," saying, "This is clear back in Chapter Three. What happens? We're going to review this later, but what happens during mitosis?"

She calls on Joe who says, "The nucleus splits up and then, uh. . . two new cells grow." Diane says, "Okay, and what happens in the nucleus? We end up getting new cells and for the cells we can say reproduce. In order for this to happen, it goes through a big process. Now, inside of our nucleus, before we get going. . . Susan?"

Susan, who has her hand up, asks, "On number fourteen on this sheet, it says m-e-i-o-s-i-s. Is that what we're talking about?" Diane says,

> No. That's a different process. That's meiosis, that's something different. Don't worry about that. That's meiosis, that's a whole different process. That's not until Thursday or Friday of this week. Okay, so everybody's with me so far. We're in the nucleus of the cell.

Diane now writes under the word "mitosis" the words "cells reproduce." She continues, "In the nucleus of the cell, we have little structures that look like X's." She puts two X's inside the nucleus. Diane continues,

> Some of you know already. Just a little more information. On these X's, we have the material that determines what the offspring will look like. Whether there will be curly hair. Whether they will be tall or short. I've got a few more hands coming up. If they, uh, will have a fast metabolism or a slow metabolism. If they can be a taster of a certain chemical or not. I think most of you are with me. Gigi, we haven't heard from you. What are we talking about?

Gigi responds, "Genes." Diane continues, "These genes. . . you're partially right but I'm looking for another word of what this X is." She points to the center of the nucleus and asks, "What is the X?" She calls on Steven, who responds, "Chromosomes." The teacher replies, "That's the chromosome." The teacher then draws a line from one of the X's inside the nucleus out to the side and writes the word "chromosome", spelling it as she does so. She continues,

> Now, on this chromosome you have genes. The genes are made up of a substance that your book doesn't go over. Let's draw a chromosome over here. . . and on different spots on the chromosome, where the genes are, we have

information there that gives the chracteristics or traits.

Diane draws additional information on the board, leading into a discussion of alleles, Mendel's genetic work, vocabulary words, and concludes by showing the students how to fill out a punnet square.

Correcting and Reviewing Worksheets (Day 3)

After a couple minutes of administrative tasks, Diane begins class by saying, "Please take out [the] six problems that you were working on yesterday. We will want to go over them to see how you're all doing; what you're understanding, what you're not understanding, so that we can help you where you need help."

It is quiet in the room and students have taken out their worksheets from yesterday. Diane assigns six students to go to the board and put their answers up, "Put that on the board for us and we can all see what is going on."

While students are putting their problems on the board, Diane attends to administrative details. Students are told to "sit patiently," until the problems are up.

Diane moves to her lab station and she picks up a copy of the six problems from yesterday. She reads problem number one, "In garden peas, tall vine is dominant and short vine is recessive. Who did number one?" Gary raises his hand and she says, "Okay, Gary." Diane points to the board and the information Gary has written there:

T=tall
t=short

	T	T	
t	Tt	Tt	0:4:0
t	tT	tT	

Gary remains at his seat and Diane says to him, "Okay, Gary, you said you're using a capital T for tall. All right. And you're using a small t for short. Is that correct?" Gary nods his head yes. Diane continues, "In a homozygous short plant, what would the alleles look like on a homozygous short plant?" Gary says, "Two small t's." She then asks him, "Why? We're talking about capital T and small t." Gary now responds, "Both." And the teacher says, "We're talking about homozygous, which means the same." Gary says, "So, it would be two small t's." And the teacher says, "Thank you, nice job."

Diane now points to the punnett square again and says, "Two small t's are crossed with homozygous tall. Chris, what would homozygous tall look like?" Chris responds, "Two large T's."

Diane moves to the chalkboard, saying, "I'm just going to add a little more on here. Two small t's crossed with two large T's. . . and she writes:

tt x TT

She turns to the class and says "What genotypes are possible in the F-1 generation? Chuck, what do we mean by the F-1 generation?" Chuck responds, "The kids." Diane replies, "So, the offspring, or the individuals. . . the first generation from the parents. . . ?" And Chuck says, "Yeah." Diane says,

> Okay, good. You're with me. What kind of a genotype do we get. . . looks like we've got a punnett square set up here with one parent along one side, another parent along the other side. . . um, and you come up with 0-4-0. Gary, what do you mean by zero?

Gary replies, "It means there are not two of the big ones." Diane says, "Okay, so you're representing your two capital T's, homozygous tall, right?" Gary shakes his head yes. The teacher then asks him, "What does the four represent?" Gary replies, "There's four of the. . . there's four of both of them, the big T, and the small t." Diane says, "Okay, and give me the word we're using for big and little." Gary replies, ". . . um. . . heterozygous." Diane compliments him, saying, "Okay, good job. Heterozygous, then, we've got four of them. What does your zero on the end mean?" Gary replies, "That's for the two small ones." Diane says, "Two small ones, or homozygous what?" Gary responds, "Short." Diane says, "Short. Is that your dominant or your recessive gene?" Gary replies, "Recessive." Diane praises him, saying, "Okay, nice job. This is correctly finished."

Diane continues working through the remaining problems in a similar fashion. The last ten minutes of class are spent reviewing and reemphasizing concepts from the problems, and a short introduction to incomplete dominance is initiated.

Students Conduct Tests to Determine Individual Traits (Day 4)

As part of today's activity Diane has drawn a chart on the front board as follows:

	DOMINANT	RECESSIVE
1. PTC paper (T,t)		
2. Earlobes (F,f)		
3. Widow's Peak (W,w)		
4. Roll Tongue (R,r)		

The students' task today is to determine whether their trait for each of the items listed in the chart is dominant or recessive. In addition, they are given instructions to go home this evening and check each of their family members for the same traits, making a separate chart for each member.

After Diane gives instructions, she tells the students to "work in tables. You can look at each other's earlobes, so that you can get the results written down, and then we'll go from there. Let's see how long it takes." The classroom becomes very noisy as students begin talking with one another. Several students are up and out of their seats. The teacher has moved to the side cupboard to the box of PTC paper. Several students are clustered around her and are asking her questions.

Diane says, "All right, first you need to get your PTC paper." She walks down the center aisle, passing out PTC paper to the students. As she does this she says, "Here is some paper for each of you to take."

Students are examining each other for the traits required by lifting hair to examine the hairline, or by looking at ears to examine the earlobe. When traits are identified, students make notations on their worksheets. As students put the PTC paper in their mouths, many make very grimacing expressions of distaste.

After allowing students time to measure and record traits, Diane begins reviewing the worksheets. She moves to the chalkboard and asks Frances, "What do I want to fill in my chart up here with?" Frances responds, "Two large T's." The teacher writes these on the board, repeating, "Two large T's." She then asks Frances, "Because the capital T was dominant, is that correct?" Frances nods her head yes. Diane then asks "Um. . . is that the only way I could write that if I'm a taster?" and calls on Ken. He responds, "You could put capital T/small t." Diane replies, "Okay, you could put capital T/small T. What do you call that?" Ken starts to respond, saying, "Um. . ." then he and many of the other students in the classroom respond in unison "Heterozygous." Diane repeats this, saying, "Hetrozygous. Let's say that I have a 'widow's peak'. Where do I signify that?" and calls on Lou. Lou replies, "Capital T/small t." Diane interrupts, saying, "I'm on W's." And Lou says, "Oh, capital W/small w." Diane responds, "Okay, suppose I <u>don't</u> have one?" Lou replies, "Two small ones." The teacher says, "Okay, two small ones, and I would fill in over here." She points to the recessive portion of the chart.

Diane concludes class by saying, "Your goal now is I want every single member of your family tested with all four tests tonight, written down in a chart form by tomorrow."

Teacher Reviews Meiosis (Day 6)

Diane spends the first three minutes of class taking roll and talking to individual students. She informs the class that they will be discussing meiosis today, to prepare for tomorrow's test. She says:

> It would be a very wise idea if you pay attention today and any questions that you have with genetics you ask. The test is tomorrow. The test will include meiosis. That's what the purpose is here.

Diane assigns pages 508-511 for review, then immediately launches into meiosis. She begins by reviewing several vocabulary terms, calling on various students to explain each. She discusses Prophase I for five minutes and then moves to anaphase.

Diane asks the class, "Let's say that they've [the chromosomes] lined up in the middle, then. What happens next?" She calls on Stuart, who says, "They go through anaphase and then. . Stuart responds, "All the cells pair themselves and separate." Diane says, "Okay. Pairs of chromosomes. Pairs of chromosomes are separated. What makes them separate? What gives them a pull?" Approximately ten seconds pass, with no response. The teacher rephrases her question, saying, "What pulls them apart. . . what pulls them apart. . . Daisy?"

Daisy is not able to answer. Diane says, "Okay, what pulls these apart?" She calls on Jaren, who says, "There are discs on each side and they pull them apart." Diane says, "Little things come in and hook on to them, yes." She then calls on Anthony, who says, "Spindle fibers. Diane repeats this, saying, "Spindle fibers. They're little hair-like structures. They're very minute and hook onto the centromere. There's another part out here called the centriole." She points to a place outside of the cell drawn on the board. She continues, "But that will just confuse you. So, just know that the spindle fibers attach onto them and then after they have lined up in the center they start to pull apart." She draws spindle fibers coming from discs on the outside of the cell into the two X's with all of its extra duplicated fibers. Now she draws a second drawing, showing the two cells beginning to pull apart. She asks, "Why do they want to pull apart, Claudia?" Claudia says, ". . . um. . . to make more. . . I think." Diane says, "You are on the right track, yes, to make more." Claudia adds. "To make new. . . um. . . things, whatever they are." Diane says, "To make new chromosomes?" Claudia nods yes, and the instructor says, "Okay, you're on the right track, but not quite there. Cheri, why do they want to pull apart?" Cheri is unable to reply, so the teacher calls on Rodney and then Kevin. Neither are able to provide an answer at first.

Then Kevin says, "To reproduce." And Diane says, "To reproduce. Keep talking." Diane now draws a third circle on the

chalkboard. Five hands are up as Kevin trys attempting to come up with an answer. Diane turns back to the class and says, "Why do they want to pull apart? Mike, why do they want to pull apart?" Mike responds, "To make more chromosomes." Diane says, "Okay, to make more chromosomes." She points to the drawing on the board and says, "Will I get more?" And Mike says, "No, you'll have more cells." Diane says, "Will I have more cells? How come I'll have more cells; I only started out with two here, and if they pull apart, won't there still be only two here?" And she points from circle #1 to circle #2. And Mike says, "Yeah but . . ." She now points to circle #3 and says, "And now that there are only single strands . . ." and she erases the chromosome strands in the drawing and redraws them so that they are once again Xs.

Susan has her hand up, and Diane calls on her. Susan says, "Well, they, uh, pull their cell apart." Diane says, "Pulls the cell apart. Keep talking." Susan says, "It pulls the cell, and then it pulls the two, and it makes . . ." Diane interrupts, saying, "Okay, okay. Now, if I were to only pull apart my chromosome in one section. . . and let's say that I ended up with one chromosome that had a double strand up here like this, do you foresee any problem?" She then draws a large X on the board, with one extra leg on the top.

Diane waits approximately twenty seconds, then says, "What do you think, Tom?" Tom says, "When they were duplicating and then when they pulled apart. . . I guess one. . . one of the, that thing . . ." Diane interjects, "Chromatids." Tom continues, ". . . chromatids. I guess one of those chromatids fell off. " Diane says, "Okay, so one of the chromatids either fell off or it ended up with an extra one. Why is that harmful?"

The students appear to be attentive and struggling to provide the correct answers to this new information. Diane rephrases her question, saying, "Is that harmful?" After approximately ten seconds with no response, she asks, "What is it that is on these chromosomes?" She goes to the board, and she draws a large X with a number of small dashes across each of the X legs. A student shouts out, "Genes." Diane says, "Genes. Good. Give me more about genes that's what we want to talk about today."

Joe has his hand raised and Diane says, "Okay, Joe." He says, "That's where your traits are." She says, "That's where your characteristics are. The traits where you get your blue eyes, or your blond hair, or if you're going to be tall, if you're going to be plump, etc., etc. Okay, let's quickly get finished with meiosis, then. We now have two cells." She goes to the board, and she draws two chromosomes in each of the two cells, and labels it 'Telo I'. Diane continues this discussion of meiosis concluding with mutations, twins, mongolism, and the effects of drugs on chromosomes.

TEACHER 5: ART MCDERMITT

by Vicki Lambert

This is a portrait of Art McDermitt's 7th-grade life science class at Bay City Junior High School. The first observations occurred in mid-December, 1983, when he taught protozoans. The second set of observations was conducted in early April, 1984, and the topic was genetics.

Background and Viewpoints

Art completed a secondary teacher training program in 1969 with a major in biology and a minor in chemistry. He began teaching science at Bay City Junior High immediately following graduation, and 15 years later remains in the same position. For the first 10 years he taught physical science, life science, and biology. He has taught seventh-grade life science for the last five years. Art has completed over 65 units of graduate work from various universities but does not hold any advanced degrees. He feels his time is better spent in a second job, where he can "make more money than with the one or two thousand dollars difference between a degree and getting another degree."

Art directs a number of school activities such as the "High Honor Roll," the spelling bee, and one period of "In-School Suspension." Also, he supervises dances, pizza parties, ice-cream busts, and movies. As he says, "Anything that has to do with the school and they want my services, I'm right there. They don't have to ask twice."

Art feels life science relates to everything in the students' environment, "whether it be math, history, or whatever." However, students are not aware of this relationship and most students do not know what science is. As Art put it, students' knowledge of science is "el-zilcho. They haven't been exposed to it. Nobody has introduced it. They don't know anything that has to do with science. It's hard to believe."

Art feels seventh graders are quite enthusiastic about science when they enter his class, and are willing to learn. As he says, "They really want to get into it with experiments and labs and stuff." He feels that girls exhibit more enthusiasm than boys, and that even dissection, which used to discourage girls, today serves to increase their enthusiasm. Art attributes this to the fact that girls mature faster than boys, that they have more patience, and follow instructions better. As he explains, "Boys try to do things without instruction. They go in there thinking 'Hey man, I can do the same thing Mr. McDermitt does,' and will go in there without bringing a book giving a step-by-

step procedure."

Art feels that his opportunity to teach seventh grade students about science is unique:

> It has to be, because I'm getting the first crop of students into the junior high school situation, or level, from an elementary school. As I've noticed in teaching my kids, a lot of them have had no science at all, and for a lot of them this is a new field for them. And so, it's like working at the ground floor. I can lay my own foundations.

As a result, Art feels strongly about providing "hands-on" experiences for the students:

> I want them to have some idea that they can try something and not be embarassed at trying it. . . You learn by doing, and that's what my class is all about. We learn in my class by doing. It's hands-on work. It's not something you read through your eyes and stick it in your head. Mine is hands-on where you do the work but you're still memorizing, remembering, or recalling what you did.

In addition, Art feels that reading about the various topics is important, even though "a lot of the kids. . . are at a fourth, fifth, or sixth grade reading level." Thus, he allows the students to progress at their own pace by providing a lot of time to read the assigned chapters and answer the questions at the end of each chapter. The reading, he feels, "helps the activity [lab] you're doing."

Art's over-all goals for his science classes include individual responsibility, participation, leadership, and curiousity. To achieve these goals, he encourages students to ask a lot of questions, no matter how afraid they may be to ask or how dumb they may feel the question to be. He says, "I don't know [the answers to] everything, but. . . I want to teach everybody all I can."

Art follows the district guidelines as he organizes his curriculum, and adds several lab activities when he feels they are needed. From year to year he makes notes in the district book on topics he feels need additional coverage, then tries to implement these changes the next time around. He also tries to vary activities frequently, doing two labs a week, bringing in guest speakers, showing films, and using the textbook for reading and writing assignments.

Classroom Description

Art's classroom is large and divided into two sections. The front section consists of 30 desks arranged in six rows of five

each and the back section consists of six lab stations in three rows of two each, with each tandem lab station connected by a central sink. Students face the front of the classroom, which is identified by the large lab station used by the teacher. Directly behind his station is a three-sectioned chalkboard, with sliding-doors. Behind these doors are shelves filled with various books and science materials. Above the chalkboards are a projection screen and three posters depicting extinct animals. On each side of the chalkboards are small bulletin boards which contain several posters of cells, a meter chart, and a poster of a motorcyclist which reads: "A few seconds can spell the difference between success and failure."

Windows, shelf units and floor-to-ceiling cupboards line the west wall of the room. Several plants are arranged in front of the windows, and a black widow spider lives in a quart jar near the plants. There is also a stack of six baskets which contain student papers for each class period. Magazines and textbooks fill the shelves beneath the plants. Posters are hung on the little available wall space. The cupboards are filled with miscellaneous science supplies, (e.g., bones, skulls, insect boards, microscopes, old batteries, rags) all of which are in general disarray. One cupboard is the instructor's "special cupboard" and contains a coffee pot, cream, sugar, coffee, and several coffee mugs. The glass doors to these cupboards are covered with posters which portray genetic disorders.

The back of the classroom is defined by a door to the adjoining classroom and low-countered shelves which extend from the doorway to the east wall. Above the shelves are bulletin boards which contain a drawing of a heart, a series of Holt Natural Cycles posters, several "feel-good" posters, and a "Taxonomy Tree." On top of the counters are several aquariums, one filled with fish, the others filled with hamsters. In one corner hangs a hornets nest atop a branch.

The east wall of the classroom is identified by a large two-door cupboard with bulletin boards on each side. The bulletin boards and the cupboard doors are covered with various posters, some of which are pre-packaged, and some that depict various activities the teacher promotes each year. An American flag and a state flag hang above the bulletin board near the front of the classroom. A television and a four-drawer file cabinet are also along this wall. The door to the classroom completes this wall.

Course Overview and Instructional Strategies

Art uses Life Science (Richardson, Harris, & Sparks, 1982,) as his main textbook and Living Things (Teter, Edwards, Fitzpatrick, & Bain, 1981) as a supplementary text. Both texts are in short supply and students must share the books with other classes. Thus, most assigned readings and assignments must be done

during class. A few students, usually those who have been absent, are allowed to check out the books to take home.

Prior to Christmas, Art covers plant cells, animal cells, epithelial cells, onion cells, and blood cells. After Christmas, he spends four weeks on plants, including bacteria, then moves into genetics and heredity of plants and animals, and ends with bones and muscles.

Art follows district guidelines in sequencing the units of instruction, and organizes the textbook chapters around these mandates. Typically, he spends five to ten days on each chapter, depending on the amount of material to be covered. Generally, the students read the chapter and answer the questions at the end of each chapter, either individually or in groups. Interspersed with these activities, Art often lectures or shows films. At least twice during each topic, labs are conducted. Students are required to fill out lab worksheets, draw what they see, and/or state their results. A test is always given at the end of a topic and is usually preceded by a verbal review in class and/or a review worksheet. In many instances, the review worksheet is similar or identical to the test. Following the exams, students exchange papers and correct the test items as the teacher gives the answers. Most worksheets and exams are from publisher-supplied workbooks or teacher-editions of the text.

Because textbooks must be shared amongst six classes, reading assignments are done in class; generally ample time is given to complete the reading. Students read individually or with groups of their own selection. These sessions are frequently interrupted by the teacher to provide additional information or to conduct various activities of his own. When assigned reading is completed, students are allowed to have "time off" for socializing. Occasionally the teacher permits "diversion days" or "fun-and-games days," where students can break away from the normal routine and discuss other topics.

Guest speakers are frequently invited into the classroom, but scheduling has proven prohibitive; topics lectured on are often out of sequence with instruction. Art frequently lectures on topics himself and often uses facial expressions, hand gestures, and students to demonstrate and amplify his topics. Student recitations usually require them to recall brief definitions or facts from prior discussions or readings. Students seldom take notes and homework is never assigned, other than reminders to study for the exams.

Excerpts from Classroom Observations
Topic One: Protozoans

Table 1 summarizes how Art taught Chapter 19, entitled "Protozoans." He spent seven days on this topic and mixed lecture and discussion with seatwork, reading, and study question assignments.

Table 1. Duration of Classroom Activities During Protozoans Unit (Teacher 5)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
5 min.	Opening Transition Students Pick Up Books	Opening Transition Students Pick Up Books	Opening Transition Students View Filmstrip Narrated by Teacher: Protozoans Student Passes Out Materials Teacher Explains Materials Students Get Books and Form Groups	Opening Transition Teacher Explains Lab on Protists Students Look at Prepared Slides of Paramecium, Amoeba, Euglena; Reproduce What They See on Their Worksheet, Labelling Each Example Students Clean up; Teacher Reviews Lab Teacher DISMISSAL	Opening Transition Teacher Explains Lab on Protists Students Prepare Slides and Look For Protists, Drawing What They See, Labelling It, and Indicating the Magnification Students Clean up and Turn in Papers Students Excused to Assembly	Opening Transition Students Get Books Students Review Chapter 19 Individually and in Groups, Preparing for Test Teacher Reviews With Students for Test Students Complete Surveys Students Have Free Time	Opening Transition Students Study Individually and in Groups for Test Teacher Passes Out Tests Students Take Tests on Protists Students Trade Tests and Correct Them with Teacher Teacher Collects Tests Students Have Free Time DISMISSAL
10 min.	Students Pick Up Books						
15 min.	Seatwork: Students Read Chapter 19 (Protozoans)	Students Continue Reading Chapter 19 and Complete Work Quiz in Book					
20 min.							
25 min.							
30 min.							
35 min.	Teacher Reviews Various Protozoans with Students: Amoeba, Paramecium, Euglena	Students Return Books	Students Continue to Answer Assigned Questions From Yesterday Students Return Books, Hand in Work; Free Time				
40 min.	Students Return Books	Teacher Reviews Vocabulary with Students					
45 min.	DISMISSAL	DISMISSAL	DISMISSAL				

Reading and Review (Day 1)

As stated previously, due to the shortage of textbooks, students are required to do assigned reading during class. Thus, the teacher begins this topic by telling the students to get the Living Things textbook and to read Chapter 19. He writes this on the chalkboard along with the beginning page number. He allows the students to read for approximately 22 minutes. During this time the teacher is at his desk correcting tests. Not all students are on task and many are talking and moving about the room. The teacher seldom admonishes any of them and continues to grade papers. Students occasionally call out questions and the teacher usually responds. In addition, the teacher frequently interrupts by commenting on the grades received by various students or making general annoucements unrelated to the present activity. He finally asks the students if they are finished, and when no one responds, he says, "Close your books. I'm going to give you a review now. . ."

Art begins the review by saying,

> . . . there are a couple of students that I have . . . noticed, and I don't want to mention names because I think they know who they are, but if they read more than one paragraph in that whole chapter they'll be lucky. Because talking and fooling around, well you're only fooling yourself. You're not fooling me. It'll tell when the grades come out, who gets the A's, B's, C's and then who gets the E's and F's.

Art then informs the students that they will be studying animals, and ". . .that you should know about [some of them] because you'll see a film tomorrow, or we'll be looking at slides, and I don't want any of you saying 'Well, what's that?'" He then points to a picture in the textbook and asks, "What animal does that look like?" He calls on Jeremy who responds hesitantly; he is not sure how to pronounce the word. Art assures him, "Well, hey, listen, pronunciation I don't care about now." Jeremy spells "a-m-b-i-a" and Art tells him "That's close enough. It's called amoeba." Art turns to the chalkboard, saying, "You can spell it several different ways. You can spell it a-m-e-b-a, b-o-e. I like to call it a-m-e-b-a, the ameba." He writes this spelling on the board, and then faces the class again.

Art now points to one of the posters hanging above the chalkboard, saying at the same time, "The next one we're going to learn about is the one that I mentioned up here. . . paramecium." He writes this word on the chalkboard and stresses the pronunciation syllable by syllable.

Art points to another poster above the board and asks, "Alright. The next one. What is the next one? What's the name

of the one with the tail on it?" When no one responds he prompts the students by saying, "This one starts with an e." After two seconds Helen raises her hand and mispronounces "Euglena." Art replies, "That's close enough. Euglena," and writes this word on the board.

With his back still to the class, Art says, "Okay. Everyone say amoeba." Most students pronounce the word in unison. Art is not satisfied and asks them to say the word again, which they do. "Okay, now paramecium," he asks, and most students say the word. He does this with euglena as well, but few students respond. He tells them, "Oh come on now. You sound like you're sick. Euglena. Now, everyone say it." This time the students respond in a much louder tone which satisfies him.

Art continues the discussion by saying,

> The last group we're going to talk about now, oh really, probably your fathers and your grandfathers had it, or if anyone's been down toward the Panama Canal, they had a great, well, they had a lot of trouble building the Panama Canal with this. What's this disease I'm talking about?

He looks around the room, and when no one reponds, he adds, "This disease is carried by mosquitos." A student responds "Malaria," and Art replies, "Malaria! These are the spore formers." After writing the word on the board he says, "Okay now. . . this is not being funny. . . When I'm talking about the 'Rocky Mountain Quick-Step,' does anyone know what [that means]?"

He calls on two different students, but is not satisfied with their answers. He tells the class, "It's like diarrhea. It's like you gotta go potty in a hurry. 'Rocky Mountain Quick-Step' is the name given to amoebic dysentary. In other words, the runs." Art now does a fancy little dance step across the front of the classroom, demonstrating what this would look like, saying "They do blup, blup, blup. That's what amoebic dysentary is-- diarrhea." All the students laugh.

When the laughter dies down, Art continues,

> Alright. The other one is called African Sleeping Sickness. That's when people who are bit by this parasite never wake up. They go in a coma and they are sleeping. They sleep, sleep, sleep. There is one person I knew about, well, that I read about anyway, who slept 2 1/2 years and never woke up.

A student makes a comment about betting that the guy was hungry when he woke up and everyone laughs.

Art continues, "The three biggies that I want you to know are malaria, African Sleeping Sickness, and 'Rocky Mountain Quick-step' or Amoebic Dysentary." Most students nod in agree-

ment. Art looks around the classroom, then moves to one of the front desks, taking Shannon by the hand and bringing her to the front of the room. He asks the class, "Does anyone know how amoeba gets food?"

When no one responds, Art points to Shannon saying, "For example, this is a piece of food, okay?" Students giggle loudly, Art says,

> This is a delicious piece of food. Think of her as a 'Big Mac,' okay? Now, I'm an amoeba, okay? These amoeba have what are called false arms. You'll see these on the little filmstrip I'm going to show you tomorrow, but they have false arms. These things move like this. . .

He demonstrates with his own arms, whisking them back and forth in the air. Art continues,

> It looks like a great big blob, and that's all it is. It will never take the same shape. It is never the same shape twice. It's always a different shape. It can look like that and within one second's difference, hey, it can be a different shape completely. It could be long like a hot-dog. But how they get their food is really kind of funny, in that they do what they call 'engulf' their food. Engulf. That's an important word. They engulf it by one arm stretching out over here, which is what they call a pseudopod. A false foot. Another foot comes out here. . .

Art demonstrates as he talks, encircling Shannon with his arms. He tells the students that the amoeba "see that great big 'Big Mac' over here and they get one foot here, another one here, until they engulf their food like this." Shannon smiles as he encircles her, and students giggle. Art continues,

> Then these two arms will grow until they join and won't allow the food to go anywhere. They will digest the food right there. And what they don't want, or they're gooey, they'll let it go. They will open up and then go somewhere else and look for something different. A 'Dee-Burger' or whatever. At any rate, they'll go.

Art excuses and thanks Shannon. He continues, "All right. That's engulfing. And that's an important word that I want you to all know and spell. So, the amoeba engulfs its food." He writes the word 'engulf' on the board, spelling it aloud as he writes.

Art now discusses paramecium, including euglena, and concludes with mention of the food chain. Students return their books to the bookshelf and class is dismissed.

Lab with Prepared Slides of Protists (Day 4)

During brief announcements over the loudspeaker, Art distributes lab worksheets, telling the students to put their name, the date, and period at the top of the worksheet. After writing some preliminary information on the board, Art says,

> Today, we're going to be looking at some prepared slides. You're going to draw and label the slides. You're going to draw the amoeba, the paramecium, and the euglena. Right now put down the subject: amoeba, paramecium, and euglena.

As he talks, Art holds up the worksheet, pointing to the appropriate places for the labels. As students fill in this information, Art takes roll. When he finishes, he says,

> All right now. One other clarification. Look at your paper. Look at your outline there that I passed out to you. It's got Plate 1, which is the slide. Okay? Then right underneath by it it's got magnification. Okay? Now, so that I don't have to repeat this fifteen million times. We've worked on this before, but, when I'm looking through an eye piece that's 10 and I'm looking through an objective lens that is 40, what is the magnification of the animal or the slide that you're looking at?

A student responds, "Four hundred". He replies, "Right. Four hundred. Good!" He continues, "If I look at a magnification, or a specimen on a slide that is 4 as the objective lens and 10 as the eye piece, what is my magnification?" Several students respond and Art says, "Forty. Good. All right, now, I think there's one other one on there. If the objective lens is 10 and the eye piece is 10, what is the magnification?" A student immediately responds "One hundred" and Art replies,

> One hundred. That looks good. So now you understand. We've gone over and done that in labs before on magnification. So, now you know from the naked eye from the eye piece of the objective lens what the magnification will be, and I want the magnification on your paper. Now, in drawing his sample, I want you to take one example, put it right there in that circle, draw it, and label it off to the side."

He points to the top circle on the lab worksheet as he says this. The students study their worksheets, noting the positioning. Art looks around the room and continues giving directions,

> Label it on the same side as the words. It says here, "use a ruler to draw the line". Well, if you don't have a ruler, use the side of your book, the edge of your book. Print all the labels so that I can read them. Label the right hand side of the plate right here.

He holds up the lab sheet and points to where he expects the students to label. He then says, "Do not cross the label lines. If you're drawing like here," (points to the lab sheet), "for example, if the 'nuculus' [pronunciation his] is here, don't put down 'nuculus' here and then come down like this and say that that one is the cilia. Okay? Do not cross lines like that." He asks if there are any questions, and no one responds. He concludes, "Okay. . . All right, now, let's go to work. You know how to carry the microscopes. The microscopes are in the back back there. All right. Let's get busy!"

All but two students get up from their desks and begin moving to the back of the classroom. There is little confusion and students seem to know this routine well. There is no pushing, shoving, or loud disruptive noise. Students quickly move to the back of the room, pick up a microscope and carry it to their lab station. Each student carries the microscope in the same manner, grasping it around the neck along the curve.

Students begin to prepare their microscopes by inserting the slides and adjusting the magnification. Noise is high, and many students are calling aloud "Mr. McDermitt, Mr. McDermitt." Art moves towards lab station #6, where he leans over one of the microscopes and adjusts the knobs. He then raises his voice and says, "Okay. For all of you who have an amoeba, look at Jake's over here. He's got a good one. It's under 10 power." He then asks Jake, "So, what would the magnification be, Jake?" Jake replies, "One hundred." Art repeats this answer so the whole class can hear. He then moves to another microscope at the same lab station and says to the entire class, "A euglena. Here's a good euglena."

Art moves to another lab station and says, "All right, you guys, if you want to look at a good paramecium, come look at Sandy's." Several students get up and come over to look in Sandy's microscope. Art indicates, "Those are the small ones. Try it again under high power." He continues to move from station to station, exchanging comments with the students each time he stops. For example, so that all students can hear, Art says

> I know this is the first time that you've worked with a pair of slides, but, you've got to move the slides around like you did when you looked at the animals in the aquarium. Okay, you've got to move it around. You can't just plunk it down and expect to find one there.

Several students leave their lab stations and go to the back counter to return the slides they have been using and pick up a new one. They have done this before and are very used to the procedure. The teacher continues to circulate around the room and is accessible to students, as much as possible. Art moves to Lab Station #5, and says in a loud voice, "If you guys want to see another one that's really good, there's one over here. It's an amoeba where the nucleus is right in the center. And it looks like a . . . uh, a sea star."

Most of the students are very involved in either looking at the slide in their microscope, or drawing their pictures. When Art stops at one lab station, he tells the students that what they're drawing is simply a glob, that he wants the single animal isolated and drawn. He says, "What you've got here is simply a blob of many. Separate them apart." A student asks him about drawing the amoeba. He shows the student what to do, then raises his voice and says to the entire class, "Hey, I know you guys are not as good as I am when it comes to drawing. And I know that none of you are Michelangelos, but try your best."

Art continues to circulate amongst the lab stations. At station #1, he picks up Angie's drawing and says, "That looks good." He now raises his voice so everyone can hear, and says,

> I'm going to use Angie's as an example. That's what she saw and that's what I like. See how well that's done? Nothing fancy, just draw what you see. Don't draw the book. Don't draw what the picture looks like in the book. Don't draw mine up there at the top, because mine looks like a bear that got excited. If you look at it. . . it really looks like an excited animal up there.

Art returns the picture to Angie and moves on. During the next five minutes, he continues to circulate amongst the lab stations, talking to the students, peering into their microscopes, and drawing pictures of what he sees.

After students clean up their materials and return to their seats, the teacher reviews instructions regarding completion of the worksheets and then reviews the lab.

Teacher Reviews for Test on Protozoans (Day 6)

At the beginning of class, students are instructed to review Chapter 19 individually. They are given ten minutes to do this, and are then instructed to return their books to the shelf. There is much confusion and Art reminds them to hurry up, saying, "Okay, let's go, let's go. Everybody sit down. Come on, let's go." As students begin to quiet down and take their seats, Art tells them, "We're going to run through my little review." A student asks, "Your little review?" to which Art replies, "Yes, my little review. It's so simple that my three-year-old cat could pass this test." Several students laugh and Art continues, "I've got it trained so well it goes, 'Hey! Two is a B.' I've got a dog that barks once for true, two for false." Again, the students laugh.

Art turns to the chalkboard where he has written: "A) flagellates; B) Ameba ciliates; C) Ciliates; D) spore formers" and directs the students' attention to the four protozoans. He turns to the class and asks, "Alright, by a show of hands so I

can call on you, what group do the paramecium belong to?" Several students raise their hands and Art points to Jeremy, who replies, "Ciliates." Art compliments him with, "Good man." He then asks, "Which one of those groups is a parasite?" Again, several students raise their hands and he calls on Sandy, who answers, "Spore formers." He responds,

> Spore formers. Good. Which of these forms the. . . well let's put it this way. The skeletons of these form limestone. Which of those up there does the skeleton form limestone?

Art calls on Shelly who responds, "Flagellates." "Flagellates," Art replies, "Does everyone think it's flagellates?" When no one answers, Art looks at Shelly and says, "That was a good try but it's no. Okay, what is it?" This time, rather than waiting for students to raise their hands, Art accepts the answer shouted out by a student, "Amoeba."

Art continues with the review and asks, "All right, which one of these animals is covered with short hair-like structures?" He calls on Jane, who replies, "Ciliates." Art says, "Ciliates, good. Which one of those groups there belongs to Euglena?" He calls on Alex, who replies, "Flagellates" and Art compliments him on his answer. Art points to the chalkboard and asks, "Which one of those moves by protoplasm?" When no one responds, Art repeats the question, adding, "You remember the one that goes like this. . ." He takes his hands and puts them out as though they are encircling someone or something. As he does this, several students immediately respond, "Amoeba." He repeasts their answer, reminding them to respond "by a show of hands."

Again, Art points to the board and asks, "Which one of these has the long whip-like structure?" A student responds, "Amoeba." Art accepts this answer, repeating, "Amoeba." However, he catches himself, saying, "No, not ameoba. Wrong. No. A whip-like structure." A student responds, "Euglena" and Art says, "Euglena, good man." Several students point out that euglena is not a choice on the board. Art looks at the board, then replies, "Euglena is right, but what is the group?" He calls on Jimmy, who says, "Flagellates" and Art replies, "Flagellates, good man." Art continues the review,

> Which one of these, now, has the whole thing with the Rocky-Mountain-quick-step--the Amoebic dysentary, which is the same. . . malaria. Which group does that belong to?

Several students reply, "Spore formers." Art repeats the answer with positive praise.

Art walks around behind his lab station, alternating between sitting and standing. He continues, "Of all of these that you have studied. . . of all these groups that are here now, is that a phylum, a class, a kingdom, or a family?" He pauses for ap-

proximately ten seconds and then calls on Jeremy, who replies, "Class." Art says, "Wrong" and calls on Mary, who answers, "Family?" Art replies, "Wrong" and a student shouts out "Phylum." Art says,

> Phylum. Remember this, this right here is a kingdom. The kingdom is a Protist, or Protozoans, and these (pointing to the four categories listed under protozoans on the board) are the phylum.

Art continues to review for tomorrow's test in the same manner. At the conclusion of the review he distributes review sheets to the students.

Excerpts from Classroom Observations
Topic Two: Genetics

Table 2 summarizes how Art taught Chapter 10, entitled, "Genetics." Although nine days were set aside for this topic, only seven days were spent on it. During the topic, Art mixed lecture and discussion segments with seatwork, reading and study question assignments. Day four was spent administering a color-blindness test to the students. Illustrative examples of the instructional segments follow.

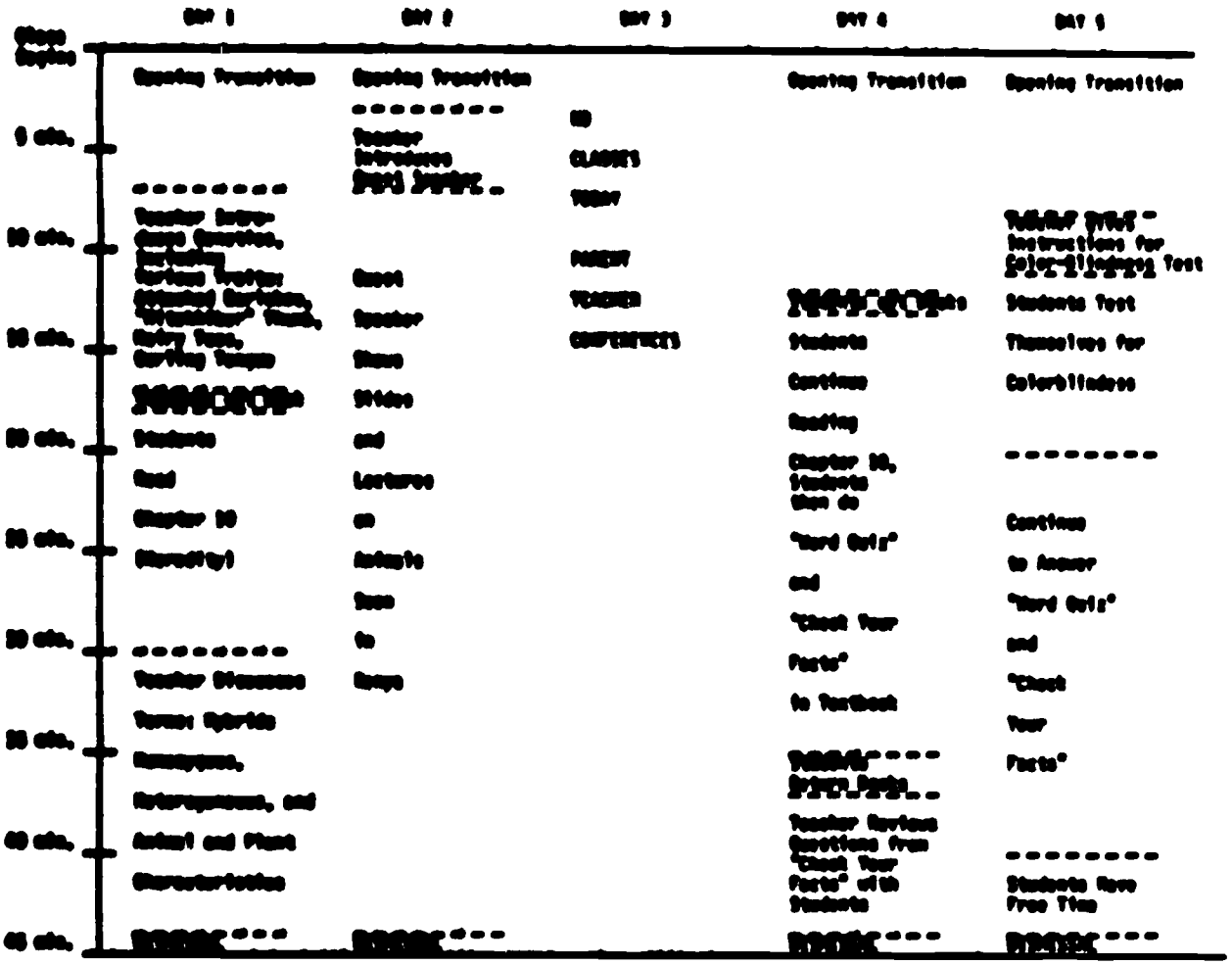
Teacher Introduces Genetics to the Students (Day 1)

After seven minutes of morning annoucements, Art silences the students and begins,

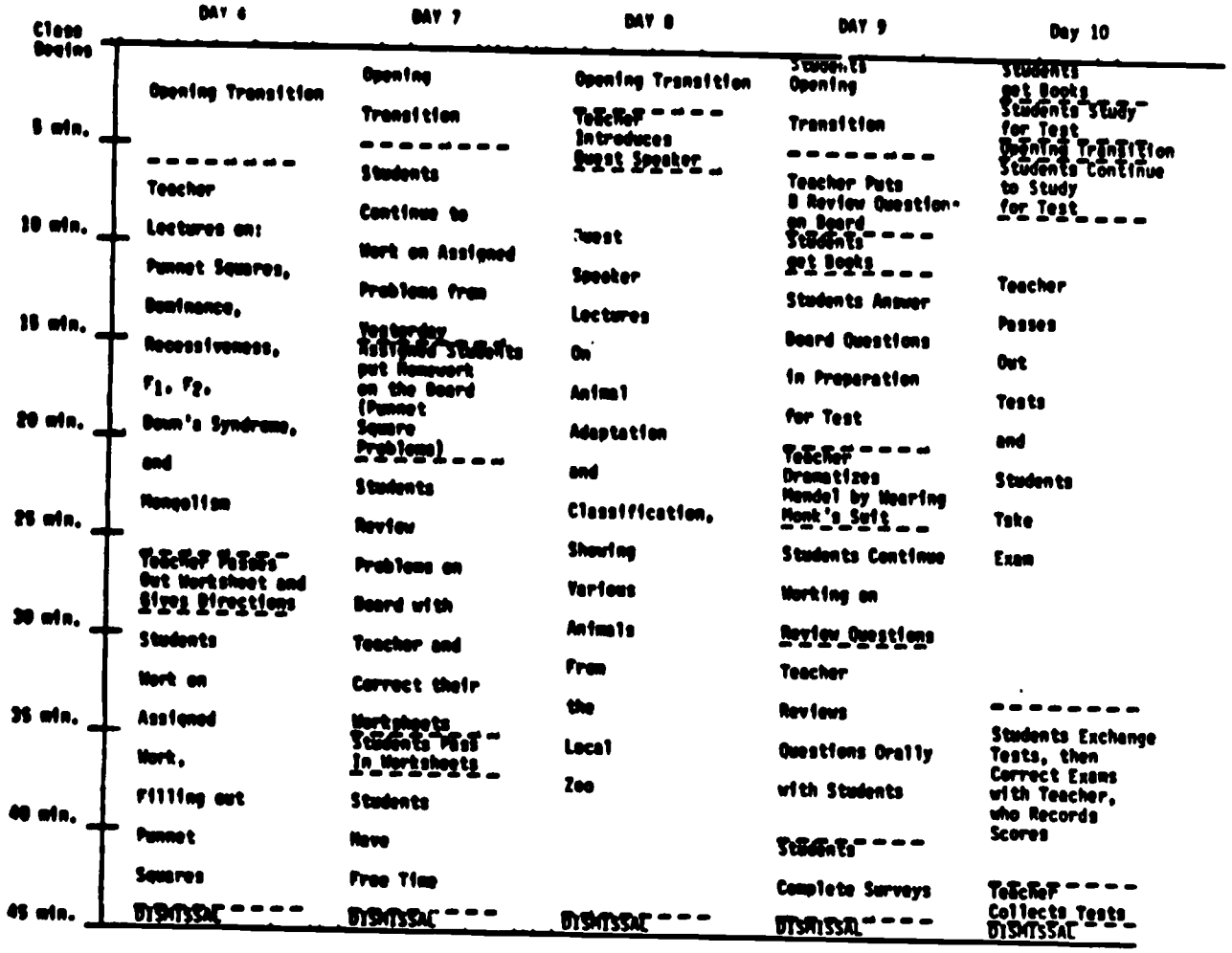
> All right now, what we're going to do now is dicuss why you are the way you are. For example, why have I got black hair? I would love to have red hair or blond hair. I would rather have had an attached earlobe. I've got this floppy old piece of meat hanging down here (he pulls on the bottom of his earlobe, shaking it back and forth). Now, let me look at some of your ears.

Art begins to walk down the aisle nearest the window and looks at each student, checking their ears. He does not find what he is looking for, and moves back up this aisle, crossing over to the next one, again checking various students' ears. As he does this, the students' attention is focused entirely on him. When he gets to the end of the aisle, he says, "Come on, let me see your ears. Get your ears out here. Who in this class has got an attached earlobe?" He peers across the room, checking the rest of the students. As he does this, Ron comments, "Attached? Or detached?" This raises a giggle from several students as well as the teacher. He replies,

Table 2. Duration of Classroom Activities During Genetics Unit (Teacher 5)



'able 2 (continued). Duration of Classroom Activities During Genetics Unit (Teacher 5)



You look around today. Look in the lunchroom, at your friends or your enemies, or whatever. . . Look, I've got this flappy thing right here. (He again demonstrates with his earlobe, pulling it in closely against his head, indicating an attachment.) Most of you have this earlobe right here, but some people have it-- BOING!! And it's attached right to their head like that. . . "

He takes his earlobe, pulls it in closely against his head and indicates an attachment.

It really is, and we're going to talk about all the different traits that are dominant. For example, we've covered all the way from protozoans all the way up to arthropods, which are the insects. We are going to cover now genetics, or heredity, and go from there into classifying vertebrates, which are on the back board - reptiles, fish, amphibians, mammals and birds. . . "

Art makes reference to the bulletin board at the back of the room with a sweep of his hand. Most of the students turn around, look at the bulletin board, then return focus to the front of the classroom. Art continues, "So, what I want you to do right now is grab a book. . . and start reading on page 86, Heredity." He asks, "Are there any questions?

When no one responds Art continues,

Tomorrow, I would like you to find out, if you can, any traits. . . talk to your parents, or your older brother and sister, or whoever you might be associated with tonight. . . to find out if there are any traits that you know of. Now, I'll give you a couple. Everybody try one, right now. Put out your hand, with your thumb like this. . .

He demonstrates by holding his hand and bending the thumb back as far as it will go on its own. "Now, try to bend your thumb all the way back. Try to bend your thumb, right here, all the way back." His thumb does not bend very far back. He then draws attention to one of the students in the class, saying "Look at Helen. Helen, I'm going to use you for an example. Come on up here."

Helen appears somewhat reluctant, but does come up, smiles, lowers her eyes, and blushes slightly at being in the front of the classroom. He has Helen put her thumb up and shows how hers bends back much further than his does. He says, "Now, look at hers. Mine can't bend that far back. That's what they call a 'hitch-hiker's thumb', so she'd be great on the old road going like this, you know. . . " And demonstrates a familiar hitch-hiker movement with the thumb in quick motion, as though indicating 'down the road'.

Helen moves back to her seat and sits down. Art says, "Another one. Do you want me to tell you something about yourself, Helen? We'll use Hiedi again. . . " and pulls Hiedi to the front of the classroom one more time. He takes Helen's hand, puts it in his, inspects it closely, and says,

> Do you know. . . without even looking. . . without even looking at Helen's foot, do you know that I can probably tell her a secret that nobody else knows about. . . we're going to tell you right now that Helen. . . now, don't be embarassed. . . you might have to go home and shave this. . . but, Helen has hair on her big toe!

Helen looks at him in surprise and says, "No, I don't!" Art replies,

> Yes, you do. And I'll show you how I can tell that. And this is a genetic trait. Everybody look at their hand right now. If you've got hair here, here, here, here and here. . . (he points to the area between the mid-knuckle and the lower knuckle of all five fingers) . . . even if it's little pores, where hair should be and isn't, you will have hair on your big toe.

The entire class now begins to inspect their hands, looking to see if they,

Art continues, "I
Now, this one is kind of gross, but it's the only way to do it. Everybody stick out your tongue." Art sticks his tongue way out to show the students what he wants them to do. Several students begin to do so but not everyone. Art continues, "All right, now. Who in here can get their tongue. . . and I can't do it, I need someone for an example. . . can get their tongue and turn it all the way around? Okay, look there's a good example, right here." He brings Melanie to the front of the classroom. He wants to demonstrate how she can turn her tongue completely around so that bottom side is now facing up. Several students are laughing and Melanie is very reluctant to go to the front of the room. He tells her, "Come on, this isn't so gross. Helen did it. It's not going to bite you. Come on." She finally demonstrates how her tongue turns. Art says, "This is a trait and it is very, very uncommon. I can't do that. Even if I try as hard as I can, I can't do that. Try it. Try it. Is there anybody else who can do that?"

Art looks around the classroom as students attempt to turn their tongues upside down. "Suzanne can do it. Look at Shelly, she can do it." Art now begins another little tongue exercise saying, "Okay, how many of you can form a little groove in your tongue?" He demonstrates again with numerous gyrations on how to fold your tongue in half creating a tunnel down the center of it. Most of the students attempt this. Art looks around the classroom, and says, "Who can't do this? Suzanne, you can't? Suzanne can't do that. You see, she can't do it."

Art continues with another example, and says,

> When you comb your hair the next time, and you're in front of a mirror, look at it. . . push your hair back and see it you have what they call a 'widow's peak'. Okay? Some people do, some people don't. I have a great big, large widow's peak because my hair is receding. I have a great big 'Mr. T.' type hairdo, if I'd cut my hair because my hairline goes way back to here. . .

He motions with his fingers on both sides of his head midway back across the top. He does not raise up his hair, but merely points with his fingers indicating where his hairline has receded to. ". . . I comb my hair forward to cover my bald spots because Mary tells me that I'm getting old. . . " He and a few students laugh at this comment.

The instructor pauses as if trying to think of another example. He looks around the room and says,

> Well, I'll leave it at that right now. . . I've got to think of some more that I've come up with. . . but, these are just some of them. This is heredity. There was a man by the name of George, no Gregory Mendel. He was an Austrian monk. And he found all of these traits out by working with peas. Common ordinary peas, like you plant in your garden. See back there in the back, I've got my tomatoes and my cucumbers and my peppers growing. When your father or your mother or whoever plants their garden, they're going to look for the best variety. And a lot of them will go and buy hybrids and that's a cross-breed between plants. We'll be learning about. . . snap dragons, cows, rabbits, dogs, and stuff like that. . . the reason why you work with peas and the reason why you work with rats or mice or hamsters or snap dragons is because. . . why? Why is it that you work with those kinds of animals and those kinds of plants? Anybody have any idea?

When no one responds, Art says, "None of you have any idea? No idea why you would work with a rat? What does a rat do when it has a litter? What is so common about a litter of rabbits or mice? They have what?" Still no one responds so Art continues, "What is the word that I'm looking for? Well, think about it. What does a hamster have, or a rabbit, or a mouse. . . it has litters. But, what am I talking about when I talk about litters?" Mary responds, They have babies." Art repeats this response, saying, "Yes, they have babies. But what's the word I'm looking for?" Jeremy contributes, "Lots of them." Art jumps on this answer, shouting,

> LOTS of them! That's the word I was looking for. They have a whole mess of them. Now, people, normal people, a woman will normally have one or two kids. That's

common. But, when you get into the threes, fours, quintuplets, quadruples, and all that other stuff. . . that's really uncommon. But, one or two is common. So, they work with animals. Now, when we come to genetic traits, we will be talking about. . . people with black hair that marries a person that has blond hair. . . what their off-spring are going to be. We will be talking about mammals. We'll be talking about like a black rabbit marries a white rabbit, what will the off-spring be? Now, some of you kids in here that have had rabbits. . . some of you have raised dogs. . . I've had dogs, rabbits, mice, hamsters. . . now, that's that only reason that I've kept those two back there. So that when we go into genetics we'll find out what the crossbreed is and see if what we got was kind of true.

Art then tells the students to spend the remainder of the class reading the chapter in their textbooks.

Students Test For Color-Blindness (Day 2)

After a few minutes of opening announcements. Art readies the students for taking a color-blindness test. He has a set of transparencies which he places on the overhead projector, one at a time. Students are required to look at the transparency and write down numbers that they see in a particular color.

Art begins, "All right, this is really simple. This is a test." He raises his voice and continues,

> Okay, now, here we go. This one is very simple. Do not do any more. Just follow my instructions, okay? What I'm asking you for right now is not to look on somebody's paper. This is for your benefit. I'm going to be able to tell you if you're colorblind. All right, now, now don't do anything until I tell you. Don't yell out any colors, don't get excited, don't. . . just play it cool. . .

He adjusts the lens on the overhead projector until the colors come into very clear focus. It is apparent that there are numbers in the midst of each color. He asks the students, "Can you see that?" A few shake their heads no, and he says, "Well, maybe we'd better get you some glasses." Most students are looking at the screen and Art continues,

> Now, on this chart I want you to first pick out the green color. Just write down the numbers of <u>green</u>. The green colors. The shades of green - light, dark green, but green. Pick the numbers.

Most of the students are writing down the numbers that appear on each of the green squares being projected onto the screen at the

front of the room. After a few minutes, Art asks, "All right, how many are not done? Raise your hand." A few students raise their hands and he allows a little more time.

After about a minute Art says, "Okay, what we're studying today. . . this is a trait, either inherited or not inherited. . . is everyone done. . . ?" Everyone indicates that they are and Art begins reading the numbers, which are green on the overhead transparency, "2, 5, 15, 16, 17, 24, 26, 28, 37, and 39. Did anybody not see any of those?" Peggy indicates she didn't write down #28 or #15. Art responds, "Wow, well, we'll talk to you in a minute, then." Angie indicates she missed #15 and #17, and Art says, "Okay, well, that's good. We'll keep you two girls in mind. Okay, Test B, now." Lynne interrupts saying that she missed #12, #28, and #39. Art says, "Did you write down 12, 28, and 39?" Lynne replies, yes, she did. Arts says, "Do they look green to you?" Lynne responds, "Kind of." Art says, "Okay, that's no problem." He now says to the entire class, "Okay, Test B, now. Put down Test B." The students write Test B on their paper.

Art then proceeds to give instructions for Test B, "I want the sample of that rose color similar to the one that's up there on B. Put down the numbers." The students begin writing down the numbers of the square that are a rosy color. After one minute, Art asks, "Okay, who's done?" A few students raise their hands and he gives them more time.

A few minutes pass and Art asks again, "Okay, who's not done? Who's <u>not</u> done?" When no one responds, he continues, "Good, Super, The numbers that you should have written down are, 1, 13, 23, 36, and 40. All right. Test C, now. Did anybody miss any of those colors that I read?" Lynne immediately replies, "Yes, I did." Arts says, "Okay, Lynne, we'll deal with you later." Art continues, "All right. . . let's see, now. . . this test is to confirm the results of A and B." A student asks, "What do you mean?" Art replies, "Well, this is just to confirm what you've seen. Now, I want you to look at color C, up there in that box. See what C looks like? Don't tell me what color it is, but see what it looks like? Mark down the numbers that are the same color as C."

After several minutes he asks, "Who's not done?" Several hands go up, so he allows them additional time. A few more minutes pass and Art again asks, "How many are not done?" No one responds and he continues, "The colors for C are 3, 21, 25, 27, 38. Did anyone miss any of those?" Several students reply "No," and Art continues,

> Test A was to differentiate. . . colorblind persons, whether too red or too green, they will include the greens or one or more greys, browns and roses. It's uncommon for them to include as many as 20 in the list. Okay? So, Test B that you did, which we had number 1, 13, 23, 36, and 40, the red blinds selects indiffer-

ently the roses and the blues. While the green blinds add the greens and the greys. The tendency for color-blind is always to select deeper colors. On the last test you took with the red color now. . . the red blind will select besides the reds, the greens and the browns, darker than the red. The green blind will add greens and browns lighter than the red. Only the more marked cases of colorblindness are likely to show their defect in this test.

Students appear confused by Art's explanation, but no one interrupts him to ask for clarification. Art calls the three girls, who did poorly on the tests, to the back of the room to re-test them. He tells the other students to work on the questions at the end of the genetics chapter.

Seatwork (Day 6)

During the last fifteen minutes of class today, Art gives the students worksheets with various genetic problems requiring crosses. The students are told they may work individually or in groups, and most students choose groups. Two students work alone.

As the students form into groups, Art moves to his special cupboard, and says, "I'm going to get a cup of coffee." He takes his cup of coffee and moves to the front of the room, checking on students as he goes.

Art interrupts, saying, "Okay, how many of you are done with the first part? The first eight?" Jeremy and Jake both raise their hand, indicating that they are complete. Shelly also raises her hand and Art responds, "Two guys and one girl. Let's go." Art circulates amongst the students, talking with them individually. Lynne asks Art a question and he interrupts the students in response, "Yeah. . . I don't want to stop you. If you've got A and B done. . . if you've got 1 through 4 done, start on. . . C, the second part." He looks down at what Mary and Lynne are doing and says, "It looks like both of you are doing quite well." He then says to the entire class, "Tonight, if you get a chance, go home and ask mother and dad what blood type they are. And ask them what your type is. Because when you were born, they had to take you blood type and put it on your birth certificate, so they know who you are." Art continues to circulate around the room stopping at the various groups along the way. Students ask him questions and he readily helps them. Two girls are having quite a bit of difficulty and he spends the remainder of the activity with them before dismissing class.

Volunteer Students Put Homework Problems on the Board for Review and Correction (Day 7)

After a few moments of administrative tasks and announce-

ments, students are given ten minutes to complete their punnet square worksheets from the previous day. Art then asks for volunteers to put the problems on the board. Six students volunteer and Art allows them approximately seven minutes to do so. While they are doing this the remainder of the students sit quietly at their desks. After the volunteers completed putting the problems on the board, Art says, "All right, let's begin a little review. . ." He looks at the worksheet and says, "All right, a little review. Using the punnet squares cross two pink four o'clocks together. Where's number one?" He looks at the board, trying to decipher which one represents problem number one. Mary tells him where it is and he says, "Okay, crossing two pink ones. . . all right, now, first of all. . . who did number one?" Mary says, "I did." Art motions to her to the front of the room, saying, "Mary, would you get up there with number one, please?" She gets out of her seat and moves to the front. Art continues, "Now, put the letters up on top so we know what we've crossed." Mary failed to put the outside marginal notations on her punnet square: Art reminds her to do this. Mary asks, "The letters?" Art responds, "Yes, the letters. What you used, put them up there." He points to the top of her punnet squares, and Mary writes the letters at the top of the Punnet square. Art says, "Big R, little r stands for pink. Now, you're crossing that with Big R,
you get two big R
corner. He then points to the top right-hand corner and says, "You get a Big R, little r, another Big r, little r. . ." and points to the bottom left-hand corner. As he points to the bottom right-hand corner, he says, "And two little r's. So you get one red one, one white one, and two pink ones." Again, he points to the proper notations as he runs through the color outcomes.

Art then says, "All right, number one, Lynne, get up there. You got to do yours all over again." Lynne moves to the front board. Art asks, "All right, number one, how many red ones have you got?" Several students shout, "One." Art says, "Now, wait a minute, let her figure it out." Lynne then replies, "One." Art tells her to write this on the board, and she does. He now asks her, "How many pink ones do you have?" And Lynne replies, "One." Art repeats the question, How many pink ones do you have?" And Lynne replies, "One." Lynne looks at her Punnet square, then says, "Oh, oh, four." Mary shouts out, "No!!" And Art repeats the question, "How many pink ones do you have, Lynne?" Lynne finally responds "Two." And Art replies, "Good girl. Lynne, up on the board, which two are pink?" Lynne looks confused and Mary shouts out, "Lynne, up on the board. Point to the ones that are pink." Still Lynne appears confused and Mary pleads with her, saying, "Lynne. . . Lynne. . . " Lynne now moves to the Punnet square and says, "You mean here?" And Art says, "Yes. Which ones are pink?" Lynne looks at the square for a minute, then correctly points to the two pink notations. Art says quite excitedly, "Good girl!! All right, which ones are the white ones? How many are there?" Lynne points to the white notations indicating there is one.

Art tells the students to "Check your papers." And then asks for number two. He asks all the students, "Is red dominant?" The class replies, "Yes." He then asks, "Is white dominant?" Half the class responds "No," and the oth half responds, "Yes." Several students raise their voices saying, "No, it's recessive." And the rest of the class accepts this response. Art continues, "Okay, the question now is, 'If you cross two roans together, what would the chances be of getting a red calf, a white calf, and a roan calf?' All right, who did that one?" Shelly raises her hand and he says, "All right, Shelly, get up there." And motions her to the front of the room.

Art asks, "All right, Shelly, how many red ones?" She replies, "One." Art says, "How many white ones?" Shelly says, "One." The instructor says, "How many roans?" Shelly replies, "Two."

A student asks, "What is a roan, anyway?" Art replies, "Now, as I explained to you before, a roan is an animal that has. . . the white cow with red spots. . . or, and I've seen some whites with red spots. Okay? So, now you have red, white and roan. Okay. Check your paper and we'll do the next one.

All right, who did number four?" Suzanne raises her hand and Art says, "Okay, Suzanne, why don't you get up there," and motions her to the front of the room. Shelly takes her seat and Suzanne moves to the front and stands by her work.

Art says, "All right, now, what kind of a cross with a red-headed bull and a roan cow. . . where's the red-headed cow. . . I mean the bull. . . ?" Suzanne points to the top of her chart and Art says, "On top. Okay. And, the roan then is on the bottom. Would any off-spring be white-haired?" The entire class responds, "No!" Art agrees, saying, "No, they would either be red or. . . roan." As he says this, several students respond in unison with him. He now tells Suzanne to sit down, then does a quick review with the students. He says, "As you can see there, she's got how many red ones?" The students respond "Two." He asks, "How many roans?" Students respond, "Two." Art says, "So, you've got a 50-50 split when you have a red one and a roan."

Art now calls on David, who did number five, and asks, "If you wanted to get all red animals, you'd have to cross what with what?" David replies, "Red with red." Art points to the board and says, "RR with RR, that means they're all red. There would be no possibility of getting anything else. All right, now, what would you do to get an all white one?" D

David replies, "Recessive." Art says, "That's right. Now remember, the dark colors are always dominant. All right, now, if I wanted an all roan population of cows, how would I get them?" David says, "One all red and one all white." Art repeats this, and adds, ". . . that would make all roans." He then looks at David and says, "Thank you, David, you did a good job."

Art now says, "Okay, let's do blood types. All right, Part C. How are we going to do blood types, now? Who did what?" Shelly raises her hand and Art says, "Thank you, Shelly. Now if your mother and father are O blood, type O blood, what do you think your chances are of being type O blood?" Shelly responds, "Ninety to one hundred percent." Art repeats this, "Ninety to one hundred percent. Because of the fact that. . . and I'm not going to get into that, but. . . but, her blood, if mom and dad are type O, hers will be type O."

Art thanks Shelly, then asks, "Who did number two?" Jane raises her hand and Art says, "And. . . here she comes, Jane mixed two people that had AB blood. All right, what's the chances, now, of getting AB blood?" The students look at their papers, and then several volunteer, "Fifty percent." Art now asks, "What are the chances of getting B blood?" Again, the students look at their papers, and Jane says, "Twenty-five percent." Art says, "Good girl. What's the percentage of getting A type blood?" Jane again responds, "Twenty-five percent." Art praises her, saying, "Good girl."

He now points to the chalkboard, saying, "You can see that on the board. You cross the A's, the AB's. . . Now. . . we are going to cross number three. . . "

The remaining two students are called individually to the front to explain their answers. Students are attentive and the teacher is loose in his interaction with them. When the problems have all been discussed, Art asks that papers be turned in, collecting them as they are passed up the aisles.

Review Questions (Day 9)

The first several minutes of today's class are taken up by announcements over the loud-speaker system and some administrative tasks by the teacher. When these are completed, Art begins class.

He writes the on the chalkboard in large capital letters, the word 'REVIEW' and underlines it. He turns facing the class, and says, "Okay, today we want to have a review for the test that will be tomorrow. I'm going to write down some [questions] that I feel are important throughout the chapter and stuff that we've covered with the crosses."

Art is briefly interrupted by another teacher who has entered the room. When she leaves he contineus, "For example. . ." and writes the word 'baldness' on the board, labels it Item #1, and places it directly under the word 'Review'. He concludes writing the word 'baldness', and says, ". . . baldness. I want to know if that's a sex-influenced trait or if it's a sex-linked trait. You tell me." He turns, facing the chalkboard and writes the word 'chromosome' directly under 'baldness' and labels it Item #2. While he is writing, he says, "A male chromosome." He

would walk. He asks, "Hey, how many are done with the eight questions?" Students shout out a variety of responses, most of them indicate that they are not done. He says, "Okay, hurry up!" One student shouts out, "What was Mendel?" And the instructor repeats this, saying "What was Mendel! You're looking at Mendel. Golly!" Although the students have been instructed to answer the eight questions on the board, the teacher occasionally interrupts them by discussing topics unrelated to the questions. Several minutes pass before Art says, "Okay, I'm going to give you guys about another five minutes. Our time is valuable."

After a few minutes, Art leaves the room. During his absence most students stop working on the questions and begin talking to one another. When Art returns the students immediately quiet down. He instructs the students to return to their regular seats and begins to review the eight questions with the students.

now writes 'Mendel' on the board and says, "Number 3, Mendel? Four is. . . uh. . . which trait is carried on the X chromosome?" and writes 'Item #4. Trait carried on X chromsome'.

Most students appear to be attending to what he is doing. A few students are taking notes, but most simply sit and listen to what he says.

Art returns to the board and again writes as he says, "All right, when you've got a trait where you've got pure red crossed with a pure white, you get a pure pink." He writes Item #5, 'Pure red X Pure white' and underneath that "Pure pink'. He continues, "All right, I want to know what kind of trait that is. Another good example would be when you possess two traits on the same gene. As he talks, he writes 'Item #6, possess two traits on same gene.' He turns, faces the class, and says, "Let's see, another prime example would be. . . what's a trait that's called a hidden trait?" Again he writes on the board 'Item #7, Hidden trait'. He continues, "Another one would be a trait that shows up even if only one gene is present." He turns around, moves closer to his lab station, and says, "Okay, so there's eight questions there. Grab a book. You'll have until about quarter to. We're going to need about 15 to 20 minutes for a review. So, grab your book and then I'll go over it with you." Students get their books off of the book shelves, and begin forming into groups. Art leaves the room for a few minutes.

When he returns he says, "I've got some pictures. I just went down to get some pictures we took when the [docent] was here the other day. Maybe some of you are in some good shots." Shelly asks, "What do you mean on question number two, Mendel?" Art responds, "Mendel, who was he? See, I want you to tell me who Mendel was. Who was the old Austrian dude that had the long beard?" Art seems to be reminded of something and says under his breath, "I wonder where that. . . It's gotta be here someplace. . . And he begins rummaging through his cupboards. A few minutes later, Art leaves the room again by the back door.

A minute later he re-enters the classroom from the back doorway wearing a brown monk's robe tied with a white rope belt and with a hood over his head. As he enters, he says, "Hey, what do you guys think?" All the students turn around as he walks towards the front of the room. They immediately moan and groan, saying, "Oh, come on, Mr. McDermitt." He responds, "Well, that's what Gregory looked like. I had to borrow my outfit from last year that I had. I stored it away and I coundn't find it, so I had to go to my skeleton closet. Gregory Mendel was an Austrian monk. Remember, I told you that." He pirouettes in the aisle for the students to get the full benefit of his costume. A student says, "Mendel wore glasses." Art replies, "Well, in those days they were monacles, and I couldn't find my monacle." Another student says, "Why are you dressed up like that?" He replies, "I found this outfit just for you guys and I'm going to wear it all period, and its' <u>not</u>! So, bear with me." He walks to the back of the room in a manner which depicts the way a monk

TEACHER 6: MATT JENKINS

by Dale Baker

Introduction

This is a brief portrait of Matt Jenkins' 7th grade life science class at Weatherby Junior High School. The school is located in a populous suburb of the capital city of a western state. The first set of observations were conducted in January, 1984, during which the teacher covered viruses and bacteria. The second set of observations were made in May, 1984, and the topic was birds and mammals.

Background and Viewpoints

Matt Jenkins was born, grew up, and received both his undergraduate and graduate training at a University in the state where he now teaches. He has undergraduate degrees in geography and mathematics. Upon graduation he was selected Outstanding Math Senior. He has a teaching credential in elementary and secondary education. Although he was enrolled in a Master's degree program in geography, he left the program before completing it.

Matt expressed dissatisfaction with the quality and nature of his education. He had planned to earn a Master's degree in math and science until he found out he had to take education courses. He said, "I've taken my last education course, all those courses were bad."

Matt does not have a degree in science, but he is knowledgable about chemistry; he worked in industry as a research assistant and holds two patents as a result of this work. Matt is also a computer buff and a reviewer for the American Mathematics Journal.

Matt never had any biology courses in college and is worried about the theory of evolution. A creationist himself, he does not "believe a lot of the stuff I have to teach as a biology teacher."

Matt entered teaching after a two year sailing trip around the world. He holds romantic views of teaching, especially about the nature of student-teacher interactions. He said,

> I think it is really important to be in tune with kids as individuals and to try and see things from their point of view. . . Not to put your ego on the line, but to see what is best for them and try to do it. I want kids to ask me why, why does it work that way? But I get very little of this. Science for me ends up being

a magic show and what I really want to do is foster discussion. I try to work on ideas during the week with open book using their notes and this turns out to be a good study time. What they're really learning is study skills. I didn't do this last term and I discovered that I wasn't getting through to them. Just covering the work is not enough. You have to teach them some other things like study skills.

Following his first year of teaching, Matt left the profession. He felt that the parents, students, and administration did not appreciate him and his efforts. At the end of the school year, he was depressed about his own performance and disillusioned with teaching. He's not sure he's the appropriate teacher for the students in his classroom. He felt he was always talking above them and had a very difficult time getting down to their level. He knew he needed more experience, yet he could not stand another year of teaching to gain the experience. He said, "I just don't think it's worth it."

Classroom Description

Matt's classroom has a chalkboard across the front of the room with closets underneath the chalkboard. In front of the chalkboard is a lab table (with a sink and gas jets) which the teacher uses as a desk. Across the rear and on the west side of the room is a lab shelf. Above the shelf is another chalkboard and a bulletin board. Half of the east wall consists of floor to ceiling closets with glass doors painted green and yellow. The remainder of the wall contains a hood and vent for dangerous chemical experiments and windows. Beneath the windows are bookcases. Student seats are arranged in seven rows of five deskchairs, which take up three quarters of the room. Behind the rows of deskchairs are three work stations which consist of two lab tables connected by a sink. There are two heavy metal doors in the rear right-hand corner of the classroom.

On the west wall, there is a chart of electromagnetic radiation with small print and many numbers and a small poster of the solar system. Across the back of the room is a map of the state, a taxonomy tree of animals, and yellow paper stars on a blue background forming the big dipper. The periodic chart of elements covers the back doors. Other walls are bare. Beneath the windows there are two living plants, a model of a generic flower and a model of a cell. A small computer and printer sit on the lab shelf in the rear of the room. There are a few books on the bookshelf about science and computers and a pile of maps of Finland, Thailand, and Japan - places he visited on his sailing trip.

Course Overview and Instructional Strategies

Matt uses the Holt Life Science text, Exploring Living Things. There are not enough books for each student to have their own, so work requiring the textbook occurs in the classroom. The teacher follows the book chapter by chapter. The students view video tapes that reinforce or extend chapter materials and do occasional lab exercises which relate to ideas in the chapter. Matt cites the state curriculum guidelines as a rationale for topic choices.

Matt's instructional strategies are built around the textbook. Students read a chapter, outline what they have read, and then answer the questions at the end of the chapter. Matt lectures in order to provide supplemental information not presented in the textbook. This information is outlined on the board and students copy it into notebooks. All the information that will be on the tests is contained in these study guides. He also uses study guides because there aren't enough books for students to take home and study. Video tapes are used to provide supplemental information or as a review for the chapter test. Labs are used occasionally to emphasize an idea. However, Matt thinks labs are not very effective because the students see them as a time to fool around. He says, "The students love to do labs but they don't make the connections that I would like them to make."

Matt likes to hold discussions with his students. These sessions consist of questions he asks the class about the lab, video tape, or their readings. Sometimes he tries to get the students to do more than repeat what they have seen or read, but they are not very good at higher order thinking. He tries to bring science into the students' lives during these discussions and uses many anecdotes from his own life. He gives tests at the end of the chapters and corrects them in class. He gives very little homework and students do not work on projects outside of class except for an occasional research report.

Excerpts from Classroom Observations
Topic One: Bacteria and Viruses

Table 1 summarizes how Matt taught bacteria and viruses. He spent eight days on this topic. During this time he used all of the instructional strategies previously described.

Introduction and Lecture (Day 1)

This is the first day back to school after the Christmas holidays. There is a feeling of good will in the classroom and the students look refreshed and ready to get down to work. Matt begins class by rearranging the class seating pattern.

Table 1. Duration of Classroom Activities During Bacteria and Viruses Unit (Teacher 6)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7
	Teacher Rearranges Seating	Roll Call	Roll Call	Roll Call	Roll Call	Roll Call	Roll Call
5 min.		Students Copy Bateria Shapes from Transparencies	Students View Videotape on Bacteria and Viruses	Students Correct Study Guide Questions	Laboratory: Students Observe and Record Characteristics of Bacteria Samples and Estimate the Number in Colony	Students View Videotape on Bacteria and Viruses for Unit Test	Students and Teacher Correct Unit Test
10 min.							
15 min.		Teacher Lectures on Aerobic & Anaerobic Bateria	Teacher Lectures and Students Take Notes on Bacteria and Viruses; Students Copy Nitrogen Cycle from Diagram			Students Study Notes for Unit Test	Teacher Records Grades
20 min.	Teacher Lectures and Students Take Notes on Bacteria and Viruses	Students Answer Questions in Study Guide		Teacher Lectures and Students Take Notes on Bacteria and Viruses		Students Take Unit Test	Students Complete Survey
25 min.							
30 min.					Students Review for Next Day's Test		
35 min.		Clean Up	Teacher Collects Bateria Samples on Petri Dishes				Teacher Lectures and Students Take Notes on Next Unit
40 min.		Review Study Guide Questions				Teacher Lectures and Students Take Notes on Fungus	
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Matt points to Sally and then to another chair. Sally's response is inaudible but her tone indicates reluctance. Matt says, "I have to move you every other day." A student suggests that all the students on the left side of the room should move to the right side of the room. Matt says, "I'm not going to do it that way." He continues, "Sandy, I want you here." Sandy moves as the teacher directs. Matt continues to silently move students into new seats by pointing to the student and then to the new seat. The students move cheerfully as they are used to doing this procedure having changed seating seating arrangements several times this semester.

The transition to classwork is abrupt. Students are told to copy an outline of the week's assignment from the board. This takes about five minutes. The teacher says, "Now I want you to take out a piece of paper." There is a bit of noise as students do this and Jerry gets up to sharpen his pencil. Matt continues,

> We are going to be doing a couple of mini lessons and I want you to know exactly what we're going to do so I'm going to outline it on the board so that you know exactly what we're going to do when. You're going to have a test and you're going to have a book assignment so that you know exactly what's to be done.

One student asks, "Does this go in the class notes?" and Matt answers, "Yes, yes, this goes in your class notes so that you'll know exactly what we're going to do when." He is writing as he speaks, "Copy this down." Students quietly copy the outline, and a student asks, "Is this going to be a whole week's unit?" Matt answers, "Yes" and continues to write. When he reaches the section on study guides, he says,

> We haven't done study guides before. The study guides are something you do as you read the chapter. You can answer the study guide and keep it in your notes and use that to study the chapter. This is going to be a short unit. Okay, that is your outline. Copy it and keep it in yor notebook and you can use it to study from.

Matt immediately launches into a lecture about viruses. The students have not yet read the chapter so this is new information. Some ideas from his lecture are written on the board and as he lectures and asks questions, students copy the information into their class notes.

Matt begins, "So now we'll start off with viruses. What is a virus? You have some association with viruses." There is a lot of calling out and it is not clear who is speaking or what they are saying. The teacher says, "A virus is a disease. It makes you sick. Are there any good viruses?" Various students respond, "Yes", simultaneously, and Matt continues,

> Just like good and bad people. We really don't know what viruses are. The one thing to remember about viruses is that they are so small that if you have a population of viruses the same population as the United States, they would fit easily, with room to spare, on the head of a pin. They are so small that you cannot see them with optical microscopes.

Shannon asks, "Is it virus or bacteria that makes us ill?" to which Matt replies,

> Viruses. There are some forms of cancer that are viruses. This is a picture or drawing of an electron microscope photograph. It looks like a mechanical device.

While he is speaking, Matt points to a very small picture in the textbook, and moves across the room. It appears that at least the back half of the class hasn't any idea of what Matt is referring to because they can't see and don't have a text of their own. Very few students are taking notes. Matt comments on the picture,

> It really looks like a Star Wars thing. Thank heaven they are small. Certain viruses only attack certain cells, and that's really how they classify viruses. First virus is a bacterial virus, and what a bacterial virus does--take note of this--bacterial virus invades bacteria.

This is the first time Matt has specifically told the students to take notes on his lecture.

He now moves to the chalkboard and writes 'virus type: bacterial viruses invade bacteria.' A student in the back of the room calls out, "Say that again." The teacher repeats, "A bacterial virus invades bacteria."

All of the students are quiet and are copying down in their notes the information Matt is writing on the chalkboard. He then writes 'plant viruses invade plants' and says, "Human and animal viruses" at which point he turns to the class and continues his lecture,

> Okay, now the human and animal viruses invade human and animal cells. Okay, if you get a plant virus it will not attack an animal cell. Let's talk about how, um, viruses invade a cell and figure out how that could be so, particularly with an animal cell not invading a plant cell. Animal viruses not invading a plant cell. Okay, first of all, are viruses alive?

Students call out answers of "Yes" and "No", and Matt continues,

> Kind of, sort of. Okay, we know the structure of living things, we know about cells, we know how cells organize into tissue. Now a virus is a sheet of protein. . .

Matt turns back to the board and writes, talking as he writes, "There are all kinds of different shapes and sizes of viruses but they are all very similar in structure. Virus is a sheet of protein surrounding. . ." He turns to the class and says, "Viruses receive the protein surrounding a DNA core." As his hand moves toward the sentence he has just written he tells the class, "They don't talk about cells of virus because (pointing) 'a virus has no cytoplasm and no nucleus.'" He continues,

> It doesn't have those structures we normally associate with living cells. But it does have the same materials that make up living cells; the same materials that make up living cells make up viruses, except that they don't have those structures, those living structures. When a virus is not in a living cell or hooked up to a living cell it will appear as dead as sand.

Shannon calls out, "Is sand dead?" Matt answers, "Well, sand probably isn't dead because it's never been alive. But it's as non living as sand."

The teacher moves to the chalkboard once more, points out what he has written, and says, "Virus is a sheet of protein surrounding a DNA core. A virus has no nucleus and no cytoplasm." The classroom is very quiet while students copy the information from the blackboard.

After the students have copied the information, Matt says, "Viruses cannot grow, reproduce, or use energy without a host cell. That is an important idea." He writes this on the board and repeats it as the students copy it down. Still at the board, he draws a picture of a cell and a virus. He points to the picture and says,

> In that picture I showed you--the electron microscope picture--it's not hard to imagine that the virus is made of metal. The virus attaches itself to the host cell like this whether the host is a plant or an animal. It then intrudes that cell, poking a hole through the cell wall or the cell membrane with a tube. See, now, this is interesting. . . Remember we talked about DNA and RNA. What is the special thing that DNA and RNA can do?

A student answers, "Reproduce." Matt continues,

> It can replicate or reproduce. Normally we associate reproduction with something like genes or chromosomes or genetic codes. Well, the virus doesn't have that material. It doesn't have those structures. Basically

this RNA formed a core and there's no cytoplasm or cell structure.

Matt continues in this manner, asking questions, presenting information in a lecture format, and highlighting the important points on the board. Students continue to copy the information on the board into their notebooks. From the lecture on viruses Matt continues to lecture on RNA and DNA replication, and the role of bacteria in fermentation and decomposition.

Using the Study Guide (Day 2)

Students have finished copying the shapes of bacteria from an overhead projected onto the front chalkboard. Matt begins, "I'm going to hand out the study guide. The first person in each row should grab the green Exploring Living Things book." The students do this in an orderly and quiet fashion. Matt continues, "Look at the outline and do the reading. Do the reading it tells you on the outline." Jack asks, "What page?" and Matt tells him to look at the outline. There are various comments made throughout the class, but the students soon settle down to work on their study guides.

Most of the students are on task at this point. Matt sits in the front of the room looking through a textbook while the students work on their study guides. He quietly answers questions that students have as they work on the assignment. After several minutes, he turns to the class and says, "Another five minutes." About half the class is finished. Those who have are talking to each other. The teacher warns students to do their own work, and asks, "Okay, how many are finished? Take another two minutes to finish them up and hand them in. Hurry! Okay, another minute. . ." Matt tells the students that time is up and they hand in their materials and quietly return the books to the shelves.

There is five minutes of class time remaining and Matt uses this time for classroom cleanup, although the room does not seem particularly dirty. He walks up and down the rows pointing to paper on the floor. The students are getting very noisy, and Matt tells them to quiet down. He adds,

> Okay, you won't be excused until it's cleaned up. Now the best thing to do to help you study is to use your notes. We will correct these tomorrow and then I'll hand them back and you can use these to study on. A lot of the answers to the test are on the study guide. Friday or Monday we'll begin a lab. Now the test is going to be different from any test we've had so far. It's just going to be one or two short answers. It's going to be. . . there's multiple choice, you have to match. Basically it's just vocabulary. You're going to have to match words with definitions. So that's basically it.

With a few minutes left in the period, Matt suddenly starts a review of the chapter they read for their study guide questions. He asks, "Now that you have read the chapter, what are some of the uses of bacteria? Okay, you need to take these notes." No one answers his question and he does not call on anyone. He writes on the chalkboard: "Some bacteria are used to flavor food, like pickles, yogurt, tea, and cocoa." At this point, a couple of students ask, "Don't you think you're overdoing it?" Matt replies, "Take these notes" and then reads what he has written on the board. The general student response is, "Ooh, yuck, disgusting" and another student comments on Matt's penmanship, telling him he is getting sloppy. Matt tells them, "Okay, it's getting noisy. Take your notes." Elizabeth calls out, "It says in the book that they eat the bad things." Matt replies, "The bacteria," and then, responding to a question inaudible to the observer, says, "It takes some materials that are organized as organic materials and reorganizes them as primary chemicals. It puts them back in the soil."

Jerry raises his hand several times during this discussion but is not recognized. He quits with a look of disgust on his face. Matt again monitors the cleanliness of the floor until the bell rings and the students leave.

Collecting Bacteria Samples (Day 3)

Today students collected bacteria samples. This activity lasted approximately seven minutes.

Matt begins, "I need some volunteers for a demonstration." Shannon, Eric, and Elizabeth rush to the front of the room. Without further explanation Matt tells Eric, "Cough or breathe over the dish, do some disgusting things." He then says to the class, "They're going to have a contest to see who grows the best bacteria." He indicates that Eric probably has really good bacteria, perhaps reinforcing the class' negative attitude toward Eric, a small, dirty, and sickly looking boy who is often absent and in trouble.

Matt asks the students to name some other places where they can get bacteria, and relates a story from another class that tried to grow bacteria using the bottom of a cat's paw. He adds, "You'd never pet another cat if you saw the kind of bacteria that grew." The teacher then walks over to Eric, wipes the petri dish across the sole of his shoe, goes back to his desk, covers the dish, and labels it. He then places the samples in the incubator in the back of the room, and announces to the class, "We need another sample, how about the door knob? Do you want to see how many bacteria are on the door knob?" He walks over to the door and rubs the petri dish on the door knowb; students cannot see what he is doing. He returns to the rear of the classroom and places this sample into the incubator. After the samples have been collected, Matt says, "Bacteria grows on the agar. It's a combination of sugar and gelatin."

At this point the students are getting restless. Matt tells them to settle down. He then begins to lecture on nitrogen fixing and how bacteria are able to fix nitrogen in the roots of plants. While he speaks, he turns on the overhead projector which shows the nitrogen cycle. The students are not paying attention to him; they are waiting for the bell to ring. Matt makes no attempt to get their attention or to quiet them down. When the bell rings the students leave the room.

The Class Corrects their Study Guides (Day 4)

As Matt passes back the study guides to the students, he announces, "We're going to correct these." Jerry asks, "Do we get our own?" And Matt replies, "No. Each blank is worth 25 points." He then proceeds to read the sentences on the study guide.

Shannon calls out, "Read the first three blanks again." Matt rereads them for her. As he reads each sentence, he stops when he comes to a blank and the whole class responds with the answer. One of the answers is "agar," which Matt pronounces correctly, adding, "I looked it up." Mickey raises his hand and calls out, "On the second side is it okay that plants can't use nitrogen like gas?" The teacher replies, "Yeah, that's okay" and continues to read sentences and answers.

When he finishes all the sentences, Matt announces, "Pass it back to the person it belongs to." The students return each other's papers with a minimum of fuss.

After the students get their own papers back, Matt calls out their names and they tell him the number of correct answers. He does not give any directions for this procedure as it is a well established practice. Twice during the recording of the grades the teacher makes comments--one positive and one negative--about the students' scores. At one point, when Eric announces he got only one answer correct, another student, Martha says, "Good boy, Eric got one." Matt makes no comment about Eric's score or the caustic remark. Martha adds, "There are 19 blanks, you said 25 possible points." The teacher tells her, "That's alright, we can work it out. Eric, I'm going to give you some points."

Observation Lab (Day 5)

In today's lab students observe bacteria on prepared petri dishes. Matt begins,

> Okay, this is a very simple lab. Why I'm doing this is to see how well you behave in the lab. I have two plans. Next week when we're on a different unit I've planned two different labs, and it just depends on your behavior. I don't mind whispering and very quiet

talking in the lab. I don't mind you whispering to your friends. It's just when it gets out of hand. If it gets out of hand then we can do things like draw things on the board, or take notes or have discussions or things like that. So I want you to be aware that I'm watching today to see how well it works.

The teacher then passes out the lab sheets and reads, "Okay, read with me. Number one: examine the plates and count the number of colonies in each." Matt walks to the back of the room, picks up a small dish, and says,

These are the plates. These are the small petri dishes I want you to examine. Okay, you can look on the back through the agar. Now I want you to count the colonies. Now some of the colonies have grown together; count them as two. You can see around the edges where they have grown together. But you can see where the colonies are, so count those. And I want you to observe the different petri dishes, okay? I want you to go around and see them all so you know exactly what we've grown. The number in each plate I want you to put in this box. The next one, you have to sketch what each petri dish looks like. What the colonies look like inside the petri dishes. You need to draw them in this area.

A student asks, "Where, under the box?" Matt answers,

Beside them, okay? All set? Then the word description. You will basically have three words on the word description. You'll choose one word from this column and you'll put that word in this row. (Matt points to all the spots on the lab sheet as he gives directions.) Okay, I don't want to go over this again. You pick one word from this column that best describes the form of the colonies you are observing. Some will be circular, some will be regular, and some will be irregular. Okay, then you pick a word out of the elevation row that best describes the culture you're observing.

Matt continues to read the directions on the lab sheet and then assigns students to lab tables. While he was giving the directions, most students were engaged in other activities. There is a lot of noise as students start the lab. Matt moves about from group to group monitoring the students, saying things such as, "Now, find the elevation." The class is very noisy, and students are asking, "What are we supposed to do?" Andy and Eric are sitting doing nothing and Shannon is wandering around the room.

After about 15 minutes, Matt says, "Okay, you should be beginning to finish up right away." He continues to go from station to station, checking work. Shannon is still wandering

around and Andy still has not done any lab work. Students spend five minutes to clean up. Most students mill about the room quietly, waiting for the next set of directions from the teacher.

End of Unit Test (Day 6)

As a review for the test the teacher shows a 10-minute movie about bacteria. When the movie ends, he says, "Take out your notes and study for two or three minutes." Most students do this, although a few are fooling around instead of studying, including Andy, who was absent every day of the unit except one and has no notes to study. Matt walks around the room monitoring the students and stands next to Paul, at which time Paul opens his book and begins to study. Matt notices that Andy is not studying and asks him, "Where is your study guide?" Andy responds that it is not finished, and the teacher sends him to the back of the room, saying, "Page 198. Finish your study guide."

The students continue to review their notes for the test. Matt now says, "Okay, close your books and put everything away. Clear the top of your desk and just write on this sheet." Matt then passes out the tests, and says,

> Now the first questions you will have to write on the back of the sheet. It's not multiple choice or anything, just a question. Write the answer on the back. Okay, the rest, from 2 to 8, is multiple choice and then there is Match Phrases and Words. The Phrases are written 1 to 10, the words are written A, B, C, D at the end of that. So, match the words and the phrases. Look at the phrases and turn the page over and there are the words. Okay? And there is an extra credit question. It's an essay. You can write that on the back if you want. I want to remind you that if I suspect you're cheating, I'll give you a zero.

Some students want to know why, and Matt responds, "It's much easier that way."

The students settle down and the teacher walks around the room, monitoring the students as they take the test. He says, "Don't spend too much time on any one question. If you can't get it right, just go on to the next one." The teacher answers several individual questions as students raise their hands. It is absolutely silent in the room and the students are all on task.

Matt tells them to bring their papers up to him when they are finished.

After allowing approximately 20 minutes for the test Matt collects the remaining tests. The students are a little

rambunctious and become noisy while he collects the tests. Matt warns them to settle down and be quiet.

Excerpts from Classroom Observations
Topic Two: Birds and Mammals

The second set of observations took place in May, 1984, two weeks before the school year ended.

Outlining Chapter 19 (Day 1)

Matt begins, "Okay, the first person in each row grab the books." As the students distribute the books, Matt tells them to turn to Chapter 19, page 360. There is a lot of noise as the students receive and open their books. Matt tells the class to settle down and he continues,

> Okay, now, this is the outline. I want you to do it. It's got to be very clear. I suggest you read the questions on the board to help you know what kinds of questions you're going to get on the test on this unit. Okay?

The teacher then proceedes to read the questions on the board:

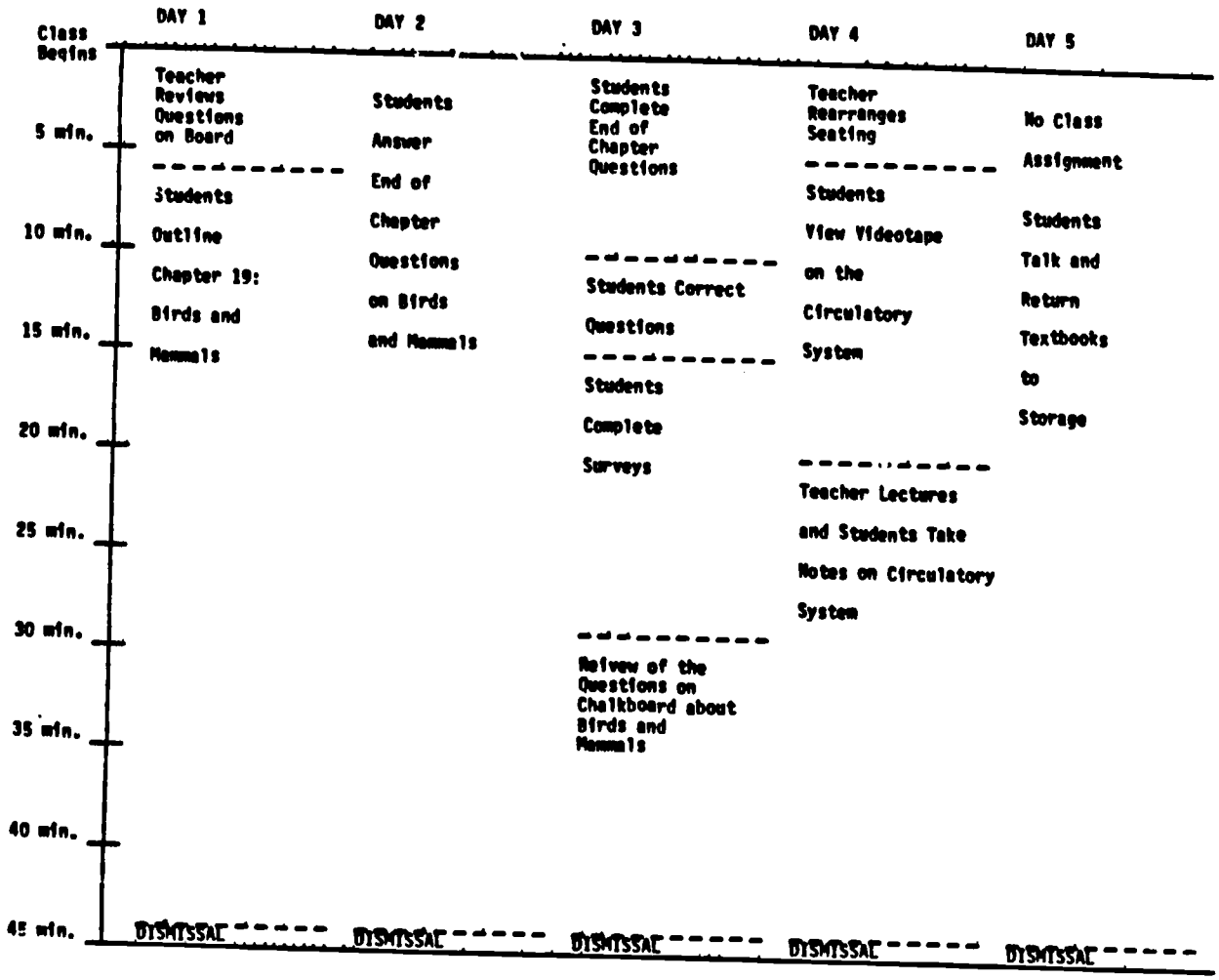
> Are birds endothermic or ectothermic? Name two important adaptions birds have acquired to help them fly. Why are most birds voracious eaters? Why is it necessary for birds to have such efficient circulatory systems? List three groups of mammals and give an example of each group. What is different in each group? What characteristics distinguish rodents?

Matt continues to read the rest of the questions on the board, discussing some of them with the students and answering questions. He finishes by telling the students to ". . . think about those questions as you're outlining this chapter." He tells the students that they can use their notes during the test, but not the books.

Matt leaves the room and quickly returns. Students begin to get papers and sharpen their pencils. They become noisy. Matt writes '3 1/2' on the board, which refers to the number of pages the students have to write in the report on birds and mammals.

Matt monitors the students as they work on their outline. He goes to all of the students who have questions and quietly answers them. The noise level gradually begins to increase as more and more students call out to the teacher rather than raise their hands.

Table 2. Duration of Classroom Activities During Birds and Mammals Unit (Teacher 6)



After 30 minutes Matt says, "Will the first person in each row put all the books away." Students pass their books to the front of the room, and the first person in each row puts the books back on the shelf. They then clear up their work, put their things away, and are dismissed.

Answering Questions at the End of Chapter 19 (Day 2)

After the bell rings, Matt asks the first person in each row to pass out the textbooks. Sandy goes to the front of the room and begins to take roll. The assignment has been written on the front board and reads: 'One page circulation due Friday. On a separate sheet do all questions on pages 378, 379 (after your outline).' There is a lot of moving of desks and a lot of talking while the books are being passed out and the roll is being taken. Matt says to the entire class, "Okay, quickly finish the outline you were working on. It's gotta be done today. I won't accept lateness, period." The students yell out, "What page is it on, Jenkins? What page is it on?" Matt answers, "360."

Students begin to work on their assignements. As they do, Matt circulates around the room talking to the students, answering their questions, and checking off assignments in his grade book. In addition to the teacher, the school counselor is also in the room. She is there to observe one student, but occasionally talks with and assists others.

A few minutes before the end of class, students are told to pass their books to the front and the first person in each row puts them back on the shelves.

Recitation on the Circulatory System (Day 4)

The students begin class today by viewing a film on the circulatory system. After the film ends, Matt begins by discussing what happens during circulation when a person exercises. He then tells the students that they can receive extra credit by doing an experiment at home. He wants them to take their heart rate during a rest state and then again after exercising.

> Here's what we do. Lie down for about ten minutes, take your heart rate. . . that is, uh, watch the clock. . . and count the number of pulses, then multiply the number of heart beats by four. . .

While he says this, he is does the mathematics on the board. Students are calling out and making noises, and Matt says, "Listen." As he multiplies on the board, he says,

> Take your resting heart rate. And then do some exercise, like run in place for as hard as you

can for about two minutes. You've got to run as hard as you can in place. Okay. Take that pulse rate again and then multiply that one by four. Now, what happened? Now you remember the bionic man and all that equipment and when he was running and various things to study. You know a graph, uh, this is the heart rate.

Matt now begins to draw a graph on the board. The left side is labelled: "Heart rate from 10 to 100" and on the lower part of the graph is labelled: "Time in Minutes." As he draws the graph, he shows the students what the graph would look like when you were resting and what it would look like when you were exercising. One student comments, "Mr. Jenkins, we did this in gym." Matt ignores this comment, and continues, with the graph, "One minute, two minutes, three minutes, four minutes, five minutes. Take you resting heart rate. If you're resting, then your heart rate will be around fifty or seventy." He draws this on the graph as he is speaking. "Your heart rate is stays around fifty-five, if you're really healthy. If you wait for one minute, rest for one minute, it will still be at fifty-five, for two minutes it will be at fifty-five. For three minutes, it will be at fifty-five. You know, I mean, if you continue resting, well, what happens when you start exercising?" The class as a group speaks out, "It will go up." And he says, "Yes, it will go up. Let's say we rest for the first minute. So, it's like that. Okay, put it 90 or so. We could move it down. Okay, you start exercising right here you start exercising." Several students say, "It goes up." Teacher responds, "Okay, it goes up. How far does it go up? It gradually goes up and then it goes up a little higher to the point at which we're at a steady state. . .but, we're exercising enough. . . those rates match. It sort of runs straight again. Let's go up a little higher, uh, say we exercise, now we stop. Do you have heart failure if you have high blood pressure?" The class laughs. "Okay, this is where health comes into this. What would happen if you're extremely healthy?" A student guesses, but it's inaudible. Matt continues, "Even if you're not healthy, it will go down. Go down what?" A student yells out, "Fast." Matt replies, "Yes, very fast. So in fact, check this all the time. . . and what sport seems to have the test circulatory system, the best cardio-vascular system; blood, lungs and all that." A student shouts, "Jumping." Teacher says, "No, there's one that's a little better." Another student yells, "Jogging."

TEACHER 7: DON SUTTER

by Ken Peterson

Introduction

This is a portrait of Don Sutter's 7th-grade life science class at Johnson Intermediate School, located in a small rural town in a mountain valley. The first set of observations occurred in early December, 1983, and encompassed 10 days on physical factors in the environment: water, soil, air, and energy. The second set of observations took place in April, 1984, and concerned 9 days on the topic of genetics and heredity.

Background and Viewpoints

Don is an energetic person, in school and out. His large family and church activities are important to him. He is quite comfortable in the small agricultural town and is acquainted with his students and their families out of school. He is connected with farm life and natural activities in the surrounding mountains.

His academic background is in life science from a private university in the West. He has taught life science for 15 years in his present location. His only other teaching assignment was math for 4 years. Don's principal describes him as one of the best junior high school science teachers in the state. Don seeks to improve his course with addition of new activities and updated topics. He expressed an interest in learning more about genetic engineering so that he could introduce it to his students. Although enrolled in inservice teaching workshops, he is not working toward a masters degree. His most useful workshops have been in geology, ideas for the gifted and talented, and reading in the content areas. While he has had some instruction in computers in education, he says "as of yet I have found very little use for the computer in my classroom setting."

According to Don, the students "know quite a bit because of their experience with nature. They camp, they are on farms, they have it around them all the time." He says that this experience enables development of their scientific knowledge because they have familiarity with the ideas he introduces in class. He sees no differences between boys and girls in his classes.

Don describes the main thrust of his life science class as an opportunity for students to better "understand their environment so that they can make decisions and enjoy the things around them more fully." He sees the value of science classes to be in increasing awareness so that people can enjoy and use the natural world. He estimates that 90% of his students attain these goals.

Classroom Description

Don's classroom is average in size. However, his facilities are unusual because he uses an empty adjacent classroom with 8 large lab tables for laboratory activities, and he has two preparation-storage rooms. This additional space enables a good number of materials to be used without a feeling of clutter and crowding. The classrooms are new and the main room is carpeted and comfortably furnished. There are six rows of desks in the classroom, each row with six individual armchair desks. The main room has no windows; the laboratory room has a glass door to the outside.

The main room has a large chalkboard at the front, flanked by bulletin boards. The bulletin boards are changed every few months, and feature pictures of outdoor scenes, pictures of animals, and statements of advice ("It is not bad to try and fail, it is bad not to try"). A long demonstration table, with sink and burner, is at the front of the room next to the teacher's desk (to the right from students' view). The right wall has a bulletin board with additional pictures of animals and outdoor scenes. The rear wall is carpeted and is bare of materials. The left wall has a clock, loudspeaker, bulletin boards, and laboratory sink-counterspace area. Students enter class from a hallway door at the right side rear. The exit to the lab room is in the rear at the right. The exit to the prep room is on the left side at the front. The room is well lit with flourescent lights. An unusual, and occasionally distracting, feature of the room is hall "elevator" music. Across the hall is a sometimes noisy social studies class.

There are reference books and old magazines in front of the demonstration table. The room is clean and uncluttered. Don reports that he is satisfied with the equipment and supplies available to him.

Course Overview and Instructional Strategies

Don builds his lessons around his verbal presentations and laboratory activities. Characteristically, he uses out of school examples and lab experiences in his verbal presentations. The textbook, Exploring Living Things published by Laidlaw Brothers, is definitely a minor resource. Students keep track of their activities with a folder or "journal" of notes and handouts which the students turn in for grades after each unit. Don also gives photocopied lab directions for lab notes and findings. A main goal is to learn vocabulary terms in each unit. Quizzes and tests are infrequently used; Don relies on a unit test each 3-4 weeks for objective grading and classroom participation for subjective assessment. Once in a while, he will bring in brief one page readings from upper level textbooks. Students complete

jective assessment. Once in a while, he will bring in brief one page readings from upper level textbooks. Students complete required reading in class, but take turns reading a paragraph to the class while the teacher comments on each passage. Homework is not used. Don often uses films to introduce topics.

Laboratory activities identified and adapted by the teacher, play a big part in course instruction. Most often the lab activity has a one- or two-page guide sheet for organization. The materials required for the lab are highlighted. Lab activities are designed to demonstrate a principle or a relationship. Don has one year-end problem solving lab activity which incorporates inquiry goals.

Excerpts from Classroom Observations
Topic One: Physical Factors in the Environment

Table 1 summarizes how Don taught the 11 days of Topic One. During this time he relied upon 8 recitation sessions usually 12-18 minutes in length, and 5 laboratory sessions, a bit longer in duration. He also included several demonstrations, brief seatwork assignments, and 3 audiovisual episodes. On day 10 students reviewed for the unit test with a recall game. The test was given on the last day of the unit. Illustrative examples of the instructional segments follow.

Recitation and Reading on Calories, Food Use, and Warm-bloodedness (Day 6)

Day 6 began with a laboratory exercise on determining the caloric content of several kinds of food: peanuts, marshmallows, and popcorn. After a three minute transition from the lab room to the main room, the teacher begins a typical 17 minute recitation and reading session. He directed students to open their textbooks and to read together a section on food materials. The students, while spirited, are compliant and cooperative. Don will use this session to develop the main points of his lesson. The students begin a bit noisily, but settle down as the reading continues. Don asks: "I'd like someone to read. This will be about some food materials, now, who would like to read?"

In Don's class students raise their hands to volunteer for reading. Kenny is selected this time and reads for just over a minute on the use of foods, that foods are more than just for enjoyment--they are a source of carbohydrates, fats, and sugars. During the reading students are quiet, attentive, and reading along. When Kenny finishes the teacher says to all:

> Okay, energy. We need energy for moving around, keeping your body temperature and moving around. Now, we talked about warm-blooded and cold-blooded animals. Fish don't have the ability to regulate their temper-

Table 1. Duration of Activities for Topic One (Teacher 7)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
5 min.	Correct Tests from Prior	Demonstrations of Air	Laboratory Instructions	Recitation on Temperature	Recitation: Caloric Content of Food and Animal Heat; Lab Preparation	Lab Instructions
10 min.	Unit	Pressure: Candles, Jar,	Laboratory: Boiling Point and	and Living Things		Laboratory: Caloric Content
15 min.	Record Scores	Balloons on	Freezing Point of	Transition to Lab		of Various
20 min.	Individual Reading	Scale, Air Pump,	Water	Laboratory:	Laboratory:	Foods
25 min.	Class Reads and	Collapsing Can,	Teacher Describes Lab;	Counting Fish	Caloric Content	Transition
30 min.	Talks About Physical	Card Under	Introduces Film	Gill Rates with	Of Various	Teacher
35 min.	Factors in Environment	Water	Film on Differences	Varied Temperature	Foods	Recitation on Calories,
40 min.	Individual Reading	Transition; Individual Reading	Between Warm-Blooded and	Data Analysis; Group Discussion	Transitions & Cleanup	Food Use, and Warm-blooded ness
45 min.	Demonstration: Air-burning Candle, water, and Jar DISMISSAL	DISMISSAL	Cold-Blooded Animals DISMISSAL	about Lab DISMISSAL	DISMISSAL	DISMISSAL

Table 1 (Continued). Duration of Activities for Topic One (Teacher 7)

	DAY 7	DAY 8	DAY 9	DAY 10	DAY 11
Class Begins	Opening Transition	Salt Water	Opening Transition	Opening Transition	Opening Transition
5 min.		Opening Transition		Rectiation: Water in the Ecosystem; Reading Passages	
10 min.	Recitation: Water in the Physical Environment	Recitation: Water in the Environment	Laboratory on Soil Composition		Unit Test
15 min.		Demonstration: Food Water Preparation, Questions for Videotape on Utah Water	Data Tabulating on Soil Composition		
20 min.		Videotape on Utah Water Supplies, Problems	Demonstration, Recitation on Soil Composition		
25 min.					
30 min.			Recitation: Soil Cycles, Soil Types	Game to Review Unit Vocabulary: Team Answers	
35 min.		Recitation: Utah Water Cycles			
40 min.	Videotape: the Shoreline and Ecosystem	Individual Seatwork: Water Cycle Questions			
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

ature like a warm-blooded animal does. Warm-blooded animals can save their temperature. Besides insulation, warm-blooded animals maintain their temperature with the food that it eats. Cells give off heat, they burn up food and they give off heat. They're like a log at home. The food goes in and it is digested and then sugar goes to the cells. Cells burn sugar like a furnace burns fuel and gives you heat from sugar.

Don goes to the board and writes down key words--the first one is carbohydrates. He begins a back and forth exchange with students based on the reading and data from the lab. "Now, carbohydrates are basically two kinds of food. What are they?" Two students answer, "Sugar and starch." Don continues, "Now, we tested two foods yesterday and today. They were basically sugar or starch. Which one was sugar?" Kenny answers, "Marshmallow." "A marshmallow. Which was basically starch?" Another student answers, "Popcorn." Don replies, "Yes, popcorn. Now, suppose. . . is there any starch in nuts?" Several students reply, "Yes, no." Don says, "Yes, there is some. Also other things. Is there oil in nuts?" Larry answers, "Yes." Don continues,

Ok, oil is a means of energy. It's also a source of energy. There's a slight amount of it in popcorn, not much at all. Popcorn is almost pure starch. Marshmallows are almost pure sugar. Now, which gave you the most calories?"

A student answers, "Marshmallow?" "Marshmallow, I mean, total calories?" Brian responds, "Peanuts." Don says, "The nuts. We can kind of see how the different calories are in foods. Ok, marshmallow and popcorn are about the same--about 150 per kernal. How about nuts? Anyone below 200?" Six students answer, "No." Don says,

Nuts are way up here, 300, maybe some of you got 400. That's because of the oil in nuts. It provides a lot more energy. What are some other things that have oil? How about butter, is it high in calories?

Three students reply, "Yes." "Ok, how about steak?" One student answers, "Protein." Don replies, "No, not protein, but fat. A lot of fat provides calories and fat is what makes the calories in a beefsteak. French fries are high in calories, too, if they're cooked in what?" "Oil," answers one student. Don continues, "Now, potatoes, which are not french fries, are they as fattening?" Three students reply, "No." Don says, "Let's go back. What do carbohydrates give you? What do they supply the body?" Two students answer, "Energy." "Do carbohydrates supply anything else," Don asks. Three students reply, "No." Don continues, "Do we need more than energy to live? Let's go on to read."

The teacher then selects Cheryl to read the next paragraph. When she finishes, Sheila volunteers to read. She reads quietly and less confidently. She stumbles over the words chemicals, phosphorus, and potassium, which Don gently corrects. Following this passage a similiar discussion ensues.

The teacher says, "Carbohydrates supply energy, what do proteins supply?" One student replies, "Teeth and bones." Don adds, "Ok, but, what for? Helen?" Helen, who did not raise her hand, replies, "Growth, reproduce, repair." Don says,

> Ok. Cells are constantly wearing out. You've got to replace them. For example, for an injury the body has to replace what's worn out. Without protein you cannot replace worn out parts. How long would a farmer be in business without taking care of his equipment? If he just put gas in?

Several students reply, "A day. A month." The teacher continues,

> Same way with you. If you just put energy into you body, like candy, soda pop, and carbohydrates, your body will be run down to a point where it doesn't function any longer. If you just keep going to 7-11 and eat candy bars, you can get along for a while, sure. But the system has got to get protein, that's what it needs. You've got to have protein for new cells and to build new parts. You're in a growth stage now. Ribosomes and other parts need new replacements. So, we have carbohydrates to provide energy and that's mostly oil, proteins, minerals, and vitamins.

Don stops here to write key words on the chalkboard. His pace is quick without being overrapid. This kind of presentation is quite typical in its references to student experience. In other discussions he includes locations in the community, local farm problems, and examples for people that students know from the community. He continues, "Minerals are needed for what purpose? Stephanie?" Stephanie gives no answer, and Don coaxes her, saying, "The very last part we read about." Brian answers, "Teeth and bones." Don says, "To build new parts. If you don't have minerals you can't build the new parts. What do vitamins do?" Ron replies, "Give minerals, like calcium." The teacher answers, "No. Another part of food." Another student adds, "You need these to be tough." "What do they do for the body," Don asks. Ron replies, "Keeps you so you don't get disease fast." The teacher responds,

> Ok, so you don't get diseases. They regulate the body functions. Your digestive juices don't flow properly, your glands wouldn't work properly if you didn't have vitamins. They regulate how other things are used. Do all types of foods give us the same amount of carbohydrates?

Four students reply, "No." Don continues,

> Ok, animals and plants use foods in a different manner. If you looked at this, oil is a very good storage package, there's lots of energy in oil. Now, starch is better than sugar. Sugar is the worst storage package. What do plants make in photosynthesis?

Two more students answer, "Sugar." Don says,

> Sugar, glucose. They use it where they change it into starch or oil. Once in awhile, sugar is stored. But, a plant can't store sugar very long. For example, an apple on a tree. That's a lot of sugar, but the apple spoils pretty soon. It's not good starage. It supplies good energy. But, take for example, a bean, a lima bean. It's mostly starch. Somehow, the plant takes water out of the sugar molecules to make starch. That starch is a much better storage place system. Starch is the most effective way to store energy for a long time. So, oil is fat. Animals store fat. They can't make starch. Too much sugar is put by an animal into oil or fat. Now, when we eat these things, our body must adjust, go back and make sugar. Sugar is the only type of molecule that can go into the cell, that's what digestion does. When you chew a soda cracker it starts off as starch, but it you don't swallow it and you've got a very perceptive tongue, you'll go from a starch flavor to a sweet flavor. Because digestive juices in the mouth change starch back into sugar. It flows into the bloodstream and cells burn sugar and keep you warm.

He's making a major link here with topics of warm-bloodness, energy, and the physical environment. He continues, "It's the same with bread. The digestion of starches starts then you chew the food. Oils take longer.

Jim asks, "Why do we worry about sugar diabetes so much? Is there too much sugar?" The teacher answers him, "Oh, sugar diabetes. Let me ask you this, let's relate this back. Have you heard of the statement 'empty calories?'" Jim says, "Yeah." Don asks him, "What's that?" and Jim replies, "Mostly full of calories and nothing else." Don adds,

> Food like sugar, candy, soda pop have just sugar and nothing else which is needed. Now, in sugar diabetics, yes, you need sugar, but other things too. You need protein. The problem with sugar diabetics is their digestive tract doesn't function properly. They can't keep a balance. There's too much insulin which can cause insulin shock. Or too little sugar to counterbalance. They have to regulate it with shots, pills, and diet. A person with slight sugar diabetes can regulate it by watching the sugar they take in.

The bell rings and the students jump up and start to talk. Don tells them, "Now just a minute! Chuck, sit down. From our lab be aware of various calorie amounts of these types of foods."

Laboratory Exercise on Fish Gill Activity (Day 4)

The period began with a recitation on the effects of environmental temperatures on living things and differences between warm- and cold-blooded animals. The presentation included references to a film on the topic viewed the previous day, and a prior lab on the freezing and boiling points of water. Don was careful to point out the effect of altitude on the findings.

Just before the lab activity, Don spends 7 minutes on background information and procedural directions for the activity. Before moving to the lab room he writes "Fish Lab" on the chalkboard and begins the description, "Let's go on. Fish Lab--we'll have fish in two different conditions. One fish will be in water that's 10 degrees Centigrade. Now, is that below or above freezing, Frank?" Frank says, "Above. You want us to write this down?" The teacher continues,

> The water won't be frozen. One fish will be in 10 degrees Centrigrade water; the other fish in 26 degree Centigrade. Twenty-six degrees Centigrade is about 78 degrees Fahrenheit, I think, I'll have to look it up. That's plenty warm.

Larry asks, "Aren't fish, can't they adjust to the water degree?" Don answers,

> Ok, we'll see that. Some of you will be looking at fish in warm water, some cold, then trade. After the fish becomes accustomed to the water for about 1-2 minutes, count the gill rate.

He writes steps on the board and asks, "How does a fish breathe? Tell me." Larry replies, "They open and close gills." Don adds,

> It's got to pass water over the gills. Sometimes it opens its mouth. It's got to get water through its mouth over its gills. The gill is slit right back here (referring to diagram on board). The water must go through this hole, through gills.

Ron asks, "Is that where lungs are?" and Don replies, "Fish don't have lungs, it uses gills." Ron asks, "Is it a fish lung?" The teacher answers,

> No, it's like a lung, it's a gill. Count the gill rate for one minute, then again for 2 more. You should have three separate counts, then take an average. (Don

writes the directions on the board). Chuck, how do you get the average?

Chuck doesn't respond. The teacher hints, "You have 3 counts, 1 minute, then 2, then 3." Ron shouts, "Put them all together." Brian says, "I don't know." And Sheila adds, "18, 23, 21, take the 21."

The teacher replies no to these guesses and asks Jeff for the answer. Jeff says, "Add together, divide by 3." Don agrees.

After instructing the students to pair off for the lab and answering some questions, Don tells them to go into the laboratory and sit down.

Students file into the lab room and form groups. Little between-group communication or socialization goes on until the end of the lab. The lab activity takes 20 minutes to complete. Students record their results on blank paper which they place in their journal notebooks. The lab is not to be graded, except as part of the unit assessment.

When students enter the room they find the materials already prepared and laid out for them. Each station contains two beakers and a thermometer. The students use the wall clock with a sweep second hand for timing. It takes 5 minutes for all the students to get their first fish, and the talk level increases until the lab becomes quite noisy. After five minutes of lab Don says, "You started out pretty good but your noise level is getting too high."

Don monitors the students by walking between the tables and looking over their shoulders. He speaks infrequently, usually making a procedural suggestion. Students have few questions of him, but talk to each other. One student holds the thermometer and counts, while the other watches the clock. Students have little difficulty doing the activity. The noise level is high.

Kenny asks "Where did the fish come from?" Don names a store downtown. Seven minutes into the lab he says "When you finish with what you've got, trade." He walks around the room without interrupting or initiating contact. He says to Sheila "Just sit down." Cheryl says to her partner "The sides are going in and out, in and out." The students begin to concentrate more on the activity as time goes on. Don says to one student "Notice the activity of the fish, too." He continues to monitor. At another table he says "Is that warm or cold water? Did you do it 3 times and average it?" About 12 minutes into the class several pairs are joining to socialize. Don stops at another table and says "OK, now, what is your average?" The student asks "What if there is a remainder?" Don replies, "If there's 2, take it up 1." At the end of the lab he gives instructions to clean up, make sure the papers are completed, and to return to the main room.

Laboratory-Based Discussion (Day 5)

The ensuing discussion is reported below as an illustration of Don's use of laboratory experiences in class.

Gill movement data for cold and warm water are listed on the chalkboard. There is an obvious difference between mean rates for the two conditions. Don begins,

> I'm not going to take the time to average these out, but you can see a big difference. The gill rate is a good indicator of the activity of fish. When you're active, the gill rate goes up. What happened to the activity that you observed?

One student responds, "Didn't move as much" and another "Wouldn't move at all." Don asks, "What about warm water?" Various students shout out, "Breathes faster", "Moves around more" and "Gills open and close faster." Don asks, "From this, what can you assume happens to cold-blooded animals when the temperature goes down?" One student responds "Stays in same spot" while another says "Body temperature goes down." Don asks, "Can a cold-blooded animal remain active during cold weather?" Students exclaim no and the teacher says,

> A cold-blooded animal has to slow down in cold weather. You remember the fish in the lake, they have to go to the bottom where the water is warmer. Each year in a lake there is what is called a turnover. That's where the water at the top goes to the bottom. When water is 4 degrees Celsius, it's heaviest and then it sinks to the bottom. The fish are not active. If any of you have gone ice fishing, you'll know what I mean. Do they fight a lot?

Kenny says, "No, ice fishing is not as much fun as in summer." Don agrees and says, "Yeah, the fish don't flop around like they do in the warm weather. They just have to slow down."

The bell rings, students jump up and start to leave. Don says quickly "Now, on the bottom of lab sheet, write what happens to cold-blooded animals in the cold."

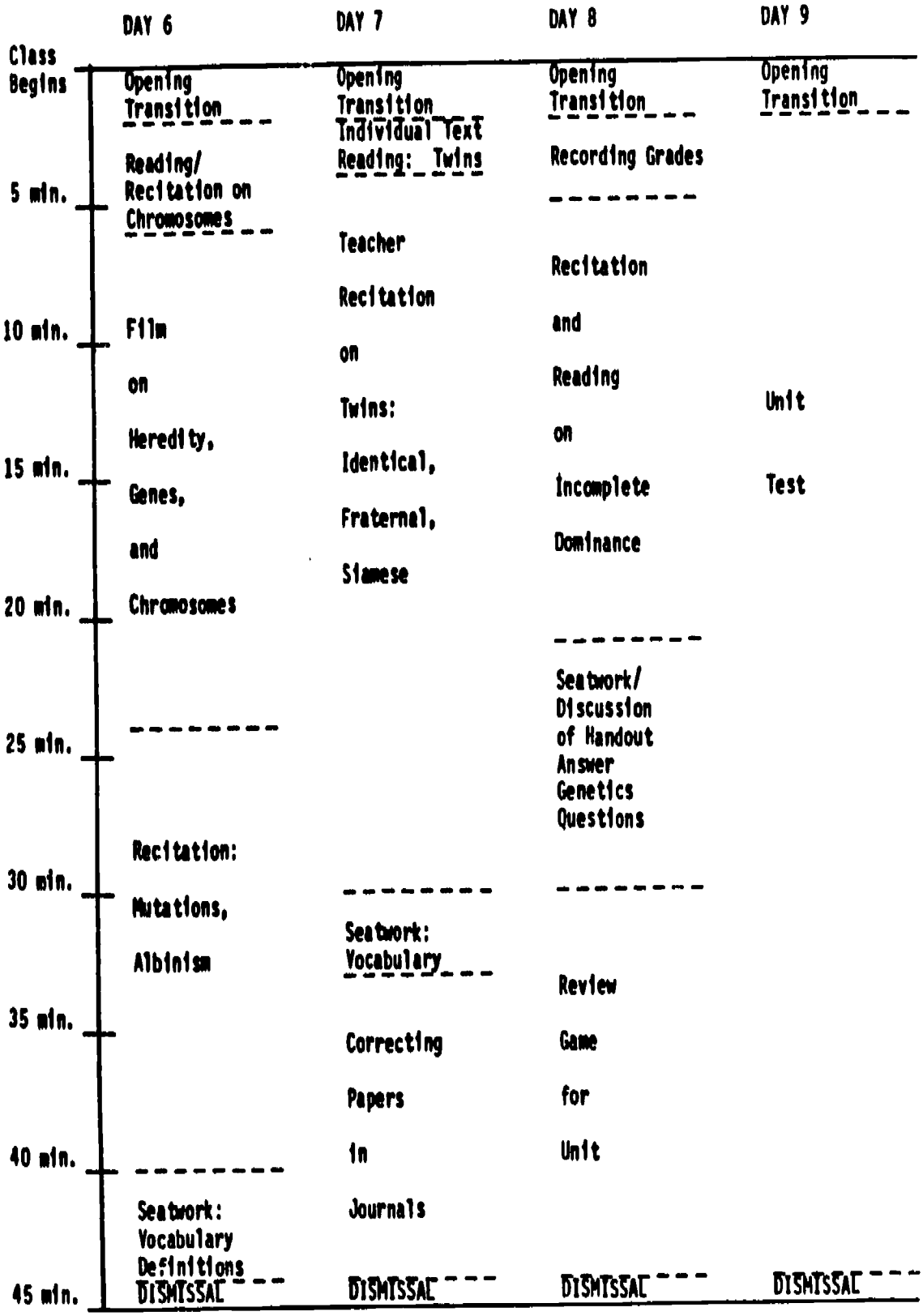
Excerpts from Classrooms Observations
Topic Two: Heredity and Genetics

The second topic observed comprised 9 days of instruction, as Table 2 summarizes. The unit focused on heredity and genetics, with most examples from human heredity. Instructional strategies followed the same patterns as in the first unit, except for a lessened reliance on hands-on laboratory activities. This reduction was due mainly to difficulties in setting up lab

Table 2. Duration of Activities for Topic Two (Teacher 7)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening
	Intro: Human Traits & Heredity Activity	Review Genetics Vocabulary	Text Reading on Cell Division	Lab Procedures: Microscopes & Cell Division	Transition
5 min.	Human Traits	Seatwork:			
	and Heredity:	Vocabulary	Teacher	1/2 Class does Seatwork (Genetics Vocabulary Puzzle) Other Half Views Mitosis Microscope Slides	Demonstration of Colorblindness Diagnosis Charts
10 min.	Family Tree	Recitation: Inherited vs. Acquired Traits	Recitation:		
	Identification		Heredity,		
	Group Activity	Illustration	Genes,		Recitation:
15 min.		(Demonstration)	and		Colorblindness
	Teacher Recitation on	of Dominant and	Chromosomes		and
20 min.	Human Trait Inheritence in	Recessive Genes		Groups Reverse:	Other
	Families			Seatwork/	Sex-linked
				Microscope	Hereditary
25 min.		Recitation:		Observations	Traits
	Seatwork on Inherited Traits	Dominance	Procedures for Seat Work		
30 min.	Teacher	and	Seatwork:		
	Recitation	Recessiveness		Recitation:	Combination:
	on	in Genetics	Stages of		Seatwork/
35 min.	Dominant and		Mitosis	Vocabulary	Recitation;
	Recessive	Seatwork/ Recitation	Recitation on	Concepts from	Worksheet on
40 min.	Human	Worktime: Dominance and	Cell Division	Seatwork:	Sex-linked
	Traits	Recessiveness	Seatwork: Stages of Cell Division	Chromosomes and Heredity	Heredity
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 2 (Continued). Duration of Activities for Topic Two (Teacher 7)



experiments for the topic and time constraints. Don emphasizes organism level biology in natural settings.

Teacher Recitation (Day 5)

The recitation begins 14 minutes into the class, following opening transitions and demonstration of a set of color blindness asessment charts. Don talks from the front of the room and uses the chalkboard. Students sit attentively, with some social talk.

> Now, I'd like to talk to you today a little bit about how color blindness is passed on as an inherited trait. Ok, now, remember in human beings we have how many chromosomes?

No students volunteer an answer so the teacher asks, "Gary, how many chromosomes?" Gary replies, "46." Don asks, "And they come in how many pairs?" Several students respond, "23." Don says,

> Actually, when you get counting, they come in 22 pairs, and an X and a Y. Now, the X and Y are not a matched pair. If we just draw a diagram (he uses the board), the Y, excuse me, the X is a great big long chromosome. The Y is a little short chromosome. Now, on this part of the X chromosome, we have genes that influence traits. Now, if a gene sits on this part of the chromosome, it can influence a trait even if it has only one recessive. Now, in the case of color blindness, color blindness is a recessive trait that is somewhere on the uncovered part of the X chromosome. Now, of course, a female is going to have two X chromosomes. And if color blindness is here as a recessive trait, she will usuallly have normal color vision. On this part of the X chromosome that is a dominant trait that will overrule this recessive trait. Remember that when you have a dominant and recessive, the dominant overrules the recessive. Right, Ron?

Ron has been talking. Most of the kids are paying attention. Several students have brief casual conversations. Ron answers unintelligibly.

> Now, in a male, he inherits the gene for color blindness on this chromosome. It's still a recessive trait. There's nothing here on this side to cover it up, and the male inherits the gene, or has the trait with only one gene. Now, in a normal population we find that about one out of every 100 X chromosomes carries the trait for color blindness. So a female has one out of 100 chances of having one chromosome with a color blindness gene. (He sketches mathematics on the board). Now, for a female to be color blind, she has to have two of them. So she's got one out of 100

chances of getting the second one. Now, if we have two chance events occuring at the same time, how do we find out what the chance is for both of them? (virtually no wait time). We times them, remember? Now, that means that a female chance, one chance out of 10,000 of being color blind, whereas a male has only got to have one of these genes, has one chance out of 100.

Don now begins to use local examples for his content. This is a typical provision of his instruction. The increased interest in student attention is noticeable.

Now, because of, and because of our population here and inbreeding in [this community], as I've looked at it, I think because of the X chromosomes in our valley, we have about one chance in 50. One in 50 X chromosomes that carries the gene for color blindness. We've got a much higher than normal percentage for color blindness in our area than the rest of the United States. Now, maybe our progenitors came into our valley, they happened to have just by chance, more color blind men and wives that carried color blindness moved into this valley. Now, you stop and think about it. This valley is pretty well related. Now aren't they? Yeah, you can't talk about anyone without talking about someone's relatives.

Several students shout, "Yeah. Too much!"

But because of this, we find that color blindness gene--now, I've made an assumption here--but as I've tested it, that we're higher than one in a hundred. But as we intermarry, someone from the valley marries someone from the valley. There are no better people to marry, so why not do it that way. But in doing so, we increase, or we keep the color blindness gene being put back in the population. So we have between one in 50 people for X chromosomes that are going to be for color blindness. Now, why are boys more often color blind? Because they can inherit it with one gene. Girls have to have two genes to be color blind. Now, do any of you know a color blind girl? A girl that's color blind. Now I've been testing the 7th grade; you know a girl that is?

Kenny says, "My grandmother. She can't see orange and green. She says, that it's weird."

And you're not color blind? If you're not color blind, there's half a chance that her rods have been damaged in some way. I would say that her color blindness is some other type. Because if your grandmother is color blind, well, there's half a chance as we look at it here. Let's put it on the chart (on the chalkboard). Here's the X chromosome; here's your grandmother's X

chromosome. Now if she's color blind, she'd have to have two of them that carried the gene. (He's working his way out of the first explanation which was not quite correct.) Now, she's going to give one of these to the mother. Here's your grandfather--not color blind, I assume. Ok, now, your mother would carry a gene for color blindness; your father or your grandfather would pass on one that is not. Now, what's the chance you'll be color blind? Now, here's your father. Your father's not color blind? (Kenny shakes his head no.) This is your mother. Now, in order for you to be, your father had two genes. He gives one, the Y. Now, your mother gives you an X chromosome. She can give you either this one or this one. And so you must have gotten this one if you are not color blind. Do you have brothers and sisters?

Kenny says, "Yeah." Don asks, "Any color blind, that you are aware of?" Kenny replies, "My first cousin in Star Valley." Don says, "Your uncle's son. Now, in that case then, your father would have given this X. Is your uncle color blind?" Kenny says, "I think so. There's certain colors he can't see." The teacher reflects,

Ok, now, if your grandmother gave--let's go back to the grandparent cross again. In order to be a boy, your grandfather had to give a Y and grandmother gave the X. And your uncle would probably be color blind, then. In fact, in this case, if it's inherited color blindness, all of the boys in your mother's family would be color blind, and then your cousin then married a woman here--we don't know if they're color blind or not. Ok, there's your father, your mother; now, a boy or a girl?

Kenny says, "A boy."

A boy cousin. Now your--doesn't have anything to do with his father; his wife may have been carrying a color blind gene. The father cannot pass on color blindness to the son; only the mother. Because the father gives his son a Y chromosome, the mother gives him an X.

Don continues the recitation for three more minutes. He talks about the possibilities for color blindness in Kenny's family. The topic then turns to hemophilia, a sex-linked human trait. The period concludes with a handout sheet on sex-linked heredity. Don continues an informal recitation during this time, and in doing so answers most of the questions.

Microscope Observations of Cell Division (Day 4)

Hands-on experiences are a major part of Don's instruction. He refers to them in his recitations and they are a significant part of the unit grading.

Day 4 began with an opening transition and then a 4 minute description of cell division in onion root tips--the content of today's lab. The lab will be done in two sections, with half the class in each while the other half completes a crossword puzzle worksheet on genetics vocabulary. Don set this up because he only has 4 microscope stations, not enough to accomodate the entire class. The early description showed stages of cell division which students are to look for, then sketch, in the lab room. Each section of the lab will take about 9 minutes to complete.

At 9:12 the lab is underway in the lab room and the students remaining in the regular room are filling in worksheets. In both rooms the students are talking socially as well as beginning to get the work done. The scene at the beginning is not one of disorder, but certainly not quiet, disciplined concentration. In the lab, students get together in same-sex groups of 2 or 3. To the students in the lab Don says "Ok, at least four kinds of cells in different stages of mitosis." Students are working at lab tables around the room. Half the talk is more social than content, but they are beginning to do some drawings and looking through the microscopes. Don moves around and adjusts one microscope to make sure it includes dividing cells in it. He shows one student a cell right next to the pointer. A student asks what to call the lab on the recording sheet. Don says, "Call it the mitosis lab." He moves around, giving students help and checking their work. He asks, "Who needs paper?" and gives instructions to draw the cell wall when they see it. He says to a number of individual students, "Ok, I want you to choose one cell." To another he says, "Draw 4 different ones. See that section there, that's one cell." To the whole class he says, "Ok, too many of you are trying to draw the whole picture."

It's 9:15. Don is still walking around the lab. He calls a number of students over to one microscope and says, "Ok, come and look at this one. Draw the cell just below the pointer." A student asks how many to draw, and Don responds "Four". Several of the students move over to the better samples and they begin to rotate. Don tells one that his drawing looks like a scribble with a line through it. At 9:16 Frank finishes, goes back to the regular room. Don says to all, "Ok one drawing from each microscope." Students continue to sketch, looking at each other's papers and still talking about outside topics. Jim says that these are hard to draw. Don says, "Not if you look closely. It's just that yours look like scribbles." He says to the entire class, "Remember, these are magnified 400 times just to see them that large." A student asks, "Do we draw one or four?" Another asks, "Is it mitosis or meiosis?"

At 9:20 another student asks, "Should we put 'onion microscope lab' on this?" In the regular room students are finishing the puzzle and helping each other. Don says "Ok, ready to change." A student says, "They all look the same to me." Most students have drawn 3 or 4 pictures.

The remainder of the period consists of switching groups and activities, and then a concluding recitation on the vocabulary words contained in the crossword puzzle.

TEACHER 8: BILL BRADFORD

by George St. Clair

Introduction

The following is a portrait of Bill Bradford and his 7th grade life science class at Larkin Intermediate School. The first topic, taught during a five day period in December 1983, was concerned with protozoa. The second topic, human digestion, was covered during an eight day period in April 1984.

Background and Viewpoints

Bill Bradford has been a full-time teacher for the past 13 years, starting out as a physical education teacher for four years at an urban intermediate school before coming to Larkin Intermediate School.

He completed both his undergraduate and graduate training in physical education (with a minor in life science) at a western state university, earning his Master's Degree in 1967. After fulfilling requirements for the general secondary teaching certificate, Bill taught physical education full time for eight years. Four years ago Bill was asked to teach life science part time when a science teacher at Larkin Intermediate was laid off because of a decline in the school's enrollment. Teaching science was new to Bill and he recalls attending an in-service conference organized by the county office of education for teachers who were being reassigned to new subject areas. He says that this inservice gave him "some good ideas." He started teaching life science full time and now he teaches four periods of life science and two periods of PE. In addition, Bill spends at least three days each week after school coaching cross country and track and field. Bill is an avid distance runner and has competed regularly in many races.

Bill believes that teaching PE demands much more organizational ability than does teaching an academic subject like science. "You can't sit down in one place, your students are all spread out, and if you're going to be teaching a skill--like passing a football, you need to be able to get the kids into positions where they can practice throwing a football, where you can watch them throw the football. . ." Another difference between PE and science is that science has more paperwork to correct.

Bill likes teaching the systems of the human body since "that's part of my background. I've taken a lot of physiology classes because of my PE major. I'm into physical fitness too, so I like teaching all those kinds of [things since] they're related to health."

In addition to the usual topics that are covered, Bill likes to have each of his science classes write up at least one long-term science project each term. During my observation of the first topic on protozoa, Bill introduced a "plant project." Bill explained that for this project, "they do an experiment with plants, they decide what to do and they do it here in class. They research it and watch it grow, make measurements, they use the scientific method when they do this. . . measure it, make observations."

Bill describes the expectations he holds for his science students in this way:

> Speaking very generally, I'd like them [the students] to know some of the key points of each unit that we go into. For example, let's take flowering plants. I want them to know what the purpose of the flower is and I want them to know how, in nature, a flower or a new plant would grow. What would be the steps to make that happen? Let's take the digestive system. I'd like them to know how the digestive system works [and] what each organ in that system does. They don't have to tell me in a very technical fashion, but they should know what the purposes of the digestive system are. That kind of thing.

Bill attaches special importance in his teaching to inculcating an appreciation for life science, for plants and animals, and for the fact that they all live together and are interdependent. He adds, "When I'm talking about the systems of man, I emphasize that one of the key things we're learning is about ourselves, and if you're going to take care of yourself you need to know how you work. I emphasize that quite a bit and I want them to know that."

In questioning students, Bill says that he tries to encourage deductive reasoning. "I might say, well, how do you think this flower became pollinated, or something like that. So they have to do a little bit of thinking about what goes on. . . a little deduction of some facts that they know Maybe it involves a little higher thinking than just shooting out a fact."

In addition, Bill says that he tries to encourage good note-taking and listening skills among his students. "I encourage them all to be good students, be responsible, be organized. Bill doesn't assign much homework but when he does he expects it to be done.

Classroom Description

Bill says that his classroom is an ideal set-up for teaching science. It has ample sinks and workspace, gas jets, aquaria and terreria, 15 compound microscopes, and a large prep room packed with equipment and supplies. The large and windowless classroom (approximately 45' x 36') is wider in the rear than it is in the front and has plenty of open floorspace. There are five-foot long sinks (with covers) along the rear wall for lab work. The students sit in groups of three around nine tables arranged in neat rows of three each.

Separating Bill's classroom from the teacher next door is an easily accessible anteroom having sinks and a workbench. It is used when additional space is required for lab work or for students to sit while taking make-up tests.

Above and below the lab bench at the rear of the room are cupboards filled with preserved animal specimens, some student-collected and others commercially bought. Commerically available plastic models of the human heart, ear, hip joint, brain, fetal development, and of mitosis are also found. A collection of color posters line the outside of these cupboards showing the human heart, the human hand, the human musculature, a nutrition poster, and photographs depicting typical freshwater organisms.

A unique feature of the classroom is the six aquaria and two terreria built into one wall of the classroom. Students and others have access to these tanks only through a small adjoining workroom.

In front of the room at the side are two mobile lab benches which Bill uses to give demonstrations and to place materials needed by students when they do their lab work. Next to the chalkboard and behind the teacher's desk is a bulletin board announcing Homeroom News, various time schedules, the first quarter honor roll, a couple of local newspaper science articles and three lists of school-wide rules on general deportment, speaking and listening, and written expression.

Next to the teacher's desk is a door leading to a well-stocked science prep room shared by both the physical and life science teachers. The large room is filled with a variety of equipment and supplies including: a small oven, refrigerator, sink, chemicals, dissecting trays, glassware, textbooks, zoological charts and posters, plastic buckets containing recent orders of preserved leopard frogs and perch (fish) for dissection, and an assortment of audio-visual materials including slides and filmstrips.

Bill's knowledge of--and enthusiasm for--sports of all kinds permeates his science lessons and is reflected in the posters of athletes and olympic emblems located throughout the room.

Course Overview and Instructional Strategies

The broad units taught this year followed a familiar sequence: (1) introduction to science, (2) the cell, (3) overview of the plant kingdom, (4) plant physiology, (5) overview of the animal kingdom, (6) human body systems, and (7) family life education.

Bill uses a textbook published by Silver Burdett: Life Science (Richardson, Harris, & Sparks, 1982). On occasion, Bill uses the old textbook to supplement information the new text lacks. Primarily he relies on visual material he has collected over the years and has organized in file folders in his desk. Most of these files contain overhead transparencies showing examples of various organisms that may be discussed in lectures. Bill also uses commercial color slides and filmstrips from the school's media center, and an occasional movie from the county film library.

Bill relies quite heavily on the science textbook for the content of his lessons, but expands upon these somewhat by using materials he has collected or inherited from the previous science teacher. A wealth of audio-visual resources are also available to him through the school's well equipped media center.

Following a similar routine in teaching all topics, Bill will usually spend one period introducing a topic, combining both lecture and notes on the chalkboard. He may call upon individual students to read excerpts from the relevant chapter in the textbook and devote some class time to discussion of any new vocabulary words, usually listing them on the chalkboard. The ten or so new words may be assigned for homework or he may allow students to use classtime to find the correct definitions in their textbooks and copy these into their notebooks. Lectures may be punctuated by the use of overhead transparencies showing notes, illustrations of organisms, or with an appropriate filmstrip or slide(s). Lecture and notes are followed by distribution of an appropriate lab worksheet having "title," "purpose," and "procedure" sections, a section for recording observations under "results," and several spaces for short-answer questions under the heading "conclusions." Selected students are called upon to read aloud the purpose and procedure sections and after a brief discussion and clarification of the procedure by Bill, the class breaks up into groups (usually by table) to complete the lab activity and record their observations and results. Finally, students answer 2-4 short-answer questions in a "conclusions" section and typically hand in their worksheets at the end of the period, though occasionally a lab may require more than one day to complete. This cycle of events may be repeated several times during the course of a single topic, as was the case with each of the two topics observed.

Bill evaluates students' work by grading tests, lab worksheets, long term project reports, notebooks, and homework assignments. A multiple choice test consisting of 20 questions follows each topic covered (approximately one test every two weeks). The names and scores of those students gaining the highest marks are often announced when the tests are returned. Notebooks are checked at the end of each term for completeness and vocabulary, marks being deducted only when something such as a vocabulary list is missing. Students are expected to copy everything the teacher writes on the board into their notebooks.

Excerpts from Classroom Observations
Topic One: Protozoa

Table 1 summarizes how Bill taught the topic Protozoa. Bill found it necessary to supplement the primary textbook treatment of this topic with material from the previous ('more difficult') textbook and with commercial overhead transparencies and slides showing representative protozoans.

Introduction to Protozoa: Lecture & Notetaking (Day 1)

Bill usually begins a new topic with a short introduction:

> Alright, today we're going to start a new unit. We are going to leave the plant kingdom. We've been with the plant kingdom for about eight weeks. We started out studying very simple kinds of plants. Remember we said that many plants are considered so simple that many scientists don't consider them to be plants, but they are more like plants than anything else, and we call those organsims 'protists'. Then we went on to study moss, we studied ferns, we studied conifers, and then we went on to the flowering plants. And when we studied the flowering plants, we went into them in detail. . . We studied all parts of flowering plants--stems, roots, leaves. We went into quite a bit of detail. We are going to do the same thing now for the animal kingdom. We're going to start out with the very simplest of animals, and then we're going to work our way up to the more complex animals, until finally we will study the mammals, which of course includes the study of ourselves. We are going to study ourselves in detail also. We are going to look at different systems that make us work--in detail. For example, the digestive system, the respiratory system and those kinds of things. Okay? So we're going to begin today by studying an interesting type of organism which we will call the protozoa.

Bill proceeds to print the word "Protozoa" on the chalkboard and continues

Table 1. Duration of Activities for Topic One (Teacher 8)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
	Students Monitor	Return Photosynth. Test; Students	Students Monitor	Announcements	Students Monitor
5 min.	Ongoing Plant	Monitor Projects	Plant Projects	Return Protozoa Worksheet	Plant Project
	Projects	Review Photosynthesis	Seatwork:	Hand Out Lab Exercise	Multiple-
	Teacher	Test	Students	Review	Choice
10 min.	Recitation	Review Extra Credit	Complete	Procedures for	Test on
	Introducing	Procedures	Protozoa	Lab Exercise on	Protozoa
15 min.	Protozoa;		Worksheet	Protozoa	Students
	Filmstrip	Teacher	Working	Students	Talk About
	Presentation	Recitation	Individually	Begin	Protozoan Lab
20 min.	on	On	Using	Lab Exercise:	Students
	Protozoa	Characteristics	Supplementary	Observation	Finish
25 min.		of Protozoan	Textbook	of	Lab Exercise
		Classes	Students Read Answers From Protozoa Work-	Protozoa	on Observation
30 min.			sheet & Answer Teacher Ques-	in	of Protozoa
			tions Orally	Pondwater	Students Turn In Labsheets
35 min.			Oral		Students
	Seatwork: Protozoa Vocabulary	Seatwork: Filling in Protozoa	(Inter-table)	Clean-Up	Complete
40 min.	Using Textbooks	Worksheet Using Supplementary	Protozoa	and	FWL Survey
		Text	Quiz-Contest	Announcements	
43 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Protozoa actually means 'first animals.' Okay, now the protozoans are organisms that are only one-celled, okay, and these protozoa are like the first kinds of organisms we studied--the plants. They're not exactly animals, but they're more like animals than anything else. Many scientists call them animal-like protists, and it may be that these single-celled organisms evolved after many thousands and thousands of years into more and more complex animals. We'll talk about evolution some other time. There are some very interesting things to know about evolution. That'll be another topic for our discussion later on. Okay, now let's take a look and talk about the single-celled organisms for a little bit. First of all, the interesting thing about it is that they are only one-celled, and within that one cell they can do everything that they need in order to keep themselves alive. They can breathe, they can eat food and digest it, use it for energy, they can get rid of waste products, and they can reproduce. So within that one cell they can do everything in order to stay alive, and that's important, because when you look at your own selves and your own body.

He pauses to ask no one in particular, "How many cells do you have in your own body?" Cindy, who is sitting at a front desk, shouts out "trillions."

Trillions, right. You've got trillions of cells in your body, and each one of those cells works like a protozoa. It can maintain itself, it breathes--now of course it doesn't have its own lungs--but it takes in oxygen from your blood, it takes in food molecules--glucose, proteins, things like that--and uses that to stay alive. It gets rid of waste products through the cell membrane and when necessary, it divides in two as a way of reproduction. Okay? So the protozoan is in many ways like the cells in your body, okay? So that makes the protozoans interesting. We're going to study protozoans for the next three days, and hopefully on Monday we're going to get a chance to look at some protozoans under the microscope.

Moving to the rear of the classroom, Bill points to a tub into which he has added samples of pond water several students have brought to school for extra credit. He explains that he has added crushed hardboiled egg yolk to the muddy water in order to provide food for bacteria to grow, which in turn will provide food for protozoans "to have more food to eat, and pretty soon they are going to multiply and we'll be able to see them, okay?"

Kathy and Diane, sitting at a rear table with apparent impunity, are distracting one another and have been giggling almost continuously during Bill's explanation. Bill moves once

again to the chalkboard. Machine gun-like questioning about where students 'think' protozoans live elicits equally rapid-fire responses:

Student 1: "Water."
Teacher: "Water. Okay. What kinds of water?"
Student 2: "Muddy water."
Teacher: "Alright, muddy water."
Student 3: "Salt water?"
Teacher: "Okay. Good. Ocean water. Okay, so they live in freshwater and ocean water. Okay, where else would you find them?" After a short pause lasting a second or two, "Where else would you find protozoans?"
Student 2: "Swamps?"
Teacher: "Okay, what is a swamp? What does it have a lot of in it?"
Student 1: "Mud."
Teacher: "Okay. Good. So we'll find a lot of protozoans in mud."
Student 4: "Moss."
Teacher: "Excellent. Moss. How did you know that? Moss has a lot of moisture, so you're going to find a lot of protozoans wherever you have a lot of moisture, because that's their environment. They have to have water to survive, okay? They need water. Okay, so we're going to find them in those kinds of environments. There's another kind of environment that's very distinctive where you're going to find protozoans."

A three or four second silence, then Bill asks, "Is there anyone who would care to take a guess at that? One more place that you're going to find protozoans." A couple more seconds pass before a student answers, "Inside us." Bill responds, "Very good, Ron. Okay, inside us. Protozoans are sometimes parasites inside of us or in other animals."

Bill proceeds to explain that a parasite is an organism that lives off another living organism. At 11:27 Bill asks, "How many have heard of the disease malaria?" About three quarters of the students raise their hands. He continues:

> Okay now the disease malaria is caused by a protozoan. Now many people think it's caused by a mosquito. Well, that's not true. It's spread by mosquitoes. Now I'll show you quickly how that happens. Let's say, for example, David here is in the tropics.

The teacher points to David who is sitting directly in front of him. Making a motion like a flying mosquito with his finger, he "lands" on David's shoulder and continues.

. . .and he's taking a little siesta in his little hut, and along comes a mosquito and he (David) has malaria already. That's why David is sleeping. He's not doing very well. And a little mosquito comes along and takes a bite. He wants to take some blood out of him, so he sticks his little proboscis--as they call it--into his arm, takes out a little blood. He's taking out a little protozoan that is causing malaria. It's in the blood. Then that little mosquito leaves that little house that David's staying in and flies into another house. . .

Bill's finger "flies" like a mosquito from David's shoulder to Jim who is sitting at the next table, "landing" on his arm.

". . . and the mosquito comes over here and takes a little sample of Jim's blood. Then that little mosquito maybe leaves that house and flies into another house. Now when that little mosquito takes that little sample of blood, he's going to--not intentionally, but just by the process of drawing my blood--he's going to put that little protozoan into Jim's blood supply, and then that little protozoan is going to be able to feed off Jim, multiply, and make him sick.

Begin Protozoan Worksheet (Day 2)

The time is 11:48 and Bill tells the class that they will only have enough time to start work on their protozoa worksheet but will finish it tomorrow. The worksheet has a grid on it with the headings, "ciliates," "flagellates," "pseudopods," and "sporozoa" at the top of each column. Under each column students are to write brief descriptions of (1) the type of movement for each category; (2) the method of capturing food; (3) their major distinguishing characteristics; and (4) their mode of reproduction.

Bill directs the students' attention to the worksheet in front of them.

Alright, let's look at the chart. I'm going to do one with you so you'll know exactly what to do with this chart. Let's look down at the bottom, sporozoa. Now I'd prefer you to do this in pencil so that when we go over it you can make changes--if you're wrong or if you need to do some other things with it. Alright, sporozoa. Now I told you that some protozoa, like plasmodium, are carried from one organism to another by the mosquito, so what kind of movement would you put down there for sporozoa? What do you think, Ron?

Ron replies, "Insects."

"Well, how does it move itself?" asks Bill.

"It doesn't," says Ron.

"It doesn't," agrees Bill. "It has no means of locomotion, no means of movement, okay? So that would be your answer for that particular box."

Bill continues down the column, leading the students to the answers expected. Finally, he says, "Now I mentioned to you that this is going to take a little investigation on your part. Some of the answers might be in your notes; some of them might be in your head; but for sure the answers are in this book," holding up a copy of one of the supplementary textbook previously used in life science classes at Larkin Intermediate (Life: A Biological Science, published by Harcourt, Brace & Jovanovich). He continues:

> On pages 75 to 78 we have a description of paramecium which you can use for your chart as a ciliate, and on pages 280 to 286 it will explain to you, or give you, some ideas on the rest of the organisms on the chart. Although we're short of time, we'll still work on it today. I'll be here to help you, and we're going to have to work on it definitely the first half of class tomorrow.

At 11:53 the students are allowed to begin their seatwork. One student from each table goes to the side mobile lab bench to pick up sufficient copies of the supplementary textbook. Several students appear to be having difficulty in locating information in the textbook they need in order to fill in their charts. Cindy tells the teacher that she can't find enough in the text on the movement of ciliates to answer the question. Bill tells her that she'll find more information in another section of the text. Ron asks whether the worksheet is to be done for homework and Bill explains that it can't be for homework because he won't have the [supplementary] textbook to take home with him to work from. Bill allows rather loud talking among students while they work as he moves from table to table observing progress and answering questions. At one point Bill interrupts the class to say, "Some of you are looking on page 280 for the descriptions of the ciliates, but you can get a better understanding of it on page 75 to 78." Bill then moves to a table in the rear of the room and says, "No, I want to know how does the paramecium move? Does it use feet, arms, legs? How does it move? What does it use? Does it have a tail?" The students respond with a no. Then Bill says, "Okay, listen up. We're out of time. I want one person to take the books back; one person from each table and then sit down. No one leaves until all the books are piled away neatly."

Protozoan Worksheet and Review and Protozoa Quiz-Contest (Day 3)

The instructions Bill gives to the class today are to continue working on the protozoan worksheets they started yesterday

using the supplementary textbooks as their primary resource material. They will then go over their answers together in class and then he will collect them. He explains that the protozoa quiz-contest will take up the remaining 10-15 minutes of class time. They are told that if they finish their worksheets early they may study for the quiz-contest.

Several students have difficulty in certain sections of their protozoa worksheets. On more than one occasion, Bill is heard to advise students to look in their books for their answers. Diane, frustrated and apparently echoing the sentiments of many of her classmates, says in a lowered voice, "This book doesn't have anything that's good." Bill shows his own frustration at the continuous stream of questions and is in constant demand. Finally he tells the class to put down their pencils and pens, saying,

> Okay, one of the things that is happening with this particular class is that alot of you are not making an effort to investigate. Now I could easily give you all the answers, but the idea is for you to read the material, and in turn, answer them yourself and you'll learn better that way. Some of you are really giving up almost. You know, you look up something-- say 'flagellates'-- and you say to yourself, "Where is the answer? Mr. Bradford, will you come down here and tell me what the answer is? You've got to get some of these things yourselves.

"Okay, we'll start with number one on the chart. Clair... the ciliates... describe the type of movement." Clair answers, "They beat back and forth." Joe responds, "Okay... how do they move through the...?" Before he can finish, Clair says, "They beat their cilia." Bill says, "Okay, that's how they move, by beating their cilia. That is correct. That should be on your chart-- 'by moving cilia'. And how would you describe the way they move. Sarah?" Sarah answers, "Glide?" Bill says, "Glide, okay. Because of the way they move their hairlike structures." Bill then asks Kathy how they get their food. Kathy responds. "They move back and forth until they happen upon some bacteria." Bill, not satisfied, then says, "And once they happen upon bacteria, what do they do? That's the part we want to know." Kathy interrupts and continues, "Well, once they hit something they move back." Diane has her hand raised and Bill calls on her, saying, "Diane, can you help?" Her answer is, "They back up a bit and when they hit something they move in the other direction, that's what the book says." Bill, apparently still unhappy with that answer calls on Sarah who has been anxious to answer the question. "They bump against some food, push it into their mouth." Then Bill says, "Okay, how do they get it into their mouth, Eric?" Eric says, "They sweep it in." "And what do they sweep it in with," asks Bill. Eric is unable to answer the question but Ron gives the correct answer which is cilia. Bill continues, "Okay, their cilia. Okay, so they sweep it into their mouth, or their oral groove by the action of their cilia. Paula,

what are the major characteristics of all ciliates?" "Paramecium?" offers Paula. "No," says Bill, "That's a type of ciliate." Paula tries again, "It has hairlike structures?" "Correct. Hairlike structures called cilia. Okay, that's a major characteristic. And how do they reproduce, Melissa?" "By fission?" asks Melissa. "By fission. Good."

This question-and-answer period continues until 11:50. Bill asks for questions and a second later asks one person at each table to collect the worksheets, return the textbooks to their place, and quickly announces the start of the quiz-contest. Bill sits on a high chair at the front of the room and says, "The same rules as before. Listen for the question; if the first table misses a question then it goes to the next table" (there are nine tables in all competing against one another).

"Question one (the class suddenly falls very quiet)... this one's so easy I'm embarassed to ask it. How many species of protozoa... go ahead, Cindy" (who is at table one). Cindy is so anxious to speak that she interrupts with her answer, "Thirty thousand." Even though students have been told that they will be called upon only in turn (by table), several students raise their hands for every question and can barely keep from giving away the correct answers (and hence points) to the opposition by shouting them outloud.

"Question two (directed to table two), name this structure: a long whiplike tail." Bill waits ten seconds for an answer, at which point he says, "Five seconds." After one second he calls on another student at the next table who gives the incorrect answer, flagellate. Bill says, "Nope. Take it away, table three." Sam gives the correct answer, "Flagellum." Bill continues, "Okay, table #4, what are the small hairlike structures called?" The correct answer, cilia, is given. The quiz-contest continues, with the excitement becoming more intense with each question. Finally, with one minute left to go, Bil raises the excitement to a feverous pitch. He announces that the first person to put up his or her hand and correctly identify the protozoan appearing in the transparency he has placed on the overhead projector wins for his or her table a prize to be announced later. Quickly, a picture of a paramecium appears on the screen and a dozen hands shoot up. The first hand seen is Jay's, but his answer (flagellum) is incorrect. "The second hand was over here," says Bill. Diane incorrectly guesses, "Cilia". Pandemonium erupts. The boys near the front of the room are beating their fists on their table in wild anticipation. "The third hand was over here," pointing to Brent at table #3 near the front. He gives the correct answer and the boys at his table burst with uncontained joy as the bell sounds ending the period.

Lab Exercise: Observing Protozoa (Day 4)

The time is 11:32 when the class breaks into homogeneous groups (by sex) of two students per microscope. Even though

there is a microscope for every two students, three or even four students are working at several stations. Sam yells to his partner Brent, "Come on, don't keep us in suspense!" As they jockey and push each other for position and a first look, Ron says, "Oh, you've got a worm there." Brent insists it is not a worm. Several students comment about the disgusting odor of the pond water. At one point, Jenny exclaims, "They're cells... they're eating! They're eating!" She asks her partner Cindy, "Is it low power?" Cindy, now looking through the microscope, replies, "Yes" and says, "I have something. Oh gross! They're moving!" Cindy's partner asks, "Why are they moving?" Cindy responds, "Ask Ron, he's the smart one."

Bill meanwhile has been busy looking through students' microscopes and at Jim's station says (in a voice excited for Bill), "Oh, look at this. Oh, this is great!" Frank and Eric rush over to have a look and there is crowding around the microscope. Still looking through the microscope, Bill says excitedly, "Oh, you've got---cilia now. Take a look at this." Finally relinquishing the microscope, he leaves this group and continues to move from station to station looking at the organisms each group has been able to find. By this time, each group has had a chance to make several trips to the tub of pondwater.

Complaining that they haven't found anything in their first sample, Bill takes a look through Cindy and Jenny's microscope and after a slight adjustment of the focus, says, "Oh no, you have lots of things in there. You have paramecium." Jenny asks the teacher, "They're eating, right?" And he says, "Sure. That's all these things do is eat. And you've got another smaller organism there. I'm not sure what it is." The next second he says, "Holy smokes, it's loaded with stuff here!" Ron, standing next to Bill, asks, "Mr. Bradford, you want to see a whole swarm of paramecium?" Bill tells Ron that he is looking at a whole swarm right now. Ron insists that he has about thirty of them in his field of vision and Jenny says proudly, "Yeah, there's about thirty of them here too." Cindy joins in, "Yeah, Ron. Ours is better." Several students have gathered around the overhead projector (which has been left turned on throughout the period) and are trying--without much apparent success--to locate on the transparency the protozoans they have observed.

Ten minutes before the end of class, Bill tells the class that they have five more minutes for observations until the start of clean-up. Brent, Sam and Jim have convened a meeting at Frank's table to fill in their lab sheets but soon return to their microscope. Bill approaches the group and tells them, "Alright, let's go back to low power. You see, high power restricts your field of vision. You can't really find anything... Okay? Now, how many [protozoans] have you found so far?" Again looking into their microscope, Bill says, "Here's two right here. I'll put the pointer on them. Take a look. Now that one up here appears to be like Stylonchia." There are five minutes left in the period and Bill announces, "Alright, it is time to clean up your glass slides. . . cover slips. . . microscopes at low power,

turn it off." Five students have gathered around the overhead projector to try and find pictures of protozoans they might have seen under their microscopes. Ron asks no one in particular whether any amoebas were found during the period. Overhearing, Bill says, "No, I haven't seen any yet." Most students have not completed their lab sheets and they are not collected today. Bill checks the workbench for dirty glassware and the class is dismissed at 12:00.

Finish Protozoa Lab Exercise (Day 5)

The teacher administered an exam on protozoa at the start of the period. After approximately 15 minutes, all tests were completed and turned in. The students are told to take out their lab sheets from yesterday. "Let's quickly take those labs out and put them on your desk right now." A few seconds pass. Again, he reminds the class to take all labs out. Finally, he begins. "Okay, let's take a look at the labs we did yesterday, and then I'll give you an opportunity to look at your microscopes again. I know some of you are not done; some of you only found one or two organisms. I want to go over some of the organisms that we seemed to see in all of the classes (Teacher has four sections of science)..." Pointing to the chalkboard which has several diagrams of protozoans drawn, "The one that was the most common of all the organisms was this organism here (pointing to an organism labelled #1). Who knows the name of this organism?" Ron yells out that it is paramecium and Bill repeats the correct answer for the class. He continues:

> Okay, this is the one we saw in great abundance. If you followed it, you saw that it glided smoothly through the water. When it hit something it would sort of back up. . . it might just sort of reverse its direction and swim away. We saw this one more than any other kind. Another one that we saw was this organism here (pointing to an organism labelled #2). It had almost a set of 'whiskers' and another set of whiskers down here (pointing to the cilia hairs drawn on the chalkboard and if you were able to focus under high power you would see many small, hairlike structures--the cilia. This [organism] is called Stylonchia, and we saw it quite a bit. How many saw this one?

Approximately five students raise their hands in recognition. "Okay, how many were able to see the paramecium?" Perhaps half the class raise their hands. "Everybody should have seen the paramecium." Bill continues to describe several more protozoans he has pictured on the chalkboard. "Now another one that I saw as I looked through the microscopes was this flat-shaped organism which kind of whirled and as it whirled it kind of seemed to be changing shape as it moved through the water (pointing to an organism labelled #7). It sort of looked like. my idea of a torpedo in a way. How many saw that?" About four students raise their hands.

Good. And I also want to draw your attention to something I saw yesterday in the last period of the day that I have never seen before--and we've been doing this for about four years now. This thing was a single-celled organism--a protozoan. . . It was huge! Not only was it huge, but it had a real ominous look to it--scary-like. It moved very slowly and it looked like it was in charge. . . and all the other organims there were there to 'wait' on this guy or protect this guy, and it was very dramatic looking, and I have never seen that before. And it was really huge in comparison to all the others. The paramecium was not nearly as big as this one.

At this point, Mary raises her hand to say, "We saw that one!" And Bill says incredulously, "You saw that one? Are you sure? Well you should have called me. Well, I would assume that if it's in one person's slide it's going to be elsewhere in the pond water too. So it's just a matter of luck, really."

Bill tells the class that he will collect the lab sheets today and that there is very little time to look through the microscopes, adding, "Don't worry too much if you didn't have all the five [protozoans] down there (referring to the last question on the lab sheet). Okay, so let's quickly get started and go where you have to go." With this, the students rush to their lab stations. Bill adds drops of methylcellulose to slides as 6-7 students crowd around the tub of pond water trying to get at the eyedroppers. Bill says, "If anybody sees anything that we haven't seen or that's not on the board, let me know." Every few seconds or so a different group calls for Bill to come to their station. At one point Phil shouts, "Look at this one! Look at this one! It changes shape. . . Mr. Bradford!" Bill quickly comes over and looks through Phil's microscope and says, "Yeah, yeah, that's the one I mentioned before." Everyone asks Bill for its name but he admits that he doesn't know. "It whirls, right?", says Bill as he continues looking through the microscope. Phil agrees. Bill says, "It does summersaults." Phil again agrees, saying, "Yeah, pretty weird!" It is time to clean up but it takes several reminders from Bill. One person from each table collects the protozoa lab sheets and as this is done Bill announces that tomorrow is progress report day. Several students let out a disapproving sound.

Excerpts from Classroom Observations
Topic Two: Human Digestion

Introduction of Lab Exercise: Action of Saliva on Oats (Day 2)

Ron and Mickey pass out today's lab sheets to the class and the students begin reading them silently as per Bill's instructions. After a couple of minutes Bill says, "Okay, everybody

Table 2. Duration of Activities for Topic Two (Teacher 8)

	DAY 1*	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Return and Correct Circulation Test	Opening Transition	Opening Transition
5 min.	Circulation Test	Review Yesterday's Lecture on Digestion	Recitation on Structure and Fucntion of: the Mouth, Esophagus, and Stomach; Reading from Text	Digestion Vocabulary Seatwork and Discussion	Record and Talk About Final Observations from Demonstration Lab 2 (See Day 4
10 min.	Introduce Topic On Digestion	Students Read and Review Lab 1 Procedures	DISMISSAL	Finish Stomach Notes	Teacher Recitation on Digestion of Fats
15 min.	Review Text on Digestion	Students Do Lab 1: Action of Saliva on Oats		Teacher Performs Demonstration Lab 2: Digestion in The Stomach	Read and Review Procedures for Lab 3 Digestion of Fats
20 min.					
25 min.				Record and Talk About Preliminary Observations from Demonstration Lab 2 (Above)	Class Talks About Lab 3 In Groups
30 min.	Student Seatwork On Digestion Vocabulary Using Textbooks	Lab Cleanup; Transition Review Lab 1 Results Collect Lab 1		Teacher Recitation on Structure and Function of Small Intestine	Discussion of Lab 3 Results Cleanup
35 min.					
40 min.					
43 min.	DISMISSAL	DISMISSAL		DISMISSAL	DISMISSAL

*Duration of Activities on Day 1 are approximate.

Table 2. Duration of Activities for Topic Two (Teacher 8)

	DAY 6	DAY 7	DAY 8
Class Begins			
	Opening Transition (Regular	Question-and-Answer Style Review of	Opening Transition
5 min.	Teacher Absent Today)	Digestion by Small	Continue
	Rolltaking	Intestine	Lecture on
10 min.			Calories
		Review Digestion, Villi (Slide)	
	Seatwork		
15 min.		Lecture on Large	
	Assignment:	Intestine, Importance of	Transition to Seatwork
	Copy and	Water, & Cramps	
20 min.	Answer		Seatwork
	all	Question-and-Answer Period	Activity #2:
	Digestion	On Above	"Food and Energy"
25 min.	Review		(Text)
	Questions	Seatwork: Functions & Examples of	Students
30 min.	at end of	Six Classes of	Complete
	Chapter	Nutrients Using	FWL
		Text	Survey
35 min.			
	Substitute Reads	Review Answers	DISMISSAL
	Correct Answers and		
40 min.	Collects Papers	Read and Review Paragraph on Nutrients	
43 min.	DISMISSAL	Lecture on Calories	
		DISMISSAL	

should be reading the lab. I hear a lot of mumbling going on. That means you're not reading." There is still some chatter but it becomes more quiet as Bill begins to move through the classroom. After about a minute Bill says "Okay, I think that's enough time for everybody to read. What is the purpose of the lab? Frank?" Frank reads from the top of the lab sheet, "To observe the action of saliva on starches." When he is finished Bill says, "Okay, what we're going to do today is see exactly what saliva does to starches. "Equipment, David." David reads the list of equipment from the handout. Bill says "Okay. So at each table you will have a test tube rack with three test tubes and a test tube holder, which by the way, make sure is firmly on there. If you move the test tube around in the test tube holder vigorously it's going to slide out and drop." Bill picks up a test tube holder to demonstrate. He continues,

> Okay, so you will also be using Benedict's solution which is a solution to test the presence of sugar. This is poisonous. I assume nobody will drink it. You will also be using Lugol's solution, which you have used before. That's on the back counter, which is the test for the presence of starch. Okay, and you will be using some oats. Okay, now here is what you are going to be doing. . .

Bill proceeds to lead the students step-by-step through the procedure that is outlined on the handout, demonstrating as he goes. At one point he says,

> Okay, now these are oats (holding up a petri dish full of dry oats for all to see). These happen to be Quaker Oats, and these are oats that perhaps some of you had for breakfast. Okay, then you're going to do something to each of these [three] test tubes. In test tube 1, one of you at each table is going to work up a good supply of saliva. Now I don't want to hear anybody saying, "it's gross" or anything like that. It's all part of the science experiment. Okay, so then you're going to put it so it covers the oats. Make sure you shake it up a little bit so that all the oats are in the saliva. Then you put it in the test tube rack and let it sit there for approximately five minutes or so. That will give the saliva enough time to start its chemical process of digestion on those oats. Okay, so five minutes, let it rest. Now you've got to remember what to do here (most students' eyes have been on Bill). Always refer to your lab sheet before you come and ask me a question. Make sure that you have looked at your lab sheet because chances are the lab sheet is going to tell you what you're going to ask me. If it doesn't, then fine. Then ask me.

Bill then tries to refresh students' memories concerning the starch test. "Alright, now in test tube 2 you're going to test the oats to see that there is starch in these oats. Now how do

we do that?" Calling on Jay who has raised his hand, the answer of Lugol's solution is given. Bill then asks Jay, "How will I know that I've got starch using the Lugol's solution?" Jay tells Bill that "the color will turn black." Bill's response: "Black. Okay, good. Then it is starch."

Bill then demonstrates to the class the safe way to heat their test tubes containing the Benedict's solution over the Bunsen burner flame, holding the open end of the tube toward the nearest wall and away from any other person who may be around. This is followed by an explanation of how to interpret the color changes they might observe taking place upon boiling the contents.

> Now you read your results. If the solution is blue (writes "blue" on the chalkboard), or close to blue, then the substance has no sugar (writes "no sugar" underneath blue). If this turns any color of green (writes "green" next to blue) there is sugar present. If it turns yellow to orange (writes "yellow" and "orange" next to green), then there is quite a bit of sugar present, okay? So the test for sugar using Benedict's solution is to heat up the oats with the Benedict's solution and to see if there is a color change. If there's no color change...the blue may change a little bit deeper because what you've done with the heat is kind of dissolved some of the oats. So you're not going to have that bright blue anyway. Now if it turns green, yellow or orange then there is sugar present.

Bill asks the class, "How many of you have had oats for breakfast?" Several students raise their hands. "Melissa, when you have oats for breakfast, do you just warm them up and heat them or do you add something to them?" Melissa says that she adds water. Bill asks "Anything else?" Another student answers brown sugar. Then Bill says "Okay, now if you don't eat anything with the oats, do they taste good?" Most of the students shake their heads as they respond in the negative. "So would you say then that just from your knowledge right now, would you say that there is sugar in oats?" Several students shout that they would guess not. Then Bill asks, "Okay, would you say that the oats contain starch?" Most of the class answers yes. "Okay, yes. So you know a little bit about this before we start. Okay, so what we're going to see today is if our saliva is going to change our oats, which is starch, into sugar."

Bill then tells the class that by the end of the period they should have completed both the results and conclusion section of the lab sheet and gives instructions on how to clean up, adding "If you are finished very early, then I'd like [you] to work on your vocabulary until we're all done." As a final word before they begin the lab, Bill says "Now remember to read the procedures on the lab sheet. That will tell you what to do. Are there any other questions?" Brent raises his hand but Bill doesn't notice him. Bill tells the class that they may begin their work.

Lecture and Notes on the Mouth, Esophagus, and Stomach (Day 3)

Bill tells the class to take out their notes on the digestive system. He reviews the previous notes that they have been given, calling on individual students to answer specific questions as he goes. Then he proceeds to discuss and to give notes in turn on each one of the major organs of the digestive system. The organs to be covered today are the mouth, esophagus, and stomach. After eliciting responses for both mechanical digestion ("chewing the food") and chemical digestion ("saliva breaks down starches into sugar"), Bill writes these on the board after the word 'mouth'. After giving the class more than enough time to copy these words from the chalkboard Bill moves onto the next organ, the esophagus, telling students to open their texts to page 114. The class follows along in their text as Gloria reads a paragraph:

> "After it is chewed and moistened, food is swallowed. The tongue forces the food into the esophagus. When food is swallowed the entrance to the windpipe is closed. This prevents the food from going down the windpipe. If food goes down the wrong way, you cough until the windpipe is cleared. Food is pushed down the esophagus by involuntary muscle contractions. Food moves from the esophagus into the stomach."

Bill then asks Brent to explain what the esophagus does after having heard what has just been read. Brent says that "it pushes and squeezes food to the stomach." These words are written on the chalkboard after the word "esophagus". After a brief explanation of the structure and function of the esophagus, Bill asks Susan to explain how food is prevented from going down the windpipe.

"There's a flap," says Susan.

"Alright, yes, okay. There's a little covering which prevents the food from going into the trachea. What else happens? What is another thing? Let's say something gets near the windpipe and the little flap doesn't work...what happens?

Ron shouts, "You start to cough."

"Exactly," says Bill. "You start to cough. You have a reflex there, and we studied reflexes, remember? That little reflex will occur instantly. You will cough and the food will move away. How many of you have had that happen to you?" All hands shoot up.

> "Okay...everybody at one time or another. So under normal circumstances we don't need to worry about any food going down our trachea. Then it's going to go block oxygen from getting down into the lungs, and it could cause death."

After describing how thousands of needless deaths occur each year due to a lack of simple first aid knowledge, Bill decides to demonstrate the proper technique, using Sam as a model.

> "Okay, now the first thing you should do is bend them over, hold them, and right between the shoulder blades with the palm of your hand. . .(demonstrating) three sharp blows, okay? Now ordinarily that should dislodge the food that's caught there. Now that doesn't do it ther the next thing you do is the 'Heimlich' Maneuver, which is you make a fist and you're going to use that fist. . .and I'm not going to do it to you, Sam. I'm just going to demonstrate. . .and what you do is you get it [the fist] right by the belly button, and then you're going to squeeze in an upward fashion with your arms--like this (demonstrating, amongst giggling from the class, then telling Sam he may sit down). What you're basically going to do it knock the wind out of them. Now all of you have probably had the experience of having the wind knocked out of you. How many have?"

Almost all students raise their hands in response to the question. He continues

> "Alright, all of you. . .It's a very uncomfortable feeling, and what has happened is you have landed in such a way that all the air has been forced out of your mouth, and that's exactly what we're trying to do. We're trying to get air pressure to dislodge the food."

Bill asks the class whether everyone has copied the few notes on the esophagus from the board. He then announces the "next organ in line--the stomach," and writes the word 'stomach' on the board. Ron is advised to pay attention to Jim who is asked to finish reading the paragraph on the stomach from the text:

> "In figure 7.1 notice where the stomach is. It is probably higher than you thought. Feel your breastbone. Your stomach is in the area behind you breastbone. The stomach squeezes and mixes food. The breakdown of starch into sugar gradually stops. Food can stay in the stomach from 3 to 5 hours. While in the stomach, food is mixed with a very strong acid. The walls of the stomach are lined with mucus. The mucus protects the stomach walls from the acid and other digestive juices. Sometimes the mucus lining does not protect the stomach. Ulcers develop in the lining when it is not protected. Some doctors believe that nervousness and stress help to cause ulcers. The walls of the stomach secrete a digestive juice. This juice begins to breakdown the proteins."

Bill then asks the students to direct their attention to the human torso model at the side of the room. He points out the location of the stomach in relation to the rest of the organs and briefly describes its structure and function. After a description of the churning action of the stomach, Bill asks Diane for the name of this kind of digestion. Diane answers "Indigestion." Hardly taken aback, Bill replies "No, what kind of digestion is it?" Melissa gives the response Bill is looking for, "Mechanical."

Demonstration-Lab: Digestion in the Stomach (Day 4)

At 11:32 Bill asks Diane and Elaine to pass out a lab activity sheet on stomach digestion to each student. After allowing a couple of minutes for silent reading, Bill calls on Susan to read the lab's purpose. She reads, "To determine which food substance is digested by the stomach." He then asks Susan a question. "Okay, Susan, from what you have just learned about the stomach, what food substances do you know are digested by the stomach?" About three seconds pass before Bill tells Susan, as a hint, to look up at the chalkboard. Finally she gives the answer protein, and Bill continues,

> Okay, so we're going to use this experiment to see if this really is true, that it really does happen, okay? By and large the stomach does not digest carbohydrates or fats; chemically that is. Mechanically, because the stomach squeezes and churns the food, the carbohydrates are going to be reduced in size, but there really isn't any chemical digestion of carbohydrates or fats in the stomach. Basically just the protein and the curdling.

Bill moves to the demonstration lab bench and explains what he is going to do. He points to the equipment that will be used-- four test tubes, samples of four different foods, a bottle of powdered pepsin and a jar of hydrochloric acid. After mixing some in water, he tells the class:

> This pepsin is really the same thing as is in your stomach. And this hydrochloric acid is already diluted in water (holding up the beaker full of acid solution for all to see), and we keep this solution locked up in a special cabinet because it is a very strong chemical and very dangerous to work with, and that is one reason why I am having this as a demonstration lab, because you really shouldn't get this on your skin. Now this is not a really powerful solution of [hydrochloric acid] because I've already diluted it with water. But still I'd rather work with it than have you work with it. Okay, now the combination of these two [solutions] is exactly what you'll find in the stomach. Alright now what we're going to do then is to take and put four different foods into different test tubes and see what happens to them when we put these set of juices in the

test tubes. Now your [lab sheet] says [to wait] 24 hours. . . we're not going to be here tomorrow [because of the weekend] but that doesn't matter. In fact, it may even be better, because when we come back on Monday, we may see even more dramatic results.

Bill instructs the students to label on the lab sheets the foodstuff he will place inside each of four test tubes. In test tube 1 he places a piece of cooked egg white; in test tube 2 a piece of bread; in test tube 3 a piece of apple; and in test tube 4 a small amount of margarine. After each foodstuff is placed into a test tube Bill calls upon a different student to tell which food contains protein (the egg white); which contains the "starchy carbohydrate" (the bread); which the simple carbohydrate (apple); and which the fat (margarine). He then explains that he will add to each test tube a small amount of pepsin solution together with hydrochloric acid and that he will allow the test tubes to sit until Monday when they will observe the results. After carefully adding the solutions to each test tube using an eyedropper and making sure that each food is well covered by the pepsin and hydrochloric acid solutions, Bill continues,

> Okay what you need to do on your lab sheet is indicate what each of these looks like, an I'll give you a clue. First of all, look at each test tube and see if you see anything being dissolved. Now remember, the bread gets soggy so make sure you distinguish between being soggy and dissolving, okay? Check to see if everything is whole and I'm going to walk around the room with this [test tube rack holding the four test tubes] and then when we come back on Monday, you'll have something as a reference so you can compare the two. . .days, at the beginning and the end.

Bill moves quickly through the room, pointing to each test tube and repeating its corresponding number for the students at each table. He spends between 2 to 5 seconds at each table, which does not seem long enough for each student to get a close look at each test tube. He tells each group to write down what they think each of the test tubes looks like right now; "Like I said, you really want to know whether it's being dissolved right now or if it's still whole." Bill returns to the front lab bench, sets the test tube rack down and wanders through the room watching to see whether students are writing their observations on their lab sheets.

After a few minutes, Bill begins to question students about what they were able to observe, "Clair, what did you put for test tube 1?" Clair answers, "I put down that the egg white looked whole." "Okay, the egg white looked whole. Test tube 2. . . Roy?" Roy answers, "No, it was just soggy." Bill says, "Okay, just soggy. Okay, test tube 3, Melissa?" Melissa replies, "The apple was whole." "Okay the apple was whole, Lori. . .test tube 4?" Hesitating, Lori answers, "I really don't have anything written down yet." Bill says, to her, "Okay, well what would you

say based on what you've seen?" Lori replies, "It's still the same." "Okay, it's still the same...fairly whole. Okay, everybody in agreement with those we just talked about?"

Several students respond with a loud "No." Diane says, "In test tube 2 it looks like it's okay, but in test tube 3 the apple looks like it's losing its juices." Bill says "Well, from what I see, it looks to me like nothing has happened. The color of the solution looks sort of like the pepsin color, kind of orangeish color, but I don't think anything has happened yet...Alright let's put those [test tubes] aside for now.

Demonstration Lab Results and Discussion (Day 5)

After a couple of minutes, Bill brings the class to order by telling students to take out their lab sheets from last Friday's demonstration lab so that they may record today's results. After quizzing four or five students on the procedure followed during the previous class Bill begins,

"Okay, now here are the [test] tubes that we did last Friday and let's take them in reverse order. . .I'm going to ask different people to tell me what they think are the outcomes of the experiment." Perhaps 50% of the students do not appear to be listening to Bill. Many are talking quietly to their neighbors at their tables. It is 11:21. Bill holds up the four test tubes and tells the class to notice whether the foodstuff in each test tube is whole or whether it's been dissolved into smaller particles, and what differences have occurred in each since last Friday. He begins by holding up one test tube in front of Sam. "Okay, test tube 4 was the piece of margarine, which is fat of course. Sam, can you tell me what changes you see in this test tube?" Sam responds, "I think it's smaller." "Okay, but my question was: Is it whole or is it dissolved?" "Oh, whole," Sam replies. Bill continues,

> Its' still whole. Okay. So we really haven't seen any digestion taking place here in test tube 4. It's still basically whole. One difference I do notice is that the color has changed a little bit. So that is nothing really too significant. A'right, then we go to test tube 3, which is the piece of apple. Alright, Gloria, what do you think has happened to the apple as far as digetion is concerned.

Bill approaches Gloria's table, holds the test tube in front of her for a few seconds, and then she answers that the apple is still whole. Bil says to her, "Okay, Gloria indicates that the apple is still whole. . .that it is not dissolved or broken up... so the apple is not digested."

Repeating this same procedure, Bill takes the remaining test tubes and moves around the room asking questions of various

students regarding the content of the test tubes. This procedure has taken about five minutes.

Bill tells the class to look at the remaining two questions on their lab sheets under the heading 'Conclusions'. Diane is called upon to answer the first question which reads: "From your observations have you noticed any significant changes in the food in each test tube? What are these changes?" She answers,

> Well in test tube 4 (margarine), there really wasn't any digestion happening; and in test tube 3 (apple) it was still whole; and in test tube 2 (bread) it was really hard to see any digestion happening because the crust just kind of fell off; it was whole; and in test tube 1 (egg white) it looked like it had been digested into little particles.

Bill then says, "Okay, then you're saying that the significant change took place in test tube. . ." Finishing his sentence, Diane says "One." Bill replies "Very good. Okay, so I think that was shown most clearly. There may have been a little bit of a problem determining whether test tube 2 (bread) had undergone any digestion. "Okay, so what was in test tube number 1? Roy?" Roy says egg white. Calling on Kathy, Bill asks "What is egg white, what kind of food?" After several seconds Kathy is able to give protein as the correct response. Then Sam is called upon to answer question two, ("Based on your observations, what nutrients are digested in the stomach by pepsin and hydrocholoric acid?"), Sam responds, "Protein." The time is 11:27.

Bill tells the class that he will not check the lab sheets they have just completed since they went over them together in class, but he will look at them when he collects their notebooks at the end of the term. The remainder of the period is spent discussing the most recent digestion notes. He also gives additional notes covering absorption of food by the small intestine, incorporating this into his usual question-and-answer style of lecturing. The time is 11:32.

Lecture on Importance of Water: Cramps (Day 7)

The time is 11:27. After spending five minutes on a discussion of the structure and function of the large intestine using the human torso model, Bill next discusses the importance of water to bodily functions. He calls upon individual students to name common sources of water in foods we eat (e.g., milk, juice, fruits) and emphasizes the need for between 6 and 8 glasses of water per day. Continuing, Bill explains

> Doctors today are becoming increasingly aware of how important water is and particularly when you're really active or on hot days. They're finding out now that the way your body feels or performs is directly related to how much water you have in your body.

All eyes are following Bill as he continues. "How many of you have seen runners drink water, like on television, when they show a marathon?" Almost everyone raises their hands. Bill walks over to Diane's table, asks whether she's paying attention, and immediately walks back to the front of the room and says without losing a beat,

> Alright, well they need water because they're really perspiring. They're getting rid of their water to lower their body heat, and they have to replace that liquid, otherwise it disrupts the chemistry in the body, okay? And that can happen to you as well. If you don't have enough water, that disrupts the chemistry in your body and your cells don't work the way they should. So now scientists are discovering. . .emphasizing. . .and they're telling doctors this. . .the need for water, and that it keeps people healthy and at the peak of what they should be at.
>
> They did a study recently, some nutritionists, and they found that some of the athletes that have the most affect from the lack of water are tennis players--especially the men because they play more sets of tennis. I'm talking about championship level of playing now. They have found that a lot of good tennis players have lost matches in the last set of their tennis match--like after three or four hours of playing--because they actually became dehydrated. And once that happens, that disrupts the chemistry in the body, and the muscles don't work, and their reflexes aren't as fast, they can't keep up with the ball, they get tired easily, and they lose the match. So those athletes are told to store up on water two or three days before the match begins. . .and they are discovering that this is helping them be stronger during the tennis match, particularly if it's going to be hot. So this is really relatively new now. Most of the time you used to hear coaches say, "Okay, don't drink water now, you're going to get a cramp". How many of you have heard that before?

Almost all students have been paying attention and raise their hands as Bill continues,

> Okay, we've all heard that--but that's not true. Now naturally if you guzzle a lot of water that might happen. But here's lots of coaches--famous coaches--that have never let their players drink water. Now that's changing. Now the professional football teams hire a nutritionist, sports medicine doctor, and they tell the coaches that they're doing it wrong. It's not the way it used to be.

Diane raises her hand and relates a story of when she was a student at another school, the PE teacher told the students after

running laps not to drink water because they might get cramps. Bill responds, "Sure. That's the way we used to think. But now we're discovering how important water is. So as people are doing reserach in more and more areas we're finding out things about how your body works."

John says "I've heard that if you drink water directly after a game--that after playing a hard game--you should relax for about five mintues before drinking some water." Bill says,

> Okay, that's probably true. Well, you can drink a little bit of water. If it's a real strenous effort you might get a stomach cramp. Generally what you is you drink a little bit of water at a time. You don't gulp it. You don't guzzle a lot of water. That's probably not very good at any time anyway.

The time is 11:34. Melissa asks "What are cramps anyway?" Bill answers,

> Like in a muscle, usually what happens is it's an electrical process. It causes your muscle to contract and the fibers in your muscle kind of slide together, like this, okay? (Bill makes a muscle sliding motion using the fingers of both hands to illustrate what he means). Something happens in the chemistry, and they're not too sure what happens, and that electrical impulse is triggered all the time and then your muscles stay contracted then they should be relaxing, okay? The balance of some of the chemicals in your body or it could be that you don't have enough water that's causing an imbalance. Cramps usually occur because people don't have enough water. You see a football player and he has to go to the sidelines because he has a cramp. I'm not exactly sure. I've done a lot of reading about that, and they're not really sure what causes cramps in the stomach or side aches or things like that. It could be a lot of different things. It could be allergies.

TEACHER 9: JIM FERBER

by David Haller

Introduction

The fol'owing is a short portrait of the 7th-grade life science class of Jim Ferber at Whitefield Intermediate School. The first topic observed took place during the middle of January, 1984 and dealt with the biology of microscopic organisms. Topic two occurred during mid-March, 1984 and included discussion of the human circulatory system.

Background and Viewpoints

Mr. Ferber received his Bachelor of Science degree from a western university. With his original career objective of becoming a coach, he received a Master of Arts in Physical Education with a minor in science. Throughout college, Mr. Ferber took many science courses, and claimed that during his graduate studies he became increasingly interested in science and decided that he would rather teach science than physical education.

For the first three years at Whitefield, Mr. Ferber was a classroom teacher for 7th and 8th grades, teaching all subjects. Then Whitefield was converted to an intermediate school, and Mr. Ferber became a science teacher exclusively. After approximately 20 years as the head of the science department, Jim is currently teaching three 7th- and three 8th-grade science classes, while also handling the coaching duties of the school's basketball team.

Jim claims that he is not an "outside community person" but does put out a newsletter to all parents discussing the annual science fair. During his interview he did not discuss many outside activities aside from the science fair and coaching the basketball team. However, he did seem to be very proud of the fact that several of his students had received honors at a recent science fair.

In his approach to science teaching, Jim believes that it is important to initiate a student's interest at an early age in order to increase their desire for future learning. He expects that when 7th graders start his class they will know a little about ecology, geology, and astronomy, since these are studied in the 6th grade at Whitefield. However, in general he looks at them as starting from scratch, with no science knowledge at all. feels that his students start off with a basically good attitude towards science, and that 95% are interested and motivated to learn. Jim believes that the ultimate goal of his class is to

give his students an understanding of and respect for natural phenomenon, and an appreciation of the plant and animal kingdom. He believes that it is his job to prepare his students for future science classes that they may take. He feels that when a student moves on to high school that student will be familiar with many of the basic concepts of biology and chemistry.

When one first enters his class there is an ove whelming feeling of order and respect that Mr. Ferber commands. Discipline is tight and the teacher appears to always have firm control of class activities. Even so, Jim encourages the students to express their ideas and thoughts. He also involves the students in science through mandatory participation in the annual science fair. He tries to get them to think about scientific method in their selection of a problem for the science fair. In general, Jim believes that developing the students' problem-solving abilities is very important in the teaching of science.

After teaching the same course for about 20 years, Jim has arrived at a stable curriculum, making few changes from year to year. He feels that the students should have a "hands-on" experience in his class, and therefore uses as many activities, such as labs and films, as he can. He thinks that this will help to keep the students interested.

Classroom Description

Mr. Ferber's science classroom measures approximately 25 feet by 50 feet, and contains 18 marble topped lab desks with space for two students at each pair. At the start of the year these desks were arranged in pairs face-to-face with four students sitting around each. These nine pairs of desks were arranged in three rows of three. During the second half of the school year the pairs of desks were separated so that all students faced the front of the class, with three rows of six lab desks. At the front of the room is the teacher's large marble laboratory table, behind which is a large chalkboard with two vertically sliding sections. On either side of the chalkboard are two doors. The left door leads to a storeroom containing equipment and assorted supplies. Jim's office is through the other door and contains papers and a large number of science books, including texts and popular publications.

Starting at the front wall, going around the room clockwise, there are several posters describing various shellfish. Next to the posters is a bulletin board with several felt collages. Along the next wall is a poster from Carolina Biological describing the anatomy of a protozoa. Next, along the far wall there are seven windows with shades drawn. The space between each window contains various small posters of animals, mostly mammals. Also along this wall, below the windows, are four lab sinks. In between the sinks is a variety of lab equipment, including beak-

ers, graduated cylinders, and Bunsen burners. Underneath the counter are cabinets storing biological specimens and lab supplies. Along the rear wall are cabinets containing a few additional laboratory supplies, but most seem to be empty. Under these cabinets is a counter with two more lab sinks, and under the counter are bookshelves with many science textbooks. There are three empty fish tanks at the far end of the counter. Along the next wall is a series of six different sized posters. The posters include a diagram of the space shuttle, descriptions of various insects, and a diagram of the human heart. These are followed by the first entrance to the room, a chalkboard approximately 18 feet in length, and then the main door to the classroom.

Overall, the room seems to be well lit and well organized, with a lot of space for the students to move around. Mr. Ferber works to keep everything in its place, and has his students take part in all classroom maintenance.

Course Overview and Instructional Strategies

The text for Jim's 7th-grade science class is Life Sciences: A Problem-Solving Approach, published by Ginn and Company. However, the text is not central to the class. Jim starts the year off with a section on chemistry, since he believes that this is the basis for all the other topics. He feels that once the students have a basic understanding of chemistry they will have an easier time with the other topics. From chemistry he progresses with a series on human body systems alternated with sections on plants and plant evolution. The final human system is the circulatory system, which he covers just before entering zoology and his discussion of animal evolution. Jim feels that inserting topics on the human systems between the major topics helps to break the monotony and keeps the students interested.

Mr. Ferber uses the same system for teaching each topic that he covers. He starts each topic with a series of lectures, and possibly a few demonstrations, and then moves on to various lab activites to illustrate the concepts that he has been lecturing about. Lab write-ups are seldom required, since all lab sheets are placed in the students' science folders which are checked and graded four times a year. A typical class starts out with a short preview of the day's activities, whether it will be a lecture or a lab exercise. During lectures and labs, Jim asks many questions of the students. He uses visual aids such as charts, drawings, and films.

The textbook is rarely used by students or teacher. Jim has taken many activities from the text and adapted them for his own use by preparing handouts for each lab exercise. After 20 years of experience teaching this same course he has developed an extensive set of class notes and laboratory activities. Jim told me that he has made little or no changes in the curriculum over the past five to ten years. Because he has become so familiar

with the material, he seldom uses notes during lectures.

At the conclusion of each topic the class is given an exam, prepared by Jim. He uses the same test questions that he has used for many years.

Excerpts from Classroom Observations
Topic One: Microscopic Organisms

Table 1 summarizes how Jim taught the topic microscopic organisms, which was within the unit on cytology. He spent a total of ten days on topic one, starting off with a short lecture on single-celled organisms on Day 1, and going right into lab activities starting on Day 2. Also included in the ten days were several additional lectures, lab exercises, one film, and an exam on Day 5. The following are several examples of instructional segments.

Lecture on Single-Celled Organisms (Day 1)

The time is 10:48. The teacher says, "Now we're going into one-cell organisms." At this point it seems that the majority of the students are attending to the topic of the class, although some are passing notes. The teacher continues, "The cell is the basic unit of life. Some microscopic organisms live as one cell and that's what we're studying, microscopic organisms. And it's interesting to see these little organisms running around doing their thing. Some are cannibals, some are being eaten, some have different forms of locomotion. Locomotion in biology means movement. And all these little one cell organisms are classified by locomotion, how they move." He then continues, "Okay, we've talked about the amoeba. We have the drawing of the amoeba." He asks the class to take their drawings of their amoeba out. Students then search through their notes for their drawing. He then repeats, "The drawing of the amoeba." As some of the students continue to look for their drawing, he continues, "So how does the amoeba move, let me know." He calls on Lisa and Lisa says, "Pseudopods." The teacher then says, "Pseudopods? What are pseudopods?" Charlotte replies, "False feet." The teacher then says. "Yes, false feet, right." He continues "So we know that amoeba move by pseudopods." There's a pause and the teacher says, "And that. . ." He pauses again before calling on a student, "Lisa what is a contractile vacuole?" There's a short pause, and Lisa says, "I don't know." The teacher then immediately calls on Charlotte who answers, "It regulates the water content of the cell." The teacher then repeats this,

> Right, it regulates the water content of the cell. The amoeba lives in water, it collects water, and it's got to get rid of it. If the cell collects water and doesn't get rid of it, it will expand and burst, and then die. So the cell has got to have a way of getting

Table 1 (Continued). Duration of Activities for Topic One (Teacher 9)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition; Students Observe Live Amoeba at Front of Class	Opening Transition
5 min.	Teacher Reviews Cytology Concepts	Teacher Reviews Paramecium from Yesterday's Lab	Teacher Lectures on the Importance of Science	Teacher Reviews Cytology Concepts	
10 min.		Teacher Lectures on the Structure of Euglena	Microscope Lab: Chloroplast Slides	Homework Collection; 3 Microbe Drawings	Exam on Cytology
15 min.					
20 min.	Teacher Lectures on Single-Celled Organisms	Film about Various Protists	Teacher Lectures on the Cross Section of the Leaf	Microscope Lab: Observe Live Paramecium	
25 min.					
30 min.					
35 min.					Microscope Lab: Observation of Live Amoeba
40 min.				Teacher Previews Tomorrow's Test	
43 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 1. Duration of Activities for Topic One (Teacher 9)

Class Begins	DAY 6	DAY 7	DAY 8	DAY 9	DAY 10
	Opening Transition	Opening Transition	Opening Tr...	Opening Transition	Opening Transition
5 min.	Teacher Returns Homework and Talks about the Exam	Teacher Lectures on Test Topics and Lab Organisms	Teacher Lectures on Mitosis	Teacher Reviews Mitosis	Teacher Reviews Mitosis and the Day's Lab
10 min.					Microscope Lab: Preserved Slides of Salamander Tail Showing the Phases of Mitosis
15 min.	Microscope Lab: Observation of Live Amoeba, Euglena, and Volvox	Microscope Lab: Observation of Live Stentor, Blephorisma, and Vortacilla		Microviewers: the Phases of Mitosis	
20 min.					
25 min.					
30 min.				Paper for Homework is Passed Out	Students Complete FWL Survey
35 min.		Teacher Reviews Lab and Previews Tomorrow			Teacher Previews Tomorrow's Activities
40 min.				Teacher Previews Tomorrow	
43 min.	DISMISSAL	DISMISSAL*	DISMISSAL	DISMISSAL	DISMISSAL

*Rainy day schedule: Class dismissed after 54 minutes.

rid of the excess water that it accumulates. This is done through the contractile vacuoles and when it gets so much water it contracts. That's what we mean by contractile vacuole. It's the vacuole that contracts. And when it contracts it forces the water out through the membrane and then it relaxes and collects more water.

John asks if he can go to the bathroom. The teacher says yes and John leaves the room. He reminds him to take a hall pass with him. The teacher then goes over and gets a small model of an amoeba, approximately 12 inches long. He holds it up and points to the various structures that they have been discussing.

We know the pseudopods capture their food this way. (As he is saying this he is pointing to the pseudopod with a small model of a piece of food between it.) The pseudopod comes and encloses this little microscopic organism, closes its ends and forms a vacuole.

It is 10:50 and he continues to describe what happens to the food particle after it is enclosed in the vacuole. He explains that enzymes then attack the food and break it down into smaller molecules. He continues by giving a concrete example, "Just like it does in your stomach. When you eat something enzymes attack that food and break it down. Enzymes attack this food." As he points to the model of the amoeba he explains that once the food is broken down it is absorbed by the animal. Pointing to the little dots on the model he says, "These are all food vacuoles and these brown dots are all waste vacuoles. These waste products are cast right out through the cell membrane." A student then asks how these vacuoles are formed. Jim says,

That's a good question. I really don't know. A vacuole here and there's the nucleous. And here's the cell membrane and all this gray stuff is all cytoplasm. I hope when we get one under the microscope, we get one that's moving and we can actually see the pseudopods being formed. It will probably try to get away from light because it's very sensitive to light.

Paramecium Lab (Day 4)

It is 10:39. The teacher is at the front of the room and he announces to the class, "Now everybody listen carefully, class." The teacher raises his voice since he is obviously upset that the students are not quieting down immediately. The teacher walks towards the north side of the classroom and continues, "Now when you look at the paramecium--you're going to look at the paramecium first--there are two things you must do. Now the one person that is in charge of the microscope will set it up, the other person . . ." At this point the teacher is distracted and walks out of the classroom. He returns approximately 15 seconds later carrying two beakers with the live specimens in them. The teach-

er puts these two beakers down on the front desk and walks back towards the north wall. He continues,

> Now when we start in to do this, one person will get the microscope and set it up, and if you can't do it properly, we'll have everybody sit down and we'll just forget it and we'll do something else. We'll look at the preserved slides. So you have to do a lot of it. It's a lot of fun to look at these one-cell organisms. (There is a five second pause) Now someone came up to me on the way over here and said 'Mr. Ferber, did you get the things?" Well to me I don't even know what he's talking about.

The teacher now makes the point that he wants the students to talk to him in a biological language and not to use terms like "things" when discussing biological specimens. He repeats to the students that he wants to encourage them to use biological terms and not common language. He feels that it is important for the students to pick up the terminology. He continues,

> When you talk to me, I want you to talk to me in the biological language. Now we are going to be looking at microorganisms. We're going to be looking at protists, the one-celled organisms, microscopic organisms, living organisms. These words describe what I'm talking about. I don't like hearing the word, things.

He continues to stress the point and says, "I don't know where you got that habit, but don't continue it. When you're talking about something specific, say what it is."

It's 10:42, and the teacher is still at the front of the class and starts to discuss todays' lab procedures. He continues,

> Alright, there's one thing that we have to do with paramecium that we don't have to do with the others. We have to use cellulose. Now whether this cellulose is that thick, I don't know. It's usually thicker. I see it's pretty thin.

The teacher is now holding up a small jar to show the class. The jar contains methyl cellulose. He continues,

> It may work anyway. I want you to take a drop of paramecium and put it on a slide. It's in a deep-welled slide. And then you will also take a drop of cellulose and put one drop in the drop of water. That will slow the paramecium down so that you can see it. Otherwise it moves very fast, and you have to continually move the slide. Does everybody understand that?

The class responds in unison. The teacher continues,

> So while one person is preparing the slide, the other person is preparing the microscope. Now when you look at it, make sure you try and look for the inclusions. Now you won't see the cilia, I don't believe, because it's too light, and light will go right through it, but look to see if you can see the oral groove and the gullet and the contractile vacuoles. See if you can see some inclusions of the cell and notice the shape. Remember, the larger end is the anterior end and the [smaller] end is the posterior end.

It is now 10:44, and the teacher tells the class that they can go to work. The students immediately leave their seats, and those assigned to get the microscopes go to the front of the class and take their assigned scope off of the cart. They then take the microscopes to the counter directly below the windows and the counter in the rear of the class and plug them into the outlets. The others that are assigned to get the slides go up to the front demonstration table and the teacher proceeds to give each student a deep welled slide. Those students who are not assigned a specific job tend to go toward the front of the class to watch the teacher prepare the live specimens. After the students receive their slides, they carry them back to their lab stations and place the slides in their microscopes. The students start to look for the paramecium in their slides. It seems that several are having trouble. Jeffery is walking around from group to group asking, "See anything in yours?" There is no audible response and he goes on to another group and repeats his question. One student in that group says, "Here's one." Meanwhile, the teacher is circulating from station to station asking whether or not they have found a paramecium. At this point there are three to four students huddled around each microscope.

It is 10:49. Catherine calls for the teacher as her group is having trouble finding a paramecium. The teacher does not respond. He is at the front of the room helping out another group. Margie, in another group, also calls for the teacher. Seeing that he is at the front ofthe room and probably did not hear her, she decides to go up to the front and get him. The teacher is over talking to one group, and says, "They're very, very small, so you have to use the red setting" (the red objective on the microscope). He then proceeds to help focus in on a paramecium. The teacher is helping Pete's group and says, "So when the paramecium moves, you'll move the slide, alright?" He is attempting to give the students hints on how to keep a paramecium within the viewing field. The teacher now continues to circulate throughout the room asking groups whether or not they have seen the paramecium yet. The teacher repeats the fact that the students have to keep moving the slide so that when the paramecium moves, the slide also moves. That way they can keep the paramecium in view. The teacher is now near the center of the room and says "Alright, who hasn't found one?" There is then a short pause and the teacher continues "It's got to be on the

red." (Again referring to the correct microscope setting.) He adds, "Don't put it under the yellow. If you can't find them under the yellow, you have to use the red." The teacher then returns to helping individual groups.

Cytology Exam (Day 5)

It is now 10:32, and the teacher, walking around the front of the demonstration table holding a stack of exams, says, "Now take your testing positions." At this point the students move around the room and take their previously assigned testing places. At each lab table there are two students sitting diagonally across from each other. In addition, there are eight students who are standing along the counter that stretches along the south and west walls of the classroom. The teacher now walks around the room placing an exam face down in front of each student. As he passes out the exam, the teacher also adjusts the students' testing positions so as to place them at maximum distance from each other. The teacher asks Lisa where she is supposed to be sitting since she has not taken her assigned spot. He then points out a spot along the south counter where she can stand. The students continue to talk quietly amongst themselves. The teacher is near the front of the room and, noticing that there is too much noise, announces, "What did I tell you about noise? Next time I mention it somebody is going to be sitting in the detention room. I don't want any noise whatsoever." The class immediately quiets down and there is no more talking.

It is 10:36, and all the students have a copy of the test; they start to work on their exams. The teacher is now at the north side of the room directly beneath the chalkboard as he announces, "Define biology means I want what is biology." The students continue to work on the exam as the teacher stands at the front desk monitoring students and looking through some papers on the desk. Then, the teacher walks around the room looking at students taking the exam. The students continue to work quietly. The teacher walks over to the door and stands there for approximately 30 seconds before walking over to the window to adjust the blinds.

At 10:39, the teacher, standing at the side of the classroom near the door, announces, "When you have finished raise your hand, and I will come by and pick up your paper. Or better yet, just bring it up to me."

Mitosis Microviewer Activity (Day 9)

The class has just completed a 10-minute review of mitosis. After three students list the five phases of mitosis, the teacher asks the class, "Do you think you could recognize those five phases if you saw them?" Several students respond affirmatively, and the teacher says, "Alright, then, let's look at them. Everybody get a microviewer and a micrograph." Students go to the

front desk to get the equipment. The microviewer is a plastic device used for viewing micrographs, which are a strip of eight color slides. The micrograph pack consists of a strip of slides plus a little booklet which describes the content of each frame. All students, except for Brian, have gotten their microviewers and have returned to their desks. The teacher is in front of the side chalkboard and says,

> As Admiral Farragut said in the Bay of someplace, I think it was Manilla, and they were torpedoing him everywhere, you know he was the navy admiral Farragut, he said, they said, "What are you going to do, retreat?" and he said, "No, damn the torpedoes, full speed ahead," and that's what we're going to do--full steam ahead.

Several of the students chuckle or smile at this little joke.

It is 10:45 and the students proceed to put their slides in the viewers along with the teacher who also puts a slide in a microviewer. The teacher is now at the side of the room again and continues,

> Alright, now let's read about it. (The teacher now proceeds to read from the card). Alright, on the first page it says, "Have you ever propagated a geranium plant by cutting? You take a small stem on which a few leaves are growing, and keep it well watered. When a few tiny roots begin to appear you plant the stem in soil. After a few weeks the cutting grows roots which are just like the roots of the original plant. The new plant has the hereditary traits of the parent plant. Many plants and shrubs are propagated this way. In each case the new plants are just like the parent plants because in each cell there is a mechanism to maintain the hereditary pattern from one cell to its daughter cells. The process by which this occurs is called cell division or mitosis. The following eight slides are photographed using a single onion root tip which was photographed under each of the phases of mitosis in sequence."

The teacher now stops reading and lectures, "It doesn't make any difference whether it's plant mitosis or animal mitosis, mitosis is all done the same way." The teacher continues reading, "The term equatorial plate and poles, as they are used in the study of mitosis, refer to certain locations in the cell." The teacher lectures,

> We know that the equator is at the middle of the cell, and the poles are where all of the spindles are attached, and that's where the chromosomes in anaphase migrate to. The magnification given is 1,000 for slide one. That means that the microscope was set at that power when the photograph was taken. Alright, now look

at No. 1, this is early prophase. This is early prophase.

The teacher continues to read,

"The cell A is in a so-called resting stage, or interphase. Actually it is not resting. It is carrying on all the functions of life except cell division. In the nucleus of cell A, you can see the very dark nucleoli and the small granules of chromatin. It is difficult to say when the first part of the cell division begins. Recent research with the electron microscope indicates that even in this interphase, the resting state, these chromosomes are already beginning to make duplicates of themselves. In cell B, the chromosomes have become shorter and thicker, and for practical purposes, we say that cell division, or mitosis, begins with this phase."

The teacher now adds,

Notice that they are using the word cell division for mitosis. Mitosis is actually what happens during cell division, and it all happens in the nucleus. So I like to say that mitosis is the process that occurs in the nucleus during cell division. Alright, if you look at A and then you look at B, you can see the formation of the chromosomes in B. They're called the prophase chromosomes. Look at No. 2.

At this point the students are now looking their microviewers along with the teacher, who says, "In No. 2 you've got the formation of the chromosomes." The teacher continues to read,

"The large cell near the center of the slide shows that chromosomes have continued to become thicker and shorter. They can now be seen very clearly inside the nucleus. Soon after they reach this stage they begin to move towards the center of the cell."

The teacher adds,

Well, they do this because in metaphase they start to move towards the center of the cell. Now this is magnified one thousand times. Now this is also, they are all magnified one thousand times. My microscope only goes up to four hundred times. Now electron microscpes can go up to 125 to 150 thousand times. Now this is only at one thousand because otherwise you wouldn't be able to see it. You'd be looking right at a chromosome if you magnified it too much.

Excerpts From Classroom Observations
Topic Two: The Circulatory System

A summary of how Mr. Ferber taught the circulatory system is contained in Table 2. The first three days were used for lectures and reviews of blood and heart circulation. The fourth day contained a limited oral exam, where about 25% of the class was required to stand in front of a large diagram of the heart and trace the path of the blood during circulation. The final two days consisted of blood typing and Rh factor labs, respectively.

Lecture on Circulatory System (Day 1)

The teacher asks the students to take out their notebooks, and he talks with them for a few minutes while they prepare to take notes. At 10:32, he begins to lecture:

> We are now in the circulatory system, and you have a definition of the circulatory system. It is now on the top board. You know that the circulatory system is a transportation system. It transports. That's what it is. It's a transportation system carrying food and oxygen to the cells and carrying away waste products, and I told you that the waste products are water and carbon dioxide.

George then calls out a question, "Is that water vapor?" The teacher responds,

> Water vapor condenses back into water and is deposited in the urinary system and is treated, whereas, the carbon dioxide is dropped off at the lungs and then exhaled, where gases are exchanged. Now I told you that there are 12 pints of blood in the system. Now we are going to be studying this circulatory system in three parts. One is the blood, one is the blood vessels, and one is the heart. So we will become an authority on each one of those sections, and then in the end, you will have a very large examination. It will cover three pages, so you've got to make sure and remember that this is going on now inside you. You can't see it, but it's there and this is what's happening. You know that all of your life you are going to be thinking about that circulatory system and later on you're going to know more about your heart and the care of your body, and you will have a good basic knowledge of what's inside you, because 9% of the body weight is in the blood and the heart--well the circulatory system in general--or actually 20 % of the whole body weight.

Table 2. Duration of Activities for Topic Two (Teacher 9)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
5 min.	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
10 min.	Teacher Lectures on the Circulatory System	Teacher Reviews Botony Exam	Teacher Lectures on the Importance of Memorization	Teacher Reviews Heart Circulation	Teacher Lectures on Blood Typing Lab	Teacher Announcements Rh Factor Lab Activity
15 min.				Oral Exam on Heart Circulation; 7 of 34 Students are Tested	Blood Typing Lab: Students Test for Their Own Blood Type	
20 min.			Teacher Lectures on Heart Circulation			
25 min.		Teacher Lectures on the Circulatory System				
30 min.				Teacher Previews Tomorrow's Blood Typing Lab		Students Complete FWL Survey
35 min.					Teacher Lectures on the Rh Factor	
40 min.						Teacher Previews Tomorrow
43 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

The teacher continues,

> Now I want you to know as much as possible about the blood. The blood is made up of a solid and a liquid. Your solids are the red and white blood cells. Now I told you yesterday that the real technical name of the red blood cells is erythrocytes, and your leukocytes are your white blood cells.

The teacher now writes these terms on the chalkboard. A student stands up and asks to sharpen a pencil. The teacher does not respond, but takes a sharp pencil out of the desk and takes it over to the student. The student then returns to his seat. The teacher continues,

> There is one type of red cell and three types of white blood cells. The white blood cells are those three listed. (The teacher points to the chalkboard where the types are written.) Now during the examination I will not ask you to list these three, but for your notes, you will know that there are three types of leukocytes; that there are granulocytes, lymphocytes and monocytes, and each one has a different function in the blood.

It is now 10:36, and the teacher continues,

> There is also in the blood, aside from red and white blood cells--if you'll call them red and white blood cells, I do--you're not going around saying "erythrocytes" and "leukocytes". If you want to that's fine, but this terminology is technical, and for the average layman, it's red and white blood cells. But there is a technical name for them, whereas people in the medical profession would be referring to them as leukocytes and erythrocytes. There is also in the blood what they call platelets.

The teacher writes "platelets" on the chalkboard and says,

> Platelets appear under the microscope as little irregular shaped black objects floating around in the blood. They are only needed for one purpose and that is blood clotting. Your blood has to clot, otherwise you would bleed to death. You'll remember that if you poke a hole there (the teacher points to his arm) and there's no way to stop the blood, you will bleed to death and if there's something to block that up, then all of the blood won't pour out of the system--all the 12 pints, which is 6 quarts--or if you want to get technical, 5.5 liters in the metric system.

The teacher writes "5.5 liters" on the chalkboard and continues lecturing. "People who can't plug that hole, they don't have platelets. People who don't have platelets can't clot their blood and they have a disease called hemophilia." The teacher

writes the term, hemophilia on the chalkboard. The teacher continues,

> A hemophiliac is a person whose blood won't clot. He has no platelets in his blood, so he must be very, very careful. He must live close to a doctor and he must live close to a hospital so he knows that if he is in an accident and his life is in jeopardy, he must have immediate hospital and doctor's attention. Now they probably have something in the medical profession by this time for a person that suffers from hemopilia. Maybe he gives them transfusions once in a while to put in platelets. Well I don't know what exactly the treatments are in modern medicine and how they treat this particular disease. That disease is something that you are born with. It's not created. You can't catch it. That's why they take your blood test immediately when you're born. They want to know your blood type and to see how many platelets you have in your blood.

Rambo raises his hand and at first the teacher doesn't notice him. After approximately 30-60 seconds, the teacher calls on Rambo who asks, "Is that a liquid or a solid, those platelets?" The teacher responds, "No, it's a solid. It's a solid like the red and white blood cells, and you'll see them. They'll look like a little black dot like that and they're black." The teacher draws a small picture of a platelet on the front chalkboard. The teacher then corrects himself and says, "Well, they're not black in the blood, they're black when they're stained."

Botony Exam Review (Day 2)

The teacher is at the demonstration table preparing to return a Botany exam. He announces, "I have corrected your tests. When I call your name, come and get your paper. Pete." The teacher proceeds to call out names and hand back papers. After approximately 30 to 60 seconds, an announcement comes over the loudspeaker that today will be a rain day from this period on. This means that the period ends at 11:21 instead of 11:10. The teacher does not stop for the announcement but continues to call out names. The students go to the front, get their exams, and return to their seats. During this process some students compare their test scores.

After passing out the tests, Jim announces to the class, "Alright, get out your notes. I just want you to open up your binders. Now I'm going to go over the answers to the test with you. Now I gave a lot of leeway on this exam because some of the questions to me pertained in a way that wasn't exactly clear to you." The teacher proceeds to go over the answers to the test questions one by one, reading off the answers to each question. This takes approximately five minutes.

Next, the teacher comments,

> Now there were a lot of 90s on this exam and 95s and 80s. You people who are getting below 60%, you had better pay more attention in class because I repeat everything fifteen times to you, and if it's in your notes, well it was a surprise exam and I wanted to know what you remembered, not what you would go home and study and then forget. I wanted to know what you've got up there now. Okay, Denise is going to go by and pick up all the papers. Be sure you give up your test papers and I'll file it for you.

Circulatory System Oral Exam (Day 4)

At the start of the period, many students are looking over their notes on heart circulation in preparation for today's oral quiz. The teacher waits until 5 minutes into the period before starting class with a 9 minute review of the circulatory system. Then, he begins the oral quiz by calling one student up to a chart of the circulatory system, "Now, Heather come to the board and you trace the blood like I told you. You tell the class, you tell the class. Now if you make a mistake, fine, I will correct you. Now go as far as you can go. Go ahead." As the teacher says this, Heather gets out of her seat and walks up to the chart. The teacher hands her the long stick which she is to use to point out the course of the blood through the circulatory system. The teacher says to the class, "Now you better listen to her, because you're going to have to do this." Heather now starts. She says, "Now the blood goes. . ." Heather stops and laughs quietly. The teacher then says, "I don't see anything funny." Heather then says, "Well, it's embarassing." Heather continues, "It then goes into the um, right ventricle and then up through here." The teacher then adds, "What do we call it?" Heather says, "The ummm. . . pulmonary artery?" The teacher nods approvingly. Heather continues, "Then it goes up to the lungs and gets oxygen and goes back to the heart." The teacher adds, "It goes back by the way of what?" Heather says, "By the pulmonary vein?"

After help from the teacher on technical terms, Heather completes tracing the blood through the system. Referring to the quality of Heather's job, the teacher says, "I would say fair." The teacher adds, speaking to the entire class, "It would be better for your own sake to learn to stand in front of a group and speak, because that's very, very important." The teacher then calls, "Alright, Elizabeth" Elizabeth gets out of her seat and walks towards the chart. The teacher speaks, "Now listen very carefully to this, because this is the way you should do it." Elizabeth proceeds to trace the blood through the system. The teacher is rather stern as he corrects Elizabeth several times when she makes errors. For example, when Elizabeth mistakenly says that the blood goes up the aorta to the lungs,

the teacher responds, "Wait, no, it doesn't go up the aorta, it goes up the pulmonary artery." The teacher is again rather stern as Elizabeth makes several more errors before finishing. After she completes the trace, the teacher says, "I would say only fair. You have a lot more studying to do, Elizabeth." The teacher now calls Pete.

It is now 10:49. As Pete makes his way up to the chart, the teacher says to the whole class, "I don't see much homework here that you were supposed to do last night on heart circulation. Alright, Pete, let's see if you can do it." Pete then proceeds to trace the blood throughout the circulatory system. Pete completes it with only one error. The teacher says, "Very good, so far, with only one error." The teacher notices that Tom has raised his hand, and says to him, "Can you do it? Alright, go ahead." Tom gets up, takes the pointer, and proceeds to trace the blood through the circulatory system. He proceeds without error until he comes to the left atrium. He is unable to think of the correct term and makes several errors before the teacher corrects him. After Tom finishes, the teacher says "Fair. Now get back there. You'd better pay more attention to the names of the chambers." This he tells to Tom as Tom goes back to his seat. The teacher adds, "But that's not bad," referring to Tom's overall performance. The teacher now announces to the class,

> Now you have to pay attention to names of the chambers because, hey, on the test you will have to write them out, and if you don't know how to spell them, you'd better learn, because you're going to be responsible for it. Now you're going to have to trace it, and you're going to have to write it out. Remember, we've got a test that is three pages long.

It is now 10:53, and teacher is looking around the class. He says, "Alright, now" and hands Bob the pointer. The teacher then says, "He looked all around instead of looking at me. That means that he doesn't know it." (I believe the teacher says this half jokingly.) As soon as he finishes, Bob begins to trace the blood through the circulatory system. Bob finishes after making only two or three errors which the teacher immediately corrected. After Bob finishes, the teacher says, "Not bad. You just only made two mistakes, three." The teacher now notices that Tony has his hand raised, and says, "Tony, you think you know it?" Tony responds, "Yes," and gets out of this seat and comes up to the chart. As Tony is walking up to the front of the class, the teacher says, "Alright, let's see what Tony has to say." After Tony finishes without making an error the teacher says, "Very good, very good, only you're supposed to say the heart contracts when it's in the right ventricle, not pulses. Very good, Tony, very good."

Blood Typing Lab (Day 5)

The laboratory on blood typing is the first activity of the period. Jim reminds students of the purpose of the lab, asks a few students to distribute materials, and lists instructions to follow: sterilize your finger with alcohol, prick the finger with the lancet, put drops of blood on the slides, then ask the teacher to add serum.

> Now everyone will take out, everyone will take out their alcohol pad and their lancet, and don't put your lancet down. Once you get the alcohol pad here, wipe your finger and then shake your hand and like this so you can get blood into that finger. Now if you want me to, I will poke you. You won't feel it when I do it, but you may feel it when you do it. But I'm not saying, you know, that I. . .

The teacher breaks off with this thought. After a ten-second pause the teacher continues, "Now you take, you've got your finger there, you take the lancet and the little notch on the end and you poke your finger like that just like I said. And when you've done that, I will come by and put the serum on for you, okay?" At this point, Margie calls for the teacher. He does not seem to notice her at first. The teacher starts to circulate around the room helping students who are having difficulty poking themselves with the lancet. The teacher notices that several students are trying to poke their index finder. He then stops and announces to the class, "Don't use this finger, use the middle finger." There is then a short pause and the teacher adds, "I'm just telling you that it's easier to use the middle finger, and you'll get more blood out of the middle finger." Margie calls for the teacher once again, but he does not respond. The teacher continues to circulate and help students poke themselves and add serum. The teacher offers to help Suzanne, but she refuses. She later returns to ask the teacher to help her. The students continue to talk very loudly amongst each other. The noise level is steadily increasing.

Margie once again calls for the teacher with no response. Approximately every 10 to 15 seconds, another six students call for the teacher. Obviously he can only help one student at a time, so the students must wait their turn; however, they still continue to call out the teacher's name every few minutes. Some students yell "ouch" when they try to poke themselves. There is a great deal of poking and laughter amongst the class. The teacher is now helping Beth prick her finger. He does this as Beth closes her eyes. He then helps her put a drop of blood on each side of the card. He then adds the serum to each drop. The teacher now moves on to help Catherine.

Tom and Tony, who sit at the same desk, are talking about pricking themselves with the lancet. They seem to be having a tough time. Tom says to Tony, "I didn't think it would be this hard." Tony does not respond. He is fairly involved in trying

to prick his own finger. After a few seoncds, Tom says, "It hurts more to think about it than to actually do it." Margie yells to Tony, "Tony, did you cut yourself?" Tony responds, "No, not yet." The students continue to talk and have a good time. Some of the students try to prick themselves while waiting for the teacher.

The teacher helps students draw their blood, giving the serum to each of the students and identifying the blood types of individuals. Many of the students wait at their desks for the teacher to come around and help them draw their blood. Students appear to be joking and having fun. After 20 minutes of lab, the teacher asks students to clean up their work areas.

TEACHER 10: SAM BENTLEY

by Alexis Mitman

Introduction

The following pages present a summary portrait of Sam Bentley's 7th grade life science class at Whitefield Intermediate School. The first topic was cell structure/genetics, which was introduced in December, 1983 and continued in January, 1984. The second topic was the human circulatory and skeletal systems, which was addressed in May, 1984.

Background and Viewpoints

Sam received a B.S. degree in science from a university in the southern area of the country. He majored in biology and minored in physical science. Sam remained in the southern region to attend a year of medical school. Once decided on a teaching career, Sam attended a university in the San Francisco Bay area, where he received a secondary teaching credential. This credential designated biology as his major and the physical sciences as a minor. Following receipt of his credential, Sam taught science at the high school level in San Francisco for four years. Then he transferred to Whitefield Intermediate School, where he has been working for the last six years. At Whitefield, Sam's typical assignment each year has been to teach four units of 8th-grade physical science and two units of 7th-grade life science.

In an interview, Sam discussed some of his professional acitivities outside of class. His most memorable science-specific experience was a series of workshops he attended at the Lawrence Hall of Science. The purpose of these workshops was to increase teachers' repertoires of hands-on activities for students. Sam noted that he has incorporated many good ideas from these workshops into his lessons, but that carrying out many of the activities as originally specified is unrealistic because they require a great variety and quantity of materials. Along more general lines, Sam mentioned a 5-day workshop on effective teaching that he attended the previous year. He indicated that this workshop was important because it increased his awareness about maximizing academic time. Finally, Sam mentioned the school's annual Science Fair. While the Fair is a 7th grade requirement that receives class time, Sam noted that it still entails a lot of energy and involvement from the science teachers outside of class.

In discussing his view of 7th-grade life science, Sam described three major goals he wanted his students to obtain:

. . .one thing is right up there above the board, which is why it's up there [teacher is pointing to saying that reads "everythingconnectstoeverything"]. The last day of the year they have to write me, tell me what that means. That there's a connectiveness. And I think that's what life science is really about, that things are related and depend on other things. I guess the second thing is that they should feel confident in their own ability to solve a problem. I guess that's really what the Science Fair is about and it doesn't really work for all of them, but being educated really is not when you attain a certain number of facts but when you find a way to find things out for yourself and have faith that you can do it. At this point in school, they have to be told everything and they haven't got that ability. And I think science should give them confidence in their own ability to solve and learn things on their own. And the third thing I guess is just a reasonable amount of facts about life science, in this case. So that they have a good background for other classes of things that they might take.

Sam estimated that approximately 80% of his students begin the year with a great deal of interest and excitement about science. He added that parental attitudes toward science probably are a major factor in determining students' predispositions toward science. Sam also estimated that approximately 75% of his students achieve his three goals to some extent.

When asked about specific kinds of behaviors he liked to see from his students, Sam said:

Well, questions always. This is not something they do, but I try to encourage them being comfortable and enjoying the class. There's always a certain problem there, like they can enjoy it too much and not learn as much, or they can enjoy it with the structure. . . but I don't like to scare them. I like to make them feel comfortable when they come in.

I love it when a student comes in or when a mother comes in or a father and tells me that the student's been talking about something I said in class. Or when they bring in some extra information. Sometimes to some students, it seems like "Why are we learning this?", but other students carry it another step further and, you know, find an application.

Sam listed off-task behavior as the main thing he tries to discourage among students. For examples of off-task behavior he mentioned not bringing books to class, a failure to read lab

directions in the book before starting the lab, not listening to rules and directions, not having things organized, and forgetting to do assignments.

Classroom Description

Sam works in a rectangular-shaped room that forms one outside corner of an older building that used to be a high school. The building has interior closed hallways lined with lockers and doors to the various rooms. The longest dimension of Sam's room runs east-west. One enters his room by going through a door on the south wall, near the east end of the room. The floor of the room is wood and appears well-worn. The walls are painted a light orange color, and the ceiling is paneled with yellow acoustical tiles.

The teacher has a wooden desk in the southeast corner of the room, immediately to the right as one enters the door. In front of the center of the south wall, there is a large rectangular podium desktop that serves as the teachers' lab station. Also it is Sam's main focal location for recitations and demonstrations. A large green chalkboard hangs behind this lab station.

In front of the teacher's lab station are three rows of student desks running in the east-west direction. In addition, there are two columns of desks, one on the west side of the room and the other on the east. Each row or column consists of three large black-top wooden tables that have no storage space. Two students can fit at one table, so that six are accommodated in each row or column. Students seated in the rows face the teacher's lab station; students in the columns face towards the center of the room. Finally, there is one isolated desk in the northeast corner of the room. This desk is occupied by some of the ESL (English as a Second Language) students and a teacher aide.

The perimeters of the room contain a vast assortment of science-related materials and decorations. In addition to the chalkboard, the south wall has a bulletin board with posters, a large periodic chart of the elements, a moon exploration chart, and a ledge with a plant, styrofoam-ball molecular models, and two commercial cellular models. The west wall is occupied primarily by a filing cabinet and two cabinets with countertops and sinks. Different pieces of equipment, including glassware, cylinders, scales, clamps, and test tubes, rest on the coutertops. Above the cabinets, a variety of posters are pinned up; some are astronomical, some show different animals, and others are more "message oriented," like the anti-smoking poster with Brooke Shields and a Smokey the Bear poster. Also there is a door leading to the teacher's supply room along this wall. The north wall is occupied by a large heater, large windows looking out to a street, and four sections of wooden bookshelves. The shelves hold numerous natural specimens, more laboratory equipment, and different journals and books. The east wall is

lined mostly with bookshelves containing papers, books, and other odds and ends. The bookcases are broken up in the center by another sink cabinet and two windows above the sink. An aquarium and plants rest on the cabinet's countertop. This wall has several posters, and the upper ledges of the bookshelves hold more styrofoam-ball molecular models and a large commercial model of a flower and its reproductive parts.

Course Overview and Instructional Strategies

The main textbook in Sam's class is Life Science: A Problem Solving Approach published by Ginn and Company. Selected by the science department before Sam came to Whitefield, this text is described by Sam as mainly a lab book. In an interview, Sam said the book gives "the kids enough information to do the labs and that's about it." At the end of the year, Sam estimated that this book was used in connection with about 60% of his lessons. Sam then indicated a couple ways in which he supplements this text.

First, he mentioned using another text, Life: Its Forms and Changes, published by Harcourt, Brace, and Jovanvich, as one supplement:

> And what I use it for mostly is that it has a lot of pictures, which this book [the Ginn] doesn't. So when I want to show them something and I don't have a model or a specimen or anything, I'll just say, 'Look on this page and do that.' And when we do classification, I have them take notes from the board, using my drawings, and they can see photographs or other things of the animals if we don't have a movie or something involving that, then I have them turn to a page in that book and maybe make a copy of the picture labeling some of the parts.

The second and more major supplementary tool was described by Sam as follows: "In general, what I do is I put the notes on the board and I explain them myself because I think that's necessary no matter what book you use. . . I make my own notes up from a variety of sources." Sam also indicated that he usually makes up his own worksheets and tests.

When asked to characterize the typical organization of his instruction, Sam described it as follows:

> Okay, I would say the material is presented in the lecture, with them taking notes from the board. If a lab is possible for the information that I am doing, then we usually do a lab activity, either from the book or from somewhere else. Or I do a demonstration to illustrate what it is I am talking about. Also, I have a system where I go back and ask questions about material that's already been presented. I'll say, "Remember

yesterday, we talked about atoms," and somebody will tell me what an atom is. Sometimes I'll ask for volunteers if I think it's something that is maybe a little fresh in their minds and they don't really have a good concept of it yet. Other times, I ask them not to put up their hands, and I go around and I ask generally just different kids to find out if they know it or if they're paying attention or whatever. But always we try to have labs with the materials, or if we can't have a lab, something visual, Something besides just me talking. But the responsibility for taking the notes and having the information organized in a notebook is theirs.

Excerpts from Classroom Observations
Topic One: Cell Division and Genetics

Table 1 summarizes the activities in Sam's class as he taught his unit on cell division and genetics. Sam spent a total of 13 days on this unit. For the first two days, which were the last days before Christmas vacation, Sam devoted almost all his time to recitation on cell division. When students returned from vacation, days were typically filled with a greater variety of activities. While recitation still played a prominent role, students completed worksheets, saw two films, and spent time preparing for the final unit test. Also, the largest single activity during the last week, spanning Days 9-11, was the "Gene Monsters" Lab. On Day 13 (which does not appear in Table 1), students took the final unit test.

The teacher did not refer to any textbook during the presentation of this unit. Instead, as indicated earlier, he relied on his own set of notes and lectured from them. Typically, the teacher put the key points from his notes up on the board; students were responsible for copying them down, knowing that they would be graded on the presence of these notes in their Science Notebooks. Except for the "What are Genes?" worksheet, the article on Barbara McClintock, and the "Gene Monster" lab packets, all written materials were developed by Sam.

Teacher Recitation on Phases of Mitosis (Day 2)

It's now 11:30. After having spent some time presenting information about the different numbers of chromosomes in different plants and animals, the teacher focuses directly on mitosis:

"Okay, now in your body, all your cells have to work together, so they have to have the same pattern in your chromosomes. So the first kind of cell division that we talked about yesterday was mitosis, and that creates cells just like the other cells that are there, so they can all work together."

Table 1. Duration of Activities for Topic One (Teacher 10)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
5 min.	Teacher reviews procedures; students copy notes from board	Opening Transition	Opening Transition	Opening Transition	Opening Transition Science World Magazine Passed Out	Opening Transition; Students Copy From Board Teacher
10 min.	Teacher Recitation on Cell Division; Introduction to Mitosis and Meiosis	Teacher Recitation on Chromosomes and Phases of Mitosis	Teacher Reviews Assignments, Due Dates, and Class Rules	Students Fill Out Worksheet, "What are Genes?" Teacher Goes Over Worksheet Answers	Students read Article on Barbara McClintock and Answer 4 Questions About her that are on the Board	Introduces and Shows Film, "From One Cell"
15 min.					Teacher Goes Over Answers to 4 questions	
20 min.				Teacher Guides Class as They Look at Mitosis Slide-Strips in Microviewers	Teacher Recitation on Phases of Meiosis	Teacher Introduces "Gene Monster" Lab for Next Week
25 min.			Teacher Reviews Cell Structure and Stages of Mitosis			
30 min.						Teacher Recitation on Genet'cs Vocabulary Words
35 min.					Teacher Reviews Some Questions that will be on Topic Test	
40 min.	Closing Transition	Teacher hands out ditto and introduces ditto on mitosis phases		Closing Transition		
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL

Table 1 (Continued). Duration of Activities for Topic One (Teacher 10)

Class Begins	DAY 7	DAY 8*	DAY 9	DAY 10	DAY 11	DAY 12
	Opening Transition; Graded Papers Returned, PTC Paper Handed Out; Students Copy Notes from Board	Opening Transition	Opening Transition; "Gene Monster" Dittos Handed out	Opening Transition	Opening Transition; Students Copy Notes From Board	Opening Transition
5 min.	Teacher Recitation on More Genetics Vocabulary Words; Teacher Points out Some Genetic Features on Which Students Differ, Including Test of PTC Paper	Teacher Introduces and Shows Film on X and Y Chromosomes	Teacher Describes Procedures for "Gene Monster" Lab	Teacher Describes next Procedures for "Gene Monster" Lab	Teacher Recitation on Human Dominant and Recessive Traits	Teacher Reviews Procedures for Winding up Unit
10 min.						
15 min.					Teacher Reviews Gene Monster Procedures and Assigns Test Review Sheet	Teacher Goes Over Test Review Sheet With Class
20 min.				Students Continue Work on Gene Monster Lab, Filling Out Dittos as They Work		
25 min.		Teacher Recitation on More Genetics Vocabulary Words	Students Work on Gene Monster Lab, Filling out Dittos as They Work		Students Continue Work on Gene Monster Lab, Filling Out Dittos As They Work	
30 min.						
35 min.						
40 min.	Students Complete FWL Student Class Survey					Students Hand in "Gene ster" Lab
45 min.	DISMISSAL	DISMISSAL	DISMISSAL	Closing Transiton DISMISSAL	Closing Transition DISMISSAL	DISMISSAL

*Duration of activities of Day 8 are approximate.

Laura has her hand raised and the teacher calls on her. She asks, "How often does it happen?"

Sam replies, "Well, there's a lot of variation there. Well, like in a baby it goes very fast. In your body, it goes fast too, but I can't say how fast, like twenty minutes. I can't say that--but fast. You're growing a lot."

Jane calls out, "Is ours faster than yours?"

Sam responds, "Much faster than mine, but does that mean that my body doesn't do mitosis?" (A few students call out, "No.") "It has to because my cells are wearing out and they have to be replaced, okay? Let's continue with our notes, okay?"

At this point, Sam finishes giving students the definition of meiosis that he started yesterday. Then he tells the class that he wants to talk about the stages of mitosis; he tells them he will be making a simplified drawing of each stage on the board. After Sam has made his first drawing, he asks the students whether they think it is an animal or plant cell. Various opinions are offered and briefly discussed in terms of cell structure. The teacher then continues,

> So, we don't really know what kind of cell it is, but I'm going to say it's an animal cell, okay? Okay, some of you, because it was a rectangualr shape, might have thought it was a plant cell. Okay, write this word down. This is the name of this phase, stage, It's called "interphase." (Teacher writes the word next to his diagram.) Okay, have you ever heard your parents say that they think you're going through a phase? (Quite a few students call out "Yeah.") Okay, what they meant is they think you are changing, okay--that you are going through changes and that hopefully you will change fast and get out of that phase, right? Okay, that's what this means too. 'Phase' means changes, and "inter" means between. This is the way the cell looks in between changes, okay? So this is the normal cell. This is the cell that's carrying on all the life activities but isn't dividing. Are your cells dividing all the time? (One student calls out "Yeah.") Well, some are, but some aren't. Some are growing and using food and giving off waste material and doing all the other things. Okay, interphase is the normal or resting cell--this is what the cell is doing when it's not dividing--it is carrying on the life activities though. Sometimes, when I say this, people think the cell isn't doing anything because it's resting, but it just means it's not dividing. (Pause.) Okay, yesterday I had this diagram on the board of the nucleus. What were these parts?

Sam points to three parts of the nucleus in his diagram and calls on three volunteers who answer correctly. Jack first answers, "Nucleolus." Russ answers "Chromatin" next. Then Mack answers, "Nuclear Membrane." Sam continues:

> Okay, this chromatin is what I want to talk about now. Some of you asked if you can see chromosomes. Well, some of the time you can see chromosomes, but probably most of the time you can't, because when the chromosome is not actually in the process of dividing, it spreads the material out throughout the cell, and that's what chromatin is. It's sort of spread-out, dissolved chromosome. Okay, so what I want you to put down, is put down "chromatin" and then in parentheses, put down "genetic material," because that's what chromatin is. Okay, genetic material is spread throughout the cell--- excuse me, not throughout the cell, but throughout the nucleus.

Sam has now written out next to his first diagram, "Interphase - normal or resting - chromatin (genetic material) is spread throughout the nucleus." It's 11:39 and the teacher turns to the class and tells them that he'll wait for them to finish copying this since he'll need the board space to put up the other five stages. Art then raises his hand. The teacher acknowledges him and Art asks, "Is that little dot in there the nucleolus?" Sam responds, "Yes, it is." Art proceeds to ask a few more questions about the parts of the cell, indicating that he is confused about what some of the parts are. The teacher briefly runs through the major parts. The teacher then checks to be sure everyone has the first phase copied down. He then continues his recitation on the remaining phases, going until 11:55.

Students Read Article on Barbara McClintock and Write Answers to Four Questions About Her (Day 5)

Three minutes before the class bell rings, Sam is standing to the left of the doorway with a stack of Science World magazines in one arm, and he's handing one to each student that enters the classroom. A minute before the bell rings, Sam enters the classroom where most students already are seated. He tells the class that they have an assignment on the board and that they are to read an article in the magazine they've just been given. Some students continue to talk to one another. A couple students go up to the teacher individually and ask questions I can't hear. One student apparently is requesting a copy of the magazine. The teacher asks the class if they see an extra magazine anywhere. No one responds. As a solution, Sam asks Melanie and June, who are sitting next to one another in the front row, to share; he then gives one of their magazines to the student.

The following is on the left side of the chalkboard:

"January 5. Please read article on page 8.
Answer these questions:
1) Who was Barbara McClintock?
2) What did she discover?
3) Why is her work important?
4) What honor did she win?
Ten minute limit."

At 11:16, after the bell has rung, the teacher says:

Okay, everbody, listen. At about 25 after, which is about 8 or 9 minutes from now, I'm going to stop you and we'll talk about these questions--but just real briefly. I mentioned this yesterday. I want you just to write down who this lady is, what did she discover and why it is important, and what honor did she win. And the last time we did this [referring to his earlier class], some students said it would be easier just to answer these like in one sentence. You know, like the first one--they said, "Barbara McClintock is blank, blank, blank, blank, and she did this, blank, blank, blank, blank." And that way they can combine the answers, you know, in one sentence. So, whatever is convenient for you to do--but I want you to know that information, okay?

The teacher notices that George has his hand raised and calls on him. George asks what he should do given that his right arm and hand are in a cast. The teacher responds that he should read and think about it anyway, and then copy it from someone else later on.

It's 11:19 and students are all reading or writing. The noise level is low, with individual students commenting to one another only occasionally. Sam begins to walk around the room picking up various supply items; he takes them over to a cart that's near the chalkboard. Next the teacher goes into the supply room, presumably to put some things away. At 11:20, Sam comes out of the supply room and begins to monitor students by walking behind their seats. The room is quiet. As he walks behind the second row of seats, Connie looks up and asks the teacher a question that I can't hear. Sam responds. Sam then walks up to his lab station and takes a rack of test tubes and puts them over on one of the countertops along the west wall. The next several minutes continue in much the same way. The teacher continues to walk around the room, monitoring students, and a few students ask the teacher questions about the assignment. At 11:24, it appears that about half the students are finished writing. Those that are finished generally are sitting quietly at their seats. A few comment to one another and at least one of the students is reading other articles in Science World.

At 11:26 the teacher asks the class, "Have most of you had time to read this now?" Students do not answer and Sam goes on to ask whether most of them have finished writing. A few

students indicate they are still working. Sam responds, "Okay, I think what we're going to do now is we're going to talk about the answers to the questions, and those of you who haven't finished, just listen and write down the information." At this point, Sam notices Doreen, who has been standing very close to his side. She asks an inaudible question, and Sam responds, "Yes." Doreen quickly returns to her seat. Sam continues:

> "Okay, first of all, does somebody want to volunteer and answer for number one? Who is Barbara McClintock?" Mitch has his hand raised and Sam calls on him. Mitch says, "She is an 81-year-old scientist." Sam replies, "Okay, can you make that a little more complete by telling what she studies?" Mitch then says, "She studies genes." Sam accepts this answer by saying, "Good." He then goes on, "Is she doing that work right now? Has she been doing it awhile or. . . ?" Mitch answers again, saying, "Two decades." Sam responds that it actually says four decades. He then asks the class, "How long is four decades?" Russ calls out, "Forty years."

At this point, Sam is again interrupted by Doreen who has walked up to him, and he says something quickly to her and sends her back to her seat. He then continues, "Yeah, the discoveries she's getting credit for she actually made some time ago, but now they're starting to understand the importance of her discoveries. Okay. Number two. What did she discover?"

It's 11:28 and Sam calls on Sally, a nonvolunteer. Sally looks at the teacher and indicates that she doesn't want to answer. Sam tries to encourage her by saying, "Why don't you say what you wrote--I bet you got it right." Sally responds by nodding her head in the negative. Sam calls on Susan, another nonvolunteer.

Susan reads off her paper, "She discovered that the genes in corn don't stay in one place." Sam responds,

> Okay, right. She discovered that genes, particularly in corn, which she was studying, don't stay in one place. We've described genes when we've talked about them in here as little particles that are lined up in a certain order on a chromosome. But according to her, some genes can move, right? Can move from one place to another on a chromosome. So, anyway, the answer to number two is that genes can move from one place to another--that's what she discovered.

Sam continues to review with the class the answers to the last two questions. Students appear very attentive the entire time. This activity ends at 11:30.

Teacher Introduces and Shows Film, "From One Cell" (Day 6)

As students enter the room today, Sam indicates that they should be copying down the genetics vocabulary words and definitions that are up on the board. He tells them that he will need a few more minutes to get the film projector ready. He proceeds to rewind the film and reload it. A few students ask the teacher procedural questions as he is working with the projector. The teacher gives them answers. At 11:19, Sam says:

> Okay, everybody, just listen a moment. I want to tell you something about this film. Okay, this film is called "From One Cell." Okay, and what it does is it starts with the fertilization of a sperm and an egg. Okay, what's the process of cell division that makes a sperm or an egg?

Paul has his hand raised and Sam calls on him. Paul answers, "Meiosis." Sam continues,

> Okay, meiosis. That's where the film starts. The rest of the film talks about how that cell, that one cell fertilized, grows into a human being and also how the body grows and how it repairs itself. What process would that be? Lenny?"

Lenny has not volunteered. After a few seconds, Lenny indicates to the teacher that he doesn't know the answer. Sam then calls on Russ. Russ answers, "Mitosis and meiosis." Sam replies that he only wants one answer and Russ then says, "Mitosis. Sam says,

> Mitosis, yeah. Meiosis makes the sex cells that come together to make a new individual. Mitosis helps that individual to grow and function, okay? Um, I'm going to turn this film off in several places--hopefully, not several, but a few places--and tell you a couple of things about the film, okay? Sally, just wait a minute, okay? [Sally has started to turn the lights off for the film.] A couple of things I want you to pay attention to. They show mitosis in the film, and they go through the stages--up in the corner of the screen they name the stages. We're going to stop there. We're going to go through it once. I'm going to turn it backward and run the film backward so you can see it backwards--just so you can see the stages--then we're going to turn it forwards again so you can follow through with it, okay? Another thing about this film. It was made by the American Cancer Society and the whole last part of this film is about cancer. We're not really studying cancer although we mentioned it, but I'm not going to show you probably the last four minutes of the film, okay? But if you pay attention to the first part, I think you'll see it's a review of what we've done so far. Um, if you haven't copied down

all the words, you can get them when the film's being rewound [referring to the vocabulary words on the board].

As Sam finishes this introduction, Art calls out that he needs the notes from yesterday because he was absent. Sam tells Art that he'll have to borrow them from someone to copy them. Lenny calls out that he's willing to lend Art his, but Art doesn't appear to hear Lenny.

It's now 11:22 and Sam indicates to Sally that she can turn out the lights. Sam turns the film on. After the title of the film appears, the film shows a young girl looking at a variety of animals in a zoo. The film narrator is saying that even though there are many life forms on earth, they all have in common a basic building block, the cell. The film then shows one diagram of a cell followed by animation showing the cell intaking food. As this occurs, Sam calls out, "What's that structure moving around in there?" Several students call out answers, but they are difficult to decipher above the noise level of the film. Sam ends up finishing his own question by saying, "Vacuole." The film goes on to describe and animate the cell dividing and resulting in an identical copy of itself. As this happens, Sam calls out, "What process is that--meiosis or mitosis?" Most students call out, "Mitosis," and Sam confirms this.

It's 11:24 and the film narrator goes on to say that each human being begins with the fertilization of an egg by sperm and that this combination is called the zygote. Sam is walking around the room during this portion of the film. Most students appear attentive to the film, and there is occasional chatting between some students sitting next to one another. When the teacher walks near Doreen, she raises her hand. She asks an inaudible question and Sam responds. Sam then goes up to June and says something to her. The film now is communicating that the zygote cell undergoes cell division using the code contained in the chromosomes via DNA. Then there is an animated segment illustrating the division of the zygote into eight cells. Sam stops the film at this point and tells the class he's going to run it back. He also tells them to pay attention to what the chromosomes are doing and the name of the stage. Sam, thus, plays this film segment backwards and then lets the film go forward again, without interruption.

The film goes on to indicate that after many cell divisions, a hollow ball of cells is formed. These cells then specialize into different kinds of tissue and body parts, probably through some code in the DNA, but the process isn't fully understood. At this point, the film shows footage of a new baby. The narrator says that the baby continues to grow by mitosis, the same cell division process that occurred in the zygote. The film goes on to show animation of a young child's body. Several examples are given of specialized cells, namely muscle tissue and bone.

It's now 11:26. Sam lets the film run until 11:34. Students appear attentive until the end of the film.

Students Work on "Gene Monsters" Lab (Day 10)

Today is the second day that the major activity is the "Gene Monsters" Lab. For the Lab, each student received a 9-page dittoed pamphlet which contained directions and worksheets. The first step of "Gene Monsters," which was the assignment yesterday, is to flip a coin to select one of a pair of genes (dominant or recessive) from a list of 20 characteristics (e.g., long or short arms), one list for each parent. Then the chosen genes are combined to make a new list of the characteristics of the offspring. Templates of the various alternative characteristics are provided, and students proceed to trace and color their first offspring "gene monster." Today, the assignment is for members of the class to pair up, and to breed their first gene monsters with one another to produce two offspring each. At 11:20, Sam is continuing to give directions. He says:

> You can choose, you can mate your monster with whomever you wish. Anyway, the monster that you choose for that, you will put in this column right here. [He is pointing to the right-hand column on the page he is holding up.] Okay? You'll put it in this column right here. Okay, then you'll follow the same method as you did yesterday. You'll flip a coin for each pair of genes because you have to choose whether the one on the left or the one on the right will be contributing to the baby. Okay, does that make sense? Do you understand? (At least one student calls out, "No" at this point.) You list your gene monster's genotype, you list somebody else's gene monster's genotype and you flip a coin to find out which genes the baby monster will get, okay?

It's 11:21, and Sam continues:

> Okay, this is what I'd like you to do today. I would like each of your monsters to have two children--two, two. The way you have two children is you do this--okay, you have a column in the middle here for a new gene monster, right? Just do that once and you'll have one monster, right? And then go through the same process again. Just make another couple of blanks there, okay? That's not hard to do, so you'll make two monsters today. That means--Walt, are you and Eric together today?--okay, if you and Eric are going to work together today, that means that you would make two, and he would make two. Between the two of you those two monsters would have four children, right? Does that make sense? Yeah, and then you'll draw them. I brought in some crayons here, so if you need colors today while you're doing it, you know, just come up and get them. Just make sure you put them back when you're done.

Sam continues to elaborate on the directions for another couple minutes. During this time, a few students ask questions, and Sam responds. At 11:24, he tells the class that that's all he has to say and that he will stop them about five minutes before the period ends. Sam then starts to walk away from his lab station. As he does so, Doreen immediately comes up to him and asks an inaudible question. Sam responds, and as he finishes, Laura calls out, "Can you breed your gene monster with its baby?" Sam responds, "I guess you can." Sam then walks over towards the east side of the room and talks to Walt. Then the teacher aide walks up to Sam and they have a brief conversation.

Looking around the room now, some students are walking around to one another, looking at each others' monsters. Presumably, they are seeking the partners with monsters that they would like to breed with. The noise level is moderate. Sam walks back to his lab station. While he is there, Lenny comes up to him with a question, and then Jack follows him. Their exchanges are inaudible. June stands up and walks up to the lab station and takes some crayons out of the box sitting there. Laura has moved to work with Doreen and they're sitting across from one another. Several other students are rapidly asking Sam questions while he is in the vicinity of his lab station. Then Chuck calls out in a loud voice, "I don't get this. I think we're doing it wrong." Sam starts to walk over to Chuck, indicating to several other students that he'll get back to them later. Sam then stands inbetween Chuck and Mitch and listens to their questions. I don't hear the questions clearly, but Sam ends up running through the basic directions again, telling them to copy down their own and their partner's genotypes in the columns and then to toss the coin to determine what their offspring will be like. He also indicates to them that they will each have a different offspring by virtue of the coin tossing. As Sam explains this, Jane and Lenny are waiting nearby. Jane and Lenny never end up asking Sam a question, but just stand there listening. As Sam finishes up with Chuck and Mitch, he turns around and tells Art to sit down.

It's 11:27 and Russ has his hand raised. Sam walks over to him and they converse. Then Laura has her hand raised, and he goes over and answers her question. Jack and Lenny are standing together nearby, and Sam asks them whether they have a question. They reply that they don't. Then Ralph raises his hand and Sam walks over to him and provides assistance. Next, Sam starts to walk towards his lab station, but he stops behind Art and George's seats on the way. Sam asks them what's going on, and he spends a short time talking with them. Larry then looks over and sees Sam and tells him that he needs a coin. I believe Sam provides one. Jane then comes up to Sam with a question. When he has answered Jane, Sam walks over to the table with the teacher aide and appears to be assessing the progress of the ESL students.

It's 11:30. Both Jane and Susan stand up and move over to where Sam is standing. The teacher deals with their inquiries

for awhile. I would now characterize the noise level in the room as moderate. Looking around, some students are tossing coins while others are writing and tracing. Still others are conversing with one another or appear to be waiting for help. While Sam is still in the east corner of the room, June walks up to him with a question I can't hear. The teacher responds and then moves toward the first row of seats. As he passes Sally, he asks whether she's doing okay. Then he says, "Let me see your monster." Sally shows it to him and he indicates approval. Sam then walks to his lab station and looks at what Mitch is doing. Sam then notices Dean sitting next to Mitch, and he asks Dean whether he understands this. Dean indicates that he does. Sam moves down this row to June and looks on at the whole group of girls, which includes Melanie and Connie. Sam then starts circling the room again, going towards the back. As he passes Mitch and Chuck, they again ask him a question. I don't hear it, but the teacher responds that you make one baby first, and then, if you have time, you make a second one. As Sam is finishing saying this, June comes up to the teacher. She asks a general question about what to do next, and Sam tells her that she should find someone to mate with.

This activity continues in much the same fashion until 11:57, when Sam asks the class to finish up what they're doing and take their original seats.

Excerpts from Classroom Observations
Topic Two: Human Circulatory and Skeletal Systems

Sam devoted 10 days to the unit on the human circulatory and skeletal systems. Table 2 summarizes the activities during this time. Sam introduced the unit on Day 1 by presenting the functions of all ten major systems in the human body. After this, he focused first on the circulatory system, devoting parts of the next four days to recitations about it. On Day 6, Sam devoted a good portion of the period to a recitation about the skeletal system. On Day 7, students formed groups and rotated around the room to nine different activity stations. Six of these stations had materials about the circulatory or skeletal systems (the remaining three had more to do with the digestive system, a topic the teacher never had time to develop). Days 7 through 10 were devoted to some combination of test review and/or testing.

There are two aspects of this unit worth further mention. First, this unit was addressed during the last two and one-half weeks of school. This probably accounts for why Sam devoted some blocks of time (see Days 5 and 6) to clarifying exactly how the remaining days of the school year would be spent. It also accounts for the occurrence of the FWL posttest on Day 8. Another interesting aspect of the scheduling is that assignments on the circulatory and skeletal systems were discrete but overlapped in their timing. For example, the largest assignment students received was "Edna," the piecing together and labeling of a dittoed

Table 2. Duration of Activities for Topic Two (Teacher 10)

	DAY 1	DAY 2	DAY 3	DAY 4*	DAY 5	DAY 6
Class Begins	Opening Transition; Teacher Reviews Activities for the Day and Assignment on the Board	Opening Transition	Opening Transition; Teacher Previews Directions on Board	Opening Transition; Students Copy Notes on Board	Teacher Describes Activities and Procedures for Next 1 1/2 Weeks	Graded Papers Handed Back From Last Unit; Teacher Goes Around and Grades "Edna"
5 min.		Students Copy Down Notes on Circulatory System from Board	Student Seatwork Labeling a Dittoed Heart Diagram, with Text as Resource			Teacher Reviews Ditto Listing Assignments for next 2 Weeks
10 min.	Students Take Test on Previous Unit, the Frog System	Teacher Hands Out 2 Dittos and Assigns "Edna" as Homework	Teacher Recitation on Parts and Functioning of Heart, Providing Answers to Ditto; Teacher Gives Additional Directions	Teacher Recitation on the Composition of Blood	Teacher Orally Quizzes Three Rows on Circulatory System	Teacher Recitation on Sample Quiz Items
15 min.		Teacher Introduces Part of Film, "Mr. Hemo"				
20 min.					Teacher Recitation On Blood Types	Teacher Reviews More on Assignments
25 min.	Students Fill in Seatwork Ditto on Human Systems, Using Text as Supplement		Teacher Shows Second Part of Film, "Mr. Hemo"	Students can Look at Bone Sample DISMISSAL		Teacher Recitation on Skeletal System
30 min.					Teacher Prepares to do Blood Test Demonstration	
35 min.					Blood Test Demonstration With 2 Volunteers DISMISSAL	
40 min.	Teacher Previews Unit Activities					
45 min.	DISMISSAL	DISMISSAL	DISMISSAL			DISMISSAL

*Minimum day.

Table 2 (Continued). Duration of Activities for Topic Two (Teacher 10)

	DAY 7	DAY 8	DAY 9
Class Begins	Teacher Hands Out Test	Opening Transition	Teacher Gives Directions for Test and Reading Science World; Hands Test out
5 min.	Students Take Test on Human Systems		Students
10 min.	Teacher Explains Lab Procedures: Rotating to 9 Activity Stations		Take Test on Circulatory
15 min.		Students Take FWL Posttest	System; Read Article in Science World if finished early
20 min.	Student Lab, Rotating in Groups to 9 Activity		
25 min.	Stations on Human Systems	Teacher Recitation; Reviewing for Test On Circulatory System by Orally Quizzing Students	Teacher Recitation; Reviewing for Tomorrow's Test on Skeletal System
30 min.			
35 min.			
40 min.	Students Complete FWL Student Survey		Teacher Describes Film He'll Show Later this week
45 min.	DISMISSAL	DISMISSAL	DISMISSAL

diagram of the human skeleton. This was assigned as homework on Day 2; Sam did not lecture on the skeletal system until Day 6. Testing also fit this pattern. Sam broke the testing on this unit into three pieces, one on the functions of the ten human systems, one on the circulatory system, and one on the skeletal system. The human systems test was administered on Day 7. Reviews for the test on the circulatory system took place on Days 5 and 8, with the test occurring on Day 9. A review for the test on the skeletal system took place on Day 9, with the test occurring on Day 10 (not shown in Table).

As was the case with Topic 1, Sam did not rely on a textbook as a major resource for this unit. He did use the supplementary text, Life: Its Forms and Changes, for some seatwork assignments where students worked from the labeled diagrams of the human systems. Also, while some dittos that Sam used were based on commercial sources (e.g., "Edna"), many were developed by Sam (e.g., all three tests). As always, Sam relied on his own set of notes for his recitations.

Teacher Orally Quizzes Three Rows on the Circulatory System (Day 5)

It's 11:26 and Sam tells the class that they will now have the "quiz" that he told them about yesterday, where each of the center three rows of students will be responsible for telling the class about one aspect of the circulatory system. In preparation, Sam takes the large plastic model of the human heart from the back of the room and carries it to the counter top of his lab station. Sam then says that he believes he asked the third row to be able to label the parts of the heart. He asks them how many of them think they can do that. I believe everyone raises their hands. Sam then asks June if she wants to do it, and she indicates that she does. As June walks toward the front lab station, Sam reminds the class that it might be them doing it, and if they want to, they can work in groups. At this point, June looks back to her row and sees Connie, who is saying that she wants to come along too. June indicates her agreement, so Connie walks up to the front of the room to join her.

Standing near the back of the room, Sam reminds June and Connie that they are just to say the chambers of the heart. The noise level of the class is moderate as the two girls work on holding up the model so that the class can see it. June then begins in a very soft voice, saying that the two bottom chambers are the ventricles. Sam asks her which one is the right and which one the left, and June indicates the opposite of what is correct. Several students correct her, and she goes along with them. Sam then asks her what the two upper chambers are called, and she correctly answers the left and right atrium. He then asks June what the big red tube is coming from the left side of the heart. June says she doesn't know, and Sam calls on Chuck, a nonvolunteer from June's row. Chuck says, "The aorta," and Sam indcates he is right. Sam then calls on Mitch, seated next to

Chuck, and asks him what the large blue tube is going into the right atrium. Mitch answers in a hesitant voice, "The pulmonary." Sam responds that that's not right, that instead it's the vein from the upper part of the body. Sam then walks up to the front of the room and says, "Good, girls," indicating that June and Connie can return to their seats. Sam then picks up the model and says:

> Okay, one more time. Okay, look [as he points]--right atrium, right ventricle, left atrium, left ventricle--the aorta carries blood away from the heart--the aorta, veins, pulmonary--because it goes to the lungs, and so forth. Okay, the second group is going to tell you, is going to trace the path of blood, right?

It's 11:28, and before Sam even has the chance to designate any students from the second row, Laura and Doreen stand and move towards the front of the room. Doreen holds up the model, and Laura begins to speak immediately, but she is interrupted by members of the class who indicate they can't see clearly. In response, Doreen steps back further and holds the model up higher. Laura begins again:

> One of the blue veins goes into the right atrium from the body, bringing the red oxygenated blood--settle down, Art--then it goes into the right ventricle, and it is squeezed out into the pulmonary artery--which goes to the lungs and gets oxygen and comes back through the pulmonary artery into the right--left atrium and goes into the right--I mean left--ventricle and is squeezed out into the rest of the body.

Sam responds,

> Okay, that's it. There was only one little mistake, and it wasn't a very big one. It's that when the blood comes back from the lungs into the atrium there, it's red, but it's in a vein, not an artery. Because if it goes towards the heart, those are veins even though it may have, in that one case, oxygenated blood. Okay, thanks, that was real good. Okay, now, the front row was going to do what? You were going to talk about the different parts of the circulatory system, right? Okay. Any volunteers?

It's now 11:30. Mitch raises his hand and the teacher calls on him. He starts to stand up, but Sam tells him he can sit down and talk. Mitch starts by saying that the pupose of the heart is to pump blood through the body. He goes on to say that the arteries carry blood away from the heart and that the veins carry used blood with carbon dioxide away from the cells back to the heart. Sam then intervenes and asks Art to define the capillaries. Art says the capillaries are where the arteries and veins meet. Sam responds, "Okay, but what happens there?" Art indicates he doesn't know. Sam pauses to give Art a little

time, and then surveys the row as if deciding who else to call on. Meanwhile, George, who sits in the second row, has gotten out of his seat and moved up to an empty one in the front row, waving his hand enthusiastically for the chance to respond. George's actions provoke laughter from many students. Sam tells George he's only going to call on people from the first row and asks him to move back to his seat. George complies. Sam then calls on Paul, who answers with some hesitation that capillaries are where the blood comes into contact with the cells. Sam then says, "Okay, one other part that you guys left out. What's a real important part of the circulatory system that you didn't mention?" Several students call out various answers, including, "The brain," and "The lungs." Sam tells the class that the answer he was looking for was "The blood." It's now 11:32, and the teacher makes a transition to a recitation on blood types.

Teacher Recitation on the Skeletal System (Day 6)

It's 11:34, and after a brief pause, Sam asks everyone to get out the skeleton ditto that was handed out last week. He holds the sheet up and says, "On the back of this sheet are our notes on the skeletal system, which we're going to cover right now. We're going to do this all this period. Um, what we cover today will be what your test will be on a week from today, okay?"

At this point, Sam goes to the side of the room and picks up a small skeletal model that's about one and one-half feet in height, suspended from a pole over a pedestal. As he's carrying this back to his lab station, students are chatting, and some are asking the teacher questions. Art, for example, asks Sam whether they will have a diagram on their test that's like the one on their ditto. Sam responds that they will and that they will have to label it in much the same way. Then Chuck asks whether they have to keep "Edna." Sam responds that he wants it in their notebooks and that all they have to do is fold it up and place it there. Sam then continues:

> Okay, everybody. I hope you learned a little from Edna--Edna is a good thing for you to use as a study guide because you can point out the bones. There are two ways to study for the test on the skeletal system. One is to study with a friend, using Edna. The other is to study with yourself, using you. It's always good to learn the parts on you. See, I've got all my parts right up here [he's pointing to the T-shirt he's wearing, which has a skeletal diagram on the front and back]. Um, I'm not Mr. Edna, either. This is Mr. Edna right up here [pointing to skeletal model]. His name is Huey. Yeah, this is Edna's husband, Huey.

At this point Jane asks something about the coloring of the model, referring to the blue parts of the rib cage. Sam responds that he didn't put the blue there--that it's there to represent cartilage. Next, another student makes a remark that's inaudi-

ble. Then Art raises his hand. Sam calls on him and Art asks another question about what the test on the skeletal system will be like. Sam responds that there will be a diagram of the skeleton and a list of the actual bones and that they will have to match the words to their correct location on the diagram. Sam wraps up this topic by saying, "It's easy, you'll see." After a few more remarks from students, Sam continues:

> Okay, let's just real quickly run through the bones. Look at that diagram and let's see if you are aware of where the arrows are pointing to. Uh, we have a few bones here that we can use to help us. (Sam, at this point, pulls out a rubber dishpan which is full of bone fragments.) Anybody see 2001 on TV last night? (Several students call out "Yeah.") Okay, so you know what this is for [holding up one bone joint as if it were a club]. So be quiet and listen. Okay, the first thing, I think,--I'm just going to use Huey rather than this diagram You can refer to your diagram, and I'm going to try to go over all these bones, but I'm going to try to do it fast since we have other things to do as well. Okay, first of all, the whole area that I'm holding right here is called the what?

It's 11:35 and several students call out, "Cranium," while some others call out, "Skull." Sam goes on, "The skull, okay, the skull, It's actually made up of a lot of different bones, but I'm only requiring you to know three--two bones and one general area. What do you call the general area right here? Okay, Chrissie?"

Doreen has volunteered and she answers, "Cranium."

Sam responds, "Cranium, okay. Let's see. Um, Loni, what do you call the upper jaw?"

Loni is a nonvolunteer and she hesitates for several seconds. Sam says, "Look on your notes." Sam gives her several more seconds, but Loni still doesn't answer. Then a couple students start to say the answer softly. Loni finally responds, "Maxilla," and Sam corrects her pronunciation by repeating the word. Sam then says, "Okay, the lower jaw, Evan, is what?"

Evan also is a nonvolunteer. Evan hesitates and then says something I can't hear. Sam reacts as if it's a wrong answer and helps by saying, "The lower jaw is the mandible. Okay, so just go quickly everybody--I want you to do this on youselves, okay? Okay, we're all going to look silly today, okay? Do this [pointing to top of his skull]. What's this?"

Most of the class calls out, "Cranium," and Sam goes on to point to the two sections of his jaws. Again, students call out, "Maxilla," and "Mandible." Sam goes on, "Okay, now, moving down. Okay, everybody in here knows what these are. These are [pointing to his chest]..."

Sam's sentence is completed by several students who call out, "Ribs." Sam goes on, "Okay, now what about right here [pointing to himself]?" A couple students call out, "Collarbone," and yet another says, "Clavicle." Sam says that collarbone is the common name for it, but that clavicle is right. Sam then directs the class to grab that particular bone on themselves and to repeat the word several times. The class says, "Clavicle," in unison a couple times. Sam then adds that there won't be any collarbone on the test, so they will have to know clavicle.

Sam continues his recitation, working his way through the skeleton until 11:50. He then uses the remaining 10 minutes of class to point out the most important information on the back of the skeleton ditto--e.g., the three kinds of joints, the definition of cartilage.

TEACHER 11: WENDY JOHNSON

by John Mergendoller

Introduction

In the following pages I present a portrait of Wendy Johnson's 7th grade life science class at Camino Middle School. The first set of observations occurred in January, 1984 when she was teaching the class about the different ecosystems found in North America. The second set of observations was conducted in April, 1984. At this time the class topic was bacteria and viruses.

Background and Viewpoints

While taking courses for her BA in education from a university in the Pacific Northwest, Wendy also majored in social science. She then travelled to the Bay Area and took the courses required to receive the California K-8 credential. After teaching elementary school for 12 years, she is now in her third year of science teaching. Since moving from elementary to middle school, Wendy has taught both physical and life science. This year her assignment includes three life science classes, one physical education class, and sponsorship of the student council.

In school and out, Wendy is extremely active. As sponsor of the student council, she is responsible for all talent shows, dances, fund raising, and any other non-athletic activities designed to promote school spirit. She is a pilot and has been active in a local flying club. As an avid skier, she spends several weekends a year in the Sierras. On a more academic note, she has accumulated 70 hours of inservice credit since migrating to California.

Wendy describes life science as a very personal course; students are naturally curious, and they can see how science applies to their lives. Her students are drawn from five different elementary schools and demonstrate tremendous variation in their science knowledge. As she put it: "You start mostly at zero; eighty percent of them don't have a really strong science background."

During her interview, Wendy expressed multiple expectations for her students: she wants them to realize how science applies to their own lives, and how it is a part of current events. In addition, she hopes they will become familiar with the science content she covers: "If they've got some idea, when they take biology again in high school, they can recall it and say, 'Oh yeah; I remember studying about that.'" At the same time, she is concerned with developing positive attitudes toward science:

I'd like them to have a good feeling about science, so that they don't go into eighth grade saying, "Oh, science [grimaces]." There's a lot of kids that don't like science, and it's interesting. So if I can make it interesting so that later on in life they want to pick up a magazine or want to read an article, then I feel like I've accomplished a lot.

After teaching elementary school, Wendy was struck by the different developmental characteristics of the early adolescents she works with in middle school. Rather than "clinging" to the teacher, and being concerned with the teacher's approval, middle school students were concerned with the approval of their peers. With this is mind, Wendy tries to create a classroom atmosphere that is encouraging and conducive to learning. She notes:

There's an awful lot of peer pressure in the seventh grade, and at the beginning of the year, they are very inhibited about volunteering any information because somebody might make a comment--a putdown. Boy, that'll shut them up for a long time. So I'll try to call on anybody that volunteers and make it pretty clear at the beginning of the year that if somebody makes a negative comment that we just don't appreciate that. . . If students give me a wrong answer, I'll make an effort not to tell them it's wrong. I'll say, "You're thinking. You're close, you're thinking. Alright, let's let somebody help you out," and it's not a negative kind of thing, so students might want to volunteer again to give me an answer.

Wendy changes her curriculum slightly from year to year, dropping or modifying activities and discussions that did not "work" and adding new material. She is constantly looking for movies, filmstrips, and activities to supplement the text book.

I get bored teaching the book all the time . . . so I need to add something to the class. I find that in a 45 minute period you only get two if not three things covered. So we'll read for 15 minutes, then they'll do some writing for 15 minutes, and the last 15 might be a filmstrip or a movie or something else . . . But to read the whole hour or to have them write the whole hour on just one thing--it doesn't work. If you're going to survive, if the class is going to work, then you've got to be able to come up with something creative.

At the same time, she varies activities to maintain her students' attention; she is concerned with providing effective instruction. She has developed a system to help students master science content. She uses advance organizers to orient students to the main points the text discusses, and makes up a study aid for each chapt

I found that what I have to do is to write a study sheet [to complement the questions at the end of each

textbook chapter]. Students just don't have the study skills on how to pick out the important facts, so what I do is more or less outline the chapter, go through the chapter and ask some questions page by page, and that helps them to do a lot better on the tests.

Classroom Description

Wendy's classroom measures approximately 20 by 40 feet, and contains five rows of seven desks. These face the front of the room which is identified by a flag, a chalkboard, movie screen and a demonstration table with gas jet and sink. A low shelf lines the left-hand wall of the room; pictures of animals are affixed on the bulletin board above this shelf. A sink, phone, and file cabinets occupy the front left side of the classroom. One row of desks is placed along the right wall. Above the desks are posters describing various parts of the human body. A teacher's desk sits in the rear right corner of the room, and provides a place for the student teaching assistant to work. Bookshelves, stacks of extra credit assignments, and lined paper for class use appear at intervals along the circumference of the room. Thirty to forty large format books illustrating various scientific topics and a number of old science textbooks fill the bookshelves. In one corner, an "Incentive Chart" displays colored dots by the names of students who have turned in all their homework each week. There is also a school calendar with student events ("Christmas Dress Up Day" "Secret Pals Day") noted, and a list of Class Rules. The class rules read: "1) I will listen quietly while others are speaking without interrupting; 2) I will raise my hand and wait to be called upon before speaking; 3) I will not cuss, put down others or make sound distractions; 4) I will keep my hands and feet to myself; 5) I will not throw any objects in the classroom; 6) If I need to get out of my desk, I will do so without disturbing others; 7) I will not chew gum in class; 8) During study time, whispering will be the acceptable noise level for our room; and 9) I am responsible for my actions, so I will think before I act." Without being chaotic, the room has a pleasant but somewhat disordered air.

Course Overview and Instructional Strategies

Wendy uses the Silver Burdett textbook, Life Science (Richardson, Harris & Sparks, 1979). Rather than simply moving through the chapters, however, she rearranges some of the topics so they fit with the school's vacations. She begins at the front of the book with Human Body Systems, and moves on to ecology and the environment just before Christmas. When the new semester begins in January, she begins the discussion of animals and plants moving from simple to complex animals, and then follows the same evolutionary progression with plants. The year ends with several weeks of drug and sex education--two topics mandated

by the state of California for coverage during the seventh-grade year. Wendy builds her lessons around the testbook. Typically, it takes a week to cover one chapter. During this time students read and discuss the chapter out loud in class, and complete a study sheet that she has provided as well as the exercises that appear at the end of the chapter. The textbook provides a list of words that students must define, review questions based on the content of the chapter, and a set of questions that require students to apply what they have learned. Depending upon the nature of the topic and the availability of supplies and audio-visual materials, students may be assigned a laboratory activity or see a film or filmstrip in addition to working with the text-book.

To ensure that students understand the science content appearing in each chapter, Wendy takes tight control of students' attention, and orchestrates blocks of both oral and silent reading. At the beginning of these blocks, she informs the class what they will learn from reading the text. She then moves from explaining the general theme of the reading to focusing down on the meaning of each paragraph. Before calling on students to read, she asks orienting questions or gives specific directions (e.g., "Read to find out why the forest is like a ten story building." "Are protists plants or animals? Read to see what you think.") Wendy then calls on a volunteer to read a paragraph of the text. At the conclusion of each paragraph's reading, she asks the students questions to make sure they understood what they have just read, and to "help them recall a bit more of something they ought to know." At this time she also makes additional comments and seeks to connect the science content just covered to the daily reality of the students' lives.

When the class has completed reading and discussing each chapter, they complete the exercises at the end of the chapter. This is followed by a test. Wendy uses the test questions supplied with the textbook but supplements them with questions taken directly or paraphrased from the study sheet she has prepared.

Excerpts from Classroom Observations
Topic One: Different Environments of Living Things

Table 1 summarizes how Wendy taught Chapter 23, entitled "Different Environments of Living Things." She spent 6 days on this topic, and during this time mixed reading and discussion segments with written seatwork or audiovisual presentations. On Day 3, she organized a game during which students used the facts they had written the previous day about tundra, deserts, grasslands, and coniferous forests to quiz other students who had completed the same reading. On Day 6 (which does not appear on Table 1) students took a test on Chapter 23. Illustrative examples of the instructional segments follow.

Table 1. Duration of Activities for Topic One (Teacher 11)

Class Begins	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
	Opening Transition	Opening Transition	Opening Transition	Opening Transition Teacher Corrects Vocabulary Words Orally	Opening Transition
5 min.	*				
	Students Read and Talk About Text pp. 420-426 (Tundra and Deserts)	Students Read and Talk About Text pp. 426-432 (Grasslands and Coniferous Forests)	Students Call on Other Students And Ask Them Questions Based on the 20 Facts Recorded Yesterday	Students Complete Review Questions and Study Sheets	Teacher Corrects Review Questions and Study Sheets Orally
10 min.					
20 min.					
			Students Read and Talk About Text pp. 432-436 (Deciduous Forests)		Students Watch Synchronized Slide and Audiotape Presentation On Adaptation
10 min.	*				
	Students View Filmstrip: Ecology Prairie	Students Write 20 Questions About: Tundra Deserts Grasslands Coniferous Forests	Students Write the Definition of Vocabulary Words Appearing on p. 436 of Text	Students Complete Survey	Teacher Lectures on Grunion
0 min.					
8 min.	DISMISSAL	DISMISSAL	Obs. talks to class DISMISSAL	Obs. talks to class DISMISSAL	DISMISSAL

*Duration of Activities on Day 1 are Approximate

Reading and Answering the Teacher's Questions (Day 2)

It is 10:15. The teacher has completed her administrative chores at the start of class and looks up from the demonstration table. She addresses the class in a clear voice that indicates that the business of the period is about to begin:

> Okay, yesterday we began reading about biomes. The first section was tundra and the second section was deserts, and I showed you a filmstrip on grasslands. Today we're going to start talking about the grasslands and other biomes. I think I told you yesterday that we were going to start writing some facts about the different sections, so as you're reading these sections you might want to keep in mind some of the facts that you're going to jot down later on so you can say, "Oh, yeah. I remember that. I remember that." Okay, let's go to the grasslands on page 426.

There is a rustle of pages as students open their books and find the correct page. Wendy calls on a girl, and indicates that she is to begin reading at the heading marked "Grasslands." There is some talking, some ving about, but generally the students are paying attention. I would estimate they are perhaps 90% on task. The first girl finishes the paragraph, and then Wendy recognizes Brad Jones who begins to read somewhat slowly and carefully as if the words were a little difficult for him to read. He makes mistakes on the first sentence and says that the grasslands cover most of Central America and then corrects himself and says "South America." He makes a similar mistake a few lines later and says "Central America" instead of "Central Canada." Wendy does not respond to these errors.

When Brad finishes reading, Wendy addresses the class: "All right, if you look on page 427, where that orange area is, what states would be in that area?"

One boy raises his hand, receives a nod from Wendy, and he calls out, "Texas." Wendy says, "Okay." Another boy shouts, "Minneapolis." Another boy raises his hand, and is recognized by the teacher; he says, "Indiana and part of Idaho." The teacher responds in a hesitant voice, "I think you're a little over to the west; keep trying." Other students say, "Oklahoma" and "North Dakota." Wendy asks rhetorically, "And under that would be what?" A student responds, "South Dakota." Several students call out "Montana," and then one says, "Colorado and Wyoming." Wendy asks the class, "What state is underneath South Dakota and above Oklahoma?" One boy says, "Nebraska." Another calls out, "Tennessee." The teacher accepts both answers and says, "Those are the areas they're talking about." (During this time, the teacher has been involved in a cat-and-mouse game with Steve Gilbert who throughout his recitation has been smiling and talking with Jamie Lewis. Steve has been consistently fiddling with a book that is open on his desk next to the text. Finally,

Wendy comes over, reaches down and takes the book away from Steve.)

With calm restored between Steve and Jamie, Wendy asks the class which side of the grasslands receives the most moisture, the west side or the east side. One boy calls out, "Wisconsin." Several students chant, "East, East." Wendy accepts their answers and says:

> In the east side would be parts of Nebraska and Kansas. If you're travelling across Kansas, that is from the left side in your book, the west side to the east, you'll find that it starts out very dry and then things grow better on the eastern side because it's wetter. One side is called the prairie, and the other side is called the plains. Which is which?

Wendy calls on Drew who responds, "The prairie is wetter and on the, uh, east." Wendy reinforces his answer saying:

> Yes, that's right. The prairie is the drier side and with part of Wyoming and part of Nevada and part of Colorado; then you're in what they call the plains, and the wetter area is what they call the prairie. When you hear somebody talk about that, now, you'll have some ideas of what they're talking about.

She then instructs the class:

> Read page 427 to yourself and find out what kind of soil there is in Nebraska. Is it good soil, bad soil? Find out why and find out what sod is and what it's used for.

The time is 10:20. Approximately 95% of the students appear to be reading quietly. Wendy is also reading the book. No student conversations are audible, although some students are tapping their desks.

Students Quiz Other Students about Biomes (Day 3)

After spending several minutes taking care of administrative details, and talking with several students at the front of the room, Wendy begins the class at 10:15 by informing students that the first activity will use the 20 facts or statements they had written yesterday. She explains that they are to take one of their statements, turn it into a question, and ask another student the question. If the respondent gives the correct answer, then he or she has the right to ask someone else a question. If not, the questioner asks other students until a correct answer is obtained. Wendy then tells the class to take out the 20 statements and select and mark the statements they think are best. With some confusion, students pull lined sheets of paper with their statements on them from backpacks and notebooks and begin

to read over what they have written. Wendy circulates around the class answering questions. She tells one boy, "You haven't been listening," and then explains to him what he is to do. She answers several other students' questions, and then begins to return to the front of the room. There is a fair amount of noise at this time, as students ask each other what they are to do. Although Wendy's instructions were clear, she gave them before she had captured everybody's attention. As a consequence, roughly 60% of the students appear to understand their task and are quietly making marks on the papers in front of them. The remainder of the students appear confused.

The teacher reaches the front, turns around and addresses the class:

> "All right, we're going to assume then that most of you have your statements marked off. You're going to read your statement, and if someone answers it with the right answer, then they get to read theirs. We'll do this until everyone has a chance.

Wendy calls on Connie who is not yet ready, and then calls on Jon. Jon is ready, and he reads from his paper: "It stretches across the entire northern part of Canada." Wendy responds, "If anybody knows the answer, raise your hand, and I'll call on somebody." No hands go up. Wendy tells Jon to read the statement again. This time Carl and Jean Smith put their hands up. Jon calls on Carl, who says, "Tundra?" in a questioning voice. Jon responds, "Correct." A boy calls out, "What is it?" and Carl responds, "Tundra." Wendy adds, "If you don't know the answer, you can also look in your book." Carl asks the teacher if he is to ask the next question, and she tells him that he is. Carl reads in a soft voice: "Over five thousand kinds of animals can be found there."

David Keane says loudly, "Say it again; say it one more time." Wendy sanctions David by calling his name, and David protests: "I only heard half of it." He points at Joan Crenshaw and says, "She was talking to me." Joan is indignant: "I am not talking!" Another student chimes in: "First one to hit the buzzer wins!" David responds, "Desert, am I right?" Spirits are high, and there is a synthesizer inspired chorus of "Wroooooonggggggggg" from the class. In actuality, David has given the correct answer based on the textbook.

David gets to ask the next question, and he reads: "Runs southward to the Gulf of Mexico." A student calls out, "Baja California." Another suggests, "The Gulf of California." Wendy reminds the class, "If you know the answer, raise your hand." David now calls on Carl who replies, "Grasslands." One of the students who had previously answered the question says, "That's what I meant." In an even voice, Wendy tells the class," Let's listen so you can hear the questions."

It's now 10:19. Carl reads, "In the summer, only the top layer of soil thaws. The ground underneath it never thaws at all." Several students call out, "Oh, I know!" and Carl calls on Larry who says, "Tundra." Larry is slow in continuing the game, and the teacher tells him that he is to ask someone else a question. Looking down at his sheet, he reads, "Days are shorter than in the tundra." A student asks, "Than what?" Larry repeats, "The tundra." There is some confusion. Another student says in a quizzical tone, "Days are shorter than the tundra? That's weird," and begins laughing. Larry calls on Evelyn Long who has her hand raised. Evelyn says, "Coniferous forests." Throughout the questioning game, the noise level has remained moderate. Students are talking to one another, joking, and apparently enjoying the activity a great deal.

Students Complete Review Questions and Study Sheets (Day 4)

At 10:18, after spending several minutes in administrative chores, and 4 minutes correcting vocabulary words, Wendy gives the students the day's seatwork assignment:

> Okay. What I'd like you to do is to do page 437, and you can use the back of your vocabulary paper. If you don't have enough room, you can get another piece of paper. The first three sections are just putting down the answers. The bottom part, "Applying What You've Learned," requires fuller answers. That shouldn't take more than about 10 minutes. I'm also going to give you study sheets. This study sheet has 22 questions. You'll need another piece of paper to put the answers down, because there's not enough room there.

Wendy's voice is drowned out by students' voices and general classroom noise as students begin to start the assignments. Students are up sharpening their pencils, getting pieces of fresh paper, and generally jostling with each other. Several ask their friends, "What do we have to do?" The response is terse: "Study Sheets," and indicates that this assignment is a familiar part of the week's activities. Wendy breaks in and tells the class: "You'll have to work until about 20 to 11:00 and then I'm going to show you some slides. So let's make the best use of your time so you won't have to do homework." Wendy begins moving around the classroom, quieting individual students, and answering questions about what they are supposed to do.

After the initial commotion, students settle down and begin work by turning to page 437 and reading the first review question. They then flip back through the chapter to look for the answer, find it, and write it on their paper. Students whisper softly as they flip their books back and forth. For 9 minutes, the class is generally quiet. Then the noise level begins to creep up, and Wendy admonishes: "Settle down and work quietly." The noise level falls immediately.

During this time, Wendy is alternately at the demonstration table at the front of the room, and walking among the desks monitoring student progress and answering questions. After a while the noise level creeps up again, and Wendy reminds the students: "If you're visiting, you should not be." This is said matter of factly, at moderate volume, and might be missed by students not sitting near Wendy. This time the comment appears to have no particular effect on the noise level of the class.

At intervals, students get out of their seats and walk up to the demonstration table to ask Wendy a question. Others go over to sharpen their pencils. Some non-academic conversations erupt at the pencil sharpener, but these are usually quelled with a glance fron Wendy. The seatwork continues smoothly with occasional quieting from the teacher until forty minutes have passed.

Teacher Corrects Review Questions and Study Sheets (Day 5)

Wendy is all business when it is time to correct study sheets. She devotes only a minute or so to the opening transition, and begins the day's work at 10:17:

> All right, the first thing we want to do today is to start correcting page 437, the section that you worked on on Friday. Finished or not finished, pass you paper to the person behind you. The person in the back of the row bring it to the front. Put your name on the bottom to show you've corrected it.

Jon calls out in a loud voice without being recognized, "What are we correcting first?" Wendy does not answer, and there is considerable noise as students take out papers and pass them to other students. Several students get up and go over to the pencil sharpener. Jon makes another comment, but it is drowned out by the general noise. Wendy notices one student combing her hair, and walks down the aisle and confiscates the red comb that she has been using.

It takes the students three minutes to exchange papers and get themselves ready for the correction. When they are settled, Wendy says in a moderately loud voice, "Okay, let's start. The first thing we're going to correct is page 437. Will you please see that your name is on the bottom of the paper so I'll know who corrected it."

The students quiet down after this comment, and look up at Wendy. She tells them:

> If you're unsure about whether an answer is right or not, raise your hand and read me the answer. If you come to a point where someone didn't finish, draw a line under the last answer. When you get your paper back, finish it up. You'll get more credit than if you turn in a paper which isn't finished.

The pencil sharpener rings out again, and Joan Crenshaw says, "There's no room at the bottom to write my name." Wendy responds in a tone that does not suggest that Joan has made a silly comment:

> Write it on the side or anywhere, just so I'll know that you're not correcting your own paper. I can't give you much credit if you correct your own paper because I don't know if you answered it when you corrected it or answered it before. Okay, let's start with 437.

Wendy reads the first four review questions rapidly inserting the correct answer in the question and then repeating the correct answer. ("The environment where there is the least rainfall is the (slight pause) desert. Desert.") After finishing the fifth question, Wendy asks: "Any questions on those?" The correction of the first 5 questions has taken approximately 30 seconds. Evelyn has begun a note to Angie, and divides her attention between correcting Stan's paper, and the note.

No hands are raised indicating questions, and Wendy continues:

> Next part, true-false. Number 1, there are hot and cold deserts. True. Two, the largest rodent in North America is the Rat. False. Three, all animals hibernate in or migrate to the tundra during the winter. False. Four, the leaves of pine needles--pine trees--are called needles. True. Five, the cause of a desert is very little water. True.

Taking approximately one minute, the second section has been corrected without any elaboration or exposition of the answers. Wendy scurries through the next five multiple choice questions in one minute and then comes to "Applying What You Learned." She begins this section without pausing, and starts to give the students the answers:

> Okay, the last part are questions. Number 1. Even though the tundra has the longest days in the summer, why doesn't the sun warm that region?

Wendy's tone is matter of fact; she is not asking questions, but recalling the question asked by the textbook. She moves on to answer her own question:

> Because the sun's rays don't hit it directly. They hit it from the side and bounce off. You can say they're absorbed in the atmosphere.

Looking up from the paper he is correcting, one student raises his hand, and Wendy recognizes him. He asks: "What if they say it's a cooler climate?" Wendy pauses to think for two or three seconds,

and then says, "That doesn't explain why." The student who asked the question marks the question wrong. Several other students petition Wendy with their hands. Wendy calls on Sal, who asks, "Because of its northern location?" Wendy thinks and replies, "That's all right; I'll accept that."

This evidently satisfies the other students, and they put their hands down. Wendy pauses for a few seconds, looking for new hands. There are none. She continues the correction: "Number 2. How does staying in underground burrows during the day protect desert animals?" Without pausing, she answers her question. "Uh, they stay cooler." Wendy elaborates this point while one boy, in all seriousness, asks his neighbor, "She said warmer?" Several students chuckle at his confusion.

Another boy raises his hand, and is recognized. He asks, "What if they put, 'The temperature gets very hot?'" Wendy considers this for a few seconds and then accepts the response, noting that a burrow protects desert animals from the temperature because it's underground.

The correction continues in this manner: Wendy gives the correct answer and then responds to students' questions regarding the correctness of other answers. Since many of the students either copy, or paraphrase, the text, most answers do not require Wendy's adjudication, and the five questions in "Applying What You've Learned" are completed by 10:23.

Excerpts from Classroom Observations
Topic Two: Viruses, Bacteria, and Protists

During the second period of observation, Wendy taught Chapter 16, "Viruses, Bacteria, and Protists." Table 2 summarizes how she taught this topic. She allotted seven days to the subject and divided her instructional time between reading and discussion segments, written seatwork, and a laboratory session. On each day the teacher and students spent time discussing procedures for the Science Fair. The following excerpts describe the types of instructional segments that occurred during Topic Two: the lab preparation, the laboratory session, discussions of the Science Fair, and correcting a study sheet.

Lab Preparations and Procedures (Day 2)

From the previous activity, Wendy moves quickly to prepare her class for the lab session scheduled for the next day. During this lab, the students, working in small groups, will study paramecia and complete study sheets based on their observations. To begin the preparation, Wendy says,

> All right, let's go over to the lab page [in the text], page 484-485, and you can see what you're going to do because then tomorrow we can quickly pass out lab sheets.

Table 2. Duration of Activities for Topic Two (Teacher 11)

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Class Begins	Opening Transition	Opening Transition	Opening Transition	Opening Transition	Opening Transition
5 min.	Students Read and Talk About Text pp. 273-276 (Viruses)	Students Read and Talk About Text pp. 277-283 (Protists)	Review Tests; Teacher Gives Answers	Talk About Science Fair	Teacher Explains Scie Fair
10 min.			Brian Shows Class Hexcell	Talk About and Questions on Hexcell	Study Questions on pp. 279-288
20 min.			Questions and Answers About Lab Sheet and Procedures	Review Lab Sheets	Students work at Seats
30 min.	Filmstrip on Causes of Cancer		Lab: Students Look at Paramecium on Slide; Fill out Lab Sheet	Students Read and Talk About Text pp. 286-288 (Protists and Algae)	DISMISSAL
40 min.	Questions and Answers about Filmstrip	Lab Procedures pp. 284-285 Read, Questions, and Answers Slides, Reading Script	Clean-Up	Seatwork: Vocabulary (288) Questions (289) Finish Lab 10 Questions Students Complete FWL Survey	
48 min.	DISMISSAL	DISMISSAL	DISMISSAL	DISMISSAL	

Table 2 (Continued). Duration of Activities for Topic Two (Teacher 11)

	DAY 6	DAY 7
Class Begins	Opening Transition	Opening Transition Talk About Science Fair
	Teacher	Teacher
5 min.	Reviews Science	Leads Correction of
10 min.	Fair	Student Sheets
	Class Talks About Student Council	Transition to Text
	Students	Students
20 min.	Finish Questions on pp. 289; Students Receive Extra Credit if	Take Test
30 min.	Seatwork is Completed	Teacher Tells Students if Assignments Are Missing
40 min.	Correction of Questions	Students Chat
48 min.	DISMISSAL	DISMISSAL

She then tells the class to read silently the list of lab procedures, labeled A-J, printed in the textbook. After the class has read silently for three minutes, Wendy announces that tomorrow she will distribute a "ditto sheet which has A, B, C, D, E, F, J, on it with spaces on the lines for you to put in the answers."

Wendy then begins to quiz the class on their understanding of the procedures: "What do you do first?" A girl replies that you have to take a medicine dropper, get the paramecium culture, and place a drop of it on a slide. You also place a bit of thread on the slide. This answer is correct--a paraphrase of the book. Wendy asks why the thread is necessary, and students spontaneously respond that the thread allows them to judge the size of the paramecium. The teacher confirms the answer by rephrasing the answers.

Wendy asks a student to begin reading where the discussion has left off. A student reads aloud about placing a cover slip on the slide, and Wendy comments on this aspect of the procedure. The TA approaches her and asks her a question; Wendy responds and then continues her remarks to the class about the slide cover.

The fourth direction in the book asks the students to determine which ends of the paramecium are the front and back. Wendy asks the students how they can tell front from back. Rick answers, "Well, whatever way it moves." Other students volunteer their opinions, and the teacher agrees that the front end usually "goes first." Wendy continues to go over every step of the lab procedure in this manner: students read the direction out loud, Wendy asks questions, and comments on the answer. The discussion of lab procedures lasts nine minutes, and the students are attentive.

Laboratory (Day 3)

As Table 2 shows, Wendy reviewed the lab procedures for 6 minutes before allowing the students to begin the laboratory exercise. The exercise begins when Wendy announces, "You can work by yourself or [share a microscope] with a partner." Hardly waiting for the teacher to finish this directive, the students noisely lunge for the microscopes. The noise level in the classroom rises considerably as the students grab their equipment, jostle each other, and scoot around the room searching for a place to work. The room is short on work space, so students spread out on the floor as well as along the counter. Through the clamor, Wendy attempts to help confused students, telling them where they may set up their microscopes and so on.

In order for the microscopes to operate properly, the students must plug them into an electrical outlet, and an extension cord with multiple plugs lies on the floor. One student remarks that the cord is "not plugged in," but no one heeds the warning.

"The microscopes," Evelyn exclaims, "don't work. There's something wrong with these things." Wendy hears Evelyn and walks over to her and says, "Well, it's not plugged in. You've got to plug it into the wall." Evelyn and her partner laugh embarrassedly

After setting up their microscopes, the students set about making their slides from the culture on the teacher's lab counter. Two groups find paramecium at the same time and fill the room with their cries of "I see it, I see it!" and "There they are!" The level of excitement is high; the students seem to feel as if they were on a treasure hunt. When one student finds a paramecium (or a paramecium swims into view), the student's cry of delight is followed by the partner's "Let me see it, too" or "Can I see that?" At the same time students address Wendy: "Mrs. Johnson, look at this," "Is this one?" or "I can't find anything."

The groups work and talk eagerly, mixing discussion of the task at hand with marginally related concerns, group discipline, and digressions. For example, two groups of two boys each are working closely together: "Four, four," referring to the desired magnification; "That's the thread there;" "I see 'em." One of the boys begins working on the lab sheet, "We have to do A. We did A. Huh. We did B. Okay, it says to change to high power." There upon the students discuss the use of high power, but quickly return their attention to the lab sheet.

Suddenly two of the boys argue over possession of a lab sheet:

Stan begins, "Hey, Carl, you took mine--"

"What?" Carl says.

"--took my lab sheet."

Carl denies the accusation and the two boys repeat the accusation and denial several times until Drew says, "This one is yours, stupid, you left it in your book."

Stan responds, "That's his. You took mine. That's mine? No way!"

Larry joins in, "Here, give me the blank one," and adding disgust to his voice, "You're stupid, Carl."

Drew concludes with laughter, "You're stupid, Carl."

The boys return to looking through the microscope and filling in their sheets. They have repeated difficulty trying to locate the paramecium under high power and comment, "Ours are trying to hide" and "We found it on low." Completing the required drawing is also difficult because, "He left. He don't want to be seen," and "He swam off the picture."

A strange shape on the slide diverts the boys from their task: "What the heck's that?" The partner replies, "I don't know. It looks like eyebrows or something, huh?" Their excitement rises, and the other boy says, "It does, it does a bit." They continue in this vein for a minute or so.

Returning to the elusive paramecium, they discuss solutions to the problem of its evasiveness. "I wish we could kill it. I wish we could make it dead. Watch this." The speaker pushes the objective of the microscope down into the slide. His partner laughs delightedly, "Gross, you're so..."

Wendy approaches the boys and asks how they are getting on. One of the boys says with disappointment in his voice that he and his partner haven't even been able to find one under low power. The teacher sympathizes, "They're hard to find." Stan says, "I think they're hiding." Wendy continues, "If you move the slide around and the slide picks up pieces of food and that kind of garbage then you. . ." She trails off and turns to look through the microscope. She suggests they make a new slide, but continues to look through the scope. She finds one and says, "Take a look." A boy looks and at first does not see it, but then says, "Oh, there he is, there he goes. He slinks around."

Another boy attracts the teacher's attention and asks her a question about the chart on the wall that records the students' completion of homework. The teacher and the boy discuss the chart, and the boy negotiates with the teacher for an improvement in his score. Agreeing to the improvement, Wendy tells the boy to return to work.

Wendy leaves these boys and continues around the room. She quiets students down, helps them focus their microscopes, and gives them advice. The level of excitement declines as the students move from finding paramecium to completing their lab sheets. Two boys comment on each others' work: "Larry, let me see your drawing. I want to copy it. Oh, it's good man." Other students roam around the room, drawing a rebuke from one group: "Split the scene, pervert." The boys' level of involvement decreases, and they joke about a lost pencil, quarrel over possession of a microscope, and speculate if they will have social studies later in the day.

The lab sheet asks the students to find the oral groove, the nucleus, and the food vacuole. These directions result in difficulty for many students. In one group a boy reads from the sheet, "Can you see evidence of a food vacuole forming?" and his partner replies, "I can't see nothing in here. . .I can't do it, see it. . . the power is too low." Another boy says, reading the text, "Do you see a nucleus in the paramecium?" Stan says, "Say 'no;' put 'no,' Man." The boy responds, "But there is one." Stan: "We can't see it. . ." Perhaps they could identify these parts under high power, but then they could not see the paramecium as it swims too fast. Thus the boys are unable to resolve their dilemma: should they take the question literally and risk

a wrong answer, or should they fib and copy from the book. The boys continue grappling with this problem until the teacher says to the class, "All right, we need to start cleaning up."

Discussion of Laboratory (Day 4)

Wendy allotted three minutes to discussion of the previous day's laboratory experience. She tells the students to take out their lab sheets and waits 30 seconds for them to do so. She begins the discussion by asking the students, "Okay, what was the biggest problem that you found that you had on this lab?" Students raise their hands, and Wendy calls on Jon. Jon says he had trouble finding the paramecium. Wendy continues, "Good point. Why couldn't you find them very good?" She calls on Brad.

Before Brad can answer, a girl interrupts and asks for a lab sheet as she was absent. Tess comes up to have the teacher sign a yellow slip, and Lonnie comes up to get a ditto master. Wendy repeats the conversation so far, and calls on Drew to explain, "Why couldn't you find it very good?" Drew replies, "They were real small and moved around really fast.

Wendy expands on the issue:

> If we could figure out a way to slow those paramecium down; if we could slow them down they'd be easier to see...
>
> So as far as the drawing that you made, I don't expect a real fantastic drawing because it was really hard to see them, but I do really want to make sure that you answer the four questions down at the bottom where it says "report." Those four questions you can answer without looking through the microscope. If you saw enough through the microscope, you can use it to answer those questions. You have the book if you can't answer that way. Make sure that you do all the questions and you should have a drawing of some sort and the questions answered. If you didn't see them, then the question should be answered "No" or whatever they ask you to do.

Having completed stating her expectations for the lab write up, Wendy concluded the discussion of the lab.

Discussion of Science Fair (Day 6)

The students have been working on a project for the school Science Fair for sometime now and today the projects are due. Wendy begins the class by calling roll and asks the students if they have brought in their projects. Students respond as the teacher calls their names, and most have turned in their pro-

jects. However, a few haven't, and they discuss their situation with Wendy. For example, when Wendy calls Drew's name: "We got the report and the project," but he and Sal haven't brought it in. The teacher says, "Okay, just bring it in tomorrow. . ."

The teacher moves on to Lonnie. Lonnie hasn't brought it in; Wendy asks, "Will you bring it in tomorrow?" Lonnie says, "Yeah," but the implication is that no one will ever see his project. Another student with a problem is Jon, who has mislaid part of his project; he leaves the room to search in his locker. While the teacher calls the roll, the uninvolved students talk relatively quietly among themselves.

Wendy reminds the students that no matter how the partners divided the work, they each receive the same grade. She concludes the roll call by noting, "As long as it's in there by tomorrow morning before school starts, that's fine."

A student asks Wendy if she is going to judge the project. She responds that she will not judge them, because she knows the students too well to judge objectively. Rick raises his hand and when Wendy recognizes him, asks, "Are there going to be prizes or anything?" Wendy discusses the grading system: "Yeah. A first place ribbon is an A, second place ribbon is a B, third place ribbon is a C." A student echoes, "A fourth place ribbon is a D," and students laugh. The teacher continues, "And if you don't make third place and you get an honorable mention, you get a certificate." The students laugh again. Wendy continues, "Okay, that means you didn't put a heckuva a lot of effort into it. I think last year, of all the prizes there were only two projects that didn't get ribbons."

A student wants to know if any parents from this class are judges (No), and Lonnie wants to know when the students may see the projects (at the open house tomorrow evening). The conversation then returns to grading. Wendy reads from the direction sheet previously distributed to the students: "A blue ribbon, you get a possible 100 points. All right, now between 90 and 100 points is a blue ribbon. Between 67 and 89 points is a red ribbon. Between 40 and 66 points is a white ribbon." Drew asks what the blue ribbon is, and Wendy repeats the grading scheme. She continues with discussion of the grading criteria: scientific information and knowledge, 50 points; accuracy, 25; construction of the project, 10; attractiveness, 10; the test, 5. The students pay close attention to this explanation, as if the details of grading are very salient.

The discussion reverts to the topic of judges and more extensively, why Wendy is not a judge. A student asks how the Science Fair project is weighed in the report card grade, and Wendy indicates that she weighs each assignment equally. A student responds in surprise, "That's it?" In a moment Drew picks this theme up and asks, "You said you had about 25 grades in your

grade book?" Wendy nods. "Do you count our daily assignments as highly as you count the tests?" Wendy's reply implies that this is the case.

The students then express interest in when they will receive their grades and ribbons for the project. Wendy tells them they will know tomorrow.

Teacher Corrects Study Sheets (Day 7)

Bringing a discussion of the Science Fair to a close (see Table 2), Wendy says in a louder voice, "All right, first thing I want to do is correct the study sheet. Would you get yours out and pass it on, pass it to the person in front of you." As the students comply, the noise level rises and some engage in horseplay.

She moves quickly through the first three questions, as if to rivet the class's attention and to indicate she will not wait for stragglers.

> All right, put your name down at the bottom. Every question is worth one point unless it says name two things or name three things. Okay, Number 1. "What is a virus made of?" Reproductive material, also saying that it has a protein covering.

She stops briefly to sanction Sal for misbehavior and then proceeds with questions 2 and 3.

> Number 3. "What is a latent virus? It is a virus that's inactive and will become active at a later time.

Two students raise their hands to determine if the answer on their paper is correct. Larry reads from his paper: "The virus remains inactive until certain conditions." The teacher indicates the answer is correct. Stan then reads his answer: "It seems lifeless. Is that Okay?" Again, Wendy says the answer is correct.

The teacher rapidly leads the class through the study sheet, providing correct answers and judging the validity of answers students are unsure of.

> 10. "How is bacteria harmful?" Two ways, so it's two points. It can damage food, destroys food; it causes disease. All right, number 11. "Ways that bacteria are useful." You need four ways, four points. It decays plants and materials; it put nutrients back in the soil; it puts nitrogen there; it's used in making anti-biotics.

Students are attentive to their teacher. The only digression involves the influence the test they are about to take will have on their quarter's grade. Bruce asks, "Is this test going

to count on our grade for this quarter?" The teacher nods that it is, and Bruce says quietly, "Oh no." Several students echo the same response. Wendy recognizes Sal and he asks, "Are you going to tell us our grades for the quarter?"

The teacher moves rapidly through the remaining questions without changing her procedure. She breaks off once to discipline Sal who persists in talking and interrupting. In general, however, the students remain attentive. It takes Wendy eleven minutes to provide answers for the 25 questions.